Microscopic Determination of the Nonopaque Minerals

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JOHN J. MATZKO

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A revision of Bulletin 848 by Larsen and Berman (1934),
including new optical data and new methods of determination

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PREFACE TO THE THIRD EDITION

The first edition of "The Microscopic Determination of the Nonopaque Minerals" by Esper S. Larsen, Jr., was published in 1921 as U.S. Geological Survey Bulletin 679 after more than 10 years of preparation. Preparation involved not only compilation of data from the literature, but also new determinations of optical properties on about 500 samples. These new descriptions accounted for 126 of the 294 pages of the 1921 edition.

The second edition, by Larsen and Harry Berman, both then at Harvard University, published in 1934 as U.S. Geological Survey Bulletin 848, increased the data in Bulletin 679 by more than 50 percent. The second edition was republished in Russia in 1965 (Petrov, 1965) with insertions of newer data from the literature.

Assembly of new data on optical properties of minerals was begun by Fleischer and Matzko in 1950, and compilation in the present tabular format was begun in 1965. Insofar as possible, data from the literature up to August 1, 1983 have been included in the tables. The introductory text on methods was written by Wilcox, who also critically reviewed and suggested minor modifications of the tables as prepared by Fleischer.

The present edition, in holding to the objective of mineral identifications, omits discussion of statistics of mineral optics, as covered in Chapter 3 of the 1934 edition. Modern treatments of the Gladstone-Dale relation and other aspects of the relations of refractive index to density and chemical composition can be found in Allen (1956), Jaffe (1956), Batsanov (1961), Anderson (1975), Pabst (1975), Mandarino (1976, 1978, 1979, 1981) and Bloss and others (1983). The Commission on New Minerals and Mineral Names, International Mineralogical Association (American Mineralogist, v. 67, p. 191-192), states for new minerals, "It is recommended that the relationship between chemical composition, density, and refractive indices, be checked by the Gladstone-Dale rule."

CONTENTS

Page

FIGURES

Page

TABLES

Page

Microscopic Determination of the Nonopaque Minerals

By Michael Fleischer, Ray E. Wilcox, *and* John J. Matzko

CHAPTER I. INTRODUCTION

Identification of an unknown mineral in former times was a haphazard operation, involving determination of a few optical, physical, and chemical properties for comparison with a woefully incomplete set of properties of known minerals. Today, not only can the diagnostic optical properties be determined more reliably and the chemical composition more rapidly, but several X-ray techniques are available for determination of diagnostic crystal structure.

Compilation of X-ray data in a form useful for mineral identification has proceeded apace and has far outstripped the compilation of new optical data, with the unfortunate result that the use of the polarizing microscope in mineralogic and petrologic investigations has decreased markedly; in addition, the time allotted in the curriculum of many colleges for training in optical crystallography has been reduced. The polarizing microscope nevertheless remains a powerful and sometimes indispensable tool in mineral identification, and to help restore its usefulness the authors have taken on the task of bringing up to date the tables compiled by Larsen and Berman (1934).

The tables, which appear in chapters 3 and 4 herein, are a compilation of properties of known minerals. They have been updated by adding optical data that have appeared in the literature since the 1934 edition and up until August 1, 1983. The range of optical properties of previously listed minerals and isomorphous groups has been corrected or extended, and the names and data for newly discovered minerals have been inserted. Methods for the measurement of optical properties are outlined in chapter 2.

Identification of an unknown by its optical properties proceeds most effectively in three stages: (1) measurement under the microscope of selected key properties; (2) elimination from further consideration minerals not having these properties; and (3) determination of selected additional diagnostic properties to eliminate all but one or a very few candidates. For confirmation of that one mineral or a final choice between remaining candidates, one may then turn to X-ray or chemical analysis.

It is important that this process of elimination using the tables be given the same care and attention as the measurements of the basic optical properties, for to overlook a possible candidate at this stage can jeopardize the correctness of the eventual identification. For the final stage, one should consult published encyclopedic descriptive mineralogies (for example, Deer and others, 1962, 1963, 1978; Tröger, 1967, 1979; Winchell and Winchell, 1951) then return to the microscope to determine the needed additional diagnostic characteristics.

Scope of the Tables

For each known mineral, tables 3 to 7 list optical properties readily determinable by the polarizing microscope and its accessories, and they also note certain nonmicroscopic but useful identifying properties such as bulk color, fusibility, hardness, and chemical behavior. The minerals are grouped in separate tables according to basic optical character (isotropic, uniaxial, or biaxial) and according to optic sign (positive or negative). For convenience in entering the tables by means of optical data routinely obtained by the so-called immersion method (see chap. 2), the minerals in each table are arranged in order of increasing refractive index. The tables may also be entered with refractive indices estimated from thin sections, although a much greater number of listed minerals will usually have to be considered as possible candidates due to the uncertainty of the estimate.

Need for Additional Data

Although the tables in chapters 3 and 4 have been updated, they contain many imperfections and cannot be regarded either as complete or entirely correct. The reliability of the individual listings varies widely and for some minerals cannot be estimated, inasmuch as the source literature does not supply adequate descriptions of methods used. Indeed, in too many cases it is painfully evident that no set of minimum standards was adhered to in carrying out the original optical determination, much less in the preparation and purification of the minerals for chemical analysis. Still remaining to be filled are gaps in the knowledge of the ranges of optical properties of rare minerals, many of which, judging from their determined chemical compositions, are members of isomorphous series. Finally, there is the certainty that some naturally occurring minerals still wait to be discovered and described optically.

Optical methods of mineral identification are useful not only as an adjunct to the powerful methods of X-ray and electron microprobe but in many situations also as the most reliable and rapid means of identification. However, the gaps and flaws mentioned above in available optical data of minerals are a matter of concern particularly because identification rests on the process of elimination. One therefore must keep in mind the possibility, remote as it might be, that the unknown mineral under examination is not listed in the part of the table involved. The use of optical methods in the modern laboratory will not reach full effectiveness until these shortcomings are corrected. Fortunately, basic optical data can now be obtained with greater reliability and with considerably less tedium than formerly, thanks to the availability of more documented mineral specimens and more advanced development of instrumentation and methods. Also, many of the difficulties due to limited sample size that plagued the early workers in descriptive mineralogy are now avoidable because optical, X-ray, and chemical analyses can be carried out on extremely small samples, using the spindle stage, the single-crystal X-ray goniometer, and the electron microprobe.

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We are indebted to many friends and colleagues for valuable suggestions, particularly to G. Donald Eberlein, Richard C. Erd, George T. Faust, Glen A. Izett, and Benjamin F. Leonard of the U. S. Geological Survey, to Horace Winchell of Yale University, and to J.A. Mandarino of the Royal Ontario Museum. Special thanks for reading and commenting on early drafts of the text portion are due F. Donald Bloss of Virginia Polytechnic Institute and State University, Stearns A. Morse of the University of Massachusetts, and Richard E. Stoiber of Dartmouth College. Finally, we are deeply indebted to Constance M. Schafer, who designed the special computer codes for entering and formatting the extensive tables, to Constance J. Conte, who typed the text and the extensive tables for camera-ready copy, to James W. Babcock, who carried out the optic angle calculations and to Jane Jenness, who edited, cross-checked, and proofread the tables through successive stages of their development.

CHAPTER II. DETERMINATION OF OPTICAL PROPERTIES OF TRANSPARENT MINERALS BY THE IMMERSION METHOD

Whereas the textures and interrelations of minerals in rocks, so important in petrologic interpretations, are well seen in thin section, measurements of principal refractive indices and other optical properties necessary for reliable identification are better accomplished on individual fragments by the so-called immersion method. Advantages of this method include the ability to manipulate crystal fragments individually without the handicap of interference from adjacent crystals.

For the immersion method, the sample is crushed to separate the individual crystal units and expose fresh surfaces, so that fragments can be chosen and their refractive indices can be compared under the microscope with successive liquids of known refractive indices until a match is found. In the same mounts, birefringence, optic angle, optic sign, pleochroism, and the relationships of optical directions to crystallographic directions (extinction angle and sign of elongation, and so on) may be measured or estimated.

It is possible here to give only a brief review of established procedures and techniques; emphasis will be on several practical techniques not yet fully covered in most textbooks. For details of the conventional techniques, the reader is referred to textbooks such as Bloss (1961), Wahlstrom (1969), Hartshorne and Stuart (1969, 1970), Burri (1950), Tatarskii (1965), Stoiber and Morse (1972), Hutchison (1974, especially p. 78-93, 247-263), Schumann and Kornder (1973), McKie and McKie (1974), and el-Hinnawi (1966). Several useful works deal with problems encountered in special fields: industrial chemistry and product control (Hartshorne and Stuart, 1970; Chamot and Mason, 1958; McCrone and Delly, 1973; Lehr and others, 1967), ceramics (Insley and Frechette, 1955; Dietzel and Köppen, 1974), identification and characterization of synthetic inorganic substances (Winchell and Winchell, 1964; Kordes, 1960; Lehr and others, 1967), and organic compounds (Winchell, 1954).

Refractive Index

Three techniques are especially useful for determination of refractive index, the primary basis for entry into the tables: (1) central illumination ("Becke line"), (2) inclined illumination ("Schroeder van der Kolk"), and (3) dispersion coloration ("dispersion staining"). All three techniques depend on the same basic optic phenomenon: the smaller the difference of index between fragment and liquid, the less strongly diverted the light rays passing through an inclined interface. The techniques differ only in the manner of illumination and in the resulting observed effects. Because the immersion liquids are so important for the correctness of the determination, their calibration and use will be dealt with first.

Immersion Liquids

Sets of liquids ranging in index from about 1.46 to 1.80 and separated by regular index intervals, say 0.005 or 0.002, are available commercially. In choosing the interval between liquids, it may be kept in mind that the greater initial cost of a set having the smaller interval may be more than compensated by the saving of time and the greater precision of results. The label on each bottle in the set should show not only the index of refraction for the D-line of the spectrum, but also its coefficients of temperature and dispersion. With some care and effort, sets of liquids can be made up in the laboratory from end members, as described by Harrington and Buerger (1931), Butler (1933), and Meyrowitz (1955, 1956). Useful general discussions of possible end-member liquids are given by Johannsen (1918, p. 259), Burri (1950, p. 221), Wilcox (1964), and Hartshorne and Stuart (1970, p. 265).

The refractive index of a typical organic immersion liquid decreases significantly with increasing temperature--on the order of 0.0004 to 0.0005 per degree Celsius; the corresponding change of index of the immersed crystal fragment is an order of magnitude smaller, thus negligible in the present application. A bottle label reading $n_D^{25°}=1.534$ indicates that the refractive index of its contained liquid is 1.534 at 25°C in light of the D-line (wavelength 589.3 nm). A further notation,

$$-\frac{dn}{dt} = 0.00039/°C,$$

indicates the magnitude of the inverse change of index with temperature. Thus, after reaching the match between fragment and liquid, it is necessary to make an index correction for the difference between the temperature of the immersion mount itself and the temperature at which it was calibrated. If, for instance, the above liquid was found to match the index of a fragment at 28°C, the correction to be made would be 3x 0.00039, or 0.00117, to be subtracted from 1.534 to give 1.53283, rounded for the present application to 1.533. This is the refractive index of the matching liquid under these conditions and thus of the index of the fragment.

The refractive index of each liquid in the set must be rechecked from time to time, depending on the stability of the liquid and on the accurancy required in use. Adequate for most mineralogical laboratories is the Abbe-type refractometer for indices up to about 1.70 with a precision about ±0.0002. Although a prism of special glass may be substituted to permit measurements to higher than 1.80, the glass commonly used for this purpose is a high-lead glass that is vulnerable to corrosion from most liquids used in this higher range. Less expensive refractometers, such as that designed by E.E. Jelley (1934; see also Edwards and Otto, 1938), extend to 1.90, are not damaged by liquids above 1.70, and are precise enough (about ±0.001) for much work. Whatever the refractometer, it too should be calibrated carefully according to the directions of the manufacturer (see also Fisher, 1958).

In some applications it is necessary to know the dispersion strength of the immersion liquids. This property may be expressed as the difference between refractive indices at two standard wavelengths, such as the F- and C-lines. A common expression of the dispersive power of the liquid is the coefficient:

$$\nu = \frac{n_D - 1}{n_F - n_C}$$

Dispersion can be determined by measurement of refractive indices of the liquid at the wavelengths of the F-, D-, and C-lines by minimum deviation on a goniometer using a prism-cell, or on an Abbe refractometer making corrections for the dispersion of the glass of its reference prism. Considerably more convenient, however, is use of an Abbe refractometer equipped with Amici prisms, whereby a measure of the dispersion is obtained in the course of determination of n_D in white light.

Central Illumination ("Becke Line") Technique

The so-called Becke line test of the refractive index difference between fragment and immersion liquid is carried out in illumination consisting of a narrow cone of light symmetrically about the axis of the microscope. The fragment in liquid is brought into sharp focus. (If anisotropic, the fragment should be placed in a position of extinction, then the upper polar is withdrawn.) As the focus is raised slightly, that is, as distance between objective lens and object is increased, a bright-line (the Becke line) forms at the edge of the fragment and moves toward the substance of higher index. Thus, if refractive index of the fragment is higher, the Becke line moves inward; if lower, it moves outward. As the focus is raised further, the line fades and the image blurs. The basis for this fading and blurring has been variously ascribed to the crude lens effect of the solid fragment and to total reflection of rays by the very steep interfaces at the edge of the fragment.

Determination of the refractive index of the fragment becomes a matter of finding the matching liquid in a set of graduated index liquids. As this matching liquid is approached in successive liquids, the Becke line noticably weakens but, up to a point, may be made more visible by stopping down the substage aperture iris diaphragm. In a liquid near the match and with white light for illumination, the edges of the fragment take on faint colors. Attention to the quality of these faint dispersion colors enables one to recognize a close approximation of the true match (Emmons and Gates, 1948). A more exact match may be established using monochromatic light, such as that of the standard sodium line (589.3-nm wavelength); when the index of the solid and liquid are the same in monochromatic light, the Becke line disappears completely, and the fragment becomes invisible except for flaws and inclusions.

If the host fragment is crowded with inclusions, precise results are not attainable by the Becke line method, for as the matching liquid is approached in successive mounts, the still strong Becke lines of the crowded inclusions coalesce to form a single bright line that prevents recognition of the fading and disappearance of the Becke line of the host. A further difficulty, possibly related, arises from the so-called "spurious Becke line," a light line that moves opposite to the true Becke line. This situation is often encountered with fragments having appreciable light absorption (body color) or unfavorable fragment contour. Here at best one finds only a broad minimum in the intensity of the light lines through a series of adjacent immersion liquids, leaving in question the refractive index of the true match.

Oblique Illumination (Schroeder van der Kolk) Technique

The oblique illumination technique, details of which are given in most textbooks and in the excellent discussion by Wright (1911, p. 92-95), is capable of greater sensitivity than the Becke line method. Briefly, to obtain oblique illumination, the entering cone of light is blocked on one side at the proper level in the substage or in the microscope tube to produce a sidelighting effect that enhances the appearance of relief (mismatch) of the fragment in respect to the immersion liquid: one edge of the fragment is highlighted while the opposite edge is shaded. As a general rule, the index of the fragment is higher than the liquid if its brighter side is toward the more brightly illuminated portion of the field of view. It is advisable, however, to check the behavior of a particular microscope and illuminating system in this respect by use of a fragment of known index in a liquid of known direction of mismatch.

In white light, as the indices of liquid and fragment become more nearly equal in successive mounts, the apparent relief of the fragment decreases. At match, one edge of the fragment is bluish and the opposite edge reddish. One learns to recognize the diagnostic shades and intensities of colors that are obtained on either edge when a match has been reached, keeping in mind that the quality of the colors is affected to some extent by the natural body color of the fragment as well as the spectrum of the light source. The match point is more precisely defined with monochromatic illumination, for at match the fragment completely disappears except for flaws and inclusions. In order to cancel disturbing effects due to differences in shape of opposite edges of the fragment, it is helpful to observe the fragment at the one position of the microscope stage, then rotate the fragment 180° on the stage and observe it again to confirm that the relief effect is in the same relation to the lighter side of the field.

Dispersion Coloration Technique Using Central Focal Masking

This method is rapid and in large part free of misleading effects such as the "spurious Becke line" encountered in the central illumination method. Although the precision of this method is somewhat less than that of oblique monochromatic illumination, it is quite adequate for purposes of crystal identification. In addition to its value for determination of refractive indices, the method enables rapid distinction between different mineral species in a fragmental mixture and determination of the kind and amount of undesired constituents in a product at successive stages in a purification process. Details of the method and its variants may be found in descriptions by Cherkasov (1960), Wilcox (1962, 1983), Brown and McCrone (1963), Brown and others (1963), and Hartshorne and Stuart (1970, p. 437). Similar color effects are obtained in the "Grenzdunkelfeld" technique described by Schmidt and Heidermanns (1958) and in the early "dispersion staining" technique of Crossmon (1948). In the two latter techniques, however, some light rays traverse the fragment at an appreciable angle to the axis of the microscope, leading to possible inaccuracies when working with strongly anisotropic substances.

The immersion mount is illuminated by a narrow beam of ordinary white light, produced by severely restricting the substage aperture diaphragm. With a small opaque dot mask installed in the objective near the focal point, the image of the fragment appears on the dark field in a color that indicates the degree of match or mismatch with the immersion liquid. These useful color effects result from the appreciably greater dispersion of the liquid over that of the solid of similar refractive index. Thus in figure 1, the refractive index of the glass matches that of the liquid for light of wavelength near that of the D-line (5893 Å or 589.3 nm) but is progressively less than that of the liquid at shorter wavelengths and greater at longer wavelengths.

The critical color effects begin to appear as the index of the immersion liquid approaches to within about 0.01 of that of the fragment, depending on the relative dispersive strengths of fragment and liquid. In liquids of index outside this range in either direction, the fragment edges are imaged brightly in the color of the source light. To determine whether to go to a liquid of higher or lower index, one simply observes the movement of the single strong Becke line as the focus is raised.

Under the microscope a fragment immersed in a matching liquid and illuminated by a thin beam of white light refracts the various wavelengths differently (fig. 2). Light beams of a wave-

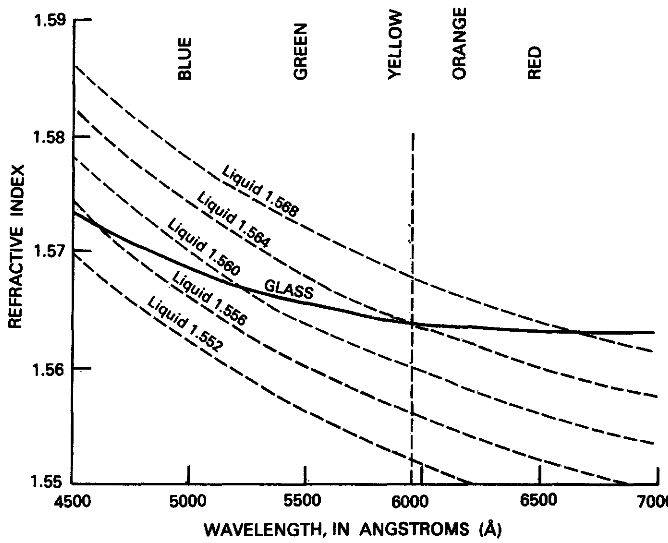

Figure 1. Dispersion of the refractive index of a typical inorganic solid compared to dispersions of successive members of a typical set of organic immersion liquids.

length close to the standard yellow wavelength, 589.3 nm, are blocked by the opaque dot at the focal point of the objective, while beams of shorter wavelengths (more blue) and of longer wavelengths (more red) bypass the opaque dot and combine again to form an image of the fragment edges in deep violet color. This violet image is the combined effect of the spectral colors remaining after the band near the yellows has been subtracted. The field of view is otherwise dark, because beams not passing through inclined surfaces of the fragment edge are also blocked by the opaque dot. By raising the focus slightly, a red outline of the image moves inward and a blue outline moves outward. (These, of course, are the Becke lines for light of the respective wavelengths.)

From figure 1 it can be further deduced that, in a liquid of slightly lower index, say by 0.002, the edges of the fragment would be seen as noticeably richer in reds; in this case a band in the blue-green would have been subtracted. Similarly the edges of the fragment in a liquid higher by 0.002 would be seen as richer in blue.

Table 1 gives word descriptors of the colors seen in different situations. Each person should learn the color of the match as seen by eye, however. To this end, one may make a mount of a solid in a liquid as closely matched as can be judged by inclined illumination (described above) using monochromatic sodium-D illumination, then change to central focal masking illumination to observe and fix in mind the quality of color seen at the match.

Techniques of Higher Precision

Very precise determination of refractive indices beyond the third decimal place is seldom required for identification of unknown minerals. Should greater precision be desired, for instance in the characterization of newly discovered minerals or in applications to crystal structures, a number of techniques are available, each of which requires special auxilliary equipment. Perhaps the most rapid of these is the wavelength-variation method introduced by Wherry (1918), Posnjak and Merwin (1922), and extended by Emmons (1929, 1943). A precision of ±.0001 refractive index is estimated for this method, as refined by Morse (1968) using a convenient substage variable interference filter and immersion liquids for which dispersion strengths have previously been determined. A further extension of the method enables determination of members of an isomorphous series, such as the plagioclase series, for which dispersion characteristics are also known.

Sueno (1933) and Micheelson (1957) use wavelength-variation techniques, adding glass powders of precisely known index to the immersion mount of the unknown substance to act in the role of refractometer, thus eliminating the necessity of temperature correction. In the double-variation method of Emmons (1929, 1943), both wavelength and temperature are changed at will to match solid and liquid at several wavelengths, enabling one to determine not only the refractive index of the solid at the D-line, but also the dispersion curve. For greater sensitivity in determination of the index match between liquid and immersed solid, Saylor (1935) developed a double-diaphragm mask for the microscope objective and substage. Used with an ultrasensitive stage refractometer (Saylor, 1966), this mask enables precision to the fifth decimal place in determining the refractive index. Chao (1976) attains precision to the fourth place by interference microscopy.

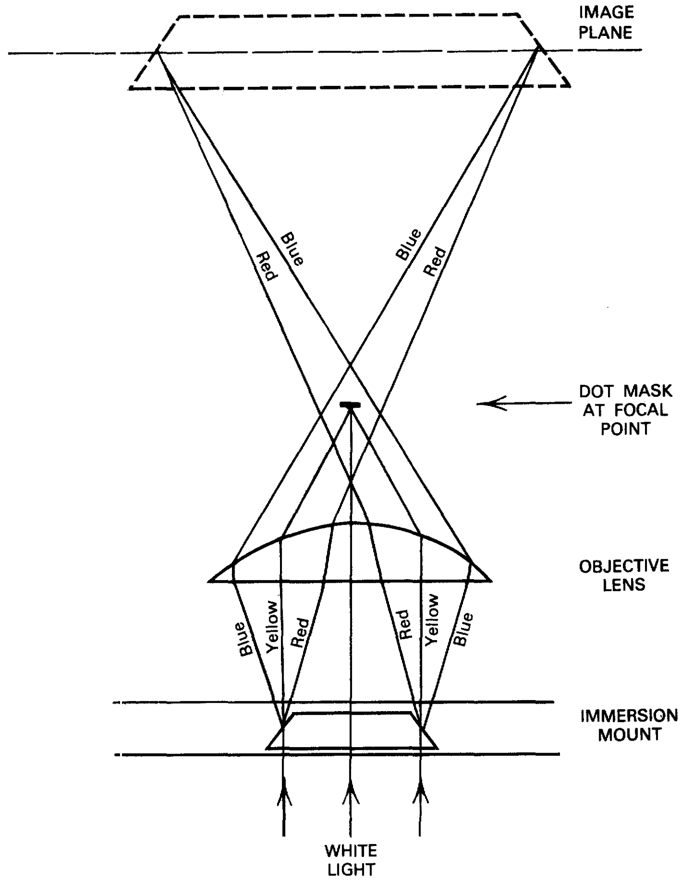

Figure 2. Formation of violet image (spectrum minus yellow band) of a fragment whose refractive index matches the liquid for the yellow band of wavelengths of light.

Determination of Refractive Index of Optically Isotropic Substances

Light in an optically isotropic substance can vibrate in all directions in a plane perpendicular to its direction of transmission, and the refractive

Table 1. Dispersion colors observed at edges of fragments on dark field with central focal masking technique
[Modified from Cherkasov, 1960]

Matching wavelength (nm)	Observed color			Refractive index n_D of solid is
	At focus	Raising focus		
		Moving in	Moving out	
660	bright greenish blue	(none)	bright greenish blue	less
625	sky blue	(none)	sky blue	than
600	blue	faint dark red	greenish blue	liquid
589	DEEP VIOLET	WEAK RED	STRONG BLUE	SAME AS LIQUID
575	purple	red	blue	
540	reddish purple	orange-red	bluish-violet	greater
505	orange-red	orange	weak blue violet	than
480	orange	yellow	weak violet	liquid
465	bright gold	bright gold	(none)	

index is the same regardless of the directions of passage and vibration. Hence the refractive index of such a substance may be determined in a straightforward manner by making a series of immersion mounts of randomly oriented crushed fragments to find the matching liquid. Having found the liquid that matches the fragments, an appropriate correction for the temperature may be applied, as outlined in the section entitled "Immersion Liquids."

Determination of Refractive Indices of Anisotropic Substances

Light traveling in an anisotropic substance is polarized, that is, its vibrations are confined to two directions that are perpendicular both to each other and to the direction of transmission. Refractive indices depend on vibration directions and may vary between limits set by the extreme values of the principal refractive indices, determinations of which are necessarily more involved than for an isotropic substance because the fragment first must be properly oriented.

To aid in visualizing the behavior of light in anisotropic crystals, one may make use of the optical indicatrix, an ellipsoid in which the length of a given radius represents the refractive index of the light wave vibrating in the direction of the radius. Thus, the indicatrix of an isotropic substance is a sphere. Anisotropic crystals may be divided into two classes: uniaxial and biaxial. The indicatrix of a uniaxial crystal is an ellipsoid of revolution (fig. 3*A*), having its axis (called the optic axis) coincident with the crystallographic symmetry axis *c*, perpendicular to which is the circular section. Light traveling in the uniaxial crystal at an angle to the optic axis is polarized. One wave (called the ordinary or O wave) vibrates in the plane of the circular section and has a refractive index ω, which is represented by the radius of the circular section. The other wave (called the extraordinary or E wave) vibrates at right angles to that of ω (fig. 3*A*) and has a refractive index ε' which is represented by the radius of the ellipsoid in vibration. The index ω is called the *ordinary principal refractive index*, and ε' is called the *extraordinary refractive index*. The extreme value of ε', obtained when light travels perpendicular to the optic axis, is designated as ε, the *extraordinary principal refractive index*.[1] Note that, in this case, the other polarized wave again has ω as its refractive index. Light traveling parallel to the optic axis is not polarized and has the ordinary principal refractive index ω. Crystals in which ε is greater than ω are said to be optically positive (the indicatrix is a prolate ellipsoid, such as that of fig. 3*A*). Where ε is the lesser index (an oblate ellipsoid), the crystal is said to be optically negative.

The optical indicatrix of a biaxial crystal (fig. 3*B*) is an ellipsoid in which the three unequal symmetry axes represent the principal vibration directions X, Y, and Z of light for the three principal refractive indices: α, the lowest; β, intermediate; and γ, the highest.[2] Such an ellipsoid has two circular sections, the normals to which here are called the optic axes. These axes define the optic plane, and the angle between them is the optic angle 2V. The optic plane includes the principal vibration directions X and Z as bisectrices of the optic angle. The crystal is said to be optically positive when 2V is acute about Z and optically negative when 2V is acute about X.

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[1] Other symbols for refractive indices used in some publications are,
for ω: n_ω, n_O, n^O, or merely O,

for ε: n_ε, n_E, n^E, or E.

[2] Other symbols used in some publications are,
for α: n_α, n_x, n_p, or merely X,
for β: n_β, n_y, n_m, or Y,
for γ: n_γ, n_z, n_g, or Z.

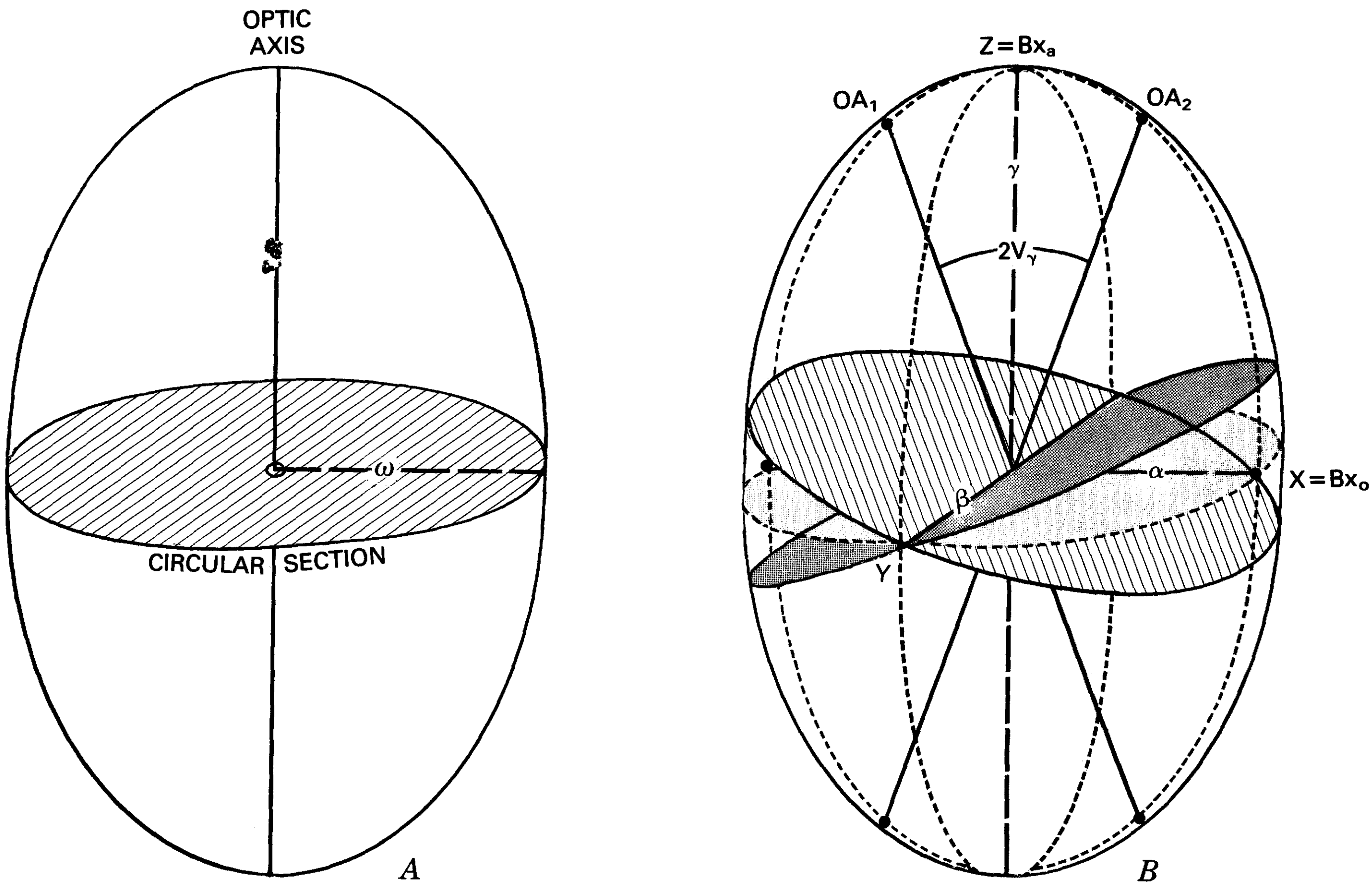

Figure 3. Indicatrices of anisotropic crystals. *A*, Uniaxial positive (a prolate ellipsoid of revolution, $\omega<\epsilon$). *B*, Biaxial positive ($2V_z<90°$).

Light traveling parallel to an optic axis vibrates in the circular section, is not polarized, and has β as its refractive index. (Although optic axes are customarily shown in the indicatrix, as in figure 3, it should be kept in mind that they really represent directions of travel and that the corresponding fundamental vibrational elements are the circular sections.) Light traveling at an angle to the optic axes is polarized into two waves vibrating at right angles to each other. One wave vibrates in the dihedral angle of the circular sections that includes the bisectrix X, and in the general case it has refractive index α', a nonprincipal index between α and β. The other wave vibrates in the other dihedral angle that includes the bisectrix Z and has refractive index γ' between γ and β. Light traveling parallel to a symmetry plane of the indicatrix, XY, XZ, or YZ, will have one wave with a principal refractive index, γ, β, or α, and generally ally the other wave with a nonprincipal index. Light traveling parallel to a symmetry axis X, Y, or Z will have both waves with principal refractive indices.

As can be seen from the foregoing discussion, to determine a principal refractive index of an anisotropic crystal by the immersion method, the crystal fragment must be oriented so that the plane-polarized light from the polarizer of the microscope vibrates parallel to the corresponding principal vibration direction in the crystal. In practice, one has a choice of (1) the "method of random grain mounts," in which properly oriented fragments are sought in successive immersion mounts of multiple fragments, (2) the coated-slide technique, in which one seeks properly oriented fragments among the scattered fragments held on a thin film of adhesive on a slide and then changes liquids as necessary to reach a match, or (3) a method wherein single fragments are mounted on a spindle for orientation so that each principal refractive index can be determined in its respective position.

The method of random grain mounts.--This method, described in varying detail in textbooks, is carried out using loose-grain mounts in a chosen succession of immersion liquids. It needs no special auxiliary equipment but does require a thorough and logical procedure to ensure useful results in a reasonable time. The first step is to examine the behavior of the interference figures of a series of grains in a preliminary immersion mount to ascertain whether the unknown is uniaxial or biaxial. If uniaxial, every grain should show the ω-index at one or the other extinction position; one may, therefore, make a series of mounts in liquids leading to a match of ω. In another series of mounts, the other principal index, ε, is to be sought from grains showing highest interference colors, the correctness of the orientation being confirmed finally by the interference figure, which should be a symmetrically behaving flash figure.

For a biaxial substance, successive mounts may be made to match the index of grains that show very little or no interference color on the rotation between crossed nicols. This index is β, confirmed by a centered optic axis figure. Proceeding next through a series of mounts of progressively lower index and observing fragments showing relatively high interference colors, the extreme low index is sought; this will be the principal index, α, confirmed by an interference figure symmetrical about the crosshair that is perpendicular to the vibration direction of the polarizer. Helpful details in the use of such symmetrically behaving interference figures in this procedure are given by Slawson and Peck (1936) and by Stoiber and Morse (1972, p. 188-198, 211-214). (See also discussion in section on "Spindle Stage," below). Similarly, the highest index, γ, is sought in grains showing high interference colors in mounts of index successively greater than β, again confirmed by the appropriately symmetrical interference figure.

If the unknown has marked cleavage oblique to the principal vibration directions, the chances are much reduced of finding fragments oriented suitably for determination of all principal refractive indices. Further, if the crushed sample contains two or more substances of overlapping optical properties, the unsophisticated or impatient investigator may settle on a set of totally misleading principal refractive indices and birefringence for the unknown "substance."

The coated slide technique.--In this technique, fragments of the unknown are scattered over a glass slide thinly coated with tacky material, such as gelatin (Olcott, 1960), thermal-setting epoxy (Langford, 1962), thick water glass (Lindberg, 1944), quick setting epoxy, or other colorless adhesive not affected by immersion liquids. Having once located a suitably oriented fragment by use of interference figures, the liquids can be changed to find the match for the respective principal refractive index without loss or disturbance of the fragment. In many cases, this is a considerable improvement over the method of random loose-grain mounts, in that new fragments need not be sought for each change of liquid. But this technique suffers also from the hazards and uncertainties arising when the unknown is composed of two or more substances of overlapping optical properties.

Spindle Stage

Most satisfactory for entry into the identification tables is a complete set of basic optical data from the unknown crystal fragment. For their determination, the spindle stage is well suited, enabling determination of all principal refractive indices as well as optic angle and relation of optical symmetry axes to cleavage.[3] A succession of fragments should of course be examined to establish the range of optical properties of the unknown mineral and whether the sample is composed of more than one mineral species. Procedures for the use of the spindle stage are given by Rosenfeld (1950), Wilcox (1959), Wilcox and Izett (1968), Hartshorne and Stuart (1970), Bloss and Light (1973), and Bloss (1981). The essentials will be outlined in the following.

To carry out the determination on the spindle stage, the crystal fragment is cemented on the tip of the spindle and placed on the base plate (fig. 4) attached to the stage of the microscope. With the fragment in the transparent immersion cell, orientation is accomplished by rotation about the horizontal (spindle) axis and vertical (microscope) axis. At the orientation for each principal refractive index, immersion liquids are changed successively to arrive at the match.

The adhesive for mounting the fragment must be insoluble in the immersion liquids, and ordinary water-soluble carpenter's glue works well for this if mixed with an appropriate amount of molasses, corn syrup, or similar substance to lengthen its period of tackiness. The mineral fragments, crushed to a convenient size (usually less than 0.2-mm diameter), are viewed under a stereomicroscope, and the desired fragment is isolated. The tip of the spindle is touched to a drop of the adhesive, then brought into the field of the stereomicroscope, holding the spindle as nearly vertical as practical and barely touching it to the fragment (fig. 5A).

[3]The universal stage (Emmons, 1943) also enables determination of these diagnostic properties to a high precision but requires an array of peripheral equipment as well as a much greater expenditure of time.

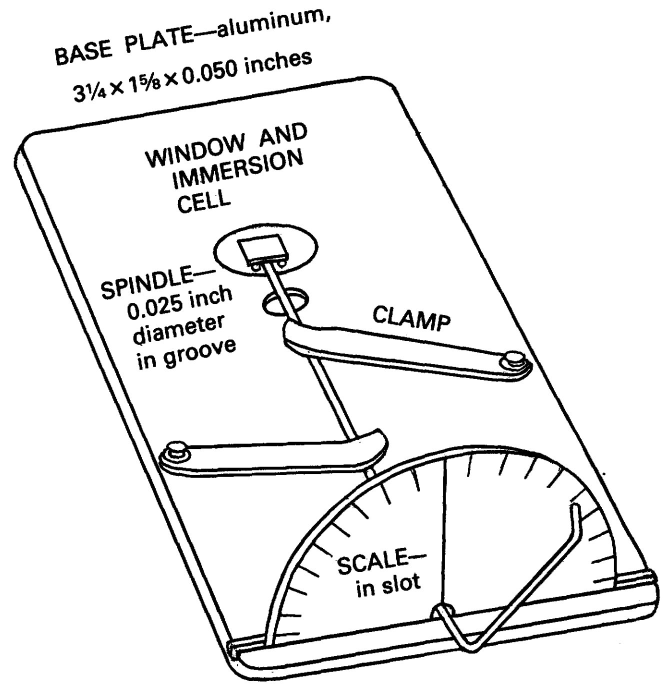

Figure 4. Spindal stage (modified from Wilcox, 1959).

With the fragment clinging to the spindle tip, the mount may be breathed on gently, whereupon the moisture-sensitive adhesive flows onto the fragment to hold it more securely. (Care must be taken, however, not to moisten it so much that the adhesive completely coats the fragment.) If the fragment is out of line, as in figure 5B, it may be gently nudged with a dissecting needle while viewed under the stereomicroscope to move it into the axis of rotation of the spindle (fig. 5C).

After allowing a minute or two for the adhesive to set, the spindle with fragment thus randomly mounted is clamped in the groove of the base plate, then pushed forward to insert the fragment into the immersion cell, and the small scale for the spindle arm is put in place. A trial immersion liquid is introduced at the front end of the cell, into which it moves by capillary action. Under low power, the image of the fragment is brought to the crosshair intersection by shifting the base plate. Liquids can be changed by holding a tab of blotting paper at the rear of the cell along the shank of the spindle (fig. 6). After the old liquid is

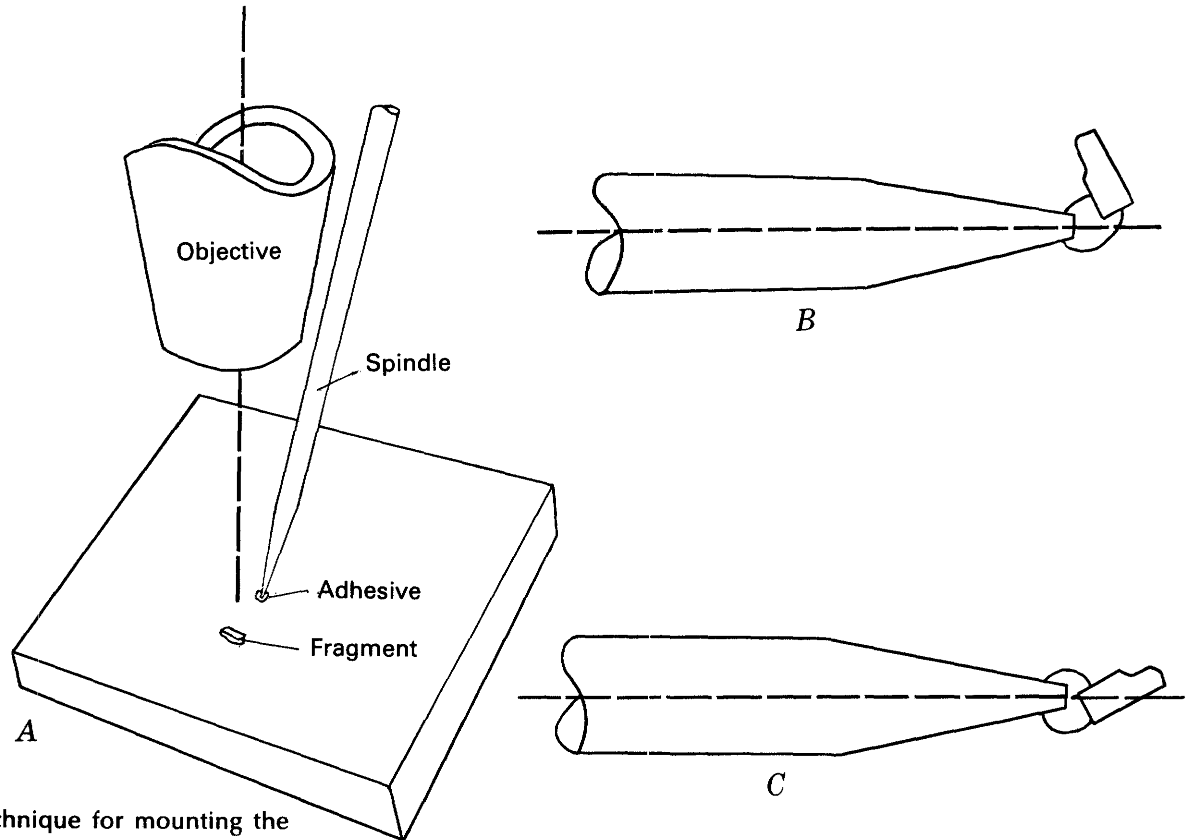

Figure 5. Technique for mounting the fragment on spindle: *A*, The spindle with adhesive is touched to the fragment. *B*, Fragment out of line. *C*, Fragment nudged into line with the spindle axis.

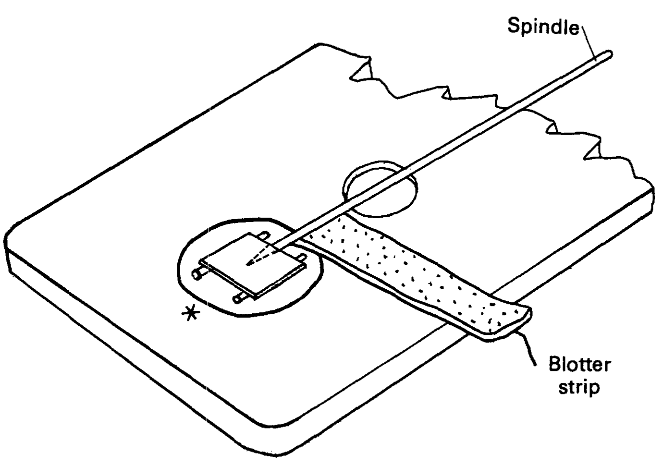

Figure 6. Withdrawal of liquid from immersion cell using absorbent paper.

removed, the new liquid is introduced at the front of the cell as before. This operation should be repeated once to flush out old liquid trapped in the cell and once again if the index change is large.

Orientation of the fragment for index determination may be carried out conoscopically (Wilcox, 1959, p. 1277), enabling at the same time an overview of other optical properties such as optic angle and optic sign. If the fragment is too small or if interference figures cannot be obtained, the somewhat more time-consuming orthoscopic procedure (Wilcox, 1959, p. 1281; Bloss and Riess, 1973; Bloss, 1981) can be used.

For a biaxial crystal, the correct orientation for index comparison is recognized conoscopically by an interference figure having bilateral symmetry along the crosshair perpendicular to the plane of the polarizer, as pointed out by Slawson and Peck (1936). Typical examples are shown in figure 7, in which the polarizer is NS. For any randomly mounted fragment, there are three orientations (within the upper hemisphere of rotation) that satisfy this criterion and at which the respective principal refractive indices are to be determined. It is advantageous to start with the orientation for β, that is, the orientation where the optic plane isogyre is symmetrically disposed along the EW crosshair. This isogyre is recognized, even before reaching the symmetrical setting, by its "counterrotating" behavior (Stoiber and Morse, 1972, p. 122, 172) or by the presence of the melatope itself, about which the isogyre pivots. With this isogyre symmetrically along the EW crosshair, the settings of spindle stage arm and microscope stage, at which β is to be determined, are recorded.

One then proceeds toward the setting for the next principal index by small rotations about the spindle axis followed by compensating rotations on the microscope stage to keep the one isogyre always well within the field of view. Eventually another symmetrical interference figure must be encountered, with an isogyre lying either along the EW crosshair, which is the desired setting, or along the NS crosshair, in which case the desired setting is made by rotating 90° on the microscope stage. The accessory plate may be used to establish whether it is the vibration direction of α or γ that is now NS, and the readings of spindle arm and microscope stage are recorded. One proceeds in the same manner to establish the setting for the third principal index. Converting now to orthoscopic illumination and a lower power objective, the index of the liquid is compared with each of the three principal indices at its respective setting by means of one of the index comparison techniques outlined in earlier sections. Liquids are changed accordingly to find the matching liquid for each index and, after correcting for temperature, the principal refractive indices are recorded.

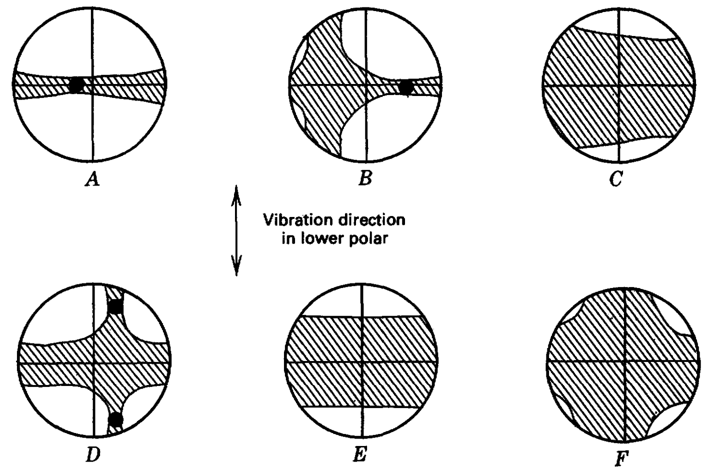

Figure 7. Examples of typical isogyre configurations to be seen when a principal vibration direction is horizontal EW; that is, when the crystal is oriented for comparison of the corresponding principal refractive index with the immersion liquid (polarizer NS).

The procedure for a uniaxial crystal is somewhat simpler, once having established from an optic axis figure that it is indeed uniaxial. Here one simply places an isogyre along the EW crosshair and, by incremental rotations of spindle and stage, "follows" this isogyre to the flash figure. The vibration direction of ω is now NS and, converting to orthoscopic illumination at this setting, ω may be compared with the liquid. Rotating 90° to the other extinction position similarly permits ε to be compared with the liquid.

Birefringence

The difference between the extreme principal refractive indices, α and γ, or ω and ε, ordinarily referred to as the birefringence of the mineral, is very helpful in identification. Birefringence is especially useful for identification of an unknown that is a member of an isomorphous series, for birefringence usually remains within relatively narrow limits while the refractive indices may have a wide range.

In routine immersion work, birefringence is usually taken as the difference between the already measured values of γ and α, or of ω and ε. Lacking these measurements, it can be estimated from the order of interference color observed between crossed polars, giving due consideration to the orientation and the probable thickness of the fragment. (This approach, of course, is the basis for rapid recognition of many minerals in thin section, where the thickness is known.) Maximum birefringence may also be determined on the spindle stage, following the suggestion of Fisher (1960, p. 87), by mounting the fragment on the spindle so that the optic plane can be made horizontal (flash figure), in which position the maximum retardation, R, is determined at the point where thicknesses is greatest using a compensator.[4] That thickness, t, is measured with the ocular micrometer after rotating the fragment 90° about the spindle axis to show it in profile. Birefringence, B, is then B = R/t.

[4]If the optic plane of the randomly mounted fragment is oblique to the spindle axis, it cannot be made horizontal by simple rotation about the spindle axis. With practice, however, it is not difficult to correct the position of the fragment by (1) rotating the optic plane to verticality, (2) noting the angle of the optic plane with the spindle, (3) withdrawing the spindle, (4) dipping the spindle tip in solvent to remove the oil, (5) breathing gently on the mount to soften the adhesive, and finally (6) under the stereomicroscope with a dissecting needle, nudging the fragment the estimated amount necessary to place the optic plane in line with the spindle.

Optic Angle and Optic Sign

The optic angle, usually designated as 2V, is the angle between the two optic axes (see fig. 3). A statement of the numerical value of the angle is not complete without an indication of optic sign. A positive optic angle may be shown, for example, as (+)2V=47°, $2V_Z$= 47°, or $2V\gamma$=47°. The size of the optic angle can be calculated from the relationships among the three principal indices of refraction or can be measured independently, thus offering a means of checking on the consistency of the measured values of principal refractive indices.

Calculation of Optic Angle

The relation of optic angle to the principal refractive indices may be expressed as

$$2V_Z = 2 \text{ arc cos } \frac{\alpha}{\beta} \sqrt{\frac{\gamma^2 - \beta^2}{\gamma^2 - \alpha^2}} \qquad (1)$$

where $2V_Z$ is the angle between the two optic axes across the bisectrix Z. A simpler approximation,

$$2V_Z = 2 \text{ arc cos } \sqrt{\frac{\gamma - \beta}{\gamma - \alpha}} \qquad (2)$$

is accurate within a degree or two if the optic angle or birefringence is not too high (see also Wright, 1951; Tröger, 1952).

Convenient nomograms based on the exact equation (Mertie, 1941) are reproduced by Bloss (1961, p. 158) and by Hartshorne and Stuart (1970, p. 393, and folding plate). Knowing any three terms of equation (1), the fourth term may quickly be determined from the nomogram. Thus, it is easy to determine not only the nominal value of 2V, but also the range of uncertainty due to the estimated inaccuracies in the refractive index determination, as illustrated by the example in table 2 (see also

Table 2. Range of calculated optic angles, taking into account a possible ±.001 error of refractive index determinations

	α	β	γ	2V by exact formula	2V by approx. formula	2V by nomogram
Measured refractive indices (±.001)	1.534	1.545	1.560	(+)81° 46'	(+)81° 10'	(+)82°
Lowest worst case	1.535	1.544	1.561	(+)72° 40'	(+)72° 10'	(+)73°
Highest worst case	1.533	1.546	1.559	(+)89° 24'	90° 00'	(+)89°
Range, lowest to highest				16° 44'	17° 50'	16°

Willard, 1961). Obviously it is more realistic and informative to state the calculated value as $(+)2V_{calc}=82°\pm8°$ than to imply an unjustifiable precision, such as $(+)2V_{calc}=81°46'$.

An approximate value of optic angle, quite adequate for much work, may be obtained from figure 8A. This nomogram is based on equation (2) using the form proposed by Tröger (1952). Like Tröger's nomogram, its error is considerably less than the error resulting from the usual uncertainties in the determination of the principal refractive indices themselves, especially for minerals of low or moderate birefringence. Should high birefringence justify refinement, a correction, to be added algebraically to the approximate value, may be obtained from figure 8B.

As an example, using the following measurements of a specimen of augite:

$\alpha=1.680\pm0.001$ $\quad\gamma-\beta=0.019$
$\beta=1.686\pm0.001$ $\quad\gamma-\alpha=0.025$
$2V_z$ (measured)$=61°\pm2°$

$\gamma=1.705\pm0.001$ $\quad\frac{\gamma-\beta}{\gamma-\alpha}=0.760$

From fig. 8A:
approximate $2V'_z=(+)58.7°$
From fig. 8B:
correction $+\ 0.6$
Corrected calculated
optic angle, $2V_z=\ 59.3°$,
compared to value obtained from equation (1): $2V_z$ (calc)$=59.2°\pm11°$.

Similarly, for a specimen of hastingsite:

$\alpha=1.653\pm0.001$ $\quad\gamma-\beta=0.010$
$\beta=1.665\pm0.001$ $\quad\gamma-\alpha=0.022$
$2V_x$ (measured)$=80°\pm2°$

$\gamma=1.675\pm0.001$ $\quad\frac{\gamma-\beta}{\gamma-\alpha}=0.455$

From fig. 8A:
approximate $2V'_x=(-)84.8°$
From fig. 8B:
correction $+\ 0.6°$
Corrected calculated
optic angle, $2V_x=\ 84.2°$,
compared to value obtained from equation (1): $2V_x$ (calc)$=84.2°\pm10.5°$.

This relation between optic angle and the three principal refractive indices provides a useful test of the internal consistency of the measured results. If the value of optic angle calculated from measured α, β, and γ is not in reasonable agreement with the optic angle, there must be an error in one or more of the measured values, and a recheck is in order. For tables 6 and

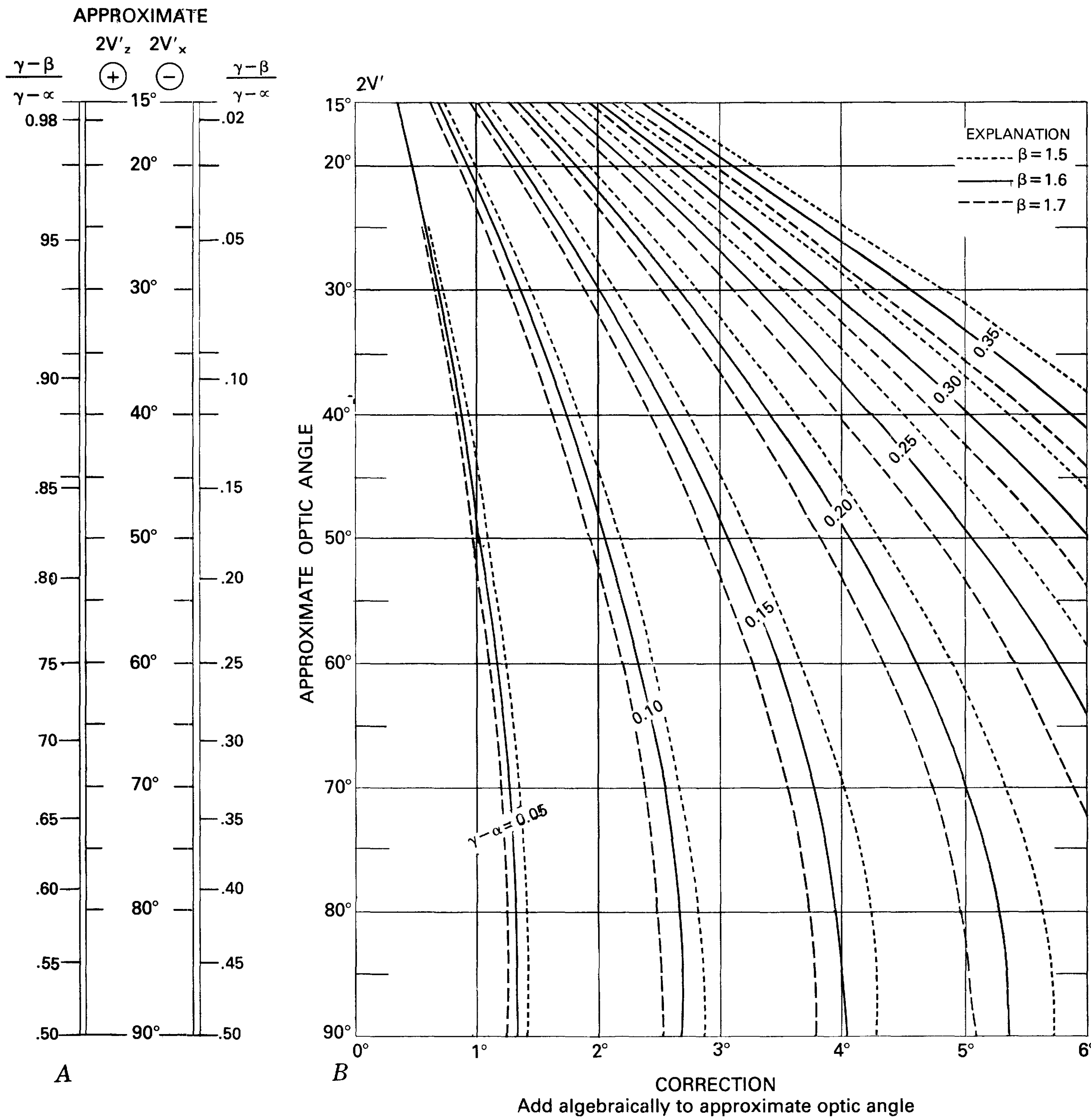

Figure 8. Nomogram for determination of optic angle from ratio of partial birefringences, $\frac{\gamma-\beta}{\gamma-\alpha}$: *A*, Approximate optic angle. *B*, Correction to be added algebraically.

7, this test has been run on the data as reported; where agreement is poor, the calculated value of optic angle has been inserted in parentheses below the reported optic angle as a cautionary signal. Also shown in the parentheses is a tolerance angle based on assumed "worst case" errors of ±1 significant figure in the values reported for principal refractive indices.[5]

[5]Unfortunately few data in the literature are accompanied by estimates of error. The "worst case" assumed here may err on the side of charity for many of the reported data and may be too pessimistic for others.

Measurement of Optic Angle

Among several means available to measure optic angles of crystal fragments in immersion mounts are the following:

(1) direct measurement conoscopically on the universal stage or spindle stage by placing the optic plane perpendicular to the rotation axis, then rotating from one melatope to the other across an identified bisectrix. Somewhat less reliably (Fairbairn and Podolsky, 1951), the optic angle may be determined by doubling the angle of rotation from one melatope to a bisectrix;

(2) measurement of the angle between stereographically plotted optic axis positions, as determined conoscopically by an extension of Mallard's method on the spindle stage (Wilcox and Izett, 1968; Noble, 1968);

(3) stereographic plotting of a series of orthoscopic extinction positions, determined on the spindle stage, from which the unique positions of the optic axes may be inferred (Wilcox, 1960; Tocher, 1962; Bloss and Reiss, 1973; Bloss, 1981). This procedure is analogous to the Berek-Dodge Method for universal stage (Emmons, 1943, p. 28), without requiring corrections of rotations.

Whatever the method of determining the optic angle, the identity of the acute bisectrix, X or Z, must also be determined to establish the optic sign. Direct measurement of optic angle by rotation from one optic axis to the other is of course to be preferred when the situation permits. On the universal stage, the optic plane may be brought directly into position for the rotational measurement, to which are applied corrections for index difference between mineral and hemispheres. On the spindle stage, the fragment may be nudged into position after the adhesive has been softened, and no correction to the rotational measurement is required. All three methods provide greater accuracy than can usually be obtained by calculation of optic angle from principal refractive indices, particularly for substances of low or moderate birefringence.

Estimation of Optic Angle and Determination of Sign

For rough work, one may use the method developed by Wright (1911, p. 168) to obtain an estimate of optic angle. This requires an optic axis interference figure, that is, a melatope near the center of the conoscopic field, and judgment of the curvature of the isogyre when the optic plane is at 45° to the polars. The dark band of the isogyre is distinctly curved for small optic angles and straight diagonally across the field for optic angles approaching 90°. Estimates of optic angle to within about 10° can be made using figure 9, modified from Wright's

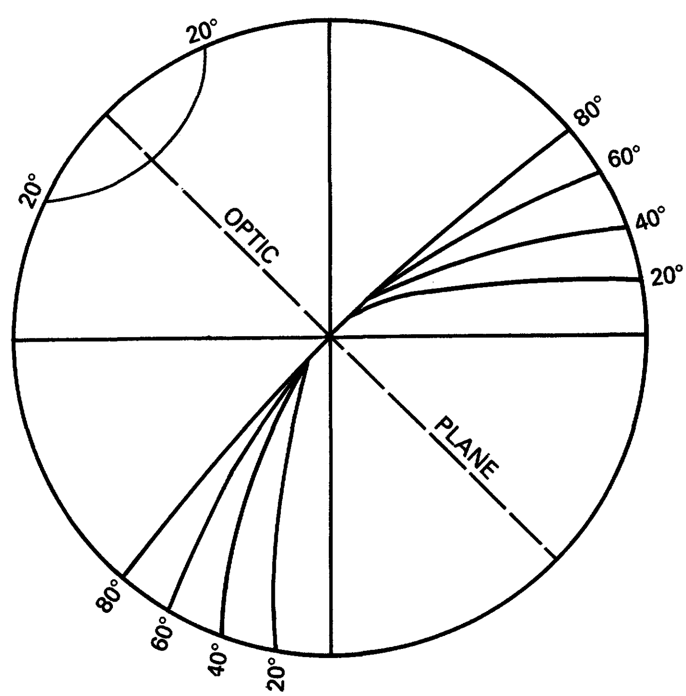

Figure 9. Curvatures of superimposed isogyres for centered optic axis figure of optic angles 20°, 40°, and 80° (after Wright, 1911).

(1911) composite of superposed isogyres, keeping in mind that objectives of higher numerical aperature will display a greater length of isogyre (see Winchell, 1965, p. 11). Determination of optic sign is made on the same interference figure by placing the optic plane in the diagonal position parallel to the vibration direction of the slow ray (high index) of the inserted accessory plate. For an optically positive crystal, insertion of the plate raises the retardation color on the concave side of the isogyre at the melatope.[6]

When both melatopes lie symmetrically disposed in the conoscopic field, one may use Mallard's method sensu stricto, on the basis of separation of the melatopes (Johannsen, 1918). When the melatopes are not symmetrically disposed, one may still estimate the size of the optic angle by comparison of their separation with the total diameter of the conoscopic field of known angular aperture. With one melatope and a bisectrix in the conoscopic field, the half-optic angle can be estimated in a similar manner but with reduced precision. When both melatopes lie outside the conoscopic field of a near-centered bisectrix figure or flash figure, the optic angle may be estimated roughly by the amount of rotation of the microscope stage that is required to move the isogyres from the crossed position to a certain radial distance representing a known angular aperture (Johannsen, 1918, p. 472; Kamb, 1958). Inasmuch as it is the darkest band of the diffuse and varying isogyre that must be set at the reference radial distance, the latter is best chosen well within the field rather than at the extreme outer edge, as done in the theoretical treatment by Kamb (1958). A useful discussion of this and other conoscopic methods is given by el-Hinnawi (1966, p. 114-136).

[6]To avoid misreading the direction of curvature, especially for a crystal of large optic angle, a setting is first made with the isogyre parallel to (not necessarily on) the NS crosshair. The stage is then rotated exactly 45° to read the curvature of the isogyre. The farther the melatope from the center of the field, of course, the smaller is the length of isogyre available on which to estimate curvature and, in general, the less precise is the estimate.

Dispersion of the Optic Axes

If the directions of the optic axes change with wavelength, the mineral is said to have dispersion of the optic axes, a characteristic often helpful in distinguishing it from otherwise similar minerals. This property is included in the tables together with the nominal value of 2V for the standard yellow light. For example, for the biaxial positive minerals (table 6), wavellite at β=1.524 shows $2V_z$ as "60°, $\underline{r} > \underline{v}$ wk," meaning that the optic angle for red is slightly greater and for blue slightly less than the 60° for yellow.

Dispersion of an optic axis may be recognized in white light illumination using a near-centered optic axis figure with the optic plane 45° to the polars. Because the melatope for each wavelength (color) is a point of _no_ illumination and because these melatopes are now slightly spread out along the trace of the optic plane, the melatope for the red wavelengths is represented by a bluish color, while that for the blue wavelengths is represented by a reddish or, more commonly, brownish color. Thus, if the concave side of the isogyre is seen as bluish and the convex side reddish or brownish, it is concluded that the optic angle for red is greater than that for blue wavelengths, $\underline{r} > \underline{v}$.

Relation of Optical to Crystallographic Directions

The orientation of the indicatrix with respect to crystallographic elements, such as crystal axes, faces, cleavages, and twin planes, can be of much help in identification of an unknown, particularly after the number of candidates has been reduced to a manageable few on the basis of the observed principal refractive indices, optic angle, and sign. Firm establishment of the relation of indicatrix axes to crystallographic axes would require coordinated optical and X-ray structural investigation of the same crystal fragment (see for instance Chao and Minkin, 1970). For many unknowns, however, much can be inferred from the behavior of interference figures of fragments lying on a prominent cleavage (see for instance Ehlers, 1980) and from such readily determinable properties as extinction angle and sign of elongation.

Extinction Angle

The extinction angle is the angle through which the microscope stage must be rotated to change it from a position in which a specified crystallographic direction is parallel to the crosshair to the extinction position in which the specified vibration direction is parallel to the crosshair. The vibration direction may be a principal symmetry axis of the indicatrix, such as X or Z, or, when the symmetry planes of the indicatrix are oblique to the section, merely an extinction position expressed then as X' or Z'. If the extinction angle is not given as such in tables 6 and 7, it often can be inferred from the basic information provided in the columns on "Optical orientation," "System," and "Cleavage." Helpful in visualizing these relationships are the admirable perspective sketches of typical crystals in Tröger (1979).

Extinction angles serve to distinguish between certain important minerals or mineral groups, for instance, between clinopyroxenes and clinoamphiboles using the angle Z:c. Extinction angles serve further to distinguish between members in an isomorphous series, such as the plagioclase series using X':a. On the spindle stage the crystallographic directions of a fragment may be inferred by orienting and plotting the bounding cleavage surfaces, from which the specified extinction angle can be read off the stereogram. Alternatively the fragment can be mounted with a recognizable crystallographic zone axis parallel to the spindle axis so that the extinction angle can be read directly.

Sign of Elongation

The sign of elongation is positive if a characteristic direction of elongation of the fragment or crystal is less than 45° to the extinction position of the slow wave (high index). A mineral with two directions of good or excellent cleavage will generally break into elongate fragments. Thus, cleavage fragments of most amphiboles show positive elongation, since Z is at a low angle to c, defined by the intersection of the excellent prismatic cleavages. For most micas, both Y and Z lie in or very near the plane of the one perfect cleavage, so that cleavage flakes, viewed edge-on in thin section or on the spindle stage, show positive elongation. In random immersion mounts, of course, this relation is generally not seen because the flakes lie on their cleavage.

Color and Pleochroism

The color of the hand specimen, together with its luster, can be helpful in sight-identification of some minerals. Caution is required here, however, because the color can be affected appreciably by foreign inclusions, internal flaws, fractures, or by variations of certain minor chemical constituents. Under the stereo-microscope with standard conditions of illumination, small fragments may show characteristic colors and lusters, enabling approximate modal counts and removal of certain species by hand picking.

In plane-polarized transmitted light, the colors of small fragments are diagnostic of certain mineral species. Pleochroism, the change in color with the change in direction of vibration of the plane-polarized light, is especially useful in sight identification. Pleochroism is customarily described in terms of colors observed for light vibrating parallel to the respective axes of the indicatrix: O and E for uniaxial crystals and X, Y, and Z for biaxial crystals. (Strictly speaking for monoclinic and triclinic crystals, however, the principal axes of the indicatrix do not necessarily coincide with the principal axes of the "absorption ovaloid." Clinopyroxenes provide an example, for which a more consistent convention was proposed by Hess (1949, p. 632).)

Depth of color for light transmitted through fragments in immersion mounts increases with the thickness of the fragment, so that the intensities of the observed colors may not correspond strictly to the pleochroic colors listed in tables 4-7. An added complication may arise in immersion mounts due to changes in dispersion colors or relief with rotation of the stage, for either may simulate pleochroism or mask a faint body color. These disturbing effects can largely be eliminated by swinging in the substage auxiliary condenser to flood the crystal with light. One must keep in mind, however, the differences in the spectral distribution of the source illumination from one microscope to another. In addition, one must be aware of the subjective nature of the descriptive terms used in the tables; these terms might be interpreted differently by different observers.

CHAPTER III. IDENTIFICATION TABLES (TABLES 3–7)

List of Abbreviations

a----crystallographic axis a
Ab----albite
abs----absorption
acic----acicular
Ak----Akermanite
Al----Almandine
alk----alkaline
amor----amorphous
An----Anorthite, Andradite
anom----anomalous
b----crystallographic axis b
bb----before the blowpipe
biax----biaxial
biref----birefringence, birefringent
c----crystallographic axis c
Ca----Calderite
calc----calculated
char----character
clv----cleavage
Cn----Celsian
cols----colorless
comp----composition
compd----compound
concd----concentrated
conch----conchoida
cryptocryst----cryptocrystalline
cryst----crystalline
crystn----crystallization
cub----cubic
dec----decomposed
dehyd----dehydrates
deliq----deliquesces, deliquescent
detd----determined
diff----difficult, difficulty
dil----dilute
disp----dispersion
diss----dissolved
dist----distinct
dod----dodecahedral
E----extraordinary wave
eff----effervesces, effervescence
effl----efflorescent
el----elongation
En----Enstatite
ext----extinction
extr----extreme
F----fusibility
Fa----Fayalite
fib----fibers, fibrous
fluor----fluoresces
Fo----Forsterite
fr----fracture
Fs----Ferrosilite
fus----fusible
G----specific gravity
Ge----Gehlenite
gel----gelatinizes
Go----Goldmanite
Gr----Grossularite
grp----group
H----hardness
hex----hexagonal
hyg----hygroscopic
imperf----imperfect
insol----insoluble
isomor----isomorphous
isot----isotropic

Kn	Knorringite
lam	lamellar, lamellae
mass	massive
mcl	monoclinic
Me	Meionite
med	medium
mic	micaceous
mod	moderate
n	refractive index
neg	negative
O	ordinary wave
oct	octahedral
opt	optical, optically
Or	Orthoclase
org	organic
orth	orthorhombic
pct	percent
penet	penetration
perc	perceptible
perf	perfect
pl	plane
pleoc	pleochroic, pleochroism
poly	polysnythetic
pos	positive
pris	prismatic
ps	pseudo
Py	Pyrope
pyram	pyramidal
r	optic angle in red light
rect	rectangular
sepn	separation
ser	mineral series
sol	soluble
soln	solution
Sp	Spessartite
spher	spherulites, spherulitic
sq	square
str	strong
symm	symmetrical
synth	synthetic
tab	tabular
tcl	triclinic
tet	tetragonal
tetrah	tetrahedral
tr	trace
trig	trigonal
tw	twinning
u	usually
uniax	uniaxial
unk	unknown
Uv	Uvarovite
UV	ultra-violet
v	optic angle in blue light
var	variety
volat	volatilizes
wk	weak
X, Y, Z	vibration directions for α, β, γ, respectively
$2V_X$	optic angle about X
$2V_Z$	optic angle about Z
⊥	perpendicular to
∥	parallel to
>	greater than
<	less than
~	near, approximately
±	plus or minus
001, $00\bar{1}1$	Miller symbols for all faces of a form (conventional braces have been omitted)
:	angle with
α, β, γ	lowest, intermediate, and highest principal refractive indices of biaxial crystals, respectively
ω, ε	ordinary and extraordinary principal refractive indices of uniaxial crystals

Arrangement of Data

The minerals are divided among five tables according to their basic optical characteristics: isotropic minerals, including mineraloids and natural glasses, are in table 3; uniaxial positive minerals are in table 4; uniaxial negative minerals are in table 5; biaxial and positive minerals are in table 6; biaxial negative minerals are in table 7. The mineral names generally follow those of Fleischer (1983), and the chemical formulas attempt to convey the type of compounds and interchangeable elements without necessarily indicating lattice positions or other structural aspects.

In table 3 the isotropic substances are listed in order of increasing refractive index, n, shown in the second column. In the first column, titled "Other entries," arrows with values of refractive index indicate the next higher or lower listing of the particular mineral. Since the determined value of refractive index of the unknown will generally fall between those of the representative entries of that mineral in the table, it is essential to give close attention to the indications of index variation shown in this column. Known variations of index too small to justify separate entries are indicated by square bracket symbols, with or without numerical values. The lack of a variability notation in this column opposite a mineral name, however, does not mean that variability does not exist, rather merely that none was found in published descriptions, a point to be kept in mind especially for the lesser known minerals of complex composition.

Next in table 3 are columns for crystal "System and habit" and for "Cleavage or fracture." Here note that the conventional enclosing braces denoting forms are omitted from the Miller symbols because of space limitations. The "Color" column indicates the color of fragments in reflected light. "Hardness, specific gravity, and fusibility" are shown in the next column, and finally in the "Remarks" column are given various additional helpful properties, such as optical anomalies, weight percentages of selected oxides of the chemical analysis, and behavior in chemical tests. Dilute acids are understood unless otherwise specified.

In tables 4 and 5 the uniaxial minerals are listed in order of increasing values of the ordinary principal refractive index, ω, with the extraordinary principal index, ε, given in the adjacent column. In addition to the properties already mentioned for table 3, the "Remarks" column of tables 4 and 5 gives information on twinning, sign of elongation, and pleochroism.

In tables 6 and 7, the biaxial minerals are listed in order of increasing intermediate principal refractive index, $\underline{\beta}$, with the values of α and γ in adjacent columns and with birefringence in another column. (Parentheses around an index or birefringence indicate a value calculated from the reported value of optic angle). The column for "2V" gives the reported value of optic angle, and if this value does not appear to be consistent with the reported values of α, β, and γ, the calculated value of optic angle is given in parentheses, along with a plus-or-minus tolerance based on possible errors of one in the last significant figure of the reported indices. (No calculated values are shown for minerals of low birefringence, since here normal errors in index would lead to wide variations in calculated optic angle). Also shown is the reported dispersion of the optic angle. The column for "Optic orientation" gives diagnostic relationships between indicatrix symmetry axes X, Y, and Z, and crystallographic axes, $\underline{a}$, $\underline{b}$, and $\underline{c}$, as well as extinction angle and sign of elongation. The statement "el clv pos," for instance, indicates positive elongation as seen with steeply dipping cleavage.

Because of the variations of optical character, some minerals are listed in more than one table. For example, a normally isotropic mineral that is weakly anisotropic in some occurrences may be listed in both table 3 (isotropic minerals) and in the appropriate table for anisotropic minerals. Furthermore, in some isomorphous series the optic sign may reverse due to progressively changing relations between the principal refractive indices. The melilite group, for instance, passes from optically uniaxial negative gehlenite through "isotropic" melilite to uniaxial positive akermanite and thus is listed in three tables. In the olivine group, the magnesium-rich members are optically positive, but as the Fe/Mg ratio increases the optic angle passes through 90° near Fa_{15} and the remainder of the series is optically negative. In table 6 (biaxial positive minerals), therefore, an olivine group mineral is entered at β-values of 1.651, 1.664, 1.674, and finally at 1.680, at which point a switch to table 7 (biaxial negative minerals) is indicated by the notation $1.680_{neg.}$ Due to thermal history or other factors, the cross-over in an isomorphous series may not take place precisely at the same value of β-index in every case; so that, with an unknown of observed optic angle near 90°, likely candidates should be sought in both tables near the measured value of β.

Use of the Tables for Identification

In all cases, a systematic and thorough procedure must be carried out, and the following approach is recommended: For an isotropic unknown, one enters the table at the determined value of refractive index and then examines the other properties given for minerals of index within a reasonable range above and below the determined refractive index. Unfortunately for isotropic crystals there are no other optical-crystallographic parameters easily measured under the microscope, so one must depend heavily on cleavage, hardness, solubility, and so on. Those minerals that correspond to the unknown in these respects should be listed and consideration then given as to whether X-ray, chemical analysis, or another approach will be most effective in making the final assignment of identity.

For an anisotropic unknown, after having determined the values of principal indices, birefringence, optic angle, and optic sign, the following steps are recommended:

(1) enter the appropriate table at the determined value of ω or β.

(2) proceed both above and below in the table for a distance of at least 0.020 difference in index, listing the names of those minerals whose values of birefringence and optic angle are in reasonable agreement with those of the unknown.

(3) for each mineral so listed, check the remaining columns for distinguishing properties, returning to the microscope or the original sample as necessary to make diagnostic tests and crossing out each nonconforming mineral.

(4) for the remaining candidate or candidates, consult encyclopedic optical descriptions for further distinguishing properties.

(5) confirm or complete identification if necessary by X-ray and chemical analyses.

Examples

Example No. 1.--is crushed material from clusters of clear, colorless crystals in small lithophysae in rhyolite. Fragments mounted on the spindle stage show:

α 1.611±.001	γ-α 0.011±.002
β 1.614±.001	$2V_z$ 65°±2° measured
γ 1.622±.001	

Entering the table for biaxial positive minerals (table 6) at β=1.614 and proceeding toward lower and higher values of β, the following minerals seem reasonable possibilities (keeping in mind that, due to chemical complexity, some of them may be expected to vary in index even though it is not so indicated in the "Other entries" column).

Looking at the characteristics listed in other columns of table 6, tuhualite can be eliminated at once on the basis of its "dark blue to black" color; probably uranopilite ("bright yellow, straw yellow") can also be eliminated. In a simple hardness test, particles of the unknown leave scratches when rubbed between two glass slides, showing that it has a hardness of 5 or greater; this finding confirms the elimination of tuhualite and uranopilite, and also eliminates crandallite, uralborite, and buchwaldite. Under the microscope, the unknown appears to show one perfect cleavage, casting doubt on stokesite, which should show two cleavages. As a test of density, particles of the unknown in a drop of methylene iodide (sp gr 3.3) on a microscope slide are seen to rest at the bottom of the liquid; this eliminates stokesite (sp gr 3.19), afwillite (sp gr 2.62) and cuspidine (sp gr 2.86-3.05), all of which should float. The unknown is found to be insoluble eliminating hydrophilite, and is unaffected by acids, eliminating latiumite, afwillite, cuspidine, and uranopilite. This leaves only topaz which possesses all the observed characters of the unknown. According to the variation diagram given by Winchell and Winchell (1951, p. 509), the optical properties would imply a high fluorine variety of topaz.

	Other entries	β	Birefringence	$2V_z$
Cuspidine		1.595	.012	62°
Hydrophilite		1.605	.012	med
Latiumite		1.606	.014	83°-90°
Crandallite		1.607	.013	70°-75°
Uralborite		1.609	.011	85°
Topaz		1.610	.011	67°
Buchwaldite		1.610	.009	(?)
Tuhualite		1.612	.013	60°-70°
Stokesite		1.613	.010	70°
(UNKNOWN IN QUESTION)		1.614 ±.001	.011 ±.002	65° ± 2°
Topaz		1.618	.009	61°
Afwillite		1.619	.015	55°
Stokesite		1.621	.012	70°
Uranopilite		1.624	.011	small to large
Topaz		1.631	.099	48°

Example No. 2.--In a crushed sample of a coarse igneous rock as seen under the stereomicroscope, fragments of the unknown are clear and faintly honey-brown in color. Mounted on the spindle stage they show the following optical properties:

α 1.682±.001	γ-α .014±.002
β 1.691±.001	$2V_X$ 70°±2° measured
γ 1.696±.001	(73°±17° calc)

Biaxial negative minerals of similar optical properties in table 7 within about 0.020 of this β-index form an extensive list as follows:

	Other entries	β	Bire-fringence	$2V_X$
Bustamite		1.675	.015	53°
Gerstmannite		1.675	.013	50°-60°
Ferroaxinite		1.676	.011	69°
Bronzite, orthopyroxene		1.680	.011	79°
Tinzenite		1.681	.014	large
Manganaxinite		1.687	.014	75°
Lavenite		1.690	.016	68°
Chlorophoenicite		1.690	.015	83°
(UNKNOWN IN QUESTION)		1.691 ±.001	.014 ±.002	70° ± 2°
Tinzenite		1.693	.010	med
Bronzite, orthopyroxene		1.695	.015	69°
Bustamite		1.695	.015	43°
Arfvedsonite		1.695	.015	69°
Kempite		1.695	.014	med
Ferroaxinite		1.695	.011	70°
Ferro-richterite		1.699	.016	35° (68° ± 15°)
Tinzenite		1.701	.011	63°
Barylite		1.702	.013	70°
Bustamite		1.708	.015	34°

At the outset it would appear doubtful that the unknown could be bustamite, due to the fairly large discrepancy in optic angle. This doubt is confirmed on fragments of the unknown on the spindle stage. There they are seen to have two good cleavages, whereas bustamite has three cleavages, two good and one perfect. Members of the axinite group (ferroaxinite, manganaxinite, and tinzenite) with lavenite and gerstmannite are similarly eliminated, inasmuch as they have only one cleavage. Cleavage fragments of the unknown show parallel extinction and positive elongation, eliminating arfvedsonite and ferrorichterite, which have inclined extinction. Although barylite fragments should also show two good cleavages (001 and 100) and parallel extinction, the elongation would be negative, since X=b. A scratch test of fragments of the unknown between glass slides shows their hardness to be between 5 and 6, eliminating kempite and chlorophoenicite, having hardness 3.5, and confirming the elimination of gerstmannite, having hardness 4.5.

This leaves only orthopyroxene as a viable candidate; and, indeed, under the polarizing microscope the fragments show the pleochroism common in many orthopyroxenes: Z faint green, X faint reddish brown. An orthopyroxene with these refractive indices would have composition near En_{73} (Deer, Howie, and Zussman, v. 2A, 1978, p. 109).

TABLES 3–38

Table 3. Isotropic minerals and mineraloids

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.309	ICE H_2O	HEX	Conch	Cols	H 1.5 G 0.92	Melts at 0°C. Biref v low, pos.
	1.326	VILLIAUMITE NaF	CUB u mass	001 perf	Carmine-red to cols	H 2-3.5 G 2.79 F easy	Sol in H_2O. Also uniax neg, biref v low. Pleoc, O carmine-red, E golden-yellow.
	1.333	WATER H_2O	Liquid	---	Cols	G 1.00	---
	1.339	CRYOLITHIONITE $Na_3Li_3Al_2F_{12}$	CUB	011 dist	Cols	H 2.5-3 G 2.77 F easy	Diss by acids.
	1.340	HIERATITE K_2SiF_6	CUB cubo-oct	111 perf	Cols, gray	H ~ 2.5 G 2.67	Sol in hot water.
	1.362	CAROBBIITE KF	CUB	001	Cols	G 2.50 (synth) F easy	Sol in H_2O.
	1.364	NEIGHBORITE $NaMgF_3$	ORTH ps cub	Uneven	Cols to brownish	H 4.5 G 3.03	Slowly diss by hot acids. Biref 0.002.
	1.369	CRYPTOHALITE $(NH_4)_2SiF_6$	CUB cubo-oct	111 perf	Cols	H ~ 2.5 G 2.03 volat	Sol in H_2O.
	1.376	ELPASOLITE K_2NaAlF_6	CUB	Uneven	Cols	H 2.5 G 2.99 F 3	Slowly diss by concd H_2SO_4.
v 1.427	1.38	Unnamed fluoride near Ralstonite $(Ca,Na)(Mg,Al)_2(F,OH)_6 \cdot H_2O$	CUB oct	---	Yellow	---	Diss by acids. Am. Mineral., 28, 283-284 (1943).
v 1.434	1.406	OPAL $SiO_2 \cdot xH_2O$	Amor	Conch	Cols, white, gray, green	H ~ 6 G 1.9-2.3	Insol in acids, diss by KOH soln.
v 1.467	1.423	MELANOPHLOGITE SiO_2 + C, H, O, S	TET ps cub	---	Cols, brownish	H 6.5-7 G 1.99 infus	Insol in acids. Turns black when heated (organic matter). Biref wk.
1.38 ^	1.427	RALSTONITE $Na_xMg_xAl_{2-x}(F,OH)_6 \cdot H_2O$	CUB	111 poor	Cols to yellowish	H 4.5 G 2.52-2.62 infus	Dec by H_2SO_4. Opt anom, divided into oct biref sectors.
v 1.440	1.434	FLUORITE CaF_2	CUB	111 perf	Cols, green, violet, yellow	H 4 G 3.18 F 1.5	Diss by acids.

1.406 ^v 1.46	1.434	OPAL $SiO_2 \cdot xH_2O$	Amor	Conch	Cols	H ~ 6 G 1.86	Insol in acids, diss by KOH soln. Contains 12.6% H_2O.
	1.439	SODIUM ALUM $NaAl(SO_4)_2 \cdot 12H_2O$	CUB oct	Conch	Cols	H ~ 3 G 1.67	Sol in H_2O.
v 1.443	1.440	CHUKHROVITE $Ca_3(Y,Ce)Al_2(SO_4)F_{13} \cdot 10H_2O$	CUB oct "Porcelain-like"	111 indist uneven	Cols, white	H 3 G 2.27-2.40 F easy	Diss by acids. Anom biref.
1.434 ^v 1.457	1.440	FLUORITE, yttrian $(Ca,Y)F_{2-3}$	CUB u mass	111	Cols, green, violet	H 4 G 3.41 F 2	Slowly diss by HCl. Contains 6.9% Y_2O_3.
1.440 ^	1.443	CHUKHROVITE-(Ce) $Ca_3(Ce,Y)Al_2(SO_4)F_{13} \cdot 10H_2O$	CUB	---	---	---	---
v 1.51	1.44	HISINGERITE $(Fe^{+3},Mg,Fe^{+2})_2Si_2O_5(OH)_4 \cdot 2H_2O$	MCL cryptocryst	Conch	Brownish-black	H 3.5 G 2.5 infus	Dec by acids.
v 1.465	1.445	EVANSITE approx. $Al_3(PO_4,SiO_4)(OH)_6 \cdot xH_2O$	Amor	Conch	Cols, yellowish	H 3-4 G 1.87-2.13	Diss by hot H_2SO_4.
v 1.462	1.450	NATROPHOSPHATE $Na_7(PO_4)_2F \cdot 19H_2O$	CUB	Conch	Cols to white	H 2.5 G 1.72	---
	1.455	SULPHOHALITE $Na_6(SO_4)_2FCl$	CUB dod	Conch	Cols	H 3.5 G 2.50 F 1	Slowly sol in H_2O.
	1.456	POTASSIUM ALUM $KAl(SO_4)_2 \cdot 12H_2O$	CUB oct	Conch	Cols	H 2-2.5 G 1.76 F 1	Sol in H_2O.
1.440 ^	1.457	FLUORITE, yttrian $(Ca,Y)F_{2-3}$	CUB	111 imperf	Yellowish	H 4.5 G 3.55 fus	Diss by acids.
	1.458	TSCHERMIGITE $(NH_4)Al(SO_4)_2 \cdot 12H_2O$	CUB oct	Conch	White	H 1.5 G 1.65 F 1	Sol in H_2O. Opt anom.
1.434 ^	1.46	OPAL $SiO_2 \cdot xH_2O$	Amor	Conch	Cols, white, gray, green	H ~ 6 G ~ 2.2 infus	Insol in acids, diss by KOH soln.
v 1.48	1.46	Glass, "Lechatelierite" mainly SiO_2	Amor	Conch	Cols	H 6 G 2.19 infus	Natural fused silica from fulgurite. SiO_2 99%.
1.450 ^	1.462	NATROPHOSPHATE $Na_7(PO_4)_2F \cdot 19H_2O$	CUB	Conch	Cols to white	H 2.5 G 1.72	---

1.406 ◊ 1.46	1.434	OPAL $SiO_2 \cdot xH_2O$	Amor	Conch	Cols	H ~ 6 G 1.86	Insol in acids, diss by KOH soln. Contains 12.6% H_2O.
	1.439	SODIUM ALUM $NaAl(SO_4)_2 \cdot 12H_2O$	CUB oct	Conch	Cols	H ~ 3 G 1.67	Sol in H_2O.
v 1.443	1.440	CHUKHROVITE $Ca_3(Y,Ce)Al_2(SO_4)F_{13} \cdot 10H_2O$	CUB oct "Porcelain-like"	111 indist uneven	Cols, white	H 3 G 2.27-2.40 F easy	Diss by acids. Anom biref.
1.434 ◊ 1.457	1.440	FLUORITE, yttrian $(Ca,Y)F_{2-3}$	CUB u mass	111	Cols, green, violet	H 4 G 3.41 F 2	Slowly diss by HCl. Contains 6.9% Y_2O_3.
1.440 ^	1.443	CHUKHROVITE-(Ce) $Ca_3(Ce,Y)Al_2(SO_4)F_{13} \cdot 10H_2O$	CUB	---	---	---	---
⌐v 1.51	1.44	HISINGERITE $(Fe^{+3},Mg,Fe^{+2})_2Si_2O_5(OH)_4 \cdot 2H_2O$	MCL cryptocryst	Conch	Brownish-black	H 3.5 G 2.5 infus	Dec by acids.
v 1.465	1.445	EVANSITE approx. $Al_3(PO_4,SiO_4)(OH)_6 \cdot xH_2O$	Amor	Conch	Cols, yellowish	H 3-4 G 1.87-2.13	Diss by hot H_2SO_4.
v 1.462	1.450	NATROPHOSPHATE $Na_7(PO_4)_2F \cdot 19H_2O$	CUB	Conch	Cols to white	H 2.5 G 1.72	---
	1.455	SULPHOHALITE $Na_6(SO_4)_2FCl$	CUB dod	Conch	Cols	H 3.5 G 2.50 F 1	Slowly sol in H_2O.
	1.456	POTASSIUM ALUM $KAl(SO_4)_2 \cdot 12H_2O$	CUB oct	Conch	Cols	H 2-2.5 G 1.76 F 1	Sol in H_2O.
1.440 ^	1.457	FLUORITE, yttrian $(Ca,Y)F_{2-3}$	CUB	111 imperf	Yellowish	H 4.5 G 3.55 fus	Diss by acids.
	1.458	TSCHERMIGITE $(NH_4)Al(SO_4)_2 \cdot 12H_2O$	CUB oct	Conch	White	H 1.5 G 1.65 F 1	Sol in H_2O. Opt anom.
1.434 ^	1.46	OPAL $SiO_2 \cdot xH_2O$	Amor	Conch	Cols, white, gray, green	H ~ 6 G ~ 2.2 infus	Insol in acids, diss by KOH soln.
v 1.48	1.46	Glass, "Lechatelierite" mainly SiO_2	Amor	Conch	Cols	H 6 G 2.19 infus	Natural fused silica from fulgurite. SiO_2 99%.
1.450 ^	1.462	NATROPHOSPHATE $Na_7(PO_4)_2F \cdot 19H_2O$	CUB	Conch	Cols to white	H 2.5 G 1.72	---

1.471 ^	1.48	FAUJASITE (Zeolite grp) $(Na_2,Ca)(Al_2Si_4)O_{12} \cdot 8H_2O$	CUB oct	111 dist	White	H 5 G 1.92 F 3	Dec by HCl. On losing H_2O, becomes uniax, pos, in 8 sectors.
	1.482	Unnamed calcium silicate	---	---	White, silky fibers	Soft	Am. Mineral., 26, 375 (1941).
v 1.487	1.483	SODALITE (Sodalite grp) $Na_8Al_6Si_6O_{24}Cl_2$	CUB dod	110 poor	Gray, white, blue	H 6 G 2.30 F 3.5-4	Gel with acids. Cl 7.1, H_2O 2.5%.
	1.486	CRISTOBALITE SiO_2	TET ps cub, oct	---	White	H 6-7 G 2.3 infus	Insol in acids. Biref very low. Intricate tw.
1.483 ^	1.487	SODALITE, var Hackmanite (Sodalite grp) $Na_8Al_6Si_6(O,S)_{24}Cl_2$	CUB dod	110 poor	Reddish-violet, blue	H 5 G 2.2-2.3 F 4	Gel with acids. Color fades in sunlight.
	1.489	D'ANSITE $Na_{18}Mg(SO_4)_{10} \cdot 3NaCl$	CUB	---	Cols, yellow	G 2.66 F easy	Sol in H_2O.
[ ]	1.49	VISHNEVITE (Cancrinite grp) $(Na,Ca)_{6-8}(Al_6Si_6O_{24})$ $(SO_4,CO_3,Cl)_2 \cdot 1\text{-}2H_2O$	HEX	$10\bar{1}0$ perf	Cols	H 5 G 2.32 F 2	Gel with acids. Also uniax pos and neg. Biref .002.
1.47 ^ v 1.52	1.49	ALLOPHANE Hydrous aluminum silicate	Amor	---	White, blue, green	H 3 G 1.86 infus	Gel with acids. Comp variable, may contain $(PO_4)^{-3}$.
	1.490	SYLVITE KCl	CUB	Cub, perf	Cols, white, red, yellow	H 2 G 1.99 F 1.5	Sol in H_2O. Tastes bitter.
1.479 ^ v 1.505	1.493	ANALCIME (Zeolite grp) $NaAlSi_2O_6 \cdot H_2O$	CUB 211	100 poor	Cols, white	H 5 G 2.25 F 3.5	Gel with HCl.
v 1.509	1.494	HAUYNE (Sodalite grp) $(Na,Ca)_{4-8}Al_6Si_6(O,S)_{24}$ $(SO_4,Cl_2)_{1-2}$	CUB dod	110 poor	Blue, white	H 6 G 2.40 fus	Gel with acids. SO_3 9.8, Cl 1.3, Na_2O 19.9, CaO 4.9%.
1.470 ^	1.495	NOSEAN (Sodalite grp) $Na_8Al_6Si_6O_{24}(SO_4)$	CUB dod	110 poor	Blue, white	H 6 G 2.3-2.4 F 4.5	Gel with acids.
	1.498	ZAHERITE $Al_{12}(SO_4)_5(OH)_{26} \cdot 20H_2O$	Mass, fine-grained	One clv	White	H 3.5 G 2.01 infus	Biref < .001.
	1.50	ROSIERESITE Hydrous phosphate of Pb, Cu, Al	Amor compact	---	Yellow, brown	G 2.2 infus	Diss by HNO_3. Blackens bb.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.48 ◊ 1.53	1.50	Glass rhyolitic to dacitic comp	Amor	Conch	Cols, gray	H 5-6 G ~ 2.4	Insol in acids.
[ ]	1.50	STEVENSITE (Smectite grp) $Mg_3Si_4O_{10}(OH)_2 \cdot xH_2O$	MCL mass	---	Buff, pink	H 2.5 G 2.15-2.57 infus	Dec by HCl. Biref 0 to .02.
1.465 ^	1.50	EVANSITE $Al_3PO_4(OH)_6 \cdot 6H_2O$	Amor	Conch	Cols, brown, yellow	H 3-4 G 1.9-2.1 infus	Diss by hot H_2SO_4.
v 1.522	1.500	LAZURITE (Sodalite grp) $(Na,Ca)_{7-8}(Al,Si)_{12}(O,S)_{24}$ $[SO_4,Cl_2,(OH)_2]$	CUB dod	110 poor	Azure blue	H 6 G 2.4 F 3.5	Gel with acids, gives off H_2S.
⊔ 1.51	1.50	BOLIVARITE $Al_2(PO_4)(OH)_3 \cdot 4\text{-}5H_2O$	Amor	Splintery to conch	Greenish-yellow to green	H 2.5 G 2.05	---
	1.502	NASTROPHITE $Na(Sn,Ba)PO_4 \cdot 9H_2O$	CUB	Conch	Cols	H 2 G 2.05	Dec by H_2O, diss by HCl.
	1.504	NABAPHITE $NaBaPO_4 \cdot 9H_2O$	CUB	100 dist	Cols	H ~ 2 G 2.3	Dec by H_2O, diss by acids.
1.48 ^	1.505	VASHEGYITE $Al_4(PO_4)_3(OH)_3 \cdot 13H_2O$ (?)	ORTH (?) cryptocryst	---	White, green, yellowish	H 3.5 G 1.98 infus	Diss by acids.
1.493 ◊ 1.507	1.505	ANALCIME, cesian (Zeolite grp) $(Na,Cs)AlSi_2O_6 \cdot H_2O$	CUB	100 poor	Cols, white	H 5 G 2.60 F 4.5	Diff dec by acids. Cs_2O 14.9%.
1.505 ◊ 1.525	1.507	POLLUCITE (Zeolite grp) $(Cs,Na)AlSi_2O_6 \cdot H_2O$	CUB u mass	Uneven	Cols, white	H 6.5 G 2.85 F diff	Dec by acids.
v 1.550	1.508	TYCHITE $Na_6Mg_2(CO_3)_4(SO_4)$	CUB oct	Conch	Cols	H 3.5-4 G 2.46-2.59 F 1	Slightly sol in H_2O, diss by acids with eff. Compare Northupite.
	1.509	LEUCITE $KAlSi_2O_6$	TET ps cub, 211	110 poor	Cols	H 5.5 G 2.47 infus	Dec by acids. In part cryptocryst.

1.494 ^	1.509	HAUYNE (Sodalite grp) $(Na,Ca)_{4-8}Al_6Si_6(O,S)_{24}$ $(SO_4,Cl_2)_2$	CUB dod	110 poor	Blue, white	H 6 G 2.51 fus	Gel with acids. Na_2O 13.2, K_2O 2.8, CaO 10.1%.
1.44 ◊ 1.57	1.51	HISINGERITE $Fe^{+3}{}_2Si_2O_5(OH)_4\cdot 2H_2O$	MCL cryptocryst	Conch	Brownish-black	H 3 G 2.5-3.0 infus	Dec by acids. In part cryptocryst.
[ ]	1.51	MOTUKOREAITE $Na_2Mg_{38}Al_{24}(CO_3)_{13}(SO_4)_8(OH)_{108}\cdot$ $56H_2O$	HEX cryptocryst	---	White to pale yellowish-green	H 1-1.5 G 1.48-1.53	---
	1.513	CADWALADERITE $Al(OH)_2Cl\cdot 4H_2O$	Amor (?)	Conch	Lemon-yellow	G 1.6	---
v 1.550	1.514	NORTHUPITE $Na_6Mg_2(CO_3)_4Cl_2$	CUB oct	Conch	Cols	H 3.5-4 G 2.38 F 1	Slightly sol in H_2O, diss by acids with eff. Tw common. Compare Tychite.
[ ]	1.517	PLANERITE $(Ca,Cu)Al_6(PO_4)_4(OH)_8\cdot 4H_2O$ (?)	Cryptocryst	---	Green	H 5 G 2.65	Slightly sol in acids. In part biref.
[ ]	1.517	SEPIOLITE, var Meerschaum $Mg_4Si_6O_{15}(OH)_2\cdot 6H_2O$	ORTH cryptocryst	---	White	H 1-2 G 2.0	Biref 0 to 0.02.
1.49 ^	1.52	ALLOPHANE Hydrous aluminum silicate	Amor	---	White, brown	H 3 G 1.9 infus	Gel with acids. Fe_2O_3 5-6%.
1.500 ^	1.522	LAZURITE (Sodalite grp) $(Na,Ca)_{7-8}(Al,Si)_{12}(O,S)_{24}$ $[SO_4,Cl_2,(OH)_2]$	CUB dod	110 poor	Azure blue	H 6 G 2.4 F 3.5	Gel with acids, gives off H_2S.
1.507 ^	1.525	POLLUCITE (Zeolite grp) $(Cs,Na)AlSi_2O_6\cdot H_2O$	CUB u mass	Uneven	Cols, white	H 6.5 G 2.90 F diff	Dec by acids.
1.50 ◊ 1.57	1.53	Glass andesitic comp	Amor	Conch	Cols, gray	H 5-6 G ~ 2.5	Insol in acids.
[ ]	1.53	KEHOEITE $(Zn,Ca)Al_2(PO_4)_2(OH)_2\cdot 5H_2O$	Amor (?) mass	---	White	G 2.34 infus	Diss by acids. Status of mineral in doubt.
	1.530	VISEITE $NaCa_5Al_{10}(SiO_4)_3(PO_4)_5(OH)_{14}\cdot$ $10H_2O$ (?)	CUB mass	---	White, bluish, yellowish	H 3-4 G 2.2 F easy	---
v 1.572	1.534	LANGBEINITE $K_2Mg_2(SO_4)_3$	CUB tetrah	Conch	Cols, yellow	H 3.5-4 G 2.83 F 2	Slowly sol in H_2O.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
[ ]	1.535	SUCCINITE (Amber) a hydrocarbon	Amor	Conch	Amber-yellow	Soft G 1.07 F easy	---
1.530 [ ] 1.54	1.537	TACHARANITE $Ca_{12}(Mg,Al)_2Si_{18}O_{51}\cdot 18H_2O$ (?)	MCL mass	001 good	White	G 2.36	Biref low.
1.47 ^	1.54	NEOTOCITE MnO, SiO_2, H_2O	Amor	Conch	Brown to black	H 4 G 2.7 F diff	Dec by acids.
1.47 ^	1.54	Hydrated basaltic glass ("Chlorophaeite")	Amor	Conch	Yellow, brown, orange-brown	H 1.5-3 G 1.8-2.2	Color may darken on exposure.
	1.541	AJKAITE a resin	Amor	---	Pale yellow to red-brown	H 2.5 G 1.0 F easy and burns	Gives off H_2S when heated. C 80, H 10, O 9, S 1%.
	1.542	TELEGDITE a resin	Amor	---	---	H 2.5 G 1.09	Partly diss by alcohol. C 76.9, H 10.2, O 11.2, S 1.7%.
v 1.555	1.542	HALLOYSITE $Al_2Si_2O_5(OH)_4$	MCL u crypto-cryst	---	White, blue	H 2 G 2.6 infus	Insol in acids. When dried at 60°C, n increases to 1.555.
	1.544	HALITE NaCl	CUB	Cub, perf	Cols, yellow, red	H 2 G 2.17 F 1.5	Sol in H_2O, salty taste.
1.514 ^	1.550	NORTHUPITE $Na_6(Mg,Fe)_2(CO_3)_4Cl_2$	CUB oct	Conch	Bright green	H 3.5-4 G 2.52 F 1	Slightly sol in H_2O, diss by acids with eff. FeO up to 7.6%.
1.508 ^	1.550	FERROTYCHITE $Na_6(Fe^{+2},Mg,Mn)(SO_4)(CO_3)$	CUB	Conch	Cols to light yellow	H 4 G 2.79	---
1.542 ^	1.555	HALLOYSITE $Al_2Si_2O_5(OH)_4$	MCL u crypto-cryst	---	White, blue	H 2 G 2.6 infus	Insol in acids.
v 1.570	1.558	SERPENTINE $Mg_3Si_2O_5(OH)_4$	MCL or ORTH cryptocryst	---	Green	H 4 G 2.5 F 6	Dec by acids. Biref low. Contains NiO 2.6%. Species not detd.

v 1.59	1.56	ZARATITE $Ni_3(CO_3)(OH)_4 \cdot 4H_2O$	CUB	Conch	Emerald-green	H 3-3.5 G 2.57-2.69 infus	Diss by acids with eff.
v 1.606	1.560	GUTSEVICHITE $(Al,Fe)_3(PO_4,VO_4)_2(OH)_3 \cdot 8H_2O$ (?)	Crusts, concretions	---	Yellow-olive to dark green	H 2.5 G 1.9-2.0	Diss by acids.
v 1.59	1.563	Ni analogue of Serpentine ("Garnierite") $(Ni,Mg)_3Si_2O_5(OH)_4$	MCL (?) cryptocryst	---	Green	G 2.58 infus	Dec by acids. (= Pecoraite or Nepouite?)
v 1.592	1.563	ZUNYITE $Al_{13}Si_5O_{20}(OH,F)_{18}Cl$	CUB tetrah	111	Cols	H 7 G 2.87 infus	Insol in acids. F 12.5, Cl 2.2, H_2O 6.5%.
v 1.676	1.565	ALUMOPHARMACOSIDERITE $KAl_4(AsO_4)_3(OH)_4 \cdot 6.5H_2O$	CUB	---	White	G 2.68	---
v 1.59	1.569	CARBONATE-FLUORAPATITE ("Collophane")(Apatite grp) $Ca_5(PO_4,CO_3)_3(F,OH)$	HEX cryptocryst	---	White, brown	H 3.5 G ~ 2.6 F diff	Diss by acids.
1.51 ^ v 1.59	1.57	HISINGERITE $Fe^{+3}{}_2Si_2O_5(OH)_4 \cdot 2H_2O$	MCL microcryst	Conch	Brownish-black	H 3.5 G 2.5-3.0 infus	Dec by acids.
1.53 ^ v 1.61	1.57	Glass andesitic to latitic comp	Amor	Conch	Pale brown, yellowish	H 5 G ~ 2.06	Insol in acids.
1.558 ^	1.570	SERPENTINE, zincian $(Mg,Zn)_3Si_2O_5(OH)_4$	MCL or ORTH cryptocryst	---	Green	H 4 G 2.5 F 6	Dec by acids. ZnO 7.25%.
v 1.60	1.57	BORICKITE Hydrous Ca ferric phosphate	Amor	---	Reddish-brown	H 3.5 G ~ 2.7 F easy	Diss by acids.
	1.571	NITROBARITE $Ba(NO_3)_2$	CUB oct	---	Cols	G 3.25 F 1	Sol in H_2O.
1.534 ^	1.572	MANGANOLANGBEINITE $K_2Mn_2(SO_4)_3$	CUB tetrah	---	Rose-red	G 3.02	Sol in H_2O.
	1.573	MILLOSEVICHITE $(Al,Fe)_2(SO_4)_3$	---	---	Cherry-red	G 1.72	Diss by acids. Fe_2O_3 8.8%.
	1.577	NAMUWITE $(Zn,Cu)_4(SO_4)(OH)_6 \cdot 4H_2O$	HEX	0001 perf	Pale sea-green	H 2 G 2.77	ZnO 37.8, CuO 22%.
v 1.65	1.58	KONINCKITE $FePO_4 \cdot 3H_2O$	TET spherulitic	---	Yellow	H 3.5 G 2.3 F 3	Diss by hot acids.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
┌┐ └┘	1.582	CHINGLUSUITE $Na_4Mn_5Ti_3Si_{14}O_{41}\cdot 9H_2O$	Amor	Uneven	Black	H 2-3 G 2.15 F easy	Gel with acids.
1.57 ^v 1.66	1.59	HISINGERITE $Fe^{+3}{}_2Si_2O_5(OH)_4\cdot 2H_2O$	MCL cryptocryst	Conch	Brownish-black	H 3 G 3.0 infus	Dec by acids.
1.56 ^v 1.61	1.59	ZARATITE $Ni_3(CO_3)(OH)_4\cdot 4H_2O$	CUB	Conch	Emerald-green	H 3-3.5 G 2.6 infus	Diss by acids with eff.
1.569 ^v 1.63	1.59	CARBONATE-FLUORAPATITE ("Collophane")(Apatite grp) $Ca_5(PO_4,CO_3)_3(F,OH)$	HEX cryptocryst	---	White, brown	H 3.5 G 2.6-2.7 F diff	Diss by acids.
1.563 ^ └┘	1.59	Ni analogue of Serpentine ("Garnierite") $(Ni,Mg)_3Si_2O_5(OH)_4$	MCL (?) cryptocryst	---	Green	H 2 G ~ 2.6 infus	Dec by acids. (= Pecoraite or Nepouite?)
v 1.667	1.59	SCHOENFLIESITE $MgSn(OH)_6$	CUB mass	---	Brown	G 3.48 infus	Diss by HCl, slowly by NaOH soln.
1.563 ^v 1.600	1.592	ZUNYITE $Al_{13}Si_5O_{20}(OH,F)_{18}Cl$	CUB tetrah	111	Cols	H 7 G 2.89 infus	Insol in acids. F 5.5, Cl 2.6, H_2O 10.0%.
v 1.608	1.593	VOLTAITE $K_2Fe^{+2}{}_5Fe^{+3}{}_4(SO_4)_{12}\cdot 18H_2O$	CUB	Conch	Dull oil-green, brown, black	H 3 G 2.6-2.8	Diss by acids. Oil-green in thin section.
	1.593	GEORGEITE $Cu_5(CO_3)_3(OH)_4\cdot 6H_2O$	Amor	---	Light blue	Soft G 2.55	---
└┘	1.595	COESITE SiO_2	MCL ps hex	Subconch	Cols	G 2.92 infus	Insol in acids. Biref .003 - .005.
v 1.64	1.595	VUDYAVRITE Hydrous silicate of Ce, La, Ti	Amor	Conch	Brown, cream, yellow	H ~ 3 G 2.40-2.52	Dec by acids.
┌┐ └┘	1.596	STURTITE $(Mn,Mg)_6Fe^{+3}{}_2Si_8O_{25}\cdot 23H_2O$ (?)	Amor	Conch	Brownish-black	H 3 G 2.05 F diff	Dec by acids.
	1.598	COMBEITE $Na_2Ca_2Si_3O_9$	TRIG	---	Cols	G 2.84	Diss by hot dilute HCl. Biref very low.

1.57 ^v 1.67	1.60	BORICKITE Hydrous Ca ferric phosphate	Amor	---	Reddish-brown	H 3.5 G ~ 2.7 F easy	Diss by acids.
⌐v 1.70	1.60	STIBICONITE (Stibiconite grp) $Sb^{+3}Sb^{+5}{}_2O_6(O,OH)$	CUB u mass	Conch	Gray, white, yellow	H 4-6 G 5.1-5.6 infus	Insol in acids. _n_ highly variable.
1.592 ^	1.600	ZUNYITE $Al_{13}Si_5O_{20}(OH,F)_{18}Cl$	CUB tetrah	111	Cols	H 7 G 2.88 infus	Insol in acids. F 0.5, Cl 3.5, H_2O 11.4%.
[ ]	1.602	EUDIALYTE $Na_4(Ca,Ce)_2(Fe^{+2},Mn^{+2})ZrSi_8O_{22}$ $(OH,Cl)_2$	TRIG	0001 dist	Yellow, pink, brown	H 5-5.5 G 2.9-3.1 F 3	Gel with acids. Uniax, pos or neg.
1.560 ^	1.606	GUTSEVICHITE $(Al,Fe)_3(PO_4,VO_4)_2(OH)_3 \cdot 8H_2O$ (?)	Crusts, concretions	---	Dark green to brown	H 2.5 G 1.9-2.0	Diss by acids.
[ ]	1.608	CALCIUM FERRI-PHOSPHATE $CaFe^{+3}{}_2(PO_4)_2(OH)_2 \cdot 9H_2O$ (?)	Amor	---	Light brown	H 2-3	Diss by acids.
1.593 ^	1.608	VOLTAITE $K_2Fe^{+2}{}_5Fe^{+3}{}_4(SO_4)_{12} \cdot 18H_2O$	CUB	Conch	Dull oil-green, brown, black	H 3 G 2.6-2.8	Diss by acids. Oil-green in thin section.
1.57 ^v 1.65	1.61	Glass basaltic comp	Amor	Conch	Brown	H 5 G 2.8	---
1.59 ^	1.61	ZARATITE $Ni_3(CO_3)(OH)_4 \cdot 4H_2O$	CUB	Conch	Emerald-green	H 3 G ~ 2.6 infus	Diss by acids.
[ ]	1.61	DIADOCHITE $Fe_2(PO_4)(SO_4)(OH) \cdot 5H_2O$	TCL u cryptocryst	Uneven to conch	Brown, yellow	H 3-4 G 2.0-2.4 F easy	Diss by HCl.
⌐v 1.68	1.61	ALLANITE (Epidote grp) $(Ca,Ce,Y)_2(Al,Fe)_3(SiO_4)_3(OH)$	MCL metamict	---	Brown, black	H 6 G 2.96 F 3	Gel with acids. In part biref.
	1.613	HSIANGHUALITE $Ca_3Li_2Be_3(SiO_4)_3F_2$	CUB dod	---	White	H 6.5 G 2.98	---
v 1.643	1.614	MAYENITE $Ca_{12}Al_{14}O_{33}$	CUB mass	---	White	G 2.85 infus	Insol in dil acids.
v 1.635	1.616	PITTICITE Hydrous ferric arsenate-sulfate	Amor	---	Brown, yellow	H 2-3 G 2.2-2.5 F easy	Diss by HCl. Comp widely variable.
	1.618	METABORITE HBO_2	CUB tetrah	Conch	Cols to brownish	H 5 G 2.47 F 1	Slowly sol in H_2O.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
⊓ ⊔	1.62	ZIRFESITE $Zr_3Fe_2Si_4O_{17}\cdot15H_2O$ (?)	Amor	---	Pale yellow	G 2.70	Gel with acids.
	1.625	BICCHULITE $Ca_2Al_2SiO_6(OH)_2$	CUB	---	Cols	G 2.75 (synth)	---
	1.629	KAMAISHILITE $Ca_2Al_2SiO_6(OH)_2$	TET	---	Cols	---	---
1.59 ^ ⊔	1.63	CARBONATE-FLUORAPATITE ("Collophane")(Apatite grp) $Ca_5(PO_4,CO_3)_3(F,OH)$	HEX cryptocryst	---	White, brown	H 3.5 G 2.7 F diff	Diss by acids.
v 1.66	1.63	GRIPHITE $Na_4Ca_6(Mn,Fe^{+2},Mg)_{19}Li_2Al_8(PO_4)_{24}(F,OH)_8$	CUB u mass	Conch	Brown	H 5.5 G 3.4 F easy	Diss by HCl.
⊓ v 1.685	1.63	TRITOMITE-(Y) ("Spencite") $(Y,Ca,La,Fe^{+2})_5(Si,B,Al)_3(O,OH,F)_{13}$ (?)	TRIG (?) metamict	---	Reddish-brown	H 3.5 G 3.1 F 3	---
	1.633	BURTITE $CaSn(OH)_6$	CUB	001 good	Cols	H ~ 3 G 3.28	Diss by HCl.
1.616 ^	1.635	PITTICITE Hydrous ferric arsenate-sulfate	Amor		Brown, yellow	H 2-3 G 2.2-2.5 F easy	Diss by HCl. Comp widely variable.
	1.639	SALAMMONIAC NH_4Cl	CUB	111 imperf	Cols	H 1.5-2 G 1.53 F 1 volat	Sol in H_2O.
v 1.653	1.639	HARKERITE $Ca_{24}Mg_8Al_2(SiO_4)_8(BO_3)_6(CO_3)_{10}\cdot2H_2O$	CUB oct	---	Cols	H 4 G 2.95	Diss by HCl. Anom biref.
⊔	1.639	TOMBARTHITE $Y_4(Si,H_4)_4O_{12-x}(OH)_{4+2x}$	MCL metamict	Conch	Brown, black	H 5-6 G 3.51-3.65	---
	1.63- 1.66	THOROSTEENSTRUPINE $(Ca,Th,Mn)_3Si_4O_{12}\cdot6H_2O$	Amor metamict	Conch	Dark brown	H 4 G 3.02	ThO_2 35.7%. Weakly magnetic.
⊓ v 1.685	1.64	THORITE $ThSiO_4$ (+ xH_2O)	TET metamict	---	Brown to yellow	H 2-4 G 3.8-4.3	Gel with warm acids.

⌄ 1.68	1.64	PICITE Hydrous ferric phosphate	Amor	---	Dark brown	H 3-4 G 2.8 F easy	Diss by acids.
[ ]	1.64	HOMILITE (altered) $Ca_2(Fe^{+2},Mg)B_2Si_2O_{10}$	MCL mass	Conch	Black	H 3 G 3.35	Gel with acids.
	1.64	UMBOZERITE $Na_3Sr_4ThSi_8(O,OH)_{24}$	Amor metamict	Conch	Bottle-green to greenish-brown	H ~ 5 G 3.60	---
⌄ 1.74	1.64	COFFINITE $U(SiO_4)_{1-x}(OH)_{4x}$	TET metamict	---	Yellow, brown	G 3.6-3.9	---
1.595 ^	1.64	VUDYAVRITE Hydrous silicate of Ce, La, Ti	Amor	Conch	Brown, cream, yellow	H ~ 3 G 2.40-2.52	Dec by acids.
[ ]	1.642	SAKHAITE $Ca_3Mg(BO_3)_2CO_3 \cdot xH_2O$ (x < 1)	CUB	---	Gray, white	H 5 G 2.78-2.84	Diss by HCl with eff.
1.614 ^	1.643	MAYENITE $Ca_{12}Al_{14}O_{33}$	CUB mass	---	Cols	G 2.85 infus	Insol in dil acids.
1.58 ^	1.65	KONINCKITE $FePO_4 \cdot 3H_2O$	TET spherulitic	---	Yellow	H 3.5 G 2.3 F 3	Diss by hot acids.
[ ]	1.65	EGUEIITE Hydrous Ca ferric phosphate	Amor	---	Yellow-brown	G 2.60 F easy	Diss by acids.
⌄ 1.675	1.65	GREENALITE $(Fe^{+2},Fe^{+3})_{2-3}Si_2O_5(OH)_4$	MCL microcryst	---	Green to brown	G 2.8-3.0	Dec by HCl.
1.61 ^	1.65	Glass basaltic comp	Amor	Conch	Brown	H ~ 5 G ~ 3	---
⌄ 1.77	1.65	MELANOCERITE $(Ca,Ce)_5(Si,B)_3O_{12}(OH,F) \cdot xH_2O$ (?)	HEX metamict	Conch	Dark brown to black	H 5-6 G 4.1 infus	Dec by HCl. Apatite structural type.
1.648 uniax pos ◇ uniax neg 1.653	1.65	MELILITE (Melilite grp) $(Ca,Na)_2(Mg,Al)(Si,Al)_2O_7$	TET	001 dist	Cols to brown	H 5 G 3.0 F 3	Gel with acids. Comp close to Gehlenite 50, Akermanite 50. Biref .001.
1.639 ^	1.653	HARKERITE $Ca_{24}Mg_8Al_2(SiO_4)_8(BO_3)_6(CO_3)_{10} \cdot 2H_2O$	CUB oct	---	Cols	H 4 G 2.95	Diss by HCl. Anom biref.
⌄ 1.71	1.655	ZIRCON $ZrSiO_4$ (+ xH_2O)	TET metamict	---	Yellow, brown	G 2.9 infus	Partly diss by acids.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.63 ^	1.66	GRIPHITE $Na_4Ca_6(Mn,Fe,Mg)_{19}Li_2Al_8(PO_4)_{24}(F,OH)_8$	CUB u mass	Conch	Brown	H 5.5 G 3.4 F easy	Diss by HCl.
1.59 ^	1.66	HISINGERITE $Fe^{+3}Si_2O_5(OH)_4 \cdot 2H_2O$	MCL cryptocryst	Conch	Brownish-black	H 3 G 3.0 F diff to infus	Dec by acids.
[ ]	1.66	VESUVIANITE $Ca_{10}(Mg,Fe)_2Al_4(Si_2O_7)_2(SiO_4)_5(OH,F)_4$	TET metamict	---	Brown	H 6 G 3.3 F 3	Insol in acids.
1.59 ^ v 1.705	1.667	SCHOENFLIESITE $(Mg,Mn)Sn(OH)_6$	CUB mass	---	Brown	G 3.49 infus	Diss by HCl.
1.60 ^	1.67	BORICKITE Hydrous Ca ferric phosphate	Amor	---	Reddish-brown	H 3.5 G ~ 2.7 F 3-4	Diss by acids.
v 1.702	1.670	HYDROGROSSULAR (Garnet grp) $Ca_3Al_2(SiO_4)_{3-x}(OH)_{4x}$	CUB dod	---	Cols	H 6-6.5 G 3.1 infus	Gel with acids. Some samples divided into biref sectors. H_2O 8-9%.
1.65 ^	1.675	GREENALITE $(Fe^{+2},Fe^{+3})_{2-3}Si_2O_5(OH)_4$	MCL microcryst	---	Green to brown	G 3.0	Dec by HCl.
1.565 ^ v 1.704	1.676	PHARMACOSIDERITE $KFe_4(AsO_4)_3(OH)_4 \cdot 6H_2O$	CUB cubes, tetrah	100 imperf	Brown, green	H 2.5-3 G 2.8-3.0 F 1	Diss by HCl. Biref 0 to 0.01.
1.64 ^	1.68	PICITE Hydrous ferric phosphate	Amor	---	Dark brown	H 3-4 G 2.8 F easy	Diss by acids.
1.67 [ ] 1.71	1.680	HUTTONITE $ThSiO_4$ (+ xH_2O)	MCL metamict	---	Cols to yellow	---	---
v 1.73	1.68	DELVAUXITE $CaFe^{+3}_3(PO_4,SO_4)_2(OH)_8 \cdot 4\text{-}6H_2O$ (?)	Amor (?)	---	Brown	H 2.5-4 G 2.0-2.8	Diss by acids.

1.61 ^v 1.72	1.68	ALLANITE (Epidote grp) $(Ca,Ce,Y)_2(Al,Fe)_3(SiO_4)_3(OH)$	MCL metamict	---	Brown, black	H 6 G 3.4-3.7 F 3	In part biref. May gel with acids.
	1.68	SATPAEVITE $Al_{12}V^{+4}{}_2V^{+5}{}_6O_{37}\cdot 30H_2O$	ORTH (?)	One pina-coidal, perf	Canary- to saffron-yellow	H 1.5 G 2.4	Diss by acids. In section greenish-yellow to olive. U biaxial, pos.
1.63 ^v 1.763	1.685	TRITOMITE-(Y) ("Spencite") $(Y,Ca,La,Fe^{+2})_5(Si,B,Al)_3$ $(O,OH,F)_{13}$	TRIG metamict	---	Reddish-brown	H 3.5 G 3.3 F 3	---
1.64 ^v 1.715	1.685	THORITE $ThSiO_4$ (+ xH_2O)	TET metamict	---	Brown, yellow	H 2-4 G 4.4	Gel with acids. H_2O 9%.
[ ]	1.694	RHODIZITE $(Cs,K)Al_4Be_4B_{11}O_{25}(OH)_4$	CUB dod	111, $\bar{1}$11 diff	Cols	H 8 G 3.31-3.44 infus	Insol in acids. Opt anom.
⌐v 1.78	1.70	GADOLINITE $(Y,Ca)_2FeBe_2Si_2O_{10}$	MCL metamict	Conch	Greenish-black	H 7 G 4.0 infus	Gel with acids. Pale green in section.
1.60 ^v 1.74	1.70	STIBICONITE (Stibiconite grp) $Sb^{+3}Sb^{+5}{}_2O_6(O,OH)$	CUB u mass	Conch	Gray, white, yellow	H 4-6 G 5.1-5.6 infus	Insol in acids. n highly variable.
1.670 ^v 1.734	1.702	HYDROGROSSULAR (Garnet grp) $Ca_3Al_2(SiO_4)_{3-x}(OH)_{4x}$	CUB dod	---	Cols	H 6-6.5 G 3.35 infus	Diff sol in acids. May gel.
1.676 ^v 1.712	1.704	PHARMACOSIDERITE $KFe_4(AsO_4)_3(OH)_4\cdot 6H_2O$	CUB cubes, tetrah	100 imperf	Brown, green	H 2.5-3 G 2.8-3.0 F 1	Diss by acids. Biref 0 to 0.01.
v 1.726	1.704	ROWLANDITE $Y_3(SiO_4)_2(OH,F)$ (?)	Amor metamict	Conch	Green, red	H 6-7 G 4.4-4.5 infus	Gel with acids.
1.667 ^	1.705	WICKMANITE $MnSn(OH)_6$	CUB oct	001 good	Brownish-to honey-yellow	H 3.5 G 3.89	---
v 1.748	1.707	BERZELIITE $(Ca,Na)_3(Mg,Mn)_2(AsO_4)_3$	CUB	Subconch to uneven	Yellow, orange	H 5 G 4.08 F 3	Diss by acids. MnO 1.3%. Garnet-type structure.
1.655 ^v 1.79	1.71	ZIRCON $ZrSiO_4$ (+ xH_2O)	TET metamict	---	Yellow, brown	G 3.0-3.5 infus	Nearly insol in acids.
1.704 ^	1.712	BARIUM-PHARMACOSIDERITE $Ba(Fe,Al)_4(AsO_4)_3(OH)_5\cdot 5H_2O$ (?)	TET (?)	100 good	Yellow-brown	H 2-3 G 3.00	Diss by acids.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v 1.741	1.714	PYROPE (Garnet grp) $Mg_3Al_2(SiO_4)_3$	CUB 110, 211	---	Cols	H 7 G 3.58 F 4	Insol in acids. Data for synth end-member.
v 1.738	1.714	SPINEL (Spinel grp) $MgAl_2O_4$	CUB oct	111 imperf	Cols, red, green	H 8 G 3.58 infus	Insol in acids. Data for synth end-member.
1.685 ^v 1.804	1.715	THORITE $(Th,U)SiO_4$ (+ xH_2O)	TET metamict	---	Brown, green, yellow	H 4 G 3.8-4.4	Gel with acids.
1.68 ^v 1.75	1.72	ALLANITE (Epidote grp) $(Ca,Ce,Y)_2(Al,Fe)_3(SiO_4)_3(OH)$	MCL metamict	---	Brown, black	H 6 G 3.4-3.7 F 3	In part biref. May gel with acids.
⌐v 1.75	1.72	BRITHOLITE $(Ce,Ca)_5(SiO_4,PO_4)_3(OH,F)$	HEX metamict	---	Yellow, brown	H 5 G 3.85 infus	Gel with HCl. Yellow in section. Apatite structural type.
⌐v 1.79	1.72	BINDHEIMITE (Stibiconite grp) $Pb_2Sb_2O_6(O,OH)$	CUB u mass	Conch	Yellow, brown, gray	H 4-4.5 G 4.6-5.6 F 3-4	Dec by HCl.
⌐ ⌙	1.72	CALCIOURANOITE $(Ca,Ba,Pb)U_2O_7 \cdot 5H_2O$	Amor	---	Brown to orange	H 4 G 4.62	Weakly anisotropic.
	1.725	DZHALINDITE $In(OH)_3$	CUB	---	Yellow-brown	G 4.34 infus	Pale yellow in section.
1.704 ^	1.726	ROWLANDITE $Y_3(SiO_4)_2(F,OH)$ (?)	Amor metamict	Conch	Green, red	H 6-7 G 4.4-4.5 infus	Gel with acids.
1.68 ^	1.73	DELVAUXITE $CaFe^{+3}{}_3(PO_4,SO_4)_2(OH)_8 \cdot$ $4\text{-}6H_2O$ (?)	Amor (?)	---	Brown	H 2.5-4 G 2.0-2.8	Diss by acids.
v 1.738	1.732	HELVITE (Helvite grp) $(Mn,Fe,Zn)_4Be_3(SiO_4)_3S$	CUB tetrah	111 imperf	Yellow	H 6 G 3.22 F 3	Gel with acids. MnO 45.5, FeO 2.2, ZnO 1.2%.
1.702 ^v 1.752	1.734	GROSSULAR (Garnet grp) $Ca_3Al_2(SiO_4)_3$	CUB 110, 211	Uneven	White, green, pink, brown	H 6-7 G 3.59 F 3	Insol in acids. Opt anom. Data for synth end member.

v 1.756	1.735	PERICLASE MgO	CUB 100, 111	100 perf, parting 110	Cols	H 5.5 G 3.56 infus	Diss by acids.
	1.735	VISMIRNOVITE $ZnSn(OH)_6$	CUB	---	Pale yellow	H 4 G 4.04	Diss by HCl.
	1.736	SÖHNGEITE $Ga(OH)_3$	CUB	---	Light brown	H 4-4.5 G 3.84 infus	---
1.732 ◊ 1.744	1.738	HELVITE (Helvite grp) $(Mn,Fe,Zn)_4Be_3(SiO_4)_3S$	CUB tetrah	111 imperf	Brown	H 6 G 3.4 F 3	Gel with acids. MnO 29.9, FeO 10.1, ZnO 5.2%.
1.714 ◊ 1.747	1.738	SPINEL (Spinel grp) $(Mg,Fe)Al_2O_4$	CUB oct	111 imperf	Green, black	H 8 G 3.62 infus	Insol in acids. FeO 5.6, Fe_2O_3 1.5, MnO 0.1%.
1.64 ◊ 1.92	1.74	COFFINITE $U(SiO_4)_{1-x}(OH)_{4x}$	TET metamict	---	Yellow, brown	G 3.6-3.9	---
[ ]	1.74	CARYOCERITE Borosilicate of Y, Ce, Ca, Th	ps trig, metamict	Conch	Brown	H 5-6 G 4.30	Dec by hot HCl. Swells without fusing bb. Compare Melanocerite.
[v] 1.77	1.74	THOROGUMMITE $(Th,U)(Si,P)O_{4-x}(OH)_{4x}$	TET metamict	---	Brown to black	H 3 G ~ 4.6 infus	Gel with acids. Gum-like. Compare Thorite.
1.70 ◊ 1.80	1.74	STIBICONITE (Stibiconite grp) $Sb^{+3}Sb^{+5}{}_2O_6(O,OH)$	CUB u mass	Conch	Gray, brown, yellow	H 4-5.5 G 5.2-5.6 infus	Insol in acids.
1.714 ◊ 1.766	1.741	PYROPE-ALMANDINE (Garnet grp) $(Mg,Fe)_3Al_2(SiO_4)_3$	CUB 110, 211	---	Red, brown	H 7 G 3.72 F 3.5	Insol in acids. Py 66, Al 20, Sp 1, Gr 11, An 2.
1.738 ◊ 1.745	1.744	GENTHELVITE (Helvite grp) $(Zn,Fe)_4Be_3(SiO_4)_3S$	CUB tetrah	---	Brown, red	H 6 G 3.66 F 4	Gel with acids. ZnO 46.0, FeO 6.1, MnO 1.5%.
1.744 ◊ 1.747	1.745	DANALITE (Helvite grp) $(Fe,Zn,Mn)_4Be_3(SiO_4)_3S$	CUB tetrah	---	Pink, brown	H 6 G 3.44 F 3.5	Gel with acids. FeO 22.4, ZnO 20.0, MnO 8.15%.
1.738 ◊ 1.776	1.747	SPINEL, zincian (Spinel grp) $(Mg,Fe,Zn)Al_2O_4$	CUB oct	---	Greenish-black	H 8 G 3.97 infus	Insol in acids. ZnO 18.2, MgO 16.8, FeO 1.9%.
1.745 ◊ 1.760	1.747	HELVITE (Helvite grp) $(Mn,Fe,Zn)_4Be_3(SiO_4)_3S$	CUB tetrah	---	Brown	H 7 G 3.31 F 3.5	Gel with acids. MnO 28.0, FeO 15.8, ZnO 7.8%.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.707 ◊ 1.777	1.748	BERZELIITE $(Ca,Na)_3(Mg,Mn)_2(AsO_4)_3$	CUB	Subconch to uneven	Yellow, orange	H 5 G 4.27 F 3	Diss by acids. MnO 8.8%. Garnet-type structure.
[ ]	1.75	YTTRIALITE $(Y,Th)_2Si_2O_7$	HEX (?) metamict	Conch	Olive-green	H 6.5 G 4.3-4.7 infus	Gel with acids.
[ ]	1.75	HELLANDITE $(Ca,Y)_6(Al,Fe)Si_4B_4O_{20}(OH)_4$	MCL metamict	---	Brown	H 5.5 G 3.70 F 2-3	Gel with acids.
1.72 ◊ 1.81	1.75	BRITHOLITE $(Ce,La,Ca)_5(SiO_4,PO_4)_3(OH,F)$	HEX metamict	---	Yellow, brown	H 5 G 3.85 infus	Gel with HCl. Apatite-like structure.
1.72 ^	1.75	ALLANITE (Epidote grp) $(Ca,Ce,Y)_2(Al,Fe)_3(SiO_4)_3(OH)$	MCL metamict	---	Brown, black	H 6 G 3.4-3.7 F 3	In part biref. May gel with acids.
1.734 ◊ 1.773	1.752	GROSSULAR (Garnet grp) $Ca_3(Al,Fe)_2(SiO_4)_3$	CUB 110, 211	Uneven	Brown, white, green	H 6-7 G 3.57 F 3	Insol in acids. Gr 85, An 13, Py 1.
	1.755	ARSENOLITE As_2O_3	CUB oct	111	White	H 1.5 G 3.80 F 1	Sol in H_2O. Volat when heated.
	1.755	NATANITE $Fe^{+2}Sn(OH)_6$	CUB	---	Greenish-brown	H 5 G 4.07	Diss by HCl.
1.735 ^	1.756	PERICLASE (Mg,Fe)O	CUB	100 perf parting 110	Cols	H 5.5 G 3.56 infus	Diss by acids. FeO 5.8%.
	1.758	AZOVSKITE $Fe_3(PO_4)(OH)_6$	Amor (?)	---	Dark brown	H 4 G 2.5	Diss by acids. Faintly biref.
1.747 ^	1.760	DANALITE (Helvite grp) $(Fe,Mn,Zn)_4Be_3(SiO_4)_3S$	CUB tetrah	---	Dark red	H 6 G 3.41 F 3	Gel with acids. FeO 38.4, MnO 7.1, ZnO 6.8%.
1.685 ^	1.763	TRITOMITE $(Ce,Y,La,Th)_5(Si,B)_3(O,OH,F)_{13}$	TRIG metamict	---	Reddish-brown	H 4-5.5 G 4.2 F 3	Gel with acids.

1.741 ◊ 1.782	1.766	PYROPE-ALMANDINE (Garnet grp) $(Mg,Fe,Ca)_3(Al,Fe)_2(SiO_4)_3$	CUB 110, 211	Uneven	Red, brown	H 7 G 3.88 F diff	Insol acids. Py 43, Al 41, Sp 2, Gr 8, An 6.
[ ]	1.768	RINGWOODITE $(Mg,Fe)_2SiO_4$	CUB	---	Purple	G 3.90	Structure of spinel type.
1.65 ^	1.77	MELANOCERITE $(Ca,Ce)_5(Si,B)_3O_{12}(OH,F)\cdot xH_2O$ (?)	HEX metamict	Conch	Dark brown to black	H 5-6 G 4.1 infus	Dec by HCl. Apatite structural type.
1.74 ^	1.77	THOROGUMMITE $ThSiO_{4-x}(OH)_{4x}$	TET square prisms metamict	---	Black	H 5.5 G 5.4 infus	Diff sol in acids, gel. Clouded in section.
1.752 ◊ 1.796	1.773	GROSSULAR-SPESSARTINE (Garnet grp) $(Ca,Mn,Fe)_3Al_2(SiO_4)_3$	CUB	---	Peach-tan	H 7 G 3.80 F 4	Insol in acids. Gr 56, Sp 25, Al 11, An 7.
1.747 ◊ 1.798	1.776	HERCYNITE, magnesian ferrian ("Pleonaste") (Spinel grp) $(Fe,Mg)(Al,Fe)_2O_4$	CUB oct	Uneven	Greenish-black	H 8 G 4.20 infus	Insol in acids. Deep green in section. FeO 23.3, MgO 10.8, Fe_2O_3 11.7%.
1.748 ^	1.777	MANGANBERZELIITE $Ca_3Mn_2(AsO_4)_3$	CUB	Subconch to uneven	Yellow, orange	H 5 G 4.45 F 3	Diss by acids. Data for synth end-member. Garnet-type structure.
	1.78	HAWLEYITE CdS	CUB	---	Bright yellow	G 4.87 infus	Dec by acids.
1.70 ◊ 1.81	1.78	GADOLINITE $Y_2FeBe_2Si_2O_{10}$	MCL metamict	Conch	Black to greenish-black	H 6.5-7 G 3.9-4.3 infus	Gel with acids. Heated material is biref with <u>n</u> = 1.82.
1.766 ◊ 1.797	1.782	ALMANDINE-PYROPE (Garnet grp) $(Fe,Mg,Ca)_3Al_2(SiO_4)_3$	CUB 110, 211	Uneven	Red to brown	H 7 G 4.02 F 4	Insol in acids. Al 55, Py 27, Gr 14, Sp 3.
1.776 ◊ 1.805	1.782	GAHNITE (Spinel grp) $(Zn,Fe,Mg)Al_2O_4$	CUB oct	111 imperf	Gray, green, black	H 8 G 4.38 infus	Insol in acids. ZnO 31.4, FeO 8.5, MgO 2.4%.
1.71 ◊ 1.82	1.79	ZIRCON $ZrSiO_4$ (+x H_2O (?))	TET metamict	---	Yellow, brown	H 6 G 3.9-4.0 infus	Insol in acids.
1.72 ◊ 1.84	1.79	BINDHEIMITE (Stibiconite grp) $Pb_2Sb_2O_6(O,OH)$	CUB u mass	Conch	Yellow, brown, gray	H 4-4.5 G 4.6-5.6 F 3-4	Dec by HCl.
	1.790	PHILIPSBORNITE (Crandallite grp) $PbAl_3(AsO_4)_2(OH)_3\cdot H_2O$	TRIG	Conch	Grayish-green	H ~ 4.5 G (4.33)	---

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.773 ◊ 1.800	1.796	GROSSULAR-UVAROVITE (Garnet grp) $Ca_3(Al,Cr,Fe)_2(SiO_4)_3$	CUB dod	Uneven	Green	H 7 G 3.68 F 4	Insol in acids. Gr 52, Uv 40, An 8.
1.782 ◊ 1.805	1.797	ALMANDINE (Garnet grp) $(Fe,Mg,Mn,Ca)_3Al_2(SiO_4)_3$	CUB 110, 211	Uneven	Reddish-brown	H 7 G 4.10 F 4	Insol in acids. Al 60, Py 18, Sp 15, Gr 7.
1.776 ◊ 1.833	1.798	SPINEL, chromian (Spinel grp) $(Mg,Fe)(Al,Cr,Fe)_2O_4$	CUB oct	Uneven	Black	H 8 G 3.94 infus	Insol in acids. MgO 19.5, FeO 9.8, Al_2O_3 48.3, Cr_2O_3 19.6%.
1.74 ◊ 1.90	1.80	STIBICONITE (Stibiconite grp) $Sb^{+3}Sb^{+5}{}_2O_6(O,OH)$	CUB u mass	Conch	Gray, brown, yellow	H 4-5.5 G 5.2-5.6 infus	Insol in acids.
	>1.80	MANGANOSTEENSTRUPINE $(Ce,La,Th,Ca)MnSiO_3(OH)_2 \cdot 2H_2O$	Amor	Conch	Black	H 5.5-6 G 3.29	Brownish-red in section.
1.796 ◊ 1.801	1.800	SPESSARTINE (Garnet grp) $Mn_3Al_2(SiO_4)_3$	CUB 110, 211	Uneven	Red to brown	H 7 G 4.18 F 3	Insol in acids. Synth end-member.
	1.800	YAFSOANITE $(Zn,Ca,Pb)_3TeO_6$	CUB	---	Light to dark brown	---	Diss by acids.
1.800 ◊ 1.805	1.801	GROSSULAR-ANDRADITE (Garnet grp) $(Ca,Fe,Mn)_3(Al,Fe)_2(SiO_4)_3$	CUB 110, 211	Uneven	Green, red, brown	H 7 G 3.71 F 4.5	Insol in acids. Opt anom. Gr 52, An 42, Al 4, Sp 2.
1.766 ◊ 1.855	1.803	KNORRINGITE (Garnet grp) $(Mg,Ca,Fe)_3(Cr,Al)_2(SiO_4)_3$	CUB u mass	Uneven	Blue-green	H 7 G 3.76	Insol in acids. Kn 53, G 19, Al 14, Py 10, An 3.
1.715 △	1.804	THORITE $(Th,U)SiO_4$ $(+ xH_2O)$	TET metamict	---	Brown, green, yellow	H 4 G 4.8-6.4	Gel with acids.
1.782 ◊ 1.818	1.805	GAHNITE (Spinel grp) $ZnAl_2O_4$	CUB oct	---	Black	H 8 G 4.61 infus	Insol in acids. Synth end-member.
1.800 ◊ 1.814	1.805	SPESSARTINE (Garnet grp) $(Mn,Fe)_3Al_2(SiO_4)_3$	CUB 110, 211	Uneven	Red, brown	H 7 G 4.20 F 3.5	Insol in acids. Sp 80, Al 17, Py 2.
1.797 ◊ 1.814	1.805	ALMANDINE (Garnet grp) $(Fe,Mg,Ca)_3Al_2(SiO_4)_3$	CUB 110, 211	Uneven	Red, brown	H 7 G 4.15 F 4	Insol in acids. Al 74, Py 11, Gr 11, Sp 4.

1.78 ^	1.81	GADOLINITE $Y_2FeBe_2Si_2O_{10}$	MCL metamict	Conch	Black to greenish-black	H 6.5-7 G 3.9-4.3 infus	Gel with acids.
1.75 ^	1.81	BRITHOLITE $(Ce,La,Ca)_5(SiO_4,PO_4)_3(OH,F)$	HEX metamict	---	Yellow, brown	H 5 G 4.1 infus	Gel with HCl. Apatite-like structure.
1.82	1.81	ANTHOINITE $Al_2W_2O_9 \cdot 3H_2O$	MCL (?) mass	---	White, chalky	H 1 G 4.6	Slowly diss by acids, diss by strong KOH soln.
1.805 ◊ 1.818	1.814	SPESSARTINE-ALMANDINE (Garnet grp) $(Mn,Fe)_3Al_2(SiO_4)_3$	CUB 110, 211	Uneven	Red, brown	H 7 G 4.23 F 3.5	Insol in acids. Sp 53, Al 45, Py 1, Gr 1.
v 1.87	1.817	ROMEITE (Stibiconite grp) $(Ca,Na)_2Sb_2O_6(O,OH)$	CUB oct	Conch	Yellow	H 5.5-6.5 G 4.7-5.4 F diff	Insol in acids. Opt anom with low biref.
1.805 ^	1.818	GAHNITE (Spinel grp) $(Zn,Fe)(Al,Fe)_2O_4$	CUB oct	---	Black	H 8 G 4.60 infus	Insol in acids. FeO 1.7, Fe_2O_3 2.55%.
1.805 ◊ 1.830	1.818	ALMANDINE (Garnet grp) $(Fe,Mn)_3Al_2(SiO_4)_3$	CUB 110, 211	Uneven	Red, brown	H 7 G 4.25 F 4	Insol in acids. Al 74, Sp 20, Py 5, Gr 11.
1.79 ^	1.82	ZIRCON, var Malacon (Naegite) $(Zr,Th,U)SiO_4$ $(+ xH_2O)$	TET metamict	Conch	Brown, green	H 3-7 G 4.0-4.3 infus	Partly diss by acids.
1.801 ◊ 1.834	1.821	GOLDMANITE (Garnet grp) $Ca_3(V,Al,Fe)_2(SiO_4)_3$	CUB dod mass	---	Deep green to dull green	G 3.74	Weakly biref. V_2O_3 18.3, Fe_2O_3 5.4, Al_2O_3 4.9%.
1.801 ◊ 1.855	1.825	UVAROVITE-GROSSULAR (Garnet grp) $Ca_3(Cr,Al)_2(SiO_4)_3$	CUB dod	---	Green	H 7.5 G 3.81 infus	Insol in acids. n is for green light. Uv 72, Gr 26, An 1, Py 1.
1.801 ◊ 1.863	1.827	ANDRADITE-GROSSULAR (Garnet grp) $Ca_3(Fe,Al)_2(SiO_4)_3$	CUB 110, 211	Uneven	Red, brown, green	H 7 G 3.77 F 4	Insol in acids. An 57, Gr 32, Al 5, Py 3, Sp 3.
	1.83	LIANDRATITE $U^{+6}(Nb,Ta)_2O_8$	HEX u metamict	Conch	Yellow to yellow-brown	H 3.5 G 6.8	---
1.818 ^	1.830	ALMANDINE (Garnet grp) $Fe_3Al_2(SiO_4)_3$	CUB	Uneven	Red	H 7 G 4.32 F 3	Insol in acids. Synth end-member.
[ ]	1.83	YTTROPYROCHLORE ("Obruchevite") (Pyrochlore grp) $(Y,Ca,Na,U)_{1-2}(Nb,Ta,Ti)_2(O,OH)_7$	CUB	Conch	Dark brown	H 4.5-5 G ~ 3.7	Insol in acids.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.798 ◊ 1.835	1.833	SPINEL, chromian (Spinel grp) $(Mg,Fe)(Al,Cr,Fe)_2O_4$	CUB oct	Uneven	Black	H 7 G 3.93 infus	Insol in acids. MgO 19.3, FeO 11.7, Al_2O_3 45.4, Cr_2O_3 16.85, Fe_2O_3 5.8%.
1.821 ◊ 1.855	1.834	GOLDMANITE (Garnet grp) $Ca_3V_2(SiO_4)_3$	CUB	---	Green	G 3.765	Data for synth compd.
1.833 ◊ 1.90	1.835	HERCYNITE (Spinel grp) $FeAl_2O_4$	CUB oct	Uneven	Greenish-black	H 8 G 4.40 infus	Insol in acids. Data calc for end-member.
	1.838	LIME CaO	CUB	100 perf	Cols	H 3-4 G 3.32 infus	Diss by acids, slightly sol in H_2O. Rapidly alters on exposure to moist air.
1.79 ◊ 1.94	1.84	BINDHEIMITE (Stibconite grp) $Pb_2Sb_2O_6(O,OH)$	CUB u mass	Conch	Yellow, gray, green	H 4-4.5 G 4.6-5.6 F 3-4	Dec by HCl.
1.825 ^	1.855	UVAROVITE (Garnet grp) $Ca_3(Cr,Al)_2(SiO_4)_3$	CUB 110, 211	Uneven	Deep green	H 7.5 G 3.77 infus	Insol in acids. Opt anom. Uv 91, Gr 6, Py 2, An 1.
1.834 ^	1.855	GOLDMANITE (Garnet grp) $(Ca,Mn)_3V_2(SiO_4)_3$	CUB	---	Dark green	G 3.91	V_2O_3 24.9, Al_2O_3 2.0, Fe_2O_3 1.1, MnO 15.9%.
v 1.923	1.856	GALAXITE (Spinel grp) $(Mn,Fe)(Al,Fe)_2O_4$	CUB oct	Conch	Black	H 7.5 infus	Insol in acids. MnO 33.1, FeO 2.3, Fe_2O_3 6.4%.
⎵	>1.86	ARSENOBISMITE $Bi_2(AsO_4)(OH)_3$	CUB (?) ocherous masses	---	Yellow-brown to green	G ~ 5.7	---
1.827 ◊ 1.887	1.863	ANDRADITE (Garnet grp) $(Ca,Fe,Mn)_3(Fe,Al)_2(SiO_4)_3$	CUB 110, 211	Uneven	Red, brown, green	H 7 G 3.72 F 3.5	Gel imperfectly with HCl. Opt anom. An 78.5, Gr 12, Al 5.5, Sp 4.
1.817 ◊ 2.09	1.87	ROMEITE (Stibiconite grp) $(Ca,Mn)_2Sb_2O_6(O,OH)$	CUB oct	Conch	Yellow	H 5.5-6.5 G 4.7-5.4 F 4.5	Insol in acids. Opt anom. MnO 6.3%.
v 1.915	1.87	PYROCHLORE (Pyrochlore grp) $(Na,Ca)_2(Nb,Ta)_2O_6(OH,F)$	CUB oct	Conch	Brown, yellow	H 5-6 G 3.77 infus	Dec by H_2SO_4.

v 2.00	1.88	CHEVKINITE $(Ca,Ce,Th)_4(Fe,Mg)_2(Ti,Fe)_3Si_4O_{22}$	MCL metamict	Conch	Black to reddish-brown	H 5 G 4.3-4.6 F 4	Gel with acids. Red-brown in section. In part biref.
1.863 ^v 1.890	1.887	ANDRADITE (Garnet grp) $Ca_3Fe_2(SiO_4)_3$	CUB dod	---	Red	H 7 G 3.86 F 3.5	Gel imperfectly with acids. Data for synth end-member.
1.887 ^v 1.893	1.890	CALDERITE-ANDRADITE (Garnet grp) $(Mn^{+2},Ca)_3Fe^{+3}{}_2(SiO_4)_3$	CUB	Conch	Red-brown	H 7 G 4.07	Fe_2O_3 29.0, MnO 19.3%. (Ca 47, An 45, Gr 8%.) (Min. Abs. 32, 310.)
1.890 ^v 1.94	1.893	ANDRADITE-SPESSARTINE (Garnet grp) $(Ca,Mn)_3(Fe,Al)_2(SiO_4)_3$	CUB 110, 211	---	Dark green	H 7 G 3.98 F 3.5	Nearly insol in acids. An 71, Sp 28, Al 1.
1.80 ^v 2.05	1.90	STIBICONITE (Stibiconite grp) $Sb^{+3}Sb^{+5}{}_2O_6(O,OH)$	CUB u mass	Conch	Yellow, gray, brown	H 4.5-5.5 G 5.2-5.6 infus	Insol in acids.
1.835 ^v 1.97	1.90	MAGNESIOCHROMITE (Spinel grp) $MgCrO_4$	CUB oct	Uneven	Gray-green	H 7 G 4.39 infus	Insol in acids. Data for synth end-member.
1.87 ^v 1.925	1.915	BETAFITE (Pyrochlore grp) $(Ca,Na,U)_2(Ti,Nb,Ta)_2O_6(OH)$	CUB oct	Conch	Greenish-black	H 5 G 4.0 infus	Dec by H_2SO_4.
1.74 ^	1.92	COFFINITE $U(SiO_4)_{1-x}(OH)_{4x}$	TET metamict	---	Yellow, brown	G 4.2-4.8	---
1.856 ^	1.923	GALAXITE (Spinel grp) $(Mn,Fe)Al_2O_4$	CUB oct	Conch	Black	H 7.5 G 4.23 infus	Insol in acids. Mahogany-red in section. MnO 34.0, FeO 16.4, MgO 1.5%.
1.915 ^v 1.94	1.925	MICROLITE (Pyrochlore grp) $(Ca,Na)_2(Ta,Nb)_2O_6(OH,F)$	CUB oct	Conch	Yellow, brown	H 5.5 G ~ 5.5 infus	Dec by H_2SO_4.
	1.93	NANTOKITE CuCl	CUB	011	Cols	H 2.5 G 4.1 fus	Sol in H_2O. Oxidizes rapidly. Data on synth compound.
v 1.985	1.93	KALIPYROCHLORE (Pyrochlore grp) $(K,Sr)_{2-4}Nb_2O_6(O,OH)\cdot xH_2O$	CUB	---	Yellow, greenish	H 4-4.5 G 3.42	---
1.84 ^	1.94	BINDHEIMITE (Stibiconite grp) $Pb_2Sb_2O_6(O,OH)$	CUB u mass	Conch	Gray, brown, green	H 4-4.5 G 5.0-5.6 F 3-4	Dec by HCl.
1.893 ^v 1.98	1.94	ANDRADITE (Garnet grp) $Ca_3(Fe,Ti)_2(SiO_4)_3$	CUB 110, 211	Conch	Black	H 7 G 3.79 F 4	Gel with acids. TiO_2 9.4%.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.94	MELANITE $Ca_3(Fe^{+3},Ti)_2(SiO_4)_3$	---	---	---	G 3.79	TiO_2 9.4%.
[ ]	1.94	KIMZEYITE (Garnet grp) $Ca_3(Zr,Ti)_2(Al_2Si)O_{12}$	CUB	---	Brown	H 7 G 3.94	ZrO_2 29.9, TiO_2 5.6%.
1.925 ◊ 1.97	1.94	BETAFITE (Pyrochlore grp) $(Ca,Na,U)_2(Ti,Nb,Ta)_2O_6(OH,F)$	CUB oct	Conch	Black, brown, yellow	H 5 G 5.2 infus	Dec by H_2SO_4.
v 2.11	1.95	BRANNERITE $(U,Th,Ce)Ti_2O_6$	MCL metamict	Conch	Black, brown, yellow	H 5-6 G 4.0-4.3 infus	Diss by acids.
	1.95	STETEFELDTITE (Stibiconite grp) $Ag_2Sb_2(O,OH)_7$ (?)	CUB mass	---	Black, brown	H 3.5-4.5 G 4.1-4.6	---
1.90 ◊ 2.10	1.97	MAGNESIOCHROMITE (Spinel grp) $(Mg,Fe)(Cr,Al,Fe)_2O_4$	CUB oct	Uneven	Black	H 6 G 4.67 infus	Insol in acids. MgO 16.0, FeO 11.1, Cr_2O_3 43.6, Al_2O_3 24.4, Fe_2O_3 4%.
1.94 ◊ 2.00	1.97	URANMICROLITE ("Djalmaite") (Pyrochlore grp) $(Ca,Na,U)_2(Ta,Nb,Ti)_2O_6(OH)$	CUB oct	Uneven	Brown, black	H 5.5 G 5.8	Dec by H_2SO_4.
⊔ 1.98	1.97	MOLURANITE $H_4U^{+4}(UO_2)_3(MoO_4)_7 \cdot 18H_2O$	Amor	Conch	Black	H 3-4 G ~ 4	Diss by acids.
[ ]	1.98	URANPYROCHLORE ("Hatchettolite") (Pyrochlore grp) $(U,Ca,Ce)_2(Nb,Ta)_2O_6(OH,F)$	CUB oct	Conch	Brown	H 5 G ~ 4.8 infus	Insol in acids.
1.94 ^	1.98	SCHORLOMITE (Garnet grp) $Ca_3(Fe,Ti)_2(Si,Ti)_3O_{12}$	CUB 110, 211	Conch	Black	H 7 G 3.85 F 4	Gel with acids. Opt anom. TiO_2 16.9%.
	1.983	MAGNUSSONITE $Mn_5(AsO_3)_3(OH,Cl)$	CUB and TET	---	Grass- to emerald-green	H 3.5-4.0 G 4.30	---
1.93 ^	1.985	KALIPYROCHLORE (Pyrochlore grp) $(K,Sr)Nb_2O_6(O,OH) \cdot xH_2O$	CUB	---	Greenish	H 4-4.5 G 3.48	---
1.88 ^	2.00	CHEVKINITE $(Ca,Ce,Th)_4(Fe,Mg)_2(Ti,Fe)_3Si_4O_{22}$	MCL metamict	Conch	Black	H 5 G 4.3-4.7 F 4	Gel with acids. Red-brown in section. In part biref.

1.97 ^v 2.02	2.00	PYROCHLORE (Pyrochlore grp) $(Ca,Na)_2(Nb,Ta)_2$	CUB oct	111 fr conch	Brown, red	H 5 G 4.1-4.3 infus	Dec by H_2SO_4. Heated material had *n* 2.23.
[ ]	>2.00	BISMUTOMICROLITE ("Westgrenite") (Pyrochlore grp) $(Bi,Ca)(Ta,Nb)_2O_6(OH)$	CUB	Uneven	Yellow, pink, brown	H 5 G 6.5-7.2 infus	Insol in acids.
	>2.0	CAFARSITE $Ca_8(Ti,Fe^{+2},Fe^{+3},Mn)_{6-7}(As^{+3}O_3)_{12}\cdot 4H_2O$	CUB	Conch	Dark brown	H 5.5-6 G 3.90	---
2.00 ^v 2.023	2.02	BETAFITE (Pyrochlore grp) $(Ca,Na,U)_2(Ti,Nb,Ta)_2O_6(OH,F)$	CUB oct	Conch	Black	H 4.5 G 4.76 infus	Dec by H_2SO_4.
2.02 ^v 2.07	2.023	MICROLITE (Pyrochlore grp) $(Ca,Na)_2Ta_2O_6(O,OH,F)$	CUB oct	Conch	Brown, yellow	H 6 G 6.42 infus	---
	2.04	CHOLOALITE $PbCu(TeO_3)_2\cdot H_2O$	CUB	Uneven	Deep green	H 3 G 6.4	---
1.90 ^	2.05	STIBICONITE (Stibiconite grp) $Sb^{+3}Sb^{+5}{}_2O_6(O,OH)$	CUB u mass	Conch	Yellow, brown	H 4-4.5 G 5.2-5.6 infus	Insol in acids.
[ ]	2.05	GOETHITE ("Limonite") $FeO(OH)$	ORTH cryptocryst	---	Ocher-yellow	H 4 G ~ 3.8 infus	Diss by HCl.
	2.05	PERCYLITE $PbCuCl_2(OH)_2$	CUB	100	Sky-blue	H 2.5 G 5.25 F 1	Diss by HNO_3. Sky-blue in section. A doubtful mineral.
	2.05	EULYTITE $Bi_4Si_3O_{12}$	CUB tetrah	110 imperf	Brown, yellow, gray	H 4.5 G 6.11 F 2	Gel with acids. Opt anom.
v 2.19	2.05	FERGUSONITE $(Y,U)(Nb,Ta)O_4$	TET metamict	Conch	Dark brown	H 5 G 4.2-5.8 infus	Diss by hot concd H_2SO_4. Reddish-brown in section.
v 2.18	2.06	ZIRKELITE $(Ca,Th,Ce)Zr(Ti,Nb)_2O_7$	MCL ps cub	Uneven to conch	Brown to black	H 6 G 4.02 infus	Dec by hot HCl.
	2.06	LORANSKITE $(Y,Ce,Ca)ZrTaO_6$ (?)	ORTH (?) metamict	Conch	Black, brown yellow	H 5 G 4.2-4.6	Status doubtful, perhaps = Euxenite.
[v 2.24	2.06	EUXENITE $(Y,Ca,Ce,U,Th)(Nb,Ta,Ti)_2O_6$	ORTH metamict	Conch	Brownish-black	H 6.5 G 4.6-5.5 infus	Insol in acids. Reddish-brown in section. After ignition, *n* = 2.22.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
□	2.065	MOSESITE $Hg_2N(Cl,SO_4,MoO_4)\cdot H_2O$	CUB oct	Uneven	Lemon- to canary-yellow	H 3 G 7.72 volat	In part anom biref.
2.023 ◊ 2.18	2.07	MICROLITE (Pyrochlore grp) $(Ca,Na)_2Ta_2O_6(O,OH,F)$	CUB oct	Conch	Brown, yellow	H 6 G 5.95 infus	Insol in acids.
v 2.15	2.071	CHLORARGYRITE $Ag(Cl,Br)$	CUB u mass	Sectile	Gray, yellowish	H 2.5 G 5.56 F 1	Diss by NH_4OH.
2.07 □ 2.11	2.08	BARIOPYROCHLORE ("Pandaite") (Pyrochlore grp) $(Ba,Sr)_2(Nb,Ti)_2(O,OH)_7$	CUB	111 poor fr conch	Yellow, gray	H 4-4.5 G 3.7-4.0 infus	Insol in HCl.
□	2.08	PLUMBOPYROCHLORE (Pyrochlore grp) $(Pb,Y,U,Ca)_2Nb_2O_6(OH)$	CUB	---	Greenish-yellow to brown	G 6.34	---
	2.085	GIANELLAITE $Hg_4N_2(SO_4)$	CUB	---	Straw-yellow	H ~ 3 G 7.19 volat	Dec by concd HCl.
□	2.087	SENARMONTITE Sb_2O_3	CUB oct	111 poor	Cols	H 2 G 5.50 F 1.5 volat	Diss by HCl. Anom biref.
	2.09	BISMUTOSTIBICONITE (Stibiconite grp) $(Bi,Fe)Sb_2O_7$	CUB	---	Yellow to yellow-brown	G 7.38	---
1.87 ◊ 2.20	2.09	ROMEITE, var Schneebergite (Stibiconite grp) $(Ca,Fe,Mn,Na)_2(Sb,Ti)_2O_6(O,OH,F)$	CUB oct	111 dist	Honey-yellow	H 6.5 G 5.41 F diff	Insol in acids. Opt anom, low biref.
2.05 □ 2.20	~2.1	FERRITUNGSTITE $(W,Fe^{+3})(O,OH)_3$ (?)	CUB	---	Yellow	G 4.4-5.2	Dec by HCl.
1.97 ◊ 2.12	2.10	CHROMITE (Spinel grp) $(Mn,Fe,Mg)(Cr,Al)_2O_4$	CUB oct	Uneven	Brownish-black	H 6 G 4.65 infus	Insol in acids. Cr_2O_3 49.7, Al_2O_3 17.6, Fe_2O_3 8.1, MnO 9.3, FeO 8.7, MgO 2.4, ZnO 4.1%.
v 2.20	2.10	THORIANITE $(Th,U)O_2$	CUB	001 poor fr uneven	Black to brown	H 6 G 9.2 infus	Slowly diss by HNO_3 or H_2SO_4.

[ ]	2.10	THORUTITE $(Th,U)Ti_2O_6$	MCL metamict	Conch	Brownish-black	H 5-6 G 5.82 infus	Compare Brannerite.
v 2.38	2.105	LOPARITE (Perovskite grp) $(Ce,Na,Ca)_2(Ti,Nb)_2O_6$	ORTH metamict	---	Reddish-brown	H 5-5.5 G 4.48 infus	Insol in acids.
1.95 ^v 2.49	2.11	BRANNERITE $(U,Th,Ce)Ti_2O_6$	MCL metamict	Conch	Black	H 4.5 G 4.2-4.6 infus	Diss with diff by hot HNO_3.
v 2.3	2.11	DAVIDITE $(La,Ce)(Y,U,Fe^{+2})(Ti,Fe^{+3})_{20}$ $(O,OH)_{38}$	TRIG metamict	---	Brownish-black	H 6-7 G 4.4-4.6 infus	Dec by hot H_2SO_4.
	>2.11	CLIFFORDITE UTe_3O_9	CUB oct	---	Bright yellow	H 4 G 6.6 (synth)	Diss by concd HCl.
2.10 ^	2.12	CHROMITE (Spinel grp) $FeCr_2O_4$	CUB oct	Uneven	Black	H 6 G 5.22 infus	Insol in acids. Data for synth compd.
v 2.26	2.12	BISMUTITE $Bi_2(CO_3)O_2$	TET u earthy mass	001 dist	Yellow, brown	H 2.5-4 G 6.7-7.4 F 1.5	Diss by acids with eff.
	2.13 Na	BORNITE Cu_5FeS_4	CUB u mass	Uneven	Red-brown, tarnishes purple	H 3 G 5.07 F 2	Dec by HNO_3.
2.11 [	2.13	MURATAITE $(Na,Y)_4(Zn,Fe)_3(Ti,Nb)_6O_{18}$ $(F,OH)_4$	CUB	Conch	Black	G 4.50-4.69	Insol in acids except HF.
v 2.25	2.13	SAMARSKITE $(Y,U,Ca,Fe)(Nb,Ta,Ti)_2O_6$	MCL metamict	Conch	Black	H 4 G 4.0-4.3 F 4.5	Diss by hot concd acids. Reddish-brown in section.
2.12 [ ] 2.15	2.13	YTTROCRASITE $(Y,Th,U,Ca)Ti_2(O,OH)_6$	ORTH metamict	Conch	Black	H 4-6 G 4.80 infus	Diss by hot H_2SO_4. Amber in section. In part birefringent.
	2.14	OLDHAMITE (Ca,Mn)S	CUB	100	Pale brown	H 4 G 2.61 infus	Diss by acids. Rapidly dec in air. Meteorite mineral.
	2.14	FORMANITE $(Y,U)(Ta,Nb)O_4$	TET metamict	Conch	Black	H 5.5-6.5 G 6.17 infus	Diss by hot concd H_2SO_4.
2.12 [ ] 2.18	2.14	AESCHYNITE-(Y), var Priorite $(Y,Ce,Ca,Th)(Ti,Nb)_2O_6$	ORTH metamict	Conch	Brown to black	H 5-6 G 4.7-5.0 infus	Diss by hot concd acids.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
[ ]	2.15	YTTROTANTALITE $(Y,U,Fe)(Ta,Nb)O_4$	ORTH metamict	010 indist fr conch	Black, brown, yellow	H 5 G 5.7-6.1 infus	Insol in acids. Reddish-brown in section.
2.071 ↕ 2.20	2.15	BROMARGYRITE, var Embolite Ag(Br,Cl)	CUB u mass	Sectile	Cols, yellow	H 1-1.5 G 5.6-6.0 F 1	Diss by NH_4OH.
[ ]	2.155	FERGUSONITE-BETA-(Ce) $(Ce,La,Nd)NbO_4$	MCL metamict	---	Reddish-brown	H 6 G 5.34-5.44 infus	Dec by H_2SO_4.
	2.16 Li	BLAKEITE Ferric tellurite	Mass	---	Reddish-brown	H > 2 G > 3.1	Diss by acids.
	2.17	MANGANOSITE MnO	CUB oct, u mass	001 fair	Emerald-green, turns black	H 5-6 G 5.36 infus	Diss by acids. Emerald-green in powder and section.
2.07 ↕ 2.2	2.18	PYROCHLORE (Pyrochlore grp) $(Ca,Na,Ce)_2Nb_2O_6(OH,F)$	CUB oct	111 poor fr conch	Brownish-red	H 5 G 4.1-4.3 infus	Dec by H_2SO_4.
2.06 ↕ 2.28	2.18	ZIRKELITE $(Ca,Th,Ce)Zr(Ti,Nb)_2O_7$	MCL ps cub	Conch	Black to dark brown	H 5-6 G 4.3-4.7 infus	Insol in acids. Reddish-brown in section.
2.05 ^	2.19	FERGUSONITE $(Y,U,Ce)(Nb,Ta)O_4$	TET metamict	Conch	Black	H 6 G ~ 5.8 infus	Dec by H_2SO_4. After ignition, $\underline{n}$ = 2.14, biref.
	2.192	BIDEAUXITE $Pb_2AgCl_3(F,OH)_2$	CUB	Conch	Cols to pale lavender	H 3 G 6.26 F 1	Diss by HNO_3, dec by HCl or by warm NH_4OH.
2.10 ^	2.20	THORIANITE $(Th,U)O_2$	CUB	001 poor fr uneven	Black	H 6 G 9.32 infus	Slowly diss by HNO_3 or H_2SO_4. Nearly opaque.
2.15 ↕ 2.253	2.20	BROMARGYRITE, var Iodobromite Ag(Br,Cl,I)	CUB	Sectile	Cols to yellow	H 2 G 6.0-6.2 F 1	Diss by NH_4OH.
	2.20	MIERSITE (Ag,Cu)I	CUB	011 perf sectile	Yellow	H 2.5 G 5-6.4 F 1	Diss by NH_4OH. Tw pl 111.

2.09 ^	2.20	ROMEITE, var Lewisite (Stibiconite grp) $(Ca,Fe)_2(Sb,Ti)_2O_6(O,OH)$	CUB oct	111 good	Honey-yellow to brown	H 5.5 G 4.95 fus	Insol in acids. Opt anom.
	2.205	KOBEITE $(Y,U)(Ti,Nb)_2(O,OH)_6$ (?)	Amor	---	Dark brown	---	---
2.18 ^	2.2 calc	STIBIOBETAFITE (Pyrochlore grp) $(Ca,Sb^{+3})_2(Ti,Nb,Ta)_2(O,OH)_7$	CUB	---	Brownish-black	H ~ 5 G 5.30	Nb_2O_5 21.6, Ta_2O_5 19.3, TiO_2 16.5, Sb_2O_3 23.2, CaO 14.5%.
[]	2.22	POLYMIGNITE $(Ca,Ce,Th,Fe)(Nb,Ti,Ta,Zr)O_4$	ORTH metamict	Conch	Black	H 6.5 G 4.8 infus	Reddish-brown in section.
2.19 [] 2.26	2.23	AESCHYNITE $(Ce,Ca,Fe,Th)(Ti,Nb)_2(O,OH)_6$	ORTH metamict	Conch	Brownish-black	H 5.5 G 4.9-5.2 infus	Insol acids. Reddish-brown in section. Biref after ignition.
2.06 ^ 2.28	2.24	EUXENITE $(Y,Ca,Ce,U,Th)(Nb,Ta,Ti)_2O_6$	ORTH metamict	Conch	Brownish-black	H 6.5 G 4.6-5.5 infus	Insol in acids. Reddish-brown in section.
2.13 ^	2.25	SAMARSKITE $(Y,U,Ca,Fe)(Nb,Ta,Ti)_2O_6$	MCL metamict	Conch	Black	H 4-6 G 5.6-5.7 F 5	Diff sol hot acids. In section deep brown to opaque.
[]	2.25	POLYCRASE $(Y,Ca,U,Th)(Ti,Nb)_2O_6$	ORTH metamict	Conch	Black	H 5-6 G 4.7-4.9 infus	Insol in acids. Reddish-brown in section. Ti analogue of Euxenite.
[]	2.25	TAZHERANITE $(Zr,Ca,Ti)O_2$	CUB	Uneven	Orange to red	H 7.5 G 5.01 infus	---
2.20 ^	2.253	BROMARGYRITE Ag(Br,Cl,I)	CUB	Sectile	Yellow, green	H 2.5 G 6.3 F 1	Diss by NH_4OH.
2.12 ^	2.26	BISMUTITE $Bi_2(CO_3)O_2$	TET u mass earthy	001 dist	Yellow, brown	H 2.5-4 G 6.7-7.4 F 1.5	Diss by acids with eff.
⊔ 2.315	2.262	JIXIANITE $Pb(W,Fe^{+3})_2(O,OH)_7$	CUB	---	Brownish-black	H ~ 5 G 5.30	---
v 2.40	2.265	PEROVSKITE, var Knopite and Dysanalyte (Perovskite grp) $(Ca,Ce)_2(Ti,Nb)_2O_6$	ORTH ps cub	100	Black	H 5 G 4.1-4.2 infus	Dec by hot H_2SO_4. In part biref.
2.18 ^	2.28	ZIRKELITE $(Ca,Th,Ce)Zr(Ti,Nb)_2O_7$	MCL ps cub	Conch	Black to dark brown	H 5-6 G 4.3-4.7 infus	Insol in acids. Reddish-brown in section.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
2.11 ^	2.3	DAVIDITE $(La,Ce)(Y,U,Fe^{+2})(Ti,Fe^{+3})_{20}$ $(O,OH)_{38}$	TRIG metamict	---	Brownish-black	H 6-7 G 4.4-4.6 infus	Dec by hot H_2SO_4.
	2.3 (?)	TREVORITE (Spinel grp) $NiFe_2O_4$	CUB oct	Uneven	Black	H 5 G 5.2 infus	Nearly opaque. Strongly magnetic. _n_ = 2.39 calc.
v 2.585	2.30	JACOBSITE (Spinel grp) $(Mn,Fe^{+2},Mg)Fe^{+3}{}_2O_4$	CUB oct	Uneven	Brownish-black	H 5.5-6.5 G 4.75-4.93 infus	Diss by HCl. Nearly opaque. Weakly magnetic.
	2.34	WINSTANLEYITE $TiTe_3O_8$	CUB	---	Yellow, tan	H 4 G 5.57	Diss slowly in warm HNO_3.
	2.346 Na 2.313 Li	MARSHITE CuI	CUB tetrah	011 perf	Yellow, brown, red	H 2.5 G 5.68 F 1.5	Diss by acids. Disp exceeds that of diamond.
v 2.45	2.36 Li	FRANKLINITE (Spinel grp) $(Zn,Mn,Fe^{+2})(Mn,Fe^{+3})_2O_4$	CUB oct	Uneven	Iron-black	H 6 G 5.2 infus	Diss by HCl. Reddish-brown in section. Weakly magnetic.
	2.37 Li	BUNSENITE NiO	CUB oct	---	Dark green	H 5.5 G 6.90 infus	Diff sol in acids.
v 2.40	2.37 Na 2.34 Li	SPHALERITE ZnS	CUB tetrah	110 perf	Cols to pale yellow	H 3.5 G 4.1 F 5	Diss by HCl. Luster resinous. Data for pure ZnS.
v 2.42	2.38 Na 2.34 Li	MAGNESIOFERRITE (Spinel grp) $(Mg,Fe)Fe_2O_4$	CUB oct	Uneven	Black	H 6-6.5 G 4.5-4.7 infus	Diss by HCl. Nearly opaque to dark red in section. Strongly magnetic.
2.105 ^	2.38	LOPARITE (Perovskite grp) $(Ce,Na,Ca)_2(Ti,Nb)_2O_6$	ORTH metamict	---	Black to brown	H 5-5.5 G 4.7-4.8 infus	Insol in acids.
2.265 ^	2.40	PEROVSKITE (Perovskite grp) $Ca_2Ti_2O_6$	ORTH ps cub	100	Brown to black	H 5-5.5 G 4.1-4.48 infus	Dec by hot H_2SO_4. In part biref.
	2.40	ROMANECHITE $BaMn^{+2}Mn^{+4}{}_8O_{16}(OH)_4$	MCL ps orth	---	Black	H 5-6 G 4.4-4.7 infus	Diss by HCl with evolution of Cl.

2.37 ^ v 2.43	2.40	SPHALERITE (Zn,Fe)S	CUB tetrah	110 perf	Brown	H 3.5-4 G 4.0-4.1 F 5	Diss by HCl. Luster resinous. Fe 5.5%.
	2.418	DIAMOND C	CUB tetrah	111 highly perf	Cols, yellow, blue	H 10 G 3.51 infus	Insol in acids. Tw pl 111. Disp extr.
2.38 ^	2.42	MAGNETITE (Spinel grp) $FeFe_2O_4$	CUB oct	Parting 111 fr uneven	Black	H 6 G 5.17 infus	Diss by HCl. Nearly opaque. Strongly magnetic.
	>2.42	SILLENITE $Bi_{12}SiO_{20}$	CUB	---	Green	H soft G 8.8 calc	---
2.40 ^ v 2.47	2.43	SPHALERITE (Zn,Fe)S	CUB tetrah	110 perf	Brown to black	H 3.5-4 G 4.0 F 5	Diss by acids. Luster resinous. Fe 10.4%.
[ ]	2.45	BIXBYITE $(Mn,Fe)_2O_3$	CUB	111 in traces	Black	H 6-6.5 G 4.95-5.05 F 4 to infus	Slowly diss by HCl.
2.36 ^	2.45 Na 2.41 Li	FRANKLINITE (Spinel grp) $(Zn,Mn,Fe^{+2})(Mn,Fe^{+3})_2O_4$	CUB oct	Uneven	Iron-black	H 6 G 5.2 infus	Diss by HCl. Reddish-brown in section. Weakly magnetic.
2.43 ^	2.47	SPHALERITE (Zn,Fe)S	CUB tetrah	110 perf	Brown to black	H 3.5-4 G 3.9 F 4.5-5	Diss by acids. Luster resinous. Fe 17.1%.
2.11 ^	2.49	BRANNERITE $(U,Ca,Ce)Ti_2O_6$	MCL metamict	Conch	Black	H 4.5 G 4.4-5.0 infus	Diff sol in acids. Light reddish-brown in section.
	2.49 Li	CADMIUM OXIDE CdO	CUB	111	Black	H 3 G 8.1-8.2 infus	Diss by HCl.
	2.5	STILLEITE ZnSe	CUB	---	---	H 4-5 G 5.29 calc F 5	---
	>2.5	CORDEROITE $Hg_3S_2Cl_2$	CUB	---	Orange-pink	G (6.89)	---
	2.58 Na 2.49 Li	EGLESTONITE $Hg_6Cl_3O_2H$	CUB	---	Yellow	H 2-3 G 8.33-8.55	Dec by acids. Volat when heated. Anom biref. Darkens on exposure.
2.30 ^	2.585 Na 2.535 Li	JACOBSITE (Spinel grp) $(Mn,Mg,Fe^{+2})Fe_2O_4$	CUB oct	Uneven	Black to brownish-black	H 5.5-6.5 G 4.76 infus	Diss by HCl. Weakly to moderately magnetic.

Table 3. Isotropic minerals and mineraloids (continued)

Other entries	Refractive index	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
[ ]	2.6	MAGHEMITE γ-Fe_2O_3	CUB	---	Brownish-black	H 5 G ~ 4.8 infus	Diss by HCl. Strongly magnetic.
[ ]	2.60	CRYPTOMELANE $K(Mn^{+4},Mn^{+2})_8O_{16}$	MCL ps tet u mass botryoidal	---	Steel-gray to black	H 6 G 4.2-4.4 infus	Diss by HCl. Streak brownish-black.
	2.68 Na 2.62 Li	HAUERITE MnS_2	CUB pyrito-hedral	001 perf	Brownish-black	H 4 G 3.46 F 3	Diss by HCl. Streak reddish.
	2.69 Na 2.68 Li	METACINNABAR HgS	CUB tetrah	Subconch to uneven	Grayish-black	H 3 G 7.65 volat	---
	2.78 Na 2.73 Li	ALABANDITE MnS	CUB 100, 110	100 perf	Iron-black	H 3.5-4 G 4.0 F 3	Diss by HCl. Streak green.
	2.85 Li	CUPRITE Cu_2O	CUB gyroidal	111 inter-rupted	Red	H 3.5-4 G 6.14 F 3	Diss by HCl. Streak crimson.
	2.93 Na 3.09 Li	DOMEYKITE Cu_3As	CUB u mass	Uneven	Tin-white to steel-gray	H 3-3.5 G 7.2-7.9 F 2	Dec by HNO_3.
3.54	3.02 Na 2.97 Li	TENNANTITE $(Cu,Fe)_{12}(As,Sb)_4S_{13}$	CUB u mass tetrah	---	Gray, iron-black	H 3-4.5 G 4.6-5.1 F 1.5	Dec by HNO_3. In section bright red to opaque. Tw pl 111.
	3.24 Na 3.22 Li	TIEMANNITE HgSe	CUB tetrah	Uneven to conch	Steel- to blackish-gray	H 2.5 G 8.30-8.47 volat	Dec by HNO_3.
	3.30 Na 4.16 Li	ALTAITE PbTe	CUB u mass	001 perf	Tin-white	H 3 G 8.15 F 1.5	Dec by HNO_3.
	3.45 Na 3.37 Li	PETZITE Ag_3AuTe_2	CUB u mass	001, fr subconch	Steel-gray	H 2.5 G 9.13 F 1.5	Dec by HNO_3.
	3.50 Na 3.79 Li	SPERRYLITE $PtAs_2$	CUB	001 indist fr conch	Tin-white	H 6-7 G 10.58 fus	---

3.80 Na 4.27 Li	LINNAEITE $(Co,Ni)_3S_4$	CUB oct	001 imperf fr uneven	Steel-gray	H 4.5-5.5 G 4.85 F 2	Dec by HNO_3.
3.89 Na 3.87 Li	GALENA PbS	CUB	001 perf	Lead-gray	H 2.5-3 G 7.58 F 2	Dec by HNO_3.
4.50 Na 4.18 Li	PYRITE FeS_2	CUB pyrito- hedral	Conch to uneven	Pale brass- yellow	H 6-6.5 G 5.02 F 2.5-3	Dec by HNO_3.

Table 4. Uniaxial positive minerals

Other entries	Refractive index ω	Refractive index ε	Bire-frin-gence	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.309	1.312	.003	ICE H_2O	HEX mass	Conch	Cols	H 1.5, G 0.92	Melts at 0°C.
	1.378	1.390	.012	SELLAITE MgF_2	TET prism	010, 110, perf	Cols	H 5, G 3.16, F 5	Diss by concd H_2SO_4. F with intumescence. El pos.
1.46	1.40	---	mod	"CHRYSOCOLLA" $Cu_2H_2Si_2O_5(OH)_4 \cdot xH_2O$	Fib $\underline{c}$ opal-like	---	Green	H $2\underline{+}$, G 2, infus	Dec by acids. Pleoc faint, O nearly cols, E pale bluish-green. Perhaps stained opal.
	1.439	1.442	.0029	KOGARKOITE $Na_3(SO_4)F$	MCL ps trig	---	Cols	H 3.5, G 2.67, F 1.5	Sol in H_2O. Biref determined on synth crystal.
	1.443	1.445	.0012	SCHAIRERITE $Na_{21}(SO_4)_7F_6Cl$	TRIG steep rhombs	Conch	Cols	H 3.5, G 2.62, F 1.5	Sol in H_2O.
	1.447	1.449	.002	GALEITE $Na_{15}(SO_4)_5F_4Cl$	TRIG	---	White	G 2.61, F 1.5	Sol in H_2O.
	1.0 red 1.45 Na 1.80 Tl	---	---	COVELLITE CuS	HEX plates	0001 perf	Indigo-blue	H 1.5-2, G 4.6-4.76, F 2	Diss by HNO_3. Translucent only in thinnest plates. In transmitted light, green and pleoc. Disp extr.
1.40	1.46	1.57	.11	"CHRYSOCOLLA" $(Cu,Al)_2H_2Si_2O_5(OH)_4 \cdot xH_2O$	MCL fib	---	Bluish-green	H 3, G 2.4, infus	Dec by acids. Pleoc faint, O nearly cols, E pale bluish-green. index increases with absorption of immersion liquid.
	1.460	1.478	.018	LANNONITE $HCa_4Mg_2Al_4(SO_4)_8F_9 \cdot 3H_2O$	TET	---	White	G 2.22	Diss by acids.
	1.461	1.474	.013	TINCALCONITE $Na_2B_4O_7 \cdot 5H_2O$	TRIG	Hackly	Cols, white	H 2.5, G 1.88, F 2	Sol in H_2O. Data for synth compd.
1.487	1.461	1.465	.004	CHABAZITE (Zeolite grp) $(Ca,Na_2)Al_2Si_4O_{12} \cdot 6H_2O$	TRIG rhombs	$10\bar{1}1$ dist	White, red	H 4.5, G 2.05, F 3	Dec by HCl with sepn of slimy silica. 2V small to 0°.
1.477	1.468	1.473	.005	ERIONITE (Zeolite grp) $(K_2,Ca,Na_2)_2Al_4Si_{14}O_{36} \cdot 15H_2O$	HEX fib	---	White	G 2.02, F easy	Diff dec by HCl with sepn of silica. El pos.

	1.47	1.50	.03	HATCHETTITE $C_{40}H_{82}$	ORTH (?)	001 good	White	H 1, G. 0.9, F 1	Sol in org liquids. Melts at 65° and burns.
⊔ 1.475	1.470	1.474	.004	GMELINITE (Zeolite grp) $(Na_2,Ca)Al_2Si_4O_{12}\cdot 6H_2O$	HEX	$10\bar{1}0$ dist	White	H 4.5, G 2.0-2.1, F 3	Dec by HCl. 2V small to 0°. Tw axis <u>c</u>.
⊔ 1.476	1.471	1.474	.003	HERSCHELITE (Zeolite grp) $(Na_2,Ca)Al_2Si_4O_{12}\cdot 6H_2O$	TRIG	---	White	H 4.5, G 2.1, F 3	Dec by HCl.
⊔ 1.475	1.472	1.492	.020	GAGARINITE $NaCaY(F,Cl)_6$	HEX	Prism, fair	Creamy, yellow	H 3-4.5, G 4.1-4.2	Dec by acids. Anom biax, 2V up to 20°.
1.468 ^	1.477	1.480	.003	ERIONITE (Zeolite grp) $(K_2,Ca,Na_2)_2Al_4Si_{14}O_{36}\cdot 15H_2O$	HEX fib	---	White	G 2.08, F easy	Diff dec by HCl with sepn of silica. El pos.
	1.478	1.484	.006	BENTORITE $Ca_6(Cr,Al)_2(SO_4)_3(OH)_{12}\cdot 26H_2O$	HEX	$10\bar{1}0$ perf 0001 dist	Bright violet	H 2 2.03	Cr_2O_3 7.5, Al_2O_3 1.0%. Pleoc, E pale violet, O nearly cols.
	1.48	---	wk	FAUJASITE (Zeolite grp) $(Na_2,Ca)Al_2Si_4O_{12}\cdot 8H_2O$	CUB oct	111 dist	White	H 5, C 1.92, F 3	Dec by HCl. Uniax in 8 segments.
	1.480	1.493	.013	TETRANATROLITE (Zeolite grp) $Na_2Al_2Si_3O_{10}\cdot 2H_2O$	TET	---	White	H 5, G 2.25, F 2	Gel with HCl.
	1.481	1.483	.002	LEVYNE (Zeolite grp) $CaAl_2Si_4O_{12}\cdot 6H_2O$	TRIG	$02\bar{2}1$ dist	White	H 4, G 2.14, F 2-2.5	Gel with acids.
	1.484	1.603	.119	UREA $CO(NH_2)_2$	TET pyram	---	Yellow, brown	G 1.33	Diss by H_2O.
v 1.498	1.487	1.492	.005	APHTHITALITE $(K,Na)_3Na(SO_4)_2$	TRIG tab, rhombs	$10\bar{1}0$ fair 0001 poor	White	H 3, G 2.68, F 1.5	Slowly sol in H_2O.
1.461 ◊ 1.503	1.487	1.489	.002	CHABAZITE (Zeolite grp) $(Ca,Na_2)Al_2Si_4O_{12}\cdot 6H_2O$	TRIG rhombs	$10\bar{1}1$ dist	White, red	H 4.5, G 2.08, F 3	Dec by HCl with sepn of silica. 2V small to 0°.
	1.488	1.500	.012	DOUGLASITE $K_2FeCl_4\cdot 2H_2O$	MCL u mass	---	Light green, alters to reddish	G 2.16	Nearly uniax. Sol in H_2O. Tends to lie on face normal to opt axes.
	1.490	1.502	.012	NATROLITE (Zeolite grp) $(Na_2,Ca)Al_2Si_3O_{10}\cdot 2H_2O$	ORTH fib	110 perf 010 imperf	White	H 5, G 2.26, F 2-3	Gel with acids. El pos. Submicroscopic intergrowths of fibers give 2V near 0°.
	1.491	1.507	.016	GIUSEPPETTITE (Cancrinite grp) $(Na,K,Ca)_{7-8}(Si,Al)_{12}O_{24}(SO_4,Cl)_{1-2}$	HEX	---	Pale violet-blue	H 6-7, G 2.35	---

Table 4. Uniaxial positive minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Birefringence	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
ˇ 1.504	1.496	1.542	.046	PARAFFIN (mixt. of hydrocarbons)	HEX and ORTH plates and fib	---	White, cols	H 1, G 0.9, F very easy	Insol in acids.
1.492 ⌐¬	1.496	1.502	.006	TUGTUPITE $Na_4BeAlSi_4O_{12}Cl$	TET	Pyramid, conch	Rose, gray, bluish	H 4, G 2.34	---
1.487 ^	1.498	1.503	.005	APHTHITALITE $(K,Na,Cu)_3Na(SO_4)_2$	TRIG	$10\bar{1}0$ fair 0001 poor	White, blue, yellowish	H 3, G 2.68, F 1.5	Slowly sol in H_2O.
⌴ 1.505	1.500	1.502	.002	GARRONITE (Zeolite grp) $Na_2Ca_5Al_{12}Si_{20}O_{64}\cdot 27H_2O$	ORTH ps tet, radiating	2 at 90°, poor	Cols	G 2.15, H 4	---
1.487 ^	1.503	1.507	.004	CHABAZITE (Zeolite grp) $(Ca,Na_2)Al_2Si_4O_{12}\cdot 6H_2O$	TRIG rhombs	$10\bar{1}1$ dist	White, red	H 4.5, G 2.09, F 3	Dec by HCl with sepn of silica. 2V small to 0°.
1.496 ^	1.504	1.550	.046	PARAFFIN (mixt. of hydrocarbons)	HEX (?) and ORTH, plates and fib	---	White, cols	H 1, G 0.9, F very easy	Insol in acids. Lies on base when crushed below cover glass.
	1.508	1.509	.001	LEUCITE $KAlSi_2O_6$	TET ps cub, 211	110 poor	Cols	H 6, G 2.5, infus	Dec by acids. Inclusions are characteristic. 2V small to 0°. Poly tw.
⌴ 1.513	1.510	1.515	.005	FRANCOANELLITE $H_6(K,NH_4)_3Al_5(PO_4)_8\cdot 18H_2O$	TRIG nodular, pulverulent	---	Yellow, white	Very soft, G 2.27	Diss by acids.
	1.510	1.512	.002	FRANZINITE (Cancrinite grp) $(Na,Ca)_7(Si,Al)_{12}O_{24}(SO_4,CO_3,OH,Cl)_3\cdot H_2O$	HEX pris	---	White	H 5, G 2.49	---
⌴ 1.518	1.511	1.518	.007	LEIFITE $Na_2(Si,Al,Be)_7(O,OH,F)_{14}$	TRIG pris	Pris dist	Cols	H 6, G 2.5, F easy	Insol in HCl. El pos.
	1.514	1.522	.008	NITROCALCITE $Ca(NO_3)_2\cdot 4H_2O$	Fib, efflor	One perf	Cols	G 1.90	Readily sol in H_2O, hygroscopic. Data on natural material (synth material biax neg, β = 1.498).
⌐¬ ⌴	1.515	1.54	.025	OZOCERITE (hydrocarbon)	ORTH (?) fib	---	Pale yellow	H 2.5, G 1.9-2.1, F very easy	Insol in acids. Burns. El neg. Lies on base.

1.515 neg ^ 1.522	1.518	1.521	.003	DAVYNE (Cancrinite grp) $(Na,Ca,K)_8Al_6Si_6O_{24}$ $(Cl,SO_4,CO_3)_{2-3}$	HEX	$10\bar{1}0$, 0001 perf	Cols	H 5.5, G 2.4±, F 4	Gel with acids. F with intumescence. Also isotropic and uniax neg.
v 1.537	1.518	1.561	.043	FIBROFERRITE $Fe^{+3}SO_4(OH)\cdot5H_2O$	MCL fib, ps trig	001 perf	Pale yellow	H 2.5, G 1.9-2.1 F 4.5-5	Dec by H_2O, diss by HCl. El pos. Pleoc wk, O nearly cols. E pale yellow.
v 1.555	1.52	1.55	.03	KOENENITE $Na_4(Mg,Ca)_9Al_4(OH)_{22}Cl_{12}$	TRIG foliated	0001 mic	Yellow to red	H 1.5, G 1.98	Dec by H_2O, diss by acids. Pleoc, O red-brown, E cols. El neg.
	1.520	1.540	.020	ANDERSONITE $Na_2Ca(UO_2)(CO_3)_3\cdot6H_2O$	TRIG ps cub	---	Yellow green	G 2.8	Sol in H_2O. Pleoc, O cols, E pale yellow. Fluor bright green in UV.
[ ]	1.521	1.529	.008	MICROSOMMITE (Cancrinite grp) $(Na_2,Ca,K_2)_{7-8}(Al,Si)_{12}$ $O_{24}(Cl_2,CO_3,SO_4)_{2-3}$	HEX	$10\bar{1}0$ perf 0001 less so	Cols	H 6, G 2.4, F 4	Gel with acids. Polytype of Davyne.
⌴ 1.529	1.523	1.544	.021	WEDDELLITE $CaC_2O_4\cdot2H_2O$ (oxalate)	TET	---	White	H 4, G 1.94, infus	Diss by acids.
⌴ 1.528	1.523	1.529	.006	AFGHANITE (Cancrinite grp) $(Na,Ca,K)_8(Al,Si)_{12}O_{24}$ $(Cl,SO_4,CO_3)_3\cdot H_2O$	HEX	$10\bar{1}0$ perf	Bluish-white	H 5.5-6, G 2.55, fus	Gel with acids.
1.522 ⌐	1.524	1.532	.008	BERLINITE $AlPO_4$	TRIG	Conch	Cols	H 6.5, G 2.64, infus	Insol in acids. Isostructural with Quartz.
	1.525	1.525	<.001	KALBORSITE $K_6Al_4BSi_6O_{20}[B(OH)_4]Cl$	TET	110 perf	Cols to rose	H 6, G 2.5	---
v 1.552	1.536	1.572	.036	COQUIMBITE $Fe_2(SO_4)_3\cdot9H_2O$	TRIG	$10\bar{1}1$ imperf	Cols to violet	H 2.5, G 2.07, F 4.5-5	Sol in H_2O. Al_2O_3 6.9%.
	1.536	1.545	.009	ASHCROFTINE $KNaCaY_2Si_6O_{12}(OH)_{10}\cdot4H_2O$	TET acic	100 perf 001 good	White, pink	H 5, G 2.61	---
	1.536	1.544	.008	YAGIITE $(Na,K)_3Mg_4(Al,Mg)_6$ $(Si,Al)_{24}O_{60}$	HEX	---	Light blue to cols	G 2.70	Pleoc wk, E cols, O very bright blue.
1.530 ⌐v 1.542	1.536	1.538	.002	FLUORAPOPHYLLITE $KCa_4Si_8O_{20}(F,OH)\cdot8H_2O$	TET	001 perf 110 poor	Cols	H 5, G 2.44, F 2	Dec by HCl with sepn of slimy silica. Opt anom.
1.518 ^	1.537	1.572	.035	FIBROFERRITE $Fe^{+3}SO_4(OH)\cdot5H_2O$	MCL ps trig, fib	001 perf	Pale yellow	H 2.5, G 1.9-2.1, F 4.5-5	Dec by H_2O, diss by HCl. El pos. Pleoc wk, O nearly cols, E pale yellow.

Table 4. Uniaxial positive minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Birefringence	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.537	1.542	.005	ROEDDERITE (Osumilite grp) $(Na,K)_2Mg_5Si_{12}O_{30}$	HEX	---	Cols	G 2.6	---
	1.540	1.560	.020	CHLORMAGALUMINITE $(Mg,Fe^{+2})_4Al_2(OH)_{12}$ $(Cl,.5CO_3)\cdot 2H_2O$	HEX	0001 perf	Cols to greenish-brown	Soft, G 2.0-2.1, infus	Diss by acids.
v 1.546	1.540	1.546	.006	OSUMILITE-(Mg) (Osumilite grp) $(K,Na)(Mg,Fe)_2(Al,Fe)_3$ $(Si,Al)_{12}O_{30}\cdot H_2O$	HEX	---	Light blue	G 2.63	Pleoc wk, O cols, E pale blue.
1.536 ^	1.542	1.543	.001	HYDROXYAPOPHYLLITE $KCa_4Si_8O_{20}(OH,F)\cdot 8H_2O$	TET	001 perf	Cols	H 4.5-5, G 2.37, F 2	Dec by HCl with sepn of slimy silica. Opt anom.
	1.543	1.5455	.0025	EIFELITE (Osumilite grp) $K_2Na_4Mg_9Si_{24}O_{60}$	HEX	---	---	---	Stated to be negative.
	1.544	1.553	.009	QUARTZ SiO_2	TRIG hex prisms and pyramids	Conch	Cols	H 7, G 2.66, infus	Insol in acids, dec by HF.
1.540 ^	1.546	1.550	.004	OSUMILITE $(K,Na)(Mg,Fe)_2(Al,Fe)_3$ $(Si,Al)_{12}O_{30}\cdot H_2O$	HEX	---	Cols, blue, red	G 2.62	Pleoc wk, O light blue, E cols.
v 1.558	1.547	1.575	.028	BASSANITE $2CaSO_4\cdot H_2O$	HEX ps hex, fib	---	White	G 2.7	Diss slowly by acids. El pos.
	1.550	1.650	.100	VATERITE $CaCO_3$	HEX fib	---	Cols	G 2.64, infus	Diss by acids with eff. Spher aggregates give lower <u>ns</u> down to 1.538.
1.536 ^	1.552	1.558	.006	COQUIMBITE $Fe_2(SO_4)_3\cdot 9H_2O$	TRIG	$10\bar{1}1$ imperf	Cols to violet	H 2.5, G 2.1, F 4.5-5	Sol in H_2O.
1.52 ^	1.555	1.585	.030	KOENENITE $Na_4(Mg,Ca)_9Al_4(OH)_{22}Cl_{12}$	TRIG foliated	0001 mic	Yellow to red	H 1.5, G 2.15	Dec by H_2O, diss by acids. Pleoc, O red-brown, E cols. El neg.
	1.556	1.645	.089	JULIENITE $Na_2CO(SCN)_4\cdot 8H_2O$	TET pris	001	Blue	G 1.65	Sol in H_2O. An artifact?
	1.558	1.613	.055	FERRINATRITE $Na_3Fe(SO_4)_3\cdot 3H_2O$	TRIG acic	$10\bar{1}0$ perf $11\bar{2}0$ less so	White, greenish	H 2.5, G 2.57, F 1.5	Sol in H_2O.

1.547 ^	1.558	1.586	.028	BASSANITE $2CaSO_4 \cdot H_2O$	HEX ps hex, fib	---	White	G 2.7	Diss slowly by acids. El pos.
v 1.592	1.559	---	Low to med	MERRIHUEITE (Osumilite grp) $(K,Na)_2(Fe^{+2},Mg)_5Si_{12}O_{30}$	HEX	---	Greenish-blue	G 2.87 (calc)	Opt char unk. FeO 10.5%. Pleoc cols to greenish-blue.
v 1.59	1.559	1.580	.021	BRUCITE $Mg(OH)_2$	TRIG tab to fib	0001 mic	White	H 2.5, G 2.39, infus	Diss by acids. Flexible. Luster pearly on base. Opt anom. El neg.
v 1.576	1.562	1.576	.014	CLINOCHLORE (Chlorite grp) $(Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	MCL ps hex, plates	0001 mic	White	H 2.5-3, G 2.5, F diff	Diff dec by acids. El neg. Fe_2O_3 1.7%.
	1.564	1.577	.013	PERHAMITE $Ca_3Al_7(SiO_4)_3(PO_4)_4(OH)_3 \cdot 16H_2O$	HEX	0001 perf	Brown, white	H near 5, G 2.64	---
	1.565	1.575	.010	PINNOITE $MgB_2O_4 \cdot 3H_2O$	TET	Uneven	Yellowish	H 3.5, G 2.27, F 3	Diss by acids.
	1.569	1.581	.012	SCHAURTEITE $Ca_3Ge(SO_4)_2(OH)_6 \cdot 3H_2O$	HEX acic	---	White	G 2.65	---
	1.571	1.590	.019	NEFEDOVITE $Na_5Ca_4(PO_4)_4F$	TCL ps tet	Conch	Cols	H 4.5, G 3.01	Diss by acids.
v 1.583	1.572	1.592	.020	ALUNITE (Alunite grp) $KAl_3(SO_4)_2(OH)_6$	TRIG tab 0001, u mass	0001 dist	White, yellow, reddish	H 3.5-4, G 2.6, infus	Insol in acids, but sol in acids after gentle heating. El neg.
	1.572	1.586	.014	EUCRYPTITE $LiAlSiO_4$	TRIG	Conch	Cols	H 5.5-6.5, G 2.66	Gel with acids. Fluor pink in UV.
	1.573	1.599	.026	TUNISITE $NaCa_2Al_4(CO_3)_4(OH)_8Cl$	TET	001 perf pris good	Cols	H 4.5, G 2.51, infus	Insol in H_2O.
v 1.603	1.574	1.590	.016	NATROALUNITE (Alunite grp) $NaAl_3(SO_4)_2(OH)_6$	TRIG tab 0001, u mass	0001 dist	White, yellow	H 4, G 2.78, infus	Insol in acids, but diss after gentle heating. El neg. Na_2O 7.6, K_2O 0.1%.
1.562 ^v 1.587	1.576	1.579	.003	CLINOCHLORE (Chlorite grp) $(Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	MCL ps hex, plates	001 perf	Green, white	H 2, G 2.7, F 5-5.5	Dec by H_2SO_4. El neg. Abnormal blue interf color. Pleoc, X, Y green, Z cols.
	1.577	---	very low	NAMUWITE $(Zn,Ca)_4(SO_4)(OH)_6 \cdot 4H_2O$	HEX	0001 perf	Pale sea-green	G 2.77	Opt sign unk.
[ ]	1.580	1.588	.008	COERULEOLACTITE $(Ca,Cu)Al_6(PO_4)_4(OH)_8 \cdot 4\text{-}5H_2O$	TCL (?) fib crusts	---	Milk-white, light blue	H 5, G 2.55-2.70, infus	Diss by acids. Related to turquoise.

Table 4. Uniaxial positive minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Birefringence	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.572 ^v 1.620	1.583	1.595	.012	ALUNITE (Alunite grp) $(K,Na)(Al,Fe)_3(SO_4)_2(OH)_6$	TRIG tab 0001 u mass	0001 dist	White, red, yellow	H 4, G 2.7, infus	Insol in acids, but diss by acids after gentle heating. El neg.
1.575 v 1.604	1.585	1.656	.071	CACOXENITE $Fe^{+3}{}_9(PO_4)_4(OH)_{15}\cdot 18H_2O$	HEX needles <u>c</u>	---	Yellow to brownish	H 3-4, G 2.3, F 2.5-3	Diss by acids. Pleoc, O cols to pale yellow, E orange- to canary-yellow.
v 1.594	1.586	1.595	.009	WARDITE $NaAl_3(PO_4)_2(OH)_4\cdot 2H_2O$	TET	001 perf	Cols to pale green	H 5, G 2.87, F 3	Slowly diss by acids. Opt anom, biax in sectors. El neg.
1.576 ^v 1.598	1.587	1.594	.007	CLINOCHLORE (Chlorite grp) $(Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	MCL ps hex, plates	001 perf	Greenish-gray	H 2.5, G 2.67, F 4.5	Slowly dec by acids. 2V 0-5°. El neg.
v 1.604	1.588	1.593	.005	EUDIALYTE $Na_4(Ca,Ce)_2FeZrSi_8O_{22}(OH,Cl)_2$	TRIG	0001 dist 10$\bar{2}$0 poor	Yellow, pink, brown	H 5-5.5, G 2.85, F 3.0	Gel with acids. Opt anom, biax. Pleoc wk in pink and yellow.
	1.588	1.589	.001	RINNEITE $K_3NaFeCl_6$	TRIG	11$\bar{2}$0 good	Cols, rose, yellow	H 3, G 2.35, F easy	Sol in H_2O. Anom biax. Abnormal interf colors in ultrablue.
1.559 ^v 1.707	1.59	1.60	.01	BRUCITE $(Mg,Mn)(OH)_2$	TRIG	0001 perf	Light brown	H 2.5, G 2.5, infus	Diss by HCl. El neg. MnO 18.1, ZnO 3.7%.
	1.59	---	very wk	CHLORMANGANOKALITE K_4MnCl_6	TRIG	Conch	Yellow	H 2.5, G 2.31, F easy	Sol in H_2O. Deliq.
1.559 ^	1.592	---	low to med	MERRIHUEITE (Osumilite grp) $(K,Na)_2(Fe^{+2},Mg)_5Si_{12}O_{30}$	HEX	---	Greenish-blue	---	Opt char unk. MgO 4.4 FeO 24.9%.
1.586 ^	1.594	1.604	.010	WARDITE $NaAl_3(PO_4)_2(OH)_4\cdot 2H_2O$	TET	001 perf	Cols to green	H 5, G 2.81, F 3	Slowly diss by acids. Opt anom, biax in sectors. El neg.
	1.597	1.612	.015	AMESITE (Kaolinite-Serpentine grp) $(Mg,Fe)_4Al_2(Al_2Si_2)O_{10}(OH)_8$	MCL ps hex, plates	001 mic	Pale bluish-green	H 2-3, G 2.77, infus	Slowly dec by HCl. El neg.
1.587 ^v 1.618	1.598	1.606	.008	CLINOCHLORE (Chlorite grp) $(Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	MCL ps hex, plates	001 mic	Green	H 2, G 2.80, F 5	Diff dec by HCl. 2V 0-20°. El neg. FeO 9.1, Fe_2O_3 1.9%.

	1.598	1.598	very wk	COMBEITE $Na_2Ca_2Si_3O_9$	TRIG pris	---	Cols	G 2.84	Gel with hot HCl.
v 1.612	1.601	1.632	.031	NARSARSUKITE $Na_2(Ti,Fe)Si_4(O,F)_{11}$	TET tab	110 good 010 dist	Honey-yellow to reddish	H 6-7, G 2.75, F easy	Insol in acids. Pleoc wk, O yellow, E cols.
1.574 ^	1.603	1.611	.008	NATROALUNITE (Alunite grp) $(Na,K)Al_3(SO_4,PO_4)_2(OH)_6$	TRIG tab 0001, u mass	0001 dist	White, yellow	H 4, G 2.78, infus	Insol in acids but diss in acids after being heated gently. Na_2O 3.9, K_2O 2.3, P_2O_5 5.1%.
	1.603	1.609	.006	CALCIUM CATAPLEIITE $CaZrSi_3O_9 \cdot 2H_2O$	HEX	One clv	Pale yellow, cream	H 4.5-5, G 2.77	
1.585 ^	1.604	1.676	.072	CACOXENITE $Fe^{+3}{}_9(PO_4)_4(OH)_{15} \cdot 18H_2O$	HEX needles <u>c</u>	---	Yellow to brownish	H 3-4, G 2.3, F 2.5-3	Diss by acids. Pleoc, O cols, E canary yellow.
	1.604	1.615	.011	SARCOLITE $(Ca,Na)_{7-8}Al_4Si_6O_{24}$ $(OH)_2$ (?)	TET	---	Light rose	H 6, G 2.93, F 3 (?)	Gel with acids. Anom biax.
1.588 ^v 1.624	1.604	1.607	.003	EUDIALYTE $Na_4(Ca,Ce)_2FeZrSi_8O_{22}$ $(OH,Cl)_2$	TRIG	0001 dist $10\bar{2}0$ poor	Yellow, pink, brown	H 5-5.5, G 2.84, F 4-5	Gel with acids. Opt anom, biax. Pleoc wk in pink and yellow.
	1.606	1.620	.014	SARYARKITE $Ca(Y,Th)Al_5(SiO_4)_2$ $(PO_4,SO_4)_2(OH)_7 \cdot 6H_2O$	HEX microcryst	---	White	H 3.5-4, G 3.1	Dec by acids. Related to Rhabdophane.
	1.606	1.608	.002	SOGDIANITE (Osumilite grp) $(K,Na)_2Li_2(Li,Fe^{+3},Al)_2$ $ZrSi_{12}O_{30}$	HEX	---	Violet	H 7, G 2.90	ZrO_2 9.8, TiO_2 2.9, FeO 1.2, Fe_2O_3 4.6, Na_2O 2.8, K_2O 4.8, Li_2O 3.7%. Reported as uniax neg.
v 1.625	1.610	1.620	.010	GORCEIXITE (Crandallite grp) $(Ba,Ca,Ce)Al_3(PO_4)_2(OH)_5 \cdot H_2O$	TRIG u mass	---	Brown, white	H 6, G 3.1-3.3	---
1.601 ^	1.612	1.660	.048	NARSARSUKITE $Na_2(Ti,Fe)Si_4(O,F)_{11}$	TET tab	110 good 010 dist	Honey-yellow to reddish	H 6-7, G 2.78, F easy	Insol in acids. Pleoc wk, O yellow, E cols.
v 1.623	1.613	1.622	.009	CRANDALLITE (Crandallite grp) $CaAl_3(PO_4)_2(OH)_5 \cdot H_2O$	TRIG u fib	0001 perf	Cols, yellow	H 5, G 2.8, F 3	Diff sol in acids. Fuses with intumescence. El neg.
	1.615	1.617	.002	FLUOCERITE $(Ce,La)F_3$	HEX	0001 perf	Reddish-yellow	H 4, G 5.8, infus	Insol in HCl or HNO_3, diss by H_2SO_4.
	1.618	1.630	.012	GAINESITE $Na_2Zr_2Be(PO_4)_4$	TET	Conch	Pale bluish-lavender	H 4, G 2.94	Insol in HCl.

Table 4. Uniaxial positive minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Bire-frin-gence	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.598 ^	1.618	1.621	.003	CLINOCHLORE (Chlorite grp) $(Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	MCL ps hex	001 perf	Green	H 2, G 2.8	Pleoc wk in green. FeO 13.7, Fe_2O_3 1.9%.
1.583 ^	1.620	1.641	.021	ALUNITE (Alunite grp) $K(Al,Fe)(SO_4)_2(OH)_6$	TRIG u mass	0001 dist	White to reddish	H 4, G 2.81, infus	Insol in acids, but after gentle heating diss by acids. El neg. Fe_2O_3 5.0%.
v 1.640	1.620	1.630	.010	GOYAZITE (Crandallite grp) $SrAl_3(PO_4)_2(OH)_5 \cdot H_2O$	TRIG tab 0001	0001 perf	Cols to brown	H 4.5-5, G 3.15-3.26, F 4	Slowly diss by acids. Zoned. Anom biax on basal sections. Pleoc, O red-brown, E yellow.
1.613 ◇ 1.627	1.623	1.634	.011	CRANDALLITE (Crandallite grp) $CaAl_3(PO_4)_2(OH)_5 \cdot H_2O$	TRIG u fib	0001 perf	Cols to yellow	H 5, G 2.8, F 3	Diff sol in acids. Fuses with intumescence. El neg.
v 1.624	1.624	1.673	.049	WADEITE $K_2CaZrSi_4O_{12}$	HEX	2 dist fr conch	Cols, rose, lilac	H 6, G 3.11, F diff	Insol in acids. El pos.
1.624 ^	1.624	1.653	.029	WADEITE $K_2CaZrSi_4O_{12}$	HEX	2 dist fr conch	Cols, rose, lilac	H 6, G 3.10, F diff	Insol in acids. Anom biax. El pos.
1.604 ^	1.624	1.629	.005	EUDIALYTE $Na_4(Ca,Ce)_2FeZrSi_8O_{22}(OH,Cl)_2$	TRIG	0001 dist $11\bar{2}0$ poor	Yellow, pink, brown	H 5-5.5, G 2.94, F 4-5	Gel with acids. Opt anom, biax. Pleoc wk in pink and yellow.
1.610 ^	1.625	---	wk	GORCEIXITE (Crandallite grp) $(Ba,Ca,Ce)Al_3(PO_4)_2(OH)_5 \cdot H_2O$	TRIG u mass	---	Brown, white	H 6, G 3.09-3.32	---
v 1.639	1.626	1.640	.014	SVANBERGITE (Beudantite grp) $SrAl_3(PO_4)(SO_4)(OH)_6$	TRIG ps cub	0001 dist	Cols, yellow, brown	H 4.5, G 2.98-3.22, F diff	Diss with diff by acids. Basal section may show 6 biax sectors.
1.62 □ 1.63	1.626	1.627	.001	METATORBERNITE (Meta-autunite grp) $Cu(UO_2)_2(PO_4)_2 \cdot 8H_2O$	TET tab 001	001 mic	Green	H 2.5, G 3.6-3.8, F 3	Diss by acids. Pleoc wk, O bright green, E cols. Not fluor in UV.
1.623 ^	1.627	1.632	.005	CRANDALLITE (Crandallite grp) $(Ca,Sr,Ce)Al_3(PO_4)_2(OH)_5 \cdot H_2O$	TRIG u fib	0001 perf	Cols to yellow	H 5, G 3.2, F 4	Diff sol in acids. SrO 5.1, RE_2O_3 10.5%.

	1.629	---	very low	KAMAISHILITE $Ca_2Al_2SiO_6(OH)_2$	TET	---	Cols	---	Opt sign unk.
	1.629	1.632	.003	BABEFPHITE $BaBe(PO_4)(O,F)$	TET tab	---	White	G 4.31	Insol in acids, diss by aqua regia or HF.
	1.630	1.638	.008	HAUCKITE $Zn_{18}(Mg,Mn)_{24}Fe^{+3}(SO_4)_4(CO_3)_2(OH)_{81}$ (?)	HEX	001 perf	Orange to yellow	H 2-3, G 3.10	Pleoc, O golden-brown, E pale yellow. ZnO 36.0, MnO 17.1%.
v 1.632	1.630	1.637	.007	MELILITE (Melilite grp) $(Ca,Na)_2(Mg,Al)(Si,Al)_2O_7$	TET	001, 110	Cols	H 5, G 2.95-3.05, F 3	Gel with acids. Fe_2O_3 1.9, FeO 3.1, Na_2O 3.75%.
	1.631	1.652	.021	FAHEYITE $(Mn,Mg)Fe^{+3}{}_2Be_2(PO_4)_4\cdot 6H_2O$	HEX fib	Pris perf	White to brownish	G 2.66	Slowly diss by hot acids. El pos.
1.630 ^ v 1.648	1.632	1.639	.007	AKERMANITE (Melilite grp) $Ca_2MgSi_2O_7$	TET	001, 110	Cols	H 5, G 2.95	Gel with acids. Data for synth compd.
	1.633	---	low	BURTITE $CaSn(OH)_6$	TRIG	001 good	Cols	H ~ 3, G 3.28	Anom biax.
v 1.662	1.636	1.647	.011	WOODHOUSEITE (Beudantite grp) $CaAl_3(PO_4)(SO_4)(OH)_6$	TRIG	0001 good	Cols	H 4.5, G 3.01	Diff diss by acids. Basal section may show biax sectors.
1.626 ^	1.639	1.646	.007	SVANBERGITE (Beudantite grp) $SrAl_3(PO_4)(SO_4)(OH)_6$	TRIG ps cub	0001 dist	Cols, yellow, brown	H 4.5, G 2.98-3.22, F diff	Diff diss by acids. Basal section may show 6 biax sectors. SrO 21.2, CaO 1.0%.
1.620 ^	1.640	1.651	.011	GOYAZITE (Crandallite grp) $SrAl_3(PO_4)_2(OH)_5\cdot H_2O$	TRIG tab 0001	0001 perf	Cols to brown	H 4.5-5, G 3.15, F 4	Diff diss by acids. Anom biax. 2V 0-20°.
v 1.670	1.643	1.755	.112	PARISITE-(Y) ("Yttroparisite") $Ca(Y,Ce)_2(CO_3)_3F_2$	HEX	0001	Yellow, brown	---	No analysis, needs confirmation.
⌴ 1.650	1.643	1.73	.087	SYNCHYSITE-(Y) ("Doverite") $CaY(CO_3)_2F$	ORTH ps hex, u mass	001	Red-brown	G 3.6-3.7 (?)	Diff diss by acids.
v 1.674	1.644	1.744	.100	SYNCHYSITE $CaCe(CO_3)_2F$	ps hex	---	Red-brown	H 4.5, G 3.9	Diff diss by acids.
	1.644	1.664	.020	TRISTRAMITE $(Ca,U^{+4},Fe^{+3})(PO_4,SO_4)\cdot 2H_2O$	HEX fib	---	Pale- to greenish-yellow	G 3.8-4.2	Not fluor in UV light.
	1.646	1.647	.001	BRAITSCHITE $(Ca,Na_2)_7(Ce,La)_2B_{22}O_{43}\cdot 7H_2O$	HEX mass	---	White to pink	G 2.90	---

Table 4. Uniaxial positive minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Birefringence	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.632 ◊ 1.653 neg	1.648	1.649	.001	MELILITE (Melilite grp) $Ca_2(Mg,Al)(Si,Al)_2O_7$	TET	001, 110	Cols	H 5, G 2.9-3.1, F 3	Gel with acids. Data for synth Ak 60, Ge 40.
∨ 1.680	1.653	1.675	.022	PLUMBOGUMMITE (Crandallite grp) $PbAl_3(PO_4)_2(OH)_5 \cdot H_2O$	TRIG gum-like	---	Yellow, brown	H 4-5, G 4.0, F 4-5 (?)	Diss with diff by HNO_3.
∨ 1.678	1.653	1.661	.008	FLORENCITE (Crandallite grp) $CeAl_3(PO_4)_2(OH)_6 \cdot H_2O$	TRIG	0001	Pink	H 5, G 3.46, infus	Diss with diff by acids.
∨ 1.675	1.654	1.703	.049	RHABDOPHANE $(Ce,La)PO_4 \cdot H_2O$	HEX fib, mass	Uneven	Brown, white, reddish	H 3-4, G 3.5-4.0, infus	Diss by acids.
	1.654	1.670	.016	PHENAKITE Be_2SiO_4	TRIG pris	$11\bar{2}0$ dist $10\bar{1}1$ imperf fr conch	Cols, yellow	H 7.5, G 2.97, infus	Insol in acids. Tw pl $\bar{1}010$ penet.
⊔ 1.662	1.655	1.656	.001	CAHNITE $Ca_2BAsO_4(OH)_4$	TET	110 perf	Cols	H 3, G 3.06, F 3	Diss by acids. Tw. Abnormal interf colors in brown.
1.652 ⊔ 1.658	1.656	1.708	.052	DIOPTASE $CuSiO_2(OH)_2$	TRIG	$10\bar{1}1$ perf	Emerald-green	H 5, G 3.28, infus	Gel with acids. Anom biax. Abs in thick sections O > E.
	1.656	1.682	.026	DESPUJOLSITE $Ca_3Mn^{+4}(SO_4)_2(OH)_6 \cdot 3H_2O$	HEX	Conch	Lemon-yellow	H 2.5, G 2.46	Diss by HCl with evolution of chlorine. Pleoc wk, O pale yellow, E yellow.
	1.660	1.756	.096	RÖNTGENITE $Ca_2Ce_3(CO_3)_5F_3$	TRIG	---	Cols to light yellow	G 4.2	Diff diss by acids.
1.636 ^	1.662	1.669	.007	WOODHOUSEITE (Beudantite grp) $CaAl_3(PO_4)(SO_4)(OH)_6$	TRIG	0001 good	Cols, gray, lilac	H 4-4.5, G 2.9-3.0	Diff diss by acids. Basal section may show biax sectors.
	1.664	1.672	.008	MELIPHANITE var Gugiaite $(Ca,Na)_2Be(Si,Al)_2(O,OH,F)_7$	TET thin tab	010 perf 001 dist	Cols	H 5, G 3.03	Gel with acids.
∨ 1.692	1.665	1.685	.020	THOROGUMMITE $(Th,Ce)(SiO_4)_{1-x}(OH)_{4x}$	TET u mass earthy	Conch	Yellow, brown	H 3, G 4.0-4.7, infus	Gel with acids.

	1.666	1.747	.081	PETERSITE $(Y,Ce,La,Ca)Cu_6(PO_4)_3(OH)_6 \cdot 3H_2O$	HEX	---	Yellow-green	G 3.41	Dec by HCl. Pleoc, O light yellow-green, E green.
1.643 ^v 1.678	1.670	1.768	.098	PARISITE $Ca(Ce,La)_2(CO_3)_2F$	TRIG	0001	Yellow	H 4.5, G 4.0-4.4, infus	Diss by acids. Pleoc, O pale yellow, E yellow-brown. El neg.
v 1.688	1.67	1.70	.03	HINSDALITE (Beudantite grp) $PbAl_3(PO_4)(SO_4)(OH)_6$	TRIG	0001 perf	Cols	H 4.5, G 3.65, infus	Anom biax in 6 basal sectors. El neg.
	1.673	1.678	.005	FILLOWITE $Na_2Ca(Mn,Fe)_7(PO_4)_6$	MCL ps hex	001 perf	Yellow, brown, cols	H 4.5, G 3.43, F 1.5	Diss by acids.
1.644 ^	1.674	1.770	.096	SYNCHYSITE $CaCe(CO_3)_2F$	ps hex	---	Red-brown	H 4.5, G 3.9, infus	Diff diss by acids.
1.654 ^v 1.692	1.675	1.705	.030	RHABDOPHANE $(Ce,La)PO_4 \cdot H_2O$	HEX fib, mass	Uneven	Brown, gray-green	H 3-4, G 3.3-4.0, infus	Diss by acids.
v 1.681	1.675	1.685	.010	BAZIRITE $BaZrSi_3O_9$	HEX pris	0001	Cols	G 3.82 calc	Fluor whitish-blue in short-wave UV.
1.670 ^	1.678	1.767	.089	PARISITE $Ca(Ce,La)_2(CO_3)_3F_2$	TRIG	0001	Yellow, brown	H 4-5, G 4.0-4.4, infus	Diss by acids. Pleoc, O pale yellow, E yellow-brown. El neg.
1.653 ^v 1.695	1.678	1.684	.006	FLORENCITE (Crandallite grp) $CeAl_3(PO_4)_2(OH)_6$	TRIG	0001	Brown	H 5-6, G 3.46, infus	Diff diss by acids.
1.653 ^	1.680	1.698	.018	PLUMBOGUMMITE (Crandallite grp) $PbAl_3(PO_4)_2(OH)_5 \cdot H_2O$	TRIG gum-like		Yellow, brown, gray	H 4.5, G 4.0-4.9, F 4-5 (?)	Diss with diff by HNO_3.
	1.680	1.695	.015	BROCKITE $(Ca,Th,La)(PO_4)$	HEX mass, earthy		Reddish-brown to yellow	G 3.9	Related to Rhabdophane.
1.675 ^	1.681	1.691	.010	BAZIRITE $BaZrSi_3O_9$	HEX pris	0001	Cols	G 3.82 calc	Fluor whitish-blue in short-wave UV.
	1.688	1.698	.010	WEILERITE (Beudantite grp) $BaAl_3(AsO_4)(SO_4)(OH)_6$ (?)	TRIG crusts	---	White	---	Diss by acids. Opt char unk.
1.67 ^	1.688	1.697	.009	HINSDALITE (Beudantite grp) $PbAl_3(PO_4)(SO_4)(OH)_6$	TRIG	0001 perf	Cols	H 4.5, G 3.65, infus	Anom biax in 6 basal sectors. El neg.
	1.689	1.695	.006	ILIMAUSSITE $Ba_2Na_4CeFe^{+3}Nb_2Si_8O_{28} \cdot 5H_2O$	HEX	Conch	Brownish-yellow	H ~ 4, G 3.6	---

Table 4. Uniaxial positive minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Bire-frin-gence	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v 1.720	1.690	1.760	.070	XENOTIME YPO_4	TET	100 perf	Yellow, brown	H 4-5, G 4.7-5.1, infus	Insol in acids. Pleoc wk, O pale yellow, E greenish-yellow.
v 1.714	1.691	1.719	.028	WILLEMITE Zn_2SiO_4	TRIG	0001, 11$\bar{2}$0	Green, white, red, brown	H 5.5, G 4.05-4.20, infus	Gel with acids. Fluor bright green in UV. MnO 0.12%.
1.675 ^v 1.721	1.692	1.732	.040	RHABDOPHANE-(La) $(La,Ce)PO_4 \cdot H_2O$	HEX mass	Uneven	Brown, gray	H 3-4, G 4.4, infus	Diss by acids.
1.665 ^v 1.78(?)	1.692	1.710	.018	THOROGUMMITE $(Th,Ce)(Si,P)(O,OH)_4$	TET u mass, earthy	Conch	Yellow, brown	H 3, G 4.0-4.7, infus	Gel with acids. Forms series with Thorite?
	1.694	1.701	.007	FLORENCITE-(La) (Crandallite grp) $(La,Ce)Al_3(PO_4)_2(OH)_6$	TRIG	Splintery	Cols to pale yellow	H 5, G 3.52	Diff diss by acids.
v 1.717	1.695	1.785	.090	BASTNAESITE $(Ce,La)CO_3F$	HEX pris	Parting 0001	Yellow, brown, reddish	H 4, G 4.9-5.1, infus	Diff diss by acids. Pleoc wk, abs E > O.
1.678 ^v 1.713	1.695	1.705	.010	FLORENCITE (Crandallite grp) $CeAl_3(PO_4)_2(OH)_6$	TRIG	0001	Cols, brown	H 6, G 3.69, infus	Diff diss by acids.
	1.697	1.704	.007	MUIRITE $Ba_{10}Ca_2MnTiSi_{10}O_{30}(OH,Cl,F)_{10}$	TET	001, 100 indist	Orange	H 2.5, G 3.86, F 3	Dec by acids. Anom purplish-brown interf colors.
	1.701	1.707	.006	KEMMLITZITE (Beudantite grp) $SrAl_3(AsO_4)(SO_4)(OH)_6$	TRIG	0001	Grayish-brown	H 5.5, G 3.63	---
v 1.722	1.702	1.706	.004	VESUVIANITE $Ca_{10}Mg_2Al_4(Si_2O_7)_2(SiO_4)_5(OH,F)_4$	TET pris	110 poor	Cols, green, brown, yellow	H 6-6.5, G 3.37, F 3	Insol in acids. Pleoc wk. Anom biax. Abnormal interf colors in blue and brown.
	1.704	1.765	.061	GOUDEYITE $Cu_6(Al,Y)(AsO_4)_3(OH)_6 \cdot 3H_2O$	HEX pris <u>c</u>	---	Yellow-green	H 3-4, G 3.50	Pleoc, O pale yellow-green, E green. Compare Mixite.
v 1.722	1.705	1.777	.072	AGARDITE $(Y,Ca)Cu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$	HEX	---	Blue-green	G 3.72	Diss by acids.

1.59 ^	1.707	1.722	.015	AMAKINITE (Brucite ser) $(Fe,Mg)(OH)_2$	TRIG	0001 fr uneven	Greenish, turns brown	H 3.5-4, G 2.98, infus	Diss by acids. Fe_2O_3 31.6, FeO 30.4, MgO 10.1, MnO 3.6%. Compare Brucite at ω = 1.59.
v 1.730	1.71	(1.715)	.005	HIDALGOITE (Beudantite grp) $PbAl_3(AsO_4)(SO_4)(OH)_6$	TRIG mass	---	White	H 4.5, G 3.96	Insol in acids.
1.695 ^	1.713	1.719	.006	FLORENCITE (Crandallite grp) $CeAl_3(PO_4)_2(OH)_6$	TRIG	0001	Cols, brown	H 6, G 3.4-3.6, infus	Diff diss by acids.
1.691 ^	1.714	1.732	.018	WILLEMITE $(Zn,Mn)_2SiO_4$	TRIG	0001, $11\bar{2}0$	Reddish-brown	H 5, G 4.05-4.20, infus	Gel with acids. MnO 6.8, FeO 0.2%.
v 1.75	1.714	1.731	.017	OSARIZAWAITE $PbCuAl_2(SO_4)_2(OH)_6$	TRIG mass	---	Green	G 4.04	Diss by hot HNO_3. Anom biax.
	1.715	1.728	.013	JASMUNDITE $Ca_{11}(SiO_4)_4O_2S$	TET	---	Dark brown	G 3.03	---
1.695 ^v 1.730	1.717	1.818	.101	BASTNAESITE $(Ce,La)CO_3F$	HEX pris	Parting 0001	Yellow, brown, reddish	H 4, G 4.9-5.1, infus	Diff diss by acids. Pleoc wk, abs E > O.
	1.719	1.733	.014	BROMELLITE BeO	HEX	$10\bar{1}0$ good $11\bar{2}0$, 0001 poor	Cols	H 8.5-9, G 3.02, infus	Insol in acids.
[v 1.81	1.72	---	very wk	ZIRCON "Malacon" $ZrSiO_4$	TET	Uneven	Brown	H 6-7, G ~ 4	Metamict. Insol in acids.
1.690 ^v 1.753	1.720	1.820	.100	XENOTIME YPO_4	TET	100 perf	Yellow to reddish-brown	H 4-5, G 4.7-5.1, infus	Insol in acids. Pleoc wk, O pink to pale yellow, E pale greenish-yellow.
1.692 ^	1.721	1.748	.027	RHABDOPHANE $(Ce,La)PO_4 \cdot H_2O$	HEX u mass	Uneven	Greenish-yellow, brown	H 3-4, G 3.3-4.0, infus	Diss by acids.
1.705 ^	1.722	1.815	.093	AGARDITE $(Y,Ca)Cu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$	HEX	---	Blue-green	G 3.72	Diss by acids. Compare Mixite at ω = 1.730.
1.702 ^	1.722	1.725	.003	VESUVIANITE $Ca_{10}Mg_2Al_4(Si_2O_7)_2(SiO_4)_5(OH,F)_4$	TET pris	110 poor	Cols, green, brown, yellow	H 6-6.5, G 3.4, F 3	Insol in acids. Pleoc wk. Anom biax. Abnormal interf colors in blue and brown.
v 1.736	1.724	1.746	.022	CONNELLITE $Cu_{19}(SO_4)Cl_4(OH)_{32} \cdot 3H_2O$	HEX acic	---	Fine blue, greenish-blue	H 3, G 3.36, F 2.5	Diss by acids.

Table 4. Uniaxial positive minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Birefringence	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v 1.780	1.728	1.730	.002	BRITHOLITE-(Y) ("Abukumalite") $(Y,Ca,Ce)_5(SiO_4,PO_4)_3(OH,F)$	HEX	0001, 10$\bar{1}$0, imperf	Reddish-brown	H 6-6.5, G 4.25	Dec by acids. Apatite structural type.
1.717 ^ v 1.757	1.730	1.830	.100	BASTNAESITE $(Ce,La)CO_3F$	HEX pris	parting 0001	Yellow, brown, reddish	H 4, G 4.9-5.1, infus	Diff diss by acids.
v 1.749	1.730	1.810	.080	MIXITE $BiCu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$	HEX acic	One perf	Emerald- to bluish-green	H 3-4, G 3.8, F 2	Diss by acids. Pleoc very wk in shades of green.
1.71 ^	1.730	1.735	.005	HIDALGOITE (Beudantite grp) $PbAl_3(AsO_4)(SO_4)(OH)_6$	TRIG	---	Pale green to emerald-green	H 4.5, G 3.95	Insol in acids. MoO_3 3.5%.
1.724 ^	1.736	1.756	.020	CONNELLITE $Cu_{19}(SO_4)Cl_4(OH)_{32} \cdot 3H_2O$	HEX acic	---	Fine blue, greenish-blue	H 3, G 3.36, F 2.5	Diss by acids.
	1.738	1.752	.014	BUTTGENBACHITE $Cu_{19}(NO_3)_2Cl_4(OH)_{32} \cdot 2H_2O$	HEX acic	---	Azure-blue	H 3, G 3.33, F 2	Diss by acids or by NH_4OH.
	1.747	1.776	.029	FLEISCHERITE $Pb_3Ge(SO_4)_2(OH)_6 \cdot 3H_2O$	HEX fib	---	White to pale rose	H soft, G 4.2-4.4	---
1.730 ^	1.749	1.83	.081	MIXITE $BiCu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$	HEX acic	One perf	Blue-green	H 3-4, G 3.8, F 2	Diss by acids.
1.714 ^	1.75	~1.76	~.01	OSARIZAWAITE $Pb(Cu,Al)_3(SO_4)_2(OH)_6$	TRIG	---	Green	---	Diss by hot HNO_3. Anom biax.
1.720 ^ v 1.783	1.753	~1.84	~.09	CHERNOVITE (Xenotime ser) $Y(As,P)O_4$	TET pris	100 perf	Brown, yellow	H 4-5, G 4.8, infus	Insol in acids. Forms a series with Xenotime.
	1.756	1.802	.046	BENITOITE $BaTiSi_3O_9$	HEX pyram or tab	10$\bar{1}$1 imperf fr conch	Blue	H 6, G 3.65, F 3	Insol in acids. Pleoc, O cols, E purplish-blue.
1.730 ^	1.757	1.864	.107	HYDROXYLBASTNAESITE $(Ce,La)CO_3(OH,F)$	HEX pris	11$\bar{2}$0 imperf	Reddish-brown, yellow	H 4, G 4.7, infus	Slowly diss by acids.
1.754 □ 1.761	1.757	---	very wk	MCGOVERNITE $(Mn,Mg,Zn)_{22}(AsO_3)(AsO_4)_3(SiO_4)_3(OH)_2$	TRIG	0001 mic	Reddish-bronze	H 3, G 3.72	El neg.

	1.759	1.760	.001	THEOPHRASTITE $Ni(OH)_2$	TRIG	0001 perf	Emerald-green	H 3.5, G 4.00	Pleoc wk.
	1.765	1.800	.035	HENRITERMIERITE (Garnet grp) $Ce_3(Mn,Al)_2(SiO_4)_2(OH)_4$	TET	Conch	Clove-brown	G 3.34, fus	Dec by HCl. Anom biax. Pleoc wk, O pale yellow, E lemon-yellow.
1.76 □ 1.78	1.765	1.782	.017	STILLWELLITE $(Ce,La,Ca)BSiO_5$	TRIG	Conch	Pinkish-gray, brown	H 5-6, G 4.6	Anom biax, 2V 0-6°.
∨ 1.855	1.77	---	.03-.04	LUSUNGITE (Crandallite grp) $(Sr,Pb)Fe^{+3}(PO_4)_2(OH)_5 \cdot H_2O$	TRIG	---	Dark brown	---	Pleoc wk.
□ 1.795	1.778	1.801	.023	CONICHALCITE $CaCu(AsO_4)(OH)$	ORTH fib	Uneven	Pistachio- to emerald-green	H 4-5, G 4.13, F 3	In section green, pleoc wk. U biax.
1.692(?) ∧∨ 1.837	1.78	1.79	.01	THORITE $ThSiO_4$	TET	110 dist	Brown, yellow	H 5, G 4.4-5.7, infus	Gel with acids.
1.728 ∧	1.780	1.783	.003	BRITHOLITE-(Y) ("Abukumalite") $(Y,Ca,Ce)_5(SiO_4,PO_4)_3(OH,F)$	HEX	0001, $10\bar{1}0$, imperf	Reddish-brown	H 6, G 4.35	Dec by acids. Apatite structural type.
1.753 ∧	1.783	1.879	.096	CHERNOVITE $YAsO_4$	TET pris	100 perf	Yellow	H 4-5, G 4.87 infus	Insol in acids. Pleoc wk, O cols, E pale pinkish-yellow.
	1.794	1.803	.009	CARYINITE $(Na,Ca,Pb)_3(Mn,Mg,Fe^{+3})_4(AsO_4)_4$ (?)	MCL u mass	110, 010	Brown	H 3-4, G 4.25, F 2-3	Diss by acids. Orange to red in section, not pleoc.
	1.800	1.845	.045	STISHOVITE SiO_2	TET	---	Cols	G 4.35, infus	Insol in acids, very slowly diss by HF.
1.785 ⊓	1.80	1.81	.01	NIGERITE $(Zn,Mg,Fe)(Sn,Zn)_2(Al,Fe)_{12}O_{22}(OH)_2$	TRIG	---	Dark brown to yellow	H 8-9, G 4.08-4.51	Insol in acids.
	1.805	---	wk	KRAISSLITE $(Mn,Mg)_{24}Zn_3Fe^{+3}(AsO_3)_2(AsO_4)_3(SiO_4)_6(OH)_{18}$	HEX	0001 perf	Deep coppery brown	H 3-4, G 3.88	Brittle.
⊔ 1.82	1.806	1.808	.002	CERITE $(Ce,Ca)_9(Mg,Fe)Si_7(O,OH,F)_{28}$	TRIG	Uneven	Brown, reddish	H 5.5, G 4.75, infus	Gel with acids. Commonly biax, 2V 0-25°.

Table 4. Uniaxial positive minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Birefringence	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.81	2.02	.21	GAUDEFROYITE $Ca_4Mn^{+3}{}_{3-x}(BO_3)_3(CO_3)(O,OH)_3$	HEX pris	Pris	Black	H 6, G 3.35	Diss by HCl. Pleoc, O reddish-brown, E orange-red.
1.72 ^ v 1.878	1.81	1.86	.05	ZIRCON $ZrSiO_4$	TET pris	110 fr uneven	Brown, yellow	H 7.5, G 4.56, infus	Insol in acids. El pos. Partly metamict.
v 1.85	1.81	1.84	.03	CHROMATITE $CaCrO_4$	TET	Conch	Lemon-yellow	---	Diss by acids.
	---	---	mod	DOWNEYITE SeO_2	TET	---	Cols to yellow	G calc 4.15	Sol in H_2O, very hygroscopic. Mean _n_ calc = 1.84.
1.78 ^	1.837	1.898	.061	THORITE $(Th,U)SiO_4$	TET	110	Green, brown	H 5, G 6.63, infus	Gel with acids.
	1.842	1.848	.006	PARATACAMITE $Cu_2Cl(OH)_3$	TRIG	$10\bar{1}1$ good	Green	H 3, G 3.74, F easy	Diss by acids or NH_4OH. Tw $10\bar{1}1$, poly.
	1.85	1.93	.08	ZEMANNITE $(Zn,Fe)_2(TeO_3)_3Na_xH_{2-x}\cdot yH_2O$	HEX pris	---	Light to dark brown	Soft, G 4.36	Pleoc, E yellow-brown, O reddish brown, abs O > E.
1.81 ^	1.85	1.88	.03	CHROMATITE $CaCrO_4$	TET	Pris poor, fr conch	Lemon-yellow	---	Diss by acids.
1.77 ^	1.855	---	.03-.04	LUSUNGITE (Crandallite grp) $(Sr,Pb)_3Fe_3(PO_4)_2(OH)_5\cdot H_2O$	TRIG	---	Dark brown	---	Pleoc wk.
v 1.908	1.855	1.860	.005	BYSTROMITE $MgSb_2O_6$	TET u mass	---	Blue-gray	H 7, G 5.5 calc	Pleoc, O straw yellow, E brownish-yellow. Opt char unk.
	1.864	1.88	.016	WELINITE $(Mn^{+4},W)_{1-x}(Mn^{+2},W,Mg)_{3-y}Si(O,OH)_7$	HEX	0001 poor to dist	Red-brown to reddish black	H 4, G 4.47	Dec by HCl. Blood-red in section. Anom biax with small 2V.
1.81 ^ v 1.925	1.878	1.895	.017	ZIRCON $ZrSiO_4$	TET pris	110, fr uneven	Brown, yellow	H 7, G 4.62, infus	Insol in acids. El pos.

	1.880	1.884	.004	MORELANDITE (Apatite grp) $Ba_5(AsO_4)_3Cl$	HEX	0001 poor	Light yellow to gray	H 4.5, G 5.33	Diss by cold HNO_3.
	1.89	2.00	.11	DENNINGITE $(Mn,Zn)Te_2O_5$	TET platy	001 perf fr conch	Cols to pale green	H 4, G 5.05, F easy	Diss by cold HCl, insol in HNO_3. Anom biax, 2V 0-15°.
	1.898	1.915	.017	HUEGELITE $Pb_2(UO_2)_3(AsO_4)_2(OH)_4 \cdot 3H_2O$	MCL tab	100 good	Brown to orange-yellow	G 5.0	Diss by HNO_3. Pleoc, O yellow, E cols to pale yellow. Anom interf color.
	1.90	2.12	.22	TRIPPKEITE $CuAs_2O_4$	TET	100 perf 110 good	Bluish-green	Soft, G 4.8, F easy	Diss by acids. Breaks into flexible pieces. Bluish-green in section, not pleoc.
1.855 ^	1.908	1.915	.007	BYSTROMITE $MgSb_2O_6$	TET u mass	---	Blue-gray	H 7, G 5.5-5.7	Diss by concd HCl + KI. Opt char unk.
	1.910	1.945	.035	GANOMALITE $Pb_6(Ca,Mn)_4(Si_2O_7)_3(OH)_2$	HEX tab 0001	0001, 10$\bar{1}$0 perf	Gray	H 3, G 5.74, F 3 (?)	Gel with acids. Anom biax. Biref variable.
v 1.930	1.912	1.925	.013	SCHEELITE $CaWO_4$	TET oct or tab	101 dist	White, yellow, gray, brown	H 4.5-5, G 6.1, F 5	Dec by HCl with sepn of yellow WO_3. Fluor bright blue (purple) to yellow in UV (purple when Mo is present).
v 1.945	1.913	1.923	.010	NASONITE $Pb_6Ca_4(Si_2O_7)_3Cl_2$	HEX pris	0001, 10$\bar{1}$0 imperf	White	H 4, G 5.5, F easy	---
1.878 ^v 1.960	1.925	1.983	.058	ZIRCON $ZrSiO_4$	TET pris	110, fr uneven	Brown, cols, yellow, green, purple	H 7.5, G 4.70, infus	Insol in acids. El pos.
1.912 ^v 1.951	1.930	1.947	.017	SCHEELITE $Ca(W,Mo)O_4$	TET oct or tab	101 dist	White, brown	H 4.5-5, G 6.1, F 5	Dec by HCl with sepn of yellow WO_3. Fluor yellow in UV.
	1.94	2.16	.22	BAOTITE $Ba_4(Ti,Nb)_8Si_4O_{28}Cl$	TET	2 clvs	Light brown to black	H 6, G 4.42-4.71	Pleoc, O cols to brown, E greenish-yellow to dark red-brown.
1.913 ^	1.945	1.970	.025	NASONITE $Pb_6Ca_4(Si_2O_7)_3Cl_2$	HEX pris	0001, 10$\bar{1}$0 imperf	White	H 4, G 5.5, F easy	---
	1.948	1.958	.010	HEDYPHANE (Apatite grp) $(Pb,Ca)_5(AsO_4)_3Cl$	HEX mass, fib	2 clvs	White	H 4, G 5.7, F 1	Diss by HNO_3.
1.930 ^v 1.974	1.951	1.967	.016	POWELLITE (Scheelite ser) $Ca(Mo,W)O_4$	TET pyram	---	White, yellow	H 4, G 5.3, F 5	Dec by HCl with sepn of yellow WO_3. Data for synth. $CaMoO_4$ 60, $CaWO_4$ 40%.

Table 4. Uniaxial positive minerals (continued)

Other entries	Refractive index		Bire-fringence	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	ω	ε							
1.925 ^	1.960	2.015	.055	ZIRCON $ZrSiO_4$	TET pris	110 fr uneven	Brown, yellow, cols	H 7.5, G 4.65 infus	Insol in acids. El pos.
	1.96	---	wk	DIXENITE $Cu^{+1}Mn_{14}Fe^{+3}(AsO_3)_5(AsO_4)(SiO_4)_2(OH)_6$	TRIG plates	0001 mic	Dark brown	H 3-4, G 4.20-4.36	Dec by HCl. Glowing red in transmitted light.
	1.973Na 1.956Li	2.656Na 2.601Li	.683 .645	CALOMEL Hg_2Cl_2	TET	110 good 011 imperf sectile	Cols, gray	H 1.5, G 6.8-7.15, volat	---
1.951 ^	1.974	1.984	.010	POWELLITE (Scheelite ser) $CaMoO_4$	TET pyram	Uneven to conch	White	H 4, G 4.23, F 5	Diss by HCl. Data for synth. $CaMoO_4$. Fluor yellow in UV.
1.993 □ 2.008	2.001	2.098	.097	CASSITERITE SnO_2	TET pyram	100 imperf fr subconch to uneven	Brown, black, white	H 6-7, G 6.98-7.02, infus	Insol in acids. Tw 011 poly. Sometimes dichroic in brown.
	2.013Na 1.990Li	2.029Na 2.005Li	.016 .015	ZINCITE ZnO	HEX	$10\bar{1}0$ good $11\bar{2}0$, 0001 poor	Deep red	H 4, G 5.66, infus	Diss by acids. In section deep red, not pleoc. MnO 0.27%.
2.01 □ 2.05	2.03	---	high	VOLTZITE ZnS + Zn-salt of organic acid	HEX spherical globules	---	Yellow, brown, black	H 4-4.5, G 3.1-3.7, infus	Dec by acids, leaving an organic residue.
	>2.0	---	high	BEHIERITE $(Ta,Nb)BO_4$	TET pyram	110, 010 dist	Grayish-pink	H 7-7.5, G 7.86, infus	Insol in acids. Mean _n_ calc = 2.12.
	>>1.74	---	~.1	SCHAFARZIKITE $FeSb_2O_4$	TET pyram	110 perf 100 good	Red to reddish-brown	H 3.5, G 5.5 calc	Pleoc, O straw yellow, E brownish yellow. Mean _n_ calc = 2.10.
2.27	2.10	2.26	.16	CALZIRTITE $CaZr_3TiO_9$	TET pris	Conch	Yellow- to dark-brown	H 6-7, G 5.07, infus	Partly diss by concd acids. Not pleoc.
	2.116	2.143	.027	PHOSGENITE $Pb_2CO_3Cl_2$	TET pris tab	001, 110 dist	White, gray, yellow	H 2-3, G 6.13, F 1	Diss with eff by HNO_3. Pleoc wk, O reddish, E greenish.
	2.13	2.21	.08	PENFIELDITE $Pb_2Cl_3(OH)$	HEX pris	001 dist	White	G 5.9-6.6, F 1	Diss by HNO_3. Tw.
	>2.1	---	---	PRIDERITE $(K,Ba)(Ti,Fe)_8O_{16}$	TET pris	001 perf pris fair	Reddish-black	G 3.86, infus	Pleoc, O deep reddish-brown, E deep reddish-brown to black.

	2.15	2.275	.125	RANCIEITE $(Ca,Mn^{+2})Mn^{+4}{}_4O_9\cdot 3H_2O$	HEX (?) mass	---	Dark brown, streak purplish	Soft. G 3.3	Diss by HCl. Opt char unk.
	2.18	---	---	RUSSELLITE Bi_2WO_6	TET mass	---	Yellow	H 3.5, G 7.37	Opt char unk.
⌴ 2.21	2.18	2.19	.01	IODARGYRITE AgI	HEX thin plates	0001 perf sectile	Yellow, green, brown	H 1-1.5, G 5.6-5.7, F 1	Becomes isotropic at 146°C. Abnormal green interf colors. Anom biax, 2V small. El neg.
	2.19	2.21	.02	KLEINITE $Hg_2N(Cl,SO_4)\cdot xH_2O$	HEX short prisms	0001 easy uneven, 10$\bar{1}$0 imperf	Yellow, orange	H 3.5-4, G ~ 8, volat	Diss by acids. Uniax above 130°C, biax neg at room temp.
	2.19Li	2.21Li	.02	MACKAYITE $FeTe_2O_5(OH)$	TET	Subconch	Green to yellow-green	H 4.5, G 4.86, fus	Pleoc, O green, E yellow.
	>2.0	---	---	ORDONEZITE $ZnSb_2O_6$	TET tw	Conch	Pale to dark brown	H 6.5, G 6.64	Insol in acids. Tw pl (013). Mean *n* calc = 2.28.
	2.21	---	wk	ZAVARITSKITE BiOF	TET	---	Gray	G (9.2)	Opt sign unk.
	2.27	2.43	.16	PARATELLURITE TeO_2	TET pyram	102 perf 110 dist	Grayish-yellow	H 3, G 5.60, fus	---
˅ 2.35	2.27Li	2.42Li	.15	TAPIOLITE $Fe(Ta,Nb)_2O_6$	TET	---	Black	H 6, G 7.3-8.2, infus	Red-brown in section. Pleoc str, O yellow to reddish-brown, E nearly opaque.
2.10 ^	2.27	2.36	.09	CALZIRTITE $CaZr_3TiO_9$	TET pris	Conch	Yellow- to dark-brown	H 6-7, G 5.0, infus	Partly diss by concd acids.
2.27 ^	2.35	2.47	.12	TAPIOLITE $Fe(Ta,Nb)_2O_6$	TET	---	Black	H 6-7, G 7.49, infus	---
˅ 2.374	2.36Na 2.33Li	2.38Na 2.35Li	.02 .02	WURTZITE (Zn,Fe)S	HEX pris	11$\bar{2}$0 good 0001, 10$\bar{1}$0 poor	Brownish-black	H 3.5-4, G 3.98, F diff	Diss by acids. Pleoc wk.
	2.37Li	2.42Li	.05	FREUDENBERGITE $Na_2(Ti,Fe)_8O_{16}$	MCL ps hex	2 good	Brownish-black	G 4.3	Insol in acids. Pleoc, O dark brown, E yellow-brown.
2.36 ^˅ 2.39	2.374Li	2.395Li	.021	WURTZITE (Zn,Cd)S	HEX pris	11$\bar{2}$0 good 0001 poor	Green	H 3.5-4, G 4.44, F diss	Diss by acids. Data for 41.5 mol % CdS. Fluor yellow in UV.
2.374 ^˅ 2.50	2.39Li	2.41Li	.02	GREENOCKITE (Cd,Zn)S	HEX pris	10$\bar{1}$0 good 11$\bar{2}$0, 0001 poor	Orange	H 3-3.5, G 4.53, infus	Diss by acids. Data for 57.6 mol % CdS. Fluor orange-red in UV.

Table 4. Uniaxial positive minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Birefringence	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
2.39 ^	2.50Na 2.43Li	2.53Na 2.45Li	.024 .024	GREENOCKITE CdS	HEX pris	$10\bar{1}0$ good $11\bar{2}0$, 0001 poor	Yellow, green	H 3-3.5, G 4.9-5.0, infus	Diss by acids. Data for synth CdS.
	2.45	2.51Li	.06	DERBYLITE $Fe_4Ti_3SbO_{13}(OH)$	MCL pris	Conch	Black	H 5, G 4.53, infus	Insol in acids. Not pleoc.
	2.476	2.485	.009	CHANGBAIITE $PbNb_2O_6$	TRIG	0001 perf	Brown, yellow-brown, creamy-white	H 5-5.5, G 6.48	---
v 2.65	2.61Na 2.56Li	2.90Na 2.84Li	.287 .28	RUTILE TiO_2	TET pris	110 dist 100 less so	Brown, red, yellow	H 6-6.5, G 4.22, infus	Insol in acids. Pleoc wk, abs O < E. El pos.
2.61 ^	2.65	2.80	.15	RUTILE, var Ilmenorutile (niobian) $(Ti,Nb,Fe)O_2$	TET pris	110 dist 100 less so	Black	H 6-6.5, G 4.36, infus	Insol in acids. Pleoc wk in brown, abs O < E.
	2.65Na 2.63Li	2.69Na 2.67Li	.043 .040	MOISSANITE SiC	HEX plates 0001	Conch	Green, blue-black, black	H 9.5, G 3.22, infus	Insol in acids. Pleoc, O light blue, E deep indigo blue. Data for synth compd.
	2.85Na 2.82Li	3.20Na 3.15Li	.347Na .327Li	CINNABAR HgS	TRIG	$10\bar{1}0$ perf	Cochineal-red	H 2-2.5, G 8.09, volat	Streak scarlet. Disp very high. Circular polarization.

Table 5. Uniaxial negative minerals

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.312	1.309	.003	MALLADRITE Na_2SiF_6	TRIG	---	Cols, rose	G 2.71 F 1	Sol in hot H_2O.
	1.327	---	very wk	VILLIAUMITE NaF	CUB ps tet, u mass	001 perf	Carmine-red	H 3.5 G 2.79 F 1.5	Sol in H_2O. Pleoc, O carmine-red to pink, E yellow.
	1.349	1.342	.007	CHIOLITE $Na_5Al_3F_{14}$	TET sq prisms	001 perf 011 dist	White	H 3.5-4 G 3.00 F 1.5	Diss by acids.
	1.388	1.385	.003	COLQUIRIITE $CaLiAlF_6$	TRIG	Conch	Cols, white	H 4 G 2.94	---
	1.406	1.309	.097	BARARITE $(NH_4)_2SiF_6$	HEX	0001 perf	White	H 2.5 G 2.15 volat	Sol in H_2O.
	1.458	1.432	.026	MENDOZITE $NaAl(SO_4)_2 \cdot 11H_2O$	MCL fib	100 good	Cols	H 3 G 1.75 F 1	Sol in H_2O.
1.489	1.462	1.460	.002	CHABAZITE (Zeolite grp) $(Ca,Na)Al_2Si_4O_{12} \cdot 6H_2O$	TRIG rhombs	$10\bar{1}1$ dist	White, red	H 4.5 G 1.97 F 3	Dec by HCl with sepn of slimy silica. Anom biax.
1.491	1.464	1.458	.006	ETTRINGITE $Ca_6Al_2(SO_4)_3(OH)_{12} \cdot 26H_2O$	HEX acic	$10\bar{1}0$ perf	Cols, white	H 2-2.5 G 1.77 F 3	Diss by acids. Indices increase on dehydration.
	1.474	1.436	.038	HUMBERSTONITE $K_3Na_7Mg_2(SO_4)_6(NO_3)_2 \cdot 6H_2O$	TRIG platy 0001	0001 perf	Cols	G 2.25	Diss by H_2O. El pos.
1.485	1.474	1.470	.004	HERSCHELITE (Zeolite grp) $(Na,Ca,K)AlSi_2O_6 \cdot 3H_2O$	TRIG plates	---	White	H 4 G 2.06 F 3	Dec by acids.
1.465 1.484	1.477	1.475	.002	GMELINITE (Zeolite grp) $(Na_2,Ca)Al_2Si_4O_{12} \cdot 6H_2O$	HEX rhombs	$10\bar{1}0$ good 0001	Cols, rose	H 4.5 G 2.04 F 3	Dec by acids. Anom biax with small 2V. Tw axis c.
	1.479	1.408	.071	ZHEMCHUZHNIKOVITE $NaMg(Al,Fe)(C_2O_4)_3 \cdot 8H_2O$	TRIG acic	0001 fair	Smoky green	H 2 G 1.69 infus	An oxalate. Sol in H_2O. Pleoc, O greenish-yellow, E reddish-violet.
	1.481	1.461	.020	HANKSITE $KNa_{22}(SO_4)_9(CO_3)_2Cl$	HEX short prisms	0001 good	White	H 3-3.5 G 2.56 F 1.5	Easily sol in H_2O.

	1.487	1.484	.003	CRISTOBALITE SiO_2	TET ps cub, oct	---	Cols	H 6-7 G 2.33 infus	Insol in acids. Some samples are biax.
1.479 [ ] 1.493	1.487	1.486	.001	ANALCIME (Zeolite grp) $NaAlSi_2O_6 \cdot H_2O$	CUB, 211	001 poor	Cols, white	H 5 G 2.25 F 3.5	Dec by acids. Commonly biax. Lam tw on 001 and 110.
⊔ 1.495	1.489	1.486	.003	OFFRETITE (Zeolite grp) $(K_2,Ca)_5Al_{10}Si_{26}O_{72} \cdot 30H_2O$	HEX pris	0001	Cols, white	G 2.13 F 3	Dec by acids. El neg.
1.462 ^v 1.518	1.489	1.486	.003	CHABAZITE (Zeolite grp) $(Ca,Na)Al_2Si_4O_{12} \cdot 6H_2O$	TRIG rhombs	$10\bar{1}1$ dist	White, red	H 4.5 G 2.06 F 3	Dec by HCl with sepn of slimy silica. Anom biax.
v 1.510	1.489	1.487	.002	LEVYNE (Zeolite grp) $CaAl_2Si_4O_{12} \cdot 6H_2O$	TRIG	$02\bar{2}1$ dist	White	H 4 G 2.14 F 2-2.5	Gel with acids.
	1.490	1.471	.019	LOEWEITE $Na_{12}Mg_7(SO_4)_{13} \cdot 15H_2O$	TRIG	Conch	White, yellow	H 2.5-3 G 2.40 F 1.5	Sol in H_2O. Opt anom.
	1.490	1.476	.014	WARDSMITHITE $Ca_5MgB_{24}O_{42} \cdot 30H_2O$	HEX platy	$10\bar{1}0$ perf 0001 (?) good	White	H 2.5 G 1.88 F easy	Diss by acids.
1.464 ^	1.491	1.470	.021	ETTRINGITE $Ca_6Al_2(SO_4)_3(OH)_{12} \cdot 26H_2O$	HEX acic	---	Cols, white	H 2-2.5 G 1.77 F 3	Diss by acids. Indices increase on dehydration.
	1.492	1.475	.017	CHARLESITE $Ca_6(Al,Si)_2(SO_4)_2B(OH,O)_{16} \cdot 26H_2O$	HEX	$10\bar{1}0$ perf	Cols	H 2.5 G 1.77	---
	1.493	1.482	.011	WERMLANDITE $Ca_2Mg_{14}(Fe^{+3},Al)_4(CO_3)(OH)_{42} \cdot 14\text{-}15H_2O$	HEX	0001 perf	Greenish-gray	H 1.5 G 1.93	Diss by HCl. In part biax, 2V 3-5°.
v 1.507	1.494	1.467	.027	THAUMASITE $Ca_3Si(OH)_6(CO_3)(SO_4) \cdot 12H_2O$	HEX fib columnar	---	White	H 3.5 G 1.87 infus	Dec by acids with eff. El neg.
	1.494	1.489	.005	GOBBINSITE (Zeolite grp) $Na_4(Ca,K_2)Al_6Si_{10}O_{32} \cdot 12H_2O$	TET fib	---	White	G 2.19	El neg.
	1.495	1.460	.035	ACETAMIDE CH_3CONH_2	TRIG	Conch	Cols to grey	H 1-1.5 G 1.17 F easy	Diss by H_2O.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.490 v 1.515	1.499	1.493	.006	VISHNEVITE (Cancrinite grp) $Na_6Ca_2Al_6Si_6O_{24}(SO_4,CO_3,Cl_2)_{2-4}$	HEX	10$\bar{1}$0 perf	Cols	H 5 G 2.40 F 2	Gel with acids. SO_3 4.7, CO_2 2.2%. Some samples are isotropic, some uniax pos.
	1.502	1.449	.053	UNGEMACHITE $K_3Na_8Fe^{+3}(SO_4)_6(OH)_2 \cdot 10H_2O$	TRIG	0001 perf	Cols, pale yellow	H 2.5 G 2.29	Diss by acids. El clv pos.
	1.504	1.49	.01	NYEREREITE $(Na,K)_2Ca(CO_3)_2$	ORTH ps hex, tab	---	Cols	G 2.41-2.54 fus	Diss by acids with eff. Tw poly.
	1.505	1.486	.019	SACROFANITE (Cancrinite grp) $(Na,Ca,K)_9(Si,Al)_{12}O_{24}[(OH)_2,SO_4,CO_3,Cl_2]_3 \cdot xH_2O$	HEX	0001, 0$\bar{1}$10 perf	Cols	H 5.5-6 G 2.42	---
	1.506	1.499	.007	MAZZITE (Zeolite grp) $K_2CaMg_2(Al,Si)_{36}O_{72} \cdot 28H_2O$	HEX acic	---	Cols	G 2.11	---
	1.507	1.464	.043	MCALLISTERITE $Mg_2B_{12}O_{14}(OH)_{12} \cdot 9H_2O$	TRIG	0001, 01$\bar{1}$2 good	Cols	H 2.5 G 1.87	Diss by acids.
1.494 ^	1.507	1.468	.039	THAUMASITE $Ca_3Si(OH)_6(CO_3)(SO_4) \cdot 12H_2O$	HEX fib columnar	---	White	H 3.5 G 1.87 infus	Dec by acids with eff. El neg.
	1.507	1.502	.005	TARANAKITE $KAl_3(PO_4)_3(OH) \cdot 9H_2O$	TRIG u mass	---	White	Soft G 2.09-2.15 F easy	Diss by acids.
v 1.515	1.507	1.505	.002	GARRONITE (Zeolite grp) $Na_2Ca_5Al_{12}Si_{20}O_{64} \cdot 27H_2O$	ORTH ps tet radiating	2 at 90°	Cols	G 2.15	---
	1.510	1.486	.024	RETGERSITE $NiSO_4 \cdot 6H_2O$	TET tab	001 perf	Emerald-green	H 2.5 G 2.05	Sol in H_2O.
v 1.530	1.510	1.486	.024	FLUOBORITE $Mg_3BO_3(F,OH)_3$	HEX fib	0001 indist	White	H 3.5 G 2.96	Diff diss by acids. Comp near F end member.
1.489 ^	1.510	1.502	.008	LEVYNE (Zeolite grp) $CaAl_2Si_4O_{12} \cdot 6H_2O$	TRIG	02$\bar{2}$1 dist	White	H 4 G 2.14 F 2-2.5	Gel with acids.

⌴ 1.52	1.511	1.495	.016	HYDROTALCITE $Mg_6Al_2CO_3(OH)_{16}\cdot 4H_2O$	TRIG plates	0001 perf	White, luster pearly	H 2 G 2.06 infus	Diss by acids. El pos. Anom biax.
	1.513	1.470	.043	ARCHERITE $(K,NH_4)H_2PO_4$	TET	---	Cols	Soft G 2.23	Sol in H_2O.
	1.515	1.417	.098	STEPANOVITE $NaMgFe^{+3}(C_2O_4)_3\cdot 9H_2O$	TRIG	---	Yellow-green	H 3 G 1.61	An oxalate. Diss by H_2O. Pleoc, E cols, O yellow-green.
1.499 ^ 1.518 pos v 1.528	1.515	1.496	.019	CANCRINITE (Cancrinite grp) $Na_6Ca_2Al_6Si_6O_{24}(CO_3)_2$	HEX	$10\bar{1}0$ perf	Cols	H 5 G 2.42 F 2	Gel with acids. CO_2 7.0, SO_3 1.4, Cl 0.4%.
1.507 ^	1.515	1.512	.003	GARRONITE (Zeolite grp) $Na_2Ca_5Al_{12}Si_{20}O_{64}\cdot 27H_2O$	ORTH ps tet radiating	2 at 90°	Cols	G 2.15	---
v 1.533	1.516	1.470	.046	BEIDELLITE (Smectite grp) $(Na,Ca)_{0.33}Al_2(Si,Al)_4O_{10}(OH)_2\cdot xH_2O$	MCL u mass	001 mic	White, brown, yellow	H 1.5 G 2.6 infus	2V 0-16°. El clv pos. Indices increase on standing in certain oils.
	1.517	~1.501	~.016	MEIXNERITE $Mg_6Al_2(OH)_{18}\cdot 4H_2O$	TRIG	0001 perf	Cols	G 1.9 infus	Diss by acids.
1.489 ^	1.518	1.515	.003	CHABAZITE (Zeolite grp) $(Ca,Na)Al_2Si_4O_{12}\cdot 6H_2O$	TRIG rhombs	$10\bar{1}1$ dist	White, red	H 4.5 G 2.18 F 3	Dec by HCl with sepn of slimy silica. Anom biax.
	1.519	1.503	.016	TEEPLEITE $Na_2B(OH)_4Cl$	TET tab	Uneven	Cols	H 3-3.5 G 2.08 F 1	Diss by H_2O.
	1.52	1.51	.01	MOUNTKEITHITE $(Mg,Ni)_{11}(Fe^{+3},Cr,Al)_3(OH)_{24}(SO_4,CO_3)_{3.5}\cdot 11H_2O$	HEX	0001 perf	Pale pink to white	H soft G 2.12	Diss by acids. Pleoc pale pink to cols.
	1.520	1.512	.008	TACHYHYDRITE $CaMg_2Cl_6\cdot 12H_2O$	TRIG	$10\bar{1}1$ perf	Wax- to honey-yellow	H 2 G 1.67 F 1	Easily sol in H_2O. Deliq.
	1.521	1.517	.004	CARLETONITE $KNa_4Ca_4Si_8O_{18}(CO_3)_4(F,OH)\cdot H_2O$	TET	001 perf 110 good	Pink to blue	H 4-4.5 G 2.45	Blue var pleoc, O pale blue, E pale pinkish-brown.
	1.524	1.510	.014	MANASSEITE $Mg_6Al_2CO_3(OH)_{16}\cdot 4H_2O$	HEX foliated	0001 perf	White	H 2 G 2.05 infus	Diss by acids. El clv pos.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.520 (mean <u>n</u>)		.005-.006	VIRGILITE $Li_xAl_xSi_{3-x}O_6$ (x = 0.5 to 1.0)	HEX	---	Cols	G 2.46 calc	---
	1.525	1.459	.066	NATROFAIRCHILDITE $Na_2Ca(CO_3)_2$	ORTH (?) ps hex	One perf 001 (?)	White	H 2.5	Poly tw. In part biax. = Nyerereite (?), ω = 1.504.
	1.525	1.480	.045	BIPHOSPHAMMITE $(NH_4,K)H_2PO_4$	TET	---	White to dark brown	G 2.04 volat	Diss in H_2O.
v 1.537	1.526	1.495	.031	SLAVIKITE $NaMg_2Fe_5(SO_4)_7(OH)_6 \cdot 33H_2O$	TRIG tab	---	Yellow-green	G 1.95	Diss by acids. Pleoc, O lemon-yellow, E pale yellow to cols.
1.515 ^	1.528	1.503	.025	CANCRINITE (Cancrinite grp) $Na_6Ca_2Al_6Si_6O_{24}(CO_3)_2$	HEX	10$\bar{1}$0 perf	Cols	H 5 G 2.48 F 2	Gel with acids. El clv neg. CO_2 6.2, SO_3 0.2, Cl 0.1%.
1.510 ◇ 1.547	1.530	1.507	.023	FLUOBORITE $Mg_3BO_3(F,OH)_3$	HEX fib	0001 indist	White	H 3.5 G 2.95	Diff diss by acids. F 20.9, H_2O 3.2%.
1.528 △	1.530	1.528	.002	LIOTTITE (Cancrinite grp) $(Ca,Na,K)_8(Si,Al)_{12}O_{24}$ $(SO_4,CO_3,Cl,OH)_4 \cdot H_2O$	HEX flat prisms	---	Cols	H 5 G 2.56	SO_3 8.7, Cl 2.6, CO_2 2.1%.
v 1.539	1.531	1.527	.004	NEPHELINE $(Na,K)AlSiO_4$	HEX	10$\bar{1}$0 dist 0001 imperf	Cols	H 6 G 2.58 F 3.5	Gel with acids. Luster greasy.
v 1.546	1.532	1.522	.010	MARIALITE (Scapolite grp) $3NaAlSi_3O_8 \cdot NaCl$	TET	100 perf 110 less so	Cols	H 6 G 2.55 F 3	Insol in acids. Na_2O 7.1, CaO 6.3, K_2O 4.3, Cl 1.0, CO_2 2.0%.
1.530 □ 1.536	1.532	1.527	.005	KALIOPHILITE $KAlSiO_4$	HEX pris	10$\bar{1}$0 dist	Cols	H 6 G 2.60 F 3.5	Gel with acids.
v 1.553	1.532	1.529	.003	MILARITE (Osumilite grp) $K_2Ca_4Al_2Be_4Si_{24}O_{60} \cdot H_2O$	HEX	0001 indist	Cols, pale green, pink	H 5-5.5 G 2.57 F 3	Insol in acids. Basal section shows 6 biax segments.
	1.533	1.498	.035	FAIRCHILDITE $K_2Ca(CO_3)_2$	HEX plates	0001 good	Cols	G 2.45 F 2	Diss by acids with eff. El pos.

1.516 ^v 1.549	1.533	1.502	.031	BEIDELLITE (Smectite grp) $Na_{0.33}(Al,Fe^{+3})_2(Al,Si)_4O_{10}(OH)_2 \cdot xH_2O$	MCL u mass	001 perf	White, brown, yellow	H 1.5 G 2.6 infus	2V small. El clv pos. Fe_2O_3 8.7%.
	1.534	---	---	STRAETLINGITE $Ca_2Al_2SiO_7 \cdot 8H_2O$	TRIG	001 perf	Cols to light green	G 1.9	---
	1.534	1.514	.020	ZINCALUMINITE $Zn_6Al_6(SO_4)_2(OH)_{26} \cdot 5H_2O$	HEX or ps hex, plates	---	White	H 2.5-3 G 2.26 infus	Diss by acids. In part biax with small 2V.
v 1.554	1.535	1.531	.004	KALSILITE $(K,Na)(Al,Fe)SiO_4$	HEX	---	Cols	G 2.65 F 3.5	Gel with acids.
v 1.545	1.537	0.490	.047	SCHROECKINGERITE $NaCa_3(UO_2)(CO_3)_3(SO_4)F \cdot 10H_2O$	TCL ps hex	001	Greenish-yellow	H 2.5 G 2.54	Diss by H_2O. 2V 0-18°. Fluor yellow-green in UV.
1.526 ^	1.537	1.498	.039	SLAVIKITE $NaMg_2Fe_5(SO_4)_7(OH)_6 \cdot 33H_2O$	TRIG tab	---	Yellow-green	G 1.45	Diss by acids. Pleoc, O lemon-yellow, E pale yellow to cols.
	1.538	1.535	.003	INDIALITE $Mg_2Al_4Si_5O_{18}$	HEX	---	Cols to blue	H 6-7 G 2.6 infus	Insol in acids. Dimorph with Cordierite.
1.531 ^v 1.546	1.539	1.536	.003	NEPHELINE $(Na,K)AlSiO_4$	HEX	$10\bar{1}0$ dist 0001 imperf	Cols	H 6 G 2.60 F 3.5	Gel with acids. Luster greasy. K_2O 5.7, CaO 1.45%.
v 1.562	1.540	1.510	.030	BRUGNATELLITE $Mg_6FeCO_3(OH)_{13} \cdot 4H_2O$	HEX tab 0001	0001 mic	White, brownish	H 2 G 2.14 infus	Diss by acids. El pos. Pleoc, O yellow-red, E cols.
	1.540	1.512	.028	MELLITE (aluminum mellitate) $Al_2[C_6(COO)_6] \cdot 16H_2O$	TET	011 indist	Honey-yellow, white	H 2-2.5 G 1.64	Diss by HNO_3, dec by hot H_2O. In part biax with small 2V. Pleoc wk, E cols, O pale yellow.
	1.540	1.535	.005	TETRAKALSILITE $(K,Na)AlSiO_4$	HEX	---	Cols	G 2.59 F 3.5	Gel with acids.
v 1.560	1.540	1.517	.023	VERMICULITE $(Mg,Fe,Al)_3(Al,Si)_4O_{10}(OH)_2 \cdot 4H_2O$	MCL ps hex	001 mic	Green, white	H 1.5 G 2.3	Dec by acids. Exfoliates when heated. El clv pos.
	1.542	1.533	.009	IOWAITE $Mg_4Fe^{+3}(OH)_8OCl \cdot 2\text{-}4H_2O$	HEX	0001 perf	Bluish-green	H 1.5 G 2.11	Diss by acids. Anom biax. El clv pos.
1.537 ^	1.545	1.496	.049	SCHROECKINGERITE $NaCa_3(UO_2)(CO_3)_3(SO_4)F \cdot 10H_2O$	TCL ps hex	001	Greenish-yellow	H 2.5 G 2.55	Diss by H_2O. 2V 0-18°. Fluor yellow-green in UV.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.542 □ 1.553	1.545	1.518	.027	STICHTITE $Mg_6Cr_2CO_3(OH)_{16}\cdot 4H_2O$	TRIG plates 0001	0001 perf	Lilac	H 1.5-2 G 2.16 infus	Diss by acids. Anom biax. El pos. Pleoc wk, abs O > E.
1.532 ◊ 1.561	1.546	1.542	.004	MARIALITE (Scapolite grp) $3NaAlSi_3O_8\cdot NaCl$	TET	100 perf 110 less so	Cols	H 6 G 2.62 F 3	Insol in acids. Na_2O 10.5, CaO 4.8, K_2O 1.2, Cl 3.0, CO_2 1.1% (Me_{19}).
1.539 ^	1.546	1.542	.004	NEPHELINE $(Na,K)AlSiO_4$	HEX	10$\bar{1}$0 dist 0001 imperf	Cols	H 6 G 2.65 F 3.5	Gel with acids. Luster greasy. K_2O 8.7, CaO 3.7%.
1.530 ◊ 1.570	1.547	1.522	.025	FLUOBORITE $Mg_3BO_3(F,OH)_3$	HEX fib	0001 indist	White	H 3.5 G 2.92	Diff diss by acids. F 17.6%.
1.545 □ 1.549	1.547	1.536	.011	GYROLITE $Ca_2Si_3O_7(OH)_2\cdot H_2O$	HEX fib	0001 mic	White	H 3-4 G 2.39 F diff	Dec by acids. El clv pos.
1.533 ◊ 1.585	1.549	1.517	.032	BEIDELLITE (Smectite grp) $Na_{0.33}(Al,Fe)_2(Al,Si)_4O_{10}(OH)_2\cdot xH_2O$	MCL u mass	001 mic	Brown, yellow	H 1.5 G 2.6 infus	2V small. El clv pos.
	1.549	1.522	.027	TRUSCOTTITE $(Ca,Mn)_{14}Si_{24}O_{58}(OH)_8\cdot 2H_2O$	HEX	One mic	White	G 2.47	Dec by HCl. Commonly biax, 2V small.
	1.550	1.495	.055	ANTARCTICITE $CaCl_2\cdot 6H_2O$	TRIG	0001 and pris, perf	Cols	G 1.7	Readily sol in H_2O.
v 1.570	1.550	1.522	.028	TAENIOLITE (Mica grp) $KLiMg_2Si_4O_{10}F_2$	MCL ps hex	001 perf	Cols, yellowish	H 3 G 2.82 F 3	Nearly insol in acids. Biax, 2V small. El clv pos.
1.532 ^	1.553	1.549	.004	MILARITE (Osumilite grp) $K_2Ca_2Al_2Be_4Si_{24}O_{60}\cdot H_2O$	HEX	0001 indist	Cols, pale green, pink	H 5.5-6 G 2.57 F 3	Insol in acids. Basal section may show 6 biax segments.
1.535 ^	1.554	1.550	.004	KALSILITE $(K,Na)(Al,Fe)SiO_4$	HEX	---	Cols	G 2.66 F 3.5	Gel with acids.
	1.556	1.540	.016	JOURAVSKITE $Ca_3Mn^{+4}(SO_4,CO_3)_2(OH)_6\cdot 12H_2O$	HEX	Pris, good	Greenish-yellow, orange	H 2.5 G 1.95	In section bright yellow, pleoc wk. Abnormal interf colors.

	1.557	1.529	.028	BARBERTONITE $Mg_6Cr_2CO_3(OH)_{16}\cdot 4H_2O$	HEX u mass	0001 perf	Lilac, rose-pink	H 1.5-2 G 2.10 infus	Diss by acids.
v 1.592	1.559	---	wk to med	MERRIHUEITE (Osumilite grp) $(K,Na)_2(Fe^{+2},Mg)_5Si_{12}O_{30}$	HEX	---	---	G 2.87 calc	Opt char unk. FeO 10.5%.
	1.559	1.557	.002	HOLTEDAHLITE $Mg_2PO_4(OH)$	HEX	---	Cols	H 4.5-5 G 2.94	---
	1.560	1.507	.053	CHLORALUMINITE $AlCl_3\cdot 6H_2O$	TRIG	---	Cols to yellowish	---	Sol in H_2O. Deliq.
v 1.593	1.560	1.540	.020	SAPONITE (Smectite grp) $(Na,Ca)_{0.33}(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2\cdot 4H_2O$	MCL ps hex	001 perf	White, green	H 1-2 G 2.26 F diff	U biax, 2V small. El clv pos. Al_2O_3 7.2, Fe_2O_3 1.0%.
1.540 ^v 1.583	1.560	1.540	.020	VERMICULITE $(Mg,Fe,Al)_3(Al,Si)_4O_{10}(OH)_2\cdot 4H_2O$	MCL ps hex	001 mic	Green	H 1.5 G 2.3	Dec by HCl. Exfoliates when heated. El clv pos. Fe_2O_3 4.2, FeO 1.8%.
v 1.572	1.560	1.545	.015	PYROAURITE $Mg_6Fe_2CO_3(OH)_{16}\cdot 4H_2O$	TRIG tab 0001 fib	0001 mic	White, yellowish	H 2.5 G 2.12 infus	Diss by acids. El pos. Pleoc, O yellow-red, E cols. Dimorph with Sjögrenite.
1.546 ^v 1.574	1.561	1.546	.015	SCAPOLITE (Scapolite grp) $3NaAlSi_3O_8\cdot NaCl$ - $3CaAl_2Si_2O_8\cdot CaCO_3$	TET	100 perf 110 less so	Cols, brown	H 6 G 2.63 F 3	Insol in acids. Na_2O 8.6, CaO 8.3, K_2O 1.1, Cl 2.2, CO_2 1.7, SO_3 0.4% (Me_{33}).
v 1.578	1.561	1.549	.012	LOVOZERITE $Na_3ZrSi_6(O,OH)_{18}$	TRIG	Uneven to conch	Dark brown to black	H 5 G 2.64 F 2	Insol in acids. Tw.
1.540 ^	1.562	1.543	.019	BRUGNATELLITE $Mg_6(Fe,Cr)CO_3(OH)_{13}\cdot 4H_2O$	HEX tab 0001	0001 mic	Brown	H 2 G 2.1 infus	Diss by acids. Cr_2O_3 4.9-6.2%.
v 1.584	1.564	1.535	.029	PHLOGOPITE (Mica grp) $K(Mg,Fe)_3AlSi_3O_{10}(F,OH)_2$	MCL ps hex, platy	001 perf	Yellow, brown	H 2-2.5 G 2.75 F diff	Insol in acids. 2V 0-10°. El pos.
	1.565	1.535	.030	ZAKHAROVITE $Na_4(Mn,Fe)_5Si_{10}O_{24}(OH)_6\cdot 5H_2O$	TRIG	0001 perf conch	Yellow	H 2 G 2.61	Strongly electromagnetic.
	1.565	1.560	.005	ZEOPHYLLITE $Ca_4Si_3O_8(OH,F)_4\cdot 2H_2O$	TCL ps trig	001 perf	Cols, white	H 3 G 2.76 F 2	Gel with acids. Biax, 2V 0-27°. El clv pos.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.567	1.566	.001	BRANNOCKITE (Osumilite grp) $KLi_3Sn_2Si_{12}O_{30}$	HEX	---	---	G 2.98	Fluor bluish white in UV. K_2O 3.7-4.5, Li_2O 3.75, SnO_2 28.2%.
	1.568	1.563	.005	REYERITE $(Na,K)_4Ca_{14}(Si,Al)_{24}O_{60}$ $(OH)_5 \cdot 5H_2O$	trig radiating	0001 perf	Cols	G 2.55	Dec by HCl. El clv pos.
v 1.576	1.568	1.564	.004	BERYL $Be_3Al_2Si_6O_{18}$	HEX pris	0001 imperf	Green, blue, cols	H 8 G 2.66 infus	Insol in acids. Pleoc variable. El neg. Data for nearly alkali-free mineral.
	1.569	1.547	.022	DESAUTELSITE $Mg_6Mn^{+3}{}_2(CO_3)(OH)_{16} \cdot 4H_2O$	TRIG tab	0001 perf	Orange	G 2.13	Diss by acids.
	1.569	1.549	.020	KALISTRONTITE $K_2Sr(SO_4)_2$	TRIG	0001 perf	Cols	H 2 G 3.20	Dec by dil acids.
	1.57(?)	---	wk	LAWRENCITE $(Fe,Ni)Cl_2$	HEX tab	0001 imperf	Green, brown	G 3.16	A meteorite mineral. Diss in H_2O. Alters readily. El pos.
1.547 ^	1.570	1.534	.036	FLUOBORITE $Mg_3BO_3(F,OH)_2$	HEX fib	0001 indist	White	H 3.5 G 2.8	Diff diss by acids. F 14.8%.
1.550 ^	1.570	1.540	.030	TAENIOLITE (Mica grp) $KLiMg_2Si_4O_{10}F_2$	MCL ps hex	001 perf	Brown	H 3 G 2.82 F 3	Nearly insol in acids. Biax, 2V ~ 5°. El clv pos. TiO_2 2.0, FeO 1.9%.
	1.570	1.564	.006	CESANITE $Ca_2Na_3(SO_4)_3(OH)$	HEX	---	Cols	H 2-3 G 2.79	---
1.560 ^	1.572	1.549	.023	PYROAURITE $Mg_6Fe_2CO_3(OH)_{16} \cdot 4H_2O$	TRIG tab 0001	0001 mic	White, yellow	H 2.5 G 2.12 infus	Diss by acids. El pos. Pleoc, O yellow-red, E cols. Dimorph with Sjögrenite.
	1.573	1.572	.001	STEACYITE $Th(Ca,Na)_2K_{1-x}Si_8O_{20}$ (x = 0.2-0.4)	TET	---	Dark brown	H 5 G (3.02)	---
	1.573	1.550	.023	SJÖGRENITE $Mg_6Fe_2CO_3(OH)_{16} \cdot 4H_2O$	HEX plates	0001 perf	Yellowish	H 2.5 G 2.11 infus	Diss by acids. El pos. Dimorph with Pyroaurite.

v 1.609	1.573	1.572	.001	EKANITE $(Th,U)(Ca,Fe,Pb)_2Si_8O_{20}$	TET	---	Cols, green, brown	G 3.3	---
	1.574	1.547	.027	PORTLANDITE $Ca(OH)_2$	HEX	0001 perf	Cols	H 2 G 2.23 infus	Diss by acids. El clv pos. Luster pearly.
1.561 ◇ 1.587	1.574	1.549	.025	SCAPOLITE (Scapolite grp) $3NaAlSi_3O_8 \cdot NaCl$ - $3CaAl_2Si_2O_8 \cdot CaCO_3$	TET	100 perf 110 less so	Cols, brown	H 5-6 G 2.68 F 4	Insol in acids. Na_2O 5.4, CaO 12.5, K_2O 1.0, CO_2 2.9, Cl 1.4%.
	1.574	1.552	.022	Unnamed P analogue of Troegerite (Autunite grp) $(UO_2)_3(PO_4)_2 \cdot 8H_2O$	TET	001 perf	Yellow to greenish	H 3 G 3.76	Diss by acids. El clv pos.
1.571 ⊓	1.574	1.559	.015	SALEEITE (Autunite grp) $Mg(UO_2)_2(PO_4)_2 \cdot 10H_2O$	MCL ps tet tab	001 perf	Yellow	H 2-3 G 3.27	Diss by acids. El pos. Pleoc, O pale yellow, E cols. Fluor yellow in UV. Biax in part.
□	1.575	1.57	.005	CALCIOFERRITE $Ca_2Fe_2(PO_4)_3(OH) \cdot 7H_2O$	MCL scales, nodules	0001 perf	Yellow-green	H 2.5 G 2.53 F easy	Diss by HCl. El clv pos.
v 1.586	1.575	1.572	.003	AUTUNITE (Autunite grp) $Ca(UO_2)_2(PO_4)_2 \cdot 10\text{-}12H_2O$	TET tab	001 perf 100 indist	Yellow to yellow-green	H 2-2.5 G 3.2 F 3	Diss by acids. Fluor yellow in UV. U biax, 2V 0-30°. El pos.
	1.576	1.546	.030	PARSETTENSITE $(K,Na,Ca)(Mn,Al)_7Si_8O_{20}(OH)_8 \cdot 2H_2O$ (?)	MCL ps hex	001	Copper-red	G 2.59-2.68 fus	Dec by hot HCl. Pleoc, O greenish-yellow, E cols.
1.568 ◇ 1.584	1.576	1.573	.003	BERYL $Be_3Al_2Si_6O_{18}$	HEX pris	0001 imperf	Pale green	H 8 G 2.71 infus	Insol in acids. El neg. Pleoc variable. Fe_2O_3 0.7, total alkalies 0.7%.
1.561 ^	1.578	1.538	.040	LOVOZERITE $Na_3ZrSi_6(O,OH)_{18}$	TRIG	Uneven to conch	Dark brown to black	H 5 G 2.63 F 2	Insol in acids. Tw.
	1.578	1.548	.030	NOVACEKITE (Autunite grp) $Mg(UO_2)_2(AsO_4)_2 \cdot 12H_2O$	TET tab	001 perf 100 dist	Yellow	H 2-2.5 G 3.23	Diss by acids. Fluor yellow in UV. Commonly biax, 2V 0-40°.
	1.578	1.559	.019	SODIUM AUTUNITE (Autunite grp) $Na_2(UO_2)_2(PO_4)_2 \cdot 8H_2O$	TET plates	001 perf 100 less so	Lemon-yellow	H 2-2.5 G 3.58	Diss by acids. El clv pos. Pleoc, O light yellow, E pale yellow. Fluor yellow-green in UV.
	1.578	1.577	.001	ARCTITE $Na_2Ca_4(PO_4)_3F$	TRIG	001 perf	Cols	H 5 G 3.13	Diss by acids.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.579	1.577	.002	CLINOCHLORE, var Penninite (Chlorite grp) $(Mg,Fe)_5Al(Si,Al)_4O_{10}(OH)_8$	MCL ps trig, plates	001 perf	Green, brown, cols	H 2 G 2.7 F diff	Dec by H_2SO_4. Biax, 2V small. El clv pos. Pleoc, O green, E nearly cols. Abnormal blue interf colors.
	---	1.577	very low	NAMUWITE $(Zn,Cu)_4(SO_4)(OH)_6 \cdot 4H_2O$	HEX	001 perf	Pale sea- green	G 2.77	Opt sign unk.
	1.580	1.575	.005	DARAPIOSITE (Osumilite grp) $KNa_2Li(Mn,Zn)_2ZrSi_{12}O_{30}$	HEX	---	---	H 5 G 2.92	Na_2O 3.0, K_2O 5.1, ZrO_2 5.0, MnO 8.2, ZnO 7.8%.
	1.580	1.485	.095	BERBORITE $Be_2(BO_3)(OH,F) \cdot H_2O$	TRIG	0001 perf	Cols	H 3 G 2.20 infus	Insol in acids. El clv pos.
	1.580	1.550	.030	ZINNWALDITE (Mica grp) $KLiFe^{+2}AlSi_3AlO_{10}(F,OH)_2$	MCL ps trig	001 perf	Brown	H 2.5-4 G 3.01 F 2.5	Insol in acids. 2V 0-30°.
	1.581	---	---	META-ANKOLEITE (Meta-autunite grp) $(K_2,Ba,Ca)(UO_2)_2(PO_4)_2 \cdot 6H_2O$	TET thin plates	001 perf 100 dist	Yellow	G 3.54	Diss by acids. El pos. Fluor yellow-green in UV.
	1.582	1.564	.018	SABUGALITE (Autunite grp) $HAl(UO_2)_4(PO_4)_4 \cdot 16H_2O$	TET plates	001 perf	Yellow	H 2.5 G 3.20	Diss by acids. El clv pos. Fluor bright yellow in UV. Commonly biax, 2V 0°-med.
1.576 1.603	1.583	1.554	.029	STILPNOMELANE $K(Fe^{+2},Mg,Fe^{+3},Al)_{10}Si_{12}O_{30}(O,OH)_{12}$	MCL and TCL ps hex	001 mic	Brown	H 3.5 G 2.74 F 3.5	Dec by acids. El clv pos. Pleoc, E pale yellow, O green. FeO 26.7, Fe_2O_3 2.1%.
1.560 1.607	1.583	1.564	.019	VERMICULITE $(Mg,Fe)_3(Al,Si)_4O_{10}(OH)_2 \cdot 4H_2O$	MCL ps hex	001 mic	Green	H 1.5 G 2.67	Dec by HCl. Exfoliates when heated. El clv pos. Fe_2O_3 6.2, FeO 2.6, MgO 27.3%.
1.599	1.584	1.545	.039	TALC $Mg_3Si_4O_{10}(OH,F)_2$	TCL ps hex	001 perf	White to green	H 1 G 2.7 infus	Tric analogue of monoclinic Talc. 2V 0-10°. Pearly luster, greasy feel. El clv pos.
1.564 1.598	1.584	1.555	.029	PHLOGOPITE (Biotite ser, Mica grp) $K(Mg,Fe)_3Si_3AlO_{10}(F,OH)_2$	MCL ps hex, plates	001 perf	Brown	H 2-2.5 G 2.86 F diff	Insol in acids. 2V 0-30°. El pos. FeO 4.2, Fe_2O_3 3.7%.

1.576 ◇ 1.595	1.584	1.577	.007	BERYL $Be_3Al_2Si_6O_{18}$	HEX pris	0001 imperf	Azure-blue, green	H 8 G 2.72 infus	Insol in acids. El neg. Pleoc variable. Data for mineral with 1-2% alkalies.
1.549 ^	1.585	1.559	.026	BEIDELLITE (Smectite grp) $Na_{0.33}(Al,Fe)_2(Al,Si)_4O_{10}(OH)_2 \cdot xH_2O$	MCL u mass	001 mic	Brown	H 1.5 G 2.7 infus	Biax, 2V 0-30°. El clv pos.
v 1.600	1.586	1.559	.027	GLAUCONITE, var Skolite (Mica grp) $(K,Na)(Al,Fe,Mg)_2(Si,Al)_4O_{10}(OH)_2$	MCL ps hex	001 perf	Cols, blue, green	H 2 G 2.6 fus	Dec by acids. 2V small. El clv pos. Fe_2O_3 6.4, Al_2O_3 18.2, FeO 2.6%.
⊓⊔	1.586	1.560	.026	URANOSPINITE (Autunite grp) $Ca(UO_2)_2(AsO_4)_2 \cdot 10H_2O$	TET	001 perf	Yellow	H 2-3 G 3.45 fus	Diss by acids. Commonly biax. El clv pos. Pleoc, O pale yellow, E cols. Fluor bright yellow in UV.
1.575 ^	1.586	1.578	.008	AUTUNITE (Autunite grp) $Ca(UO_2)_2(PO_4)_2 \cdot 10H_2O$	TET tab	001 perf	Yellow to yellow-green	H 2-2.5 G 3.2 F 3	Diss by acids. Commonly biax, 2V 0-30°. El clv pos. Fluor yellow in UV.
	1.587	1.336	.251	NITRATITE (Soda niter) $NaNO_3$	TRIG	$10\bar{1}1$ perf	White	H 1.5-2 G 2.27 F 1	Sol in H_2O. Taste cooling. Deflagrates when heated.
1.574 ◇ 1.607	1.587	1.555	.032	MEIONITE (Scapolite grp) $3CaAl_2Si_2O_8 \cdot CaCO_3$ - $3NaAlSi_3O_8 \cdot NaCl$	TET	100 perf 110 less so	Cols to brown	H 5-6 G 2.70 F 4-5	Insol in acids. CaO 15.8, Na_2O 2.4, K_2O 2.4, SO_3 0.9, CO_2 2.9% (Me_{70}).
	1.587	1.570	.017	SHAFRANOVSKITE $(Na,K)_6(Mn,Fe)_3Si_9O_{24} \cdot 6H_2O$	TRIG	0001 perf	Dark green	H 2-3 G 2.77	Magnetic.
v 1.606	1.588	1.560	.028	COALINGITE $Mg_{10}Fe_2CO_3(OH)_{24} \cdot 2H_2O$	TRIG plates	0001	Reddish-brown	G 2.33 infus	Diss by acids. Pleoc, O golden-brown, E cols. Anom biax, 2V 5-20°. El clv pos.
v 1.619	1.589	1.583	.006	KAEMMERERITE (Chlorite grp) $(Mg,Al,Cr)_6(Si_3Al)O_{10}(OH)_8$	MCL ps hex	001 perf	Rose, lilac	H 2.5 G 2.72 F diff	Insol in HCl. El clv pos. FeO 2.0, Cr_2O_3 7.9%. 2V 0-8°.
⊔ 1.594	1.590	1.543	.047	MONOHYDROCALCITE $CaCO_3 \cdot H_2O$	HEX	---	White	Infus	Diss by acids with eff.
	1.59	1.56	.03	"CONNARITE" $(Mg,Ni)_3Si_2O_5(OH)_4$ (?)	MCL ps hex (?)	001 perf	Yellow-green	H 2.5-3 G 2.5 infus	Pleoc wk. El clv pos (interlayered vermiculite-chlorite).
	1.590	1.585	.005	IRAQUITE $(K,Ce,La,Th)(Ca,La,Na)_2Si_8O_{20}$	TET	2 good fr uneven	Pale greenish yellow	H 4.5 G 3.27	In part biax, 2V up to 7°. Compare Ekanite.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.588 □ 1.596	1.591	1.573	.018	METAVOLTINE $K_2Na_6Fe^{+2}{}_2Fe^{+3}{}_6(SO_4)_{12}O_2\cdot 18H_2O$	HEX scales	0001 perf	Yellow-brown, greenish-brown	H 2.5 G 2.53 F 5	Dec by hot H_2O, diss by acids. El clv pos. Pleoc, O yellow, E pale yellow.
1.559 ^	1.592	---	wk to med	MERRIHUEITE (Osumilite grp) $(K,Na)_2(Fe^{+2},Mg)_5Si_{12}O_{80}$	HEX	---	---	---	Opt char unk. MgO 4.4, FeO 29.7%.
	1.592	1.582	.010	TORBERNITE (Autunite grp) $Cu(UO_2)_2(PO_4)_2\cdot 10\text{-}12H_2O$	TET tab	001 perf 100 indist	Green	H 2-2.5 G 3.22 F 3	Diss by acids. El clv pos. Pleoc, E pale green, O dark green to blue. Not fluor in UV.
1.560 ^	1.593	1.573	.020	SAPONITE (Smectite grp) $Na_{0.33}(Mg,Fe,Fe^{+3})_3(Si,Al)_4O_{10}(OH)_2\cdot 4H_2O$	MCL ps hex	001 perf	White, green	H 1-2 G 2.39 F 4	U biax, 2V small. Fe_2O_3 19.9, FeO 5.3, Al_2O_3 5.7%.
	1.593	1.585	.008	MACHATSCHKIITE $(Ca,Na)_6(AsO_4)(AsO_3OH)_3(PO_4,SO_4)\cdot 15H_2O$	TRIG	Conch	Cols	H 2-3 G 2.5-2.6	Diss by acids.
v 1.605	1.595	1.455	.140	BUETSCHLIITE $K_2Ca(CO_3)_2$	TRIG	---	Cols	G 2.60	Dec by acids with eff.
1.584 ◊ 1.608	1.595	1.587	.008	BERYL $Cs_x[Al_{2-x}Li_x]Be_3Si_6O_{18}$	HEX pris	0001 imperf	Pink	H 8 G 2.79 infus	Insol in acids. El neg. Na_2O 1.6, Li_2O 1.7, $(Cs,Rb,K)_2O$ 1.7%.
	1.595	1.589	.006	WENKITE $Ba_4Ca_6(Si,Al)_{20}O_{39}(OH)_2(SO_4)_3\cdot xH_2O$ (?)	HEX pris	Pris, poor	White, gray	H 6 G 3.19	In part biax, 2V 0-10°. Cancrinite grp?
	1.597	1.570	.027	ABERNATHYITE (Meta-autunite grp) $K_2(UO_2)_2(AsO_4)_2\cdot 4H_2O$	TET tab	001 perf	Yellow	H 2-3 G 3.74	Diss by acids. El pos. Pleoc, O yellow, E pale yellow. Fluor yellow-green in UV. In part biax.
1.584 ◊ 1.640	1.598	1.558	.040	BIOTITE (Mica grp) $K(Mg,Fe)_3(Al,Fe)Si_3O_{10}(OH,F)_2$	MCL ps hex, plates	001 mic	Dark brown to green	H 2-2.5 G 2.95 F 3-4	2V 0-13°. El pos. FeO 13.85, Fe_2O_3 2.1, MnO 0.4%.
	1.598	1.598	<.001	COMBEITE $Na_2Ca_2Si_3O_9$	TRIG pris	---	Cols	G 2.84	Gel with hot HCl.

1.584 ^	1.599	1.554	.045	TALC $(Mg,Fe)_3Si_4O_{10}(OH)_2$	TCL ps hex	001 perf	Green	H 1 G 2.87 infus	Insol in acids. 2V 0-28°. El clv pos. Luster pearly. FeO 13.4, Fe_2O_3 1.7%.
1.586 ≎ 1.618	1.600	1.585	.015	GLAUCONITE (Mica grp) $(K,Na)(Al,Fe,Mg)_2(Si,Al)_4O_{10}(OH)_2$	MCL ps hex	001 perf	Green, blue, cols	H 2 G 2.59 fus	Dec by acids. 2V 0-10°. El clv pos. Fe_2O_3 14.1, Al_2O_3 8.9, FeO 1.6%.
v 1.611	1.600	1.598	.002	META-AUTUNITE (Meta-autunite grp) $Ca(UO_2)_2(PO_4)_2\cdot 6H_2O$	TET tab	001 perf	Yellow to greenish-yellow	H 2-2.5 G 3.5 F 3	Diss by acids. El clv pos. Commonly biax, 2V small. Fluor yellow-green in UV.
	1.601	1.480	.121	GRIMSELITE $K_2Na(UO_2)(CO_3)_3\cdot H_2O$	HEX prism	Conch	Yellow	H 2-2.5 G 3.30	Sol in H_2O. Pleoc, O yellow, E nearly cols.
	1.601	1.591	.010	DAVISONITE $Ca_3Al(PO_4)_2(OH)_3\cdot H_2O$	HEX fib, botryoidal crusts	0001 perf	Cols, white	H 4.5 G 2.85	Diss by acids. El clv pos.
1.598 ⊓	1.602	1.594	.008	TAKOVITE $Ni_6Al_2(OH)_{16}(CO_3,OH)\cdot 4H_2O$	TRIG	---	Yellow-green to blue-green	G 2.80 infus	Diss by acids. Compare Hydrotalcite.
1.583 ≎ 1.634	1.603	1.555	.048	STILPNOMELANE $K(Fe^{+2},Mg,Fe^{+3})_{10}Si_{12}O_{30}(O,OH)_{12}$	MCL and TCL ps hex	001 mic	Brown	H 3.5 G 2.80 F 3.5	Dec by acids. Pleoc, E pale yellow, O deep olive-brown. El pos. FeO 21.6, MnO 1.4, Fe_2O_3 6.4%.
v 1.622	1.603	1.598	.005	CARBONATE-HYDROXYLAPATITE (Apatite grp) $Ca_5(PO_4,CO_3)_3(OH,F)$	HEX u mass	---	Cols, gray, brown	H 5 G 2.9 F diff	Diss by HCl with slight eff. CO_2 3.4, SO_3 0.4, H_2O 3.9%.
	1.605	1.450	.155	EITELITE $Na_2Mg(CO_3)_2$	TRIG	0001	Cols	---	Dec by HCl with eff.
1.595 ^	1.605	1.453	.152	BUETSCHLIITE $K_2Ca(CO_3)_2$	TRIG	---	Cols	G 2.60	Dec by HCl with eff.
	1.605	1.574	.031	HEINRICHITE (Autunite grp) $Ba(UO_2)_2(AsO_4)_2\cdot 10\text{-}12H_2O$	TET	001 perf 100 dist	Yellow to green	H 2.5	Diss by acids. Pleoc, O pale yellow, E cols. In part biax, 2V 0-20°. Fluor green to greenish-yellow in UV.
	1.606	1.608	.002	SOGDIANITE (Osumilite grp) $(K,Na)_2Li_2(Li,Fe^{+3},Al)_2ZrSi_{12}O_{30}$	HEX	---	Violet	H 7 G 2.90	ZrO_2 9.8, TiO_2 2.9, FeO 1.2, Fe_2O_3 4.6, Na_2O 2.8, K_2O 4.8, Li_2O 3.7%. Opt sign pos by indices.
1.588 ≎ 1.634	1.606	1.575	.031	COALINGITE $Mg_{10}Fe_2CO_3(OH)_{24}\cdot 2H_2O$	TRIG platy	0001	Reddish-brown	G 2.32 infus	Diss by acids. El pos. Pleoc, O golden-brown, E cols. Anom biax, 2V 5-20°.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
˅ 1.630	1.606	1.602	.004	EUDIALYTE $Na_4(Ca,Ce)_2(Fe^{+2},Mn^{+2})ZrSi_8O_{22}(OH,Cl)_2$	TRIG	0001 dist $10\overline{1}0$ poor	Yellow, pink, brown	H 5-5.5 G 2.85 F 3	Gel with acids. Pleoc wk in pink and yellow. Anom biax. Also uniax pos.
1.583 ˄˅ 1.648	1.607	1.560	.047	VERMICULITE $(Mg,Fe,Al)_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$	MCL ps hex	001 perf	Green, brown	H 1.5 G 2.77 F 5	Dec by HCl. El clv pos. Exfoliates when heated. Fe_2O_3 4.5%.
1.587 ˄	1.607	1.571	.036	MEIONITE (Scapolite grp) $3CaAl_2Si_2O_8 \cdot CaCO_3$ - $3NaAlSi_3O_8 \cdot NaCl$	TET	100 perf 110 less so	Cols to brown	H 5-6 G 2.7 F 4-5	Insol in acids (Me_{84}).
[ ]	1.607	1.602	.005	JAMBORITE $(Ni^{+2},Ni^{+3},Co,Fe)(OH)_2(OH,S,H_2O)$ (?)	HEX fib, platy	---	Green	G 2.67 infus	Slowly diss by cold HCl.
˅ 1.623	1.607	1.604	.003	WHITLOCKITE, carbonatian, var Martinite $Ca_9(Mg,Fe)H(PO_4,CO_3)_7$	TRIG u mass	---	Cols	H 5 G 3.12 infus	Diss by acids.
1.595 ˄	1.608	1.599	.009	BERYL $Cs_x[Al_{2-x}(Li,Fe)_x](Be_{3-x}Fe_x)Si_6O_{18}$	HEX pris	0001 imperf	Blue-green	H 8 G 2.92 infus	Insol in acids. El neg. FeO 2.2, Fe_2O_3 2.0. Total alkalies 8.2%.
	1.608	1.606	.002	SOGDIANITE (Osumilite grp) $(K,Na)_2Li_2(Li,Fe^{+3},Al)_2ZrSi_{12}O_{30}$	HEX	0001 perf	Violet	H 7 G 2.90	---
	1.609	1.596	.013	HILAIRITE $Na_2ZrSi_3O_9 \cdot 3H_2O$	TRIG	Conch	Pale brown	H > 4 G 2.72	Slightly attacked by HCl at room temp.
1.573 ˄	1.609	1.604	.005	EKANITE $(Th,U)(Ca,Fe,Pb)_2Si_8O_{20}$	TET	---	Green, brown, cols	G 3.3	---
	1.610	1.605	.005	ZIRSINALITE $Na_6(Ca,Mn,Fe)ZrSi_6O_{18}$	TRIG	Uneven to conch	Cols	H 5 G 2.90 F 3	Dec by warm HCl.
	1.610	1.607	.003	SUGILITE (Osumilite grp) $(K,Na)(Na,Fe)_2(Li,Fe)Si_{12}O_{30}$	HEX	0001 poor	Light brownish-yellow	H 6-6.5 G 2.74	---

	1.611	1.592	.019	MELIPHANITE $(Ca,Na)_2Be(Si,Al)_2(O,F)_7$	TET pyram	001 perf	Yellow	H 5-6 G 3.01 fus	Insol in acids. Anom biax. El clv pos.
1.600 ^	1.611	1.594	.017	META-AUTUNITE (Meta-autunite grp) $Ca(UO_2)_2(PO_4)_2 \cdot 6H_2O$	TET tab	001 perf	Yellow to greenish	H 2-2.5 G 3.5 F 3	Diss by acids. Fluor yellow-green in UV. Commonly biax neg, 2V small.
	1.612	1.585	.027	SODIUM URANOSPINITE (Meta-autunite grp) $(Na_2,Ca)(UO_2)_2(AsO_4)_2 \cdot 5H_2O$	TET tab, fib	001 perf 010, 100 dist	Yellow, yellow-green	H 2.5 G 3.85	Diss by acids. Fluor yellow-green in UV. Anom biax. Pleoc, E cols, O yellowish.
1.610 □ 1.616	1.613	1.585	.028	ZEUNERITE (Autunite grp) $Cu(UO_2)_2(AsO_4)_2 \cdot 10\text{-}16H_2O$	TET tab	001 perf 010 dist	Green	H 2-2.5 G 3.4 fus	Diss by acids. El clv pos. Does not fluor in UV.
	1.614	1.595	.019	SEMENOVITE $(Ca,Ce,La,Na)_{10\text{-}12}(Fe,Mn)$ $(Si,Be)_{20}(O,OH,F)_{48}$	ORTH ps tet	Uneven	Cols	H 3.5-4 G 3.14	Tw 110.
1.609 □ 1.618	1.614	1.608	.006	FLUOCERITE $(Ce,La)F_3$	HEX	0001 dist	Wax-yellow to brown	H 4-5 G 5.8-6.0 infus	Insol in HCl or HNO_3, diss by H_2SO_4. Anom biax.
1.598 ◊ 1.640	1.617	1.575	.042	BIOTITE, var Manganophyllite (Mica grp) $K(Mg,Fe,Mn)_3(Al,Fe)Si_3O_{10}$ $(OH,F)_2$	MCL ps hex	001 perf	Reddish-brown	H 2.5-3 G 2.98 F 3-4	2V 0-30°. El clv pos. Pleoc, O dark brown, E brown. Fe_2O_3 5.8, FeO 1.2, MnO 6.2%.
	1.617	1.595	.022	KARNASURTITE $(La,Ce,Th)(Ti,Nb)(Al,Fe)$ $(Si,P)_2O_7(OH)_4 \cdot 3H_2O$ (?)	HEX (?)	One good	Yellow	H 2 G 2.92	Anom biax.
v 1.632	1.618	1.552	.066	CHALCOPHYLLITE $Cu_{18}Al_2(AsO_4)_3(SO_4)_3(OH)_{27} \cdot$ $33H_2O$	TRIG tab	0001 perf	Deep emerald-green	H 2 G 2.69 F 2-2.5	Diss by acids or NH_4OH. El clv pos. Pleoc, O blue-green, E nearly cols. Indices increase with loss of H_2O.
1.600 ◊ 1.634	1.618	1.597	.021	GLAUCONITE (Mica grp) $(K,Na)(Al,Fe,Mg)_2(Si,Al)_4$ $O_{10}(OH)_2$	MCL ps hex	001 perf	Green	H 2 G 2.7 fus	Dec by acids. El clv pos. Pleoc, E yellow, O bluish-green. Fe_2O_3 18.8, Al_2O_3 8.5, FeO 4.0, MgO 3.6%.
v 1.632	1.618	1.606	.012	BURBANKITE $(Na,Ca)_3(Sr,Ba,Ce)_3(CO_3)_5$	HEX u mass	Pris, 0001	Yellow, pink	H 4.5-5 G 3.39-3.60 infus	Diss by acids with eff.
1.589 ^	1.619	1.605	.014	CLINOCHLORE (Chlorite grp) $(Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	MCL ps hex	001 perf	Olive- to dark-green	H 2 G 2.8 F 5	Dec by acids. El clv pos. Pleoc, E pale green, O green. 2V 0-5°.
1.611 □ 1.622	1.619	1.611	.008	CYMRITE $BaAl_2Si_2(O,OH)_8 \cdot H_2O$	MCL ps hex	001 perf pris imperf	Cols	H 2-3 G 3.45	Slightly sol in acids. El clv pos.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.619	1.618	.001	GILLESPITE $BaFeSi_4O_{10}$	TET platy	001 mic	Rose-red	H 3 G 3.33 F easy	Dec by HCl. El pos. Pleoc str, O pale pink, E deep rose-red.
	1.621	1.609	.012	KHANNESHITE $(Na,Ca)_3(Ba,Sr,Ce,Ca)_3(CO_3)_5$	HEX	Prism indist	Pale yellow	H soft G 3.8-3.9	Diss by HCl.
v 1.636	1.622	1.606	.016	BAZZITE $Be_3(Sc,Al,Fe)_2Si_6O_{18}$	HEX barrel-shaped	---	Bright blue	H 7 G 2.78 infus	Insol in acids. Pleoc, E azure-blue, O pale yellow to cols.
1.603 ^v 1.640	1.622	1.614	.008	CARBONATE-FLUORAPATITE (Apatite grp) $Ca_5(PO_4,CO_3)_3(F,OH)$	HEX pris, fib	0001 perf	Gray to greenish	H 5 G 3.05 F 3	Diss by acids. El clv pos. Basal section may show biax segments.
	1.622	1.615	.007	HUNTITE $CaMg_3(CO_3)_4$	TRIG u mass	---	White	H 2-2.5 G 2.70 infus	Diss by HCl with eff.
1.607 ^v 1.630	1.623	1.620	.003	WHITLOCKITE ("Merrillite") $(Ca,Na)_9(Mg,Fe)H(PO_4)_7$	TRIG	---	Cols	H 5 G 3.1 infus	Diss by acids. Meteorite mineral.
	1.623	1.619	.004	OLGITE $Na(Sr,Ba)PO_4$	HEX	---	Bright blue, greenish-blue	H 4.5 G 3.94	---
	1.624	1.591	.033	TISINALITE (Lovozerite grp) $Na_3H_3(Mn,Ca,Fe)TiSi_6(O,OH)_{18}\cdot 2H_2O$	TRIG	Uneven to conch	Yellow to orange	H 5 G 2.67	---
1.624 □ 1.630	1.627	1.582	.045	TROEGERITE (Autunite grp) $(UO_2)_3(AsO_4)_2\cdot 12H_2O$ (?)	TET tab 001	001 perf 100 good	Lemon-yellow	H 2-3 G 3.3 F 2.5	Diss by acids. Fluor Fluor yellow in UV.
	1.629	---	very low	KAMAISHILITE $Ca_2Al_2SiO_6(OH)_2$	TET	---	Cols	---	Opt sign unk.
v 1.653	1.629	1.624	.005	MELILITE (Melilite grp) $(Ca,Na)_2(Mg,Al)(Si,Al)_2O_7$	TET	001 dist	Cols	H 5 G 2.98 F 3	Gel with acids. MgO 8.2, FeO 2.1, Fe_2O_3 1.2, Al_2O_3 6.9, Na_2O 3.2%.

	1.63	1.59	.04	HYDROHONESSITE $Ni_6Fe^{+3}_2(SO_4)(OH)_{16}\cdot 7H_2O$	HEX	---	Bright yellow	---	Diss by acids.
1.606 ◇ 1.652	1.630	1.620	.010	EUDIALYTE $Na_4(Ca,Ce)_2(Fe^{+2},Mn)ZrSi_8O_{22}(OH,Cl)_2$	TRIG	0001 dist $10\bar{1}0$ poor	Yellow, brown, pink	H 5-5.5 G 3.03 F 3	Gel with acids. Pleoc wk in pink and yellow. Anom biax.
1.623 ^	1.630	1.627	.003	WHITLOCKITE $Ca_9(Mg,Fe)H(PO_4)_7$	TRIG u mass	---	Cols	H 5 G 3.12 infus	Diss by acids.
1.625 ⊓	1.631	1.628	.003	METATORBERNITE (Meta-autunite grp) $Cu(UO_2)_2(PO_4)_2\cdot 4\text{-}8H_2O$	TET tab	001 perf 100 indist	Green	H 2.5 G 3.7-3.8 F 3	Diss by acids. Pleoc, O dark green, E pale green to blue. Does not fluor in UV.
1.618 ^	1.632	1.575	.057	CHALCOPHYLLITE $Cu_{18}Al_2(AsO_4)_3(SO_4)_3(OH)_{27}\cdot 33H_2O$	TRIG tab	0001 perf	Deep emerald-green	H 2 G 2.69 F 2-2.5	Diss by acids or NH_4OH. El clv pos. Pleoc, O blue-green, E nearly cols.
v 1.650	1.632	1.602	.030	BEMENTITE $Mn_8Si_6O_{15}(OH)_{10}$	MCL fib	001 perf	Brown	H 4-6 G 2.7-3.1 F 3	Pleoc wk, O yellow, E nearly cols.
1.618 ^	1.632	1.620	.012	BURBANKITE $(Na,Ca)_3(Sr,Ba,Ce)_3(CO_3)_5$	HEX u mass	Pris, 0001	Yellow, pink	H 4.5-5 G 3.39-3.60 infus	Diss by acids with eff.
	1.633	1.590	.043	CUPRORIVAITE $CaCuSi_4O_{10}$	TET	001 perf	Blue	H 5 G 3.08	Insol in acids. El clv pos. Pleoc, O blue, E pale rose.
1.622 ◇ 1.638	1.633	1.630	.003	FLUORAPATITE (Apatite grp) $Ca_5(PO_4)_3F$	HEX pris	0001 imperf	Cols, green, brown	H 5 G 3.2 F 5	Diss by acids. El neg. Data for synth compd.
1.603 ◇ 1.661	1.634	1.575	.059	STILPNOMELANE $K(Fe^{+2},Mg,Fe^{+3},Al)_{10}Si_{12}O_{30}(O,OH)_2$	MCL and TCL ps hex	001 mic	Brown	H 3.5 G 2.84 F 3.5	Dec by acids. Pleoc, O dark brown, E pale brown. El clv pos. FeO 22.7, Fe_2O_3 12.2%.
1.606 ^	1.634	1.590	.044	COALINGITE $Mg_{10}Fe_2CO_3(OH)_{24}\cdot 2H_2O$	TRIG platy	0001	Reddish-brown	G 2.32 infus	Diss by acids. Pleoc, O deep golden brown, E cols. Anom biax.
1.618 ◇ 1.643(?)	1.634	1.610	.024	GLAUCONITE (Mica grp) $(K,Na)(Fe^{+3},Al,Mg,Fe^{+2})_2(Si,Al)_4O_{10}(OH)_2$	MCL ps hex	001 perf	Green	H 2 G 2.74 fus	Dec by acids. El clv pos. Pleoc, E yellow-green, O blue-green. Fe_2O_3 24.5, Al_2O_3 7.3, FeO 2.9%. 2V 0-15°.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v 1.638	1.634	1.612	.022	DRAVITE (Tourmaline grp) $NaMg_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$	TRIG pris	$11\bar{2}0$, $10\bar{1}1$ very poor	Brown	H 7 G 3.03 infus	Insol in acids. El neg. Pleoc, abs O > E. MgO 8.4, FeO 0.2, Na_2O 1.9%.
v 1.637	1.635	1.618	.017	ELBAITE (Tourmaline grp) $Na(Al,Li)_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$	TRIG pris	$11\bar{2}0$, $10\bar{1}1$ very poor	Red	H 7 G 3.02 infus	Insol in acids. El neg. Pleoc, abs O > E. Fe_2O_3 0.3, Li_2O 1.9, CaO 0.4, Na_2O 2.4%.
[ ]	1.635	---	wk	EYLETTERSITE (Crandallite grp) $(Tn,Pb,Ba)Al_3(PO_4,SiO_4)_2(OH)_6$ (?)	TRIG	---	White to cream	G 3.38-3.44	Fluor wk greenisn-yellow in short-wave UV.
1.622 ^	1.636	1.618	.018	BAZZITE $Be_3(Sc,Fe)_2Si_6O_{18}$	HEX barrel-shaped	---	Blue	H 7 G 2.78 infus	Insol in acids. Pleoc, E azure blue, O pale yellow to cols.
	1.637	1.615	.022	MITSCHERLICHITE $K_2CuCl_4\cdot 2H_2O$	TET tw on 001	---	Green to blue	H 2.5 G 2.40 fus	Sol in H_2O. Pleoc, E sky-blue, O grass-green. Anom biax. Data for synth compd.
v 1.649	1.637	1.615	.022	CHAMOSITE (Chlorite grp) $(Mg,Fe^{+2},Fe^{+3})_5Al(Si_3Al)O_{10}(O,OH)_8$	MCL ps hex	001 mic	Green	H 2.5 G 3.0 F diff	Dec by acids. Pleoc, E olive-green, O brownish-yellow. FeO 22.8, Fe_2O_3 9.1, Al_2O_3 22.1%.
[ ]	1.637	1.620	.017	METANOVACEKITE (Meta-autunite grp) $Mg(UO_2)_2(AsO_4)_2\cdot 8H_2O$	TET tab	001 perf 100 dist	Yellow	H 2-2.5 G 3.66	Diss by acids. Fluor yellow in UV. Commonly biax, 2V 0-20°.
1.635 ^ v 1.646	1.637	1.621	.016	LIDDICOATITE (Tourmaline grp) $Ca(Li,Al)_3Al_6(BO_3)_3Si_6O_{18}(O,OH,F)_4$	TRIG pris	$11\bar{2}0$, $10\bar{1}1$ very poor	Brown, pink, green	H 7.5 G 3.02 infus	Insol in acids. Pleoc, O dark brown, E light brown. El neg. CaO 4.2, Na_2O 0.9, Li_2O 2.5, F 1.7%.
1.634 ^ v 1.653	1.638	1.619	.019	UVITE (Tourmaline grp) $(Ca,Na)(Mg,Fe)_3Al_5Mg(BO_3)_3Si_6O_{18}(OH,F)_4$	TRIG pris	$11\bar{2}0$, $10\bar{1}1$ very poor	Brown	H 7 G 3.08 F 5	Insol in acids. El neg. Pleoc, abs O > E. MgO 15.4, FeO 0.5, CaO 5.5, Na_2O 0.2%.
1.633 ^ v 1.644	1.638	1.634	.004	FLUORAPATITE (Apatite grp) $(Ca,Sr)_5(PO_4)_3F$	HEX pris	0001 imperf	Cols	H 5 G 3.32 F 5	Diss by acids. El neg. SrO 11.6%.

1.617 ◊ 1.652	1.640	1.590	.050	SIDEROPHYLLITE (Biotite ser, Mica grp) $KFe_2Al(Al_2Si_2)O_{10}(F,OH)_2$	MCL ps hex	001 mic	Black, dark brown	H 3 G 3.12 F 4	El clv pos. Pleoc, X brown, Y and Z dark brown. FeO 30.2, MnO 1.0%.
1.622 ◊ 1.651	1.640	1.633	.007	CARBONATE-FLUORAPATITE ("Dehrnite") (Apatite grp) $(Ca,Na,K)_5(PO_4,CO_3)_3(F,OH)$	HEX pris, fib	0001 good	Gray to greenish	H 5 G 3.05 F 3	Diss by acids. El clv pos, el crystal neg.
	1.641	1.609	.032	METAHEINRICHITE (Meta-autunite grp) $Ba(UO_2)_2(AsO_4)_2 \cdot 8H_2O$	TET	001 perf 100 dist	Yellow to green	H 2.5 G 4.04	Diss by acids. Pleoc, O pale yellow, E cols. Fluor yellow-green in UV.
	1.642	1.608	.034	METAKAHLERITE (Meta-autunite grp) $Fe(UO_2)_2(AsO_4)_2 \cdot 8H_2O$	TET	001 perf 100 good	Sulfur-yellow	---	Diss by acids. Does not fluor in UV. Anom biax.
1.634(?) ◊ 1.663	1.643	1.612	.031	CELADONITE (Mica grp) $(K,Na)(Fe^{+3},Al,Fe^{+2},Mg)_2(Si,Al)_4O_{10}(OH)_2$	MCL ps hex	001 perf	Bright green	H 2 G 2.8 F 3	Dec by HCl. Pleoc, E yellow-green, O green. Fe_2O_3 24.3, Al_2O_3 1.0, FeO 9.8, MgO 3.7%.
	1.643	1.623	.020	ZUSSMANITE $K(Fe,Mg,Mn)_{13}(Al,Si)_{18}O_{42}(OH)_{14}$	TRIG tab	0001 perf	Pale green	G 3.15	El clv pos. Pleoc wk, O pale green, E cols.
	1.644	1.542	.102	EWALDITE $Ba(Ca,Y,Na,K)(CO_3)_2$	HEX	---	Blue-green, brick red	H 3 G 3.42	---
	1.644	1.617	.027	METAKIRCHHEIMERITE (Meta-autinite grp) $CO(UO_2)_2(AsO_4)_2 \cdot 8H_2O$	ORTH ps tet (?) plates	001 perf	Rose	H 2-2.5 G > 3.33	Diss by acids. El clv pos. Not fluor in UV.
1.638 ◊ 1.651	1.644	1.638	.006	FLUORAPATITE (Apatite grp) $(Ca,Mn)_5(PO_4)_3F$	HEX pris	0001 imperf	Blue	H 5 G 3.26 F 5	Diss in acids. El neg. Fluor orange in UV. MnO 4.7%.
1.637 ^	1.646	1.625	.021	ELBAITE (Tourmaline grp) $Na(Al,Li,Fe)_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$	TRIG pris	$11\bar{2}0$, $10\bar{1}1$ very poor	Blue-green	H 7 G 3.09 infus	Insol in acids. El neg. Na_2O 2.5, Li_2O 1.2, FeO 4.9, MnO 0.7%.
	1.646	1.635	.011	ZAPATALITE $Cu_3Al_4(PO_4)_3(OH)_9 \cdot 4H_2O$	TET	001 good	Pale blue	H 1.5 G 3.02	Pleoc, wk in green, abs E > O. Diss by acids.
	1.646	1.639	.007	KELLYITE (Kaolinite-Serpentine grp) $(Mn,Al,Mg)_3(Si,Al)_2O_5(OH)_4$	TRIG and HEX granular	0001 perf	Yellow	G 3.07	Anom biax. Pleoc wk, E cols, O pale yellow.
	1.647	1.637	.010	AMINOFFITE $Ca_2(Be,Al)(Si,Al)_2O_7(OH) \cdot H_2O$	TET pyram	001 poor fr conch	Cols	H 5.5 G 2.94	Anom biax, 2V 0-15°.
1.607 ^	1.648	1.622	.026	VERMICULITE $(Mg,Ni,Fe)_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$	MCL ps hex	001 perf	Brownish-black	H 1.5 G 2.8 F 5	Dec by HCl. El clv pos. Exfoliates when heated. Fe_2O_3 19.2, FeO 5.0, MgO 13.9, NiO 8.6%.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.643 □ 1.651	1.648	1.624	.024	METAZEUNERITE (Meta-autunite grp) $Cu(UO_2)_2(AsO_4)_2 \cdot 8H_2O$	TET tab	001 perf 010 dist	Green	H 2.5 G 3.67	Diss by acids. Does not fluor in UV.
	1.648	1.625	.023	KAZAKOVITE $Na_6H_2TiSi_6O_{18}$	TRIG	Uneven to subconch	Pale yellow	H 4 G 2.84 F 1.5	Tw poly.
1.637 ^v 1.685	1.649	1.643	.006	CHAMOSITE (Chlorite grp) $(Fe^{+2},Mg,Fe^{+3})_5Al(Si_3Al)O_{10}(OH,O)_8$	MCL ps hex	001 perf	Dark green	H 2 G 3.20	Dec by hot HCl. El clv pos. Pleoc, O olive-green, E pale yellow.
	1.649	1.641	.008	JEREMEJEVITE $Al_6B_5O_{15}(OH)_3$	HEX pris	Conch	Cols to yellow-brown	H 6.5 G 3.28 infus	After ignition, diss by concd H_2SO_4 or KOH. El neg. Pleoc, O yellowish, E light blue. Anom biax.
v 1.724	1.65	1.60	.05	PYROCHROITE $Mn(OH)_2$	TRIG	0001 perf	Cols to brown	H 2-2.5 G 3.1-3.2 infus	Diss by acids. Rapidly darkens in air. El clv pos.
1.632 ^	1.650	1.624	.026	BEMENTITE $Mn_8Si_6O_{15}(OH)_{10}$	MCL fib	001 perf	Brown	H 4-6 G 2.7-3.1 F 3	Dec by acids. Pleoc wk, O yellow, E nearly cols.
1.644 ^v 1.660	1.651	1.637	.014	STRONTIUM-APATITE (Apatite grp) $(Sr,Ca,Ba)_5(PO_4)_3(F,OH)$	HEX	---	Cols to green	H 5 G 3.84	Diss by acids. El neg. SrO 4.6, CaO 10.8, BaO 2.7%.
1.640 ^	1.651	1.644	.007	HYDROXYLAPATITE (Apatite grp) $Ca_5(PO_4)_3(OH,F)$	HEX	---	Cols	H 5 G 3.21 infus	Diss by acids. El neg. F 0.16, H_2O 1.86%.
1.640 ^v 1.672	1.652	1.595	.057	BIOTITE (Mica grp) $K(Fe,Mg)_3(Al,Fe)Si_3O_{10}(OH,F)_2$	MCL ps hex	001 perf	Dark brown	H 2.5-3 G 3.05 F 4	El clv pos. Pleoc, O dark brown, E brown. FeO 19.9, MnO 0.4, Fe_2O_3 3.2%.
1.630 ^	1.652	1.640	.012	EUDIALYTE $Na_4(Ca,Ce)_2(Fe^{+2},Mn)ZrSi_8O_{22}(OH,Cl)_2$	TRIG	0001 dist $10\bar{1}0$ poor	Pink	H 5-5.5 G 2.87 F 3	Gel with acids. Pleoc wk in pink. MnO 10.8, Fe_2O_3 1.9%.
1.647 □ 1.655	1.652	1.649	.003	"WILKEITE" (Apatite grp) $Ca_5(SiO_4,PO_4,SO_4)_3(O,OH,F)$	HEX u mass	0001 imperf	Yellow, reddish	H 5 G 3.1 F diff	Dec by acids. P_2O_5 15.9, SO_3 13.5, SiO_2 12.0%. = Silicatian Sulfatian Apatite or phosphatian Fluorellestadite.

1.638 ^v 1.660	1.653	1.637	.016	DRAVITE (Tourmaline grp) $(Na,Ca)(Mg,Fe)_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$	TRIG pris	$11\bar{2}0,10\bar{1}1$ very poor	Dark brown	H 7 G 3.25 F 5	Insol in acids. El neg. Pleoc, O deep olive-green, E pale brown, abs O > E. MgO 9.3, FeO 3.6, Fe_2O_3 2.2, CaO 1.6, Na_2O 1.7%.
	1.653	1.642	.011	CHANTALITE $CaAl_2SiO_4(OH)_4$	TET	---	Cols, white	G 2.8-2.9	---
1.629 ^v 1.672	1.653	1.652	.001	MELILITE (Melilite grp) $(Ca,Na)_2(Mg,Al)(SiAl)O_7$	TET	001 dist	Cols	H 5 G 3.0 F 4	Gel with acids. Data for synth Ge 50, Ak 50.
v 1.681	1.654	1.629	.029	FRIEDELITE $(Mn,Fe)_8Si_6O_{15}(OH,Cl)_{10}$	MCL ps trig tab 0001	0001 perf $10\bar{1}0$ imperf	Pink, brown	H 4.5 G 3.17 fus	Dec by acids. Fus to black glass. Anom biax, 2V small. El pos.
⊔ 1.660	1.655	1.645	.010	KONINCKITE $FePO_4 \cdot 3H_2O$	TET fib	---	Yellow-green	H 3 G 2.4 F 2.5-3	Diss by concd acids.
1.654 ⊓v 1.703	1.655	1.650	.005	ELLESTADITE (Apatite grp) $Ca_5(SiO_4,PO_4,SO_4)_3(OH,Cl,F)$	HEX	0001 imperf	Cols, pale rose, purple	H 5 G 3.1-3.2 F diff	Dec by acids. El neg. SiO_2 17.3, SO_3 26.7, P_2O_5 3.1%.
v 1.672	1.658	1.486	.172	CALCITE (Calcite grp) $CaCO_3$	TRIG	$10\bar{1}1$ perf	Cols, pink, brown	H 3 G 2.71 infus	Diss by acids with eff. Data for pure $CaCO_3$.
v 1.666	1.658	1.653	.005	CHLORAPATITE (Apatite grp) $Ca_5(PO_4)_3(Cl,F,OH)$	MCL ps hex	001 imperf	Greenish-yellow	H 5 G 3.18 F 5	Diss by acids. El neg. Cl 3.7, F 1.15%.
	1.66	1.57	.09	MCKELVEYITE $Ba_3Na(Ca,U)Y(CO_3)_6 \cdot 3H_2O$	TCL ps trig tab	---	Dark green	G 3.5-3.6	Diss by acids. Pleoc in green, abs O > E.
1.651 ^	1.660	1.640	.020	BELOVITE (Apatite grp) $(Sr,Ce,Na,Ca)_5(PO_4)_3(OH)$	HEX pris	Pris, pinacoidal, imperf	Honey-yellow	H 5 G 4.19 F diff	Diss by acids. El neg.
	1.66	---	wk	FERMORITE (Apatite grp) $(Ca,Sr)_5(PO_4,AsO_4)_3(OH,F)$	HEX pyram	---	Pink to white	H 5 G 3.52 F diff	Diss by acids.
1.653 ^v 1.661	1.660	1.639	.021	UVITE (Tourmaline grp) $Ca(Mg,Fe)_3Al_5Mg(BO_3)_3Si_6O_{18}(OH,F)_4$	TRIG pris	$11\bar{2}0$, $10\bar{1}1$ very poor	Dark brown	H 7 G 3.16 F 5	Insol in acids. El neg. Pleoc, abs O > E. MgO 11.0, FeO 5.8, Fe_2O_3 2.7, CaO 7.5%.
1.634 ^v 1.685	1.661	1.584	.077	STILPNOMELANE $K(Fe^{+3},Fe^{+2},Mg)_{10}Si_{12}O_{30}(O,OH)_{12}$	MCL and TCL ps hex	001 perf	Brown	H 3.5 G 2.80 F 3.5	Dec by acids. El clv pos. Pleoc, O deep brown, E golden-yellow. FeO 8.9, MnO 2.9, Fe_2O_3 19.4%.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.660 ◇ 1.675	1.661	1.632	.029	SCHORL (Tourmaline grp) $NaFe_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$	TRIG pris	$11\bar{2}0$, $10\bar{1}1$ very poor	Black	H 7 G 3.17 F diff	Insol in acids. El neg. Pleoc, abs O > E. FeO 8.7, MgO 5.6, Fe_2O_3 0.8, Na_2O 2.3%.
v 1.667	1.661	1.646	.015	PENNANTITE (Chlorite grp) $Mn_5Al(Si_3Al)O_{10}(OH)_8$	MCL ps hex, plates	001 perf	Orange-brown	H 2.5 G 3.06	Pleoc in orange. El clv pos. MnO 38.9, Al_2O_3 18.6, Fe_2O_3 4.4%.
1.643 ^	1.663	1.644	.019	CELADONITE (Mica grp) $(K,Na)(Al,Fe,Mg)_2(Si,Al)_4O_{10}(OH)_2$	MCL ps hex	001 perf	Bright green	H 2 G 2.8 F 3	Dec by HCl. El clv pos. Pleoc, E yellow-green, O emerald-green. Fe_2O_3 26.9, Al_2O_3 2.1, FeO 9.3%.
v 1.669	1.664	1.634	.030	PYROSMALITE $(Fe,Mn)_8Si_6O_{15}(OH,Cl)_{10}$	TRIG	0001 perf	Brown	H 4.5-5 G 3.11 fus	Dec by HCl. El clv pos. Pleoc, O light brown, E dark brown.
	1.664	1.646	.018	GONYERITE (Chlorite grp) $(Mn,Mg)_5Fe(Si_3Fe)O_{10}(OH)_8$	ORTH (?) ps hex	001 perf	Deep brown	H 2.5 G 3.01	Dec by HCl. El clv pos. Pleoc, O light brown, E dark brown.
	1.666	1.653	.013	TIENSHANITE $BaNa_2MnTiB_2Si_6O_{20}$	HEX	0001 dist	Pistachio-green	H 6-6.5 G 3.29 F 2	---
1.658 ^	1.666	1.660	.006	CHLORAPATITE (Apatite grp) $Ca_5(PO_4)_3Cl$	MCL ps hex	001 imperf	Cols	H 4.5 G 3.2 F 5	Diss by acids. El neg. Data for synth compd.
1.661 ◇ 1.673	1.667	1.658	.009	PENNANTITE ("Grovesite") (Chlorite grp) $(Mn,Fe)Al(Si_3Al)O_{10}(OH)_8$	MCL ps hex	001	Blackish-brown	G 3.15	Pleoc, O very dark brown, E reddish-brown.
1.664 □ 1.671	1.667	1.662	.005	STEENSTRUPINE $(Ce,La,Na,Mn)_6(Si,P)_6O_{18}(OH)$	HEX	---	Brown, red, yellow	H 5 G 3.5 infus	Pleoc wk in brown and yellow.
	1.668	1.641	.027	MCGILLITE $(Mn,Fe^{+2},Mg)_8Si_6O_{15}(OH)_8Cl_2$	MCL ps trig	0001 good	Pink	G 2.98	Dec by HCl.
1.664 ◇ 1.682	1.669	1.631	.038	MANGANPYROSMALITE $(Mn,Fe)_8Si_6O_{15}(OH,Cl)_{10}$	HEX	0001 perf	Brown	H 4.5-5 G 3.13 fus	Dec by HCl. El clv pos. Pleoc, O greenish-yellow, E cols.

	1.669	1.657	.012	HARDYSTONITE (Melilite grp) $Ca_2ZnSi_2O_7$	TET granular	001 good 100, 110 rare	White	H 3 G 3.4 F diff	Gel with acids.
1.653 ^v 1.672	1.669	1.658	.011	GEHLENITE (Melilite grp) $Ca_2Al(AlSi)O_7$	TET	001 imperf	Cols	H 6 G 3.04 F 6	Gel with acids. Data for synth compd.
1.658 ^v 1.710	1.672	1.501	.171	CALCITE (Calcite grp) $(Ca,Mn,Mg)CO_3$	TRIG	$10\bar{1}1$ perf	White, pink	H 3 G 2.82 infus	Diss by acids with eff. MnO 4.2, FeO 2.1, MgO 1.3%.
1.652 ^	1.672	1.624	.048	ANNITE (Biotite ser, Mica grp) $KFe_3AlSi_3O_{10}(OH,F)_2$	MCL ps hex	001 perf	Dark brown	H 2.5-3 G 3.0 F 4	Pleoc, O dark brown, E brown. FeO 32.1, Fe_2O_3 3.1, TiO_2 3.6%.
1.669 ^	1.672	1.661	.011	MELILITE (Melilite grp) $(Na,Ca)_2(Mg,Fe,Al)(Si,Al)_2O_7$	TET	001 dist	Brown	H 5 G 3.1 F 4	Gel with acids. Fe_2O_3 8.4, Al_2O_3 8.4, FeO 1.1, MgO 4.7, Na_2O 3.8%.
	1.672	1.527	.145	PARALSTONITE $(Ba,Sr)Ca(CO_3)_2$	TRIG	---	White, cols	H 4-4.5 G 3.60 infus	Fluor pale to bright orange in long-wave UV.
1.667 ^	1.673	1.664	.009	PENNANTITE (Chlorite grp) $(Mn,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	MCL ps hex	001 perf	Brown	H 2.5 G 3.04	Pleoc in browns. El clv pos.
	1.675	1.59	.085	CHLOROMAGNESITE $MgCl_2$	HEX plates	---	Cols	H soft G 2.33 F 2	Sol in H_2O, deliq.
1.661 ^v 1.693	1.675	1.643	.032	DRAVITE (Tourmaline grp) $NaMg_3(Al,V)_6(BO_3)_3Si_6O_{18}(OH)_4$	TRIG pris	$11\bar{2}0$, $10\bar{1}1$ very poor	Green	H 7 G 3.13 F 5	Insol in acids. El neg. Pleoc, E pale green, O red-brown. MgO 6.3, FeO 1.3, V_2O_3 8.0%.
v 1.686	1.678	1.630	.048	SPANGOLITE $Cu_6Al(SO_4)(OH)_{12}Cl\cdot 3H_2O$	TRIG tab	0001 perf	Dark- to bluish-green	H 2-3 G 3.14 F 3	Diss by acids. El pos. Pleoc, O green, E bluish-green.
v 1.694	1.680	1.501	.179	DOLOMITE (Dolomite grp) $CaMg(CO_3)_2$	TRIG	$10\bar{1}1$ perf	White, buff	H 3.5-4 G 2.865 infus	Diss with eff in warm HCl. FeO 0.5%.
[ ]	1.680	1.655	.025	SINCOSITE $CaV^{+4}{}_2(PO_4)_2(OH)_4\cdot 3H_2O$	MCL ps tet, tab	001 good 100, 110 poor	Leek-green	H soft G 2.84 fus	Diss by acids to a blue soln. Pleoc, O gray-green, E nearly cols.
1.654 ^	1.681	1.643	.038	FRIEDELITE $(Mn,Fe)_3Si_6O_{15}(OH,Cl)_{10}$	MCL ps trig tab 0001	0001 perf $10\bar{1}0$ imperf	Brown	H 4.5 G 3.3 fus	Dec by HCl. El pos. Pleoc in browns.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.669 ^	1.682	1.650	.032	PYROSMALITE $(Fe,Mn)_8Si_6O_{15}(OH,Cl)_{10}$	HEX	0001 perf	Brown	H 4.5-5 G 3.1 fus	Dec by HCl. Anom biax. El clv pos.
	1.683	1.672	.011	VERPLANCKITE $Ba_2(Mn,Fe^{+2},Ti)Si_2O_6(O,OH,Cl,F)_2\cdot 3H_2O$	HEX	$11\bar{2}0$ good	Orange to yellow	H 2.5-3 G 3.52	Pleoc, O orange-yellow, E cols.
v 1.716	1.684	1.672	.012	SVABITE (Apatite grp) $Ca_5(AsO_4,PO_4)_3(F,OH)$	HEX	---	Green	H 4-4.5 G 3.54 F 5	Diss by acids. P_2O_5 12.5, F 1.4%.
1.661 ^ v 1.705	1.685	1.595	.090	STILPNOMELANE $K(Fe^{+3},Fe^{+2},Mg)_{10}Si_{12}O_{30}(O,OH)_2$	MCL and TCL ps hex	001 mic	Brownish-black	H 3.5 G 2.85 F 3	Dec by acids. El clv pos. Pleoc, O dark olive-brown, E yellow. FeO 13.7, Fe_2O_3 22.0%.
1.649 ^	1.685	1.670	.015	CHAMOSITE (Chlorite grp) $(Fe^{+2},Fe^{+3},Mg)_5Al(Si_3Al)O_{10}(OH,O)_8$	MCL ps hex	001 perf	Brown	H 6 G 2.96	Dec by hot HCl. El clv pos. Pleoc, O dark green, E yellow.
	1.685	1.674	.011	PABSTITE $Ba(Sn,Ti)Si_3O_9$	HEX	---	Cols, white	H 6 G 4.03	Anom blue-violet and yellow interf colors. Fluor bluish white in short-wave UV.
1.678 ^	1.686	1.635	.051	SPANGOLITE $Cu_6Al(SO_4)Cl(OH)_{12}\cdot 3H_2O$	TRIG tab	0001 perf	Dark- to bluish-green	H 2-3 G 3.14 F 3	Diss by acids. El clv pos. Pleoc, O green, E bluish-green.
	1.687	1.684	.003	JOHNBAUMITE (Apatite grp) $Ca_5(AsO_4)_3(OH)$	HEX	100 dist	Cols, white	H 4.5 G 3.68	Fluor med pink-orange in short-wave UV.
	1.690	1.684	.006	COMBLAINITE $(Ni^{+2},Co^{+3})(OH)_2(CO_3)\cdot xH_2O$	TRIG	---	Turquoise	G 3.05	---
v 1.705	1.691	1.527	.164	BENSTONITE $(Ba,Sr)_6(Ca,Mn)_6Mg(CO_3)_{13}$	TRIG	$10\bar{1}1$ very good	White	H 3-4 G 3.60 infus	Diss by acids with eff. Fluor red in UV.
	1.691	1.641	.050	BANDYLITE $CuB(OH)_4Cl$	TET tab	001 perf	Deep blue	H 2.5 G 2.81 F 2	Diss by acids or by NH_4OH. El clv pos. Pleoc, O deep blue, E pale greenish-yellow.

	1.692	1.648	.044	WICKENBURGITE $Pb_3CaAl_2Si_{10}O_{24}(OH)_6$	HEX tab	0001 indist	White, pink	H 5 G 3.85 F 3	Insol in acids. Fluor dull orange in UV.
1.675 ^v 1.710	1.693	1.659	.034	SCHORL (Tourmaline grp) $NaFe_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$	TRIG pris	$11\bar{2}0$, $10\bar{1}1$ very poor	Black	H 7 G 3.2 F 5	Insol in acids. El neg. Pleoc, abs O > E. MgO 7.3, FeO 0.6, Fe_2O_3 9.2, CaO 1.5, Na_2O 2.6, TiO_2 2.2%.
1.680 ^v 1.700	1.694	1.510	.184	DOLOMITE (Dolomite grp) $Ca(Mg,Fe)(CO_3)_2$	TRIG	$10\bar{1}1$ perf	White, brown	H 3.5-4 G 2.92 infus	Diss by warm HCl. FeO 8.4, MnO 1.1, SrO 0.4%.
1.687 v 1.712	1.694	1.519	.175	NORSETHITE (Dolomite grp) $BaMg(CO_3)_2$	TRIG	$10\bar{1}1$ perf	White to yellow-green	H 3.5 G 3.74-3.84 infus	Diss by acids.
	1.696	1.694	.002	ALFORSITE (Apatite grp) $Ba_5(PO_4)_3Cl$	HEX	---	Cols	G 4.80	Data for synth.
v 1.724	1.699	1.658	.041	PHOSPHURANYLITE $Ca(UO_2)_4(PO_4)_2(OH)_4 \cdot 7H_2O$	ORTH plates	100 good 010	Lemon-yellow	H 2.5-3 G 4.1 fus	Diss by acids. Pleoc, E pale yellow, O golden-yellow. U biax, 2V 0-20°. Not fluor in UV.
1.694 ^v 1.710	1.700	1.21	.179	DOLOMITE, zincian (Dolomite grp) $Ca(Mg,Zn)(CO_3)_2$	TRIG	$10\bar{1}1$ perf	White, brown	H 3.5-4 G 2.95 infus	Diss by warm HCl. Fluor red in UV. FeO 2.2, ZnO 8.3, PbO 1.1%.
v 1.711	1.700	1.509	.191	MAGNESITE (Calcite grp) $MgCO_3$	TRIG u mass	$10\bar{1}1$ perf	Cols, white	H 3-4 G 2.96 infus	Diss by warm acids. Data for pure $MgCO_3$.
v 1.714	1.702	1.700	.002	VESUVIANITE $Ca_{10}(Mg,Fe)_2Al_4(Si_2O_7)_2(SiO_4)_5(OH,F)_4$	TET	110 poor	Brown, green, blue	H 5.5-6 G 3.40 F 4	Nearly insol in HCl. FeO 2.0, Fe_2O_3 2.3, TiO_2 1.7%.
1.655 ^v 1.752	1.703	1.699	.004	APATITE-BRITHOLITE (Apatite grp) $(Ca,Ce)_5(PO_4,SiO_4)_3F$	HEX mass	---	Reddish-brown	H 4.5 G 3.83 infus	Dec by HCl. P_2O_5 17.3, SiO_2 12.4, Ce_2O_3 12.9%.
	1.704	1.679	.025	SCHALLERITE $(Mn,Fe)_{16}Si_{12}As^{+3}{}_3O_{36}(OH)_{17}$	TRIG	0001 perf	Reddish-brown	H 4.5 G 3.37 F diff	Slowly dec by HCl. El clv pos. MnO 44.7, FeO 2.1%.
1.691 ^	1.705	---	very str	BENSTONITE $(Ba,Sr)_6(Ca,Mn)_6Mg(CO_3)_{13}$	TRIG	$10\bar{1}1$ very good	White	H 3-4 G 3.58 infus	Diss by HCl with eff. BaO 44.2, CaO 12.3, PbO 2.8, MgO 4.7, MnO 1.6%.
1.685 ^v 1.735	1.705	1.596	.109	STILPNOMELANE $K(Fe^{+3},Fe^{+2},Mg)_{10}Si_{12}O_{30}(O,OH)_2$	MCL and TCL ps hex	001 mic	Brownish-black	H 3.5 G 2.85 F 3	Dec by acids. El clv pos. Pleoc, E golden-yellow, O dark red-brown. Fe_2O_3 23.9, FeO 13.2%.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.700 ◊ 1.711	1.710	1.519	.191	KUTNOHORITE (Dolomite grp) $Ca(Mn,Mg)(CO_3)_2$	TRIG	$10\bar{1}1$ perf	Pink, brown	H 3-4 G 3.00 infus	Diss by hot acids. MnO 17.6, MgO 10.0, FeO 1.3%.
1.672 ◊ 1.713	1.710	1.523	.189	CALCITE, cadmian (Calcite grp) $(Ca,Cd)CO_3$	TRIG	$10\bar{1}1$ perf	Cols to yellow	G 2.9 infus	$CaCO_3$ 73, $CdCO_3$ 27%.
1.693 ◊ 1.735	1.710	1.664	.046	DRAVITE, chromian (Tourmaline grp) $NaMg_3(Al,Cr)_6(BO_3)_3Si_6O_{18}(OH)_4$	TRIG pris	$11\bar{2}0$, $10\bar{1}1$ poor	Green	H 7 G 3.13 infus	Insol in acids. El neg. Pleoc, abs O > E. Cr_2O_3 17.8, Fe_2O_3 1.0, FeO 1.8%.
1.700 ◊ 1.726	1.711	1.519	.192	MAGNESITE, nickeloan (Calcite grp) $(Mg,Ni)CO_3$	TRIG	$10\bar{1}1$ perf	Green	H 3-4 G 3.15 infus	Diss by hot acids. NiO 13.55%.
1.710 ◊ 1.740	1.711	1.520	.191	DOLOMITE, ferroan (Dolomite grp) $Ca(Mg,Fe)(CO_3)_2$	TRIG	$10\bar{1}1$ perf	Brown	H 3.5-4 G 3.01 infus	Diss by warm HCl. FeO 12.6, MnO 1.2%.
1.694 ^	1.712	1.512	.200	NORSETHITE (Dolomite grp) $Ba(Mg,Fe)(CO_3)_2$	TRIG	$10\bar{1}1$ perf	White to yellow-green	H 3.5 G 3.85 infus	Diss by acids. FeO 3.6, MnO 0.8%.
	1.712	---	str	PALMIERITE $(K,Na)_2Pb(SO_4)_2$	TRIG plates	---	Cols	G 4.5 F easy	Dec by boiling H_2O, diss by HNO_3. Luster pearly.
1.710 ◊ 1.731	1.713	1.519	.194	CALCITE, manganoan (Calcite grp) $(Ca,Mn)CO_3$	TRIG	$10\bar{1}1$ perf	Pink	H 3 G 3.02 infus	Diss by acids with eff. MnO 20.1, ZnO 0.4%.
	1.714	1.702	.012	TRASKITE $Ba_9Fe_2Ti_2Si_{12}O_{36}(OH,Cl,F)_6 \cdot 6H_2O$	HEX	Conch	Brownish-red	H 5 G 3.71 F 3.5	Insol in acids. Pleoc, O brown-red, E cols to straw-yellow.
1.702 ◊ 1.742	1.714	1.709	.005	VESUVIANITE $Ca_{10}Mg_2Al_4(Si_2O_7)_2(SiO_4)_5(OH,F)_4$	TET	110 poor	Brown	H 5 G 3.38 F 4	Nearly insol in HCl. Fe_2O_3 3.3, MnO 3.3, BeO 1.6%.
1.684 ^	1.716	1.698	.018	SVABITE (Apatite grp) $Ca_5(AsO_4)_3(Cl,F)$	HEX	---	Green, brown	H 4-4.5 G 3.5 F 5	Diss by acids. Cl 1.9, F 0.45%.
	1.721	1.719	.002	SATTERLYITE $(Fe^{+2},Mg,Fe^{+3})_2(PO_4)(OH)$	HEX	---	Pale brown, pale yellow	H 4.5-5 G 3.68 fus	Diss by acids. Pleoc, O pale yellow, E brownish-yellow, abs E > O.

	1.722	1.718	.004	TAAFFEITE $Mg_3Al_8BeO_{16}$	HEX	---	Mauve	G 3.61	---
	1.723	1.716	.007	HATRURITE Ca_3SiO_5	ps hex	---	Cols	---	Dec by H_2O.
1.699 ^	1.724	1.674	.050	PHOSPHURANYLITE $Ca(UO_2)_4(PO_4)_2(OH)_4 \cdot 7H_2O$	ORTH plates	100 good 010	Lemon-yellow	H 2.5-3 G 4.1 fus	Diss by acids. Pleoc, E pale yellow, O golden-yellow. U biax, 2V 0-20°.
1.65 ^	1.724	1.682	.042	PYROCHROITE $Mn(OH)_2$	TRIG	0001 perf	White to brown	H 1.5-2 G 3.1-3.25 infus	Diss by acids. El clv pos. Darkens in sunlight. Abs O > E.
1.711 ^ v 1.788	1.726	1.528	.198	MAGNESITE (Calcite grp) $(Mg,Fe)CO_3$	TRIG	$10\bar{1}1$ perf	White to brown	H 3-4 G 3.10 infus	Diss by hot acids. FeO 9.5, CaO 0.4%.
	1.727	---	---	KITTATINNYITE $Ca_4Mn^{+3}{}_4Mn^{+2}{}_2Si_4O_{16}(OH)_8 \cdot 18H_2O$	HEX	0001 perf	Bright yellow	H ~ 4 G 2.61	Pleoc wk, abs E > O.
	1.728	---	---	WALLKILLDELLITE $Ca_4Mn^{+2}{}_6As^{+5}{}_4O_{16}(OH)_8 \cdot 18H_2O$	HEX	0001 perf	Dark red	G 2.85	Pleoc, O reddish-orange, E orange-pink, abs O > E.
	1.73	1.69	.04	BIRNESSITE $Na_4Mn_{14}O_{27} \cdot 9H_2O$	ORTH mass	---	Brownish-black	H 1.5 G 3.0 infus	Diss by HCl. Nearly opaque.
	~1.73	1.72	.01	MELANOCERITE $(Ca,Ce,Y)_5(Si,B)_3O_{12}(OH,F) \cdot xH_2O$	HEX tab	Conch	Deep brown to black	H 5-6 G 4.13 infus	Dec by acids. Pale yellow in section.
1.713 ^ v 1.753	1.731	(1.55)	.18	RHODOCHROSITE (Calcite grp) $(Mn,Ca)CO_3$	TRIG	$10\bar{1}1$ perf	Pink	H 4 G 3.05 infus	Diss by hot acids. MnO 33.4, CaO 21.0, FeO 2.7, MgO 2.2%.
[ ]	1.733	1.714	.019	HEMATOLITE $(Mn,Mg,Al)_{15}(AsO_4)_2AsO_3(OH)_{23}$	TRIG	0001 perf	Brown to red	H 3.5 G 3.49 infus	Diss by acids. El clv pos. In section yellow to brown. Anom biax, small 2V.
v 1.750	1.734	1.592	.192	MINRECORDITE (Dolomite grp) $Ca(Zn,Mg)(CO_3)_2$	TRIG	$10\bar{1}4$ perf	Cols	H 3.5 G 3.32	Slowly diss by cold HCl.
1.705 ^	1.735	1.625	.110	STILPNOMELANE $K(Fe,Mg,Al)_{10}Si_{12}O_{30}(OH)_{12}$	MCL and TCL ps hex	001 mic	Brownish-black	H 3.5 G 2.83 F 3	Dec by acids. El clv pos. Pleoc, E golden yellow, O deep red-brown. Fe_2O_3 31.7, FeO 1.3, MnO 2.6%.
1.72	1.735	(~1.650)	~.085	REEVESITE $Ni_6Fe_2(OH)_{16}CO_3 \cdot 4H_2O$	TRIG	---	Yellow to greenish-yellow	G 2.80-2.88 infus	Diss by acids.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.710 ^	1.735	1.655	.080	BUERGERITE (Tourmaline grp) $NaFe_3Al_6(BO_3)_3Si_6O_{21}F$	TRIG pris	Prism, dist	Dark brown	H 7 G 3.31 F diff	Insol in acids. El neg. Pleoc, O yellow-brown, E pale yellow.
	1.738	1.728	.010	STOTTITE $FeGe(OH)_6$	TET ps oct	100, 010 good, 001	Brown	H 4-5 G 3.60	Luster greasy. Anom biax.
1.711(?) ◇ 1.741	1.740	1.547	.193	KUTNOHORITE (Dolomite grp) $CaMn(CO_3)_2$	TRIG	$10\bar{1}1$ perf	Pink, brown	H 3-4 G 3.14 infus	Diss by hot acids. MnO 31.8, ZnO 1.4, FeO 0.8, MgO 0.5%.
1.740 ^	1.741	1.536	.205	ANKERITE (Dolomite grp) $Ca(Fe,Mg)(CO_3)_2$	TRIG	$10\bar{1}1$ perf	Brown	H 3.5-4 G 3.12 infus	Diss by hot HCl. FeO 24.0, MnO 1.6%.
1.714 ◇ 1.762	1.742	1.736	.006	VESUVIANITE $Ca_{10}(Mg,Fe,Ti)_2Al_4(Si_2O_7)_2(SiO_4)_5(OH)_4$	TET	110 poor	Brown	H 5 G 3.41 F 4	Insol or partly dec by HCl. Fe_2O_3 4.4, FeO 1.6, TiO_2 4.7%.
	1.745	1.565	.180	ZHONGHUACERITE $Ba_2Ce(CO_3)_3F$	TRIG	---	Yellow	H 4.5-5 G 4.3	Diss by acids.
	1.747	1.741	.006	AKDALAITE $4Al_2O_3 \cdot H_2O$	HEX	Fr irreg	White	H 7 G 3.68	---
	1.748	1.645	.103	LAVENDULAN $NaCaCu_5(AsO_4)_4Cl \cdot 5H_2O$	ORTH ps hex	010 good 100, 001 dist	Greenish-blue	H 2.5 G 3.54 F easy	Diss by acids. Pleoc, E blue to greenish-blue, O pale blue to pale greenish-blue, abs E > O.
1.734 ^	1.750	1.550	.200	MINRECORDITE (Dolomite grp) $CaZn(CO_3)_2$	TRIG	$10\bar{1}4$ perf	Milk-white	H 3.5 G3.45	Slowly diss by cold HCl.
	1.75	1.728	.02	JASMUNDITE $Ca_{11}(SiO_4)_2O_2S$	TET	---	---	G 3.03	---
	1.751	1.645	.106	CLARAITE $(Cu,Zn)_3(CO_3)(OH) \cdot 4H_2O$	TCL (?) ps hex spherulitic	$10\bar{1}0$ perf	Bluish-green	H ~ 2 G 3.33	r > v.
[ ]	1.751	1.748	.003	CAPPELENITE $(Ba,Ca,Na)(Y,La)_6B_6Si_3(O,OH)_{27}$	HEX	---	Green to brown	H 6-6.5 G 4.41 F diff	Diss by HCl, gel.
1.703 ◇ 1.823	1.752	1.748	.004	BRITHOLITE $(Ce,Ca,Y)_5(SiO_4,PO_4)_3(OH,F)$	HEX	---	Brown	H 5 G 4.1-4.4 infus	Gel with acids. Apatite structural type.

	1.753	1.740	.004	OKANOGANITE $(Na,Ca)_3(Y,Ce,Nd,La)_{12}Si_6B_2O_{27}F_{14}$	TRIG	---	Pale pink	H 4 G 4.35	Tw.
1.731 ^v 1.803	1.753	1.560	.193	RHODOCHROSITE (Calcite grp) $(Mn,Ca)CO_3$	TRIG	10$\bar{1}$1 perf	Pink	H 4 G 3.3 infus	Diss by hot acids. MnO 44.3, CaO 13.4, MgO 2.3, FeO 0.8%.
	1.753	1.717	.036	WISERITE $Mn_4B_2O_5(OH,Cl)_4$	TET fib	Clv across fibers, perf	Dark brown	G 3.42	Diss by HCl.
	1.755	1.731	.024	CONGOLITE $(Fe,Mn,Mg)_3B_7O_{13}Cl$	TRIG	---	Pale red	G 3.58	Diss by acids.
	1.756	1.680	.076	NATISITE Na_2TiSiO_5	TET	001 perf 100 less so	Yellow-green to greenish-gray	H 3-4 G 3.15 calc F easy	Insol in dilute acids.
⊔ 1.765	1.760	1.577	.183	CORDYLITE $Ba(Ce,La)_2(CO_3)_3F_2$	HEX pyram	0001 dist	Wax-yellow	H 4.5 G 4.10 infus	Diss by acids. Pleoc, O green-yellow, E brownish-yellow.
1.742 ^v 1.795	1.762	1.750	.012	VESUVIANITE $(Ca,Ce)_{10}(Mg,Fe)_2Al_4(Si_2O_7)_2(SiO_4)_5(OH)_4$	TET	110 poor	Dark brown	H 5 G 3.60 F 4	Insol in acids. $(Ce,La)_2O_3$ 16.7, Fe_2O_3 5.4, FeO 5.5%.
	1.765	1.735	.030	SHERWOODITE $Ca_9Al_2V^{+5}_{24}V^{+4}_4O_{80}\cdot 56H_2O$	TET	Conch to uneven	Blue-black	H 2 G 2.8	Diss by acids. Pleoc, O green, E blue.
	1.766	1.585	.178	HUANGHOITE $Ba(Ce,La)(CO_3)_2F$	HEX	0001	Honey-yellow to yellow-green	H 4.5-5 G 4.58 infus	Diss by acids. Pleoc wk in yellow-green.
v 1.794	1.766	1.758	.008	CORUNDUM Al_2O_3	TRIG	Parting 0001, 00$\bar{1}$1 sometimes perf	Cols, red, blue, brown	H 9 G 4.00 infus	Insol in acids. Colored var pleoc. Anom biax, 2V 0-58°
	1.772	1.770	.002	SWEDENBORGITE $NaBe_4SbO_7$	HEX pris	0001 dist	Cols to wine-yellow	H 8 G 4.29	Insol in acids. El crystal neg.
	1.775	1.765	.010	FRESNOITE $Ba_2TiSi_2O_8$	TET	001 fair	Lemon- to canary-yellow	H 3-4 G 4.43 F 4	Insol in cold, dec by hot HCl. Pleoc, O cols, E yellow.
	1.778	1.660	.118	NORDENSKIÖLDINE $CaSnB_2O_6$	TRIG tab	0001 perf fr conch	Cols to yellow	H 5.5-6 G 4.20 infus	Diff diss by acids. El neg.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.778	1.772	.006	CHROMDRAVITE (Tourmaline grp) $Na(Mg,V,Al)_3(Cr,Fe^{+3})_6B_3Si_6O_{27}(OH)_4$	TRIG	---	Dark green	G 3.40	Pleoc, O dark green, E yellow-green, abs O > E.
v 1.846	1.78	1.75	.03	HIBONITE $(Ca,Ce)(Al,Ti,Fe,Mg)_{12}O_{19}$	HEX	0001 easy, parting $10\bar{1}0$	Brownish-black	H 7.5-8 G 3.84 infus	Insol in acids. Pleoc, O cols, E blue.
	1.782	1.780	.002	CLARINGBULLITE $Cu_8Cl_2(OH)_{14}\cdot H_2O$	HEX plates	0001 perf $10\bar{1}0$, $11\bar{2}0$ dist	Blue	G 3.9	Abnormal interf colors dark blue to yellow-green.
1.726 ^ v 1.816	1.788	1.570	.218	MAGNESITE-SIDERITE (Calcite grp) $(Mg,Fe)CO_3$	TRIG	$10\bar{1}1$ perf	White to brown	H 4 G 3.43 infus	Diss by hot acids. Calc for Mg:Fe = 1:1, FeO 35.9, MgO 20.1%.
v 1.820	1.791	1.705	.086	JAROSITE (Alunite grp) $KFe_3(SO_4)_2(OH)_6$	TRIG tab, rhombs	0001 dist	Yellow to brown	H 2.5-3.5 G 2.9-3.2 F 4.5	Diss by HCl. Pleoc, O yellow to brown, E paler to cols. Basal section may be divided into biax segments.
1.766 ^	1.794	1.785	.009	CORUNDUM $(Al,Fe)_2O_3$	TRIG	Parting 0001, $00\bar{1}1$ sometimes perf	Brown	H 9 G 4.1 infus	Insol in acids. Fe_2O_3 9.2, TiO_2 0.4%.
1.762 ^	1.795	1.775	.020	VESUVIANITE $(Ca,Sb)_{10}(Mg,Fe)_2Al_4(Si_2O_7)_2(SiO_4)_5(OH)_4$	TET pris	110 poor	Pale green	H 5 F 4	Insol in acids. El neg. E cols, O pale yellow-green. Sb_2O_3 15.7, Fe_2O_3 3.3, FeO 4.1%.
	1.80	---	str	CRONSTEDTITE (Kaolinite-Serpentinite grp) $(Fe^{+2},Mg)Fe^{+3}(SiFe)O(OH)$	HEX, TRIG, and MCL polytypes	0001 perf	Black	H 3.5 G 3.34 F 4	Gel with acids. Pleoc, E dark reddish-brown, O nearly opaque.
	1.800	1.743	.057	FERRIDRAVITE (Tourmaline grp) $(Na,K)(Mg,Fe^{+2})_3Fe^{+3}_6B_3Si_6O_{27}(O,OH)_4$	TRIG	Uneven	Black	G 3.26	Streak brown. Insol in acids.
	1.800	1.750	.050	AMMONIOJAROSITE (Alunite grp) $(NH_4)Fe_3(SO_4)_2(OH)_6$	TRIG tab	0001 dist	Pale yellow	G 3.11	Diss by HCl.

	1.80	1.795	.005	NIGERITE $(Zn,Mg,Fe)(Sn,Zn)_2(Al,Fe)_{12}O_{22}(OH)_2$	TRIG	---	Dark brown	H 8-9 G 4.25	Insol in acids. Pleoc, O yellow-brown, E yellow. U opt pos.
	1.802	1.740	.062	QUETZALCOATLITE $Zn_8Cu_4(TeO_3)_3(OH)_{18}$	HEX	$10\bar{1}0$ fair	Blue	H 3 G 6.05	Diss by acids. Pleoc, O blue-green, E nearly cols.
1.753 ↕ 1.816	1.803	1.584	.219	RHODOCHROSITE (Calcite grp) $(Mn,Ca)CO_3$	TRIG	$10\bar{1}1$ perf	Pink	H 4 G 3.65 infus	Diss by hot acids. FeO 3.8, MgO 0.6, CaO 1.3%.
	1.804	1.773	.031	CYRILOVITE $NaFe_3(PO_4)_2(OH)_4 \cdot 2H_2O$	TET	---	Yellow, brown, yellow-green	G 3.08 F 2-3	Diss by hot acids. Pleoc faint, abs O > E.
↓ 1.851	1.805	1.783	.022	HÖGBOMITE $(Mg,Fe)_2(Al,Ti)_5O_{10}$	HEX and TRIG polytypes	$10\bar{1}0$ good parting 0001	Brown, yellow	H 6.5 G 3.70 infus	Insol in acids. Pleoc, O deep yellow, E yellow. TiO_2 9.1, FeO 7.8%. Anom biax.
1.711 ↕ 1.84	1.81	1.58	.23	GASPEITE (Calcite grp) $(Ni,Mg)CO_3$	TRIG	$10\bar{1}1$ perf	Green	H 3-4 G 3.6 infus	Diss by hot acids. NiO 36.8, MgO 14.8, FeO 4.3%.
↓ 1.832	1.815	1.740	.075	NATROJAROSITE (Alunite grp) $NaFe_3(SO_4)_2(OH)_6$	TRIG plates	0001 perf	Yellow, brown	H 3 G 3.18 F 4.5	Diss by HCl. El pos. Pleoc in yellows, abs O > E. Anom biax. Basal sections divided into segments.
↓ 1.850	1.815	1.601	.214	SMITHSONITE (Calcite grp) $(Zn,Mg)CO_3$	TRIG	$10\bar{1}1$ perf	Milky white	H 4.5 infus	Diss by hot acids. ZnO 53.2, MgO 7.6, CaO 1.1%.
	1.815	1.761	.054	MOLYBDOPHYLLITE $Pb_2Mg_2Si_2O_7(OH)_2$	TRIG lam	0001 perf	Cols to pale green	H 3-4 G 4.72 F diff	Cols in section. El pos.
1.788 ↕ 1.836	1.816	1.592	.224	SIDERITE (Calcite grp) $(Fe,Mg,Mn)CO_3$	TRIG	$10\bar{1}1$ perf	Brown	H 4 G 3.59 infus	Diss by warm acids. MgO 11.8, MnO 5.9, CaO 1.4%.
1.803 ↕ 1.836	1.816	1.597	.219	RHODOCHROSITE (Calcite grp) $MnCO_3$	TRIG	$10\bar{1}1$ perf	Pink	H 4 G 3.70 infus	Diss by warm acids. Calc for pure end member.
	1.816	1.728	.088	HYDRONIUM JAROSITE (Alunite grp) $(H_3O)Fe^{+3}{}_3(SO_4)_2(OH)_6$	TRIG	0001	Yellow, brown	H 4-4.5 G 2.5-2.9, 3.17 calc	Diss by HCl.
	1.816	1.788	.028	PAINITE $CaZrBAl_9O_{18}$	HEX	---	Garnet-red	H 8 G 4.00	Insol in acids.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.791 ^	1.820	1.715	.105	JAROSITE (Alunite grp) $KFe_3(SO_4)_2(OH)_6$	TRIG tab, rhombs	0001 dist	Yellow to brown	H 2.5-3.5 G 3.2 F 4.5	Diss by HCl. Pleoc in brown and yellow, abs O > E. Anom biax, with basal segments.
	1.82	1.78	.04	NANLINGITE $CaMg_4(AsO_3)_2F_4$	TRIG	One imperf	Brownish-red	G 3.93	---
1.752 ^	1.823	1.817	.006	BRITHOLITE $(Ce,Ca,Y)_5(SiO_4,PO_4)_3(OH,F)$	HEX	---	Brown	H 5 G 4.77 infus	Gel with acids. Apatite structural type.
	1.82-1.83	---	---	ZAIRITE (Crandallite grp) $Bi(Fe,Al)_3(PO_4)_2(OH)_6$	TRIG	---	Greenish	G 4.37	---
1.816 ^v 1.836	1.830	1.605	.225	OTAVITE (Calcite grp) $(Cd,Ca)CO_3$	TRIG	10$\bar{1}$1 perf	White, yellow	G ~ 4.9 infus	Diss by acids with eff. $CdCO_3$ 91, $CaCO_3$ 9%.
1.815 ^	1.832	1.750	.082	NATROJAROSITE (Alunite grp) $NaFe_3(SO_4)_2(OH)_6$	TRIG plates	0001 perf	Yellow, brown	H 3 G 3.18 F 4.5	Diss by HCl. El pos. Pleoc in yellow, abs O > E. Anom biax with basal segments.
1.816 ^v 1.840	1.836	(1.610)	.226	RHODOCHROSITE (Calcite grp) $(Mn,Zn,Fe)CO_3$	TRIG	10$\bar{1}$1 perf	Pink	H 4 G 3.76 infus	Diss by warm acids. MnO 29.8, FeO 13.9, ZnO 14.9, CaO 3.1%.
	1.837	1.833	.004	JEANBANDYITE $(Fe^{+3},Mn^{+2})Sn(OH)_6$	TET ps cub	001 and 100 fair	Brown-orange	H 3.5 G 3.81	Diss slowly by cold HCl.
1.836 ^v 1.849	1.840	1.615	.225	RHODOCHROSITE, ferroan (Calcite grp) $(Mn,Fe)CO_3$	TRIG	10$\bar{1}$1 perf	Brown	H 4 G 3.72 infus	Diss by warm acids. MnO 35.4, FeO 26.1%.
1.81 ^	1.84	(1.62)	.22	GASPEITE (Calcite grp) $NiCO_3$	TRIG	10$\bar{1}$1 perf	Emerald-green	H 3-4 G 3.7 infus	Diss by hot acids. NiO 55.5, MgO 3.3, FeO 0.1%.
1.78 ^	1.846	1.804	.042	HIBONITE $(Ca,Ce)(Al,Ti,Fe)_{12}O_{19}$	HEX	0001 easy, parting 10$\bar{1}$0	Brownish-black	H 7.5-8 G 3.88 infus	Insol in acids. Pleoc, abs E > O.
1.840 ^v 1.860	1.849	1.615	.234	SIDERITE, manganoan (Calcite grp) $(Fe,Mn)CO_3$	TRIG	10$\bar{1}$1 perf	Brown	H 3.5 G 3.81 infus	Diss by warm acids. FeO 47.9, MnO 9.5, MgO 3.2, CaO 0.2%.

1.815 ^	1.850	1.623	.227	SMITHSONITE (Calcite grp) $ZnCO_3$	TRIG	$10\bar{1}1$ perf	Cols, green	H 4.5 G 4.42 infus	Diss by acids. FeO 0.4, MnO 0.5%.
1.83 □ 1.87	1.85	(~1.81)	~.04	BEAVERITE (Alunite grp) $Pb(Cu,Fe,Al)_3(SO_4)_2(OH)_6$	TRIG plates, u earthy	---	Canary-yellow	G 4.08-4.36	Diss by acids.
1.805 ^	1.851	1.802	.049	HÖGBOMITE $(Mg,Fe)_2(Al,Ti)_5O_{10}$	HEX and TRIG (polytypes)	$10\bar{1}0$ good parting 0001	Brown, yellow	H 6.5 G 3.81 infus	Insol in acids. Pleoc, O dark brown, E med-brown. Anom biax.
	1.855	1.60	.255	SPHAEROCOBALTITE (Calcite grp) $CoCO_3$	TRIG	$10\bar{1}1$ perf	Rose-red	H 3-4 G 4.1 infus	Diss by acids. Pleoc, O violet-red, E rose red.
1.849 ◇ 1.875	1.860	1.625	.235	SIDERITE, zincian (Calcite grp) $(Fe,Mn,Zn)CO_3$	TRIG	$10\bar{1}1$ perf	Brown	H 4 G 3.92 infus	Diss by hot acids. MnO 14.65, ZnO 11.55, MgO 0.3, FeO 36.4%.
	1.86	1.83	.03	ASBECASITE $Ca_3(Ti,Sn)As_6Be_2Si_2O_{20}$	TRIG	$10\bar{1}1$ perf	Lemon-yellow	H 6.5-7 G 3.70	Anom biax, 2V 0-17°.
v 1.915	1.860	1.855	.005	BYSTROMITE $MgSb_2O_6$	TET u mass	---	Blue-gray	H 4 G 5.7	Insol in dil acids, diss by concd HCl + KI. Opt char unk.
v 1.898	1.870	1.792	.078	ARSENIOSIDERITE $Ca_3Fe_4(AsO_4)_4(OH)_6 \cdot 3H_2O$	MCL ps tet, fib	001 perf	Yellow, brown	H 4.5 G 3.5-3.6 F 3	Diss by acids. Pleoc, O brownish-red, E pale yellow.
	1.870	1.845	.025	DUSSERTITE (Crandallite grp) $BaFe_3(AsO_4)_2(OH)_5 \cdot H_2O$	TRIG	0001	Yellow, green	H 3.5 G 3.75	Diss by acids. Anom biax, 2V 0-20°.
1.860 ^	1.875	1.633	.242	SIDERITE (Calcite grp) $FeCO_3$	TRIG	$10\bar{1}1$ perf	Brown	H 4 G 3.89 infus	Diss by hot acids. Calc for pure end-member.
	1.875	1.785	.090	PLUMBOJAROSITE (Alunite grp) $PbFe_6(SO_4)_4(OH)_{12}$	TRIG plates	$10\bar{1}4$ fair	Brown	H soft G 3.63	Diss by HCl. Pleoc, O brown-red, E pale golden-yellow.
	1.882	1.785	.097	ARGENTOJAROSITE (Alunite grp) $AgFe_3(SO_4)_2(OH)_6$	TRIG plates	0001	Yellow, brown	G 3.66	Diss by HNO_3. El pos. Pleoc in yellow, abs O > E.
1.870 ^	1.898	1.815	.083	ARSENIOSIDERITE $Ca_3Fe_4(AsO_4)_4(OH)_6 \cdot 3H_2O$	MCL ps tet, fib	001 perf	Yellow, brown	H 4 G 3.5-3.6 F 3	Diss by acids. Pleoc, O brownish-red, E pale yellow.
	1.91	(1.90)	.01	DAUBREEITE $BiO(OH,Cl)$	TET	001 perf	Yellow, brown	H 2-2.5 G 6.4-7.5 F easy	Diss by HCl. El clv pos.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.860 ^	1.915	1.908	.007	BYSTROMITE $MgSb_2O_6$	TET u mass	---	Blue-gray	H 7 G 5.7	Insol in dil acids, diss by concd HCl + KI. Opt char unk.
v 1.957	1.916	1.909	.007	BEUDANTITE (Beudantite grp) $PbFe_3(AsO_4)(SO_4)(OH)_6$	TRIG	0001 easy	Olive, brown, yellow	H 4 G 4.0-4.3 F 3.5	Diss by acids. Pleoc, O yellow, E pale yellow. Anom biax. As:S = 4:1.
	1.93	---	wk	CORKITE (Beudantite grp) $PbFe_3(PO_4)(SO_4)(OH)_6$	TRIG	0001 easy	Yellow, brown, greenish	H 4 G 4.2-4.3 F 4-5	Diss by HNO_3. Abnormal green interf colors. Anom biax.
1.916 △ 1.98	1.957	1.943	.014	BEUDANTITE (Beudantite grp) $PbFe_3(AsO_4)(SO_4)(OH)_6$	TRIG	0001 easy	Yellow, brown, black	H 4 G 4.0-4.3 F 3.5	Diss by HNO_3. Pleoc, O yellow to red-brown, E cols to yellow. Anom biax. As:S = 1:1.
	1.97	---	wk	DIXENITE $Cu^{+1}Mn_{14}Fe^{+3}(As^{+3}O_3)_5(As^{+5}O_4)(SiO_4)_2(OH)_6$	TRIG plates	0001 mic	Black	H 3-4 G 4.20	Dec by HCl. Glowing red in transmitted light. El pos.
	1.977	1.967	.010	DUGGANITE $Pb_3(Zn,Cu)_3(Te^{+6}O_6)AsO_4(OH)_3$	HEX	---	Cols to green	H 3 G 6.33	---
	1.98	1.85	.13	DIABOLEITE $Pb_2CuCl_2(OH)_4$	TET tab	001 perf	Sky-blue	H 2.5 G 5.42 F easy	Diss by HNO_3. Pleoc, O deep blue, E nearly cols. El pos.
	1.99	---	mod	Unnamed (Crandallite grp) $PbFe_3(AsO_4)_2(OH)_5 \cdot H_2O$	TRIG	0001	Brown	---	Diss by HNO_3. Anom biax, 2V 0-50°.
	2.0 red	---	extr	GRAPHITE C	HEX and TRIG	0001 perf	Black	H 1-2 G 2.2 infus	Insol in acids. Thinnest flakes are deep blue in transmitted light. Strongly pleoc. El pos.
[ ]	2.0	(1.8)	.025	JAGOITE $Pb_3FeSi_3O_{10}(OH,Cl)$	TRIG	0001 perf	Yellow-green	H 3 G 5.43	El clv pos.
	2.00	2.14	.14	WAKEFIELDITE YVO_4	TET	---	Pale tan	H 5 G (4.26)	---
	2.01	1.99	.02	ARMANGITE $Mn_{26}As_{18}O_{50}(OH)_4CO_3$	HEX	0001 fair	Black	H 4 G 4.43 F easy	Diss by HCl. Streak brown.

ˇ 2.041	2.026	1.965	.061	CUMENGITE $Pb_4Cu_4Cl_8(OH)_8 \cdot H_2O$	TET	101 good 110 dist	Indigo-blue	H 2.5 G 4.67 F 1	Diss by warm HNO_3.
	>2.0	>2.0	str	KUSUITE $(Ce^{+3},Pb^{+2},Pb^{+4})VO_4$	TET	---	Black	H 4.5 G 5.30 calc	Streak rust-brown. In section honey-yellow.
	>2.0	>2.0	---	DREYERITE $BiVO_4$	TET plates	---	Orange- to brownish-yellow	H 2-3 G (6.25)	Pleoc, O bright yelow, E brownish-yellow.
	2.026	2.010	.016	HEDYPHANE (Apatite grp) $(Ca,Pb)_5(AsO_4)_3Cl$	HEX (mcl, ps hex?)	$10\bar{1}1$	White	H 4.5 G 5.82 F 2	Diss by HNO_3.
	2.03	2.00	.03	PSEUDOBOLEITE $Pb_5Cu_4Cl_{10}(OH)_8 \cdot 2H_2O$	TET ps cub	001, 101 perf	Indigo-blue	H 2.5 G 4.85 F 1	Diss by warm HNO_3. Pearly luster on clv.
ˇ 2.07	2.033	2.015	.018	BARYSILITE $Pb_8Mn(Si_2O_7)_3$	TRIG tab	0001 dist	Gray, white	H 3 G 6.72 F 2.5	Gel with acids. MnO 3.3, MgO 0.8, ZnO 0.3%.
2.06	2.04	2.00	.04	SIMPSONITE $Al_4(Ta,Nb)_3(O,OH,F)_{14}$	TRIG	0001	White, yellow	H 7 G 6.6-7.3 infus	Fluor blue (pure Ta) to yellow (Nb present) in UV.
2.026 ^	2.041	1.926	.115	CUMENGITE $Pb_4Cu_4Cl_8(OH)_8 \cdot H_2O$	TET	101 good 110 dist	Indigo-blue	H 2.5 G 4.67 F 1	Diss by warm HNO_3.
	2.05	2.03	.02	BOLEITE $Pb_{26}Ag_{10}Cu_{24}Cl_{62}(OH)_{48} \cdot 3H_2O$	TET ps cub	001 perf 101 good	Indigo-blue	H 3-3.5 G 5.05 F 1	Diss by warm HNO_3. Pearly luster on clvs. Trillings on 001.
	2.05	---	very wk	EULYTITE $Bi_4Si_3O_{12}$	CUB tetrah	110 imperf	Gray, brown	H 4-4.5 G 6.62 F 2	Gel with acids.
	2.055	1.975	.080	GRIMALDIITE $CrO(OH)$	TRIG tab	---	Deep red	G 4.12	Data for synth compd.
2.05 ˇ 2.135	2.057	2.046	.011	PYROMORPHITE (Apatite grp) $Pb_5(PO_4)_3Cl$	HEX pris	$10\bar{1}1$ poor	Green, yellow, brown	H 3.5-4 G 7.0-7.1 F 1.5	Diss by HNO_3. Luster resinous. Pleoc, O green, E greenish-yellow. Anom biax.
	>2.05	---	---	KETTNERITE $CaBiO(CO_3)F$	TET plates	---	Brown to yellow	H "not too high" G 5.80	---
	2.06	2.05	.01	CUZTICITE $Fe^{+3}_2Te^{+6}O_6 \cdot 3H_2O$	HEX	---	Dark yellow	H 3 G 3.9	---

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
2.033 ^	2.07	2.05	.02	BARYSILITE $Pb_8Mn(Si_2O_7)_3$	TRIG tab	0001 dist	Gray, white	H 3 G 6.72 F 2.5	Gel with acids.
	2.09	1.94	.15	HYDROCERUSSITE $Pb_3(CO_3)_2(OH)_2$	TRIG plates	0001 perf	Cols	H 3.5 G 6.80 F 1.5	Diss by HNO_3. Data for synth compd. El pos.
	2.125	2.059	.074	YEDLINITE $Pb_6Cr(O,OH)_8Cl_6$	TRIG	$11\bar{2}0$ dist	Red-violet	H 2.5 G 5.85	Pleoc, O pale cobalt blue, E lavender.
2.11 □ 2.15	2.13	1.99	.14	BEYERITE $(Ca,Pb)Bi_2(CO_3)_2O_2$	TET tab	Conch	Yellow, green	H 2-3 G 6.56 F 1.5	Diss by acids.
2.057 △ 2.18	2.135	2.12	.015	MIMETITE (Pyromorphite ser, Apatite grp) $Pb_5(AsO_4)_3Cl$	MCL ps hex	$10\bar{1}1$ imperf	Yellow, brown, gray	H 3.5-4.5 G 7.1-7.24 F 1	Diss by HNO_3. Commonly biax.
	2.145	2.006	.14	MATLOCKITE PbFCl	TET tab	001 perf	Yellow, greenish	H 2.5-3 G 7.12 F 1	Diss by warm HNO_3. Anom biax. El clv pos.
	2.15	---	str	BISMOCLITE BiOCl	TET	001 perf	Yellow, brown	H 2-2.5 G 7.4-7.6 F 1	Diss by acids. El clv pos.
	2.155	1.975	.180	GRIMALDIITE CrO(OH)	TRIG	---	Deep red	G 4.12 synth infus	---
	2.155	2.120	.035	PARAKHINITE $PbCu_3TeO_4(OH)_6$	HEX	---	Dark green	H 3.5 G 6.7 calc	---
	>2.10	>2.10	mod to str	SCHUETTEITE $Hg_3(SO_4)O_2$	HEX	---	Yellow	H 3 G 8.2 volat	Diss by acids. Pleoc wk, O greenish-yellow, E orange yellow.
	2.18	---	---	RUSSELLITE Bi_2WO_6	TET mass	---	Yellow	H 3.5 G 7.37	Opt char unk.
	2.21	---	wk	ZAVARITSKITE BiOF	TET	---	Gray	G (9.2)	Opt sign unk.
v 2.43	2.25	2.20	.05	VANADINITE, arsenatian (Apatite grp) $Pb_5(VO_4,AsO_4)_3Cl$	HEX pris	---	Yellow	H 3 G 7.0 F 1.5	Diss by HNO_3. El neg.

	2.26	2.10	.16	HYDROHETAEROLITE $Zn_2Mn_4O_8 \cdot H_2O$	TET fib	001 perf	Brownish-black	H 5-6 G 4.6 infus	Diss by HCl. Pleoc wk, O red-brown, E nearly opaque.
v 2.30	2.27	2.18	.09	STOLZITE $PbWO_4$	TET pyram	001 imperf	Green, gray, brown	H 2.5-3 G 7.9-8.4 F 2	Dec by HCl. Pleoc, O pale greenish-yellow, E bright yellow.
	2.275	2.15	.125	RANCIEITE $(Ca,Mn^{+2})Mn^{+4}{}_4O_9 \cdot 3H_2O$	HEX (?) mass	---	Dark brown, streak purplish	Soft G 3.3	Diss by HCl. Opt char unk.
	2.295	2.285	.01	FINNEMANITE $Pb_5(AsO_3)_3Cl$	HEX pris	$10\bar{1}1$ dist	Olive-green, gray, black	H 2-3 G 7.27 F 2	Diss by HNO_3. El neg.
v 2.35	2.30	2.07	.23	HETAEROLITE $ZnMn_2O_4$	TET	001 indist	Black	H 6 G 5.2 infus	Diss by HCl. Red-brown in section. Pleoc wk, abs O > E.
2.27 ^v 2.35	2.30 Li	2.23 Li	.07	WULFENITE, tungstenian $Pb(Mo,W)O_4$	TET	011 dist	Yellow	H 3 G 6.6 F 2	Dec by acids. MoO_3 21%, W/Mo = 0.7.
	2.30 Li	---	---	PLATTNERITE PbO_2	TET	110	Black	H 5-5.5 G 8.5-9.5 F 2	Diss by HCl with evolution Cl_2. Nearly opaque. Basal section shows biax segments.
	2.32	2.12	.20	SANTANAITE $9PbO \cdot 2PbO_2 \cdot CrO_3$	HEX	0001 perf $1\bar{2}10$	Straw-yellow	H ~ 4	---
	2.32 Li	2.25 Li	.07	ECDEMITE $Pb_6As_2O_7Cl_4$	TET tab	001 dist	Yellow, green	H 2.5-3 G 7.14 F 1.5	Diss by HNO_3. In part biax.
2.31 [] 2.35	2.33	1.96	.37	GEIKIELITE $(Mg,Fe)TiO_3$	TRIG rhombs	$10\bar{1}1$ perf	Brownish-black	H 6 G 3.8-4.1 infus	Diff diss by HCl. Pleoc wk in red-brown, red, or purple.
2.30 ^	2.35	2.12	.23	HETAEROLITE $ZnMn_2O_4$	TET	001 indist	Black	H 6 G 5.18 infus	Diss by HCl. Red-brown in section. Pleoc wk, abs O > E.
2.30 ^v 2.47	2.35	2.29	.06	WULFENITE, uranian $Pb(Mo,U)O_4$	TET tab	011 dist	Yellow	H 3 G 6.6 F 2	Diss by HNO_3. UO_3 11.6%.
⊔ 2.40	2.35 Li	2.33 Li	.02	"LORETTOITE" $Pb_7O_6Cl_2$	TET (?) mass	001 perf	Orange-yellow	H 3 G 7.95 F 1	Diss by HNO_3. Probably synth material (?).
	2.36 Li	2.25 Li	.11	SCHWARTZEMBERGITE $Pb_5(IO_3)Cl_3O_3$	TET or ps tet	001 dist	Honey- to straw-yellow, reddish	H 2.5 G 7.39 F 1	Diss by HNO_3. Shows biax sectors.

Table 5. Uniaxial negative minerals (continued)

Other entries	Refractive index ω	Refractive index ε	Biref	MINERAL NAME and formula	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	2.36 Li	2.31 Li	.05	LANGBANITE $(Mn^{+2},Sb,Ca)_4(Mn^{+4},Fe)_3SiO_{12}$	TRIG	---	Iron-black	H 6.5 G 4.6-4.8 infus	Diff diss by HCl. Pleoc wk in reddish-brown, abs O > E.
[ ]	2.41 Li	---	wk	MINIUM Pb_3O_4	TET u mass	---	Brownish-red	H 2.5 G 9.1 F 2	Diss by acids. Abn green interf colors. Pleoc, deep red-brown to nearly cols.
2.25 ^	2.43	2.37	.06	VANADINITE (Apatite grp) $Pb_5(VO_4)_3Cl$	HEX pris	---	Red, yellow, brown	H 3 G 6.65-6.98 F 1.5	Diss by HNO_3. El neg.
	2.45	2.33	.12	TAPIOLITE $Fe(Ta,Nb)_2O_6$	TET	---	Black	H 6-7 G 7.11 infus	Pleoc str, dark red to black. U opt pos.
	2.46 Li 2.40	2.15 Li 2.15	.31	HAUSMANNITE $Mn^{+2}Mn^{+3}{}_2O_4$	TET oct	001 good	Brownish-black	H 5.5 G 4.84 infus	Diss by HCl. In section, brownish-red, not pleoc.
2.35 ^	2.47	2.26	.21	WULFENITE $PbMoO_4$	TET tab	011 dist 001, 013 less so	Yellow, orange	H 3 G 6.7 F 2	Diss by HNO_3.
	2.48 Na 2.46	2.21 Na 2.07	.27 .39	PYROPHANITE $MnTiO_3$	TRIG	$02\bar{2}1$ perf $10\bar{1}2$ less so	Deep blood-red	H 5 G 4.54 infus	Nearly insol in HCl. In section yellow-red.
	2.50 Li	---	wk to mod	SENAITE $Pb(Ti,Fe,Mn)_{21}O_{38}$	TRIG	---	Black	H 6 G 5.30	Nearly opaque. Not pleoc. Tw pl $11\bar{2}0$ common.
2.55 [ ] 2.60	2.56	2.49	.07	ANATASE TiO_2	TET oct	001, 011 perf	Brown to black	H 5.5-6 G 3.90 infus	Insol in acids. Pleoc in thick sections, O pale blue to yellow, E dark blue to orange.
	2.6 Li	---	extr	TRECHMANNITE $AgAsS_2$	TRIG	$10\bar{1}1$ good 0001 dist	Scarlet-vermilion	H 1.5-2 F 1	Streak scarlet. Pleoc, O pale red, E cols.
	2.60	2.50	.10	BRAUNITE $3Mn_2O_3 \cdot MnSiO_3$	TET pyram	112 perf	Brownish-black	H 6-6.5 G 4.72-4.83 infus	Dec by HCl.
	2.665Li	2.535Li	.130	LITHARGE PbO	TET tab	110 perf	Red	H 2 G 9.13 F 1.5	Diss by HNO_3. Fuses to a yellow bead. El clv neg.

2.70	1.75	.95	CHALCOPHANITE $(Zn,Mn)Mn_3O_7 \cdot 3H_2O$	TCL	001 perf	Brownish-black	H 2.5 G 4.0 infus	Diss by HCl. Pleoc str, O nearly opaque, E deep red.
2.98 Li 3.09 Na	2.71 Li 2.79 Na	.27 .30	PROUSTITE Ag_3AsS_3	TRIG	$10\bar{1}1$ dist	Scarlet	H 2-2.5 G 5.57 F 1	Dec by HNO_3. Streak scarlet. Bright red in section, pleoc wk, O blood-red, E cochineal-red.
3.01 Li 3.22 Na	2.78 Li 2.94 Na	.23 .28	HEMATITE Fe_2O_3	TRIG	Parting 0001	Red to black	H 5-6 G 5.26 infus	Diss by HCl. Streak red. Abs O > E.
3.08 Li	2.88 Li	.20	PYRARGYRITE Ag_3SbS_3	TRIG	$10\bar{1}1$ dist	Dark red	H 2.5 G 5.85 F 1	Dec by HNO_3. Streak purplish-red. Red in section. Tw pl $11\bar{2}0$.
3.25	2.40	.85	CREDNERITE $CuMnO_2$	MCL ps hex	001, 100 perf $\bar{1}11$ good	Iron-black	H 4 G 5.0 F diff	Diss by HCl. Poly tw.
3.30	2.90	.40	HOLLANDITE $Ba(Mn^{+4},Mn^{+2})_8O_{16}$	MCL ps tet	---	Black, gray	H 6 G 2.95 infus	Diss by HCl.
3.78	3.75	.03	GRATONITE $Pb_9As_4S_{15}$	TRIG	Conch	Lead-gray	H 2.5 G 6.22 F 1	---
4.34 Li	2.03 Li	2.31	MOLYBDENITE MoS_2	HEX	0001 perf	Lead-gray	H 1-1.5 G 4.7 infus	Dec by HNO_3. El clv pos.

Table 6. Biaxial positive minerals

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
	1.301	1.301	1.307	.006	FERRUCCITE $NaBF_4$	11°	X = b Z = c	ORTH tab	100, 010 001	Cols	H 3 G 2.50 F 1	Sl sol in H_2O, diss by acids.
	1.338	1.338	1.339	.001	CRYOLITE Na_3AlF_6	43° r < v	X = b Z:c = -44°	MCL	Parting 110, 001	White, reddish, brownish	H 2.5 G 2.97 F 2	Insol in H_2O, tw 110 lam.
	1.346	1.348	1.350	.004	WEBERITE Na_2MgAlF_7	80°	X = a Y = b	ORTH	101 poor 010	Gray	H 3.5 G 2.96	---
	1.409	1.412	1.419	.010	PACHNOLITE $NaCaAlF_6 \cdot H_2O$	76° r < v wk	X = b Z:c = 53-69° disp str	MCL	001 fair	White	H 3 G 2.98, 2.97 calc	Tw pl 100.
	1.411	1.416	1.422	.011	CARLHINTZEITE $Ca_2AlF_7 \cdot H_2O$	77°	---	TCL pris	---	White, cols	G 2.36	Tw [010].
	1.413	(1.417)	1.423	.010	YAROSLAVITE $Ca_3Al_2F_{10}(OH)_2 \cdot H_2O$	74°	---	ORTH fib	Pina-coidal	White	G 3.09	---
	1.425	1.428	1.438	.013	CALCJARLITE $(Na,K)(Ca,Sr)_3Al_3(F,OH)_{16}$	72°	Z:c = 10-15°	MCL	Uneven	Cols	H 4 G 3.51	---
	1.429	1.433	1.435	.006	JARLITE $NaSr_3Al_3(F,OH)_{16}$	~ 90°	Y = b X:c = -6°	MCL tab	---	Cols	H 4-4.5 G 3.78-3.93 F easy	Formula in doubt.
	1.422	1.435	1.480	.058	SANTITE $KB_5O_6(OH)_4 \cdot 2H_2O$	70° (58±5°)	X = c Y = b	ORTH	010 perf 100 dist	Cols	H 2.5 G 1.74	Diss by acids. Tw $01\bar{1}$.
	1.431	1.438	1.488	.057	SBORGITE $NaB_5O_6(OH)_4 \cdot 3H_2O$	35° (42±6°) r > v wk	---	MCL	---	Cols	H 3.5 G 1.71	Sol in H_2O.
	1.439	1.442	1.469	.030	STERCORITE $HNa(NH_4)PO_4 \cdot 4H_2O$	36° r > v rather str	Z = b Y:c = 30° disp str	TCL	---	Cols	H 2 G 1.6 F 1	Sol in H_2O. Section 010 shows 2 sets of tw lam at about 90°.
	1.441	1.442	1.444	.003	USOVITE $Ba_2CaMgAl_2F_{14}$	70°	---	MCL	One, perf	Brown	H 3.5 F easy	Pleoc, X and Y brownish-yellow, Z pale yellow.

	1.445	1.460	1.491	.046	MERCALLITE $KHSO_4$	56° (71±5°) r < v wk	X = b Z = a	ORTH	---	Cols, sky-blue	G 2.31 F 1	Sol in H_2O, giving an acid solution.
	1.456	1.460	1.480	.024	CHESSEXITE $Na_4Ca_2(Mg,Zn)_3Al_8(SO_4)_{10}(SiO_4)_2(OH)_{10} \cdot 40H_2O$	47°	X = a Z = b	ORTH	010	White	G 2.04	Diss by HCl.
ˇ 1.478	1.460	1.461	1.470	.010	ALUNOGEN $Al_2(SO_4)_3 \cdot 17H_2O$	31°	X ~ b Z:c = 42°	TCL tab or fib c	010 perf 100, 3$\bar{1}$3	White	H 1.5-2 G 1.77 infus	Sol in H_2O. In closed tube, melts in its water of crystn.
	1.454	1.461	1.471	.017	DORFMANITE $Na_2HPO_4 \cdot 2H_2O$	65° (80±14°) r > v wk	---	ORTH	---	White	H 1-1.5 G 2.00	Sol in H_2O, gives an alk reaction.
⌴ 1.466	---	1.461	---	low	SILHYDRITE $3SiO_2 \cdot H_2O$	---	---	ORTH	Uneven to subconch	White	G 2.14	Dec by HCl. Opt sign unk.
	1.461	1.463	1.476	.015	PICROMERITE $K_2Mg(SO_4)_2 \cdot 6H_2O$	48° r > v	Y = b X:a = -1°	MCL	20$\bar{1}$ perf	White	H 2.5 G 2.10 F 2	Sol in H_2O.
	1.459	1.464	1.470	.011	ALUMINITE $Al_2SO_4(OH)_4 \cdot 7H_2O$	Med to large (85±21°)	X = el	MCL fib	---	White	H 1-2 G 1.66-1.8 infus	Diss by acids.
	1.462	1.465	1.474	.012	MALLARDITE (Melanterite grp) $MnSO_4 \cdot 7H_2O$	Large	Z:c = 44°	MCL	001 dist	Rose	G 1.84	Sol in H_2O.
	1.462	1.466	1.469	.007	BOGGILDITE $Na_2Sr_2Al_2(PO_4)F_9$	79°	---	MCL	---	Flesh-red	H 4-5 G 3.66 F 1-2	---
	1.464	1.468	1.474	.010	KONYAITE $Na_2Mg(SO_4)_2 \cdot 5H_2O$	106° (79±24°)	---	MCL	---	Cols	H 2.5 G 2.097	Sol in H_2O. Stated to be biax neg.
	1.456	1.469	1.508	.052	LANSFORDITE $MgCO_3 \cdot 5H_2O$	60°	X = b Z ~ c	MCL tab	001 perf 100 less so	Cols	H 2.5 G 1.71 infus	Diss by acids. Alters in air to Nesquehonite.
[ ]	1.468	1.470	1.473	.005	ERIONITE (Zeolite grp) $(K_2,Ca,Na_2)_2Al_4Si_{14}O_{36} \cdot 15H_2O$	---	el pos	HEX fib	---	---	G 2.05 F easy	Diff dec by HCl with sepn of silica.
ˇ 1.484	1.468	1.470	1.474	.006	TRIDYMITE SiO_2	40°	X = b Z = c el neg	MCL ps hex, tab	---	Cols	H 6.5 G 2.25 infus	Insol in acids, diss by hot Na_2CO_3 soln. Tw, trillings, fourlings.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
∨ 1.478	1.467	1.471	1.476	.009	MELANTERITE $(Fe,Mg)SO_4 \cdot 7H_2O$	Large r > v	Y = b Z:c = 77°	MCL el c	$\bar{1}01$ perf 111 poor	Greenish	H 2 G 1.76 F easy	Sol in H_2O. MgO 7.45, CuO 0.3, ZnO 0.5%.
∨ 1.491(?)	1.470	1.471	1.479	.009	BOUSSINGAULTITE $(NH_4)_2Mg(SO_4)_2 \cdot 6H_2O$	51° r > v perc	Y = b Z:c = 12°	MCL	$20\bar{1}$ perf	Cols	H 2 G 1.72 F 1	Sol in H_2O. Continuous series to Mohrite?
	1.469	1.473	1.491	.022	META-ALUNOGEN $Al_4(SO_4)_6 \cdot 27H_2O$	Large (51±12°)	---	---	---	White	---	---
	1.458	1.473	1.501	.043	BARRINGTONITE $MgCO_3 \cdot 2H_2O$(?)	(74±6°)	el pos	TCL fib	---	Cols	G 2.82 (calc)	Optics are discordant for compn given.
	1.466	1.474	1.495	.029	CARNALLITE $KMgCl_3 \cdot 6H_2O$	70° r < v	Z = a X = c	ORTH	Conch	White, reddish	H 2.5 G 1.62 F 1-1.5	Sol in H_2O. Deliq.
1.473 [] 1.477	1.469	1.475	1.484	.015	THENARDITE Na_2SO_4	83° r > v wk	X = c Y = b	ORTH	010 perf 101 fair	White	H 2.5-3 G 2.66 F 2	Sol in H_2O.
	---	1.47-1.48	---	wk	HYDROBASALUMINITE $Al_4SO_4(OH)_{10} \cdot 12\text{-}36H_2O$	---	---	---	---	Cols to yellowish	G 1.86	Diss by acids. Opt char unk.
	1.472	---	1.487	.015	MAKATITE $Na_2Si_4O_9 \cdot 5H_2O$	---	---	ORTH or MCL spher	---	White	G 2.07	Dec by acids. Opt char unk.
∨ 1.482	1.472	1.475	1.477	.005	MORDENITE (Zeolite grp) $(Ca,K_2,Na_2)Al_2Si_{10}O_{24} \cdot 7H_2O$	80°	X = c Y = a	ORTH	100 good 010 fair	Cols, pink, yellow	H 3-4 G 2.12 F 4-5	Partly dec by HCl.
1.471 ≷ 1.483	1.471	1.478	1.486	.015	MELANTERITE $FeSO_4 \cdot 7H_2O$	85° r > v wk	Y = b Z:c = 77°	MCL el c	$\bar{1}01$ perf 111 poor	Green	H 2 G 1.90 F easy	Sol in H_2O.
1.461 ∧	1.475	1.478	1.482	.010	ALUNOGEN $Al_2(SO_4)_3 \cdot 17H_2O$	75°	X ~ b Z:c = 42°	TCL tab or fib c	010 perf 100, $3\bar{1}3$	White	H 1.5-2 G 1.79 infus	Sol in H_2O. In closed tube, melts in its water of crystn.
∨ 1.489	1.478	1.479	1.482	.004	FERRIERITE (Zeolite grp) $(Na,K)_2MgAl_3Si_{15}O_{36}(OH) \cdot 9H_2O$	50°	X = a Y = b el pos	ORTH blades 100	100 perf	White	H 3 G 2.15 F 3-4	Insol in HCl.

∨ 1.493	1.478	1.479	1.481	.003	CLINOPTILOLITE (Zeolite grp) $(Na,K,Ca)_{2-3}Al_3(Al,Si)_2Si_{13}O_{36}\cdot12H_2O$	40° r > v	X = b el c̄T̄v pos	MCL	010 perf	Cols	H 4 G 2.11 F 2	Dec by HCl. SiO_2 68.3, CaO 1.0, Na_2O 2.5%.
	1.47	1.48	1.49	.02	BOOTHITE $CuSO_4\cdot7H_2O$	Large	Y = b X ~ c	MCL fib c	001 imperf	Blue	H 2-2.5 G 2.1 F 3	Sol in H_2O. Dehydrates readily. Cols in thin section.
	1.475	1.480	1.488	.013	DIETRICHITE $(Zn,Fe,Mn)Al_2(SO_4)_4\cdot22H_2O$	Large	X = b Z:c = 29°	MCL fib c		White	H 2 infus	Sol in H_2O.
∨ 1.486	1.477	1.480	1.490	.013	NATROLITE (Zeolite grp) $Na_2Al_2Si_3O_{10}\cdot2H_2O$	63° r < v wk	X = a Z = c el pos	ORTH acic c	110 perf 010 imperf	White	H 5 G 2.22 F 2	Gel with acids. Tw pl 110, 100, rarely 301.
	1.475	1.480	1.490	.015	MAKATITE $Na_2Si_4O_9\cdot5H_2O$	(71±16°)		ORTH spher		White	H 4.5 G 2.07	---
	1.475	1.480	1.487	.012	MISENITE $K_2SO_4\cdot6KHSO_4$ (?)	Large	Z = b X:c = 29°	MCL fib c	010 dist	White	G 2.32 F 1.5	Sol in H_2O to an acid soln.
	---	1.480	---	wk	FAUJASITE (Zeolite grp) $(Na_2,Ca)Al_2Si_4O_{12}\cdot8H_2O$	~ 0°	---	CUB oct	111 dist	White	H 5 G 1.92 F 3	Dec by HCl. Shows 8 biax segments.
∨ 1.485	1.480	(1.480)	1.485	.005	CHABAZITE (Zeolite grp) $(Ca,Na_2)Al_2Si_4O_{12}\cdot6H_2O$	Small	---	TRIG rhombs	10$\bar{1}$1 dist	White, red	H 4.5 G 2.06 F 3	Dec by HCl with sepn of slimy silica.
∨ 1.496	1.480	1.481	1.485	.005	DACHIARDITE (Zeolite grp) $(K_2,Na_2,Ca)_5Al_{10}Si_{38}O_{96}\cdot25H_2O$	55-60°	X = b Z:c = 35°	MCL	100, 001 perf	White	H 4-4.5 G 2.16 fus	Dec by acids. Mimetic tw perf.
	1.470	1.481	1.497	.027	RIVADAVITE $Na_6MgB_{24}O_{40}\cdot22H_2O$	80° r > v	Y = b Z:a = -32°	MCL el b	100, $\bar{1}$01 perf 010 poor	Cols, white	H 3.5 G 1.91 F 1.5	Diss by hot H_2O.
	1.470	---	1.493	.023	NICKEL-HEXAHYDRITE $(Ni,Mg,Fe)SO_4\cdot6H_2O$	---	Z:c = 45°	MCL crusts, fib	010 perf 100	Blue-green	---	Diss by H_2O. NiO 22.6, MgO 2.8, FeO 2.6%. Opt char unk.
	---	1.482	---	.002-.008	GMELINITE (Zeolite grp) $(Na_2,Ca)Al_2Si_4O_{12}\cdot6H_2O$	~ 0°		HEX	10$\bar{1}$0 dist	White	H 4.5 G 2.0-2.1 F 3	Dec by HCl. Tw axis c.
1.475 ∧	1.481	1.482	1.486	.005	MORDENITE var. Ashtonite (Zeolite grp) $(Ca,Na_2)Al_2Si_{10}O_{24}\cdot7H_2O$	Large	X = c Y = a	ORTH radiating	100 good 010 fair	White to red	H 3-4 G 2.12 F 4-5	Partly dec by HCl. SrO 1.3%.
	1.462	(1.483)	1.531	.069	BAYLISSITE $K_2Mg(CO_3)_2\cdot4H_2O$	64°	---	MCL	Conch	Cols	H 2-3 G 2.01	Diss by acids with eff. Dec by H_2O.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.478 ^	1.479	1.483	1.488	.009	ZINC-COPPER MELANTERITE $(Zn,Cu)SO_4 \cdot 7H_2O$	Large disp wk	---	MCL fib	---	Light blue-green	H 2 G 2.02 F easy	Sol in H_2O. Dehydrates in air.
	1.480	1.483	1.486	.006	LEONITE $K_2Mg(SO_4)_2 \cdot 4H_2O$	~ 90°	Y = b Z:a small	MCL pris	Conch	Cols, yellow	H 2.5-3 G 2.20 F easy	Sol in H_2O. Poly tw.
	1.468	1.484	1.515	.083	CALCLACITE $CaCl_2 \cdot Ca(C_2H_3O_2)_2 \cdot 10H_2O$	80° (72±5°)	---	MCL or TCL	---	Cols	G 1.5	Calcium chloride-acetate (an artifact?). Sol in H_2O. The synth salt has ns 1.468, 1.502, 1.523, 2V -58°, (81±1°).
1.470 ^	1.482	1.484	1.486	.004	TRIDYMITE SiO_2	86°	X = b Z = c	MCL ps hex, tab	---	Cols	H 6.5 G 2.25 infus	Insol in acids. Diss by hot Na_2CO_3 soln. Tw trillings, fourlings.
v 1.503	1.483	1.485	1.487	.004	PHILLIPSITE (Zeolite grp) $(K_2,Ca,Na_2)_{1-2}(Al,Si)_8O_{16} \cdot 6H_2O$	63° r < v mod	X = b Z:c = 19° el pos	MCL fib a	100, 010 dist	White	H 4 G 2.19 F 3	Gel with acids. Tw pl 001 and 011 penet giving ps orth forms.
(1.480) ^v 1.492	1.485	1.485	1.488	.003	CHABAZITE (Zeolite grp) $(Ca,Na_2)_2Al_2Si_4O_{12} \cdot 6H_2O$	Med to large	---	TRIG	$10\bar{1}$ dist	Cols, white, red	H 4.5-5 G 2.1 F 3	Dec by HCl. Tw pl $10\bar{1}1$.
	---	1.485	---	low	MAGADIITE $NaSi_7O_{13}(OH)_3 \cdot 3H_2O$	---	el pos	MCL	---	White	---	Dec by HCl. Opt sign unk.
	1.472	---	1.502	.030	INDIGIRITE $Mg_2Al_2(CO_3)_4(OH)_2 \cdot 15H_2O$	---	el pos	fib	---	Snow-white	H 2 G 1.6	Diss by acids. Opt char unk.
	1.484	1.486	1.502	.018	CYANOCHROITE $K_2Cu(SO_4)_2 \cdot 6H_2O$	47° r < v str	Y = b X:c = 19°	MCL crusts	$20\bar{1}$ perf	Greenish-blue	G 2.22 F 2	Sol in H_2O.
1.480 ^	1.483	1.486	1.495	.012	NATROLITE (Zeolite grp) $Na_2Al_2Si_3O_{10} \cdot 2H_2O$	Med (60±20°) r < v wk	X = a Z = c el pos	ORTH acic c	110 perf 010 poor	White	H 5 G 2.22 F 2	Gel with acids. Tw pl 110, 100, rarely 301.
	1.470	1.487	1.540	.070	AMMONIOBORITE $(NH_4)_2B_{10}O_{16} \cdot 5H_2O$	59° r < v wk	Y = b Z:c = 7°	MCL	---	White	Soft G 1.77 volat	Slowly sol in cold H_2O.

	1.476	---	1.500	.024	UKLONSKOVITE $Na_2Mg_2(SO_4)_2(OH)_2\cdot3H_2O$	---	---	MCL	$\bar{1}01$, $\bar{1}11$ good	Cols	G 2.42-2.5	Diss by acids.
	1.484	1.487	1.496	.012	TAMARUGITE $NaAl(SO_4)_2\cdot6H_2O$	60° disp wk	Y = b X:c = 5°	MCL fib c	010 perf	Cols	H 3 G 2.07 fus	Sol in H_2O. Poly tw.
v 1.498	1.488	1.488	1.489	.001	HEULANDITE (Zeolite grp) $(Ca,Na_2)_{2-3}Al_3(Al,Si)_2Si_{13}O_{36}\cdot12H_2O$	70° r > v	Z = b el cTv neg	MCL	010 perf	White	H 4 G 2.14 F 2	Dec by HCl. SiO_2 61.8, CaO 5.5, Na_2O 1.1, K_2O 0.3%.
1.479 ^	1.489	1.489	1.49	.001	FERRIERITE (Zeolite grp) $(Na,K)_2MgAl_3Si_{15}O_{36}(OH)\cdot9H_2O$	Small	X = a Y = b el pos	ORTH blades 100	100 perf	White	H 3 G 2.21 F 3-4	Insol in HCl.
1.489 □ 1.496	1.480	1.491	1.509	.029	FLUELLITE $Al_2(PO_4)F_2(OH)\cdot7H_2O$	85° r < v	X = b Y = c	ORTH	010, 111 indist	White	H 3 G 2.16 infus	Insol in acids.
	1.488	1.491	1.505	.017	INDERITE $MgB_3O_3(OH)_5\cdot5H_2O$	37°	Z:c = 9°	MCL	110 good	Cols	H 2.5 G 1.79 F 1	Diss by acids.
1.471(?) ^	1.487	1.491	1.499	.012	MOHRITE $(NH_4)_2Fe(SO_4)_2\cdot6H_2O$	~ 75°	Y = b	MCL	$20\bar{1}$ good 010 dist	Pale bluish-green	G 1.86	Sol in H_2O. Continuous series to Boussingaultite?
1.485 ^	1.491	1.492	1.494	.003	CHABAZITE (Zeolite grp) $(Ca,Na_2)Al_2Si_4O_{12}\cdot6H_2O$	58°	---	TRIG	$10\bar{1}1$ dist	Cols, red, white	H 4-5 G 2.1 F 3	Dec by HCl. Tw pl $10\bar{1}1$.
1.479 ^	1.491	1.493	1.497	.006	CLINOPTILOLITE (Zeolite grp) $(Na_2,Ca,K_2)_{2-3}Al_3(Al,Si)_2Si_{13}O_{36}\cdot12H_2O$ $12H_2O$	72° r > v	X = b el cTv pos	MCL	010 perf	Cols	H 4 G 2.1 F 2	Dec by HCl. SiO_2 59.7, CaO 3.4, Na_2O 1.3, K_2O 4.2%.
	1.485	1.494	1.505	.020	CANAVESITE $Mg_2(CO_3)(HBO_3)\cdot5H_2O$	Very large disp wk	Z = b	MCL fib	---	Milky white	G 1.8	---
	1.494	1.495	1.497	.003	ARCANITE K_2SO_4	67° r > v mod	X = b Z = c	ORTH	010, 001 good	White	G 2.66 F 3	Sol in H_2O. Tw common.
	1.495	1.496	1.504	.009	STRUVITE $(NH_4)MgPO_4\cdot6H_2O$	37° r < v str	X = b Z = a	ORTH	001 good 100 poor	Cols to yellow	H 2 G 1.71	Diss by acids.
1.481 ^	1.493	1.496	1.500	.007	DACHIARDITE (Zeolite grp) $(K_2,Na_2,Ca)_5Al_{10}Si_{38}O_{96}\cdot25H_2O$	69°	X = b Z:c = 35°	MCL	100, 001 perf	White	H 4-4.5 G 2.17 fus	Dec by acids. Mimetic tw 001.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien- tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
⊔ 1.504	1.495	1.497	1.504	.009	YUGAWARALITE (Zeolite grp) $CaAl_2Si_6O_{16}\cdot 4H_2O$	78° r > v wk	Z = b Y:c = 7°	MCL	Parting 010	Cols	H 4.5 G 2.23	Insol in acids. U opt neg.
	1.484	1.498	1.523	.039	ARISTARAINITE $Na_2MgB_{12}O_{20}\cdot 8H_2O$	70° r > v wk	X = b Y:c = -38°	MCL	001, 100 perf 110	Cols	H 3.5 G 2.03 fus	Diss by HCl.
v 1.510	1.497	1.498	1.499	.002	GONNARDITE (Zeolite grp) $Na_2CaAl_4Si_6O_{20}\cdot 7H_2O$	Med to large	---	ORTH fib	---	White	G 2.26	---
1.488 ^ v 1.507	1.496	1.498	1.504	.008	HEULANDITE (Zeolite grp) $(Ca,K_2)_{2-3}Al_3(Al,Si)_2Si_{13}O_{36}\cdot 12H_2O$	35°	Z = b el c̄Tv neg	MCL	010 perf	White	H 4 G 2.20 F 2	Dec by HCl. SiO_2 57.4, CaO 7.0, SrO 1.55, Na_2O 0.1, K_2O 1.4%.
	1.499	1.500	1.502	.003	WAIRAKITE (Zeolite grp) $CaAl_2Si_4O_{12}\cdot 2H_2O$	75° r > v wk	X = b Z ~ c	MCL	---	White	H 5-5.6 G 2.26 F 2.5	Gel with acids.
	1.484	1.501	1.550	.066	GOWERITE $CaB_6O_{10}\cdot 5H_2O$	(63±4°) r > v wk	Y = b Z:c = 27°	MCL	001 perf	White	H 3 G 2.00 fus	Diss by acids.
1.498 □ 1.503	1.500	1.501	1.504	.004	WELLSITE (Zeolite grp) $(K_2,Ca,Ba)Al_2Si_6O_{16}\cdot 6H_2O$	39°	Z = b X:c = -52°	MCL	---	Cols	H 4-5 G 2.3 F 3	Dec by acids. Complex tw. Perhaps a barian Phillipsite.
	1.497	1.502	1.539	.042	LIEBIGITE $Ca_2(UO_2)(CO_3)_3\cdot 10H_2O$	40° r > v med	X = a Z = c	ORTH crusts	100	Green to yellow-green	H 2.5-3 G 2.41 infus	Diss by acids. Pleoc, X nearly cols, Y and Z pale yellow-green. Fluor green in UV.
	1.498	1.503	1.510	.012	HEXAHYDROBORITE $Ca[B(OH)_4]_2\cdot 2H_2O$	83° r > v very str	X:c = 14°	MCL pris	---	Cols, white	H 2.5 G 1.87	Diss by acids.
1.485 ^	1.500	1.503	1.510	.010	PHILLIPSITE (Zeolite grp) $(K_2,Ca,Na_2)_{1-2}(Al,Si)_8O_{16}\cdot 6H_2O$	Med r < v mod	X = b Z:c = 19° el pos	MCL fib a	100, 010 dist	White	H 4 G 2.15 F 3	Gel with acids. Tw pl 001 and 011, penet, giving orth forms.

	1.501	1.503	1.510	.009	PROSOPITE $CaAl_2(F,OH)_8$	63° r > v str	Y = b Z:c = -35°	MCL tab 010	111 perf	Cols	H 4.5 G 2.38 infus	---
	1.503	(1.504)	1.535	.032	SVEITE $KAl_7(NO_3)_4Cl_2(OH)_{16}\cdot 8H_2O$	Small	---	MCL	001 perf	White	Very soft G 2.0	Dec by H_2O. Sol in acids.
	1.504	1.504	1.553	.049	EVENKITE (n-tetracosene) $C_{21}H_{44}$	Small	---	MCL	One good	Cols	H 1 G 0.92	M.p. 50°C. Hydrocarbon. Poly tw.
	1.501	1.504	1.520	.019	HYDROCHLORBORITE $Ca_2B_4O_4Cl(OH)_7\cdot 7H_2O$	46° r < v	Y = b X:c = 25°	MCL mass	001 good conch	Cols	H 2.5 G 1.85	Diss by hot H_2O.
$\overset{\vee}{1.509}$	1.501	1.504	1.509	.008	HARMOTOME (Zeolite grp) $(Ba,K_2)_{1-2}(Al,Si)_8O_{16}\cdot 6H_2O$	78° disp crossed	Z = b X:a = 65°	MCL pris	010 good 001 less so	White	H 4.5 G 2.38 F 3.5	Dec by HCl. Cruciform tw, tw pl 001.
	1.493	1.505	1.529	.036	ULEXITE $NaCaB_5O_9\cdot 8H_2O$	70-73° (84±9°)	X = b Y:c ~ 20°	TRIC fib	010 perf $1\bar{2}0$ good	White	H 2.5 G 1.96 F 1	Diss by acids. Partly dec by hot H_2O.
	1.500	1.505	1.525	.025	LOUGHLINITE $Na_2Mg_3Si_6O_{16}\cdot 8H_2O$	60°	---	ORTH fib	---	White	G 2.165	Dec by HCl, slowly dec by H_2O.
	1.502	1.505	1.514	.012	RHODESITE $(Ca,Na_2,K_2)_8Si_{16}O_{40}\cdot 11H_2O$	Small (60±20°)	X = b Y = a	ORTH fib	100 good	White	G 2.36 fus	---
	1.504	1.505	1.507	.003	MESOLITE (Zeolite grp) $Na_2Ca_2Al_6Si_9O_{30}\cdot 8H_2O$	Large r > v str	Y = b X ~ c	MCL el = b	101, $\bar{1}01$ perf	White, gray	H 2.5 G 2.26 F easy	Gel with acids. Tw pl 100, 2V may vary with temp.
	1.494	1.507	1.528	.034	BISCHOFITE $MgCl_2\cdot 6H_2O$	79° r > v wk	X = b Y:c = 9.5°	MCL fib	---	Cols	H 1.5 G 1.60 fus	Sol in H_2O. Deliq.
$\underset{\wedge}{1.498}$	1.504	1.507	1.515	.011	HEULANDITE (Zeolite grp) $(Ca,Na,Sr)_{2-3}Al_3(Al,Si)_2Si_{13}O_{36}\cdot 12H_2O$	10-40° (63±22°) r > v	Z = b el c̄l̄v neg	MCL	010 perf	White	H 4 G 2.20 F 2	Dec by HCl. SiO_2 55.8, CaO 3.0, SrO 4.4, BaO 2.4, Na_2O 1.5, K_2O 1.3%.
1.512	1.504	1.508	1.543	.039	USSINGITE $Na_2AlSi_3O_8(OH)$	32-39°	Z:b = 3°	TCL	001 perf 110 fair	Rose-violet	H 6 G 2.48 F easy	Gel with acids.
	1.502	1.508	1.525	.023	RABBITTITE $Ca_3Mg_3(UO_2)_2(CO_3)_6(OH)_4\cdot 18H_2O$	(62±11°)	Y = b Z:c = 15°	MCL fib	001 and 2 pris	Pale green	H 2.5 G 2.6	Diss by acids, slowly dec by H_2O. Weakly fluor in UV.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	---	1.508	---	.001	LEUCITE $KAlSi_2O_6$	Small	Z = a	TET ps cub	110 poor	Cols	H 6 G 2.5 infus	Dec by acids. Poly tw.
	1.493	1.509	1.561	.068	LARDERELLITE $(NH_4)B_5O_6(OH)_4$	60° r < v	X = b Z:c = 30°	MCL tab	001, 010 perf	Cols	Soft G 1.91 volat	Diss by acids. Rhombs with angle 66°.
1.504 ^	1.505	1.509	1.513	.008	HARMOTOME (Zeolite grp) $(Ba,K_2)_{1-2}(Al,Si)_8O_{16}\cdot 6H_2O$	~ 90° disp crossed	Z = b X:a = 68°	MCL pris	010 good 001 less so	White	H 4.5 G 2.44 F 3.5	Dec by HCl. Tw 001 cruciform.
	1.510	1.510	1.512	.002	OLYMPITE Na_3PO_4	46°	---	ORTH	Conch	Cols	H 4 G 2.8	Sol in H_2O, gives an alk reaction.
	1.470	1.510	1.579	.109	STRONTIOBORITE $SrB_8O_{11}(OH)_4$	85°	---	MCL plates	---	Cols	G 2.81	Diss by acids.
	1.504	1.510	1.573	.069	PIRSSONITE $Na_2Ca(CO_3)_2\cdot 2H_2O$	30° r < v wk	X = a Z = b	ORTH pris or tab	Conch	Cols	H 3-3.5 G 2.36 F 2-2.5	Diss by acids with eff. Dec by hot H_2O.
v 1.523	1.508	1.510	1.569	.061	HATCHETTITE $C_{40}H_{82}$ (?)	26° r < v	---	ORTH(?)	001 good	Yellow	H 1 G 0.95 F 80°C	A paraffin hydro-carbon.
	1.510	1.510	1.545	.035	SOLONGOITE $Ca_2B_3O_4Cl(OH)_4$	Very small r > v wk	Z:c = 2.5° el pos	MCL	---	Cols	G 2.51	Diss by HCl.
⊔ 1.513	1.504	1.510	1.519	.015	MOUNTAINITE $(Ca,Na_2,K_2)_2Si_4O_{10}\cdot 3H_2O$	Med to large	Y = b Z:c = 18°	MCL fib	---	White	G 2.36	---
	1.508	1.510	1.516	.008	DYPINGITE $Mg_5(CO_3)_4(OH)_2\cdot 5H_2O$	---	---	Globu-lar aggre-gates	---	White	G 2.15 calc	Diss by HCl with eff. Fluor light blue in UV.
1.498 ^	1.508	1.510	1.513	.005	GONNARDITE (Zeolite grp) $Na_2CaAl_4Si_6O_{20}\cdot 7H_2O$	Med to large	---	ORTH fib	---	White	G 2.27	---
	1.508	1.511	1.523	.015	BREWSTERITE (Zeolite grp) $(Sr,Ba,Ca)Al_2Si_6O_{16}\cdot 5H_2O$	55° r > v wk	Z = b X:c = 22° el clv neg	MCL el c	010 perf	White	H 5 G 2.32 F 3	Dec by acids.

	1.505	1.511	1.516	.011	PETALITE $LiAlSi_4O_{10}$	83° r > v wk	Z = b X:a = -5°	MCL	001 perf 201 good	Cols, pink, white	H 6 G 2.39 F 5	Insol in acids.
	1.505	1.512	1.524	.019	FLAGSTAFFITE $C_{10}H_{22}O_3$	77° r > v	Z = a X = c	ORTH pris	110 imperf	Cols	Soft G 1.09 F 119°C	Sol in warm alcohol (= cis-terpin hydrate).
v 1.553	1.501	1.513	1.536	.035	BOBIERRITE $Mg_3(PO_4)_2 \cdot 8H_2O$	73° r < v wk	Y = b Z:c = 27°	MCL acic	010 perf	Cols	H 2-2.5 G 2.20 fus	Diss by acids. Data for synth compound.
v 1.525	1.511	1.513	1.518	.007	THOMSONITE (Zeolite grp) $NaCa_2Al_5Si_5O_{20} \cdot 6H_2O$	75° r > v	X = a Z = b	ORTH pris fib c	010 perf 100 good	White	H 5 G 2.33 F 2	Gel with acids.
	1.510	1.513	1.517	.007	MONTEREGIANITE $(Na,K)_6(Y,Ca)_2Si_{16}O_{38} \cdot 10H_2O$	87°	X = c Y = a	ORTH acic, tab a	010 perf 001 good 100 fair	White, cols	H 3.5 G 2.42	Dec by acids.
	---	1.514	---	---	KINGITE $Al_3(PO_4)_2(OH,F)_3 \cdot 9H_2O$	---	---	TCL mass	---	White	G 2.2-2.3	Opt char unk.
	1.508	1.515	1.523	.015	SCHERTELITE $(NH_4)_2H_2Mg(PO_4)_2 \cdot 4H_2O$	86°	Z = a	ORTH	---	Cols	G 1.83	Dec by hot H_2O, diss by acids.
	1.513	(1.515)	1.518	.005	LOVDARITE $(Na,K)_2(Be,Al)Si_3O_8 \cdot 2H_2O$	70°	---	ORTH pris	100, 010, 001 dist	Cols to yellowish	H 5-6 G 2.33 F 3	Insol in acids.
v 1.534	1.518	1.518	1.561	.043	FIBROFERRITE $Fe(SO_4)(OH) \cdot 5H_2O$	Small	Z = c el clv neg	MCL ps trig	001 perf	Pale yellow, pale green	H 2.5 G 1.97 F 5	Dec by hot H_2O, diss by acids. Pleoc, X and Y cols, Z pale yellow.
	1.514	1.518	1.533	.019	NEWBERYITE $MgHPO_4 \cdot 3H_2O$	45° r < v perc	X = a Y = b	ORTH tab 100	010 perf 001 imperf	White	H 3-3.5 G 2.11 infus	Diss by acids.
	1.516	1.518	1.533	.017	FELSÖBANYAITE $Al_4(SO_4)(OH)_{10} \cdot 5H_2O$	48° r > v	X = a Y = b	ORTH(?)	001 perf 100, 010	Cols	H 1.5 G 2.35 infus	Diss by acids. Clv fragments lath-shaped.
	1.501	1.519	1.755	.254	KLADNOITE $C_6H_4(CO)_2NH$	25° (34±2°)	Z = b Y:c = 16°	MCL	---	---	G 1.47 F 234°C	= Phthalimide.
	1.505	1.519	1.533	.028	STANLEYITE $VOSO_4 \cdot 6H_2O$	Large	---	ORTH	---	Deep blue	H 1-1.5 G 1.95	Sol in cold H_2O. Pleoc, X and Y blue, Z pale blue.
	1.510	1.520	1.554	.044	NOBLEITE $CaB_6O_9(OH)_2 \cdot 3H_2O$	(76±4°) r > v wk	Y = b Z:c = -7°	MCL	100 perf	Cols	H 3 G 2.09	Diss by acids.
1.51 [] 1.53	---	1.52	---	.005- .010	BASALUMINITE $Al_4(SO_4)(OH)_{10} \cdot 5H_2O$	---	el neg	Mass, compact	Conch	White	G 2.1	Diss by HCl. Opt char unk.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
1.510 ^	1.518	1.523	1.588	.070	HATCHETTITE $C_{40}H_{82}$ (?)	33° r < v	Z = c	ORTH(?)	001 good	White	H 1 G 0.95 F 80°C	A paraffin hydro-carbon.
	1.520	1.523	1.533	.013	GYPSUM $CaSO_4 \cdot 2H_2O$	58° r > v perc	Y = b X:c = 37° disp str	MCL tab 010	010 perf 011, 100 poor	White	H 1.5-2 G 2.32 F 2.5-3,	Diss by HCl. Tw pl 100.
	1.521	1.523	1.533	.012	MASCAGNITE $(NH_4)_2SO_4$	52° r < v wk	X = c Y = b	ORTH el c	001 dist	Cols, yellowish	H 2-2.5 G 177 F 1	Sol in H_2O. Volat when heated. Tw pl 110.
	1.518	---	1.530	.012	TACHARANITE $Ca_{12}Al_2Si_{18}O_{51} \cdot 18H_2O$	---	X = fib	MCL fib	001 good	Cols	G 2.35	Opt char unk.
v 1.534	1.518	1.524	1.544	.026	WAVELLITE $Al_3(PO_4)_2(OH,F)_3 \cdot 5H_2O$	60° r > v wk	X = b Y = a el pos	ORTH fib, radi-ating	110 perf 101 good 010 dist	White, yellow, green	H 3.5-4 G 2.36 infus	Diss by acids. Colored vars pleoc, X greenish, Z yellow-ish, abs X > Z.
	1.518	1.524	1.530	.012	MACDONALDITE $BaCa_4Si_{16}O_{36}(OH)_2 \cdot 10H_2O$	90°	X = c Y = b	ORTH acic	010 perf 001 good	Cols, white	H 3.5-4 G 2.27 F 5.5	Insol in cold acids, dec by boiling HCl (1:1).
	1.508	1.525	1.586	.078	SIDERONATRITE $Na_2Fe(SO_4)_2(OH) \cdot 3H_2O$	58° r > v str	X = a Y = b	ORTH fib c	001 perf	Orange to straw-yellow	H 2 G 2.28 F 2	Dec by hot H_2O, diss by HCl. Pleoc, X cols, Y pale yellow, Z pale amber-yellow.
	1.513	1.525	1.577	.064	STRONTIOGINORITE $(Sr,Ca)_2B_{14}O_{23} \cdot 8H_2O$	50°	Y = b Z:c = 40°	MCL	010 perf	White	H 3 G 2.25 fus	Diss by acids. Sr:Ca = 2:1 to 1:1.
	1.517	1.525	1.579	.062	GINORITE $Ca_2B_{14}O_{23} \cdot 8H_2O$	42° inclined disp	Y = b Z:c = 39°	MCL flat rhombs	010 perf	White	H 3.5 G 2.08 fus	Diss by acids.
	1.515	1.525	1.544	.029	PROBERTITE $NaCaB_5O_7(OH)_4 \cdot 3H_2O$	73° r > v	Y = b Z:c = 12° el pos	MCL pris	110 perf	White	H 3.5 G 2.14 F 2	Diss by acids.
v 1.547	1.513	1.525	1.542	.029	VOGLITE $Ca_2Cu(UO_2)(CO_3)_4 \cdot 6H_2O$ (?)	90° (81±8°)	X = b Y = c el cTv pos	MCL	010 perf	Emerald- to grass-green	Soft infus	Diss by acids. Pleoc, X deep blue, Y bluish-green, Z yellow. Poly tw.

	1.521	1.525	1.545	.024	SPADAITE $MgSiO_2(OH)_2 \cdot H_2O$(?)	Small to med (49±12°)	ext ~ ||, el pos	ORTH(?) felted, columnar	---	Cream to pink	G 2.2 F 5	Dec by HCl.
	1.523	1.525	1.532	.009	CHALCOALUMITE $CuAl_4(SO_4)(OH)_{12} \cdot 3H_2O$	Small r > v str	Ext 40° on flat face	MCL fib crusts	Several perf	Turquoise green to blue	H 2.5 G 2.29 F 5	Diss by hot acids. Tw pl || el.
1.513 ^v 1.533	1.523	1.525	1.532	.009	THOMSONITE (Zeolite grp) $NaCa_2Al_5Si_5O_{20} \cdot 6H_2O$	48° r > v	X = a Z = b	ORTH pris, fib c	010 perf 100 good	White	H 5 G 2.32 F 2	Gel with acids.
	1.508	1.527	1.550	.042	KALIBORITE $KHMg_2B_{12}O_{16}(OH)_{10} \cdot 4H_2O$	81°	Y = b Z:c = 65°	MCL pris	001, $\bar{1}$01 perf 100 good	White	H 4-4.5 G 2.13 F 1	Diss by acids.
v 1.537	1.523	1.527	1.545	.022	HYDROMAGNESITE $Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$	50°	Z = b X:c = 47° el clv neg	MCL ps orth fib c	010 perf parting 100	White	H 4-4.5 G 2.22 infus	Diss by hot acids. Tw pl 100, poly common.
	1.526	1.528	1.551	.025	TERUGGITE $Ca_4MgAs_2B_{12}O_{22}(OH)_{12} \cdot 12H_2O$	33° r > v wk	Z = b X:c = -26°	MCL pris	001 good 110 fair	Cols, white	H 2.5 G 2.15 fus	Diss by acids.
	1.525	1.528	1.544	.019	SAZHINITE $Na_2CeSi_6O_{14}(OH) \cdot 5H_2O$	47°	Z = a Y = b	ORTH ps tet tab	100, 010, 001 perf	Gray, white, cream	H 2-3 G 2.61	---
	1.527	---	1.531	.004	BIRUNITE $Ca_{36}(SiO_3)_{17}(CO_3)_{17}(SO_4)_2 \cdot 30H_2O$ (?)	---	---	ORTH(?) fib	One perf	White	H 2 G 2.36 infus	Gel with acids.
v 1.535	1.507	1.529	1.573	.067	MAGNESIOCOPIAPITE $(Mg,Fe)Fe^{+3}{}_4(SO_4)_6(OH)_2 \cdot 20H_2O$	73° r > v str	X ~ b Y:c ~ 38°	TCL tab	010 perf $\bar{1}$01 imperf	Sulfur- to golden-yellow	H 2.5-3 G 2.13 F 4-5	Diss by acids. Pleoc, X yellow-green, Y pale yellow, Z yellow to yellow-green.
v 1.548	1.522	1.529	1.577	.055	BOTRYOGEN $MgFe^{+3}(SO_4)_2(OH) \cdot 7H_2O$	41°	X = b Z:c = 12°	MCL reniform	010 perf 110 good	Red to orange	H 2-2.5 G 2.05-2.14 F 4.5-5	Dec by hot H_2O, diss by acids. Pleoc, X cols to brown, Y pale brown, Z golden- to orange-red.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.483	1.530	1.576	.093	CHALCONATRONITE $Na_2Cu(CO_3)_2 \cdot 3H_2O$	Large (93±2°)	Y = el Z:c small	MCL ps hex	---	Greenish-blue	Soft G 2.27	Dec by H_2O, diss by acids. Pleoc, X nearly cols, Y pale blue, Z blue.
	1.515	1.530	1.580	.065	EARLANDITE $Ca_3(C_6H_5O_7)_2 \cdot 4H_2O$	60°	---	MCL	---	White to pale yellow	G 1.95	Calcium citrate. Diss by acids.
	---	---	1.542	---	GLAUCOKERINITE $(Zn,Cu)_{10}Al_4(SO_4)(OH)_{30} \cdot 2H_2O$ (?)	---	Z = el	Radi-ating, fib	---	Sky-blue	H 1 G 2.15	Concentric color banding. Opt char unk.
	1.525	1.53	1.550	.025	ROESSLERITE $MgHAsO_4 \cdot 7H_2O$	Small	Z = b X:a = 14°	MCL	110 imperf	Cols	H 2-3 G 1.94	Diss by acids.
	1.496	1.531	1.579	.083	CHALLANTITE $6Fe_2(SO_4)_3 \cdot Fe_2O_3 \cdot 6H_2O$ $63H_2O$	80°	---	tab	---	Yellow	---	Slowly sol in H_2O, diss by HCl.
	1.530	1.531	1.534	.004	BUDDINGTONITE (Feldspar grp) $(NH_4)_2Al_2Si_6O_{16} \cdot H_2O$	---	Z = b X:a = 4°	MCL	001 good 010 dist	Cols	H 5.5 G 2.32 F 5	Insol in acids.
	1.5285	1.531	1.532	.004	Unnamed silicate $(K,Na)_4Ca_2AlSi_6(O,OH,F)_{18} \cdot NaCl$	29°	el clv neg	ORTH	One perf	Cols	H 4 G 2.58 F easy	Gel with acids (Am. Min. 44, 90).
v 1.541	1.528	1.532	1.539	.011	ALBITE plagioclase, plutic (Feldspar grp) $NaAlSi_3O_8$	74° r < v wk	X':a on 001 = 3° 010 = 20°	TCL	001 perf 010 good	Cols, white	H 6 G 2.61 F 4	End member, An_0. Insol in acids. Poly tw pl 010 almost universal. Other tw laws common.
v 1.542	1.527	1.532	1.538	.011	CORDIERITE $Mg_2Al_4Si_5O_{18}$	88°	X = c Z = b	ORTH	010 poor	Blue, cols	H 7 G 2.59 F 5.5	Nearly insol in acids. Fe_2O_3 1.5, FeO 2.2, Na_2O 0.2%. Tw 110, 120.
v 1.590	1.520	1.533	1.584	.064	KIESERITE $MgSO_4 \cdot H_2O$	55° r > v mod	Y = b Z:c = -77° disp dist	MCL	111, 110 perf $\bar{1}11$, $\bar{1}01$, 011 imperf	White	H 3.5 G 2.57 F 2-3	Slowly sol in H_2O, diss by acids. Poly tw.

1.525 ^	1.53	1.533	1.542	.012	THOMSONITE (Zeolite grp) $Na(Ca,Sr)_2Al_5Si_5O_{20}\cdot 6H_2O$	52° r > v, dist	X = a Z = b	ORTH pris, fib c	010 perf 100 good	White	H 5 G 2.37 F 2	Gel with acids.
	1.519	1.534	1.569	.050	TUNELLITE $SrB_6O_{10}\cdot 4H_2O$	(68±5°) r > v wk	Y = b Z:c = -5°	MCL	100 perf 001 dist	Cols	H 2.5 G 2.40 fus	Diss by acids.
	1.522	1.534	1.569	.047	HYDROBORACITE $CaMgB_6O_8(OH)_6\cdot 3H_2O$	63° r < v perc	Y = b X:c = 33° el neg	MCL tab 010	010 perf 100 less so	White	H 2-3 G 2.17 F 2	Diss by acids.
1.518 ^	1.533	1.534	1.575	.042	FIBROFERRITE $Fe(SO_4)(OH)\cdot 5H_2O$	Small	Z = c	MCL ps trig	001 perf	Pale yellow	H 2.5 G 1.9-2.1 F 5	Diss by acids. Pleoc, X and Y nearly cols, Z pale yellow.
	1.520	---	1.558	.038	CHELKARITE $CaMgB_2O_4Cl_2\cdot 7H_2O$ (?)	---	---	ORTH pris	Perf ‖ el	Cols to pale rose	G 2.21	Opt char unk.
1.524 ◇ 1.543	1.525	1.534	1.553	.028	WAVELLITE $Al_3(PO_4)_2(OH,F)_3\cdot 5H_2O$	72° r > v wk	X = b Y = a el pos	ORTH fib, radi-ating	110 perf 101 good 010 dist	White, yellow, green	H 3.5-4 G 2.36 infus	Diss by acids. Colored vars are pleoc, X greenish, Z yellowish, abs X > Z.
1.527 [] 1.537	1.531	1.534	1.538	.007	MINYULITE $KAl_2(PO_4)_2(OH,F)\cdot 4H_2O$	Large	X = c Y = a	ORTH acic c	---	Cols	H 3.5 G 2.46 F 4-5	Diss by warm acids.
1.529 ◇ 1.540	1.52	1.535	1.578	.06	COPIAPITE $Fe^{+2}Fe^{+3}{}_4(SO_4)_6(OH)_2\cdot 20H_2O$	70° (63±4°) r > v str	X ~ b Y:c ~ 38°	TCL tab	010 perf $\bar{1}01$	Sulfur- to golden-yellow	H 2.5-3 G 2.1 F 4-5	Diss by acids. Pleoc, X and Y pale yellow, Z yellow.
	---	1.535	---	very low	NEKOITE $Ca_3Si_6O_{12}(OH)_6\cdot 5H_2O$	70°	X:needles = 26° Z ~ ⊥ 100	TCL acic	100 good	Cols	G 2.23	Tw.
	1.531	1.536	1.544	.013	PENTAHYDROBORITE $CaB_2O(OH)_6\cdot 2H_2O$	73°	---	TCL u mass	---	Cols	H 2.5 G 2.01	Diss by acids.
	1.536	1.536	1.543	.007	ROEDDERITE (Osumilite grp) $(Na,K)_2(Mg,Fe)_5Si_{12}O_{30}$	5-8°	---	HEX	---	Cols	G 2.6	---
	1.535	1.536	1.538	.003	FLUORAPOPHYLLITE $KCa_4Si_8O_{20}F\cdot H_2O$	18-42°	Z = c	TET	001 perf 110 poor 110 poor	Cols to yellow	H 5 G 2.3-2.4 F 2	Dec by HCl with sepn of slimy silica.
1.527 ^	1.527	1.537	1.550	.023	HYDROMAGNESITE $Mg_5(CO_3)_4(OH)_2\cdot 4H_2O$	83°	Z = b X:c = 47°	MCL ps orth, fib c	010 perf parting 100	White	H 4-4.5 G 2.17 infus	Diss by hot acids. Tw pl 100, poly common.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.535	1.537	1.545	.010	ASHCROFTINE $KNaCaY_2Si_6O_{12}(OH)_{10}\cdot 4H_2O$	Small	Z = c	TET acic	100 perf 001 good	White, pink	H 5 G 2.61	---
	1.536	1.538	1.544	.008	NATROAPOPHYLLITE $NaCa_4Si_8O_{20}F\cdot 8H_2O$	32°	---	ORTH	001 perf	Cols to yellow	G 2.50	Slightly dec by HCl.
	1.536	1.539	1.603	.067	VOLKOVSKITE $(Ca,Sr)B_6O_{16}\cdot 3H_2O$	24°	Y = b Z:a = 31°	MCL	010 perf 001 good	Cols	G 2.32	---
1.535 ^v 1.545	1.525	1.540	1.590	.065	ALUMINOCOPIAPITE $AlFe^{+3}{}_4(SO_4)_6O(OH)\cdot 20H_2O$	Mod	---	TCL	010 perf	Yellow	---	Pleoc in yellow.
	1.541	1.541	1.547	.006	OSUMILITE-(Mg) (Osumilite grp) $(K,Na)(Mg,Fe)_2(Al,Fe)_3(Si,Al)_{12}O_{30}\cdot H_2O$	5-15°	---	HEX	---	Cols	G 2.63	---
1.532 ^v 1.541 neg	1.536	1.541	1.546	.010	OLIGOCLASE plagioclase, plutonic (Feldspar grp) $(Na,Ca)Al(Si,Al)Si_2O_8$	~ 90°	X':a on 001 = 1° 010 = 7°	TCL	001 perf 010 good	Cols	H 6 G 2.64	Data for An_{18}. Insol in acids. Tw poly on 010.
	1.532	1.542	1.556	.024	PHAUNOUXITE $Ca_3(AsO_4)_2\cdot 11H_2O$	80°	---	TCL	100 perf 011 good	Cols	G 2.28	Diss by acids.
	1.540	1.542	1.550	.010	RAITE $Na_4Mn_4Si_8(O,OH)_{24}\cdot 8\text{-}10H_2O$	(~ 50°)	Z:c = 0-30°	ORTH acic	100, 010, 001 perf	Gold to brown	H 3 G 2.39 F easy	Dec by acids. Pleoc, X nearly cols, Y yellowish, Z gold or brown. El pos.
1.532 ^v 1.550	1.538	1.542	1.547	.009	CORDIERITE $(Mg,Fe)_2Al_4Si_5O_{18}$	84°	X = c Z = b	ORTH	010 dist	Blue	H 7 G 2.64 F 5	Partly dec by acids. FeO 8.0, Fe_2O_3 0.6, Na_2O 1.0%.
1.534 ^	1.535	1.543	1.561	.026	WAVELLITE $Al_3(PO_4)_2(OH,F)_3\cdot 5H_2O$	65° r > v wk	X = b Y = a el pos	ORTH radiating, fib	110 perf 101 good 010 dist	White, yellow, green	H 3.5-4 G 2.30 infus	Diss by acids. Colored var pleoc, X greenish, Z yellowish, abs X > Z.
	1.534	1.543	1.558	.024	GORDONITE $MgAl_2(PO_4)_2(OH)_2\cdot 8H_2O$	73° r > v	X ⊥ 010 Z:c = 30°	TCL laths	010 perf	Cols	H 3.5 G 2.23 F 3	Diss by acids.

	1.536	---	1.550	.014	LOUDOUNITE $NaCa_5Zr_4Si_{16}O_{40}(OH)_{11}\cdot 8H_2O$	---	---	fib	---	Green to white	H 5 G 2.48	Opt sign unk. Ext wavy.
v 1.550	1.540	1.543	1.549	.009	CHKALOVITE $Na_2BeSi_2O_6$	78° r > v	Y = c	ORTH	001 good 111 poor	White	H 6 G 2.66 F easy	Dec by acids with sepn of silica.
	1.540	1.544	1.559	.019	FARRINGTONITE $(Mg,Fe)_3(PO_4)_2$	55°	Z:c = 16°	MCL	100, 010 fair to good	Cols to yellowish	G ~ 2.80	FeO 3.7-5.4%. Meteorite mineral.
	1.542	1.544	1.551	.009	CAVANSITE $Ca(VO)Si_4O_{10}\cdot 4H_2O$	52° r < v extr	X = b Y = a	ORTH pris	010 good	Greenish-blue	H 3-4 G 2.21-2.31	Diff diss by acids. Pleoc, X and Z cols, Y blue.
	1.543	1.544	1.546	.003	EPIDIDYMITE $NaBeSi_3O_7(OH)$	22-30° r > v	X = a Z = b	ORTH plates	010, 001 perf	Cols	H 5.5 G 2.58 F 3	Insol in acids. Tw.
1.540 ^v 1.550	1.525	1.545	1.595	.070	MAGNESIOCOPIAPITE $(Mg,Fe)Fe^{+3}{}_4(SO_4)_6(OH)_2\cdot 20H_2O$	Med r > v str	X ~ b el clv pos	TCL tab	010 perf	Yellow	H 2.5-3 G 2.1 F 4.5-5	Diss by acids. Pleoc, X and Y nearly cols, Z deep yellow.
	1.532	1.545	1.572	.040	HALURGITE $Mg_2B_8O_{10}(OH)_8\cdot H_2O$	(71±6°)	X = b Z ~ c	MCL	---	Cols	H 2.5-3 G 2.19	Diss by boiling H_2O.
	1.539	1.545	1.551	.012	BRUSHITE $CaHPO_4\cdot 2H_2O$	87° r > v crossed	Z = b X:c = -30°	MCL el c	010, 001 perf	White	H 2.5 G 2.30 F 3	Diss by acids.
v (1.569)	1.545	(1.546)	1.553	.008	CHRYSOTILE (Serpentine grp) $Mg_3Si_2O_5(OH)_4$	50°	---	MCL fib	---	Pale green	G 2.55 infus	Insol in acids. Fe_2O_3 2.3, Al_2O_3 1.2, FeO 1.6%.
	1.531	1.546	1.562	.031	BRASSITE $MgHAsO_4\cdot 4H_2O$	Very large	Z = c Y = a	ORTH crusts	001 perf	White	G 2.28 infus	Diss by acids.
	1.545	1.546	1.549	.004	EUDIDYMITE $NaBeSi_3O_7(OH)$	23-30° r > v	Y = b Z:c = -55°	MCL tab	001 perf	White	H 6 G 2.58 F 3	Insol in acids. Tw pl 001, lam, always present.
1.525 ^	1.541	1.547	1.564	.023	VOGLITE $Ca_2Cu(UO_2)(CO_3)_4\cdot 6H_2O$ (?)	60°	X = b Y = c	MCL	010 perf	Emerald-green	Soft infus	Poly tw lam. Pleoc str, X and Y deep bluish-green, Z yellow.
1.529 ^v 1.551	1.544	1.548	1.572	.028	BOTRYOGEN $MgFe^{+3}(SO_4)_2(OH)\cdot 7H_2O$	40° r > v str	X = b Z:c = 12° el clv pos	MCL reni-form	010 perf 110 good	Red to orange	H 2-2.5 G 2.08 F 4.5-5	Diss by acids. Pleoc, X yellow, Y red, Z orange-red.
	1.542	1.548	1.566	.024	SCHODERITE $Al_2(VO_4)(PO_4)\cdot 8H_2O$	(61±11°)	Y = b Z:c = 29°	MCL tab 010	---	Yellow-orange	H 2 G 1.88	---

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.547	1.549	1.559	.012	PARTHEITE $CaAl_2Si_2O_8 \cdot 2H_2O$	48° r > v mod	X:el = 23-30°	MCL	clv ‖ el	White	G 2.39	---
∨ 1.555	1.549	1.549	1.680	.131	STUDTITE $UO_4 \cdot 4H_2O$	Small	Z = el	MCL fib	---	Yellow	---	Slowly sol in cold dil HCl. Hydrous U-peroxide.
1.545 ◊ 1.554	1.530	1.550	1.592	.062	FERRICOPIAPITE $Fe^{+3}Fe^{+3}{}_4(SO_4)_6O(OH) \cdot 20H_2O$	69° r > v	X ~ b	TCL	010 perf	Yellow	H 2 G 2.2	Diss by acids. Pleoc in yellow.
1.542 ^	1.544	1.550	1.556	.012	CORDIERITE $(Mg,Fe)_2Al_4Si_5O_{18}$	85°	X = c Z = b	ORTH	010 dist	Blue	H 7 G 2.63 F 5	Partly dec by acids. FeO 8.4, Fe_2O_3 0.6%.
1.550 neg ◊ 1.558	1.546	1.550	1.554	.008	ANDESINE plagioclase, plutonic (Feldspar grp) $(Na,Ca)Al(Si,Al)Si_2O_8$	90°	X':a on 001 = 0° 010 = -5°	TCL	001 perf 010 good	Cols	H 6 G 2.66 F 5.5	Insol in acids. Poly tw 010. Data for An_{33}.
1.543 ^	1.549	1.550	1.553	.004	CHKALOVITE $Na_2BeSi_2O_6$	81° r > v	Y = c	ORTH	001 good 111 poor	White	H 6 G 2.66 F easy	Dec by acids with sepn of silica.
	1.549	1.551	1.621	.072	VEATCHITE-A $Sr_2B_{11}O_{16}(OH)_5 \cdot H_2O$	25°	X = c Z = b	TCL	100 perf 011, 0$\bar{1}$1 good	Cols	G 2.73	Diss by acids.
1.548 ^	1.542	1.551	1.587	.045	ZINCOBOTRYOGEN $(Zn,Mg)Fe^{+3}(SO_4)_2(OH) \cdot 7H_2O$	(54±6°) r > v	X = b	MCL pris	010 good	Orange-red	H 2.5 G 2.20	Diss by acids. Pleoc str, X yellow, Y and Z red.
	1.540	1.552	1.570	.030	RAUENTHALITE $Ca_3(AsO_4)_2 \cdot 10H_2O$	85°	Y:el = 5-10°	TCL spher	---	Snow-white	G 2.36	---
∨ 1.570	1.548	1.552	1.570	.022	NORBERGITE (Humite grp) $Mg_3SiO_4(F,OH)_2$	33° (51±13°)	X = a Z = b	ORTH	---	Cols	H 5 G 3.2 infus	Gel with acids. Data for synth F compd.
1.552 neg ◊ 1.562	1.549	1.552	1.556	.007	ANDESINE plagioclase, volcanic (Feldspar grp) $(Na,Ca)Al(Si,Al)Si_2O_8$	~ 90°	X':a on 001 = 2° 010 = -4°	TCL	001 perf 010 good	Cols	H 6 G 2.67 F 5.5	Insol in acids. Poly tw 010. Data for An_{36}.
	1.534	1.553	1.638	.104	RHOMBOCLASE $HFe(SO_4)_2 \cdot 4H_2O$	27° (53±3°)	X = c Y = a	ORTH tab 001	001 perf 110 good	Cols to yellowish	H 2 G 2.23 fus	Slowly sol in H_2O, diss by acids.

	1.543	1.553	1.620	.077	VEATCHITE $Sr_2B_{11}O_{16}(OH)_5 \cdot H_2O$	44° r > v wk	Z = b X:c = -30°	MCL	100, 011 perf	White	H 2 G 2.69 F 1.5	Diss by acids.
	1.551	1.553	1.621	.070	p-VEATCHITE $Sr_2B_{11}O_{16}(OH)_5 \cdot H_2O$	37° (20±10°)	Y = b	MCL	---	Cols	H 2 G 2.60-2.69 F 1.5	Diss by acids.
1.513 ^	1.547	1.553	1.582	.035	BOBIERRITE $(Mg,Fe)_3(PO_4)_2 \cdot 8H_2O$	57° r < v	Y = b Z:c = 27°	MCL acic	010 perf	Cols	H 2-2.5 G 2.3 fus	Diss by acids. FeO 15.1, MnO 2.95%.
	1.550	1.553	1.559	.009	CHAROITE $K(Ca,Na)_2Si_4O_{10}$ $(OH,F) \cdot H_2O$	29°	X = b Z:c = 5° el pos	MCL	3 clv	Lilac to violet	G 2.54	In thick fragments, pleoc, X rose, Z cols.
	1.540	1.553	1.570	.030	LEMOYNITE $(Na,K)_2CaZr_2Si_{10}O_{26} \cdot$ $5\text{-}6H_2O$	80° r < v wk	Y = b Z:a = 5° el pos	MCL	100	Cols	H 4 G 2.29	---
1.550 ◊ 1.575	1.534	1.554	1.586	.052	ZINCOCOPIAPITE $ZnFe_4(SO_4)_6(OH)_2 \cdot 18H_2O$	(78±5°) r < v str	X ~ b el c̄l̄v pos	TCL tab	010 perf	Yellow-green	H 2 G 2.18 F 5	Diss by acids. Pleoc str in shades of yellow.
	1.547	---	1.571	.024	GLUCINE $Ca_2Be_8(PO_4)_4(OH)_8 \cdot H_2O$	---	el pos, ext ||	Fine needles	---	Cols	H ~ 5 G 2.23-2.40	Diss by acids. Opt char unk.
	---	1.554	---	.016	GROTHINE Silicate of Ca, Al, Fe (?)	Med r < v	Y = c Z = a	ORTH tab 010	---	Cols	G 3.09 infus	Dec by H_2SO_4.
v 1.571	1.553	1.554	1.558	.005	CLINOCHLORE var. Corundophilite (Chlorite grp) $(Mg,Fe)_5Al(Si_3Al)O_{10}$ $(OH)_8$	50° r < v	Z ~ c	MCL	001 mic	Green	H 3 G 2.6 F diff	Insol in acids.
	1.491	1.555	1.654	.163	WHEWELLITE (oxalate) $CaC_2O_4 \cdot H_2O$	83° r < v wk	X = b Z:c 30°	MCL	$\bar{1}01$ good 001, 010 dist	Cols	H 2.5-3 G 2.21 infus	Diss by acids. Tw pl $\bar{1}01$.
1.549 ^	1.545	1.555	1.680	.135	STUDTITE $UO_4 \cdot 4H_2O$	Small	Z = el	MCL fib	---	Yellow	---	Slowly sol in cold dil HCl. Hydrous U-peroxide.
	1.532	1.555	1.591	.059	AMARILLITE $NaFe(SO_4)_2 \cdot 6H_2O$	Large r < v	Y = b Z:c = 51°	MCL thick tab	110 good	Pale greenish-yellow	H 2.5-3 G 2.19	Sol in H_2O.
	1.546	1.555	1.587	.041	HARTITE $C_{19}H_{32}$ (?)	Med (57±7°) r < v perc	---	TCL	---	White	H < 1 G 1.06 F 1	A hydrocarbon. Diss by alcohol or ether.
v ~1.571	1.552	1.555	1.565	.013	WOODWARDITE $Cu_4Al_2(SO_4)(OH)_{12} \cdot$ $3H_2O$ (?)	(58±19°)	---	ORTH(?) spher	---	Greenish-blue	G 2.38	---

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
	1.551	1.555	1.562	.011	VAUXITE $FeAl_2(PO_4)_2(OH)_2 \cdot 6H_2O$	32° (74±21°) r > v str	Z ~ ⊥ 001	TCL tab 010	---	Sky blue to vene-tian blue	H 3.5 G 2.39	Pleoc str, X and Z cols, Y blue.
	1.550	1.557	1.567	.017	LITHIOPHOSPHATE Li_3PO_4	69-88°	X = a Y = b	ORTH u mass	100 perf 110 dist	Cols to rose	H 4 G 2.46	Slowly sol in H_2O, diss by acids.
⊔ 1.561	1.551	1.558	1.582	.031	METAVARISCITE $AlPO_4 \cdot 2H_2O$	55° r < v wk	Y = b	MCL	010	Green	H 3.5 G 2.54 infus	Diss by HCl after being heated gently (color changes to lavender). Pleoc wk, X cols, Y and Z pale green.
	1.545	1.554	1.565	.020	Unnamed phosphate	~ 90°	ext large	MCL(?)	---	Cols	---	Occurs with Lacroix-ite (Am. Mineral., 57, 1914 (1972)).
	1.554	1.558	1.573	.019	PARAVAUXITE $FeAl_2(PO_4)_2(OH)_2 \cdot 8H_2O$	Med	---	TCL pris	010 perf	Cols	H 3 G 2.36	---
1.550 ⇕ 1.568	1.555	1.558	1.562	.007	LABRADORITE plagioclase, plutonic (Feldspar grp) $(Ca,Na)Al(Si,Al)Si_2O_8$	78°	X':a on 001 = -6° 010 = -17°	TCL	001 perf 010 good	Cols	H 6 G 2.69	Insol in acids. Poly tw 010. Data for An_{50}.
	1.536	1.559	1.697	.161	ZELLERITE $Ca(UO_2)(CO_3)_2 \cdot 5H_2O$	30-40° (47±2°) r < v wk	Z = c	ORTH fib	---	Light lemon-yellow	Soft G 3.25	Pleoc, X and Y cols, Z light green. Fluor green in UV.
	1.559	1.560	1.584	.025	BASSANITE $2CaSO_4 \cdot H_2O$	10-15°	Z ‖ fib X ⊥ fib el pos	HEX	---	White	G 2.7 F 3	Diss by HCl. Tw pl 100.
	1.557	1.561	1.569	.012	CLINOPHOSINAITE $Na_3CaPSiO_7$	80°		MCL	Conch	Pale lilac	H 4 G 2.85	Dec by HCl.
	1.494	1.561	1.692	.198	HUMBOLDTINE (oxalate) $FeC_2O_4 \cdot 2H_2O$	Large	---	MCL ps orth	---	Yellow	H 1.5-2 G 2.28 infus	Diss by acids. Pleoc, X pale yellow-green, Y pale greenish-yellow, Z intense yellow.
	1.550	1.561	1.582	.032	METAVAUXITE $FeAl_2(PO_4)_2(OH)_2 \cdot 8H_2O$	Large	X = b Z:c = -17°	MCL acic	---	Cols	H 3 G 2.34	---

	1.559	1.562	(1.572)	.013	MCNEARITE $NaCa_5H_4(AsO_4)_5 \cdot 4H_2O$	66° disp str	Y:c = 0-22° el pos	TCL fib	One perf	White	G 2.60	Diss by acids.
1.552 ◊ 1.569	1.558	1.562	1.566	.008	LABRADORITE plagioclase, volcanic (Feldspar grp) $(Ca,Na)Al(Si,Al)Si_2O_8$	76°	X':a on 001 = -15° 010 = -26°	TCL	001 perf 010 good	Cols	H 6 G 2.69 infus	Insol in acids. Poly tw 010. Data for An_{58}.
	1.561	1.563	1.567	.006	DICKITE $Al_2Si_2O_5(OH)_4$	55-80° r > v str	Z = b Y:a = 14-20°	MCL ps hex plates	001 perf	White	H 2 G 2.62 infus	Insol in acids.
	1.554	1.564	1.595	.041	BARICITE $(Mg,Fe)_3(PO_4)_2 \cdot 8H_2O$	59° r < v wk	X = b Z:c = 32°	MCL plates 010	010 perf	Cols to pale blue	H 1.5-2 G 2.42	Compare Vivianite. FeO 19.9, Fe_2O_3 2.8%.
	1.547	1.566	1.594	.047	QUENSTEDTITE $Fe_2(SO_4)_3 \cdot 10H_2O$	70° (80+5°) r < v str horizontal	---	TCL	010 perf 100 good	Violet	H 2.5 G 2.15	Sol in H_2O.
	1.562	1.566	1.587	.025	SENEGALITE $Al_2(PO_4)(OH)_3 \cdot H_2O$	53° r > v	Z = a Y = c	ORTH	---	Cols	G 2.55	---
⊔ 1.571	1.561	1.568	1.585	.024	PICROPHARMACOLITE $H_2Ca_4Mg(AsO_4)_4 \cdot 11H_2O$	Med large	X = b Z:c = 8-15° el pos	TCL fib	One good	White	G 2.64	Diss by acids.
1.5̌79	1.568	1.568	1.587	.019	GIBBSITE $Al(OH)_3$	0-5° r < v or r > v	X = b Y:c = 69°	MCL ps hex, tab 001	001 perf	White, brownish	H 3 G 2.3-2.4 infus	Diss by hot concd H_2SO_4 or by hot alkalies.
1.565 [] 1.570	1.562	1.568	1.575	.013	ELPIDITE $Na_2ZrSi_6O_{15} \cdot 3H_2O$	84° r < v dist	X = c Z = a el neg	ORTH el c	110 dist	White, red, brown	H 5-7 G 2.63	Insol in acids. Pleoc wk in yellow, abs Y > X.
1.558 ◊ 1.568 neg	1.563	1.568	1.573	.010	BYTOWNITE plagioclase, plutonic (Feldspar grp) $(Ca,Na)Al(Si,Al)Si_2O_8$	~ 90°	X':a on 001 = -16° 010 = -29°	TCL	001 perf 010 good	Cols	H 6 G 2.71 infus	Insol in acids. Poly tw on 010. Data for An_{70}.
	1.560	1.569	1.584	.024	GÖRGEYITE $K_2Ca_5(SO_4)_6 \cdot H_2O$	80°	---	MCL tab	100 dist	Cols, yellowish	H 3.5 G 2.8-2.9	Dec by H_2O, diss by acids.
1.5̌82	1.563	1.569	1.581	.018	SUDOITE (Chlorite grp) $Mg_2(Al,Fe)_3Si_3AlO_{10}(OH)_8$	54° (71±13°)	Z:c = 7° el clv neg	MCL	001 perf	White	G 2.63	Dioctahedral chlorite.
⊓ ⊔	1.568	1.569	1.581	.013	LIZARDITE (Serpentine grp) $Mg_3Si_2O_5(OH)_4$	Small	---	TRIG and HEX fib	001 perf	Green	G 2.58 infus	Nearly insol in acids. Fe_2O_3 3.6, FeO 1.1%.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.562 ^ v 1.569 neg	1.565	1.569	1.574	.009	BYTOWNITE plagioclase, volcanic (Feldspar grp) $(Ca,Na)Al(Si,Al)Si_2O_8$	~ 90°	X':a on 001 = -23° 010 = -33°	TCL	001 perf 010 good	Cols	H 6 G 2.72 infus	Insol in acids. Poly tw on 010. Data for An_{75}.
(1.546) ^	1.569	(1.569)	1.570	.001	CHRYSOTILE (Serpentine grp) $Mg_3Si_2O_5(OH)_4$	Med	---	MCL fib	---	Dark green	G 2.53 infus	Insol in acids. Fe_2O_3 1.4, Al_2O_3 0.7, FeO 1.3%.
v 1.628	1.555	1.57	1.585	.030	TENGERITE $CaY_3(CO_3)_4(OH)_3 \cdot 3H_2O$	Large	X = el	ORTH fib	---	White	Infus G 2.8	Diss by acids with eff.
1.552 ^	1.565	1.570	1.591	.026	NORBERGITE (Humite grp) $Mg_3SiO_4(F,OH)_2$	49°	X = a Z = b	ORTH	---	Yellow to brown	H 5 G 3.20 infus	Gel with acids.
v 1.582	1.569	1.570	1.582	.013	WAGNERITE $(Mg,Fe)_2(PO_4)F$	27° r > v perc	Y = b Z:c = -22°	MCL	100, 120, 010 imperf	Cols, flesh, yellow	H 5-5.5 G 3.15 F 4	Slowly diss by acids.
v 1.582	---	1.570	1.626	>.05	BUKOVSKYITE $Fe_2(AsO_4)(SO_4)(OH) \cdot 7H_2O$	---	ext at 18°	MCL(?) needles	---	Yellow to gray-green	G 2.34	Diss by HCl. Opt char unk.
	1.543	1.571	1.577	.043	SHABYNITE $Mg_5(BO_3)(Cl,OH)_2(OH)_5 \cdot 4H_2O$	---	X || el	MCL fib	---	Snow-white	H 3 G 2.32	Diss by acids.
v 1.589	1.563	1.571	1.596	.033	HOERNESITE $Mg_3(AsO_4)_2 \cdot 8H_2O$	60°	X = b Z:c = 31° el clv pos	MCL tab 010	010 perf	White	G 2.73 F 2-3	Diss by acids.
	1.565	1.571	1.584	.019 disp str	BRUCITE $Mg(OH)_2$	30-70°	X = el	TRIG fib	0001 perf	Greenish-white	H 2.5 G 2.4 infus	Diss by acids. Anom biax. Anom interf colors in some specimens.
	1.571	1.571	1.590	.019	NEFEDOVITE $Na_5Ca_4(PO_4)_4F$	~ 0°	---	TCL ps tet	Conch	Cols	H 4.5 G 3.01	Diss by acids.
	1.570	1.571	1.578	.008	BANALSITE $BaNa_2Al_4Si_4O_{16}$	41°	X = c Y = a	ORTH	110, 001 good	White	H 6 G 3.06	---

1.554 ^v 1.585	1.571	1.571	1.576	.005	CLINOCHLORE (Chlorite grp) $(Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	Small r < v	Z ~ c el neg	MCL	001 perf	Green	H 3 G 2.66 F diff	Insol in acids.
1.555 ^	1.571	---	1.576	.005	WOODWARDITE $Cu_4Al_2(SO_4)(OH)_{12}\cdot 3H_2O$ (?)	---	---	ORTH(?) spher	---	Greenish-blue	G 2.38	---
	1.562	1.572	1.585	.023	FERRARISITE $Ca_5H_2(AsO_4)_4\cdot 9H_2O$	83°	---	TCL	001 perf	Cols	G 2.63	Diss by HCl.
1.570 [] 1.575	1.572	1.572	1.594	.022	PREOBRAZHENSKITE $Mg_3B_{11}O_{15}(OH)_9$	0-20°	X = a Y = c	ORTH	---	Lemon-yellow, cols	H 4.5-5 G 2.44	---
	1.562	(1.572)	1.583	.021	Unnamed hydrous calcium arsenate	~ 90°	Z = b Y:c = 8°	MCL	---	Cols	---	Opt char unk (Am. Mineral., 58, 561 (1973)).
	1.570	1.572	1.582	.012	FROLOVITE $CaB_2(OH)_8$	75°	---	TCL	---	White	H 3.5 G 2.14	Diss by acids. Ext may be undulatory.
	1.572	(1.572)	1.582	.010	BAYERITE $Al(OH)_3$	Small	---	MCL	---	White	---	Diss by hot alkalies.
	1.543	1.575	1.634	.091	METASIDERONATRITE $Na_2Fe^{+3}(SO_4)_2(OH)\cdot H_2O$	60° (75±3°) r > v str	X = a Y = b	ORTH	001 mic 100, 010 perf	Golden- to straw-yellow	H 2.5 G 2.68	Diss by acids. Pleoc, X cols, Y light yellow, Z brownish-yellow.
1.554 ^	1.558	1.575	1.620	.062	CUPROCOPIAPITE $CuFe_4(SO_4)_6(OH)_2\cdot 20H_2O$	63° r > v str	X ~ b el c̄l̄v pos	TCL tab	010 perf	Greenish-yellow	H 2.5 G 2.1 F 5	Diss by acids. Pleoc in green, abs X and Z > Y.
	1.573	1.575	1.588	.015	AUGELITE $Al_2(PO_4)(OH)_3$	47°	X = b Z:c = 35°	MCL tab 001	110 perf $\bar{2}01$ good	Cols	H 4.5-5 G 2.69 infus	Nearly insol in acids.
	1.570	1.576	1.614	.044	ANHYDRITE $CaSO_4$	44° r < v	X = a Z = c	ORTH	010 perf 100 less so 001 good	Cols, bluish	H 3.5 G 2.98 F 3	Diss by HCl.
	1.573	1.576	1.579	.006	ILMAJOKITE $(Na,Ce,Ba)_2TiSi_3O_5(OH)_{10}\cdot xH_2O$	90°	---	MCL	2 at 72° perf	Bright yellow	H 1 G 2.20 fus	Dec by acids.
	1.554	1.577	1.618	.064	BONATTITE $CuSO_4\cdot 3H_2O$	(75±4°)	---	MCL	010 dist	Pale blue	G 2.66 F 3	Sol in H_2O. Hydrates to chalcanthite. Tw pl 100 common.
	1.54	1.578	~1.60	.06	FICHTELITE $C_{19}H_{34}$	87°	opt pl 010 Z:c = 13°	MCL tab	001 perf $\bar{1}01$ dist	White	H 1 G 1.03 F 46°C	Sol in ether. Tw pl 001. Dimethyl-isopropyl-perhydro-phenanthrene.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.575	<u>1.578</u>	1.584	.009	NIFONTOVITE $Ca_3B_6O_6(OH)_{12}\cdot 2H_2O$	76° r > v str	el pos	MCL	Poor, ‖ el	Cols	H 3.5 G 2.36	Diss by acids. Anom interf colors.
v 1.588	1.576	<u>1.579</u>	1.597	.031	COOKEITE (Chlorite grp) $LiAl_4(Si_3Al)O_{10}(OH)_8$	0-80° most ~ 50° (45±14°)	Z ~ <u>c</u> X ‖ edge el neg	MCL tab 001	001 mic	White, pink	H 2.5 G 2.67	Insol in acids. Exfoliates when heated. Base shows 6 biax segments.
1.568 ^	1.578	<u>1.579</u>	1.590	.012	GIBBSITE $Al(OH)_3$	0-5° r < v or r > v	Y = <u>b</u> Z:<u>c</u> = -30°	MCL ps hex	001 perf	White, brownish	H 3 G 2.3-2.4 infus	Diss by hot concd H_2SO_4 or by hot alkalies.
v 1.588	1.578	<u>1.579</u>	1.583	.005	BAVENITE $Ca_4Be_2Al_2Si_9O_{26}(OH)_2$	26-60°	X = <u>c</u> Z = <u>b</u> el neg	ORTH fib	100 good 001 fair	Cols, pink	H 5.5 G 2.71	Apparent tw pl 100.
v 1.591	1.543	<u>1.580</u>	1.617	.074	HAMBERGITE $Be_2BO_3(OH,F)$	90° r > v wk	X = <u>a</u> Y = <u>b</u>	ORTH pris <u>c</u>	010 perf 100 good	White	H 7.5 G 2.37 infus	Insol in acids except HF.
v 1.583	1.580	<u>1.580</u>	1.596	.016	NORDSTRANDITE $Al(OH)_3$	Small	Z:<u>c</u> = 33° el neg	TCL	---	White	G 2.43	Poly tw.
	1.567	<u>1.581</u>	1.638	.071	KORNELITE $Fe_2(SO_4)_3\cdot 7H_2O$	49-62° r > v perc	Z = <u>b</u> X:<u>c</u> = 17°	MCL pris	010 good	Pale rose, violet	G 2.3	Sol in H_2O. Poly tw pl 100.
	1.573	<u>1.581</u>	1.585	.012	SLAWSONITE (Feldspar grp) $(Sr,Ca)Al_2Si_2O_8$	82° r < v	Z = <u>b</u> X:<u>a</u> = 11°	MCL pris	001 good 100 fair	Light gray	H 5.5 G 3.12	---
1.570 ^	---	<u>1.582</u>	1.631	>.05	BUKOVSKYITE $Fe_2(AsO_4)(SO_4)(OH)\cdot 7H_2O$	---	ext 18°	MCL(?) needles needles	---	Yellow to gray- green	G 2.34	Diss by HCl. Opt char unk.
1.570 ^	1.577	<u>1.582</u>	1.595	.018	WAGNERITE $(Mg,Fe)_2(PO_4)F$	32° (64±14°) r > v perc	Y = <u>b</u> Z:<u>c</u> = -22°	MCL	100, 120, 010 imperf	Cols, flesh, yellow	H 5-5.5 G 3.23 F 4	Diss by acids. FeO 9.9, MnO 2.0%.
1.569 ^	1.578	<u>1.582</u>	1.596	.018	SUDOITE (Chlorite grp) $Mg_2(Al,Fe)_3Si_3AlO_{10}(OH)_8$	55°	Z:<u>c</u> = 7° el neg	MCL	001 perf	White	G 2.64	Dioctahedral chlorite.
	1.582	<u>1.582</u>	1.592	.010	XONOTLITE $Ca_6Si_6O_{17}(OH)_2$	0-5°	X = <u>b</u> Z = <u>c</u> el pos	MCL and TCL fib	010 perf	Cols, pink	H 6 G 2.69 F 2.5	Dec by HCl with sepn of silica.

	1.550	1.583	1.641	.091	AJOITE $(K,Na)Cu_7AlSi_9O_{24}(OH)_6\cdot 3H_2O$	80° (76±3°)	Z':c on 010 = 15°	TCL	---	Bluish-green	G 2.96	Dec by acids. Pleoc, X light bluish-green, Y and Z brilliant bluish-green.
1.580 ^	1.580	1.583	1.602	.022	NORDSTRANDITE $Al(OH)_3$	24° (44±16°) r < v perc	el neg	TCL	110 perf	Cols, white	H ~ 3 G 2.42	---
	1.580	1.583	1.590	.010	WHITEITE $Ca(Fe^{+2},Mn)Mg_2(PO_4)_4Al_2(OH)_2\cdot 8H_2O$	40-50°	X = b Y = a	MCL	---	Tan	G 2.58	---
v 1.593	1.580	(1.583)	1.590	.010	MISERITE $K(Ca,Ce)_4Si_5O_{13}(OH)_3$	60-78°	X = c Z = a el neg	TCL fib	100 good 010 imperf	Pink to violet	H 2.5 G 2.84	Insol in acids.
1.571 ^v 1.601	1.585	1.585	1.593	.008	CLINOCHLORE (Chlorite grp) $(Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	0-15° r < v	Z ~ c el neg	MCL	001 perf	Cols to green	H 3 G 2.72 F 5	Insol in acids. FeO 3.3, Fe_2O_3 2.1%.
	1.563	1.586	1.619	.056	SIGLOITE $(Fe^{+2},Fe^{+3})Al_2(PO_4)_2(O,OH)_2\cdot 8H_2O$	76° (81±4°) r < v str	---	TCL	010 perf 001 good	Straw-yellow	H 3 G 2.35	Diss by acids. Oxidation product of childrenite.
	1.584	1.586	1.600	.016	EAKERITE $Ca_2SnAl_2Si_6O_{18}(OH)_2\cdot 2H_2O$	35° r > v str	X = b Y:c = 23.5°	MCL	Conch	Cols to white	H 5.5 G 2.93	Insol in acids.
v 1.593	1.581	1.586	1.596	.015	SCHOLZITE $CaZn_2(PO_4)_2\cdot 2H_2O$	70° r < v	X = a Y = b	ORTH	100 fair	Cols	H 3-3.5 G 3.11	Diss by acids.
1.579 ^	1.584	1.588	1.598	.014	COOKEITE (Chlorite grp) $LiAl_4(Si_3Al)O_{10}(OH)_8$	60°	Z ~ c X || edge el neg	MCL tab 001	001 mic	White, pink	H 2.5 G 2.61	Insol in acids. Exfoliates when heated. Base shows 6 biax segments.
1.579 ^	1.586	1.588	1.593	.007	BAVENITE $Ca_4Be_2Al_2Si_9O_{26}(OH)_2$	60°	X = c Z = b el neg	ORTH fib	100 good 001 fair	Cols, pink	H 4.5-5 G 2.73	Apparent tw pl 100.
	1.587	1.588	1.603	.016	PARASCHOLZITE $CaZn_2(PO_4)_2\cdot 2H_2O$	25° r > v	X = b Z:c = 13°	MCL	Parting 100	Cols to white	H 4 G 3.12	Tw on 100.
1.571 ^	1.579	1.589	1.609	.030	MANGANESE-HOERNESITE $(Mn,Mg)_3(AsO_4)_2\cdot 8H_2O$	65-70° (71±8°)	X = b Z:c = 31° el pos	MCL acic	010 perf	White	G 2.76	Diss by acids.
	1.580	1.589	1.605	.025	HEIDORNITE $Na_2Ca_3B_5O_8(OH)_2(SO_4)_2Cl$	63-77° r < v	Y = b Z:a = 23°	MCL spear-like	001 perf	Cols	H 4-5 G 2.75	Diss by acids.
1.589 neg ^v 1.599	1.584	1.589	1.594	.010	CELSIAN (Feldspar grp) $BaAl_2Si_2O_8$	86°	Y = b Z:a = 28°	MCL	001 perf 010 good	Cols	H 6 G 3.37 infus	Gel with HCl.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
⌐ ⌙	1.583	1.589	(1.601)	(.018)	SUDOITE (Chlorite grp) $Mg_2(Al,Fe^{+3})_3Si_3AlO_{10}(OH)_8$	70°	---	MCL	001 good	Pale green	G 2.68	MgO 14.1, Al_2O_3 35.7, Fe_2O_3 2.7, FeO 0.2, MnO 0.3%.
1.533 ≶ 1.623	1.558	1.590	1.629	.071	SZOMOLNOKITE (Kieserite grp) $(Fe,Mg)SO_4{\cdot}H_2O$	Large r > v	Y = b	MCL	---	Yellow	H 2.5 G 2.8 fus	Slowly sol in H_2O. Fe:Mg = 3:2.
	1.587	1.590	1.597	.010	BULTFONTEINITE $Ca_2SiO_2(OH,F)_4$	70° r > v	Z:c on $0\bar{1}0$ = 28° 100 = 47°	TCL spher	010, 001 fairly good	Pink	H 4.5 G 2.73	Gel with HCl. Poly tw.
1.580 ^	1.560	1.591	1.631	.071	HAMBERGITE $Be_2BO_3(OH,F)$	87° r > v wk	X = a Y = b	ORTH pris c	010 perf 100 good	White	H 7.5 G 2.35 infus	Insol in acids except HF.
⌴	1.590	1.592	1.627	.037	CATAPLEIITE $(Na_2,Ca)ZrSi_3O_9{\cdot}2H_2O$	Small r < v wk	---	HEX	$10\bar{1}0$ perf	Yellow, brown	H 5.6 G 2.75 F 3	Gel with acids. Complex tw. Uniax when heated to 200°C.
	1.586	1.592	1.614	.028	COLEMANITE $Ca_2B_6O_{11}{\cdot}5H_2O$	56° r > v wk	X = b Y:c = -6°	MCL	010 perf 001 dist	Cols	H 4.5 G 2.42 F 1.5	Diss by hot HCl.
	1.588	1.592	1.598	.010	ALTHAUSITE $Mg_2(PO_4)(OH,F,O)$	~ 70°	X = c Y = b el neg	ORTH mass	010 perf 100 dist	Gray	H 3.5-4 G 2.97	---
1.586 ^	1.588	1.593	1.602	.014	SCHOLZITE $CaZn_2(PO_4)_2{\cdot}2H_2O$	65° r < v	X = a Y = b	ORTH	100 fair	Cols	H 3-3.5 G 3.11	Diss by acids.
(1.583) ^	1.586	1.593	1.600	.014	MISERITE $K(Ca,Ce)_4Si_5O_{13}(OH)_3$	52-78°	X = c Z = a el neg	TCL fib	100 good 010 imperf	Pink to violet	H 2.5 G 2.84	Insol in acids.
	1.562	1.595	1.632	.070	SZMIKITE $MnSO_4{\cdot}H_2O$	~ 90°	Z = b	MCL fib or platy	One perf	White to rose	Soft G 3.15 infus	Sol in H_2O.
	1.590	1.595	1.602	.012	CUSPIDINE $Ca_4Si_2O_7(F,OH)_2$	62° (81±19°) r > v	Y = b Z:c = 7° disp perc	MCL spear-shaped	001 dist	Pale rose, cols	H 5.5-6 G 2.86-3.05 F diff	Gel with acids. Poly tw.
⌴ 1.600	1.594	1.595	1.599	.005	COESITE SiO_2	54-64° r < v wk	X = b Z:c = 5°	MCL ps hex	Subconch	Cols	G 2.92 infus	Insol in acids.

	1.594	1.595	1.598	.004	FOSHAGITE $Ca_4Si_3O_9(OH)_2$	---	el pos	TCL fib	---	White	H 3 G 2.36 infus	Gel with acids.
	1.590	1.596	1.616	.026	PANASQUEIRAITE $CaMg(PO_4)(OH,F)$	51°	Z = b X:c = 22°	MCL	010 poor	Pink	H 5 G 3.27	---
1.592	1.577	1.597	1.616	.039	JOHANNITE $Cu(UO_2)_2(SO_4)_2(OH)_2 \cdot 8H_2O$	~ 90° r < v str	X ~ b disp str	TCL pris tab 001	100 good	Emerald- to apple-green	H 2-2.5 G 3.32 infus	Diss by acids. Poly tw. Pleoc str, X cols, Y pale yellow, Z greenish- or canary-yellow.
	1.593	1.597	1.619	.026	ISOKITE $CaMg(PO_4)F$	39-51° r > v	Z = b X:c = 32° el neg	MCL fib	010 very good	Cols to buff	H 5 G 3.27	Diss by acids.
	1.596	1.598	1.632	.036	PETARASITE $Na_5Zr_2Si_6O_{18}(Cl,OH) \cdot 2H_2O$	29° r < v wk	X = b Z:c = 41.5°	MCL	110 perf 001 dist	Greenish-yellow	H 5-5.5 G 2.88	Pleoc, X cols, Y and Z pale greenish-yellow.
v 1.607	1.580	1.598	1.627	.047	VIVIANITE $Fe_3(PO_4)_2 \cdot 8H_2O$	Large r < v wk	X = b Z:c = 29° disp str el clv pos	MCL	010 perf	Pale blue to bluish-green	H 1.5-2 G 2.66 F 1.5	Diss by HCl. Nearly cols fresh, oxidizes to deep blue, then pleoc, X deep blue, Y pale blue, Z olive to brown.
	1.595	1.598	1.610	.015	KOSTYLEVITE $K_2ZrSi_3O_9 \cdot H_2O$	48°	X = b Z:c = 45°	MCL	110 perf	Cols	G 2.74	Dec by HCl.
	1.598	1.598	1.605	.007	TAKOVITE $Ni_6Al_2(OH)_{16}(CO_3,OH) \cdot 4H_2O$	Small	el pos	TRIG spher	---	Blue-green	---	Diss by HCl.
	1.597	1.599	1.615	.018	AMESITE (Kaolinite-serpentine grp) $Mg_2Al(SiAl)O_5(OH)_4$	18° r < v	Z:c = 0-20° el neg	MCL or TCL ps hex plates	001 mic	Pale green	H 2-3 G 2.8 infus	Slowly dec by HCl. FeO ~ 8%.
1.589 ^	1.593	1.599	1.608	.015	CELSIAN (Feldspar grp) $BaAl_2Si_2O_8$	85°	Y = b X:a on 010 = 65°	MCL	001 perf 010 good	Cols	H 6 G 3.35 infus	Gel with HCl. Fe_2O_3 2.2, BaO 38.6, K_2O 0.5%.
	1.593	---	1.608	.015	Unnamed silicate of K, Ca, Zr	---	---	MCL ps hex	---	Brown	---	(Am. Mineral. 50, 533 (1965)).
	1.590	1.600	1.634	.044	HAIDINGERITE $CaHAsO_4 \cdot H_2O$	58° r > v wk	X = b Z = c el pos	ORTH tab 010	010 perf	Cols	H 2-2.5 G 2.85 F 2.5	Diss by acids.
	1.595	1.600	1.631	.036	PETARASITE $Na_5Zr_2Si_6O_{18}(Cl,OH) \cdot 2H_2O$	43° r < v	X = b Z:c = 41.5°	MCL	110 perf 010 very good	Greenish-yellow	H 5-5.5 G 2.88	Pleoc, X cols, Y and Z pale greenish-yellow.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.597 □ 1.61	1.595	1.60	1.628	.033	CEBOLLITE $(Ca,Na_2)_4Al_2Si_3O_{12}(OH)_2$ (?)	58°	---	ORTH(?) fib	---	White	H 5 G 2.96 F 5	Gel with acids. Alteration product of Melilite.
	1.596	1.600	1.618	.022	CHIAVENNITE $CaMnBe_2Si_5O_{13}(OH)_2\cdot 2H_2O$	50° r > v	X = a Y = b el neg	ORTH	001 perf 100, 010 good	Orange	H ~ 3 G 2.24	---
	---	~1.6	---	.014	MANANDOITE (Chlorite grp) $LiAl_4BSi_3O_{10}(OH)_8$	17°	Z ~ c el ⊥ neg	MCL ps hex	001 mic	Cols	G 2.89 F easy	Dec by H_2SO_4. Basal section divided into 6 biax segments.
1.585 ≎ 1.620	1.599	1.601	1.609	.010	CLINOCHLORE (Chlorite grp) $(Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	12-22° r < v	Z ~ c el ⊥ neg	MCL	001 perf	Cols to green	H 3 G 2.78 F 4	Nearly insol in acids. FeO 11.4, Fe_2O_3 4.3%.
	1.582	1.602	1.629	.047	GOLDICHITE $KFe(SO_4)_2\cdot 4H_2O$	82°	X = b Z:c = 11°	MCL	---	Pale green	G 2.43	Sol in H_2O.
	1.579	1.603	1.629	.050	METAVIVIANITE $Fe^{+2}_{3-x}Fe^{+3}_x(PO_4)_2(OH)_x\cdot(8-x)H_2O$	85°	X ⊥ 110	TCL pris el c	110 perf	Leek-green	G 2.69 calc F 1.5	Diss by HCl. Pleoc, X light blue to blue-green, Y yellow-green to light green, Z yellow, abs X > Z > Y.
ˇ 1.617	1.593	1.603	1.623	.030	CHONDRODITE (Humite grp) $(Mg,Fe)_5(SiO_4)_2(F,OH)_2$	71° r > v wk	Z = b X:c = 27°	MCL	100 poor	Yellow to red	H 6 G 3.18 infus	Gel with acids. Poly tw 001. Pleoc, X yellow, Y and Z nearly cols. FeO 2.8, F 7.9%.
ˇ 1.608	1.594	1.603	1.615	.021	NATROMONTEBRASITE $(Na,Li)AlPO_4(OH,F)$	Very large	Z:tw lam = 29°	TCL	2 dist	White	H 5.5 G 3.09 F easy	Diff diss by acids. Poly tw in 2 directions.
	1.577	---	1.630	.053	GUNNINGITE $(Zn,Mn)SO_4\cdot H_2O$	---	---	MCL fine-grained	---	White	H 2.5 G 3.2 infus	Sol in H_2O.
ˇ 1.636	1.599	1.604	1.638	.039	PECTOLITE $NaCa_2Si_3O_8(OH)$	59° (43±8°) r > v wk	---	TCL acic b	100, 001 perf	Cols	H 4.5-5 G 2.90 F 2	Partly dec by HCl.
	1.598	1.604	1.626	.028	METASCHODERITE $Al_2(PO_4)(VO_4)\cdot 6H_2O$	(56±10°)	Z = b Y:c = -20°	MCL	---	Yellow-orange	---	---

	1.580	1.605	1.644	.064	EUCHLORINE $(K,Na)_8Cu_9(SO_4)_{10}$ $(OH)_6$ (?)	Med large (79±4°)	---	ORTH tab	2 clv	Emerald- green	---	Partly diss by H_2O. Pleoc, X pale green, Y green, Z yellow- green.
	1.593	1.605	1.627	.034	FUKALITE $Ca_4Si_2O_6(OH)_2(CO_3)$	(74±7°)	---	ORTH	---	---	H ~ 4 G 2.77	Eff with acids.
	1.600	1.605	1.613	.013	HYDROPHILITE $CaCl_2$ (?)	Med	---	ORTH ps tet	Pris, perf	White	G 2.2 F 2	Sol in H_2O, deliq. Lam tw pl 110. Data on synth compd.
ˇ 1.623	1.598	1.606	1.630	.032	HUMITE (Humite grp) $Mg_7(SiO_4)_3(F,OH)_2$	59° r > v wk	X = a Z = b	ORTH tab 010	001 perf	Cols	H 6 G 3.20 infus	Gel with acids. Data for synth Mg-F compd.
	1.596	1.606	1.621	.025	SCAWTITE $Ca_7Si_6(CO_3)O_{18}\cdot 2H_2O$	74°	Y = b Z:a = 30°	MCL	001 perf 010 fair	Cols	H 4.5-5 G 2.74 infus	Eff and gel with acids.
⌴ 1.609	1.600	1.606	1.614	.014	LATIUMITE $(Ca,K)_8(Al,Mg,Fe)$ $(Si,Al)_{10}O_{25}(SO_4)$	83-90° r > v dist	Z = b X:c = 16- 28°	MCL tab	100 perf	White	G 2.93	---
1.598 ◇ 1.624	1.587	1.607	1.631	.044	VIVIANITE $Fe_3(PO_4)_2\cdot 8H_2O$	Large r < v wk	X = b Z:c = 27° disp str el clv pos	MCL	010 perf	Blue	H 1.5-2 G 2.66 F 1.5	Diss by HCl. Pleoc, X dark blue, Y light blue, Z nearly cols. FeO 29.3, Fe_2O_3 14.0%.
	1.602	1.607	1.615	.013	CRANDALLITE (?) (Crandallite grp) $CaAl_3(PO_4)_2(OH)_5\cdot H_2O$	70-75°	---	TCL(?) ps trig	Basal, perf	White	H 3 G 2.50 F 2.5	Diss with diff in HCl (Am. Mineral., 48, 1144 (1963)).
	1.600	---	1.620	.020	ALDZHANITE $CaMgB_2O_4Cl\cdot 7H_2O$ (?)	---	---	ORTH dipyra- midal	---	Cols to rose	G 2.21	Opt char unk.
ˇ 1.631	1.600	1.608	1.645	.045	CHURCHITE $YPO_4\cdot 2H_2O$	Med disp dist	X = b Z:c = 35°	MCL laths el c	010, 100, 001	White, yellow	H 3 G 3.26 infus	Diss by hot acids.
	1.605	1.608	1.612	.007	IMANDRITE $Na_{12}Ca_3Fe^{+3}_2Si_{12}O_{36}$	75°	---	ORTH	---	Honey- yellow	H 4 G 2.93	---
1.603 ◇ 1.624	1.597	1.608	1.632	.035	MONTEBRASITE $(Li,Na)AlPO_4(OH,F)$	Large r < v	---	TCL	100 perf 100 good 0$\bar{1}$1 dist	White	H 6 G 3.04 F 2	Diss by H_2SO_4. Poly tw in 2 directions at 90°. Li_2O 7.5, Na_2O 3.5, F 1.4%.
	1.602	1.609	1.621	.019	BRAZILIANITE $NaAl_3(PO_4)_2(OH)_4$	75° r < v wk	Y = b X:c = -20°	MCL	010 good fr conch	Yellow	H 5.5 G 2.98 F 4.5	Insol in HCl.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.604	1.609	1.615	.011	URALBORITE $CaB_2O_2(OH)_4$	85° r > v str	---	MCL pris	Parallel to el dist	Cols	H 4 G 2.60	Diss by HCl. Anom interf colors in blue and brown.
1.618	1.607	1.610	1.618	.011	TOPAZ $Al_2SiO_4(F,OH)_2$	67° r > v dist	X = a Z = c el pos el clv neg	ORTH el c	001 perf	Cols, yellow	H 8 G 3.57 infus	Insol in acids. F 20.4%.
	1.607	1.610	1.616	.009	BUCHWALDITE $NaCaPO_4$	---	el pos	ORTH	One clv	Cols	H < 3 G 3.21	Reported as opt neg.
	---	~1.61	---	wk	HARBORTITE $Al_3(PO_4)_2(OH)_3 \cdot 3H_2O$ (?)	---	---	Spher	---	White to brown	H 5-5.5 G 2.80	---
	1.610	1.610	1.611	.001	FOGGITE $CaAl(PO_4)(OH)_2 \cdot H_2O$	40-45°	X = c Y = b	ORTH plates	010 perf 100 good	Cols, white	H 4 G 2.78	---
	1.610	1.611	1.654	.044	CYCLOWOLLASTONITE $CaSiO_3$	Very small	---	TCL	---	Cols	H 5 G 2.91 F 4	Dec by acids. Also called Pseudowollastonite.
	1.608	1.612	1.621	.013	TUHUALITE $(Na,K)Fe^{+2}Fe^{+3}Si_6O_{15}$	60-70° r < v str	X = a Y = b el pos	ORTH	100, 010, 001 good	Dark blue to black	H 3-4 G 2.89	Insol in acids. Pleoc str, X pale pink, Y violet or lavender, Z deep purplish-blue.
	1.602	1.613	1.649	.047	ANAPAITE $Ca_2Fe(PO_4)_2 \cdot 4H_2O$	54° r > v perc	on 100, ext:c = 15°	TCL radiating	001 perf 010 dist	Greenish-white	H 3.5 G 2.81	Diss by acids.
1.621	1.609	1.613	1.619	.010	STOKESITE $CaSnSi_3O_9 \cdot 2H_2O$	70° r < v	Y = b X = c	ORTH pyram	110 perf 010 imperf	Cols	H 6 G 3.19	---
	1.587	1.615	1.640	.053	MONETITE $CaHPO_4$	Large r > v wk	---	TCL rhombs	3 pinacoidal, indist	Yellowish-white	H 3.5 G 2.93 infus	Diss by acids.
1.649	1.608	1.615	1.630	.022	MAGNIOTRIPLITE $(Mg,Fe,Mn)_2PO_4(F,OH)$	66° r > v perc	Y = b Z:c = 53°	MCL	100 perf	Yellow	H 5.5 G 3.47 F 3	Diss by acids. Pleoc, X pale yellow, Y and Z deep yellow. MgO 27.9, FeO 13.4, MnO 7.7%.

	1.588	1.617	1.655	.067	CYANOTRICHITE $Cu_4Al_2(SO_4)(OH)_{12}\cdot 2H_2O$	82° r < v str	Z = c el pos	ORTH acic c	---	Bright blue	G 2.8 F 3	Diss by acids. Pleoc str, X nearly cols, Y pale blue, Z bright blue.
1.603 ◊ 1.632	1.607	1.617	1.639	.032	CHONDRODITE (Humite grp) $(Mg,Fe)_5(SiO_4)_2(F,OH)_2$	80° (69±8°) r > v wk	Z = b X:c = 28°	MCL	100 poor	Yellow to red	H 6 G 3.26 infus	Gel with acids. Poly tw 001. Pleoc, X yellow, Y and Z pale yellow. FeO 5.0, Fe_2O_3 0.8%.
	1.614	1.617	1.636	.022	HEMIMORPHITE $Zn_4Si_2O_7(OH)_2\cdot H_2O$	46° r > v str	X = b Z = c	ORTH el c	110 perf 101 less so	Cols	H 5 G 3.45 F 6	Gel with acids.
	1.616	1.617	1.622	.006	KURUMSAKITE $(Zn,Ni,Cu)_8Al_8V_2Si_5O_{35}\cdot$ $27H_2O$ (?)	35°	---	fib	---	Greenish- to bright yellow	G 4.03	---
v 1.627	1.618	1.618	1.670	.052	DIADOCHITE $Fe_2(PO_4)(SO_4)(OH)\cdot 5H_2O$	Small r > v str	---	TCL u mass	Uneven to conch	Yellow to brown	H 3-4 G 2.0-2.4 fus	Diss by acids.
v 1.683	1.606	(1.618)	1.638	.032	KOETTIGITE $(Zn,Mg)_3(AsO_4)_2\cdot 8H_2O$	Large r < v	X = b el pos	MCL fib c	010 perf	White	H 3 G 2.9 F 3	Diss by acids. ZnO 27.7, MgO 7.2%.
v 1.643	1.608	1.618	1.636	.028	CLINOHUMITE (Humite grp) $Mg_9(SiO_4)_4(F,OH)_2$	59° (74±8°) r < v	Z = b X:c = 9°	MCL	---	Cols	H 6 G 3.1 infus	Gel with acid. Data for synth F end-member.
v 1.629	1.610	1.618	1.635	.025	PREHNITE $Ca_2Al_2Si_3O_{10}(OH)_2$	69° r > v	X = a Y = b	ORTH	001 good	White, green	H 6 G 2.87 F 2	Slowly dec by HCl with sepn of silica. Fe_2O_3 1.5%.
v 1.634	1.613	1.618	1.635	.022	PARGASITE (Amphibole grp) $NaCa_2Mg_4Al(Si_6Al_2)O_{22}$ $O_{22}(OH,F)_2$	61°	Y = b Z:c = 26°	MCL pris c	110 perf at 124°	Cols to brown	H 6 G 3.07	Insol in acids. Al_2O_3 11.1, Fe_2O_3 0.7, FeO 1.7, MgO 20.6, CaO 12.5, Na_2O 2.5, K_2O 1.2%.
1.610 ◊ 1.631	1.616	1.618	1.625	.009	TOPAZ $Al_2SiO_4(F,OH)_2$	61° r > v dist	X = a Z = c el pos el clv neg	ORTH el c	001 perf	Cols, blue, yellow	H 8 G 3.55 infus	Insol in acids. F 17.2, H_2O 1.6%.
	1.616	1.619	1.631	.015	AFWILLITE $Ca_3Si_2O_4(OH)_6$	55° r < v perc	Y = b X:c = 30° disp str	MCL pris b	001 perf 100 good	Cols	H 4 G 2.62 F diff	Diss by HCl, gel.
	1.61	1.62	1.71	.10	BISBEEITE $CuSiO_3\cdot H_2O$ (?)	Small	el pos	ORTH thin laths	---	Bluish-white	Soft	Abs Z > (X,Y). Status of species in doubt.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
	1.590	1.620	1.648	.058	NICKELBISCHOFITE $NiCl_2 \cdot 6H_2O$	87°	Y = b X:c = 8°	MCL	001 perf	Emerald-green	Soft	Sol H_2O, deliq. Pleoc, X pale green, Z green.
	1.60	1.62	1.65	.05	CHAVESITE Hydrous phosphate of Ca, Mn	Large	ext:tw pl ~ 30°	TCL	2 good ~ 90°	Cols	H ~ 3	Poly tw (Am. Mineral., 43, 1148 (1985)).
v 1.640	1.605	(1.620)	1.632	.027	CUMMINGTONITE (Amphibole grp) $(Mg,Fe)_7Si_8O_{22}(OH,F)_2$	89°	Z:c = 14°	MCL	110 perf at 125°	---	H 4-4.5 G 3.04	FeO 6.5, MnO 0.2, MgO 28.1, CaO 1.3, Na_2O 2.4%.
	1.612	1.620	1.648	.036	TURQUOISE $CuAl_6(PO_4)_4(OH)_8 \cdot 5H_2O$	40° (57±7°) r < v str	ext on $1\bar{1}0$ = 12° 001 = 5° 010 = 34° disp dist	TCL u mass	001 perf 010 good	Sky-blue, bluish-green	H 5 G 2.84 infus	Diss by acids only after gentle heating. Pleoc, X cols, Z pale bluish.
	1.611	1.620	1.645	.034	METAHAIWEEITE $Ca(UO_2)_2Si_6O_{15} \cdot xH_2O$	(63±7°)	---	---	---	Yellow to greenish-yellow	---	---
1.601 ◇ 1.630	1.620	1.620	1.625	.005	CHAMOSITE (Chlorite grp) $(Fe,Mg,Al)_6(Si,Al)_4O_{10}(OH)_8$	5° r < v	Z ~ c	MCL	001 perf	Green	H 3 G 2.90 F 3.5	Nearly insol in acids. FeO 19.1, Fe_2O_3 6.6%.
⊔ 1.627	1.593	1.621	1.666	.073	TINAKSITE $K_2Na(Ca,Mn)_2TiSi_7O_{19}(OH)$	76° disp str	---	TCL pris	010 perf 110 imperf	Pale yellow to pink	H 6 G 2.82-2.90	Insol in acids. Pleoc, X and Y cols, Z pale orange-yellow.
1.613 ^	1.616	1.621	1.628	.012	STOKESITE $CaSnSi_3O_9 \cdot 2H_2O$	70° r < v	X = c Y = b	ORTH pyram	110 perf 010 imperf	Cols	H 6 G 3.19	---
v 1.647	1.618	1.622	1.658	.040	VESZELYITE $(Cu,Zn)_3(PO_4)(OH)_3 \cdot 2H_2O$	39° r < v st	Y = b Z:c = 36°	MCL pris	001, 110	Dark bluish-green	H 3.5 G 3.09 fus	Diss by acids. Pleoc.
1.590 ^	1.591	1.623	1.663	.072	SZOMOLNOKITE (Kieserite grp) $FeSO_4 \cdot H_2O$	80° r > v str	Y = b X:c = -26°	MCL pyram	Conch to uneven	Yellow to brown	H 2.5 G 3.05 fus	Slowly sol in H_2O.

1.606 ^v 1.638	1.607	1.623	1.643	.036	HUMITE (Humite grp) $(Mg,Fe)_7(SiO_4)_3(OH,F)_2$	81° r > v wk	X = a Z = b	ORTH tab 010	001 perf	Yellow, brown, cols	H 6 G 3.24 infus	Gel with acids. Pleoc, X and Z pale yellow, Y nearly cols. FeO 5.4, Fe_2O_3 0.5, F 5.4%.
1.608 ^	1.614	1.624	1.644	.030	MONTEBRASITE $LiAlPO_4(OH,F)$	70° r > v str	---	TCL	100 perf 110 good	White	H 6 G 3.01 F 2	Diss by H_2SO_4. Poly tw in 2 directions. Li_2O 10.1, Na_2O 0.14%.
1.607 ^	1.600	1.624	1.650	.050	VIVIANITE $Fe_3(PO_4)_2 \cdot 8H_2O$	Large r < v wk	X = b Z:c = 27° disp str	MCL	010 perf	Blue	H 2 G 2.66 F 1.5	Diss by HCl. Pleoc, X dark blue, Y light blue, Z nearly cols. FeO 33.0, Fe_2O_3 4.1%.
v 1.744	1.622	1.624	1.642	.020	MANSFIELDITE (Variscite grp) $Al(AsO_4) \cdot 2H_2O$	30° r > v str	X = a Z = b	ORTH	201 imperf	White to green	H 3.5-4 G 3.03	Diss by acids.
	1.622	1.624	1.633	.011	URANOPILITE $(UO_2)_6(SO_4)(OH)_{10} \cdot 12H_2O$	Small to large r > v str	Z = b Y:c = 20°	MCL	010 perf	Bright yellow, straw yellow	Soft G 3.96	Diss by acids. Fluor bright yellow in UV. Pleoc, X cols, Y and Z yellow.
v 1.637	1.622	1.624	1.631	.009	CELESTITE (Barite grp) $SrSO_4$	51° r < v	Y = b Z = c	ORTH Tab 001	001 perf 210 good	Cols to pale blue	H 3-3.5 G 3.96 F 3	Slightly sol in acids.
	1.614	1.625	1.637	.023	PARAHOPEITE $Zn_3(PO_4)_2 \cdot 4H_2O$	~ 90° r < v perc	X ~ a Y:c = 30° on 100	TCL	010 perf	Cols	H 3.5-4 G 3.31 F easy	Diss by acids. Poly tw pl common 100.
	---	1.625	---	.007	SMOLIANINOVITE $(Co,Ni,Mg,Ca)_3(Fe^{+3},Al)_2(AsO_4)_4 \cdot 11H_2O$	---	el pos	ORTH fib	---	Yellow	H 2 G 2.46	Opt sign unk.
	1.623	1.626	1.631	.008	UDUMINELITE $Ca_3Al_8(PO_4)_6(OH)_4O_4$	77°	---	ORTH acic	110	White	---	---
	1.618	(~1.627)	1.642	.024	FLUCKITE $CaMnH_2(AsO_4)_2 \cdot 2H_2O$	Large	---	TCL	010 perf 100 easy	Deep to pale rose	H 3.5-4 G 3.05	Diss by acids.
1.618 ^	1.615	1.627	1.670	.055	DIADOCHITE $Fe_2(PO_4)(SO_4)(OH) \cdot 5H_2O$	Small (57±5°) r < v str	---	TCL u mass	Uneven to conch	Yellow to brown	H 3-4 G 2.30 fus	Diss by acids.
v 1.649	1.616	1.628	1.641	.025	ANTHOPHYLLITE $(Mg,Fe)_7Si_8O_{22}(OH)_2$	79° (88±9°)	Y = b Z = c el pos	ORTH pris c	210 perf at 126°	Brown	H 6 G 3.10	Insol in acids. FeO 11.1, Al_2O_3 1.9%.
1.57 ^	1.622	---	1.640	.020	TENGERITE $CaY_3(CO_3)_4(OH)_3 \cdot 3H_2O$	Large	---	ORTH fib	---	White	Infus G 2.8	Diss by acids with eff.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	Refractive index β	Refractive index γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.618 ^v 1.647	1.625	1.629	1.655	.030	PREHNITE $Ca_2Al(AlSi_3)O_{10}(OH)_2$	63° (43±10°) r > v	X = a Y = b	ORTH	001 good	Green	H 6 G 2.93 F 2	Dec by HCl with sepn of silica. Fe_2O_3 3.5, FeO 0.5%.
	1.616	(1.63)	1.677	.061	CARBONATE-CYANOTRICHITE $(Cu,Zn)_4Al_2(CO_3,SO_4)(OH)_{12}\cdot 2H_2O$	55-60° r > v str	el neg	ORTH fib	---	Pale blue to azure-blue	H ~ 2 G 2.66 fus	Diss by acids. Pleoc str, X cols, Z bright blue.
	1.623	1.630	1.684	.061	GUILDITE $CuFe(SO_4)_2(OH)\cdot 4H_2O$	Small to med (40±6°)	Y = c	MCL	100, 001 perf	Chestnut-brown	H 2.5 G 2.70	Diss by acids. Pleoc, X and Y pale yellow, Z greenish-yellow.
v 1.65	---	1.63	---	.02	HOMILITE (altered) $Ca_2(Fe,Mg)B_2Si_2O_{10}\cdot H_2O$	Med large, r < v very str	---	MCL	One imperf	Yellow	H 5 G 3 F 2	Gel with acids.
1.620 ^	1.630	1.630	1.635	.005	CHAMOSITE (Chlorite grp) $(Fe^{+2},Mg,Fe^{+3})_5Al(Si_3Al)O_{10}(OH,O)_8$	Small	Z ~ c el clv neg	MCL	001 perf	Green	H 3 G 2.9	Nearly insol in acids. Pleoc, X and Y deep green, Z greenish brown. FeO 28.7, Al_2O_3 22.9%.
1.608 ^	1.623	1.631	1.657	.034	CHURCHITE $YPO_4\cdot 2H_2O$	Small (59±8°) disp dist	X = b Z:c = 31° 31°	MCL el c	010, 100, 001	White, yellow	H 3 G 3.2 infus	Diss by hot acids.
1.618 ^	1.629	1.631	1.638	.009	TOPAZ $Al_2SiO_4(F,OH)_2$	48° r > v	X = a Z = c el pos el clv neg	ORTH el c	001 perf	Gray, brown, yellow	H 8 G 3.50 infus	Insol in acids. F 13.2%.
1.617 ^	1.619	1.632	1.653	.034	CHONDRODITE (Humite grp) $(Mg,Fe)_5(SiO_4)_2(F,OH)_2$	80° r > v wk	Z = b X:c = 27°	MCL	100 poor	Yellow, red	H 6 G 3.28 infus	Gel with acids. Poly tw 001. Pleoc, X yellow, Y and Z pale yellow. FeO 10.5, MnO 1.2, F 5.4%.
	1.605	1.633	1.703	.098	ROKÜHNITE $FeCl_2\cdot 2H_2O$	64° r < v	X = b Z:c = -49°	MCL	110 very good	Light green	---	Sol in H_2O.
1.618 ^v 1.651	1.632	1.634	1.651	.019	PARGASITE (Amphibole grp) $NaCa_2(Mg,Fe^{+2})_4Al(Si_6Al_2)O_{22}(OH,F)_2$	64° (38±20°)	Y = b Z:c = 17° el pos	MCL pris c	110 perf at 124°	Cols, brown	H 6 G 3.1	Insol in acids. FeO 4.0, Al_2O_3 13.3, CaO 10.2, Na_2O 2.6%.

	1.628	1.635	1.698	.070	SARMIENTITE $Fe_2(AsO_4)(SO_4)(OH)\cdot 5H_2O$	38°	Y = b Z:c = 12°	MCL	---	Yellow-orange	G 2.58	Diss by acids.
	1.615	1.635	1.656	.041	SKLODOWSKITE $Mg(UO_2)_2Si_2O_6(OH)_2\cdot 5H_2O$	~ 90° r < v str	Y = b	MCL el b	100 perf	Lemon-yellow	H 2-3 G 3.64	Gel with acids. U opt neg. Pleoc, X cols, Y pale yellow, Z yellow.
1.632	1.617	1.635	1.652	.035	TILLEYITE $Ca_5Si_2O_7(CO_3)_2$	88° r < v perc	Z:c = 12°	MCL	100 perf another at 42°	White	G 2.84 infus	Eff and gel with acids.
	1.618	1.635	1.650	.032	SEGELERITE $CaMgFe^{+3}(PO_4)_2(OH)\cdot 4H_2O$	Large	X = b Z = a	ORTH	010 perf	Pale green	H 4 G 2.67	Pleoc, X and Y cols, Z yellow.
	1.630	1.636	1.664	.034	HILGARDITE $Ca_2B_5ClO_8(OH)_2$	35° (50±8°) r > v	Y = b Z:c = 1.5°	MCL tab	010 perf 100 less so	Cols	H 5 G 2.71 F 2	Diss by acids.
∨ (1.639)	1.630	1.636	1.664	.034	PARAHILGARDITE $Ca_2B_5ClO_8(OH)_2$	35° (50±8°) r > v	---	TCL	010, 100 perf	Cols	H 5 G 2.71 F 2	Diss by acids.
∨ 1.654	1.632	1.636	1.643	.011	ANDALUSITE Al_2SiO_5	Large r < v str	X = a Z = c el pos	ORTH fib c	110 perf	Cols, pink	H 7 G 3.15 infus	Insol in acids. Fe_2O_3 1.5%.
1.604 ◊ 1.664	1.631	1.636	1.660	.029	PECTOLITE $Na(Ca,Mn)_2Si_3O_8(OH)$	47° r < v str	Z ~ b Y:a = 9° el pos	TCL pris b	100, 001 perf	Light red	H 5 G 2.97-3.13 F 2	Partly dec by acids. MnO 19.5, FeO 2.5%.
1.624 ◊ (1.697)	1.636	1.637	1.648	.012	BARITE $BaSO_4$	37° r < v wk	X = c Y = b el pos	ORTH tab 001	001 perf 210 less so	White, blue, yellow	H 3-3.5 G 4.50 F 3	Insol in acids.
	1.634	---	1.642	.008	IRHTEMITE $Ca_4MgH_2(AsO_4)_4\cdot 4H_2O$	---	ext angle 25° el neg	MCL spher	---	White to pale rose	G 3.09	Diss by acids.
1.623 ◊ 1.653	1.628	1.638	1.655	.027	HUMITE (Humite grp) $(Mg,Fe)_7(SiO_4)_3(OH,F)_2$	76° r > v wk	X = a Z = b	ORTH tab 010	001 perf	Yellow, brown	H 6 G 3.28 infus	Gel with acids. Pleoc, X and Z pale yellow, Y nearly cols. FeO 7.9, Fe_2O_3 1.0, MnO 1.7, F 5.0%.
	1.620	1.639	1.686	.066	KRAUTITE $MnAs^{+5}O_3(OH)\cdot H_2O$	65±5°	X = b el cTv pos	MCL	010 perf $\bar{1}01$ good	Pink	H < 4 G 3.30	---
1.636 ∧	1.638	(1.639)	1.670	.032	STRONTIOHILGARDITE $(Sr,Ca)_8B_{18}O_{33}Cl_4\cdot 4H_2O$	19-46° r > v	---	TCL	010, 100 perf	Cols	H 5 G 2.9 F 2	Diss by acids.
∨ 1.670	1.625	1.640	1.696	.071	STRUNZITE $MnFe_2(PO_4)_2(OH)_2\cdot 8H_2O$	(56±4°)	Z:c = 10°	TCL ps mcl laths	---	Straw- to brownish-yellow	G 2.47-2.56	Diss by acids. Pleoc wk in yellow, abs Z > X, Y.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.637	1.640	1.662	.025	PENKVILKSITE $Na_4Ti_2Si_8O_{22}\cdot 5H_2O$	(41±13°)	---	MCL or ORTH	001 perf	White	H 5 G 2.58 fus	Gel with acids. Clotted mass of fibers.
(1.620) ^v 1.651	1.630	1.640	1.655	.025	CUMMINGTONITE (Amphibole grp) $(Mg,Fe)_7Si_8O_{22}(OH,F)_2$	78° r > v	Y = b Z:c = 20° el pos	MCL pris c	110 perf at 125°	Brown, green	H 6 G 3.15 fus	Insol in acids. Pleoc wk, X cols, Y and Z pale green, FeO 16.8, Fe_2O_3 1.9, Al_2O_3 2.8, MnO 0.8%.
	1.64	1.64	1.66	.02	ROEBLINGITE $Pb_2(Ca,Sr)_6(Mn,Ca)(SO_4)_2Si_6O_{14}(OH)_{10}$	Small	---	MCL u mass	001 perf 100 imperf	White	H 3 G 3.43 F 3	Gel with acids.
	1.640	1.640	1.657	.017	SARCOLITE $(Ca,Na)_{7-8}Al_4Si_6O_{24}(OH)_2$ (?)	Small r > v str	---	TET cubo-oct	---	Reddish-white, flesh	H 6 G 2.7 F 3 (?)	Gel with acids.
	---	1.64	---	wk	NINGYOITE $(U,Ca,Ce)_2(PO_4)_2\cdot 1\text{-}2H_2O$	---	el pos	ORTH ps hex	---	Brown to brownish-green	---	Slightly pleoc in brown. Opt char unk.
	1.615	---	1.685	.070	LIKASITE $Cu_6(PO_4)(NO_3)_2(OH)_7$	---	X = a Z = b	ORTH ps hex	001 perf	Blue	G 2.97	Diss by acids. Pleoc, X greenish-blue, Z pale blue. Opt char unk.
v 1.650	1.633	1.641	1.652	.019	FAIRFIELDITE $Ca_2Mn(PO_4)_2\cdot 2H_2O$	Large r > v med	ext:c on 100 = 40°, on 010 = 10° disp perc	TCL pris foliated	001 perf 010 good $1\bar{1}0$ dist	White, yellowish	H 3.5 G 3.05 F 4	Diss by acids. MnO 19.7, FeO 1.0%.
	1.636	1.641	1.651	.015	ROSCHERITE $Ca(Al,Fe,Mn)_3Be_2(PO_4)_3(OH)_3\cdot 2H_2O$ (?)	Med (71±16°) r > v str	X = b Y:c = -15°	MCL and TCL pris	001 perf 010 good	Brown to olive-green	H 4.5 G 2.93 fus	Diss by acids
	1.637	(1.642)	1.670	.033	TYRETSKITE $Ca_2B_5O_8(OH)_2(OH,Cl)$	46°	---	TCL fib	---	White to brownish	G 2.19 (?)	---
	1.632	1.642	1.657	.025	COLLINSITE $Ca_2(Mg,Fe)(PO_4)_2\cdot 2H_2O$	80°	el pos	TCL bladed	001, 010 fair	Light brown	H 3.5 G 2.99 fus	Diss by acids.

v 1.657	1.638	1.642	1.653	.015	MULLITE $Al_6Si_2O_{13}$	20-60° (63±16°) r > v perc	Y = b Z = c el pos	ORTH acic c	010 perf	Cols, gray	H 6-7 G 3.23 infus	Insol in acids. Data for synth compd.
	1.640	1.642	1.647	.007	JUANITE $Ca_{10}Mg_4Al_2Si_{11}O_{39}\cdot 4H_2O$ (?)	50°	el pos	ORTH(?) fib	---	White, brownish	G 3.01 F 3	Dec by acids. Alteration product of Melilite.
	1.631	1.643	1.695	.064	RANSOMITE $CuFe_2(SO_4)_4\cdot 6H_2O$	Med	---	MCL radiating el c	010 perf	Sky-blue	H 2.5 G 2.63	Diss by acids.
1.618 ^v 1.679	1.632	1.643	1.664	.032	CLINOHUMITE (Humite grp) $(Mg,Fe)_9(SiO_4)_4(F,OH)_2$	74° r < v	Z = b X ~ c	MCL	---	Yellow to brown	H 6 G 3.28 infus	Gel with acids. FeO 6.6, MnO 1.7, F 3.2%.
	1.638	1.643	1.650	.012	MAGNESIO-ARFVEDSONITE (Amphibole grp) $(Na,Ca)_3(Mg,Fe^{+2})_4Fe^{+3}Si_8O_{22}(OH,F)_2$	80°	Y = b Z:c = 39° el pos	MCL pris c	110 perf at 124°	Blue-green	H 5-6 G 3.17	Insol in acids. FeO 8.3, MnO 6.0%.
	1.620	(1.644)	1.674	.054	ZIRCOSULFATE $Zr(SO_4)_2\cdot 4H_2O$	75°	---	ORTH	---	White	H 2.5-3 G 2.95	Sol in H_2O.
	1.640	1.644	1.650	.010	RANKINITE $Ca_3Si_2O_7$	64°	Y = b X:c = 15°	MCL	---	Cols	G 2.96 infus	Gel with acids.
v 1.663	1.618	1.645	1.679	.061	ERYTHRITE $(Co,Ni,Mg)_3(AsO_4)_2\cdot 8H_2O$	Large r < v wk	X = b Z:c = 39° el pos	MCL laths 010	010 perf	Crimson, peach-color	H 2 G 3.1 F 2	Diss by acids. Pleoc, X pale pink, Y violet, Z red. CoO 14.2, NiO 9.2, MgO 3.2%.
	1.641	1.645	1.672	.031	KURGANTAITE $(Sr,Ca)_2B_4O_8\cdot H_2O$ (?)	Small (43±11°)	el pos	TCL(?) mass	---	White	H ~ 6 G 2.9-3.0	Diss by acids. Perhaps = strontio-hilgardite.
v 1.657	1.640	1.645	1.652	.012	JADEITE (Pyroxene grp) $Na(Al,Fe^{+3})Si_2O_6$	67° r > v mod	Y = b Z:c = 40°	MCL fib c	110 good at 87°	Cols to green	H 6 G 3.25 F 2.5	Insol in acids. Fe_2O_3 0.3, FeO 0.2, CaO 1.4%.
v 1.667	1.643	1.645	1.651	.008	MOSANDRITE var. Rinkolite $(Na,Ca,Ce)_3Ti(SiO_4)_2F$	45-80° r > v str	Y = b X:c = 3°	MCL el c	100 dist 010 poor	Yellow to reddish-brown	H 4-4.5 G 3.0-3.4 F 3	Gel with acids. Pleoc wk, abs Z > Y > X.
	1.643	1.645	1.649	.006	PELLYITE $Ba_2Ca(Fe^{+2},Mg)_2Si_6O_{17}$	47° r > v very str	---	ORTH	Conch prism poor	Cols to pale-yellow	H 6 G 3.51	Dec by HCl.
1.622 ^v 1.658	1.638	1.647	1.682	.044	VESZELYITE $(Cu,Zn)_3(PO_4)(OH)_3\cdot 2H_2O$	56° r < v str	Y = b Z:c = 36°	MCL pris	001, 110	Dark bluish-green	H 3.5 G 3.43 fus	Diss by acids. Pleoc, X blue, Z yellow-green.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.629 ^	1.637	1.647	1.668	.031	PREHNITE $Ca_2Al_2Si_3O_{10}(OH)_2$	65° r > v	X = a Y = b	ORTH	001 good	Dark green	H 6 G 2.97 F 2	Dec by HCl with sepn of silica. Fe_2O_3 7.1%.
	1.642	1.647	1.672	.030	KORZHINSKITE $CaB_2O_4 \cdot H_2O$	44°	X:clv = 90° el pos	ORTH(?) pris	One clv, ‖ el	Cols	---	Diss by acids. Tw.
1.64 □ 1.66	1.642	(1.647)	1.653	.011	HIORTDAHLITE $(Ca,Na)_3ZrSi_2O_7(F,OH,O)_2$	~ 90° r > v perc	opt pl ~ 111 Ext on 100 = 65°	TCL tab 100	Pris, dist	Yellow to brown	H 5.5 G 3.25 fus	Gel with acids. Poly tw. Pleoc, X cols, Y yellowish, Z wine-yellow.
	1.637	1.648	1.676	.039	LOSEYITE $(Mn,Zn)_7(CO_3)_2(OH)_{10}$	64° r > v wk	Y = b	MCL el b	---	Bluish-white	H ~ 3 G 3.27 infus	Diss by acids.
v 1.662	1.643	1.648	1.674	.031	REDDINGITE $(Mn,Fe)_3(PO_4)_2 \cdot 3H_2O$	(48±9°) r > v dist	Y = b X = a	ORTH oct, tab	010 poor fr uneven	Pink	H 3-3.5 G 3.27 fus	Diss by acids. Pleoc, X cols, Y pink brown, Z pale yellow. MnO 48.2, FeO 2.2, MgO 0.4%.
1.615 ◊ 1.652	1.641	1.649	1.661	.020	MAGNIOTRIPLITE $(Mg,Mn,Fe)_2PO_4(F,OH)$	60° (79±12°) r > v perc	Y = b X:a = 18°	MCL	100 perf	Yellow to brown	H 5.5 G 3.57 F 3	Diss by acids. Pleoc, X and Y light yellow, Z wine-yellow. MgO 17.1, MnO 25.9, FeO 13.0%.
v 1.659	1.644	1.649	1.663	.019	MESSELITE $Ca_2(Fe,Mn)(PO_4)_2 \cdot 2H_2O$	Small (62±13°)	ext on 100 23° to c	TCL tab 100	One good	Cols to brownish	H 3-3.5 G 3.1	Diss by acids. FeO 11.5, MnO 7.35%.
1.628 ◊ 1.655	1.645	1.649	1.661	.016	ANTHOPHYLLITE (Amphibole grp) $(Mg,Fe)_7Si_8O_{22}(OH)_2$	59°	Y = b Z = c el pos	ORTH pris c	210 perf at 126°	Brown	H 6 G 3.24	Insol in acids. FeO 20.5, Fe_2O_3 1.8, Al_2O_3 1.8%.
v 1.657	1.649	1.649	1.655	.006	BOEHMITE $AlO(OH)$	Small	---	ORTH	010 perf 100 less so	Cols	G 2.98 infus	Diss by hot NaOH soln. Data for synth compd.
	1.588	1.650	1.722	.134	KRAUSITE $KFe(SO_4)_2 \cdot H_2O$	Large	Z = b Y:c = -35°	MCL pris or flat tab	001 perf 100 good	Yellowish-green	H 2.5 G 2.84	Diss by acids. Pleoc wk, X cols, Y and Z pale yellow.

	1.600	1.650	1.722	.122	BIJVOETITE $(Y,Dy,Gd)_2(UO_2)_4(CO_3)_4(OH)_6\cdot 11H_2O$	84°	X = c Y ~ a	ORTH tab	One good	Yellow	G 3.9	Pleoc, X cols, Y pale yellow, Z dark yellow.
	1.626	1.650	1.686	.060	PSEUDOLAUEITE $MnFe_2(PO_4)_2(OH)_2\cdot 8H_2O$	80°	Z = b Y:a = 12°	MCL pris and thick tab	---	Orange-yellow	H 3 G 2.46	Diss by acids.
	1.64- 1.65	---	1.67- 1.68	.03	CASSIDYITE $Ca_2(Ni,Mg)(PO_4)_2\cdot 2H_2O$	---	---	TCL fib	---	Pale- to bright-green	G 3.1-3.2	Opt char unk.
	1.633	---	1.672	.039	SHARPITE $(UO_2)(CO_3)\cdot H_2O$ (?)	---	el pos	ORTH(?)	---	Yellow-green	H 2 G > 3.3 infus	Diss by acids. Pleoc faint. Not fluor in UV.
1.641 ^	1.640	1.650	1.660	.020	FAIRFIELDITE (Fairfieldite grp) $Ca_2(Mn,Fe)(PO_4)_2\cdot 2H_2O$	86° r > v med	ext:c on 100 = 40° 010 = 10° disp perc	TCL pris, foliated	001 perf 010 good $\bar{1}10$ dist	White, yellowish	H 3.5 G 3.02 F 4	Diss by acids. MnO 14.8, FeO 4.75%.
1.63 ◊ 1.725	---	1.65	---	.02	HOMILITE (altered) $Ca_2FeB_2Si_2O_{10}\cdot xH_2O$	Small r > v or r < v str	---	MCL mass	---	Yellow	H 5 G 3.4 F 2	Gel with acids.
	1.645	1.650	1.655	.010	SAMUELSONITE $(Ca,Ba)Ca_8(Fe,Mn)_4Al_2(PO_4)_{10}(OH)_2$	Large	X:c = 22°	MCL pris	001 fair	Cols	H 5 G 3.27-3.33	
1.648 v 1.660	1.622	1.651	1.687	.065	PARASYMPLESITE $Fe_3(AsO_4)_2\cdot 8H_2O$	83°	X = b Z:c = 31° el pos	MCL tab 010	010 perf	Greenish-blue	H 2 G 3.07	Diss by acids. Pleoc, X bluish-green, Z yellowish.
	1.639	1.651	1.681	.042	VUONNEMITE $Na_4TiNb_2Si_4O_{17}\cdot 2Na_3PO_4$	53° (66±6°)	Y:c = 4°	TCL	001 and 2 others perf	Light yellow	H 2-3 G 3.13	Dec by H_2O.
v 1.664	1.636	1.651	1.669	.033	FORSTERITE (Olivine grp) Mg_2SiO_4	85° r < v	X = b Y = c	ORTH equant	010, 001 poor	Cols to green	H 7 G 3.22 infus	Gel with acids. Data for synth compd (Fo_{100}).
1.640 ◊ 1.664	1.638	1.651	1.665	.027	TIRODITE (Cummingtonite ser, Amphibole grp) $Mn^{+2}_2(Mg,Fe^{+2})_5Si_8O_{22}(OH)_2$	89° r > v	Y = b Z:c = 19° el pos	MCL pris c	110 perf at 125°	Brown, green	H 6 G 3.10 fus	Insol in acids. Pleoc wk, X cols, Y and Z brown-green. FeO 11.1, MnO 13.2%.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.634 ◊ 1.652 neg	1.641	1.651	1.664	.023	PARGASITE (Amphibole grp) $NaCa_2(Mg,Fe^{+2})_4Al(Si_6Al_2)O_{22}(OH,F)_2$	82°	Y = b Z:c = 18° el pos	MCL pris c	110 perf at 124°	Brown	H 6 G 3.18	Insol in acids. Pleoc wk, X cols to yellow, Y and Z brown to green. FeO 8.9, Fe_2O_3 1.1, Al_2O_3 15.3, CaO 12.2%.
	1.632	1.652	1.693	.061	KORITNIGITE $Zn(AsO_3)(OH)\cdot H_2O$	70°	---	TCL	010 perf 001, 100	Cols to white	H 2 G 3.54	Diss by acids.
1.649 ◊ 1.673	1.648	1.652	1.672	.024	TRIPLITE $(Mn,Fe,Mg,Ca)_2PO_4(F,OH)$	40°	Y = b X:a = 18°	MCL	100 perf 010 poor	Brown	H 5.5-6 G 3.6 F 3	Diss by acids. Pleoc in yellow. MnO 31.5, FeO 11.4, MgO 9.9%.
v 1.681	1.652	(1.652)	1.661	.009	NAGELSCHMIDTITE $Ca_{3-4}(Si,P)_2O_8$	0-20°	---	MCL(?)	001 good 110 fair	Cols	G 3.04	---
1.638 ^	1.643	1.653	1.675	.032	HUMITE (Humite grp) $(Mg,Fe)_7(SiO_4)_3(OH,F)_2$	68° r > v wk	X = a Z = b	ORTH tab 010	001 perf	Brown	H 6 G 3.27 infus	Gel with acids. Pleoc, Y pale yellow, X and Z golden-yellow. FeO 7.8, Fe_2O_3 2.7, MnO 0.7%.
	1.652	1.653	1.674	.022	KOTOITE $Mg_3B_2O_6$	21° r > v	X = a Y = b	ORTH mass	110 perf	Cols	H 6.5 G 3.10 infus	Diss by warm acids.
v 1.665	1.651	1.653	1.659	.008	GÖTZENITE $(Ca,Na)_3(Ti,Al)Si_2O_7(F,OH)_2$	~ 60° r > v str	X ~ c	TCL	100 perf 001 good	Cols, pink	H 6 G 3.11 F 3	Gel with acids. Poly tw.
v 1.669	1.650	1.653	1.658	.008	ENSTATITE (Orthopyroxene ser, Pyroxene grp) $Mg_2Si_2O_6$	59° r < v	X = b Y = a el pos	ORTH pris c	210 good at 88°	Cols	H 5-6 G 3.18 F 6	Insol in acids. Tw 100. Data for synth compd En_{100}.
1.652 □ 1.663	1.62	1.654	1.689	.069	ANNABERGITE $Ni_3(AsO_4)_2\cdot 8H_2O$	~ 90°	X = b disp dist el clv pos	MCL	010 perf	Apple-green to white	H 2.5-3 G 3.0-3.1 F 4	Diss by acids. U neg.
1.636 ◊ 1.671	1.650	1.654	1.670	.020	ANDALUSITE, manganian $(Al,Mn)_2SiO_5$	70° (54±13°) r < v str	X = a Z = c el pos	ORTH fib c	110 perf	Green	H 7 G 3.17 infus	Insol in acids. Pleoc, X yellow-green, Y emerald green, Z golden yellow. Mn_2O_3 9.5, Fe_2O_3 3.7%.

	1.650	1.654	1.661	.011	VLADIMIRITE $H_2Ca_5(AsO_4)_4 \cdot 5H_2O$	70° r > v str	Z:c = 36°	MCL	---	Cols	H 3.5 G 3.14 F diff	Diss by acids. Reported as biax neg.
v 1.678	1.651	1.654	1.660	.009	CLINOENSTATITE (Pyroxene grp) $Mg_2Si_2O_6$	54°	X = b Z:c = 22°	MCL el c	110 good at 87°	Cols	H 5-6 G 3.28 infus	Insol in acids. Poly tw 100 characteristic. Synth compd.
	1.652	---	1.659	.007	YUKSPORITE $(Na,K)_4(Ca,Sr,Ba)_4$ $(Ti,Al,Fe)_3Si_8O_{16}$ $(F,Cl)_2 \cdot 4H_2O$ (?)	---	el neg	MCL(?) fib, platy	---	Pink to red	---	---
	1.648	1.655	1.670	.022	Unnamed phosphate of Ca, Ba, Mn, Fe, Al	80°	---	fib	---	Greenish-	---	Al_2O_3 8.0, Fe_2O_3 7.6, MnO 8.6, CaO 24.2, BaO 3.5, H_2O 3.3%.
1.649 ^v 1.667	1.648	1.655	1.662	.014	GEDRITE (Amphibole grp) $(Mg,Fe)_5Al_2(Si_6Al_2)O_{22}$ $(OH)_2$	87°	Y = b Z = c el pos	ORTH pris c	210 perf at 126°	Brown	H 6 G 3.26	Insol in acids. FeO 14.6, Fe_2O_3 1.3, Al_2O_3 13.3%.
v 1.662	1.648	1.655	1.662	.014	DICKINSONITE $(K,Ba)(Na,Ca)_5$ $(Mn,Fe,Mg)_{14}Al(PO_4)_{12}$ $(OH,F)_2$	~ 90° r > v str	X = b Y:c = 15° el neg	MCL tab, foliated 001	001 perf	Olive- green	H 3-3.5 G 3.40 F easy	Diss by acids. Pleoc wk in green.
	1.649	1.656	1.714	.065	NATROCHALCITE $NaCu_2(SO_4)_2(OH) \cdot H_2O$	37° r < v str inclined	Y = b X:c = -12° el clv pos	MCL el c	001 perf	Emerald- green	H 4.5 G 3.49 F easy	Diss by acids.
	---	1.656	---	.052	DIOPTASE $CuSiO_2(OH)_2$	43°	---	TRIG	10$\bar{1}$1 perf	Emerald- green	H 5 G 3.28 infus	Gel with acids. Pleoc wk, abs X > Y and Z.
	1.652	1.656	1.672	.020	EUCLASE $BeAlSiO_4(OH)$	48° r > v	Y = b Z:c = 42°	MCL el c	010 perf 100, 001 poor	Cols to pale blue	H 7.5 G 3.06 F 5.5	Insol in acids.
v 1.664	1.643	1.657	1.681	.038	LEUCOSPHENITE $BaNa_4Ti_2B_2Si_{10}O_{30}$	78° r > v	Z = b Y ~ c el clv neg	MCL el a	010 perf 001 fair	Cols to brown	H 6-6.5 G 3.07 F diff	Insol in acids. Tw pl 001.
1.649 ^	1.648	1.657	1.668	.020	BOEHMITE $AlO(OH)$	79°	---	ORTH	010 perf 100 less so	Cols	G 2.98 infus	Diss by hot NaOH soln.
1.642 ^	1.653	1.657	1.671	.018	MULLITE $Al_6Si_2O_{13}$	20-60° (57±14°) r > v perc	Y = b Z = c el pos	ORTH acic c	010 perf	Gray, lilac	H 6-7 G 3.23 infus	Insol in acids. Fe_2O_3 0.9, TiO_2 2.3%.
1.645 ^v 1.670	1.654	1.657	1.666	.012	JADEITE (Pyroxene grp) $Na(Al,Fe)Si_2O_6$	70° r > v mod	Y = b Z:c = 34°	MCL fib c	110 good at 87°	Cols to green	H 6 G 3.34 F 2.5	Insol in acids. Fe_2O_3 0.45, CaO 0.1, Na_2O 13.4%.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	Refractive index β	Refractive index γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.640	1.658	1.760	.120	METASTUDTITE $UO_4 \cdot 2H_2O$	48°	---	ORTH fib	---	Yellow	G 4.67 calc	Sol in hot HCl. Does not fluor in UV.
1.647 ^	1.640	1.658	1.695	.055	VESZELYITE $(Cu,Zn)_3(PO_4)(OH)_3 \cdot 2H_2O$	71° r < v str	Y = b Z:c = 36°	MCL pris	001, 110	Dark bluish-green	H 3.5 G 3.43 fus	Diss by acids. Pleoc, X blue, Z yellow-green.
v 1.671	1.653	1.659	1.677	.024	SPODUMENE (Pyroxene grp) $LiAlSi_2O_6$	66° r < v	Y = b Z:c = 25° el pos	MCL pris c	110 perf at 87°	Pink, gray, green	H 6.5 G 3.14 F 3.5	Insol in acids. Abs X > Y > Z in thick sections.
1.649 ^	1.653	1.659	1.676	.023	MESSELITE $Ca_2(Fe,Mn)(PO_4)_2 \cdot 2H_2O$	25° (62±11°)	ext on 100 20° to c	TCL tab 100	One good	Cols to brownish	H 3-3.5 G 3.1	Diss by acids. FeO 20.9, Fe_2O_3 0.8, MnO 3.9, MgO 1.4%.
1.651 ^	1.628	1.660	1.705	.077	PARASYMPLESITE $Fe_3(AsO_4)_2 \cdot 8H_2O$	~ 90° (82±2°)	X = b Z:c = 31° el pos	MCL tab 010	010 perf	Greenish-blue	H 2 G 3.07	Diss by acids. Pleoc, X bluish-green, Y yellow, Z brownish-yellow.
v 1.718	1.645	1.660	1.715	.070	PLANCHEITE $Cu_8Si_8O_{22}(OH)_4 \cdot H_2O$	Large (57±4°)	el ~ Z	ORTH fib	---	Blue	H 5 G 3.4	Slightly attacked by acids. Pleoc, X pale blue, Y and Z blue.
1.592 neg ^v 1.710	1.650	1.660	1.680	.030	STRENGITE, aluminian $(Fe,Al)PO_4 \cdot 2H_2O$	Med Large r > v str	X = a Y = b	ORTH fib c	---	Gray, brown, red	H 4.5 G 2.6 fus	Diss by acids. Al_2O_3 12.5%.
⊔ 1.664	1.659	1.660	1.680	.021	SILLIMANITE Al_2SiO_5	20° r > v perc	Y = b Z = c el pos	ORTH acic c	010 perf	White, brown	H 7 G 3.23 infus	Insol in acids. Some vars pleoc, cols to blue.
	1.656	1.660	1.668	.012	MAGNESIOAXINITE $Ca_2MgAl_2BSi_4O_{15}(OH)$	Large	---	TCL	---	Pale blue	H 6.5 G 3.18 fus	Insol in acids.
	1.641	1.660	1.682	.041	JONESITE $Ba_4(K,Na)_2Ti_4Al_2Si_{10}O_{36} \cdot 6H_2O$	77°	X = b Z = c	ORTH bladed	010	Cols	H 3-4 G 3.25	Insol in HCl. Fluor orange in short-wave UV.
v 1.676	1.660	(1.661)	1.663	.003	PHARMACOSIDERITE $KFe_4(AsO_4)_3(OH)_4 \cdot 6\text{-}7H_2O$	Large r < v str	---	CUB	100 imperf	Olive-green to brown	H 2.5 G 2.8-2.9 F 2	Diss by acids. Poly tw.
	1.629	1.662	1.729	.098	LINDACKERITE $H_2Cu_5(AsO_4)_4 \cdot 8H_2O$	73° r < v str	Y = b X:el = 26°	MCL fib	010 perf	Apple-green	H 2-2.5 G 2.0-2.5 F 2-3 (?)	Diss by acids.

1.648 ◊ 1.680	1.655	1.662	1.683	.028	REDDINGITE $(Mn,Fe)_3(PO_4)_2\cdot 3H_2O$	65° r > v perc	Y = b X = a	ORTH oct, tab	010 poor fr uneven	Pink	H 3-3.5 G 3.14 fus	Diss by acids. Pleoc, X cols, Y pinkish-brown, Z yellow. MnO 38.4, FeO 12.7%.
1.655 ^	1.658	1.662	1.671	.013	DICKINSONITE $(K,Ba)(Na,Ca)_5$ $(Mn,Fe,Mg)_{14}Al(PO_4)_{12}$ $(OH,F)_2$	Med r > v str	X = b Y:c = 15° el neg	MCL tab, foli- ated 001	001 perf	Olive- green	H 3.5-4 G 3.40 F easy	Diss by acids. Pleoc wk in green.
⊔ 1.667	1.658	1.662	1.668	.010	BORACITE $Mg_3B_7O_{13}Cl$	Large	X = c Y = a	ORTH ps cub	Conch to uneven	White to greenish	H 7-7.5 G 2.95 F 2	Slowly diss by HCl. Inverts to cub at 265°C.
	1.598	1.663	1.737	.139	PARABUTLERITE $Fe(SO_4)(OH)\cdot 2H_2O$	44-87° (90±2°) r > v mod	X = b Y = c	ORTH pris	120 poor fr conch	Orange to brown	H 2.5 G 2.55	Diss by acids.
1.645 ^	1.629	1.663	1.701	.072	ERYTHRITE $Co_3(AsO_4)_2\cdot 8H_2O$	~ 90° r < v wk	X = b Z:c = 32° el clv pos	MCL laths	010 perf	Crimson	H 2 G 3.06 F 2	Diss by acids. Pleoc, X pink, Y violet, Z red. CoO 33.4, FeO 4.0%.
1.657 ^	1.649	1.664	1.691	.042	LEUCOSPHENITE $BaNa_4Ti_2B_2Si_{10}O_{30}$	76° r > v perc	Z = b Y ~ c el neg	MCL el a	010 perf 001 fair	Cols to brown	H 6-6.5 G 3.09 F diff	Insol in acids. Tw pl 001.
	1.637	1.664	1.692	.055	WILHELMVIERLINGITE $CaMnFe^{+3}(PO_4)_2(OH)\cdot 2H_2O$	(90±4°)	X = b Y = a	ORTH	---	Yellow	H 4 G 2.58	Reported to be neg with $2V_x$ 45°. Pleoc, X and Y light yellow, Z yellow.
1.651 ◊ 1.674	1.653	1.664	1.686	.033	FORSTERITE (Olivine grp) $(Mg,Fe)_2SiO_4$	87° (71±7°) r < v	X = b Y = c	ORTH equant	010, 001 poor	Cols to green	H 7 G 3.35 infus	Gel with acids. FeO 8.6, Fe_2O_3 0.4, MnO 0.2% (Fo_{93}).
1.636 ^	1.660	1.664	1.688	.028	SERANDITE $Na(Mn,Ca)_2Si_3O_8(OH)$	36° (45±11°)	Z = b X:c = 57°	TCL el b	100, 001	Rose-red	G 2.32	MnO 29.0, Fe_2O_3 1.3%.
1.651 ◊ 1.677	1.651	1.664	1.678	.027	CUMMINGTONITE (Amphibole grp) $(Fe,Mg)_7Si_8O_{22}(OH)_2$	86° r > v	Y = b Z:c = 17° el pos	MCL pris c	110 perf at 125°	Brown, green	H 7 G 3.27 fus	Insol in acids. Pleoc in green. FeO 28.0, MnO 1.0, Al_2O_3 2.4%.
	1.655	1.664	1.675	.020	ATTAKOLITE $(Ca,Mn,Sr)_3Al_6$ $(PO_4,SiO_4)_7\cdot 3H_2O$	~ 84° r > v	---	ORTH mass	---	Pink	G 3.24 F easy	Partly dec by acids.
	1.656	1.664	1.672	.016	JUNITOITE $CaZn_2Si_2O_7\cdot H_2O$	(90±14°) r < v, wk	---	ORTH hemi- morphic	010 good 100, 101 poor	Cols to milky- white	H 4.5 G 3.5 fus	Gel with acids.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v 1.687	1.657	(1.664)	1.675	.018	ROSENBUSCHITE $(Ca,Na)_3(Zr,Ti)Si_2O_8F$	80°	X:c = 9° el neg	TCL	010 perf	Yellow, brown	H 5-6 G 2.97 F easy	Gel with acids. Pleoc wk, X cols, Z yellow.
	1.663	1.664	1.675	.012	GIANNETITE Silicate of Na, Ca, Mn, Zr, Ti	30°	Y:c = 22°	TCL pris	100 perf	Cols to pale yellow	---	Validity dubious.
	(1.639)	1.665	1.704	.065	TRIANGULITE $Al_3(UO_2)_4(PO_4)_4(OH)_5 \cdot 5H_2O$	80°	---	TCL	---	Yellow	G 3.7	---
1.653 ^	1.662	1.665	1.672	.010	GÖTZENITE $(Ca,Na)_3(Ti,Al)Si_2O_7(F,OH)_2$	62° r > v str	X ~ c	TCL	100 perf 001 good	Pink, yellow	H 6 G 3.17 F 3	Gel with acids. Poly tw.
v 1.679	1.663	1.666	1.673	.010	LITHIOPHILITE $Li(Mn,Fe)PO_4$	60° r < v str	X = c Y = a el neg	ORTH el c	100 perf 010 less so	Salmon-pink	H 5 G 3.43 F 1.5	Diss by acids. Pleoc, X deep pink, Y pale yellow, Z pale pink. MnO 42.6, FeO 2.9%.
⊔ 1.675	1.650	1.667	1.688	.038	LUDLAMITE $(Fe,Mg,Mn)_3(PO_4)_2 \cdot 4H_2O$	83° r > v	Y = b Z:c = -67°	MCL tab 001	001 perf 100 dist	Bright green	H 3.5-4 G 3.2 F 2-2.5	Diss by acids.
1.655 ^v 1.681	1.657	1.667	1.678	.021	FERRO-GEDRITE (Amphibole grp) $(Fe,Mg)_5Al_2(Si_6Al_2)O_{22}(OH)_2$	87°	Y = b Z = c el pos	ORTH pris c	210 perf at 126°	Gray, brown	H 6 G 3.28	Insol in acids. FeO 18.3, Fe_2O_3 1.0, Al_2O_3 17.8%.
1.645 ^	1.662	1.667	1.681	.019	MOSANDRITE $(Na,Ca,Ce)_3TiSi_2O_7(O,OH,F)$	45-80° (62±13°) r > v	Y = b X:c = 3°	MCL el c	100 dist 010 poor	Yellow to reddish-brown	H 4-4.5 G 3.3-3.4 F 3	Gel with acids. Pleoc wk, abs Z > Y > X.
	1.646	1.668	1.705	.059	COBALTKORITNIGITE $(Co,Zn)(As^{+5}O_3)(OH) \cdot H_2O$	78°	X:b = 3° Y:a =	TCL	010 perf 100 good	Deep purple	---	Pleoc, X deep violet, Y reddish-violet, Z bluish-violet.
v 1.686	1.665	1.669	1.768	.103	NENADKEVICHITE $(Na,Ca,K)(Nb,Ti)Si_2O_6(O,OH) \cdot 2H_2O$	38° (24±5°)	X = a Z = b	ORTH	001 poor	Yellow, rose	H 5 G 2.76 F diff	Diss by H_2SO_4. Pleoc wk, X cols, Y pale yellow, Z pale rose.

1.653 ^ v 1.677	1.665	1.669	1.674	.009	ENSTATITE (Orthopyroxene ser, Pyroxene grp) $(Mg,Fe)_2Si_2O_6$	80° r < v	Y = a Z = c el pos	ORTH pris c	210 good at 88°	Green	H 5.5 G 3.2 F 5.5	Insol in acids. FeO 7.0%. Commonly faintly pleoc.
v 1.698	1.660	1.670	1.770	.110	LABUNTSOVITE $(K,Ba,Na)(Ti,Nb)$ $(Si,Al)_2(O,OH)_7 \cdot H_2O$	35° r > v	Y = b Z:c = 63°	MCL	$\bar{1}02$ perf	Dark brown	H 5 G 2.87	Pleoc wk, X cols, Z yellow.
1.640 ^ v 1.670 neg	1.619	1.670	1.720	.101	STRUNZITE $MnFe_2(PO_4)_2(OH)_2 \cdot 8H_2O$	(93±2°)	Z:c = 10°	TCL ps mcl laths	---	Straw- to brownish-yellow	G 2.47-2.56	Diss by acids. Pleoc wk in yellow, abs Z > X, Y.
v 1.681	1.664	1.670	1.685	.021	OMPHACITE (Pyroxene grp) $(Ca,Na)(Mg,Fe,Al)Si_2O_6$	66° r < v mod	Y = b Z:c = 35°	MCL pris c	110 good at 87°	Green	H 5-6 G 3.40 F 5	Insol in acids. Pleoc wk in green. FeO 2.8, Fe_2O_3 1.8, Na_2O 4.5, CaO 14.7%.
1.657 ^ v 1.681	1.662	1.670	1.682	.020	JADEITE (Pyroxene grp) $(Na,Ca)(Al,Mg,Fe)Si_2O_6$	70° r > v mod	Y = b Z:c = 35°	MCL pris c	110 good at 87°	Green	H 6 G 3.35 F 2	Insol in acids. FeO 0.5, Fe_2O_3 3.2, Na_2O 9.4, CaO 5.1%.
v 1.688	1.665	1.670	1.683	.018	PUMPELLYITE $Ca_2(Mg,Fe)Al_2(SiO_4)$ $(Si_2O_7)(OH)_2 \cdot H_2O$	15° (64±14°) r < v str rarely r > v	Y = b X:c = 15°	MCL	001 good 100 imperf	Green, bluish-green, brown	H 5.5-7 G 3.18	Insol in acids. Pleoc, X and Z pale yellow-green, Y green, abs Y > X, Z. FeO 1.4, Fe_2O_3 0.7%.
1.654 ^ v 1.722	1.662	1.671	1.691	.029	ANDALUSITE, manganian, ferrian $(Al,Mn,Fe)_2SiO_5$	71° r < v str	el pos	ORTH fib c	110 perf	Green	H 7 G 3.22 infus	Insol in acids. Fe_2O_3 4.2, Mn_2O_3 4.8, TiO_2 1.0%.
1.669 neg ^ v 1.693 neg	1.660	1.671	1.687	.027	FERROTSCHERMAKITE (Amphibole grp) $Ca_2(Fe^{+2},Mg)_3(Al,Fe^{+3})_2$ $Si_6Al_2O_{22}(OH,F)_2$	78° r > v	Y = b Z:c = 18°	MCL pris	110 good at 124°	Green, brown	H 6 G 3.2	Insol in acids. FeO 15.8, Fe_2O_3 9.3, Al_2O_3 11.2, CaO 10.2, Na_2O 1.3%.
	1.670	1.671	1.689	.019	HINSDALITE (Beudantite grp) $PbAl_3(PO_4)(SO_4)(OH)_6$	0-30°	Z = c	TRIG	0001 perf	White, gray	H 4.5 G 3.65 infus	Insol in acids. Base divided into 6 segments.
1.659 ^	1.668	1.671	1.682	.014	SPODUMENE (Pyroxene grp) $LiAlSi_2O_6$	65° r < v	Y = b Z:c = 24°	MCL pris c	110 good at 87°	Pink, gray, green	H 6.5 G 3.19 F 3.5	Insol in acids. Abs X > Y > Z.
v 1.678	1.665	1.672	1.695	.030	DIOPSIDE (Pyroxene grp) $CaMgSi_2O_6$	57° r > v wk	Y = b Z:c = 39°	MCL pris c	110 good at 87°	Cols	H 5-6 G 3.28 infus	Insol in acids. FeO 1.5, Fe_2O_3 0.6%.
v 1.690	1.669	1.672	1.667	.008	MAGNESIUM CHLOROPHOENICITE $(Mg,Mn)_3Zn_2(AsO_4)$ $(OH,O)_6$	r < v str	Y $\parallel$ el	MCL fib	Perf	White	H 3-3.5 G 3.57	Diss by acids.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.672	1.672	1.676	.004	FILLOWITE $Na_2Ca(Mn,Fe)_7(PO_4)_6$	Small r < v	X ~ c	MCL ps trig	001 very good	Yellow, brown, cols	H 4.5 G 3.43 F 1.5	Diss by acids.
	1.672	1.672	1.673	.001	BARATOVITE $KCa_8Li_2Si_{12}O_{37}F$	60° r > v str	X:c = 50°	MCL	001 perf	White	H 3.5 G 2.92	---
	1.669	1.673	1.692	.023	GOEDKENITE $(Sr,Ca)_2Al(PO_4)_2(OH)$	45-50°	X = b	MCL	100 fair	Cols to pale yellow	H 5 G 3.83 calc	---
1.652 ↕ 1.683	1.665	1.673	1.682	.017	TRIPLITE $(Mn,Fe,Mg,Ca)_2PO_4(F,OH)$	~ 90° r > v str	Y = b Z:a = 42°	MCL	100 perf 010 poor	Salmon-pink	H 3.5 G 3.7 F 2.5	Diss by acids. Pleoc, X pale red-brown, Y cols. MnO 52.4, FeO 5.0, MgO 0.6, CaO 3.2%.
1.664 ↕ 1.680	1.656	1.674	1.695	.039	CHRYSOLITE (Olivine grp) $(Mg,Fe)_2SiO_4$	89° r < v	X = b Y = c	ORTH equant	010, 001 poor	Green	H 7 G 3.33 infus	Gel with acids. FeO 10.8, Fe_2O_3 1.7, MnO 0.2% (Fo_{88}).
	1.663	1.674	1.699	.036	SPODIOSITE $Ca_2(PO_4)F$ (?)	69° r > v str	---	ORTH(?)	010 dist 001 indist	Ash-gray to brown	H 5 G 2.94 F diff	Diss by acids.
	1.665	1.674	1.686	.021	LAWSONITE $CaAl_2Si_2O_7(OH)_2 \cdot H_2O$	82° r > v	X = a Y = b	ORTH tab 001	010, 001 perf 110 good	Cols, bluish	H 8 G 3.08 F 4	Insol in acids, but after ignition gel with acids. Pleoc wk.
	1.671	1.674	1.684	.013	NATROPHILITE $NaMnPO_4$	75° r < v str	X = c Y = a	ORTH	100 good 010 indist	Deep wine-yellow	H 4.5-5 G 3.41 F 2-2.5	Diss by acids.
	1.672	1.676	1.683	.011	AKROCHORDITE $Mn_4Mg(AsO_4)_2(OH)_4 \cdot 4H_2O$	Med r < v	X = b Y:c = 45°	MCL radial aggre-gates	Two	Yellow-brown	H 3.5 G 3.26	Diss by acids.
(1.661) ↕ (1.700)	---	1.676	---	wk	PHARMACOSIDERITE $KFe^{+3}{}_4(AsO_4)_3(OH)_4 \cdot 6\text{-}7H_2O$	Large r < v str	---	CUB	100 imperf	Olive-green to brown	H 2.5 G 2.8-2.9 F 2	Diss by acids. Poly tw divided into segments.
1.664 ↕ 1.677 neg	1.660	1.677	1.693	.033	CUMMINGTONITE (Amphibole group) $(Fe,Mg)_7Si_8O_{22}(OH)_2$	Large r > v	Y = b	MCL pris c	110 perf at 125°	Green to brown	H 7 G 3.47 fus	Insol in acids. FeO 31.2, Fe_2O_3 3.4%.

1.669 ◇ 1.677 neg	1.672	1.677	1.682	.010	BRONZITE (Orthopyroxene ser, Pyroxene grp) $(Mg,Fe)_2Si_2O_6$	~ 90°	Y = a Z = c el pos	ORTH pris c	210 good at 88°	Green	H 5.5 G 3.3 F 5	Nearly insol in acids. Faint pleoc common.
	1.672	1.678	1.712	.040	MAPIMITE $Zn_2Fe^{+3}{}_3(AsO_4)_4 \cdot 4H_2O$	50° r < v str	Y = b Z:a = 13°	MCL	---	Blue to green	H 3 G 2.95	Pleoc, X pale yellow, Y deep blue, Z greenish-yellow.
1.672 ◇ 1.683	1.673	1.678	1.705	.032	DIOPSIDE (Pyroxene grp) $Ca(Mg,Fe)Si_2O_6$	48°	Y = b Z:c = 42°	MCL	110 good at 87°	Green to brown	H 6 G 3.24	Insol in acids. FeO 8.2, Fe_2O_3 1.4, Al_2O_3 4.5%.
1.654 ^	1.675	1.678	1.688	.013	CLINOHYPERSTHENE (Pyroxene grp) $(Mg,Fe)_2Si_2O_6$	57°	X = b Z:c = 36°	MCL el c	110 good at 87°	Green	H 5-6 G 3.3-3.4 infus	Insol in acids. Poly tw 100. FeO 12.6, MnO 0.5, Al_2O_3 0.5%.
1.643 ◇ 1.714	1.668	1.679	1.700	.032	CLINOHUMITE (Humite grp) $(Mg,Fe)_9(SiO_4)_4(F,OH)_2$	Med (73±7°) r < v	Z = b X ~ c	MCL	---	Yellow to red	H 6 G 3.3 infus	Gel with acids. FeO 9.9, MnO 0.3, Fe_2O_3 1.0, F 1.8%.
1.666 ◇ 1.689	1.675	1.679	1.688	.013	LITHIOPHILITE $Li(Mn,Fe)PO_4$	60° r < v str	X = c Y = a el neg	ORTH el c	100 perf 010 less so	Light brown	H 5 G 3.48 F 2	Diss by acids. MnO 31.9, FeO 11.0%.
1.674 ◇ 1.680 neg	1.661	1.680	1.697	.036	CHRYSOLITE (Olivine grp) $(Mg,Fe)_2SiO_4$	~ 90°	X = b Y = a	ORTH	010, 001 poor	Green	H 7 G 3.45 infus	Gel with acids (Fo_{86}).
1.662 ^	1.672	1.680	1.700	.028	PHOSPHOFERRITE $(Fe,Mn)_3(PO_4)_2 \cdot 3H_2O$	68° r > v dist	X = a Y = b	ORTH	010 poor fr uneven	Green	H 4 G 3.3 fus	Diss by acids.
	1.678	1.68	1.683	.003	HARSTIGITE $Ca_6(Mg,Mn)Be_4Si_6(O,OH)_{24}$	52° r < v wk	Y = b Z = a	ORTH pris c	---	Cols	H 5.5 G 3.16	Insol in acids, but gel after being heated.
1.670 ◇ 1.699	1.673	1.681	1.695	.022	OMPHACITE (Pyroxene grp) $(Ca,Na)(Mg,Fe,Al)Si_2O_6$	70° r < v mod	Y = b Z:c = 41°	MCL pris c	110 good at 87°	Green	H 5-6 G 3.34 F 5	Insol in acids. Pleoc wk in green. FeO 2.7, Fe_2O_3 1.3, Na_2O 4.6, CaO 14.7%.
(1.652) ^	1.680	(1.681)	1.698	.018	NAGELSCHMIDTITE $Ca_{3-4}(Si,P)_2O_8$	0-20°	---	MCL(?)	001 good 110 fair	Cols	G 3.04	---
1.667 ◇ 1.688	1.674	1.681	1.691	.017	FERRO-GEDRITE (Amphibole grp) $(Fe,Mg)_5Al_2(Si_6Al_2)O_{22}(OH)_2$	80°	Y = b Z = c	ORTH pris c	210 perf at 126°	Brown	H 6 G 3.36 F 6	Insol in acids. Pleoc X, Y yellow-green, Z blue-green. FeO 23.0, MnO 1.7, Al_2O_3 19.2%.
	1.676	(1.681)	1.690	.014	SATPAEVITE $6Al_2O_3 \cdot V_2O_4 \cdot 3V_2O_5 \cdot 30H_2O$	~ 70°	---	ORTH(?) micro-cryst	Pina-coidal perf	Canary-to saffron-yellow	H 1.5 G 2.4	Diss by acids. Pleoc wk, abs Z > X.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.670 ^	1.679	1.681	1.685	.006	JADEITE (Pyroxene grp) $(Na,Ca)(Al,Fe)Si_2O_6$	64° r > v mod	Y = b Z:c = 38°	MCL pris c	110 good at 87°	Green	H 6 G 3.4 F 2	Insol in HCl. FeO 1.1, Fe_2O_3 5.7, Na_2O 13.0, CaO 2.7%.
(1.618) ^	1.662	1.683	1.717	.055	KOETTIGITE $Zn_3(AsO_4)_2{\cdot}8H_2O$	74° r < v str	X = b Z:c = 37°	MCL fib c	010 perf	Carmine-red	H 2.5-3 G 3.33 F 3	Diss by acids. Pale pink in section, not pleoc.
1.678 ^v 1.685	1.676	1.683	1.705	.029	DIOPSIDE, manganoan (Pyroxene grp) $Ca(Mg,Mn,Zn)Si_2O_6$	60° r > v	Y = b	MCL pris c	110 good at 87°	Brown	H 5.5 G 3.39 F 6	Insol in acids. MnO 7.4, ZnO 3.3, Fe_2O_3 0.4%.
1.673 ^v 1.704	1.675	1.683	1.692	.017	TRIPLITE $(Mn,Fe,Mg,Ca)_2PO_4$ (F,OH)	80° r > v	Y = b X:a = 42°	MCL	100 perf 010 poor	Reddish-brown	H 4.5 G 3.87 F 2.5	Diss by acids. Pleoc in brown, abs X > Y > Z. MnO 34.8, FeO 23.5, CaO 3.5%.
v 1.698	1.684	1.684	1.707	.023	PIGEONITE (Pyroxene grp) $(Mg,Fe,Ca)(Mg,Fe)Si_2O_6$	18-26°	X = a Z:c = 40°	MCL	110 good at 87°	Cols to green	H 5-6 G 3.4 infus	Insol in acids. FeO 20.1, Fe_2O_3 3.5, CaO 5.5%.
	1.65	---	1.72	.07	OTWAYITE $Ni_2(CO_3)(OH)_2{\cdot}H_2O$	---	X = fib	ORTH fib ros-ettes	---	Bright green	G 3.41 infus	Diss slowly by cold dil HCl. Pleoc wk, abs Z > X. Opt char unk.
	1.646	1.685	1.745	.099	ERIOCHALCITE $CuCl_2{\cdot}2H_2O$	75° (80±2°) r < v str	X = b Z = a	ORTH	110 perf 001 good	Bluish-green	H 2.5 G 2.47 F easy	Sol in H_2O.
1.683 ^v 1.692	1.677	1.685	1.708	.031	DIOPSIDE (Pyroxene grp) $Ca(Mg,Fe)Si_2O_6$	59° r > v wk	Y = b Z:c = 39°	MCL pris c	110 good at 87°	Cols to green	H 5-6 G 3.28 infus	Insol in acids. FeO 5.6, MnO 0.5, Fe_2O_3 3.2, Al_2O_3 2.2%.
1.669 ^	1.659	1.686	1.785	.126	NENADKEVICHITE $(Na,Ca,K)(Nb,Ti)Si_2O_6$ $(O,OH){\cdot}2H_2O$	46° (58±2°)	X = a Z = b	ORTH	001 poor	Rose to brown	H 5 G 2.86 F diff	Diss by H_2SO_4. Pleoc wk, X cols, Y pale yellow, Z pale rose.
v 1.695	1.683	1.687	1.718	.035	BORNEMANITE $BaNa_4Ti_2NbSi_4O_{17}(F,OH){\cdot}$ Na_3PO_4	40°	X = c Z = a el pos	ORTH plates	001 perf	Pale yellow	H 3.5-4.5 G 3.48	Dec by acids with sepn of silica. Pleoc wk, X and Y cols, Z brownish.

(1.664) ^	1.678	1.687	1.705	.027	ROSENBUSCHITE $(Ca,Na)_3(Zr,Ti)Si_2O_8F$	78°	X ~ c el pos	TCL	010 perf	Yellow, brown	H 5-6 G 3.35 F easy	Gel with acids. Pleoc wk. Y cols, Z yellow, abs Z > Y > X.
	1.684	1.688	1.705	.021	PENIKISITE $Ba(Mg,Fe)_2Al_2(PO_4)_3(OH)_3$	56° r > v str	X ~ b Z:c = -6°	TCL	010, 100 fair to good	Blue to green	H 4 G 3.79	Pleoc, X grass-green, Y blue-green, Z pale pink, abs X ~ Y > Z.
1.681 ^	1.680	1.688	1.700	.020	FERRO-GEDRITE (Amphibole grp) $(Fe,Mg)_5Al_2(Si_6Al_2)O_{22}(OH)_2$	83°	Y = b Z = c el pos	ORTH pris c	210 perf at 126°	Brown	H 6 G 3.37 F 6	Insol in acids. Pleoc, X light brown, Z pale blue-green. FeO 26.2, Fe_2O_3 3.6, Al_2O_3 17.7%.
1.670 ^v 1.705	1.686	1.688	1.699	.013	PUMPELLYITE $Ca_2(Mg,Fe)Al_2(SiO_4)(Si_2O_7)(OH)_2\cdot H_2O$	50° r < v str	Y = b Z:c = 32°	MCL	001 good 100 imperf	Bluish-green	H 5.5-7 G 3.15	Insol in acids. Pleoc, X and Z pale yellow-green, Y green. FeO 3.0, Fe_2O_3 1.7%.
1.679 ^	1.688	1.689	1.695	.007	TRIPHYLITE $Li(Fe,Mn)PO_4$	Small r < v str	Z = b	ORTH	100 perf 010 less so	Grayish-green	H 5 G 3.33 F 2	Diss by acids. FeO 29.6, MnO 14.6, MgO 1.1%.
v 1.709	1.675	1.690	1.735	.060	LEGRANDITE $Zn_2(AsO_4)(OH)\cdot H_2O$	36° (61±4°) r < v dist	X = b Z:c = -38°	MCL pris	100 fair	Yellow, cols	H 5 G 3.98	Diss by acids. Pleoc faint in yellow.
1.672 ^	1.682	1.690	1.698	.016	CHLOROPHOENICITE $(Mn,Mg)_3Zn_2(AsO_4)(OH,O)_6$	83° r > v str	Y = b	MCL el b	100 good	Gray-green	H 3.5 G 3.46 F diff	Diss by acids. Color pink to purplish-red in str artificial light.
v 1.722	1.663	1.691	1.716	.053	ASTROPHYLLITE $(K,Na)_3(Fe,Mn)_7(Ti,Nb)_2Si_8O_{24}(O,OH)_7$	Large r > v str	X ~ b Z:c = 3-19°	TCL	001 perf	Yellow, brown	H 3 G 3.2 F 3	Dec by acids. Pleoc in yellow, abs X > Y > Z.
	1.686	1.691	1.708	.022	MARSTURITE $Na_2Ca_2Mn_6Si_{10}O_{28}(OH)_2$	60°	---	TCL pris	110, 001 imperf	White to pale pink	H 6 G 3.46	MnO 34%.
	1.688	1.691	1.696	.008	FERROWYLLIEITE $(Na,Ca,Mn)(Fe^{+2},Mn)(Fe^{+2},Fe^{+3},Mg)Al(PO_4)_3$	50° r < v str	---	MCL	010 perf $\bar{1}01$ dist	Bluish-green	H 4	Pleoc, X smoky blue-grey, Y bluish-green, Z green.
1.685 ^v 1.699	1.687	1.692	1.715	.028	DIOPSIDE (Pyroxene grp) $Ca(Mg,Fe)(Si,Al)_2O_6$	51°	Y = b Z:c = 42°	MCL	110 good at 87°	Green, brown	H 6 G 3.33	Insol in acids. FeO 9.5, MnO 0.2, Fe_2O_3 1.6, Al_2O_3 2.3%.
	1.691	1.692	1.713	.022	YODERITE $(Mg,Al)_8Si_4(O,OH)_{20}$	25-30°	X:a = 9°	MCL	Parting 001	Purple, emerald green	H 6 G 3.39	Pleoc, X pale blue, Y indigo, Z light olive-green. Y and Z yellow, X green.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v 1.703	1.691	1.692	1.700	.009	ZOISITE (Epidote grp) $Ca_2Al_3Si_3O_{12}(OH)$	54° r > v str	X = c Y = b	ORTH	010, 100 good but diff, fr conch	Violet-blue to cols	H 6 G 3.35 F 3.5	Insol in acids, but gel after being heated. Abn interf colors. Pleoc u wk, X violet, Y deep blue, Z yellow-green.
	1.687	(1.692)	1.698	.011	TINZENITE (Axinite grp) $(Ca,Mn,Fe)_3Al_2BSi_4O_{15}(OH)$	75-85° r < v	---	TCL	100 good	Yellow	H 7 G 3.3 F 2	Insol in acids. Anom disp, deep blue, red-brown. CaO 17.0, MnO 14.8, Fe_2O_3 2.8, MgO 0.7%.
	1.672	1.693	1.710	.038	JAGOWERITE $BaAl_2(PO_4)_2(OH)_2$	80° (97±6°)	---	TCL	100, $0\bar{1}1$ good $0\bar{2}1$ fair	Light green	H 4.5 G 4.01	Insol in acids. Fluor greenish-white in short-wave UV.
v 1.719	1.686	1.693	1.714	.028	FASSAITE (Pyroxene grp) $Ca(Mg,Fe^{+3},Al)(Si,Al)_2O_6$	56° r > v mod	Y = b Z:c = 43°	MCL pris	110 good at 87°	Green	H 6 G 3.33	Insol in acids. FeO 3.1, Fe_2O_3 2.1, Al_2O_3 13.4, TiO_2 0.5%.
v 1.700	1.691	1.693	1.719	.028	MANGAN-NEPTUNITE $KNa_2Li(Mn,Fe)_2Ti_2Si_8O_{24}$	36° r < v str	Y = b Z:c = 16-20° el pos	MCL pris c	110 perf at 80°	Black to deep red	H 5-6 G 3.20 F 2.5	Insol in acids. Pleoc str, X pale yellow, Y brownish, Z orange-red, abs Z > Y > X.
v 1.727	1.692	1.695	1.710	.018	BJAREBYITE $(Ba,Sr)(Mn,Fe,Mg)_2Al_2(PO_4)_3(OH)_3$	~ 35° r > v str	---	MCL spears	010, 100 perf	Emerald-green	H 4+ G 3.95	Pleoc wk, gray-tan to pale yellow-green. MnO 9.6, FeO 8.7%.
1.687 ^	1.682	1.695	1.720	.038	BORNEMANITE $BaNa_4Ti_2NbSi_4O_{17}(F,OH)\cdot Na_3PO_4$	66°	X = c Z = a	ORTH platy	001 perf	Pale yellow	H 3.5-4.5 G 3.48	Dec by acids with sepn of silica. Pleoc wk, X and Y cols, Z brownish.
v 1.711	1.695	1.696	1.715	.020	BEUSITE $(Mn,Fe,Ca,Mg)_3(PO_4)_2$	25° r > v str	X = b Z:c = -36°	MCL u mass	010 good 100 fair	Salmon-pink to reddish-brown	H 5 G 3.7 F 2	Diss by acids. MnO 24.8, FeO 16.8, CaO 12.2, MgO 2.4%.
1.692 □ 1.702	1.691	1.696	1.703	.012	BARYLITE $BaBe_2Si_2O_7$	60-81° r > v wk	X = b Y = a	ORTH	100 perf 210, 010	Cols, pink	H 6-7 G 4.02 infus	Insol in acids.

	1.691	1.696	1.725	.034	BRABANTITE $CaTh(PO_4)_2$	44°	---	MCL	---	Yellow, brown, green	G 5.20	Diss by HCl. Compare Cheralite, Monazite.
1.637 ^v 1.883	1.693	(1.697)	1.718	.025	BARITE (plumboan) $(Ba,Pb)SO_4$	~ 50° r < v	X = c Y = b	ORTH	001 perf 210 less so	White	H 3 G ~ 5 F 2.5	Insol in acids.
1.670 ^	1.687	1.698	1.825	.138	LABUNTSOVITE $(K,Ba,Na)(Ti,Nb)(Si,Al)_2(O,OH)_7 \cdot H_2O$	20° (35±3°) r > v	Y = b Z:c = 63°	MCL	$\bar{1}02$ perf	Dark brown	H 5 G 2.87	Pleoc wk, X and Y cols, Z pale yellow.
	1.695	1.698	1.733	.038	EUCHROITE $Cu_2(AsO_4)(OH) \cdot 3H_2O$	29° r > v mod	X = c Z = b	ORTH pris c	110, 101	Emerald- to leek-green	H 3.5-4 G 3.44 F 2-2.5	Diss by acids. Bright bluish-green in section, pleoc faint or absent.
1.684 ^v 1.714	1.696	1.698	1.721	.025	PIGEONITE (Pyroxene grp) $(Mg,Fe,Ca)(Mg,Fe)Si_2O_6$	25°	X = a Z:c = 41°	MCL	110 good at 87°	Cols to green	H 5-6 G 3.38 infus	Insol in acids. Pleoc wk. FeO 21.4, Fe_2O_3 0.8, MnO 0.4, CaO 5.5%.
1.692 ^v 1.707	1.690	1.699	1.721	.031	DIOPSIDE, manganoan (Pyroxene grp) $Ca(Mg,Mn)Si_2O_6$	60° r > v wk	Y = b Z:c = 43°	MCL pris c	110 good at 87°	Brown	H 6 G 3.3 infus	Insol in acids. MnO 10.0, FeO 1.65, Fe_2O_3 1.5%.
1.681 ^	1.689	1.699	1.718	.029	OMPHACITE (Pyroxene grp) $(Ca,Na)(Mg,Fe,Al)Si_2O_6$	64° (73±8°) r < v mod	Y = b Z:c = 41°	MCL pris c	110 good at 87°	Green	H 6 G 3.35 F 5	Insol in acids. Pleoc wk in green. FeO 5.9, Fe_2O_3 3.8, Al_2O_3 6.1, CaO 20.6, Na_2O 1.7%.
v 1.723	1.695	1.699	1.719	.024	GRAFTONITE $(Fe,Mn,Ca)_3(PO_4)_2$	50° r > v str	X = b Z:c = -36°	MCL u mass	010 good 100 fair	Salmon-pink to red-brown	H 5 G 3.7 F 2	Diss by acids. FeO 28.8, MnO 16.0, CaO 12.8%.
	---	1.70	---	.044	PENNAITE Silicate of Na, Ca, Fe, Ti, Zr	25°	Y:c = 13°	TCL(?) acic	---	Yellow to light brown	---	Pleoc, X dark yellow, Y grayish-yellow, Z bright-yellow.
1.693 ^v 1.721	1.697	1.700	1.725	.028	MANGAN-NEPTUNITE $KNa_2Li(Mn,Fe)_2Ti_2Si_8O_{24}$	36° r < v str	Y = b Z:c = 16-20° el pos	MCL pris c	110 perf at 80°	Red to black	H 5.5-6 G 3.2 F 2.5	Insol in acids. Pleoc str, X yellow, Y orange-red, Z deep red.
v (1.722)	1.695	1.70	1.722	.027	GADOLINITE $Y_2FeBe_2Si_2O_{10}$	(52±11°)	X = b Z:c = 4-13°	MCL	Conch	Black to dark brown	H 7 G 4.2 infus	Gel in part. Pale green, not pleoc in section.
1.676 ^	1.697	(1.700)	1.704	.007	PHARMACOSIDERITE $KFe^{+3}{}_4(AsO_4)_3(OH)_4 \cdot 6\text{-}7H_2O$	Large r < v str	---	CUB	100 imperf	Olive-green to brown	H 2.5 G 2.8-2.9 F 2	Diss by acids. Poly tw. Abnorm interf colors.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.692 ^	1.700	1.703	1.708	.008	ZOISITE (Epidote grp) $Ca_2Al_3(SiO_4)_3(OH)$	71° r < v or r > v	X = c Y = b	ORTH	010 perf but diff 100	Cols, green	H 6-7 G 3.35 F 3.5	Insol in acids, but gel after ignition. Abnorm interf colors. Fe_2O_3 3.1, FeO 1.3, MnO 0.8%.
v 1.717	1.700	1.703	1.706	.006	CLINOZOISITE (Epidote grp) $Ca_2Al_3(SiO_4)_3(OH)$	~ 90° r < v str	Y = b X ~ c	MCL	001 perf	Cols	H 6.5 G 3.28 F 3	Insol in acids. Abnorm interf colors. Fe_2O_3 3.2, FeO 0.6%.
v (1.741)	1.701	1.703	1.706	.005	SERENDIBITE $Ca_2(Mg,Al)_6(Si,Al,B)_6O_{20}$	~ 90° r < v str	ext:tw lam ~ 40°	TCL platy	---	Sky-blue to indigo-blue	H 6.5 G 3.42 infus	Insol in acids. Poly tw. Pleoc, X pale green, Y nearly cols, Z deep blue.
v 1.728	1.694	1.704	1.719	.025	ROSELITE $Ca_2(Co,Mg)(AsO_4)_2 \cdot 2H_2O$	75° r < v perc	Y = b X:c = 0-4°	MCL	010 perf	Pale rose	H 3.5 G 3.69 F 3	Diss by acids. Pleoc wk in rose, abs X > Y > Z.
	1.698	1.704	1.720	.022	AKATOREITE $Mn_9(Si,Al)_{10}O_{23}(OH)_9$	65.5°	---	TCL pris	010 perf 01̄2 imperf	Orange-brown	H 6 G 3.48	Pleoc, X cols, Y pale yellow, Z light canary-yellow.
1.683 ^	1.696	1.704	1.713	.017	ZWIESELITE (Triplite ser) $(Fe,Mn,Mg,Ca)_2PO_4(OH,F)$	87° r > v	Y = b X:a = 42°	MCL	100 perf 010 poor	Dark brown	H 4.5 G 3.97 F 2.5	Diss by acids. Pleoc in brown, abs X > Y > Z. FeO 42.0, MnO 18.4, MgO 0.8, CaO 1.7%.
v (1.727)	1.703	1.704	1.710	.007	SAPPHIRINE $(Mg,Al)_8(Al,Si)_6O_{20}$	Med	Y = b	MCL	010, 001, 100 poor	Pale blue	H 7.5 G 3.44 infus	Insol in acids. Pleoc in blue, abs Z > Y > X.
	1.703	1.705	1.723	.020	KULANITE $Ba(Fe,Mn,Mg)_2Al_2(PO_4)_3(OH)_3$	32° r > v str	Y = b Z:c = -8°	TCL plates	010 100 fair to good	Blue to green	H 4 G 3.91	Pleoc, X brownish-green, Y green, Z pale brown.
1.688 ^v 1.717	1.698	1.705	1.715	.017	PUMPELLYITE $Ca_2(Mg,Fe)Al_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$	68° r < v str rarely r > v	Y = b Z:c = 5-22°	MCL	001 good 100 imperf	Bluish-green	H 5.5-7 G 3.2	Insol in acids. Pleoc, X and Z yellow-green, Y green. Fe_2O_3 3.6, FeO 2.9%.
1.699 ^v 1.714	1.700	1.707	1.724	.024	SALITE (Diopside ser, Pyroxene grp) $Ca(Mg,Fe)(Si,Al)_2O_6$	52° (66±10°)	Y = b Z:c = 44°	MCL pris c	110 good at 87°	Green, brown	H 6 G 3.42	Insol in acids. FeO 9.8, MnO 0.3, Fe_2O_3 1.8, Al_2O_3 2.8%.

1.707 neg ^v 1.730	1.689	1.707	1.727	.038	GAITITE $Ca_2(Zn,Mg)(AsO_4)_2 \cdot 2H_2O$	85° (92±6°)	---	TCL	010, 001, 0$\bar{1}$1 good	Cols, white	H ~ 5	Zn:Mg = 1:1.
	1.703	1.708	1.729	.026	OXYCHILDRENITE $(Mn^{+2},Mg)(Fe^{+3},Mn^{+3})_4 Al_4(PO_4)_4(OH)_{14}$	32° (53±11°)	---	ORTH(?)	001 perf 010 less so	Reddish-brown	H 3.5-4 G 3.22 fus	Diss by acids. Pleoc, pale yellow to brownish. Fe_2O_3 18.5, Mn_2O_3 8.7, MnO 4.5%.
1.711 neg v 1.744	1.704	1.708	1.714	.010	ALLANITE (Epidote grp) $(Ca,Ce)_2(Al,Fe)_3(SiO_4)_3(OH)$	70-80° r > v	Y = b X:c = 5-40°	MCL	001 imperf	Brownish-black	H 5-6 G 3.53 F 3	Slowly attacked by HCl and gel. G and refr indices decrease with hydration. U opt neg.
1.690 ^	1.702	1.709	1.740	.038	LEGRANDITE $Zn_2(AsO_4)(OH) \cdot H_2O$	36-50° r < v dist	X = b Z:c = -38°	MCL pris	100 fair	Cols to yellow	H 4.5 G 4.0	Diss by acids. Pleoc faint in yellow.
1.660 ^v 1.733	1.708	1.710	1.746	.038	STRENGITE, manganian $(Fe^{+3},Mn^{+3})(PO_4) \cdot 2H_2O$	42° r > v str	X = a Y = b	ORTH	---	Reddish-brown	H 4-5 G 2.8 fus	Diss by acids.
1.699 ^v 1.719	1.700	1.710	1.733	.033	JOHANNSENITE (Pyroxene grp) $Ca(Mn,Mg,Fe)Si_2O_6$	60° (68±7°) r > v	Y = b Z:c = 49°	MCL pris c	110 good at 87°	Brown	H 6 G 3.38 F 5	Insol in acids. MnO 22.6, FeO 1.5, Fe_2O_3 0.8%.
	1.707	1.710	1.730	.023	NAMBULITE $NaLi(Mn,Mg)_8Si_{10}O_{28}(OH)_2$	30° r > v wk	X':c = 19° on $\bar{0}$10	TCL	001 perf 100, 010 dist	Reddish-brown	H 6.5 G 3.51	---
v 1.720	1.702	1.710	1.723	.021	MERWINITE $Ca_3Mg(SiO_4)_2$	70° r > v wk	Z = b X:c = 36°	MCL granular	010 poor	Cols	H 6 G 3.32 F 6	Gel with acid. Poly tw very common, 2 sets with angle 43° between sets.
1.696 ^	1.708	1.711	1.723	.015	BEUSITE $(Mn,Fe,Ca)_3(PO_4)_2$	45° r > v str	X = b Z:c = -36°	MCL u mass	010 good 100 fair	Reddish-brown	H 5 G 3.70 F 2	Diss by acids. MnO 33.7, FeO 17.7, CaO 3.3, MgO 2.3%.
	1.709	1.711	1.724	.015	BRANDTITE $Ca_2Mn(AsO_4)_2 \cdot 2H_2O$	23° r < v str	X = b Y:c = 7°	MCL pris	010 perf 001 good	Cols	H 3.5 G 3.67 F 2.5-3	Diss by acids. Tw common 100.
v 1.772	1.707	1.712	1.732	.025	MANGANHUMITE (Humite grp) $(Mn,Mg)_7(SiO_4)_3(OH)_2$	37° (54±11°) r > v perc	X = a Z = b	ORTH granular	010	Pale to deep orange-brown	H 4 G 3.83	Gel with acid. MnO 57.1, MgO 14.2, FeO 1.0%.
	1.709	1.712	1.716	.007	OTTRELITE $(Mn,Fe,Mg)_2Al_4Si_2O_{10}(OH)_4$	60-70° r > v str	X = b Z:c = 10° el neg	MCL and TCL	001 perf	Pistachio green	H 6 G 3.52	Pleoc, X olive-yellow, Y pale yellow, Z cols. MnO 12.6, FeO 8.0, MgO 4.4%.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien- tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.703	1.713	1.722	.019	GERHARDTITE $Cu_2(NO_3)(OH)_3$	Large r < v, very str	X = a Y = b	ORTH horizontal vicinal striations	001 perf 110 good	Emerald-green	H 2 G 3.42 F 2	Diss by acids. Pleoc, X and Y green, Z blue.
∨ (1.731)	1.708	(1.713)	1.722	.014	VARULITE $(Na,Ca)Mn(Mn,Fe^{+2},Fe^{+3})_2(PO_4)_3$	Large r > v	---	MCL	001, 010	Olive-green to brown	H 5 G 3.5-3.6 fus	Diss by acids. Pleoc, X yellow-green, Z grass-green.
1.707 ^∨ 1.732	1.708	1.714	1.736	.028	FERROSALITE (Diopside ser, Pyroxene grp) $Ca(Fe,Mg)Si_2O_6$	70° (56±10°) r > v wk	Y = b Z:c = 43°	MCL pris c	110 good at 87°	Dark green	H 6 G 3.41 F 4	Insol in acids. FeO 18.6, MnO 0.2, Fe_2O_3 0.5, Al_2O_3 1.1%.
1.698 ^	1.714	1.714	1.742	.028	PIGEONITE (Pyroxene grp) $(Mg,Fe,Ca)(Mg,Fe)Si_2O_6$	0-12°	X = a Z:c = 41°	MCL	110 good at 87°	Green	H 5-6 G 3.44 F 5-6	Insol in acids. FeO 27.8, MnO 1.0, CaO 3.8, Fe_2O_3 1.7%.
1.679 ^	1.707	1.714	1.734	.027	CLINOHUMITE (Humite grp) $(Mg,Fe)_9(SiO_4)_4(OH,F)_2$	56° r < v	Z = b X ~ c	MCL	---	Yellow to red	H 6 G 3.36 infus	Gel with acids. FeO 10.2, Fe_2O_3 1.2, TiO_2 5.1, F 0.1%.
∨ 1.728	1.712	1.714	1.726	.014	CHLORITOID $(Fe,Mg,Mn)_2Al_4Si_2O_{10}(OH)_4$	51° r > v str	X = b Z:c = 11° el neg	MCL and TCL	001 perf	Greenish-gray	H 6.5 G 3.54 F diff	Dec by H_2SO_4. Pleoc X green, Y slate blue, Z yellowish. FeO 21.2, Fe_2O_3 1.6, MnO 0.4%.
∨ 1.722	1.700	1.715	1.740	.040	DIASPORE AlO(OH)	84° r < v wk	Y = b Z = a	ORTH blades 010	010 perf 110 less so	Cols	H 6.5-7 G 3.44 infus	Insol in acids. Luster pearly. Fe_2O_3 0.1, TiO_2 0.2%.
	1.700	1.715	1.732	.032	EVEITE $Mn_2(AsO_4)(OH)$	65° (87±7°) r < v mod	---	ORTH tab 100	011 fair	Apple-green	H 4 G 3.67	Diss by acids.
	1.707	1.715	1.730	.023	LARNITE Ca_2SiO_4	Mod large	Z = b X:c = 14°	MCL	100	White	---	Gel with acids. Poly tw on 100.
∨ 1.725	1.711	1.715	1.724	.013	RHODONITE $(Mn,Ca,Mg,Fe)SiO_3$	69°	Z':c on 010 = 9° $1\bar{1}0$ = 30°	TCL	100, 001 perf 010 less so	Pink	H 6 G 3.56 F 3	Slightly attacked by acids. MnO 40.2, CaO 6.7, MgO 4.6%.

1.707 ^v 1.723	1.710	1.716	1.736	.026	FERROAUGITE (Pyroxene grp) $(Ca,Na)(Fe,Mg,Al,Ti)(Si,Al)_2O_6$	52°	Y = b Z:c = 49°	MCL	110 good at 87°	Green, brown	H 6 G 3.49	Insol in acids. FeO 20.2, MnO 1.1, Fe_2O_3 0.9, Al_2O_3 3.5%.
	1.712	1.716	1.725	.013	BREDIGITE $Ca_7Mg(SiO_4)_4$	10-34° (68±18°)	---	ORTH	130	White	G 3.38	Gel with acids. Tw 110.
v 1.767	1.707	(1.717)	1.778	.071	JOAQUINITE $Ba_2NaCe_2Fe(Ti,Nb)_2Si_8O_{26}(OH,F)\cdot H_2O$	45° r < v	Z = c X = a	MCL ps orth	---	Brown	H 5.5 G 3.62 F 2.5	Insol in acids. Pleoc wk, X and Y cols, Z light yellow.
	1.709	1.717	1.729	.020	STRINGHAMITE $CaCuSiO_4\cdot 2H_2O$	80°	X = b Y:c = 2.5°	MCL	---	Deep azure-blue	G 3.67 calc	Pleoc, X light gray-blue, Y light blue, Z dark blue.
1.705 ^	1.711	1.717	1.727	.016	PUMPELLYITE $Ca_2(Mg,Fe)Al_2(SiO_4)(Si_2O_7)(OH)_2\cdot H_2O$	Large r < v str	Y = b Z:c = 25°	MCL	001 good 100 imperf	Bluish-green	H 5.5-7 G 3.25	Insol in acids. Pleoc, X and Z yellow-green, Y green. Fe_2O_3 6.7, FeO 3.9, MnO 0.2%.
	1.715	1.717	1.728	.013	KANOITE (Pyroxene grp) $(Mn,Mg)_2Si_2O_6$	41°	Y = b Z:c = 42°	MCL	110 perf	Light pinkish-brown	H 6 G 3.66	Poly tw 100. MnO 31.2, MgO 15.1, FeO 2.6, Fe_2O_3 0.4%.
	1.713	1.717	1.723	.010	JOHACHIDOLITE $CaAlB_3O_7$	75-80° r > v str	X = a Y = c	ORTH mass	---	White	H 7.5 G 3.44 fus	Insol in acids. Fluor blue in UV.
1.703 ^ 1.720 neg v 1.733	1.715	1.717	1.721	.006	CLINOZOISITE (Epidote grp) $Ca_2Al_3Si_3O_{12}(OH)$	~ 90° r < v str	Y = b X ~ c el clv pos	MCL	001 perf	Cols to green	H 6.5 G 3.21 F 3	Insol in acids. Abnorm interf colors. Fe_2O_3 3.0, FeO 0.8%.
	1.710	1.718	1.780	.070	STRONTIOJOAQUINITE $Sr_2Ba_2(Na,Fe^{+2})_2Ti_2Si_8O_{24}(O,OH)_2\cdot H_2O$	35-45° r > v str	---	MCL	001 good	Green to yellow-green	H 5.5 G 3.68	---
1.660 ^	1.697	1.718	1.741	.044	PLANCHEITE $Cu_8Si_8O_{22}(OH)_4\cdot H_2O$	~ 90°	X = c Y = b	ORTH fib	---	Blue	H 5 G 3.65-3.80	Slightly attacked by acids. Pleoc, X pale blue, Y and Z blue.
	1.709	1.718	1.734	.025	METAHOHMANNITE $Fe_2(SO_4)_2(OH)_2\cdot 3H_2O$	(94±9°)	---	Mass, powdery	---	Orange	---	Diss by HCl. Pleoc, X pale yellow, Y reddish-yellow, Z reddish-brown.
	1.713	1.718	1.728	.015	WICKSITE $NaCa_2(Fe^{+2},Mn)_4MgFe^{+3}(PO_4)_6\cdot 2H_2O$	(71±16°)	---	ORTH	010 good	Dark blue	H 4.5-5 G 3.54	Pleoc, X blue, Y greenish-blue, Z pale yellow-brown, abs X = Y > Z.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.710 ↕ 1.728	1.710	1.719	1.738	.028	JOHANNSENITE (Pyroxene grp) $CaMnSi_2O_6$	70°	Y = b Z:c = 48°	MCL pris c	110 good at 87°	Brown to green	H 6 G 3.45 F 5	Insol in acids. MnO 26.8, FeO 1.0, MgO 1.0, Fe_2O_3 0.3%.
1.693 ↕ 1.736	1.712	1.719	1.736	.024	FASSAITE (Pyroxene grp) $Ca(Mg,Fe,Al)(Al,Si)_2O_6$ O_6	55° (66±10°) r > v	Y = b Z:c = 46°	MCL pris c	110 good at 87°	Green	H 6 G 3.34	Insol in acids. FeO 0.2, Fe_2O_3 6.1, Al_2O_3 15.75, TiO_2 0.8%.
1.710 ^	1.714	1.720	1.730	.016	MERWINITE $Ca_3Mg(SiO_4)_2$	68° r > v wk	Z = b X:c = 36°	MCL gran-ular	010 poor	Cols	H 6 G 3.32 F 6	Gel with acids. Poly tw very common, 2 sets with angle 43° between the sets.
1.700 ^	1.711	1.721	1.744	.033	NEPTUNITE $KNa_2Li(Fe,Mn)_2Ti_2Si_8O_{24}$	62° r < v str	Y = b Z:c = 16-20° el pos	MCL pris c	110 perf	Red	H 5.5-6 G 3.2 F 2.5	Insol in acids. Pleoc str, X gold-orange, Y orange-red, Z deep red.
	1.707	1.721	1.739	.032	LEUCOPHOSPHITE $KFe_2(PO_4)_2(OH)\cdot 2H_2O$	84° r < v str	X = b Z:c = 26°	MCL	001 perf	Buff	G 2.95	Diss by acids. Pleoc, cols to greenish-yellow.
	1.713	1.721	1.734	.021	HARADAITE $SrV^{+4}Si_2O_7$	105° (77±12°) r < v str	X = a Y = b	ORTH	010 perf 100, 001 dist	Bright green	H 4.5 G 3.80	Pleoc, X cols to pale green, Y cols to light yellow-green, Z bluish-green. (Reported as opt neg.)
	1.712	1.721	1.731	.019	ADELITE $CaMg(AsO_4)(OH,F)$	~ 90° r < v perc	X = a Z = b	ORTH u mass	Uneven to conch	Cols, gray	H 5 G 3.73 F easy	Diss by acids.
1.691 ↕ 1.746	(1.694)	1.722	1.757	(.063)	ASTROPHYLLITE $(K,Na)_3(Fe,Mn)_7Ti_2Si_8O_{24}(O,OH)_7$	85° r > v str	X ~ b Z:c = 3-19° el clv neg	TCL	001 perf	Red-brown	H 3 G 3.3 F 3	Dec by acids. Pleoc, X red-orange, Y yellow, Z lemon-yellow, abs X > Y > Z.
1.715 ^	1.702	1.722	1.750	.048	DIASPORE AlO(OH)	82° r < v wk	Y = b Z = a	ORTH blades 010, el c	010 perf 110 less so	Cols	H 6.5-7 G 3.44 infus	Insol in acids. Luster pearly.

1.671 ^v 1.730	(1.71)	1.722	1.74	(.03)	ANDALUSITE, manganoan $(Al,Mn,Fe)_2SiO_5$	80° r < v	X = a Y = b el pos	ORTH pris	110 good	Green	H 7 G 3.3 infus	Insol in acids. Pleoc, X yellow-green, Y deep green, Z golden. Mn_2O_3 21.4, Fe_2O_3 4.5%.
1.70 ^v 1.774	1.715	(1.722)	1.740	.025	GADOLINITE $Y_2FeBe_2Si_2O_{10}$	65°	X = b Z:c = 4-13°	MCL	Conch	Greenish-black	H 6.5 G 4.2 infus	Gel in part with acids.
1.716 ^v 1.730	1.714	1.723	1.774	.060	AUGITE, zincian (Pyroxene grp) $(Ca,Na)(Mg,Mn,Zn,Fe)Si_2O_6$	74° (47±5°)	Y = b Z:c = 55°	MCL pris	110 good at 87°	Greenish-brown	H 6 G 3.55 F 5	Insol in acids. MgO 5.9, ZnO 7.7, MnO 7.2, Fe_2O_3 4.2%.
1.699 ^	1.718	1.723	1.745	.027	GRAFTONITE $(Fe,Mn,Ca)_3(PO_4)_2$	52° r > v str	X = b Z:c = -36°	MCL u mass	010 good 100 fair	Reddish-brown	H 5 G 3.75 F 2	Diss by acids. FeO 34.3, MnO 20.1, CaO 5.1%.
	1.712	1.725	1.760	.048	KRINOVITE $NaMg_2CrSi_3O_{10}$	61°	X = b disp str	TCL	---	Deep emerald-green	H 5.5-7 G 3.38	Pleoc str, X yellow-green, Y blue-green, Z greenish-black to dark reddish-brown. Meteorite mineral.
1.65 ^	1.715	1.725	1.738	.023	HOMILITE $Ca_2(Fe,Mg)B_2Si_2O_{10}$	80° r > v rather str	Z = b Y ~ c	MCL tab 001	One indist	Black to dark brown	H 5 G 3.36 F 2	Gel with acids. Pleoc, X bluish-green, Y brownish-red, Z deep smoky gray to brownish-yellow.
1.715 ^v 1.728	1.722	1.725	1.734	.012	RHODONITE $(Mn,Ca,Mg,Fe)SiO_3$	70°	---	TCL	100, 001 perf 010 less so	Pink	H 6 G 3.54 F 3	Nearly insol in acids. MnO 41.4, CaO 6.6, MgO 2.3, FeO 1.9%.
	(1.708)	1.726	1.758	(.050)	CESIUM KUPLETSKITE $(Cs,K,Na)_3(Mn,Fe^{+2})_7(Ti,Nb)_2Si_8O_{24}(O,OH,F)_7$	75°	Z = a Y:b = 10°	TCL	001 perf	Gold-brown	H 4 G 3.68	Pleoc, X yellow-green, Y yellow to brown, Z brown.
v 1.749	1.725	1.726	1.730	.005	TRIPLOIDITE $(Mn,Fe)_2(PO_4)(OH)$	Med r > v extr	X = b Z:c = 4° disp dist	MCL pris	010 good 120 fair	Yellow-ish- to reddish-brown	H 4.5-5.5 G 3.70 F 1.5	Diss by acids. Cols in section. Mn:Fe about 3:1.
v 1.730	1.715	1.727	1.749	.034	BABINGTONITE $Ca_2(Fe^{+2},Mn)Fe^{+3}Si_5O_{14}(OH)$	76° r > v str	ext:c on 100 = 44°, 010 = 31°	TCL pris c	001 perf 010, 100 less so	Greenish- to brownish-black	H 5.5-6 G 3.34 F 3	Insol in acids. Pleoc str, X deep green, Y lilac-brown, Z pale to deep brown. Fe_2O_3 15.6, FeO 7.8, MnO 1.8%.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien- tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.695 ^	1.724	1.727	1.749	.025	BJAREBYITE $(Ba,Sr)(Mn,Fe,Mg)_2Al_2(PO_4)_3(OH)_3$	38° r > v str	Z:c = 8° el clv pos	MCL spears	010, 100 perf	Emerald-green	H 4+ G 3.90	Pleoc wk, X apple-to olive-green, Y brownish-green, Z cols to pale yellow. MnO 16.0, FeO 5.9, Fe_2O_3 3.3%.
1.704 ^	1.725	(1.727)	1.732	.007	SAPPHIRINE $(Mg,Al)_8(Al,Si)_6O_{20}$	66°	Y = b	MCL	010, 001, 100 poor	Yellow	H 7.5 G 3.4 infus	Insol in acids. Pleoc, X pale yellow, Y green, Z pale orange.
1.704 ^	1.725	1.728	1.755	.030	ROSELITE $Ca_2(Co,Mg)(AsO_4)_2\cdot 2H_2O$	60° (37±11°) r < v	Y = b X:c = 0-4°	MCL	010 perf	Dark rose	H 3.5 G 3.7 F 3	Diss by acids. Pleoc, X dark rose, Y pale rose, Z paler rose.
1.719 ⌃⌴	1.716	1.728	1.745	.029	JOHANNSENITE, ferroan (Pyroxene grp) $Ca(Mn,Fe,Mg)Si_2O_6$	64° (81±8°)	Y = b Z:c = 48°	MCL pris c	110 good at 87°	Pale green	H 6 G 3.55	Insol in acids. MnO 14.1, FeO 13.4, MgO 2.2%.
1.725 ◇ 1.736	1.725	1.728	1.737	.012	RHODONITE $(Mn,Fe,Ca,Mg)SiO_3$	70°	---	TCL	100, 001 perf 010 less so	Brownish-pink	H 4 G 3.65 F 3	Nearly insol in acids. MnO 29.2, FeO 14.5, CaO 6.6, MgO 1.9%.
1.714 ⌃⌴ 1.734	1.727	1.728	1.733	.006	CHLORITOID $(Fe,Mg,Mn)_2Al_4Si_2O_{10}(OH)_4$	53° r > v str	X = b Z:c = 12° el neg	MCL and TCL	001 perf	Greenish-gray	H 6.5 G 3.5 F diff	Dec by H_2SO_4. Pleoc, X green, Y blue, Z yellowish. FeO 27.1, MnO 0.2, Fe_2O_3 1.2%.
	1.696	1.730	1.798	.102	OJUELAITE $ZnFe^{+3}{}_2(AsO_4)_2(OH)_2\cdot 4H_2O$	(73±2°)	X = b Z = c	MCL fib	---	Chartreuse	H 3 G 3.39	Sol in acids.
	1.715	1.730	1.795	.080	RUTHERFORDINE $(UO_2)CO_3$	53°	X = b Y = c	ORTH	010 perf	Yellow	G 5.7 infus	Diss by acids with eff. Pleoc, X nearly cols, Y pale yellow, Z pale greenish-yellow.
1.727 ◇ 1.734	1.716	1.730	1.746	.030	MANGANBABINGTONITE $Ca_2(Mn,Fe)_2Fe^{+3}Si_5O_{14}(OH)$	80° r > v str	Z = b Y ~ c	TCL pris c	001 perf 010, 100 less so	Reddish-brown	H 6 G 3.45 F 3	Insol in acids. Pleoc, X green, Y pale rose, Z rose-brown. MnO 7.9, FeO 4.5, Fe_2O_3 12.3%.

1.723 ^v 1.741	1.725	1.730	1.750	.025	AUGITE, titanian (Pyroxene grp) $(Ca,Na)(Mg,Fe,Al,Ti)(Si,Al)_2O_6$	40° ($54\pm11°$)	Y = b Z:c = 45°	MCL	110 good at 87°	Brown	H 6 G 3.42	Insol in acids. FeO 5.0, MnO 0.2, Fe_2O_3 4.4, Al_2O_3 7.35, TiO_2 5.5%.
1.722 ^	1.702	1.730	1.823	.121	KANONAITE (Andalusite ser) $(Mn^{+3},Al)AlSiO_5$	53° ($60\pm2°$) disp str	X = a Y = b	ORTH	110 poor	Greenish-black	H 6.5 G 3.40 calc	Pleoc, X yellow-green, Y bluish-green, Z deep golden yellow. Mn_2O_3 32.2%.
1.707 ^	1.713	1.730	1.748	.035	GAITITE $Ca_2Zn(AsO_4)_2 \cdot 2H_2O$	88°	---	TCL	010, 001, 0$\bar{1}$1 good	White	H 5 G 3.81	ZnO 15.3, MgO 1.2%.
v 1.778	1.730	(1.730)	1.746	.016	MONAZITE, sulfatian $(Ce,La,Th)(PO_4,SO_4)$	5°	X = b	MCL	100 dist	Reddish-brown	G 4.54	SO_3 3.1%.
v 1.735	1.727	1.730	1.735	.008	CARBOIRITE $FeAl_2GeO_5(OH)_2$	55-70°	Z:c = 4-14° r > v	TCL	001 perf	Pale to bright green	---	Poly tw. Pleoc, X blue-green, Y light blue, Z cols to yellowish.
(1.713) ^v (1.766)	1.727	(1.731)	1.738	.011	ALLUAUDITE (Varulite ser) $(Na,Ca)_4Fe^{+2}{}_4(Mn,Fe^{+2},Fe^{+3},Mg)_8(PO_4)_{12}$	Large r > v	---	MCL	001	Greenish-black	H 5 G 3.5 fus	Diss by acids. Pleoc in green. "Huehnerkobelite."
	1.714	1.732	1.805	.091	LOPEZITE $K_2Cr_2O_7$	50° ($55\pm3°$) r > v med	---	TCL	010 perf 100, 001 dist	Orange-red	H 2.5 G 2.69	Sol in H_2O. Pleoc, X reddish-yellow, Y yellow, Z greenish-yellow.
1.714 ^v 1.753	1.726	1.732	1.753	.027	HEDENBERGITE (Diopside ser, Pyroxene grp) $Ca(Fe,Mg)Si_2O_6$	49° r > v wk	Y = b Z:c = 44°	MCL pris c	110 good at 87°	Green	H 6 G 3.48 F 4	Insol in acids. Pleoc, X pale green, Z dark green. FeO 24.7, MnO 0.7, Fe_2O_3 1.9%.
v 1.742	1.728	1.732	1.746	.018	PYROXMANGITE $(Mn,Fe,Mg)SiO_3$	42° ($57\pm14°$)	---	TCL	---	Pink to dark brown	H 6 G 3.61	Insol in acids. MnO 45.5, FeO 1.3, MgO 3.8, CaO 0.7, Fe_2O_3 0.3%.
v 1.79	1.720	1.733	1.935	.215	FERRIMOLYBDITE $Fe_2(MoO_4)_3 \cdot 8H_2O$ (?)	28° r < v str	Y = a Z = c	ORTH fib c	001 dist	Sulfur-yellow	H 1-2 G 2.99 F easy	Diss by acids, dec by NH_4OH. Pleoc, X and Y pale yellow, Z dirty gray to yellow-green.
	1.728	1.733	1.790	.062	BATISITE $BaNa_2Ti_2(Si_2O_7)_2$	8° ($34\pm6°$) r < v str	Y = b Z = c	ORTH	100 fair	Dark brown	H 6 G 3.43 F easy	Insol in acids. Pleoc, X cols, Y yellow-brown, Z reddish-brown.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.710 ^	1.730	1.733	1.763	.033	STRENGITE $FePO_4 \cdot 2H_2O$	Med (36±11°) r < v str	X = a Y = b	ORTH	---	Rose to violet	H 4-5 G 2.8 fus	Diss by acids. Pleoc wk, in rose, abs Z > X.
1.717 ^	1.723	1.733	1.755	.032	MUKHINITE (Epidote grp) $Ca_2Al_2V(SiO_4)_3(OH)$	88° (69±8°)	Y = b Z:a = 32°	MCL	001 perf 100 less so	Brownish-black	H 8	Diss with diff by acids. Pleoc str, X pale olive-green, Y pale red-brown, Z reddish-brown.
	1.557	1.734	2.07	.513	IDRIALITE Hydrocarbon, near $C_{22}H_{14}$	84° r > v wk	X = b Z = c el c̄Tv neg	ORTH	001 perf 100 poor	Yellow, greenish	H 1-1.5 G 1.22 F 1	Dimethylbenzphenanthrene. Pleoc, X pale yellow, Y and Z yellow.
v 1.758	1.719	(1.734)	1.778	.059	SEIDOZERITE $(Na,Ca)_2(Zr,Ti,Mn)_2Si_2O_7(O,F)_2$	62° r > v str	X = b Y:c = 13°	MCL	001 perf	Dark yellow to reddish-brown	H 4-5 G 3.43 F easy	Diff diss by HCl. Pleoc, X dark red, Y red, Z yellow.
1.730 ^	1.719	1.734	1.750	.031	BABINGTONITE $Ca_2(Fe^{+2},Mn)Fe^{+3}Si_5O_{14}(OH)$	88° r > v str	---	TCL pris c	001 perf 010, 100 less so	Greenish-black	H 5.5-6 G 3.48 F 3	Insol in acids. Pleoc, X green, Z brown. FeO 7.9, MnO 3.0, Fe_2O_3 13.6%.
1.730 ^	1.731	1.735	1.740	.009	CARBOIRITE $FeAl_2GeO_5(OH)_2$	60-75° r > v	Z:c = 7°	TCL	001 perf	Pale to bright green	---	Poly tw. Pleoc, X blue-green, Y light blue, Z cols to yellowish.
1.719 ^	1.727	1.736	1.751	.024	FASSAITE (Pyroxene grp) $Ca(Mg,Fe,Al)(Si,Al)_2O_6$	49° (76±10°) r > v	Y = b Z:c = 48°	MCL pris	110 good at 87°	Green	H 6 G 3.37	Insol in acids. FeO 1.2, Fe_2O_3 6.2, Al_2O_3 12.9, TiO_2 3.6%.
1.728 ^v 1.748	1.733	1.736	1.744	.011	RHODONITE $(Mn,Fe,Mg,Ca)SiO_3$	68°	---	TCL	100, 001 perf 010 less so	Brownish-pink	H 4 G 3.65 F 3	Insol in acids. MnO 49.2, FeO 0.6, MgO 0.8, CaO 2.6, Fe_2O_3 0.3%.
	1.726	1.737	1.766	.040	INNELITE $Na_2(Ba,K)_4(Ca,Mg,Fe)Ti_3Si_4O_{18}(OH,F)_{1.5}(SO_4)$	82° (64±6°) r > v str	Z ~ a, ⊥ 001̄ :X = 77° :Y = 12° :Z = 88°	TCL plates	010, 110, 101̄ perf 001	Yellow-brown	H 5 G 3.96	Nearly insol in acids. Poly tw. Anom blue interf colors. Pleoc, X and Y light yellow, Z pale brownish-yellow.

	1.735	1.737	1.80	.065	BARIO-ORTHOJOAQUINITE $Ba_2(Ba,Sr)_2Fe^{+2}{}_2Ti_2Si_8O_{24}O_2 \cdot H_2O$	10-15°	X = a Z = c	ORTH	---	Yellow-brown	G 3.96	---
	1.732	1.737	1.744	.012	CHAMBERSITE $Mn_3B_7O_{13}Cl$	83°	---	ORTH ps cub	Conch to uneven	Cols to deep purple	H 7 G 3.49 F 3-4	---
	1.588	1.739	1.898	.310	URICITE $C_5H_4N_4O_3$	84° (96±1°)	---	MCL	---	White	G 1.84 F 1	= Uric acid (2-,6-,8-trihydroxypurine). Insol in H_2O, diss by alkalies.
	1.726	1.739	1.788	.062	ANTLERITE $Cu_3(SO_4)(OH)_4$	55° r < v very str	X = b Y = c el pos	ORTH tab 010	010 perf 100 poor	Emerald- to light-green	H 3.5 G 3.88 F 2.5	Diss by HCl. Pleoc, X yellow-green, Y blue-green, Z green.
	1.730	(1.739)	1.748	.018	SUZUKIITE $Ba_2V^{+4}{}_2O_2Si_4O_{12}$	~ 90° r < v very str	X = a Y = b	ORTH	010 perf 001, 100 dist	Bright green	H 4-4.5 G 4.03	Pleoc, X pale green, Y yellow-green, Z bluish-green.
ˇ1.741	1.733	1.740	1.769	.036	LAMPROPHYLLITE $(Sr,Ba)_2Na_2Ti_3(SiO_4)_4(OH,F)_2$	32° (58±8°) r > v str	X = b Z:c = 0-8°	MCL	100 perf 011 good 010 dist	Yellow-brown	H 4-5 G 3.50	Poly tw 100. Pleoc wk, X and Y light yellow, Z brownish-yellow, Y brown-yellow, Z brown.
ˇ1.753	1.739	1.740	1.760	.021	ARDENNITE $Mn_4(Al,Mg)_6[(V,As)O_4]Si_5O_{18}(OH)_6$	Small r > v or r < v str	Z = a X or Y = b	ORTH pris c	010 perf 110 dist	Yellow to brown	H 6.5 G 3.65 F 2.5	Nearly insol in acids. Pleoc wk to str, X brownish yellow, Y golden yellow, Z pale yellow.
	1.740	1.740	1.760	.020	ANDREMEYERITE $BaFe^{+2}{}_2Si_2O_7$	0-80° disp extr	Z = b	MCL pris	100, 010 perf	Pale emerald-green	H 3-3.5 G 2.41	Tw on (100). 2V 0° at 490 nm, to 40° at 540, to 0° at 585, to 80° at 640 nm. X:c 2° at 670 nm to 61° at 470 nm.
ˇ1.746	1.736	1.740	1.745	.009	STAUROLITE $(Fe,Mg,Zn)_2Al_9(Si,Al)_4(Si,Al)_4O_{22}(OH)_2$	83° r > v wk	Z = c X ~ b el pos	MCL ps orth	010 dist	Yellow to reddish brown	H 7 G 3.75 infus	Insol in acids. Cruciform tw. Pleoc wk, X and Y light yellow, Z orange. FeO 12.7, Fe_2O_3 2.2%.
1.740 ^v 1.754	1.735	1.741	1.767	.032	BARYTOLAMPROPHYLLITE $(Na,K)_2(Ba,Ca,Sr)_2(Ti,Fe)_3(SiO_4)_4(O,OH)_2$	55° r > v str	X = b Z:c = -3°	MCL	100 perf 011 good	Dark brown	H 4-5 G 3.50	Poly tw 100. Pleoc str, X light yellow, Z brown, abs Z > Y > X.
1.730 ^v 1.751	1.735	1.741	1.761	.026	FERROAUGITE (Pyroxene grp) $Ca(Fe,Mg)(Si,Al)Si_2O_6$	51°	Y = b Z:c = 40°	MCL	110 good at 87°	Brown	H 6 G 3.42	Insol in acids. FeO 24.0, Fe_2O_3 1.2, Al_2O_3 4.1, MnO 0.4%.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.703 ^	1.738	(<u>1.741</u>)	1.743	.005	SERENDIBITE $Ca_2(Mg,Al)_6(Si,Al,B)_6O_{20}$	~ 90° r < v str	Ext:tw lam = 40°	TCL plates	---	Sky-blue to indigo-blue	H 6.5 G 3.52 infus	Insol in acids. Poly tw. Pleoc, X pale yellow-green, Y nearly cols, Z deep blue.
v 1.810	1.722	<u>1.742</u>	1.763	.041	ADAMITE $Zn_2(AsO_4)(OH)$	88° r < v str	X = <u>a</u> Y = <u>c</u>	ORTH	101 good 010 poor	Yellow, green, rose	H 3.5 G 4.44	Diss by acids. U opt neg. May contain Cu or Co.
1.732 ^v 1.750	1.738	<u>1.742</u>	1.754	.016	PYROXMANGITE $(Mn,Fe,Mg,Ca)SiO_3$	39° (60±16°)	Z':c = 45° on $\bar{1}00$	TCL	---	Pink to brown	H 6 G 3.76	Insol in acids. MnO 29.3, FeO 19.1, MgO 2.0, CaO 2.9%. (Series with Pyroxferroite.)
	1.715	<u>1.743</u>	1.783	.068	JOHILLERITE $Na(Mg,Zn)Cu(AsO_4)_3$	80°	Z = <u>b</u> X:<u>c</u> = 16°	MCL	010 perf 100, 001 good	Violet	H 3 G 4.15	Pleoc, X violet red, Y bluish violet, Z greenish-blue.
1.624 ^v 1.796	1.741	<u>1.744</u>	1.768	.027	SCORODITE (Variscite grp) $FeAsO_4 \cdot 2H_2O$	40° r > v str	X = <u>a</u> Y = <u>c</u>	ORTH pyram	201 imperf	Green to brown	H 3.5-4 G 3.14 F easy	Diss by acids. Fe_2O_3 25.8, Al_2O_3 4.7%.
1.708 ^v 1.768	1.738	<u>1.744</u>	1.753	.015	ALLANITE (Epidote grp) $(Ca,Ce,Y)_2(Al,Fe)_3Si_3O_{12}(OH)$	70-80° r > v	Y = <u>b</u> X:<u>c</u> = 5-40°	MCL	001 imperf	Brownish-black	H 5-6 G 3.69 F 3	Slowly attacked by HCl, gel. U pleoc in browns and reds. G and n's decrease with alteration. Fe_2O_3 + FeO = 9.2%.
	1.698	<u>1.745</u>	1.793	.095	LIBETHENITE $Cu_2(PO_4)(OH)$	90° r > v str	X = <u>b</u> Y = <u>c</u>	ORTH	100, 010 poor	Olive- to blackish-green	H 4 G 3.97 F 2	Diss by acids. Pleoc in yellow and green.
⊔ 1.75	---	<u>1.74</u>	---	---	TINTICITE $Fe_6(PO_4)_4(OH)_6 \cdot 7H_2O$	---	---	ORTH(?) earthy masses	---	Creamy white	H 2.5 G 2.8	---
1.722 ^	1.740	<u>1.746</u>	1.765	.025	ASTROPHYLLITE $(K,Na)_3(Fe,Mn)_7Ti_2Si_8O_{24}(O,OH)_7$	80° (59±10°) r > v str	X ~ <u>b</u> Z:<u>c</u> = 3-19° el clv neg	TCL	001 perf	Brown	H 3 G 3.24 F 3	Dec by acids. Pleoc, yellow to orange, abs X > Y > Z. FeO 20.7, MnO 1.4, Fe_2O_3 11.2%.

1.740 ◊ 1.751 neg 1.753	1.739	1.746	1.753	.014	STAUROLITE, cobaltoan $(Fe,Mg,Co)_2Al_9(Si,Al)_4O_{22}(OH)_2$	~ 90° r > v wk	Z = c X ~ b el pos	MCL ps orth	010 dist	Blue	H 7 G 3.76 infus	Insol in acids. Pleoc, X blue, Y violet-blue, Z violet. CoO 6.8-8.5%.
	1.737	1.747	1.768	.031	CREASEYITE $Pb_2Cu_2Fe_2Si_5O_{17}\cdot 6H_2O$	69° r < v wk	X = a Z = c	ORTH fib	---	Green	H 2.5 G 4.1 fus	Dec by hot HNO_3. Pleoc, X and Z yellow-green, Y clear green, abs Z = X > Y.
	1.746	1.748	1.768	.022	PROSPERITE $CaZn_2(AsO_4)_2\cdot H_2O$	34° r > v str	Y = b Z:c = 27°	MCL prism	---	Cols, white	H 4.5 G 4.31	---
1.736 ^	1.739	1.748	1.760	.021	RHODONITE, ferroan $(Mn,Fe,Mg,Ca)SiO_3$	75°	---	TCL	100, 001 perf 010 less so	Brownish-pink	H 4 G 3.76 F 3	Insol in acids. MnO 29.3, FeO 19.1, MgO 2.0, CaO 2.4%.
	1.746	1.748	1.756	.010	CHRYSOBERYL $BeAl_2O_4$	70° r > v	X = c Y = b	ORTH tab 100 ps hex tw	110 dist 010 imperf	Green, red, yellow	H 8.5 G 3.75 infus	Insol in acids. Tw pl 031. Pleoc, X red, Y orange to yellow, Z emerald-green.
1.726 ^	1.748	1.749	1.753	.005	WOLFEITE (Triploidite ser) $(Fe,Mn)_2(PO_4)(OH)$	Med r > v extr	X = b disp dist	MCL pris	010 good 120 fair	Reddish-brown	H 4.5-5 G 3.8 fus	Diss by acids.
v 1.763	1.715	1.75	1.80	.085	ERYTHROSIDERITE $K_2FeCl_5\cdot H_2O$	62° r > v str	X = a Z = b	ORTH tab 100	210, 011 perf	Red	G 2.37	Sol in H_2O. Yellow in thin section.
v 1.772	1.732	1.750	1.778	.046	PIEMONTITE (Epidote grp) $Ca_2(Al,Mn,Fe)_3(SiO_4)_3(OH)$	Large	Y = b X:c = -5° el clv pos	MCL pris	001 perf	Reddish-brown	H 6 G 3.45	Insol in acids. Pleoc str, X buff, Y deep lavender, Z pink. Mn_2O_3 11.8, Fe_2O_3 3.8%.
1.742 ◊ 1.758	1.748	1.750	1.764	.016	PYROXFERROITE $(Fe,Mn,Ca)SiO_3$	30°	---	TCL	---	Brown, yellow	H 6 G 3.80	Insol in acids. FeO 28.3, MnO 20.6, CaO 1.9%. (Series with Pyroxmangite.)
1.740 neg 1.741 ^	1.741	1.751	1.774	.033	ACMITE (Pyroxene grp) $Na(Fe,Zn,Mn)Si_2O_6$	Med (68±7°)	Y = b Z:c = 60°	MCL	110 good at 87°	Reddish-brown	H 6 G 3.59 F 3	Insol in acids. Fe_2O_3 12.9, FeO 1.4, ZnO 8.8, MnO 7.2, Na_2O 5.0%.
	1.745	1.751	1.760	.015	TIRAGALLOITE $Mn_4As^{+5}Si_3O_{12}(OH)$	38-46° (79±16°)	X = a Y = b Z ~ c el pos	MCL	100 good	Orange	G 3.84	Insol in HCl.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v 1.864	1.750	1.751	1.761	.011	SYNADELPHITE $(Mn,Mg,Ca,Pb)_9(AsO_3)(AsO_4)_2(OH)_9 \cdot 2H_2O$	37° r > v	---	TCL ps orth	010 imperf	Cols	H 4.5 G 3.64 F 2	Diss by acids. Pleoc wk, X and Y cols, Z light brown.
	1.740	1.752	(1.80)	(.06)	Unnamed ferric phosphate $Fe_3(PO_4)_2(OH)_3 \cdot 3\text{-}6H_2O$	Med r < v str	---	---	---	Brown	G 2.55	Pleoc, X pale brown, Z reddish brown.
1.732 ^	1.745	1.753	1.771	.026	HEDENBERGITE (Diopside ser, Pyroxene grp) $CaFeSi_2O_6$	52° (68±9°) r > v wk	Y = b Z:c = 41°	MCL pris c	110 good at 87°	Greenish-black	H 6 G 3.65 fus	Insol in acids. FeO 29.7, MnO 0.9, Fe_2O_3 1.4%.
	1.745	1.753	1.778	.033	O'DANIELITE $Na(Zn,Mg)_3(AsO_4)_3$	60°	Z = b Y:c = 18°	MCL	010, 100 perf, 001	Pale violet	H 3 G (4.49)	---
	1.750	1.753	1.780	.030	NAGASHIMALITE $Ba_4(V^{+3},Ti)_4B_2Si_8O_{27}Cl(O,OH)_2$	30° r > v str	X = a Y = c	ORTH	---	Greenish-black	G 4.08	Pleoc, X greenish-yellow, Y green, Z greenish-brown, abs Z > Y > X.
1.740 ^	1.753	1.753	1.770	.017	ARDENNITE $Mn_4Al_6[(V,As)O_4]Si_5O_{18}(OH)_6$	Small r > v or r < v str	Z = a X or Y = b	ORTH pris c	010 perf 110 dist	Yellow to brown	H 6.5 G 3.65 F 2.5	Nearly insol in acids. Pleoc in yellow, wk to str.
1.746 ^ 1.751 neg ^	1.747	1.753	1.761	.014	STAUROLITE $(Fe,Mg,Zn)_2Al_9(Si,Al)_4O_{22}(OH)_2$	80° r > v wk	Z = c X ~ b	MCL ps orth	010 dist	Reddish-brown	H 7 G 3.77 infus	Insol in acids. Cruciform tw. Pleoc wk, X and Y light yellow, Z orange-yellow.
1.741 ^v 1.760	1.743	1.754	1.777	.034	BARYTOLAMPROPHYLLITE $(Na,K)_2(Ba,Ca,Sr)_2(Ti,Fe)_3(SiO_4)_4(O,OH)_2$	30° (70±7°) r > v str	X = b Z:c = -7°	MCL	100 perf 011 good 010 dist	Dark brown	H 4-5 G 3.50	Poly tw 100. Pleoc, X light yellow, Y brown-yellow, Z brown.
v 1.775	1.725	1.755	1.815	.090	OLMSTEADITE $KFe^{+2}_2(Nb,Ta)(PO_4)_2O_2 \cdot 2H_2O$	~ 60° (73±3°)	X = c Y = a	ORTH	100, 001 good	Deep brown to black	H 4 G 3.31	Dec by warm HCl. Pleoc, X blue-green, Y yellow, Z brown, abs X > Z > Y.
v 1.774	1.752	1.756	1.779	.027	AUSTINITE $CaZn(AsO_4)(OH)$	41°	X = a Y = c	ORTH	011 good	Cols	H 4-4.5 G 4.13	Diss by acids.

	1.730	1.758	1.838	.108	AZURITE $Cu_3(CO_3)_2(OH)_2$	67° (64±2°) r > v str	X = b Z:c = -13° disp dist	MCL	011 perf inter-rupted, 100 fair	Azure-blue	H 3.5-4 G 3.77 F 3	Diss by acids with eff. Pleoc in blue, Z > Y > X.
(1.734) ^	1.725	1.758	1.830	.105	SEIDOZERITE $(Na,Ca)_2(Zr,Ti,Mn)_2Si_2O_7(O,F)_2$	68° (71±2°) r > v str	X = b Y:c = 13°	MCL	001 perf	Brownish-red to yellow	H 4-5 G 3.47 F easy	Diff diss by HCl. Pleoc, X dark red, Y red, Z yellow.
1.750 ^	1.756	1.758	1.768	.012	PYROXFERROITE $(Fe,Ca,Mn)SiO_3$	40°	---	TCL	---	Yellow, brown	H 6 G 3.80	Insol in acids.
1.754 ^	1.749	1.760	1.779	.030	LAMPROPHYLLITE $(Sr,Ba)_2Na_2Ti_3(SiO_4)_4(O,F)_2$	32° (75±8°) r > v str	X = b Z:c = 1-8°	MCL	100 perf 011 good	Yellow-brown	H 4-5 G 3.5	Poly tw 100. Pleoc wk, X and Y light yellow, Z brownish-yellow.
1.75 ^	1.733	1.763	1.807	.016	KREMERSITE (Erythrosiderite ser) $(NH_4,K)_2FeCl_5 \cdot H_2O$	70°	X = a Z = b	ORTH ps cub	---	Ruby red	G 2.18	Sol in H_2O. Data calc from end-members.
1.762 neg ≎ 1.772	1.755	1.763	1.773	.018	EULITE (Orthopyroxene ser, Pyroxene grp) $(Fe,Mg,Mn)_2Si_2O_6$	84° r > v	X = a Z = c	ORTH pris c	210 good at 87°	Dark green	H 5.5 G 3.88 F 4	Insol in acids. FeO 41.7, MnO 5.0, Fe_2O_3 0.3% (En_{12}).
	1.765	1.765	1.800	.035	HENRITERMIERITE (Garnet grp) $Ca_3(Mn,Al)_2(SiO_4)_2(OH)_4$	Small	---	TET	Conch	Clove- to apricot-brown	G 3.34 fus	Dec by warm HCl. Pleoc wk, O pale yellow, E lemon-yellow.
	1.747	1.765	1.78	.033	JOESMITHITE $(Ca,Pb)_3(Mg,Fe^{+2},Fe^{+3})_5Si_6Be_2O_{22}(OH)_2$	60-70°	---	MCL	110 perf	Lustrous black	H 5.5 G 3.83	Insol in cold acids. Pleoc, X and Z olive, Y olive-brown, abs Y > X, Z.
	1.750	1.766	1.85	.10	KOMAROVITE $(H,Ca)_2Nb_2Si_2O_{10}(OH,F)_2 \cdot H_2O$	48°	X = a Z = b	ORTH	001 fair	Pale rose	H 1.5-2	---
	1.765	---	1.775	.010	NATRODUFRENITE $Na(Fe^{+3},Fe^{+2})(Fe^{+3},Al)_5(PO_4)_4(OH)_6 \cdot 2H_2O$	---	el pos	MCL spheru-litic	---	Bronze-green	G 3.20	Pleoc, X yellow, Z green.
	1.763	---	1.769	.006	ROWLANDITE $Y_3(SiO_4)_2(OH,F)$ (?)	---	---	TCL(?)	Conch	Green, brown	H 6-6.5 G 4.85	Gel with acids. Commonly metamict.
(1.731) ≎ 1.802	1.760	(1.766)	1.775	.015	ALLUAUDITE $(Na,Ca)Fe^{+2}(Mn,Fe^{+2},Fe^{+3},Mg)_2(PO_4)_3$	Large r > v mod	Z = b Y:c = 18°	MCL u mass	$\bar{1}01$ perf 2 others	Greenish-black	H 5-5.5 G 3.5 F 3	Diss by acids.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
(1.717) ^	1.753	1.767	1.822	.069	JOAQUINITE $Ba_2NaCe_2Fe(Ti,Nb)_2Si_8O_{26}(OH,F)\cdot H_2O$	30-55° r < v	X = a Z = c	MCL ps orth	---	Brown to black	H 5 G 3.98 F 2.5	Insol in acids. Pleoc wk, X and Y cols, Z light yellow.
	1.736	1.767	1.796	.060	ARTHURITE $CuFe_2(AsO_4,PO_4,SO_4)_2(O,OH)_2\cdot 4H_2O$	~ 90°	Y = b Z:c = 10°	MCL	---	Apple-green	G 3.2	Pleoc, X cols to pale green, Y grass green, Z olive-green, abs Z > Y > X.
1.744 ^	1.763	1.768	1.788	.025	ALLANITE (Epidote gr) $(Ca,Ce,Y)_2(Al,Fe)_3Si_3O_{12}(OH)$	57° r > v	Y = b X:c = 5-40°	MCL	001 imperf	Dark brown	H 5.5 G 3.8 fus	Slowly attacked by HCl, gel. U pleoc in browns and reds. FeO 10.4, Fe_2O_3 3.8%.
	1.710	1.770	1.840	.130	ROSSITE $CaV_2O_6\cdot 4H_2O$	Large disp str	Z ~ c Y:b = 45°	TCL pris tab	010 good	Yellow	H 2-3 G 2.45 F easy	Slowly sol in H_2O. Tw on 100.
	1.769	1.770	1.785	.016	HOLDENITE $(Mn,Mg)_6Zn_3(AsO_4)_2SiO_4(OH)_8$	30° r > v perc	X = c Y = b	ORTH tab	010 poor subconch	Pink to red	H 4 G 4.11	Diss by acids.
1.750 ◊ 1.788	1.754	1.772	1.795	.041	PIEMONTITE (Epidote grp) $Ca_2(Mn,Al,Fe)_3Si_3O_{12}(OH)$	85° r < v	Y = b X:c = -6° el clv pos	MCL pris	001 perf	Reddish-brown	H 6 G 3.47	Insol in acids. Pleoc str, X yellow, Y pink, Z crimson. Mn_2O_3 22.0, Fe_2O_3 6.4%.
1.763 ^	1.768	1.772	1.790	.022	ORTHOFERROSILITE (Orthopyroxene ser, Pyroxene grp) $(Fe,Mg)_2Si_2O_6$	~ 55° r < v	X = b Z = c	ORTH	210 good at 87°	Dark green	H 5.5 F 4	Insol in acids. Extrapolated value for En_0.
1.712 ^	(1.761)	1.772	1.781	.020	MANGANHUMITE (Humite grp) $Mn_7(SiO_4)_3(OH)_2$	84°	X = a Z = b	ORTH	010	Orange-brown	H 4 G (4.05)	Gel with acids, MnO ~ 69, FeO ~ 1.0, MgO ~ 0.8%.
	1.752	1.773	1.796	.044	LUETHEITE $Cu_2Al_2(AsO_4)_2(OH)_4\cdot H_2O$	(88±5°) r < v mod	X = b Z:c = 10°	MCL tab	100 fair to good	Blue to greenish-blue	H 3 G 4.28 F easy	Diss by hot HCl. Pleoc wk in pale blue, abs Z = Y > X.
v 1.813	1.772	(1.773)	1.792	.020	WARWICKITE $(Mg,Ti,Fe,Al)_2(BO_3)O$	Small	X = c Y = b el clv neg	ORTH pris	100 perf	Dark brown to black	H 3.5-4 G 3.35 infus	Dec by H_2SO_4. Pleoc X brown, Y and Z light brown.

	1.770	1.774	1.83	.06	TARAMELLITE $Ba_4(Fe,Ti,Mg,V)_4B_2Si_6O_{29}Cl$	40° r > v str	X = a Y = b el pos	ORTH pris c	100 perf	Brownish-red	H 5.5 G 3.92 F easy	Insol in acids.
(1.722) ↕ 1.812	1.765	1.774	1.787	.022	GADOLINITE $(Y,Ca)_2FeBe_2Si_2O_{10}$	Med (80±6°) r < v	X = b Z:c = 4-13°	MCL	Conch	Greenish- to brownish-black	H 6.5 G 4.1-4.5 infus	Diff diss by acids, gel.
1.756 ↕ 1.795	1.770	1.774	1.783	.013	AUSTINITE $Ca(Zn,Cu)(AsO_4)(OH)$	Med r > v wk	X = a Y = c	ORTH	011 good	Cols to green	H 4-4.5 G 4.1	Diss by acids.
	1.765	1.775	1.800	.035	OGDENSBURGITE $Ca_4Fe^{+3}_6(AsO_4)_5(OH)_{11}\cdot 5H_2O$	25° (65±7°)	---	Thin plates	One perf	Dark reddish-brown	H ~ 2 G 2.92	Pleoc moderate, X < Y = Z.
1.755 ^	1.765	1.775	1.835	.070	OLMSTEADITE $KFe^{+2}_2(Nb,Ta)(PO_4)_2O_2\cdot 2H_2O$	~ 60° (46±5°)	X = c Y = a	ORTH	100, 001 good	Deep brown to black	H 4 G 3.36	Dec by warm HCl. Pleoc, X dark blue, Y light brown, Z dark brown, abs X > Z > Y.
	1.763	1.777	1.785	.022	YOSHIMURAITE $(Ba,Sr)_2TiMn_2Si_2O_8(PO_4,SO_4)(OH,Cl)$	80-90° (106±11°) r > v	---	TCL	010 perf 101, 10$\bar{1}$ dist	Brown	H 4.5 G 4.13	Pleoc, X bright yellow, Y orange-brown, Z brown, abs Z > Y > X. Poly tw on 010.
(1.730) ↕ 1.789	1.777	1.778	1.823	.046	MONAZITE $(Ce,La,Nd,Th)PO_4$	14.5°	X = b Z:c = 2°	MCL	100 dist	Green	H 5-5.5 G 5.3 infus	Diff sol in HCl. Pleoc wk. UO_2 1.5, ThO_2 11.3%.
	1.76	1.78	>>1.85	>>.07	KARPATITE $C_{24}H_{12}$	Small r < v extr	X = b Z:c = 21°	MCL	001, 100, $\bar{2}01$ perf	Pale	H < 1 G 1.35 F 1	A hydrocarbon, Coronene. Sol in org solvents.
	1.774	1.780	1.813	.039	BERAUNITE $Fe^{+2}Fe^{+3}_5(PO_4)_4(OH)_5\cdot 4H_2O$	Med large (47±8°) r > v str	Z = b X:c = 6°	MCL tab	100 good	Reddish-brown	H 2 G 2.9-3.1 F 3	Diss by acids. Tw. Pleoc str, X and Y pale yellow to flesh, Z carnelian red.
	1.779	1.780	1.816	.037	CHERALITE $(Ce,La,Th,Ca)(PO_4,SiO_4)$	18°	X = b Z:c = 7°	MCL	010 dist	Dark to pale green	H 5 G 5.28	Pleoc wk, X and Y green, Z yellow-green. Compare Monazite.
	1.77	1.78	1.80	.03	VANDENBRANDEITE $Cu(UO_2)(OH)_4$	Large	Opt ax ~ ⊥ (001)	TCL	110 perf 2 others	Dark green	H 4 G 5.0	Diss by hot HCl. Pleoc, yellow-green to blue-green.
	1.77	1.78	1.80	.03	MEDAITE $Mn_6V^{+5}Si_5O_{18}(OH)$	---	X = a Y = b el pos	MCL	100 good	---	G 3.70	---

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v 1.794	1.776	1.780	1.805	.029	CARYINITE $(Na,Ca,Pb)_3(Mg,Mn,$ $Fe^{+3})_4(AsO_4)_4$ (?)	41° r > v wk	X = c Y = a	MCL u mass	110, 010	Nut brown	H 4 G 4.27 F 2.5	Diss by HNO_3. Orange to red in section, not pleoc.
	1.753	1.782	1.815	.062	SHATTUCKITE $Cu_5(SiO_3)_4(OH)_2$	~ 90°	X = c Y = b	ORTH	010, 100	Blue	H 3.5 G 3.9-4.1	Pleoc, pale blue to deep blue.
	1.774	1.782	1.798	.028	RETZIAN-(Nd) $Mn_2(Nd,Ce,La)(AsO_4)$ $(OH)_4$	69°	X = c Y = b	ORTH	---	Brown	---	Pleoc, X yellow, Y reddish-brown, Z brown.
1.772 ^	1.756	1.788	1.829	.073	PIEMONTITE (Epidote grp) $Ca_2(Mn,Al,Fe)_3(SiO_4)_3$ (OH)	86° r < v	Y = b X:c = -9° el clv pos	MCL pris	001 perf	Reddish-brown	H 6 G 3.47	Insol in acids. Pleoc str, X yellow, Y violet, Z red. Mn_2O_3 22.0, Al_2O_3 12.4, Fe_2O_3 6.4%.
	1.777	1.788	1.800	.023	RETZIAN $Mn_2Ce(AsO_4)(OH)_4$	Large r < v wk	Y = b X = c	ORTH	---	Chocolate to chestnut-brown	H 4 G 4.15 F diff	Diss by acids. Pleoc, X cols, Y pale yellow-brown, Z reddish-brown.
1.778 ^v 1.801	1.787	1.789	1.839	.052	MONAZITE $(Ce,La,Nd)PO_4$	10-16° r < v wk	X = b Z:c = -4°	MCL	110 dist 010 diff	Brown to red	H 5-5.5 G 5.26 infus	Diff sol in HCl. Tw pl 100. Pleoc wk, X light yellow, Y dark yellow, Z greenish-yellow.
1.733 ^v 1.827	1.78	1.79	2.04	.26	FERRIMOLYBDITE $Fe_2(MoO_4)_3 \cdot 7\text{-}10H_2O$	Small r < v dist	Y = a Z = c	ORTH fib c	001 dist	Sulfur-yellow	H 1-2 G 2.99 F easy	Diss by HCl, dec by NH_4OH. Pleoc, X and Y pale yellow, Z yellow-green.
	1.75	1.79	1.85	.10	Hydrous U sulfate (?)	Med r < v str	Y = b Z = c el pos	ORTH 100 laths el c	---	Lemon-yellow	Soft	Diss by acids. Comp unknown.
	1.792	1.794	1.821	.029	JIMBOITE $Mn_3B_2O_6$	35° r > v	Y = b X = a el pos	ORTH	110 perf parting 101	Light purplish-brown	H 5.5 G 3.98	Diss by acids. Tw pl 101.
1.780 ^	1.794	1.794	1.803	.009	CARYINITE $(Na,Ca,Pb)_3(Mg,Mn,$ $Fe^{+3})_4(AsO_4)_4$ (?)	Small r > v wk	X = c Y = a	MCL u mass	110, 010	Brownish-red	H 3-4 G 4.3 F 2.5	Diss by HNO_3. Orange to red in section, not pleoc.

1.774 ^	1.780	1.795	1.815	.035	CONICHALCITE $CaCu(AsO_4)(OH)$	~ 90° r < v mod	---	ORTH equant	011 uneven	Grass-green	H 3 G 4.1 fus	Diss by acids. In thin-section yellow-green, faintly pleoc.
1.744 ^	1.785	1.796	1.814	.029	SCORODITE $FeAsO_4 \cdot 2H_2O$	75° r > v	X = a Y = c	ORTH pyram	201 imperf	Green to brown	H 3.5 G 3.29 F 2-2.5	Diss by acids. Pleoc wk, X and Y blue, Z red. Al_2O_3 1.8%.
	1.79	(1.79)	1.82	.03	KRYZHANOVSKITE $MnFe^{+3}{}_2(PO_4)_2(OH)_2 \cdot H_2O$	40-45° r < v str	---	ORTH pris	001 perf	Brown to greenish-brown	H 3.5-4 G 3.31 F 2.5	Diss by acids. Pleoc str, X wine-yellow, Y orange-brown, Z reddish-brown.
	1.743	1.80	1.88	.137	TUNDRITE $Na_3(Ce,La)_4(Ti,Nb)_2Si_2O_8(CO_3)_3O_4(OH) \cdot 2H_2O$	Large	Z:c = 14°	TCL	010 perf	Brownish-to greenish-yellow	H 3 G 3.7-4.0	Pleoc wk, X pale yellow, Z greenish-yellow.
	1.72	1.80	1.98	.26	HELMUTWINKLERITE $PbZn_2(AsO_4)_2 \cdot 2H_2O$	70° r < v dist	X:c = 50° Z:b = 30°	TCL	---	Cols to light blue	H 4.5 G 5.3	Diss by HCl.
	1.775	1.800	1.846	.071	BOTALLACKITE $Cu_2(OH)_3Cl$	Med large r > v str	X ⊥ clv	MCL	One direction	Bluish-green	G ~ 3.6 fus	Diss by acids. Slightly pleoc.
	1.792	1.801	1.852	.060	JINSHAJIANGITE $(Na,K)_5(Ba,Ca)_4(Fe,Mn)_{15}(Ti,Fe^{+3},Nb)_8(SiO_4)_{15}(F,OH)_{10}$	72° (47±6°) r < v	---	MCL tab	010, 100 perf	blackish-red to golden-red	G 3.61 (H 430 kg/sq mm)	Pleoc, X light golden-yellow, Y brownish-yellow, Z brownish-red.
	1.783	1.801	1.834	.051	FLINKITE $Mn^{+2}{}_2Mn^{+3}(AsO_4)(OH)_4$	Large (74±5°) disp wk	X = b Z = a	ORTH tab 001	One clv	Greenish-brown	H 4-4.5 G 3.87 F easy	Diss by acids. Pleoc, X yellow- to brownish-green, Y yellow-green, Z orange-brown.
1.789 ^v (1.821)	1.800	1.801	1.849	.049	MONAZITE $(Ce,La,Nd,Th)PO_4$	11° r < v wk	X = b Z:c = -10°	MCL	100 dist 010 diff	Yellow, red, brown	H 5 G 5.27 infus	Diff sol in acids. Pleoc wk in yellow. ThO_2 11.2%. (Solid soln with Huttonite.)
1.766 ^	1.782	1.802	1.835	.053	ALLUAUDITE $(Na,Ca)_4Fe^{+2}{}_4(Mn,Fe^{+2},Fe^{+3},Mg)_8(PO_4)_{12}$	79° r > v mod	Z = b Y:c = 18°	MCL u mass	$\bar{1}01$ perf 2 others	Greenish-black	H 5-5.5 G 3.58 F 3	Diss by acids. Pleoc, X light brown, Z dark brown.
v 1.82	1.793	1.804	1.87	.08	AENIGMATITE $Na_2Fe_5TiSi_6O_{20}$	Small	Z:c = 40°	TCL pris	010, 100	Black	H 5.5 G 3.8 F 3	Insol in acids. Tw $1\bar{1}0$. Pleoc str, X yellow-brown, Y dark brown, Z dark brown to black.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v 1.832	1.805	1.805	1.915	.110	LUDWIGITE $(Mg,Fe)_2Fe^{+3}BO_5$	Small r < v extr	X = a Y = b	ORTH	Uneven, parting 001	Greenish-black	H 5 G 3.8 F diff	Diss by acids. Pleoc, X and Y dark green, Z brown.
	~1.81	(~1.81?)	~1.83	~.02	WELSHITE $Ca_2Mg_4Fe^{+3}Sb^{+5}Be_2Si_4O_{20}$	(~ 25°)	---	TCL pris	Conch	Reddish-black	H 6 G 3.77	Opt char uncertain. 2E ~ 45°.
1.742 ^	1.772	1.810	1.863	.091	OLIVENITE $Cu_2(AsO_4)(OH)$	~ 90° r < v str	X = b Y = c	ORTH acic	101 conch	Olive-green	H 3 G 4.46 F 3	Diss by acids. In thin-section pale green, not pleoc.
	1.795	1.810	1.835	.040	TAVORITE $LiFe(PO_4)(OH)$	Large r > v str	---	TCL	---	Yellow-green	G 3.29 fus	Diss by acids. Pleoc, X and Y yellow-green, Z cols.
v 1.852	1.808	1.812	1.838	.030	TOERNEBOHMITE $(Ce,La)_3Si_2O_8(OH)$	20-30° (43±10°) r < v dist	---	MCL ps hex	---	Light green to olive	H 4.5 G 4.94	Slowly diss by hot concd acids. Pleoc, X rose to greenish-yellow, Y bluish-green, Z rose, abs Y > X = Z.
	1.80	---	1.87	.07	KEYITE $(Cu,Zn,Cd)_3(AsO_4)_2$	Disp str	Y = b X:c = 10°	MCL	001 good	Deep sky-blue	---	Pleoc, X pale blue, Y greenish blue, Z deep blue. Opt char unk.
1.774 ^	1.801	1.812	1.824	.023	GADOLINITE $Y_2Fe^{+2}Be_2Si_2O_{10}$	85° r < v	X = b Z:c = 4-13°	MCL	Conch	Greenish- to brownish-black	H 6.5 G 4.33 infus	Gel with acids. Pleoc, olive to green.
v 1.837	1.810	1.813	1.855	.045	DUFRENITE $Fe^{+2}Fe^{+3}{}_4(PO_4)_3(OH)_5\cdot 2H_2O$	Small r > v extr	Z = b el neg	MCL fib	010 perf	Dark green	H 3.5-4 G 3.2-3.4 F 2.5	Diss by acids. Pleoc str, X yellow-brown, Y deep blue, Z deep greenish-blue, abs Z > Y > X.
(1.773) ^	1.808	1.813	1.827	.019	WARWICKITE $(Mg,Fe^{+3},Ti,Al)_2(BO_3)O$	55°	X = c Y = b el c̄Tv neg	ORTH pris	100 perf	Dark brown to black	H 3.5-4 G 3.35 infus	Dec by H_2SO_4. Pleoc, X and Z dark brown, Y red-brown.
	1.81	1.815	~1.85	.04	CORNWALLITE $Cu_5(AsO_4)_2(OH)_4\cdot H_2O$	Small	---	MCL fib	Conch	Blackish-green	H 4.5 G 4.5 F 2-2.5	Diss by acids.

1.806	1.817	1.818	1.821	.004	CERITE $(Ce,Ca)_9(Mg,Fe)Si_7(O,OH,F)_{28}$	Small r < v very str	---	TRIG	Uneven	Clove-brown, reddish-gray	H 5.5 G 4.8-4.9 infus	Gel with acids.
	1.715	1.820	1.880	.165	DOLEROPHANITE $Cu_2(SO_4)O$	85° (110±1°) r > v very str crossed	Y = b Z:c = -10°	MCL	$\bar{1}01$ perf	Chestnut- to dark brown	H 3 G 4.17 fus	Diss by acids. Pleoc, X deep brown, Y brownish-yellow, Z lemon-yellow. Opt char neg?
1.804 ^	1.81	1.82	1.90	.09	AENIGMATITE $Na_2Fe_5TiSi_6O_{20}$	30-50°	Z:c = 40°	TCL pris	010, 100	Black	H 5.5 G 3.8 F 3	Insol acids. Tw pl $1\bar{1}0$. Pleoc, X yellow-brown, Y red-brown, Z dark brown to black.
v 1.85	1.81	---	1.84	.03	DEERITE $(Fe^{+2},Mn)_6(Fe^{+3},Al)_3Si_6O_{20}(OH)_5$	---	Z = c el pos	MCL acic	110 good	Black	G 3.84	Opt char not stated.
	1.813	1.820	1.830	.017	ANDREWSITE $(Cu,Fe)Fe^{+3}{}_3(PO_4)_3(OH)_2$	Large r > v extr crossed	---	ORTH fib	2 clv	Dark- to bluish-green	H 4 G 3.3-3.4	Diss by acids.
	1.809	1.821	1.857	.048	BETPAKDALITE $CaFe_2H_8(AsO_4)_2(MoO_4)_5 \cdot 10H_2O$	60°	Y = b X:c = 12°	MCL pris	---	Lemon-yellow	H 3 G 3.0 F 2	Diss by HCl. Pleoc, X pale yellow, Y greenish-yellow, Z bluish-green, abs Z > Y > X.
1.801 ◇ 1.900	1.821	(1.821)	1.825	.004	HUTTONITE cerian phosphatian $(Th,Ce)(SiO_4,PO_4)$	21° r < v wk	Y = b	MCL	---	Yellow to reddish-brown	H 5 G 5.06 infus	(Solid soln with Monazite.)
	1.799	1.822	1.855	.056	AZOPROITE $(Mg,Fe^{+2})_2(Fe^{+3},Ti,Mg)BO_5$	(81±14°)	X = b Y = a	ORTH pris	010 good 001 less so, conch	Black	H 5.5 G 3.63	Diss by HCl. Pleoc, X pale green, Y dark green, Z reddish-brown.
1.79 ^	1.806	1.827	2.005	.178	FERRIMOLYBDITE $Fe_2(MoO_4)_3 \cdot 7\text{-}10H_2O$	Small (41±2°) r < v dist	Y = a Z = c	ORTH fib c	001 dist	Sulfur-yellow	H 1-2 G 2.99 F easy	Diss by HCl. Pleoc, X and Y pale yellow, Z yellow-green.
v 1.880	1.82	1.83	1.88	.06	ROCKBRIDGEITE $(Fe^{+2},Mn)Fe^{+3}{}_4(PO_4)_3(OH)_5$	Med r > v very str	X = c	ORTH fib botry-oidal	100 perf 010 fair	Dark green	H 4.5 G 3.51 F easy	Diss by HCl. Pleoc, X yellow-brown, Y bluish-green, Z deep blue, abs Z > X > Y.
1.805 ◇ 1.865	1.825	1.832	1.940	.115	LUDWIGITE $(Mg,Fe)_2Fe^{+3}BO_5$	25-40° r < v str	X = a Y = b	ORTH	Uneven, parting 001	Greenish-black	H 5 G 3.9 F diff	Diss by acids. Pleoc, X blue-green, Y dark green, Z dark brown, abs Z > X > Y.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	---	1.833	---	wk	RUSAKOVITE $(Fe,Al)_5(VO_4,PO_4)_2(OH)_9 \cdot 3H_2O$	~ 50° r > v str	---	Cryptocryst	---	Yellow-orange	H 1.5-2 G 2.76	Diss by acids. Opt char unk.
2.02 ˇ	1.820	1.835	1.920	.100	VOLBORTHITE $Cu_3(VO_4)_2 \cdot 3H_2O$	63° (47+3°) r < v str	---	MCL	001 perf	Yellow-green	H 3-4 G 3.4-3.6	Diss by acids. Pleoc, X and Y yellow, Z yellow-green.
1.813 ^ v 1.855	1.832	1.837	1.890	.058	DUFRENITE $Fe^{+2}Fe^{+3}{}_4(PO_4)_3(OH)_5 \cdot 2H_2O$	Small r < v extr	Z = b el c̅l̅v neg	MCL fib	010 perf	Dark green to red-brown	H 3.5-4 G 3.2-3.4 F 2.5	Diss by acids. Pleoc str, X deep blue-green, Y yellow-brown, Z deep olive-brown.
	1.792	1.840	1.888	.096	LAUTARITE $Ca(IO_3)_2$	~ 90° r > v mod	Y = b X:c = 25°	MCL pris	011 good	Cols to light yellow	H 3.5-4 G 4.59 F 1.5	Slightly sol in H_2O, diss by HCl.
1.833 ⌐	1.802	1.840	1.888	.086	ORTHOERICSSONITE $BaMn_2(Fe^{+3}O)Si_2O_7(OH)$	~ 50° (85+3°) r > v str	X = b Y = c el c̅l̅v neg	ORTH	100 perf	Brownish-black	H 5.5 G 4.22	Pleoc, X yellow-brown, Y reddish brown, Z dark brown, abs Z > Y > X.
	1.842	1.842	1.848	.006	PARATACAMITE $Cu_2(OH)_3Cl$	0-50° r > v	---	TRIG	10$\bar{1}$1 good	Dark green	H 3 G 3.74 F easy	Diss by acids. Poly tw 10$\bar{1}$1.
	---	~1.84	---	---	ITOITE $Pb_3Ge(SO_4)_2O_2(OH)_2$	---	---	ORTH acic	---	White	G 6.67 calc	Opt char unk.
	1.840	1.847	1.892	.052	LAUBMANNITE $Fe^{+2}{}_3Fe^{+3}{}_6(PO_4)_4(OH)_{12}$	Med r < v extr	---	ORTH fib	Clv || fibers	Gray-green, yellow-green	H 3.5 G 3.33	Diss by acids. Pleoc, X buff, Y greenish-brown to olive-green, Z reddish-brown, abs Z > Y > X.
1.82 ^	1.840	---	1.870	.030	DEERITE $(Fe^{+2},Mn)_6(Fe^{+3},Al)_3{}^{9}9Si_6O_{20}(OH)_5$	---	Z = c el pos	MCL acic	110 good	Black	G 3.84	Opt char unk.
	1.85	1.85	1.88	.03	PARWELITE $(Mn,Mg)_5Sb(As,Si)_2O_{12}$	27° r > v str	---	MCL pris	010 fair	Yellowish brown	H 5.5 G 4.62	Insol in dil HCl.

v 1.89	1.85	1.85	1.87	.02	DUMONTITE $Pb_2(UO_2)_3(PO_4)_2(OH)_4 \cdot 3H_2O$	Small r < v str	X = b Y = c	MCL	---	Yellow	G 5.7	Diss by acids.
1.812 ^	1.845	1.852	1.878	.033	TOERNEBOHMITE $(Ce,La)_2AlSi_2O_8(OH)$	20-40° (55±8°) r < v dist	---	MCL ps hex	---	Light green to olive	H 4.5 G 4.94	Slowly diss by hot concd acids. Pleoc, X rose to greenish-yellow, Y bluish-green, Z rose.
1.854 neg ^	1.820	1.854	1.888	.068	LIEBENBERGITE (Olivine grp) $(Ni,Mg,Fe,Co)_2SiO_4$	92° r < v	X = b Z = a	ORTH	010 poor to fair 100 poor	Yellowish green	H 6-6.5 G 4.60	X, Y cols to pale green, Z greenish yellow. NiO 56.3, MgO 6.5, FeO 4.4 CoO 1.8%.
	1.852	(1.854)	1.867	.015	LUDDENITE $Pb_2Cu_2Si_5O_{14} \cdot 14H_2O$	40°	---	MCL	---	Green	H 4 G 4.45 F easy	Pleoc, X and Y yellow-green, Z emerald-green.
1.837 ^	1.845	1.855	1.890	.045	DUFRENITE $Fe^{+2}Fe^{+3}{}_4(PO_4)_3(OH)_5 \cdot 2H_2O$	Small (57±6°) r < v str	Z = b el c̄lv neg	MCL fib	010 perf	Reddish-brown	H 3.5-4 G 3.2-3.4 F 2.5	Diss by acids. Pleoc str, X pale yellow-brown, Y yellow-brown, Z red-brown.
	---	1.855	>1.88	---	ANANDITE (Mica grp) $(Ba,K)(Fe,Mg)_3(Si,Al,Fe)_4O_{10}(O,OH)_2$	Disp str	Y = b Z:a = 12° el clv pos	MCL ps hex plates	001 perf	Black	H 3-4 G 3.94	Nearly opaque. Pleoc, Y green, Z brown.
v 1.92	1.85	1.86	1.92	.07	PURPURITE $(Mn^{+3},Fe^{+3})PO_4$	Med	X = a	ORTH	100 good 010 less so	Deep red or purple	H 4-4.5 G 3.4 F easy	Diss by acids. Pleoc str, X dark brownish-gray, Y scarlet, Z purple.
	1.835	---	1.910	.075	DEMESMAEKERITE $Pb_2Cu_5(UO_2)_2(SeO_3)_6(OH)_6 \cdot 2H_2O$	---	---	TCL el ⊥ 100	---	Bottle-green	H 3-4 G 5.28	Diss by dilute HNO_3.
1.751 ^ 1.88	1.851	1.864	1.894	.043	SYNADELPHITE $(Mn,Mg,Ca,Pb)_9(AsO_3)(AsO_4)_2(OH)_9 \cdot 2H_2O$	40° (68±6°) r > v	---	TCL ps orth	010 imperf	Cols to red-brown	H 4.5 G 3.8 F 2	Diss by HNO_3. Pleoc, X light brown, Y brown, Z dark red-brown.
1.832 ^	1.850	1.865	1.985	.135	LUDWIGITE $(Mg,Fe)_2Fe^{+3}BO_5$	25-40° (41±3°) r < v str	X = a Y = b	ORTH	Uneven, parting 001	Greenish-black	H 5 G 4.0 F diff	Slowly diss by acids. Nearly opaque, X and Y dark green, Z brownish-black.
v 1.907	1.843	1.870	1.943	.100	TITANITE $(Ca,Y)TiSiO_4(O,OH)$	38° (65±3°) r > v str	Y = b Z:c = 40°	MCL wedges	110 good	Yellow to reddish-brown	H 4.5 G 3.56 F 3	Dec by hot H_2SO_4. Pleoc, X pale yellow, Y pale greenish, Z pink to reddish-brown.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien- tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
	1.817	1.879	2.057	.240	UVANITE $(U,Ca)_2V_6O_{21}\cdot 15H_2O$ (?)	52° (66±1°)	---	ORTH(?)	2 clv pina- coidal	Brownish- yellow	---	Diss by NH_4OH. Pleoc, X light brown to yellow, Y dark brown, Z greenish yellow. Not fluor in UV.
	1.841	(~1.88)	1.935	.094	PERETAITE $CaSb_4O_4(OH)_2(SO_4)_2\cdot 2H_2O$	Large	---	---	100	Cols	G 4.06	---
	1.87	1.880	1.98	.11	LEITEITE $ZnAs_2O_4$	26° r < v str	Y = b Z:c = 10°	MCL	100 perf	Cols to brown	G 4.61	Lam flexible, inelastic.
v 1.910	1.877	1.880	1.935	.058	KASOLITE $Pb(UO_2)SiO_4\cdot H_2O$	43° (27±8°)	X = b Z:c = 1° el clv neg	MCL pris	001 perf 100, 010 indist	Ocher- yellow to amber	H 4.5 G 5.8-6.5	Gel with acids. Pleoc wk or absent.
v 1.96	---	1.88	---	high	CHENEVIXITE $Cu_2Fe_2(AsO_4)_2(OH)_4\cdot H_2O$	---	X = b Z ~ c	MCL crypt- ocryst	---	Dark green to greenish- yellow	H 3.5-4.5 G 3.93 F 2.5	Diss by acids.
1.83 ^	1.875	1.880	1.897	.022	ROCKBRIDGEITE $(Fe,Mn)Fe^{+3}{}_4(PO_4)_3(OH)_5$ $(OH)_5$	Med r > v very str	X = c	ORTH fib	100 perf 010 fair	Dark green	H 4.5 G 3.5	Diss by HCl. Pleoc, X yellow-brown, Y bluish-green, Z dark bluish-green.
	>1.87	(1.88)	<1.89	---	STIBIVANITE $Sb^{+3}{}_2V^{+4}O_5$	85° r > v str	X = b Z = c	MCL fib	---	Yellow- green	---	Opt sign unk. Pleoc, X and Y emerald- green, Z olive-green.
	---	1.88	---	---	RAUVITE $Ca(UO_2)_2V_{10}O_{28}\cdot 16H_2O$	---	---	Mass	---	Purplish- black	---	Opt char unk.
(1.697) ^	1.877	1.883	1.894	.017	ANGLESITE (Barite grp) $PbSO_4$	68-75° r < v str	Y = b X = c	ORTH	001 good 210 dist	Cols	H 2.5-3 G 6.38 F 1.5	Slowly diss by HNO_3.
1.85 ^	1.88	1.89	1.90	.020	DUMONTITE $Pb_2(UO_2)_3(PO_4)_2(OH)_4\cdot 3H_2O$	Large r < v str	X = b Y = c	MCL	---	Yellow	G 5.7	Diss by acids.
	1.89	1.89	2.00	.11	DENNINGITE $(Mn,Zn)Te_2O_5$	0-15°	---	TET mass	001 perf	Pale green	H 4 G 5.05 F easy	Diss by cold HCl, insol in HNO_3.

	1.882	(1.895)	1.915	.033	HALLIMONDITE $Pb_2(UO_2)(AsO_4)_2$	80° r > v	Z':c = 11° on $\bar{1}00$, X':b = 9° on $\bar{0}01$	TCL tab	Conch	Yellow	H ~ 3 G 6.39	Diss by HNO_3.
	1.888	1.895	1.915	.027	Unknown	62° r > v str	---	---	---	Pale green	---	Labelled "scorodite," Kiura, Japan. Larsen (1921).
	1.898	(1.898)	1.915	.017	HUEGELITE $Pb_2(UO_2)_3(AsO_4)_2(OH)_4\cdot$ $3H_2O$	Small	---	MCL tab 100	100 good	Orange- yellow to brown	---	Pleoc, X yellow, Y orange-yellow, Z cols to pale yellow. Anom interf colors.
	1.898	(1.899)	1.915	.017	HUEGELITE $Pb_2(UO_2)_3(AsO_4)_2(OH)_4\cdot$ $3H_2O$	25°	---	MCL	100 very good, conch	Brown to orange	H 2.5	Pleoc, X yellow, Y yellow to orange, Z cols to pale yellow.
	<1.89	1.90	1.95	>.06	LAMMERITE $Cu_3(AsO_4)_2$	54±5°	X = b Z:c = 40°	MCL tab	010 perf 100 good	Dark green	H 3.5-4 G 5.18	Pleoc, X bright blue, Y sky blue, Z bluish- green.
	1.810	1.900	>2.01	>.20	DUTTONITE $VO(OH)_2$	60° r < v mod	X = a Y = c	MCL	---	Light brown	H 2.5 G 3.24	Pleoc, X pale pinkish-brown, Z pale brown.
	1.890	1.90	1.99	.10	BELLINGERITE $Cu_3(IO_3)_6\cdot 2H_2O$	Med r > v str	---	TCL pina- coidal	Subconch	Light green	H 4 G 4.89	Diss by HCl. Gives iodine vapor when heated in closed tube.
(1.821) ^	1.898	1.900	1.922	.024	HUTTONITE $ThSiO_4$	25° r < v mod	Y = b Z ~ c	MCL	---	Cols to pale cream	G 7.1 infus	---
	1.899	(1.901)	1.903	.004	QUEITITE $Pb_4Zn_2(SO_4)(SiO_4)$ (Si_2O_7)	~ 90° r < v str	X = b Z:a varies	MCL tab	---	Cols to pale yellow	H 4 G (6.07)	Diff diss by HNO_3. Z:a = 40° at 405 nm, 0° at 592 nm.
1.870 ↕ 1.970	1.900	1.907	2.034	.134	TITANITE $CaTiSiO_5$	27° r > v str	Y = b Z:c = 40- 50°	MCL	110 good	Yellow, brown, cols	H 5 G 3.55 F 4	Dec by hot H_2SO_4. Pleoc, X pale yellow, Y greenish, Z red to brown.
	1.85	1.91	(2.20)	.35	SPIROFFITE $(Mn,Zn)_2Te_3O_8$	55°	---	MCL mass	2 clv, conch	Red to purple	H 3.5 G 5.01 F easy	Diss by Hcl.
	1.890	1.91	1.977	.087	SCHULTENITE $PbHAsO_4$	58° disp str	X = b Z:c = 66° el pos	MCL thin plates, 010	010 good	Cols	H 2.5 G 5.94	---

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien- tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.880 ^	1.895	1.910	1.950	.055	KASOLITE $Pb(UO_2)SiO_4 \cdot H_2O$	43° (64±5°)	X = b Z:c ~ 1° el clv neg	MCL pris	001 perf 100, 010 indist	Ocher-yellow to amber-brown	H 4.5 G 5.8-6.5	Gel with acids. Pleoc wk or absent.
	---	>1.9 <2.0	---	.110	PAULMOOREITE $Pb_2As^{+3}{}_2O_5$	65° r > v very str	Y = b Z:c = 10° el clv neg	MCL	001 perf	Cols to light orange	H ~ 3 G 7.0:Luster adamantine.	Diss by 1:1 HNO_3.
	1.91	1.91	1.945	.035	GANOMALITE $Pb_6Ca_4Si_6O_{21}(OH)_2$	Small	---	HEX tab 0001	10$\bar{1}$0 perf 0001 less so	Gray	H 3 G 5.74 F 3	Gel with HNO_3.
	1.871	1.92	2.01	.139	CLAUDETITE As_2O_3	58° r < v str	Y = b Z:c = 5°	MCL thin tab 010	010 perf	Cols	H 2.5 G. 4.15 volat	Slightly sol in hot H_2O. Tw on 100, penet.
	1.89	1.92	1.95	.06	TSUMEBITE $Pb_2Cu(PO_4)(SO_4)(OH)$	88° r < v str	---	MCL tab	Uneven	Emerald-green	H 3.5 G 6.1 fus	Diss by HNO_3. Pleoc, X and Y pale blue, Z robin's egg blue.
1.86 ^	---	1.92	---	.04	PURPURITE $(Mn^{+3},Fe^{+3})PO_4$	38°	X = a	ORTH	100 good 010 less so	Deep red or purple	H 4-4.5 G 3.2-3.4 F easy	Diss by acids. Pleoc str, X dark brownish-gray, Y scarlet, Z purple.
	1.920	(1.921)	1.943	.023	OTJISUMEITE $PbGe_4O_9$	20°	X:c = 3-5°	TCL	001 in traces	Cols to white	H 3 G (5.77)	Diss by hot HNO_3.
	1.880	1.928	2.029	.149	CESBRONITE $Cu_5(TeO_3)_2(OH)_6 \cdot 2H_2O$	72° r > v mod	X = a Y = c	ORTH el a	021 good 010 poor	Green	H 3 G 4.45 F easy	Diss by acids. Pleoc, X pale bluish-green, Y yellow-green, Z deep emerald-green.
[ ]	~1.93	~1.93	1.97	.04	ZIRCON $ZrSiO_4$	0-10°	---	TET pris	110	Brown, pink, cols	H 7.5 G 4.7 infus	Insol in acids. Abnorm biax.
	1.920	1.960	2.20	.28	GRAEMITE $CuTeO_3 \cdot H_2O$	48°	---	ORTH	010 good parting 100	Blue-green	H 3-3.5 G 4.13 F easy	Diss by acids. Pleoc, X yellow-green, Y and Z blue-green.
1.88 ^	1.92	1.96	2.04	.12	CHENEVIXITE $Cu_2Fe_2(AsO_4)_2(OH)_4 \cdot 4H_2O$	(73±10°)	X = b Z ~ c	MCL	---	Dark green	H 4 G 3.5 F 2.5	Diss by acids.

	1.963	1.963	1.966	.003	HYALOTEKITE $Pb_2Ba_2Ca_2B_2(Si,Be)_2Si_8O_{28}F$	Small $r < v$ str	Opt pl ⊥ clv	TCL	2 clv at 90°	Cols	H 5-5.5 G 3.80 F 3 (?)	Insol in acids.
	1.952	---	2.002	.052	KURANAKHITE $PbMn^{+4}Te^{+6}O_6$	---	---	ORTH ps hex	---	Brown to black	H 4-5	Diss by HCl with evolution of chlorine. Opt sign unk.
1.907 ^	1.950	1.970	2.092	.142	TITANITE $CaTiSiO_5$	18° (46±2°) $r > v$ str	Y = b Z:c = 40-50°	MCL	110 good	Yellow, brown, cols	H 5 G 3.52 F 4	Dec by hot H_2SO_4. Pleoc, X pale yellow, Y greenish, Z red to brown.
	1.95	1.97	1.99	.04	BAYLDONITE $Pb(Cu,Zn)_3(AsO_4)_2(OH)_2 \cdot H_2O$	Large $r < v$ str	X = b Y:el = 45°	MCL fib c	---	Grass- to dark-green	H 4.5 G 5.6 F easy	Diss by HNO_3. Tw.
	1.96	1.98	2.06	.10	URANOSPHAERITE $Bi_2U_2O_9 \cdot 3H_2O$	56° $r < v$ str	Y = b Z = c	MCL el c	100	Reddish-orange, yellow	H 2-3 G 6.9	Diss by acids.
v 2.05	2.00	2.01	2.02	.02	CALCIOVOLBORTHITE $CaCuVO_4(OH)$	Large $r > v$ str	X = a Y = b	ORTH	010, 001	Greenish-yellow	H 3-4 G 3.75 F 2 (?)	Diss by HCl. Pleoc wk.
	1.84	>1.84	$>>1.84$	high	METAROSSITE $CaV_2O_6 \cdot 2H_2O$	Large	---	TCL	One perf	Dull yellow	Soft F easy	Diss by HCl.
1.835 ^ 2.05	2.01	2.02	2.06	.05	VOLBORTHITE $Cu_3(VO_4)_2 \cdot 3H_2O$	Large $r < v$ str	---	MCL	001 perf 010	Dark green to yellow-green	H 3-4 G 3.42-3.62	Diss by acids. Tw. Pleoc, X and Y yellow, Z yellow-green.
	1.958	2.037	2.245	.287	SULFUR S	69° $r < v$	X = a Y = b	ORTH pris	001, 110, 111 imperf	Yellow	H 2 G 2.07 F 1	Insol in acids, diss by CS_2. Burns. Tw pl 101. Pleoc.
v 2.11	1.98	2.040	2.13	.15	FERSMITE $(Ca,Ce,Na)(Nb,Ta,Ti)_2(O,OH,F)_6$	Med (82±15°)	---	ORTH	Uneven subconch	Dark yellow, brown, black	H 4-5 G 4.7-4.9 infus	Nearly insol in acids.
	2.016	2.040	2.130	.114	GAMAGARITE $Ba_4(Fe,Mn)_2V_4O_{15}(OH)_2$	47-62° $r < v$ str	Y = b	MCL	2 clv	Dark brown	H 4.5-5 G 4.63	Pleoc, red-brown to yellow.
v 2.25	1.90	2.05	2.50	.60	MANGANITE MnO(OH)	Small (71±5°) $r > v$ str	X ~ a Y ~ b	MCL pris	010 perf 110, 001 good	Steel-gray to iron-black	H 4 G 4.33 infus	Diss by HCl. Pleoc wk, abs $Z > X$ and Y.
	---	2.05	---	high	FERNANDINITE $CaV^{+4}{}_2V^{+5}{}_{10}O_{30} \cdot 14H_2O$ (?)	---	---	Cryptocryst	---	Dull green	---	Diss by acids. Not pleoc. Opt char unk.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
2.01 ^	2.01	2.05	2.09	.08	CALCIOVOLBORTHITE $CaCuVO_4(OH)$	83° r > v str	X = a Y = b	ORTH	010, 001	Greenish-yellow	H 3-4 G 3.75 F 2 (?)	Diss by HCl. Pleoc wk.
⌴ 2.07	2.05	2.05	2.07	.02	CARMINITE $PbFe_2(AsO_4)_2(OH)_2$	Med r < v str	X = c	ORTH acic	Pris	Carmine to lilac	H 3.5 G 5.22 F easy	Diss by HNO_3. Pleoc, X and Z red-brown, Y greenish-brown.
	1.96	2.055	>2.11	>.15	LUDLOCKITE $(Fe^{+2},Pb)As^{+5}{}_2O_6$	---	Z ~ a el pos	TCL tw	$0\bar{1}1$ perf	Red	H 1.5-2 G 4.40	Diss by concd acids. Sectile and flexible. Pleoc, X yellow, Y deep yellow, Z orange-yellow.
	>2.01	>2.01	>2.01	high	GERSTLEYITE $Na_2(Sb,As)_8S_{13}\cdot 2H_2O$	Large (?)	---	MCL	010, $\bar{1}01$ perf	Cinnabar-to blackish-red	H 2.5 G 3.62 F 2	Diss by alkalies. Pleoc, X salmon-red, Y and Z deep blood-red. Opt char unk.
	>2.01	>2.01	>2.01	.07	SUNDIVSITE $Pb_{10}(SO_4)Cl_2O_8$	---	---	MCL	100 perf	Cols to white	H 3 G 7.0	---
	---	2.087	---	wk	SENARMONTITE Sb_2O_3	---	---	CUB oct	111 in traces	Cols	H 2 G 5.50 F 1.5 volat	Diss by HCl. Anom biaxial.
	>2.05	>2.05	>2.05	~.14	RYNERSONITE $Ca(Ta,Nb)_2O_6$	---	X = c Y = b	ORTH fib	Uneven	Creamy white to pink	H ~ 4.5 G 6.40	Pleoc, X and Y straw yellow, Z light straw yellow.
	2.05	(2.11)	2.20	.15	BLIXITE $Pb_2Cl(O,OH)_2$	80°	---	ORTH	One dist	Pale yellow	H 3 G 7.35	Diss by HNO_3.
2.040 ^	2.095	2.11	2.23	.135	FERSMITE $(Ca,Ce,Na)(Nb,Ta,Ti)_2(O,OH,F)_6$	Med	---	ORTH	Uneven, subconch	Brown to black	H 4-5 G 4.7-4.9 infus	Nearly insol in acids.
	2.08	2.11	---	---	DUHAMELITE $Pb_2Cu_4Bi(VO_4)(OH)_3\cdot 8H_2O$	---	Z:c = 3°	ORTH	---	Yellow-green	H 3 G 5.80	Opt sign unk. Pleoc wk in yellow. Diss by HNO_3.
	2.110	2.112	2.165	.055	KHINITE $PbCu_3Te^{+6}O_4(OH)_6$	20°	---	ORTH	001 fair	Dark green	H 3.5 G 6.7	---

	2.10	---	2.30	.20	ROOSEVELTITE $BiAsO_4$	---	---	MCL	Conch	Gray to yellow	H 4-4.5 G 6.9-7.1 F 2-3	Diss by acids. Opt char unk.
	>2.11	---	<2.13	<.02	SCHNEIDERHOEHNITE $Fe^{+2}{}_8As^{+3}{}_{10}O_{23}$	---	---	TCL	100 perf 2 others	Dark brown	H 3 G 4.3	Pleoc, reddish-brown to bright yellow, abs X < Y < Z.
	2.115	2.135	2.26	.125	RAJITE $CuTe^{+4}{}_2O_5$	40° disp wk	---	MCL	010	Green	H 4 G 5.75 fus	Diss by cold acids. Pleoc wk in green, abs Z > Y > X.
	2.01	---	---	---	SANTAFEITE $Na_2(Mn,Ca,Sr)_6Mn^{+4}{}_3(V,As)_6O_{28}\cdot 8H_2O$	---	X = c	ORTH ros-ettes	010 perf 110 dist	Brownish-black	G 3.38 F easy	Diss by HCl. Pleoc yellow-brown to dark red-brown, abs X > Y > Z. Opt char unk.
	2.14	---	2.15	.01	EZTLITE $Pb_2Fe^{+3}{}_6(Te^{+4}O_3)_3(Te^{+6}O_6)(OH)_{10}\cdot 8H_2O$	---	Z:c = 3°	MCL	001	Deep orange	---	Sign unk. Not pleoc.
	---	2.15	---	high	CUPROTUNGSTITE $Cu_2(WO_4)(OH)_2$	---	---	Crypt-ocryst	---	Green	Fus	Dec by HCl. Opt char unk.
	2.14	2.15	2.18	.04	ATELESTITE $Bi_8(AsO_4)_3O_5(OH)_5$	44° r < v str	---	MCL	010 indist	Sulfur-yellow	H 4.5-5 G 6.8-7.1 F 1.5	Diss by HCl.
	>2.09	>2.09	>2.09	---	MOUNANAITE $PbFe_2(VO_4)_2(OH)_2$	---	On 010, ext:c = 38°	TCL el c	---	Brownish-red	G 4.85	Tw common. Pleoc, brownish-red to brownish-yellow. Opt char unk.
	2.130	2.16	2.195	.065	PREISINGERITE $Bi_3(AsO_4)_2O(OH)$	90°	---	TCL tab	---	White to gray	G (7.24)	---
	2.12	2.17	2.31	.19	MELANOTEKITE $Pb_2Fe_2Si_2O_9$	67° r > v str	---	ORTH pris	2 clv	Black	H 6.5 G 5.73 F 2-2.5	Dec by HNO_3. Pleoc str, X nearly cols, Y pale red-brown, Z deep reddish-brown.
2.ˇ21	2.15	2.17	2.25	.10	MANGANOTANTALITE $Mn(Ta,Nb)_2O_6$	r < v disp extr	X = a Y = b	ORTH	010 perf	Deep red to black	H 5-6 G 7.5 infus	Insol in acids. Pleoc, X and Y deep red, Z pink.
	2.17	2.17	2.18	.01	GEORGIADESITE $Pb_8(AsO_4)_2Cl_7(OH)_3$	Large r < v str	Y = b Z = c	MCL	---	White	H 3.5 G 7.1 F easy	Diss by HNO_3.
	2.11	2.18	2.22	.11	BALYAKINITE $CuTeO_3$	80°	X = a Y = b	ORTH	---	Gray-green to bluish-green	G 5.6	---
	2.14	---	2.24	.10	FORNACITE $(Pb,Cu)_3[(Cr,As)O_4]_2(OH)$	---	---	MCL	---	Olive-green	G 6.2	Slightly pleoc. Opt char uncertain.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
	2.00_{Li}	2.18_{Li}	2.35_{Li}	.35	TELLURITE TeO_2	~ 90° r < v med	X = b Z = c el pos	ORTH acic c	010 perf	Cols	H 2 G 5.90 F 2	Diss by HCl.
v ~2.23	2.14	---	2.23	.09	WODGINITE $(Ta,Nb,Sn,Mn,Fe)_{16}O_{32}$	---	Z:c = 26°	MCL	---	Red-brown	H 6 G 7.6 infus	Insol in acids. Pleoc, light yellow to reddish-brown.
	2.14	---	2.315	.18	VIGEZZITE $(Ca,Ce)(Nb,Ta,Ti)_2O_6$	Large	X = c Z = a	ORTH prism	100 dist	Orange-yellow	G (5.34)	Sign unk. Not pleoc.
	1.94	2.20	2.51	.57	LEPIDOCROCITE FeO(OH)	83° (96±4°)	X = b Y = c	ORTH blades 100	010 perf 100 less so 010 fair	Red	H 5 G 4.09 infus	Slowly diss by HCl. Pleoc str, X yellow, Y red, Z deeper red.
	2.13	2.20	2.40	.27	ANGELELLITE $Fe_4(AsO_4)_2O_3$	Med large	---	TCL	001	Blackish-brown	H 5.5 G 4.86	Pleoc str, yellow to deep red.
	2.10	2.20	2.31	.21	KENTROLITE $Pb_2Mn_2Si_2O_9$	88° r < v str	X = a Y = b	ORTH pris	110 dist	Dark reddish-brown	H 5 G 6.19 F 2-2.5	Dec by HNO_3. Pleoc, X pink, Z brownish-red, abs Z > Y > X.
	2.19	2.20	2.33	.14	TRIPUHYITE $FeSb_2O_6$	Small r < v very str	---	TET mass	---	Greenish-yellow, yellow-brown	H ~ 6 G 5.6-5.8 F 4-5 (?)	Insol in acids.
	2.18	(2.21)	2.26	.08	EUXENITE $(Y,Ca,Ce,U,Th)(Nb,Ta,Ti)_2O_6$	70°	Y = a Z = b	ORTH	Conch	Brownish-black	H 5-5.5 G 5.0-5.4 infus	Dec by hot concd acids.
2.17 ◊ 2.32	2.17	2.21	2.25	.08	MANGANOTANTALITE $(Mn,Fe)(Ta,Nb)_2O_6$	Large r < v str	X = a Y = b	ORTH pris	101 dist 100 poor	Red to reddish-brown	H 6 G 7.52 infus	Insol in acids. Pleoc, X and Y deep red, Z pink, abs X > Y >> Z.
v 2.30	2.19	2.21	2.25	.06	AESCHYNITE-(Y) $(Y,Ca,Fe,Th)(Ti,Nb)_2(O,OH)_6$	74°	el neg	ORTH	100, 010, 001 perf uneven	Yellow	H 5 G 4.4 infus	Insol in HCl, diss by H_2SO_4.
	---	2.21	---	low	ROMEITE $(Ca,Fe,Mn,Na)_2(Sb,Ti)_2O_6(O,OH,F)$	Large	---	CUB oct	111 imperf fr uneven	Yellow	H 6.5 G 5.0 infus	Insol in acids. Abnorm violet interf colors.
	2.185	2.219	2.266	.081	HEYITE $Pb_5Fe^{+2}{}_2(VO_4)_2O_4$	89° (82±3°)	Y = b X:c = 36°	MCL	Uneven	Yellow-orange	H 4 G 6.3	Tw 110.

v 2.36	2.17	2.22	2.32	.15	HUEBNERITE (Wolframite ser) (Mn,Fe)WO_4	73°	X = b Z:c = 18° el clv pos	MCL bladed, tab 100	010 perf	Brownish-red	H 5-5.5 G 7.35 F 4	Dec by HCl with sepn of yellow WO_3. Pleoc, X pale yellow, Y yellow-brown, Z green.
	2.20	2.22	2.26	.06	COTUNNITE $PbCl_2$	67°	X = b Z = c el clv pos	ORTH acic a	010 perf	White, yellow	H 2.5 G 5.8 F 1	Diss by hot water.
	2.19	2.23	2.35	.16	PLUMBOTELLURITE $PbTeO_3$	~ 50°	---	ORTH	---	Gray to brown	Soft G 7.2	---
~2.18 ^	2.20	---	2.27	.07	WODGINITE (Ta,Nb,Sn,Mn,Fe)$_{16}O_{32}$	---	---	MCL	---	Red-brown, dark brown	H 6 G 7.2-7.4 infus	Insol in acids.
2.05 ^	2.24_{Li}	2.25_{Li}	2.53_{Li}	.29	MANGANITE MnO(OH)	Small r > v str	X ~ a Y ~ b	MCL pris	010 perf 110, 001 less so	Steel-gray to black, streak brownish	H 4 G 4.33 infus	Diss by HCl. Pleoc wk, abs Z > X and Y.
	2.24	---	2.26	.02	OBOYERITE $Pb_6H_6(TeO_3)_3(TeO_6)_2\cdot 2H_2O$	---	---	TCL fib	---	White	H 1.5 G 6.46	Opt sign unk.
	2.18	2.26	2.35	.17	DESCLOIZITE Pb(Zn,Cu)VO_4(OH)	~ 90° r < v str	X = c Y = b	ORTH	Conch	Brownish-red, brown, black	H 3.5 G 5.9-6.2 F 1.5	Diss by HNO_3. Pleoc, X and Y yellow, Z brownish.
	2.17	2.26	2.34	.17	MOTTRAMITE Pb(Cu,Zn)VO_4(OH)	~ 90° r < v str	X = c Y = b	ORTH	Conch	Reddish-brown, olive-green	H 3.5 G 5.9-6.2 F 1.5	Diss by HNO_3. Pleoc, X and Y greenish-yellow, Z brownish-yellow.
	2.20	(~2.27)	2.42	.22	SCHUMACHERITE $Bi_3(VO_4)_2O(OH)$	Large	X:c = 22°	TCL tab b	Conch	Yellow	H 3 G 6.90	---
	2.24	2.27	2.31	.07	MENDIPITE $Pb_3O_2Cl_2$	~ 90° r < v str	X = a Y = b el pos	ORTH fib	110 perf 100, 010 less so	White	H 2.5 G 7.24 F 1	Diss by HNO_3.
	2.27	2.27	2.30	.03	RASPITE $PbWO_4$	Very small	Y = b Z:c = 30°	MCL tab 001	100 perf	Brownish-yellow	H 2.5-3 G 8.46 F 2.5-3	Dec by HNO_3. Abs Z > X and Y.
2.21 ◊ 2.32 neg	2.28	2.30	2.34	.06	AESCHYNITE (Ce,Ca,Fe,Th)(Ti,Nb)$_2$(O,OH)$_6$	80°	---	ORTH	Conch	Brownish-black	H 5.5 G 5.2 infus	Partly dec by hot acids. Commonly metamict.
v 2.40	---	2.30	---	low	PEROVSKITE (Ca,Ce,Na)$_2$(Ti,Nb)$_2O_6$	~ 90°	X = a Z = b	ORTH ps cub	100, 110	Brownish-black,	H 5.5-6 G 4.0-4.2	Insol in acids. Pleoc wk, X light green, Z darker green.

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
2.21 ^	2.26	2.32	2.43	.17	TANTALITE $(Fe,Mn)(Ta,Nb)_2O_6$	Large r < v str	X = a Y = b	ORTH pris	010 dist 100 less so	Black	H 6 G 6.6-8.0 infus	Insol in acids. Nearly opaque. Pleoc str, X pale yellow, Y red-brown, Z dark red-brown.
	2.31	2.35	2.40	.09	ASHANITE $(Nb,Ta,U,Fe,Mn)_4O_8$	---	X = b Y = a	ORTH	Conch	Brown to black	H 6-6.5	Pleoc, X light brownish-red, Z dark brownish-red.
	2.30_{Li}	2.35_{Li}	2.40_{Li}	.10	NADORITE $PbSbO_2Cl$	Large r > v str	X = b Z = a el pos	ORTH tab 010	010 perf	Brown to yellow	H 3.5-4 G 7.02 F 1.5	Diss by HNO_3. Tw on 101.
	2.39	(2.36)	2.52	.13	THOREAULITE $SnTa_2O_6$	30-35° r > v str	Y = b Z:c = 58°	MCL	100 good 011 less so	Brown	H 5.5-6 G 7.5-7.9	---
	2.28_{Li} 2.28_{Na}	2.36_{Li} 2.38_{Na}	2.48_{Li} 2.49_{Na}	.20 .21	BRACKEBUSCHITE $Pb_2(Mn,Fe)(VO_4)_2 \cdot H_2O$	Large r > v rather str	---	MCL acic	---	Dark brown to black	G 6.05 F 2 (?)	Pleoc str, X nearly cols, Y dark reddish-brown, Z clear reddish-brown.
2.22 ^	2.31_{Li}	2.36_{Li}	2.46_{Li}	.15	WOLFRAMITE $(Fe,Mn)WO_4$	60-70° r < v	X = b Z:c = 26° el clv pos	MCL tab 100	010 perf	Brownish-black	H 5-5.5 G 7.4 F 3	Dec by hot HCl with sepn of yellow WO_3. Nearly opaque. Pleoc str, abs X > Y > Z.
	2.31_{Li}	2.37_{Li}	2.66_{Li}	.35	CROCOITE $PbCrO_4$	55°(Na) r > v very str, inclined	Y = b Z:c = 5°	MCL	110 dist	Hyacinth-red, orange	H 2.5-3 G 6.0-6.1 F 1.5	---
	2.34_{Li} 2.38_{Na}	2.38_{Li} 2.44_{Na}	2.65_{Li} 2.65_{Na}	.31 .27	PHOENICOCHROITE $8Pb_2(CrO_4)O$	58°(Na) r > v mod	X = b Y:c = -2°	MCL tab	$20\bar{1}$ good	Cochineal-, hyacinth-red	H 2.5-3 G 7.01 F easy	Diss by HNO_3.
	2.38_{Li}	2.39_{Li}	2.42_{Li}	.04	PSEUDOBROOKITE Fe_2TiO_5	~ 50° r < v	X = b Z = a	ORTH tab 100	010 dist	Dark brown to black	H 6 G 4.3-4.4 infus	Insol in acids. Pleoc wk in reddish-brown, abs Z > Y > X.
	2.37	2.40	2.46	.09	STIBIOTANTALITE $Sb(Ta,Nb)O_4$	75° r < v str	X = a Z = b	ORTH	110 good	Dark brown, yellow-brown	H 5.5 G 6.2-7.9 F 4	Insol in acids. Data for mineral with G 6.8.

	2.39_{Li}	$\underline{2.40}_{Li}$	2.43_{Li}	.04	BISMUTOTANTALITE $Bi(Ta,Nb)O_4$	80° r < v str	X = $\underline{a}$ Z = $\underline{b}$	ORTH	110 good	Dark-brown, yellow-brown	H 5 G 8.1-8.8	---
2.30 ^	---	$\underline{2.40}$	---	low	PEROVSKITE $CaTiO_3$	~ 90°	X = $\underline{a}$ Z = $\underline{b}$	ORTH ps cub	100, 110	Brownish-black to yellow	H 5-6 G 4.0-4.2 infus	Insol in acids. Pleoc wk in green or brown.
	2.40	$\underline{2.42}$	2.46	.06	STIBIOCOLUMBITE $Sb(Nb,Ta)O_4$	73° r > v str	X = $\underline{a}$ Z = $\underline{b}$	ORTH	110 good	Dark brown, yellow-brown	H 5.5 G 5.6-6.6 F 4	Insol in acids. Data for mineral with G 6.3.
	>2.42	---	>2.42	---	BISMITE Bi_2O_3	Disp str	---	MCL mass	---	Gray-green, yellow	H 4.5 G 8.6	Opt char unk.
	2.37_{Li}	$\underline{2.45}_{Li}$	2.65_{Li}	.28	MONTROYDITE HgO	Large	Z = $\underline{a}$ Y = $\underline{b}$ (?)	ORTH pris	010 perf	Deep red, orange, brown	H 2-3 G 11.2 volat	Diss by acids.
	2.45_{Li}	$\underline{2.45}_{Li}$	2.51_{Li}	.06	DERBYLITE $Fe_4Ti_3SbO_{13}(OH)$	Small	---	MCL pris	Conch	Black	H 5 G 4.53 infus	Insol in acids. In thin-section dark brown, not pleoc.
	2.58	$\underline{2.59}$	2.70	.12	BROOKITE TiO_2	15-30° (Na), ~ 0° for green, disp very str	Y = $\underline{a}$ X = $\underline{b}$ (red) X = $\underline{c}$ (blue)	ORTH	120 indist	Brown to black	H 5.5-6 G 4.14 infus	Insol in acids. Pleoc wk, orange-brown to dark brown, abs Z > Y > X.
	2.57_{Li}	$\underline{2.61}_{Li}$	2.71_{Li}	.14	MASSICOT PbO	~ 90° (67±17°) disp str	Y = $\underline{a}$ (?)	ORTH tab 100	010 perf	Yellow	Soft G 9.6 F 1.5	Diss by HNO_3. Pleoc, Y light yellow, Z deep yellow. Opt neg in blue light.
	---	$\underline{2.63}$	---	---	CLINOBISVANITE $BiVO_4$	Disp str	---	MCL	010 perf	Orange to yellow	Soft G 6.95 calc	Opt char unk.
	---	$\underline{2.63}$ red	---	high	TENORITE CuO	Large r < v	Y = $\underline{b}$ Z ~ $\underline{c}$	MCL laths	$\bar{1}\bar{1}1$, $\bar{1}01$	Steel-gray to black	H 3.5 G 6.45	Diss by HCl. Tw common on 011. Pleoc in brown. Opt char unk.
	---	$\underline{3.17}$ blue	---	high								
	$>2.72_{Li}$	$\underline{>2.72}_{Li}$	---	extr	LORANDITE $TlAsS_2$	Large r > v str	Z = $\underline{b}$ X ~ ⊥ 100	MCL	100 perf $20\bar{1}$, 001 good	Coch-ineal-red	H 2-2.5 G 5.53 F 1	Diss by HNO_3. Deep red in thin-section. Pleoc wk, Y purple-red, Z orange-red.
	---	$\underline{>2.72}_{Li}$	---	very high	GETCHELLITE $AsSbS_3$	80° r > v str crossed	Z = $\underline{b}$ Y:$\underline{a}$ = 15°	MCL	001 perf sectile	Dark red	H 1.5-2 G 3.92 F 1	---

Table 6. Biaxial positive minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_z$ ($2V_z$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
	---	$>2.72_{Li}$	---	very high	VRBAITE $Tl_4Hg_3Sb_2As_8S_{20}$	Large r > v str	---	ORTH	010 easy	Brownish-gray to reddish	H 3.5 G 5.30 F easy	Diss by HCl.
	---	$>2.72_{Li}$	---	very high	DUFRENOYSITE $Pb_2As_2S_5$	---	---	MCL	010 perf	Lead-gray	H 3 G 5.53 fus	Opt char unk.
	---	$>2.72_{Li}$	---	very high	MIARGYRITE $AgSbS_2$	Med	---	MCL	010 traces	Iron-black	H 2-2.5 G 5.2 F 1	Dec by HNO_3. In thin-section blood-red.
	---	---	---	extr	PYROSTILPNITE Ag_3SbS_3	---	Y = b X:c = 8°	MCL	010 perf	Hyacinth-red	H 2 G 5.94 F 1	Tw pl 100.
	2.82_{Na}	2.93_{Na}	3.14_{Na}	.32	ENARGITE Cu_3AsS_4	(76±8°)	X = a Y = b	ORTH tab 001	110 perf 100, 010 dist	Gray-black, iron-black	H 3 G 4.45 fus	Tw pl 320.
	2.96_{Na}	3.09_{Na}	3.42_{Na}	.46	KERMESITE Sb_2S_2O	Med (70±6°)	Z = b	TCL pris	001 perf 100 less so	Cherry-red	H 1-1.5 G 4.68 volat	---
	3.14	3.17 (8520 nm)	3.28	.14	BOURNONITE $PbCuSbS_3$	52°	---	ORTH pris tab	010 imperf	Steel-gray	H 2.5-3 G 5.83 fus	Dec by HNO_3. Tw on 110 common.

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Table 7. Biaxial negative minerals

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.324	1.3245	1.325	.001	AVOGADRITE $(K,Cs)BF_4$	90°	X = c Y = b	ORTH tab	---	Yellow to reddish	G 2.62	Slightly sol in H_2O, diss by acids.
	1.393	1.395	1.397	.004	MIRABILITE $Na_2SO_4 \cdot 10H_2O$	76° r < v str crossed	X = b Z:c = 30°	MCL pris	100 perf 001, 010, 011	White	H 1.5-2 G 1.49 F 1.5	Sol in H_2O, effloresces.
	1.407	1.414	1.415	.008	THOMSENOLITE $NaCaAlF_6 \cdot H_2O$	50° r < v wk	Z = b X:c = -52°	MCL cube-like	001 perf 110 dist	Cols	H 2 G 2.48 F 1.5	Diss by H_2SO_4.
	1.405	1.425	1.440	.035	NATRON $Na_2CO_3 \cdot 10H_2O$	71° (81±7°) r < v perc crossed	X = b Z:c = 41°	MCL	001 good 010 imperf	White	H 1-1.5 G 1.48 F 1	Sol in H_2O, effloresces.
⊔ 1.435	1.429	1.433	1.436	.007	JARLITE $NaSr_3Al_3(F,OH)_{16}$ (?)	81-90°	Y = b X:c = -6°	MCL tab	---	Cols	H 4-4.5 G 3.78 - 3.93 F easy	---
	1.424	1.436	1.438	.012	WILCOXITE $MgAl(SO_4)_2F \cdot 18H_2O$	48°	---	TCL	---	Cols, white	H 2 G 1.58	Sol in H_2O.
	1.430	1.452	1.458	.028	KALINITE $KAl(SO_4)_2 \cdot 11H_2O$ (?)	52° disp wk	Z = b Y:c = 13°	MCL fib c	---	White	H 2-2.5 G 1.75 F 1	Sol in H_2O.
	1.440	1.453	1.454	.014	LECONTITE $(K,NH_4)Na(SO_4) \cdot 2H_2O$	30° r < v rather str	Y = a Z = b	ORTH pris	011	Cols	H 2-2.5 G 1.74 F 1	Sol in H_2O.
	1.448	1.454	1.456	.008	GEARKSUTITE $CaAl(F,OH)_5 \cdot H_2O$	Small to med	X = b Y:c large el pos	MCL acic c	---	White, chalky	H 2 G 2.74 F 2	Diss by acids.
∨ 1.470	1.433	1.455	1.461	.028	EPSOMITE $MgSO_4 \cdot 7H_2O$	52° r < v wk	X = b Z = a	ORTH el c	010 good 101 dist	White	H 2 G 1.68 infus	Sol in H_2O, taste bitter.
	1.435	1.455	1.459	.024	WATTEVILLITE $Na_2Ca(SO_4)_2 \cdot 4H_2O$	48°	---	MCL (?) acic	---	Cols	G 1.81 F diff	Dec by H_2O with sepn of gypsum, diss by acids.
1.448 ⊏⊐ 1.461	1.340	1.456	1.459	.119	SASSOLITE $B(OH)_3$	5-14°	X:c = 84-88° b ~ opt pl	TCL tab 001	001 perf	White, pearly	H 1 G 1.48 F 1	Sol in H_2O. Tw pl 001.

	1.452	1.456	1.458	.006	TIKHONENKOVITE $SrAlF_4(OH)\cdot H_2O$	70°	---	MCL pris	001 perf fr conch	Cols to rose	H 3.5 G 3.26	---
	(1.405)	1.460	1.487	(.082)	ROSTITE $AlSO_4(OH)\cdot 5H_2O$	68°	X = c Y = b	ORTH	---	Cols	G 1.93	Diss by acids. Reported α given as "1.44 calc."
1.455 □ 1.466	1.449	1.461	1.463	.014	MENDOZITE $NaAl(SO_4)_2\cdot 11H_2O$	56°	X = b Y:c = 30°	MCL laths c	100 good	White	H 3 G 1.77 F 1	Sol in H_2O. Data on synth compd.
⊔ 1.466	---	1.461	---	low	SILHYDRITE $3SiO_2\cdot H_2O$	---	---	ORTH	fr uneven to subconch	White	G 2.14	Dec by HCl. Opt sign unk.
	1.438	1.463	1.465	.027	HEXAHYDRITE $MgSO_4\cdot 6H_2O$	29° r > v	Y = b X:c = -25°	MCL	---	Cols	G 1.8 infus	Sol in H_2O. Data on synth compd.
	---	1.465	---	---	ZINCFAUSERITE $(Mn,Mg,Zn)SO_4\cdot 7H_2O$ (?)	Large	---	ORTH	010 good	Pale rose	H 2.5 G 2.00 infus	Sol in H_2O, effloresces.
1.455 ◇ 1.480	1.447	(1.468)	1.470	.023	GOSLARITE, magnesian (Epsomite grp) $(Zn,Mg)SO_4\cdot 7H_2O$	Small	X = a Z = b el clv neg	ORTH	010 perf	White	H 2 G 1.8 infus	Sol in H_2O.
	1.447	1.469	1.472	.025	BORAX $Na_2B_4O_7\cdot 10H_2O$	40° r > v str crossed	X = b Z:c = -55°	MCL pris c tab 100	100 perf 110 good	White	H 2-2.5 G 1.71 F 1-1.5	Sol in H_2O. Tw pl 100 rare.
	1.451	1.470	1.478	.027	KANEMITE $NaHSi_2O_4(OH)_2\cdot 2H_2O$	46° r > v	X = b Y = a	ORTH	010 perf 100 good	Cols, white	H 4 G 1.93	Dec by acids.
1.455 ◇ 1.493	1.447	1.470	1.473	.026	EPSOMITE, nickeloan $(Mg,Ni)SO_4\cdot 7H_2O$	47°	X = b Z = a clv pos	ORTH	010 fair	Pale blue-green	H 2 G 1.8 infus	Sol in H_2O. NiO 12.2%.
	1.463	1.470	1.471	.008	PARALUMINITE $Al_4(SO_4)O_5\cdot 15H_2O$	Small	X = el	Fib, mass	---	White, chalky	Soft	---
	1.460	1.471	1.474	.014	STARKEYITE $MgSO_4\cdot 4H_2O$	(55±18°)	---	MCL	---	White	G ~ 1.8 infus	Sol in H_2O. (Synth compd is biax pos, β 1.491.)
	1.455	1.472	1.487	.032	KERNITE $Na_2B_4O_7\cdot 4H_2O$	80° r > v dist	Z = b X:a = 38°	MCL	001, 100 perf 201 fair	White, cols	H 2.5 G 1.90 F 1-1.5	Sol in H_2O.
	1.459	1.473	1.483	.024	JURBANITE $AlSO_4(OH)\cdot 5H_2O$	80°	Y = b Z:a = -5°	MCL	---	Cols	H 2.5 G 1.79	---
	1.465	1.473	1.477	.012	SASAITE $(Al,Fe)_{14}(PO_4)_{11}(OH)_7(SO_4)\cdot 83H_2O$ (?)	---	X = c Y = b el clv pos	ORTH (?)	001 perf	White, chalky	G 1.75 infus	Diss by acids. Fe_2O_3 1.1%.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.465 □ 1.484	---	1.474	---	.002- .008	GMELINITE (Zeolite grp) $(Na,Ca)Al_2Si_4O_{12}\cdot6H_2O$	Small	---	HEX	$10\bar{1}0$ dist	White	H 4.5 G 2.0-2.1 F 3	Dec by HCl. Tw axis c.
v 1.580	---	1.474	---	0- .008	HISINGERITE $Fe^{+3}{}_2Si_2O_5(OH)_4\cdot2H_2O$	Small	---	MCL u mass	Conch	Dark brown	H 3.5 G ~ 2.5 infus	Dec by acids.
	---	1.47- 1.48	---	wk	HYDROBASALUMINITE $Al_4SO_4(OH)_{10}\cdot12\text{-}36H_2O$	---	---	---	---	Cols to yellowish	G 1.86	Diss by acids. Opt char unk.
⊔ 1.482	1.471	1.475	1.476	.005	SODIUM DACHIARDITE (Zeolite grp) $(Na,Ca,K)_{4-5}Al_8Si_{40}O_{96}\cdot26H_2O$	88-92°	Z:c = 18°	MCL	---	Cols	G 2.17	---
□ 1.480	1.472	1.475	1.477	.005	MORDENITE (Zeolite grp) $(Ca,Na,K)Al_2Si_{10}O_{24}\cdot7H_2O$	80°	X = a Z = c	ORTH	100 perf 010 good	Cols	H 5 G 2.12 F 3-4	Some samples appear to be monoclinic.
	1.461	1.478	1.484	.023	CREEDITE $Ca_3Al_2(SO_4)(F,OH)_{10}\cdot2H_2O$	64° r > v wk	Y = b Z:c = 41°	MCL pris c	100 perf	Cols	H 4 G 2.72 F diff	Diss by acids.
	1.358	1.479	1.530	.172	BARENTSITE $Na_7Al(CO_3)_2(HCO_3)_2F_4$	62° r < v wk	X = c	TCL ps hex	001, 100 perf	Cols	H ~ 3 G 2.56	Eff in acids, slowly dec by H_2O.
	1.476	1.479	1.481	.005	TVEITITE $Ca_{1-x}(Y,Ce)_xF_{2+x}$ (x ~ 0.3)	34°	---	MCL ps cub	---	White to pale yellow	---	Poly tw. Fluor faint yellow-orange in short-wave UV.
⊓v 1.484	1.476	1.479	1.479	.003	CLINOPTILOLITE (Zeolite grp) $(Na,K,Ca)_{2-3}Al_3(Al,Si)_2Si_{13}O_{36}\cdot12H_2O$	Small r < v str	X = b (?) Z:a = 15° el pos (?)	MCL tab 010	010 perf	Cols	H 3.5-4 G 2.2 F 2	Dec by HCl.
(1.468) ^	1.457	1.480	1.484	.027	GOSLARITE (Epsomite grp) $ZnSO_4\cdot7H_2O$	46° r > v wk	X = a Z = b el c⊥v pos	ORTH acic c	010 perf	Cols, yellowish	H 2-2.5 G 1.98 infus	Sol in H_2O.
	1.47	1.48	1.49	.02	BOOTHITE $CuSO_4\cdot7H_2O$	Large	Y = b X ~ c	MCL fib c	001 imperf	White, silky	H 2-2.5 G 2.1 fus	Sol in H_2O. Dehydrates to Chalcanthite.

	1.472	---	1.487	.015	MAKATITE $Na_2Si_4O_9 \cdot 5H_2O$	---	---	ORTH(?) spher- ulitic	---	White	G 2.07	Dec by HCl. Opt char unk.
	1.391	1.481	1.486	.095	DARAPSKITE $Na_3(SO_4)(NO_3) \cdot H_2O$	27° r > v rather str	X = b Z:c = 12° el clv pos	MCL	010 perf 100	Cols	H 2-3 G 2.20 F 1-2	Sol in H_2O. Poly tw 100.
	1.380	1.482	1.573	.193	KALICINITE $KHCO_3$	81° (83±1°)	Y = b X:c = 30°	MCL el b	100, 001, 101	White	G 2.16 F easy	Sol in H_2O.
	1.462	1.482	1.495	.033	AUBERTITE $CuAl(SO_4)_2Cl \cdot 14H_2O$	71° r > v mod	---	TCL	010 perf	Azure- blue	G 1.82	Sol in H_2O.
	1.462	1.482	1.490	.028	MORAESITE $Be_2PO_4(OH) \cdot 4H_2O$	65°	Z = b Y:c = 11- 23°	MCL acic	010, 001 good	White	G 1.81	Diss by acids.
	1.470	---	1.493	.023	NICKEL-HEXAHYDRITE $(Ni,Mg,Fe)SO_4 \cdot 6H_2O$	---	Z:c = 45°	MCL crusts	010 perf 100	Blue- green	---	Sol in H_2O. NiO 22.6, MgO 2.8, FeO 2.6%. Opt char unk.
1.479 ⌐ 1.488	1.477	1.482	1.484	.007	PICKERINGITE (Halotrichite grp) $MgAl_2(SO_4)_4 \cdot 22H_2O$	Med	Y = b Z:c = 30°	MCL fib	010 poor fr conch	Cols to yellow	H 2-2.5 G 1.8 infus	Sol in H_2O, taste astringent. In closed tube melts in H_2O of crystn.
	1.469	1.482	1.490	.021	REVDITE $Na_2Si_2O_5 \cdot 5H_2O$	75°	Y:c = 0- 10°	TCL	100,010 perf	Cols	H 2 G 1.94	Sol in H_2O, gives an alk soln.
ˇ 1.488	1.478	1.482	1.482	.004	APJOHNITE (Halotrichite grp) $(Mn,Mg)Al_2(SO_4)_4 \cdot 22H_2O$	Small	Y = b Z:c = 29°	MCL fib c	---	White, silky	H 1.5 G 1.78 infus	Sol in H_2O. In closed tube melts in H_2O of crystn.
	1.477	1.483	1.489	.012	BIEBERITE $CoSO_4 \cdot 7H_2O$	88° disp wk	Y = b Z:c ~ 30°	MCL	001 perf 110 fair	Rose- to carmine- red	H 2 G 1.95 infus	Sol in H_2O. Loses H_2O on exposure.
1.479 ^	1.481	1.484	1.486	.005	CLINOPTILOLITE (Zeolite grp) $(Na,K,Ca)_{2-3}Al_3$ $(Al,Si)_2Si_{13}O_{36} \cdot 12H_2O$	Large r < v str	X = b (?) Z:a = 15° el pos (?)	MCL	010 perf	Cols	H 3.5-4 G 2.2 F 2	Dec by HCl.
	1.442	1.485	1.490	.048	HUNGCHAOITE $MgB_4O_5(OH)_4 \cdot 7H_2O$	36°	---	TCL ps hex	---	White	---	Diss by acids.
	1.479	1.485	1.489	.010	BARRERITE (Zeolite grp) $(Na,K,Ca)_2Al_2Si_7O_{18} \cdot$ $6\text{-}7H_2O$	---	X = a Y = b	ORTH	---	Cols	G 2.13 fus	Sodium analogue of Stellerite.
	1.477	1.485	1.486	.009	PHOSPHORROESSLERITE $MgHPO_4 \cdot 7H_2O$	38° r > v	X = b Z:c = 7°	MCL	Conch	Cols to yellow	H 2.5 G 1.73 infus	Diss by acids.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	---	1.485	---	low	MAGADIITE $NaSi_7O_{13}(OH)_3 \cdot 3H_2O$	---	el pos	MCL	---	White	---	Dec by acids. Opt sign unk.
1.5v07	1.483	1.486	1.487	.004	BLOEDITE $Na_2Mg(SO_4)_2 \cdot 4H_2O$	71° r < v str	Y = b X:c = 37°	MCL tab 001	Conch	Cols	H 2.5-3 G 2.25 F 1.5	Sol in H_2O.
1.5v09	1.484	1.486	1.487	.003	PHILLIPSITE (Zeolite grp) $(K,Ca,Na)_{1-2}(Al,Si)_8O_{16} \cdot 6H_2O$	Med r > v	---	MCL	010, 100 good	Cols	H 4-4.5 G 2.2 F 3	Gel with acids. Penet tw.
	1.483	1.487	1.490	.007	LEONITE $K_2Mg(SO_4)_2 \cdot 4H_2O$	~ 90° r < v	Y = b Z ~ a	MCL	Conch	Cols	H 2.5-3 G 2.20 F easy	Sol in H_2O. Poly tw.
1.480 [] 1.493	---	1.487	---	.002	ANALCIME (Zeolite grp) $NaAlSi_2O_6 \cdot H_2O$	Very small	---	CUB trape-zohe-dral	100 imperf	Cols	H 4-4.5 G 2.25 F 3.5	Dec by HCl. Tw grating.
1.482 ^	1.480	1.488	1.490	.010	HALOTRICHITE $FeAl_2(SO_4)_4 \cdot 22H_2O$	Med	Y = b Z:c = 38°	MCL fib c	010 poor fr conch	White, silky	H 2 G 1.89 F 4.5-5	Sol in H_2O. Taste astringent.
	1.486	1.488	1.489	.003	VANTHOFFITE $Na_6Mg(SO_4)_4$	83° r < v wk	---	MCL	---	Cols	H 3.5 G 2.69 F 3	Sol in H_2O.
[v] 1.493	1.484	(1.488)	1.490	.006	CHABAZITE (Zeolite grp) $(Ca,Na)Al_2Si_4O_{12} \cdot 6H_2O$	60-70°	---	TRIG	10$\bar{1}$1 poor	White, reddish	H 4 G 2.05-2.10 F 3	Dec by HCl. Tw 10$\bar{1}$1, 0001.
	1.448	1.489	1.493	.045	BURKEITE $Na_6(CO_3)(SO_4)_2$	34° r > v dist	X = c Z = b	ORTH	Conch	White	H 3.5 G 2.57 F 1.5	Sol in H_2O.
	1.473	(1.489)	1.490	.017	Unnamed Na-Mg-U sulfate-borate	17-27°	ext 28°	TCL	---	Pale yellow	---	Tw. Fluor bright yellow-green in UV. Am. Mineral., 62, 1261 (1977).
1.5v02	1.482	1.489	1.496	.014	STILBITE (Zeolite grp) $NaCa_2Al_5Si_{13}O_{36} \cdot 14H_2O$	43° (90+17°)	Y = b X:a = 2-9°	MCL acic a	010 perf	White, pink, yellow	H 4 G 2.15 F 3	Dec by HCl. Tw 001 cruciform, penet. Var with high Na.

	1.485	1.490	1.494	.009	AMICITE (Zeolite grp) $K_2Na_2Al_4Si_4O_{16}\cdot 5H_2O$	82°	---	MCL radi- ating	---	Cols	H soft G 2.06- 2.23	---
	1.454	1.491	1.500	.046	BAYLEYITE $Mg_2(UO_2)_2(CO_3)_3\cdot 18H_2O$	30° (51±6°)	Z = b X:c = 8- 15°	MCL	---	Sulfur- yellow	G 2.05	Sol in H_2O. Pleoc wk, X pinkish, Y and Z pale greenish-yellow. Fluor yellow-green in UV.
v 1.512	1.482	1.492	1.493	.011	PENTAHYDRITE (Chalcanthite grp) $MgSO_4\cdot 5H_2O$	45° r < v	X ~ b	TCL	---	Cols	G 1.77 infus	Sol in H_2O. Data for synth compd.
	1.472	---	1.502	.030	INDIGIRITE $MgAl(CO_3)_2(OH)\cdot 7.5H_2O$	---	el pos	fib	---	Snow- white	H 2 G 1.6	Diss by acids.
1.470 ^	1.470	1.493	1.500	.030	MORENOSITE (Epsomite grp) $NiSO_4\cdot 7H_2O$	42° r > v wk	X = b Z = a	ORTH acic c	010 dist	Apple- green	H 2-2.5 G 1.95 infus	Sol in H_2O.
(1.488) ^	1.487	1.493	1.495	.008	CHABAZITE (Zeolite grp) $(Ca,Na)Al_2Si_4O_{12}\cdot 6H_2O$	60°	---	TRIG	$10\bar{1}1$ poor	White, reddish	H 4 G 2.08 F 3	Dec by HCl. Tw $10\bar{1}1$, 0001.
	1.416	1.494	1.542	.126	TRONA $Na_3(CO_3)(HCO_3)\cdot 2H_2O$	75° r < v str	X = b Z:c = 83°	MCL el b	100 perf $10\bar{1}$	White	H 2.5-3 G 2.15 F 3	Sol in H_2O, gives an alk soln.
	1.465	1.494	1.495	.030	BIANCHITE $(Zn,Fe,Mg)SO_4\cdot 6H_2O$	10-20° r > v wk	Y = b X:c = -26°	MCL	---	White to pale green	H 2.5 G 2.03 infus	Sol in H_2O. Tw 001. ZnO 20.0, FeO 8.8%.
	1.476	(1.494)	1.496	.020	Unnamed Na-Mg-U sulfate-borate	~ 30°	---	---	---	Yellow	---	Fluor bright yellow-green in UV. Pleoc, X cols, Z yellowish. Am. Mineral., 62, 1261 (1977).
	1.486	1.494	1.496	.010	STELLERITE (Zeolite grp) $CaAl_2Si_7O_{18}\cdot 7H_2O$	38-48°	X = a Y = c el clv neg	ORTH	010 perf	Cols to flesh-red	H 3.5-4 G 2.14 F easy	Dec by HCl. Not tw.
	1.468	---	1.498	.030	FERROHEXAHYDRITE $FeSO_4\cdot 6H_2O$	---	---	MCL fib	---	Cols	---	Sol in H_2O. Opt sign unk, put here by analogy to related minerals.
	1.471	1.496	1.497	.026	MOORHOUSEITE $(Co,Ni,Mn)SO_4\cdot 6H_2O$	10-30°	Y = b	MCL mass	Conch	Pink	H 2.5 G 1.97 infus	Sol in H_2O. Pleoc, abs X > Z. Data on synth $CoSO_4\cdot 6H_2O$.
	1.465	1.498	1.504	.039	NITROCALCITE $Ca(NO_3)_2\cdot 4H_2O$	50° disp wk	X ⊥ clv el clv pos	MCL pris	One perf	Cols	Soft G 1.90 F easy	Sol in H_2O, hygroscopic. Data on synth compd.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.495	1.498	1.502	.007	GOOSECREEKITE (Zeolite grp) $CaAl_2Si_6O_{16}\cdot 5H_2O$	82°	Y = b Z:c = 46°	MCL	010 perf	Cols	H 4.5 G 2.21	Insol in HCl.
	1.490	1.498	1.501	.011	HYDROGLAUBERITE $Na_4Ca(SO_4)_3\cdot 2H_2O$	60°	Z:c = 3.5° el pos	MCL acic	010	White	G 2.40	Dec by H_2O, diss by HCl.
	1.493	1.499	1.503	.010	YUGAWARALITE (Zeolite grp) $CaAl_2Si_6O_{16}\cdot 4H_2O$	65-71° r < v	Z = b X:c = -9°	MCL	Parting 010	Cols	H 4.5 G 2.23	Insol in acids.
	1.499	1.500	1.501	.002	MERLINOITE (Zeolite grp) $(K,Ca,Na)_7Si_{23}Al_9O_{64}\cdot 23H_2O$	56° r > v	X = b Z = a el pos	ORTH	---	White	G 2.14-2.27	---
	1.442	(1.500)	1.504	.062	ADMONTITE $Mg_2B_{12}O_{20}\cdot 15H_2O$	30° r < v	X:c = 45°	MCL tab 100	Conch	Cols	H 2-3 G 1.82	---
	---	1.500	---	wk	BILINITE (Halotrichite grp) $Fe^{+2}Fe^{+3}{}_2(SO_4)_4\cdot 22H_2O$	---	ext 35-39°	MCL radi-ating, fib	---	White to yellowish	H 2 G 1.88	Diss in H_2O.
	1.442	(1.500)	1.504	.062	Unnamed magnesium borate	~ 30° r < v	---	ORTH	---	Cols	---	Am. Mineral., 62, 1261 (1977).
	1.377	1.501	1.583	.206	NAHCOLITE $NaHCO_3$	75° (72±1°) r > v wk	Y = b X:c = 27°	MCL pris	101 perf 111 good	White	H 2.5 G 2.21 F 1	Sol in H_2O, gives an alk soln.
	1.490	---	1.502	.012	BEARSITE $Be_2AsO_4(OH)\cdot 4H_2O$	---	Z:c = 9°	MCL fib	---	White	G 2.2	---
	1.498	(1.501)	1.502	.004	WAIRAKITE (Zeolite grp) $CaAl_2Si_4O_{12}\cdot 2H_2O$	75° r > v	X ~ b Z ~ c	MCL	---	White	H 5.5-6 G 2.26 F 2.5	Gel with acids. U biax pos.
1.489 ^	1.494	1.502	1.507	.013	STILBITE (Zeolite grp) $NaCa_2Al_5Si_{13}O_{36}\cdot 14H_2O$	30-50° (76±18°)	Y = b X:a = 2-9°	MCL acic a	010 perf	White, pink, yellow	H 4 G 2.15 F 3	Dec by HCl. Tw 001, cruciform, penet.
	1.414	1.503	1.527	.113	NESQUEHONITE $Mg(HCO_3)(OH)\cdot 2H_2O$	53° r < v wk	X = a Z = b	ORTH el c	110 perf 001 poor	Cols	H 2.5 G 1.85 infus	Diss by cold acids with eff.

	1.455	1.503	1.549	.094	HELLYERITE $NiCO_3 \cdot 6H_2O$	85°	---	---	One perf 2 good	Light blue	H 2.5 G 1.97 infus	Diss by acids with eff. Faintly pleoc.
v 1.508	1.472	1.503	1.526	.054	AKSAITE $MgB_6O_{10} \cdot 5H_2O$	80°	X = c Z = b	ORTH	100, 101	Cols, gray	H 2.5 G 2.0	Diss by acids.
	1.498	1.503	1.506	.008	HARMOTOME (Zeolite grp) $(Ba,K)_{1-2}(Si,Al)_8O_{16} \cdot 6H_2O$	75-82°	Z = b Y:c = 28°	MCL	010 good 001 fair	Cols	H 4.5 G 2.44 F 3.5	Dec by HCl. Tw cruciform, penet on 001.
	1.426	(1.504)	1.508	.082	Unnamed carbonate of K, Ca	~ 25°	X = el	ORTH	---	Pale rose	---	Am. Mineral., 58, 139 (1973).
	1.332	1.504	1.504	.172	NITER KNO_3	5-7° r < v wk	X = c Z = b	ORTH	011 perf 010 good 110 poor	Cols	H 2 G 2.11 F 1	Sol in H_2O.
	1.492	1.505	1.517	.025	INYOITE $Ca_2B_6O_{11} \cdot 13H_2O$	80° r < v wk	Y = b X:c = 36°	MCL tab 100	001 good 010	Cols	H 2.5-3 G 2.13 F 2	Sol in hot H_2O.
	1.494	1.505	1.516	.022	KAINITE $MgSO_4 \cdot KCl \cdot 3H_2O$	85° r > v wk	Y = b Z:c = 13°	MCL tab 001	001 perf 110 dist	Cols	H 2.5-3 G 2.13 F 2	Sol in H_2O.
	1.344	1.506	1.506	.162	NITROMAGNESITE $Mg(NO_3)_2 \cdot 6H_2O$	5° r < v perc	---	MCL pris	110 perf	Cols	G 1.58	Sol in H_2O, taste bitter.
	1.420	1.506	1.524	.104	THERMONATRITE $Na_2CO_3 \cdot H_2O$	48° r < v wk	X = b Z = a	ORTH flat-tened 001 or 010	100 diff	White	H 1-1.5 G 2.26 F 1.5	Sol in H_2O, gives an alk soln.
	1.470	1.506	1.527	.057	EZCURRITE $Na_4B_{10}O_{17} \cdot 7H_2O$	73° r > v	---	TCL	110, 010 good 100, $\bar{1}26$ fair	Cols	H 3-3.5 G 2.1 F easy	Sol in H_2O.
v 1.525	1.498	1.506	1.508	.010	SEPIOLITE $Mg_4Si_6O_{15}(OH)_2 \cdot 6H_2O$	50°	Z = el	ORTH fib	---	White to yellow	H 2 G 2.3 infus	Dec by HCl with sepn of silica.
1.486 ◊ 1.518	1.504	1.507	1.509	.005	NICKELBLOEDITE $Na_2(Ni,Mg)(SO_4)_2 \cdot 4H_2O$	60-70°	Y = b	MCL	---	Light green	G 2.3	Sol in H_2O. Ni 8.8, Mg 3.0, Cu 0.6, Co 0.3%.
1.503 ^	1.473	1.508	1.528	.055	AKSAITE $MgB_6O_{10} \cdot 5H_2O$	(73±4°)	X = c Z = b	ORTH	100, 101	Cols, gray	H 2.5 G 2.0	Diss by acids.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.486 ^	1.505	1.509	1.511	.006	PHILLIPSITE (Zeolite grp) $(K,Ca,Na)_{1-2}(Al,Si)_8O_{16}\cdot 6H_2O$	Med r > v	---	MCL	010, 100 good	Cols	H 4-4.5 G 2.2 F 3	Gel with acids. Penet tw.
1.5̌15	1.505	1.509	1.509	.004	COWLESITE (Zeolite grp) $CaAl_2Si_3O_{10}\cdot 5\text{-}6H_2O$	30°	X = a Y = b el pos	ORTH bladed	010 perf	Cols, white	H 5-5.5 G 2.13	---
	1.470	1.510	1.579	.109	STRONTIOBORITE $SrB_8O_{11}(OH)_4$	80-100° (102±2°)	---	MCL plates	---	Cols	G 2.81	Diss by acids.
	1.465	1.51	1.540	.075	SWARTZITE $CaMg(UO_2)(CO_3)_3\cdot 12H_2O$	(40°)	---	MCL pris	---	Green	G 2.3	Diss by acids. Pleoc, X cols, Y and Z green. Fluor bright green in UV.
	1.490	1.510	1.524	.034	KURNAKOVITE $MgB_3O_3(OH)_5\cdot 5H_2O$	80° r > v	Y ~ b Z:c = -22°	TCL	010 perf 1$\bar{1}$0 good	Cols	H 3 G 1.86 F 2	Diss by acids.
1.5̌31	1.479	1.510	1.511	.032	SAPONITE (Smectite grp) $(Na,Ca)_{0.33}Mg_3(Al,Si)_4O_{10}(OH)_2\cdot 4H_2O$	20-30°	X ⊥ 001 el pos	MCL scales	001 perf	White, waxy	H 1-2 G 2.2 F diff	Dec by acids.
1.5̌38	1.492	1.510	1.522	.030	URANOSPATHITE $HAl(UO_2)_4(PO_4)_4\cdot 40H_2O$	69-76° r > v	X = c Y = b	ORTH plates	001 perf 100, 010 good	Yellow to pale green	H 2-2.5 G 2.50	Diss by acids. Pleoc, X pale yellow, Y and Z yellow. Fluor wk yellow-green in UV.
	1.498	1.510	1.517	.019	JOKOKUITE $MnSO_4\cdot 5H_2O$	70-80°	---	TCL	No clv	Pale pink	H 2.5 G 2.03	Sol in H_2O.
	1.496	---	1.512	.016	Unnamed Na-Mg-U-borate-sulfate A	Small	---	---	---	Yellow	---	Dec by H_2O. Pleoc, X cols, Z yellow. Fluor bright yellow-green in UV. Am. Mineral., 62, 1261 (1977).
	1.500	1.511	1.513	.013	EPISTILBITE (Zeolite grp) $CaAl_2Si_6O_{16}\cdot 5H_2O$	40° r > v str	Y = b Z:c = 9°	MCL el c	010 perf	Cols	H 4 G 2.25 F 3	Dec by acids.

	1.508	1.511	1.512	.004	GARRONITE (Zeolite grp) $Na_2Ca_5Al_{12}Si_{20}O_{64}\cdot$ $27H_2O$	0-30°	---	ORTH ps tet	2 poor at 90°	Cols	H 4.5 G 2.15	---
v 1.521	1.483	1.512	1.530	.047	INDERBORITE $CaMg[B_3O_3(OH)_5]_2\cdot 6H_2O$	77°	Z = b X:c = 2°	MCL	100 good fr conch	Cols	H 3.5 G 2.00 fus	Diss by acids.
	1.494	1.512	1.524	.030	NASINITE $Na_2B_5O_8(OH)\cdot 2H_2O$	67° (78±7°)	Y = b Z:a = 7°	MCL	---	Cols	F 1.5	Sol in H_2O.
1.492 ^v (1.526)	1.495	1.512	1.518	.023	PENTAHYDRITE (Chalcanthite grp) $(Mg,Cu)SO_4\cdot 5H_2O$	55° r < v	X ~ b	TCL	---	Blue	G 2.01 infus	Sol in H_2O. CuO 9.0, ZnO 5.6, FeO 1.4%.
v 1.534	1.494	1.512	1.512	.018	MONTMORILLONITE (Smectite grp) $(Na,Ca)_{0.33}(Al,Mg,Fe)_2$ $Si_4O_{10}(OH)_2\cdot xH_2O$	Small	Y = b X ~ c	MCL u mass	001 perf	Cols, gray, green	H 1-2 G 2.3	Dec by acids.
	1.497	1.512	1.513	.016	META-ALUMINITE $Al_2SO_4(OH)_4\cdot 5H_2O$	Small	Z = b (?) Y:el = 43°	MCL laths	---	White	G 1.85	---
v 1.524	1.504	1.512	1.516	.012	LAUMONTITE var Leonhardite (Zeolite grp) $CaAl_2Si_4O_{12}\cdot 4H_2O$	44° (70±19°) r < v str	Y = b Z:c = 30°	MCL	010, 110 good	White	H 3.5-4 G 2.3 F 2.5-3	Gel with acids. H_2O 12.8%.
v 1.535	1.512	1.514	1.515	.003	OKENITE $CaSi_2O_4(OH)_2\cdot H_2O$	Large	Z ~ c	TCL fib c	010 perf	White	H 5 G 2.3 F 2.5	Gel with acids.
	---	1.514	---	---	KINGITE $Al_3(PO_4)_2(OH,F)_3\cdot 9H_2O$	---	---	TCL (?) mass	---	White	G 2.2-2.3	Opt char unk.
	1.508	1.515	1.520	.012	NACAPHITE $Na_2Ca(PO_4)F$	80° r > v wk	---	ORTH	Conch	Cols	H 3 G 2.85	Diss by HCl.
	1.445	1.515	1.523	.078	GAYLUSSITE $Na_2Ca(CO_3)_2\cdot 5H_2O$	35° r < v str crossed	X = b Z:c = -15° disp str	MCL el a	110 perf 001 diff	Cols	H 2.5-3 G 1.99 F 1.5	Dec by H_2O, diss by acids with eff.
1.509 ^	1.512	1.515	1.517	.005	COWLESITE (Zeolite grp) $CaAl_2Si_3O_{10}\cdot 5\text{-}6H_2O$	44-53°	X = a Y = b el pos	ORTH bladed	010 perf	Cols, white	H 5-5.5 G 2.13	---
	1.501	1.516	1.525	.024	LETOVICITE $(NH_4)_3H(SO_4)_2$	75°	Z = b Y:c = -12°	MCL tab 001	001 dist	Cols	G 1.83 volat	Sol in H_2O. Tw lam.
v 1.528	1.512	1.516	1.518	.006	GISMONDINE (Zeolite grp) $(Ca,Na)Al_2Si_2O_8\cdot 4H_2O$	Large r < v wk	Y = b Z:c = 42°	MCL ps tet	---	Cols	H 4.5 G 2.2 fus	Gel with acids. Tw.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.513	1.516	1.518	.005	LOVDARITE $(Na,K,Ca)_2(Be,Al)Si_3O_8 \cdot 2H_2O$	~ 90°	---	ORTH pris	100, 010, 001	Cols to yellowish	H 6.5 G 2.33 F 3.5	Insol in acids.
	1.501	1.517	1.518	.017	SYNGENITE $K_2Ca(SO_4)_2 \cdot H_2O$	28° r < v str	Z = b X:c = -2° el neg	MCL laths el c	110, 100 perf 010	White	H 2.5 G 2.60 F 1.5-2	Dec by H_2O, diss by acids. Tw pl 100 common.
	1.507	1.517	1.521	.014	NATROSILITE $Na_2Si_2O_5$	55° r < v	Y ~ c	MCL ps hex thick tab	100 perf 001 dist 011 poor	Cols	G 2.48 F 2	Dec by acids. Anom blue interf colors.
	1.508	1.518	1.522	.014	ILESITE $(Mn,Zn,Fe)SO_4 \cdot 4H_2O$	Med	Y = b Z:c = 5°	MCL tab 100	---	Clear green	G 2.25	Sol in H_2O. Data on synth compd.
[]	1.512	1.518	1.519	.007	SCOLECITE (Zeolite grp) $CaAl_2Si_3O_{10} \cdot 3H_2O$	35° r < v str	Z = b X:c = 18° el neg	MCL el c	110 perf	White	H 5 G 2.27 F 2	Gel with acids. Tw 100 common
1.507 ^	1.513	1.518	1.520	.007	NICKELBLOEDITE $Na_2Ni(SO_4)_2 \cdot 4H_2O$	60-70°	Y = b	MCL	---	Light green	G 2.43	Sol in H_2O. Ni 13.3, MgO 1.0, FeO 0.9%.
	1.433	1.519	1.528	.095	WEGSCHEIDERITE $Na_5(CO_3)(HCO_3)_3$	(34±4°)	---	TCL	---	Cols	G 2.34 F easy	Sol in H_2O, gives an alk soln.
1.51 [] 1.53	---	1.52	---	.005-.01	BASALUMINITE $Al_4SO_4(OH)_{10} \cdot 5H_2O$	---	el neg	Mass compact	Conch	White	G 2.1	Diss by HCl. Opt char unk.
	---	1.52	---	wk	CHLOROCALCITE $KCaCl_3$	---	---	ORTH (?) ps cub	Three clv	Cols	H 2.5-3	Sol in H_2O, deliq. Poly tw. Validity dubious.
1.512 ^	1.496	1.521	1.539-1.544	.043-.048	INDERBORITE $CaMg[B_3O_3(OH)_5]_2 \cdot 6H_2O$	80-86°	Z = b X:c = 2.5°	MCL	100 good fr conch	Cols	H 3.5 G 2.00 fus	Diss by acids.
	1.510	1.521	1.523	.013	BIKITAITE $LiAlSi_2O_6 \cdot H_2O$	45° r < v	Z = b X:c = 28°	MCL	001, 100 poor	Cols	H 6 G 2.30	---
	1.504	1.522	1.539	.035	HANNAYITE $(NH_4)_2H_4Mg_3(PO_4)_4 \cdot 8H_2O$	~ 90° r < v wk	---	TCL tab 100	1$\bar{1}$1 complete $\bar{1}$00, 0$\bar{1}$0 poor	Cols to yellowish	G 2.03 fus	Diss by acids. Data on synth compd.

	1.518	1.522	1.524	.006	MICROCLINE (Feldspar grp) $KAlSi_3O_8$	60-70° r > v	X':a on 001 = 0-10° 010 = 5°	TCL	001 perf 010 good	White, pink, green	H 6 G 2.56 F 4	Insol in acids. Poly grating tw on 010 and 100.
v 1.539	1.519	1.522	1.524	.005	ANORTHOCLASE (Feldspar grp) $(K,Na)AlSi_3O_8$	51° r > v wk	X':a on 001 = 0-3° 010 = 8-9°	TCL	001 perf 010 good	White, cols	H 6 G 2.57 F 4	Insol in acids. Tw pl 010, 100, giving very fine grating. K_2O 3.7, Na_2O 8.4, CaO 0.7%. (K_2O and Na_2O interchanged?)
	1.504	1.523	1.531	.027	IVANOVITE Chloride-borate of Ca	58-72° r < v	X = b Z:c = 20-26° el clv pos	MCL ps hex	010 good	---	H 2-3 G 1.96	Sol in H_2O.
	(1.492)	(1.524)	1.526	(.034)	SWINEFORDITE (Smectite grp) $(Li,Ca,Na)(Al,Li,Mg)_4(Si,Al)_8O_{20}(OH,F)_4$	29-45°	X ~ c Y = a	MCL mass	---	Greenish-gray to olive	H ~ 1	Pleoc wk, Y nearly cols, Z pale yellow-brown.
	1.518	1.524	1.530	.012	MACDONALDITE $BaCa_4Si_{16}O_{36}(OH)_2\cdot 10H_2O$	90°	X = c Y = b	ORTH acic	010 perf 001 good	Cols, white	H 3.5-4 G 2.27 F 5.5	Dec by boiling HCl.
1.512 ^	1.513	1.524	1.525	.012	LAUMONTITE (Zeolite grp) $CaAl_2Si_4O_{12}\cdot 4H_2O$	25° r < v str	Y = b Z:c = 20-30°	MCL	010, 110 good	White	H 3.5-4 G 2.3 F 2.5-3	Gel with acids.
1.522 ⌐v 1.544	1.519	1.524	1.525	.006	ORTHOCLASE (Feldspar grp) $KAlSi_3O_8$	46° r > v wk	Y or Z = b X:a = 3-12° r < v	MCL	001 perf 010 good	Cols, flesh, pink, etc	H 6 G 2.57 F 4	Insol in acids. Tw axis c comp pl 010, others less common.
⌐v 1.529	1.520	1.525	1.525	.005	SANIDINE (Feldspar grp) $(K,Na)AlSi_3O_8$	24°	X':a on 010 = 6°	MCL	001 perf 010 good	White, cols	H 6 G 2.56	Insol in acids.
	1.510	1.525	1.536	.026	URALOLITE $CaBe_3(PO_4)_2(OH)_2\cdot 4H_2O$	(80±9°)	Z':el = 20°	MCL fib aggregates and needles	⊥ el indist	Cols, white	H 2.5 G 2.1	---
	1.518	---	1.530	.012	TACHARANITE $Ca_{12}Al_2Si_{18}O_{51}\cdot 18H_2O$	---	X:fib = 0°	MCL fib	001 good	Cols	G 2.36	Opt char unk.
1.506 ◇ 1.553	1.516	1.525	1.526	.010	SEPIOLITE $Mg_4Si_6O_{15}(OH)_2\cdot 6H_2O$	Med	---	ORTH fib	---	White	H 2 G 2.3 infus	Dec by HCl with sepn of silica. Fe_2O_3 2.5%.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.512 ◊ 1.537	1.513	(1.526)	1.534	.021	SIDEROTIL (Chalcanthite grp) $(Fe,Cu)SO_4 \cdot 5H_2O$	60°	---	TCL	---	Pale green to blue	H 2-3 G 2.1-2.2	Sol in H_2O.
v 1.535	1.521	1.526	1.528	.007	CORDIERITE $Mg_2Al_4Si_5O_{18}$	64°	X = c Y = b	ORTH ps hex	010 fair	Cols	H 7 G 2.51 F 5.5	Partly dec by acids. Data for synth compd.
	1.452	1.527	1.538	.086	STENONITE $(Sr,Ba,Na)_2Al(CO_3)F_5$	43°	X = b Z:c = -32°	MCL	001, 120	Cols, white	H 3.5 G 3.86	Diss by acids.
	1.429	1.528	1.538	.109	AMEGHINITE $NaB_3O_3(OH)_4$	33° r < v	Z = b X:c = 9°	MCL	100 good 010, 001 poor	Cols	H 2.5 G 2.03 F easy	Sol in H_2O. Fluor pale blue in UV.
1.516 ◊ 1.543	1.522	1.528	1.530	.008	GISMONDINE (Zeolite grp) $(Ca,Na)Al_2Si_2O_8 \cdot 4H_2O$	15-90° r < v wk	Y = b Z:c = 42°	MCL ps tet	---	Cols	H 4.5 G 2.22 F 3	Gel with acids. Tw pl 110, 001.
1.525 ◊ 1.534	1.523	1.529	1.530	.007	SANIDINE (Feldspar grp) $(Na,K)AlSi_3O_8$	33°	---	MCL	001 perf 010 good	Cols	H 6 G 2.56	Insol in acids.
	1.365	1.530	1.595	.265	GLUSHINSKITE (an oxalate) $MgC_2O_4 \cdot 2H_2O$	(58±1°)	---	MCL	---	---	H 2 G 1.85 infus	Diss by HCl.
v 1.536	1.518	1.530	1.542	.024	MINASRAGRITE $VO(SO_4) \cdot 5H_2O$	Med large (89±9°)	X = b Z ~ c	MCL pris	---	Blue	G 2.03 F easy	Sol in H_2O. Pleoc str, X deep blue, Y blue, Z nearly cols, abs X > Y > Z.
v 1.546	1.522	1.530	1.533	.011	PALYGORSKITE $MgAlSi_4O_{10}(OH) \cdot 4H_2O$	61°	---	ORTH fib	---	White	G 2.13 - 2.27 infus	Insol in acids.
	1.522	1.530	1.531	.009	FEDORITE $(Na,K)Ca(Si,Al)_4(O,OH)_{10} \cdot 1.5H_2O$	32° r < v	X ~ c Y ~ b	TCL	001 perf	Cols to pale red	G 2.58 F easy	Insol in acids.
1.510 ◊ 1.565	1.490	1.531	1.534	.044	SAPONITE (Smectite grp) $(Ca,Na)_{0.33}(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$	Med (30±8°)	X ⊥ 001 Z = el	MCL plates	001 perf	White, pink, gray, green	H 1.2 G 2.3 F diff	Dec by acids.
	1.522	(1.531)	1.536	.014	BOYLEITE $(Zn,Mg)SO_4 \cdot 4H_2O$	70°	---	MCL	Uneven	White	G 2.41 infus	Sol in H_2O.

	1.524	1.532	1.536	.012	KOKTAITE $(NH_4)_2Ca(SO_4)_2 \cdot H_2O$	72°	Y = 2° b Z:c = 2° el pos	MCL acic	---	Cols	G 2.09	Dec by H_2O, diss by acids. Tw 100.
	1.529	1.532	1.533	.004	DELHAYELITE $(Na,K)_{10}Ca_5Al_6Si_{32}O_{80}$ $(Cl,F,SO_4)_3 \cdot 18H_2O$	~ 90°	X = a Y = c	ORTH platy	010 dist	Cols	H ~ 4 G 2.60 F 3	Diss by acids. Wavy ext, anomal blue-gray ∥ b.
	1.511	1.533	1.535	.024	NYEREREITE $(Na,K)_2Ca(CO_3)_2$	29°	X = c Y = a	ORTH tab	---	Cols	G 2.54 fus	Diss by acids with eff. Tw.
	1.515	1.533	1.535	.020	SEARLESITE $NaBSi_2O_5(OH)_2$	Med	Z = b X:c = 30°	MCL pris	100 perf	White	Soft G 2.45 F easy	Diss by acids.
1.529 [] 1.535	1.488	1.534	1.556	.068	ARTINITE $Mg_2CO_3(OH)_2 \cdot 3H_2O$	70°	Y = b Z:c = 30°	MCL acic, radi-ating, botry-oidal	100 perf 001 good	White, silky	H 2.5 G 2.02	Diss by acids with eff.
1.512 ^	1.503	1.534	1.534	.031	MONTMORILLONITE (Smectite grp) $(Na,Ca)_{0.33}(Al,Mg,Fe)_2$ $Si_4O_{10}(OH)_2 \cdot xH_2O$	Small	Y = b X ~ ⊥ 001	MCL ps hex earthy	001 perf	White, gray, pink	H 1-2 G 2.06-2.23	Dec by acids.
1.529 ^v 1.543	1.527	1.534	1.535	.008	ALBITE plagioclase, volcanic (Feldspar grp) $(Na,Ca,K)AlSi_3O_8$	~ 50°	X':a on 001 = 3° 010 = 23°	TCL	001 perf 010 good	Cols	H 6 G 2.60 F 4	Insol in acids. Forms series with Anorthite and Sanidine. Data for end member $Ab_{100}An_0Or_0$.
v (1.543)	1.528	(1.534)	1.536	.008	APLOWITE $(Co,Mn,Ni)SO_4 \cdot 4H_2O$	Med	---	MCL	---	Pink	H 3 G 2.33 infus	Sol in H_2O.
	1.410	1.535	1.543	.133	NATRITE Na_2CO_3	28°	Y ~ b	MCL	001 perf 010, 100 less so	---	H 3.5 G 2.54	Sol in H_2O. Poly tw.
	1.500	1.535	1.560	.060	MEYERHOFFERITE $Ca_2B_6O_{11} \cdot 7H_2O$	78° r > v perc	Z':c on 100 = 25° 010 = 60°	TCL tab 100	010 perf	Cols, white	H 2 G 2.12 F easy	Diss by acids.
	1.515	1.535	1.536	.021	GLAUBERITE $Na_2Ca(SO_4)_2$	7° r > v str	Z = b Y:a = 12° el clv pos	MCL tab 001	001 perf 110 in-dist brittle	Gray, cols, yellow-red	H 2.5-3 G 2.75-2.85 F 1.5	Dec by hot H_2O, diss by acids.
1.514 ^	1.530	1.535	1.540	.010	OKENITE $CaSi_2O_4(OH)_2 \cdot H_2O$	Large	Z ~ c	TCL fib c	010 perf	White	H 5 G 2.3 F 2.5	Gel with acids.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
	1.531	1.535	1.541	.010	VERTUMNITE $Ca_4Al_4Si_4O_6(OH)_{24}\cdot 3H_2O$	62°	X = c Z:b = 16°	MCL	Conch brittle	Cols	H 5 G 2.15	Gel with acids.
1.526 ◇ 1.546	1.530	1.535	1.538	.008	CORDIERITE $(Mg,Fe)_2Al_4Si_5O_8$	84°	X = c Y = b	ORTH ps hex	010 fair 001 poor	Blue, green, cols	H 7 G 2.59 F 5.5	Partly dec by acids. Tw sectors, also lam. Pleoc, X cols to pale yellow, Y pale to dark blue, Z pale blue. FeO 2.1%.
	1.423	1.536	1.554	.131	TESCHEMACHERITE $(NH_4)HCO_3$	49° (41±2°) r < v	X = a Y = b	ORTH mass	110 perf	Cols to yellowish	H 1.5 G 1.57 volat	Sol in H_2O, eff with acids.
v 1.561	1.494	1.536	1.536	.042	BEIDELLITE (Montmorillonite grp) $(Na,Ca)_{0.33}Al_2(Si,Al)_4O_{10}(OH)_2\cdot xH_2O$	9-16°	X = c Z = a el c̄v pos	MCL earthy	001 perf	White, reddish, gray	G 2.0 infus	Refractive indices increase when immersed in certain oils.
1.530 ^	1.513	1.536	1.545	.032	MINASRAGRITE $VO(SO_4)\cdot 5H_2O$	Med large	X = b Z ~ c	MCL pris	---	Blue	G 2.03 F easy	Sol in H_2O. Pleoc str, X deep blue, Y blue, Z nearly cols, abs X > Y > Z.
	1.527	1.536	1.541	.014	ROZENITE $FeSO_4\cdot 4H_2O$	Large r < v wk	---	MCL	---	Cols to greenish	G 2.20	Sol in H_2O.
	---	---	1.542	---	GLAUCOKERINITE $(Zn,Cu)_{10}Al_4SO_4(OH)_{30}\cdot 2H_2O$ (?)	---	Z = el	Radi-ating, fib	---	Sky-blue	H 1 G 2.15	Concentric color banding. Opt char unk.
⊔ 1.545	1.490	1.537	1.538	.048	SCHROECKINGERITE $NaCa_3(UO_2)(CO_3)_3(SO_4)F\cdot 10H_2O$	18°	X = c Y = b	TCL ps hex	001	Greenish-yellow	H 5 G 2.54	Diss by H_2O. Fluor yellow-green in UV.
(1.526) ^	1.501	1.537	1.539	.038	CHALCANTHITE $CuSO_4\cdot 5H_2O$	56° r < v perc	---	TCL pris	110 im-perf fr conch	Dark blue	H 2.5 G 2.29	Sol in H_2O.
	1.455	1.538	1.545	.090	IKAITE $CaCO_3\cdot 6H_2O$	~ 45° (31±5°) disp inclined	Y = b Z:c = 17°	MCL	---	Cols	G 1.77	Dec by acids.

	1.516	1.538	1.547	.031	KORSHUNOVSKITE $Mg_2Cl(OH)_3 \cdot 3.5H_2O$	62°	el neg	TCL pris	---	Cols	H ~ 2 G 1.80	Sol in dil acids.
1.510 ^	(1.522)	1.538	1.542	(.020)	ARSENURANOSPATHITE $HAl(UO_2)_4(AsO_4)_4 \cdot 40H_2O$	52° r > v	X = c el pos	TET or ORTH ps tet	001 perf 100, 010 good	Pale yellow	H 2 G 2.54	Sol in acids. Fluor wk in UV.
	1.534	1.538	1.543	.009	CANASITE $(Na,K)_6Ca_5Si_{12}O_{30}(OH,F)_4$	58°	Y = b	MCL	2 perf at 118°	Greenish-yellow	G 2.71 F easy	Dec by acids. Poly tw.
	1.496	1.539	1.557	.061	BIRINGUCCITE $Na_4B_{10}O_{16}(OH)_2 \cdot 2H_2O$	63°	Y = b Z:a = 5°	MCL acic	001, 100 good	Cols	---	Diss in H_2O.
1.522 ^	1.536	1.539	1.541	.005	ANORTHOCLASE (Feldspar grp) $(K,Na,Ca)AlSi_3O_8$	62° r > v wk	ext on 010 = 3°	TCL	010, 001 perf	White, pink, etc	H 6 G 2.62 F 4	Insol acids. Tw pl 010, 100, giving very fine grating. Na_2O 7.2, K_2O 3.3, CaO 3.7%.
	1.522	1.540	1.552	.030	SULFOBORITE $Mg_3B_2(SO_4)(OH)_{10}$	70-88°	Y = b X = a	ORTH pris	110 good 001 fair	Cols	H 4-4.5 G 2.42 fus	Diss by acids.
1.541 pos ◊ 1.546	1.536	1.541	1.546	.010	OLIGOCLASE plagioclase, plutonic (Feldspar grp) $(Na,Ca)(Al,Si)_2Si_2O_8$	~ 90° r < v wk	X':a on 001 = 1° 010 = 7°	TCL	001 perf 010 good	White	H 6 G 2.64 F 4-5	Insol in acids. Tw pl 010 poly, almost universal. Data for An_{18}.
	1.520	1.541	1.545	.025	LUENEBURGITE $Mg_3B_2(PO_4)_2(OH)_6 \cdot 5H_2O$	62° (47±15°)	---	MCL fib	Pris	Cols to brownish	H 2 G 2.05 fus	Diss by acids.
1.537 ⌐	1.466	1.542	1.596	.130	DAWSONITE $NaAlCO_3(OH)_2$	77° r < v wk	X = a Y = c	ORTH bladed acic	110 perf	Cols, white	H 3 G 2.44 infus	Diss by acids with eff.
	1.528	1.542	1.549	.021	KOVDORSKITE $Mg_{10}(PO_4)_4(CO_3)_2(OH)_4 \cdot 9H_2O$	81° r > v wk	Z:c = 1-3° el pos	MCL	Conch to uneven	Pale rose	H 4 G 2.60	---
	1.535	1.542	1.549	.014	FOSHALLASITE $Ca_3Si_2O_7 \cdot 3H_2O$	12-18° (90±16°)	---	MCL(?) tab	100 perf	Snow-white	H 2.5-3 G 2.5	---
1.528 ^	1.538	1.543	1.548	.010	GISMONDINE (Zeolite grp) $(Ca,Na)Al_2Si_2O_8 \cdot 4H_2O$	15-90° r < v wk	Y = b Z:c = 42°	MCL ps tet	---	Cols, white	H 4.5 G 2.22 F 3	Gel with acids. Tw common, tw pl 110, 001.
	1.536	---	1.550	.014	LOUDOUNITE $NaCa_5Zr_4Si_{16}O_{40}(OH)_{11} \cdot 8H_2O$	---	---	fib	---	Green to white	H 5 G 2.48	Sign unk. Ext wavy.
1.534 ◊ 1.552	1.538	1.543	1.546	.008	OLIGOCLASE plagioclase, volcanic (Feldspar grp) $(Na,Ca)(Al,Si)_2Si_2O_8$	65°	X':a on 001 = 3° 010 = 4°	TCL	001 perf 010 good	White, cols	H 6 G 2.63 F 4-5	Insol in acids. Tw pl 010 poly. Data for An_{20}.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
(1.534) ^	1.533	(<u>1.543</u>)	1.546	.013	APLOWITE $(Co,Mn,Ni)SO_4 \cdot 4H_2O$	Med	---	MCL	---	Pink	H 3 G 2.33 infus	Sol in H_2O.
	1.539	<u>1.543</u>	1.544	.005	EPIDIDYMITE $NaBeSi_3O_7(OH)$	2-3°	X = <u>a</u> Z = <u>b</u>	ORTH	001 good 010 perf	Cols	H 5.5 G 2.61 F easy	Insol in acids. Multiple tw.
	1.522	<u>1.544</u>	1.552	.030	MUNDRABILLAITE $(NH_4)_2Ca(HPO_4)_2 \cdot H_2O$	(61±9°)	X = <u>b</u> Y:<u>c</u> = 26°	---	---	Cols	Soft G 2.05	Sol in H_2O.
	1.533	<u>1.544</u>	1.548	.015	BEHOITE $Be(OH)_2$	82° r < v str	Y = <u>a</u> Z = <u>c</u>	ORTH	Conch	White	H 4 G 1.92	Diss by acids.
	1.533	<u>1.544</u>	1.547	.014	PENTAGONITE $Ca(VO)Si_4O_{10} \cdot 4H_2O$	50° r > v str	X = <u>b</u> Y = <u>a</u>	ORTH	010 good	Greenish-blue	H 3-4 G 2.33	Pleoc str, X and Z cols, Y blue.
1.524 ◊ 1.568	1.542	<u>1.544</u>	1.546	.004	HYALOPHANE (Feldspar grp) $(K,Ba)Al(Si,Al)_3O_8$	75° r > v	Z = <u>b</u> X:<u>a</u> = -18°	MCL	010, 001 perf	Cols, white	H 6 G 2.79 F diff	Insol in acids. BaO 6.9% (Cn_{37}).
v 1.560	1.525	<u>1.545</u>	1.545	.020	VERMICULITE $(Mg,Fe,Al)_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$	~ 0°	X ⊥ plates	MCL	001 perf	Greenish, brownish	H 1.5 G 2.28 F 5	Dec by HCl. Exfoliates when heated. FeO 0.7, Fe_2O_3 4.2%.
	1.533	<u>1.545</u>	1.547	.014	MOOREITE $(Mg,Zn,Mn)_8SO_4(OH)_{14} \cdot 3H_2O$	50° r > v wk	X = <u>b</u> Z:<u>c</u> = 44° el clv pos	MCL tab to platy 010	010 perf	Cols, white	H 3 G 2.47 infus	Diss by acids. Mg:Zn:Mn = 4:2:1.
1.541 ◊ 1.550	1.541	<u>1.546</u>	1.550	.009	OLIGOCLASE plagioclase, plutonic (Feldspar grp) $(Na,Ca)(Al,Si)_2Si_2O_8$	~ 78°	X':<u>a</u> on 001 = 1° 010 = 2°	TCL	001 perf 010 good	Cols, white	H 6 G 2.65 F 4-5	Insol in acids. Tw pl 010, poly. Data for An_{25}.
	1.487	<u>1.546</u>	1.560	.073	BRADLEYITE $Na_3Mg(PO_4)(CO_3)$	49° r < v	X = <u>b</u> Y:<u>c</u> = 7°	MCL flattened 001	Conch	White, gray	H 3.5 G 2.72	Dec by H_2O, diss by acids with eff.
	1.507	<u>1.546</u>	1.569	.062	CARBOBORITE $Ca_2Mg(CO_3)B_2(OH)_8 \cdot 4H_2O$	75°	Y = <u>b</u> Z:<u>c</u> = 12° el pos	MCL pris	100 perf	Cols	H 2 G 2.12	Fluor white in UV, pale green phosphorescence.
1.530 ◊ (~1.57)	1.528	<u>1.546</u>	1.548	.020	PALYGORSKITE $(Mg,Al,Fe)_2Si_4O_{10}(OH) \cdot 4H_2O$	30-35°	---	ORTH fib	---	White, greenish	G 2.4-2.5 infus	Insol in acids. Fe_2O_3 6.6%.

1.535 ◇ 1.560	1.540	1.546	1.548	.008	CORDIERITE $(Mg,Fe)_2Al_4Si_5O_{18}$	68°	X = c Y = b	ORTH ps hex	010 fair 001 poor	Blue, green, cols	H 7 G 2.61 F 5.5	Partly dec by acids. Tw sectors, also lam. Pleoc, X pale yellow, Y dark blue, Z blue. FeO 5.1, Fe_2O_3 0.4%.
	1.438	1.547	1.595	.157	OXAMMITE $(NH_4)_2C_2O_4 \cdot H_2O$	62° r < v dist	X = c Y = a el clv pos	ORTH acic c	001 dist	Cols to yellowish	H 2.5 G 1.5 F volat	An oxalate. Sol in H_2O.
	1.537	1.547	1.549	.012	GYROLITE $Ca_2Si_3O_7(OH)_2 \cdot H_2O$	Small	el clv pos	HEX	0001 perf	Cols	H 3-4 G 2.40 F diff	Dec by acids.
v 1.564	1.522	(1.548)	1.549	.027	PHLOGOPITE (Mica grp) $KMg_3Si_3AlO_{10}(F,OH)$	14° r < v	Y = b el clv pos	MCL ps hex	001 perf	Cols	H 2-2.5 G 2.88	Data for synth fluor-phlogopite. (Pleoc, X cols, Y = Z brown, abs X < Y < Z?)
v 1.555	1.529	1.548	1.553	.024	LEPIDOLITE (Mica grp) $K(Li,Al)_3(Si,Al)_4O_{10}(F,OH)_2$	39° (54±12°) r > v	Z':clv = 0-7° el clv pos	MCL ps hex	001 perf	Cols, pink, gray	H 2.5-4 G 2.81 F 2.5	Insol in acids. FeO 0.1, Fe_2O_3 0.2, MnO 0.7, Li_2O 5.6%.
	1.522	1.549	1.549	.027	TRUSCOTTITE $(Ca,Mn)_{14}Si_{24}O_{58}(OH)_8 \cdot 2H_2O$	Small	---	HEX	One perf	White	G 2.47	Dec by HCl.
[ ]	1.519	1.550	1.559	.040	"RECTORITE" $Na(Mg,Al)_2(Si,Al)_4O_{10}(OH)_2 \cdot 2H_2O$	0-39° (56±7°)	---	MCL	001	White	H 1-2 G 2.2 infus	Interstratified Pyrophyllite-Vermiculite.
	1.520	---	1.558	.038	CHELKARITE $CaMgB_2O_4Cl_2 \cdot 7H_2O$ (?)	---	---	ORTH pris	Perf ∥ el	Cols to pale rose	G 2.21	Opt char unk.
[v 1.59	1.530	(1.550)	1.551	.021	SAUCONITE (Smectite grp) $Na_{0.33}Zn_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$	0-20°	X ⊥ clv Y = b el clv pos	MCL u mass	001 perf	White, yellow, brown	H 1.5-2 G 2.61	Dec by acids. ZnO 35.7, MgO 2.4, Al_2O_3 0.4%.
	1.537	1.550	1.556	.019	NAUJAKASITE $Na_6(Fe,Mn)(Al,Fe)_4Si_8O_{26}$	52-71°	---	MCL ps hex plates	001 perf	Silvery, gray	H 2-3 G 2.62 F 3	Gel with HCl.
1.546 ◇ 1.550 pos	1.546	1.550	1.554	.008	ANDESINE plagioclase, plutonic (Feldspar grp) $(Na,Ca)(Al,Si)_2Si_2O_8$	~ 90	X':a on 001 = 0° 010 = -5°	TCL	001 perf 010 good	White, cols	H 6 G 2.65 F 4.5	Insol in acids. Poly tw 010. Data for An_{33}.
	1.530	---	1.559	.029	YOFORTIERITE $(Mn,Mg)_5Si_8O_{20}(OH)_2 \cdot 8\text{-}9H_2O$	---	X:fib = 8°	ORTH or mon fib	---	Pink to violet	H 2.5 G 2.18	Opt char unk. Pleoc.
	1.519	1.552	1.561	.042	BALAVINSKITE $Sr_2B_6O_{11} \cdot 4H_2O$	Large (54±6°)	---	---	---	---	---	---

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.535	1.552	1.553	.018	SATIMOLITE $KNa_2Al_4B_6O_{15}Cl_3 \cdot 13H_2O$	Small	---	ORTH	---	White	G 2.1	---
1.543 ≶ 1.552 pos	1.549	1.552	1.556	.007	ANDESINE plagioclase, volcanic (Feldspar grp) $(Na,Ca)(Al,Si)_2Si_2O_8$	~ 90°	X':a on 001 = 2° 010 = -4°	TCL	001 perf 010 good	Cols	H 6 G 2.66 F 4.5	Insol in acids. Tw pl 010 poly. Data for An_{38}.
v 1.567	1.485	1.553	1.570	.085	ALUMOHYDROCALCITE $CaAl_2(CO_3)_2(OH)_4 \cdot 3H_2O$	64° (51±3°)	X = b ext = 7-10°	MCL	100 perf	Chalky to pale blue	H 2.5 G 2.23 infus	Dec by hot H_2O, diss by acids with eff.
	1.550	1.553	1.554	.004	CHAROITE $(K,Ba,Sr)(Ca,Na)_2Si_4O_{10}(OH,F) \cdot H_2O$	30°	ext:el = 5°	MCL	Three clv	Lilac to violet	G 2.54	In thick fragments pleoc, X rose, Z cols. U pos.
v 1.570	1.522	1.553	1.553	.031	TAENIOLITE (Mica grp) $KLiMg_2Si_4O_{10}F_2$	0-5° r > v	Y = b el ⊥ cTv pos	MCL ps hex	001 perf	Cols to brown	H 2.5-4 G 2.83	Insol in acids.
1.525 ^	(1.522)	1.553	1.579	(.057)	SEPIOLITE (ferrian) $(Mg,Fe)_4Si_6O_{15}(OH)_2 \cdot 6H_2O$	83°	el pos	ORTH fib	001, 010	Brown	H 2.5 G 2.3 infus	Dec by HCl. Fe_2O_3 10.0, FeO 1.2%.
	1.535	1.553	1.557	.022	HYDROCALUMITE $Ca_4Al(OH)_7 \cdot 3H_2O$	25° (50±12°) r < v	Y = b el pos	MCL ps hex	001 perf	Cols to light green	H 3 G 2.15 infus	Diss by acids. Becomes uniax at about 90°C.
	1.541	1.553	1.560	.019	BERYLLITE $Be_3SiO_4(OH)_2 \cdot H_2O$	Small (74±12°)	el pos	Fib	---	White	Soft G 2.20	---
⌐ 1.549	1.541	1.553	1.557	.016	EDINGTONITE (Zeolite grp) $BaAl_2Si_3O_{10} \cdot 4H_2O$	54° r < v wk	X = c Z = a el neg	ORTH ps tet	110 perf 1$\bar{1}$0	Cols	H 4 G 2.75 F 5	Gel with acids.
	1.498	1.554	1.594	.096	MINGUZZITE $K_3Fe(C_2O_4)_3 \cdot 3H_2O$	78°	---	MCL tab	010 perf	Green to yellow-green	G 2.03	An oxalate. Sol in H_2O. Pleoc, X yellow green, Z bright emerald-green.
	1.545	1.554	1.565	.020	Unnamed phosphate	~ 90° disp wk	---	MCL	---	Pale yellow, pale green	H 4.5 G 3.13	Diss by acids.

	1.531	1.555	1.570	.039	SHORTITE $Na_2Ca_2(CO_3)_3$	75° r < v mod	X = c Z = b	ORTH hemi-morph	010 dist	Cols to yellowish	H 3 G 2.6 F 1	Dec by H_2O, diss by acids with eff.
1.548 ^v 1.567	1.537	1.555	1.559	.022	LEPIDOLITE (Mica grp) $K(Li,Al)_3(Si,Al)_4O_{10}(F,OH)_2$	38° r > v	Z':clv = 0-7° el clv pos	MCL ps hex	001 perf	Cols, pink, lilac	H 2.5-4 G 2.86 F 2.5	Insol in acids. Fe_2O_3 1.1, FeO 0.7, MnO 0.9, Li_2O 5.5%.
v 1.568	1.545	1.555	1.555	.010	LIZARDITE (Serpentine grp) $Mg_3Si_2O_5(OH)_4$	Very small	Y = b Z = a	MCL fib	001 perf	Green	G 2.55 infus	Slowly attacked by acids. Fe_2O_3 2.2%.
	1.552	(1.556)	1.559	.007	HALLOYSITE, chromian $(Al,Cr)_2Si_2O_5(OH)_4$	~ 90°	---	MCL mass	---	Pale greenish-blue	H 2.5 G 2.1 infus	Insol in acids.
⊔ 1.57	1.545	---	1.56	.015	"MN-PALYGORSKITE" $NaMgMn(Fe,Al)_3Si_7O_{20}(OH)_2 \cdot 10H_2O$ (?)	Large	Z = c	Spher-ulitic	---	Rose to red	G 2.62	Pleoc, X yellow, Z red-brown, abs Z > X. Am. Mineral., 55, 2139 (1970).
	1.552	1.558	1.561	.009	BERYLLONITE $NaBePO_4$	68° r < v wk	X = b Z = c	MCL ps orth tab	010 perf 100 good	Cols to pale yellow	H 5.5-6 G 2.81 F 3	Slowly diss by acids.
	1.514	1.559	1.562	.048	ZINCSILITE $Zn_3Si_4O_{10}(OH)_2 \cdot 4H_2O$ (?)	0-22°	Z:c = 3°	MCL	001 perf	White to bluish	H 1.5-2 G 2.69	---
	1.551	1.559	1.562	.011	ARMENITE (Osumilite grp) $BaCa_2Al_6Si_9O_{30} \cdot 2H_2O$	60°	---	HEX	Three clv	Cols	H 7-8 G 2.77	---
	1.541	1.560	1.567	.026	FENAKSITE $(K,Na,Ca)_4(Fe^{+2},Fe^{+3},Mn)_2Si_8O_{20}(OH,F)$	77° (62±10°)	Z = b	TCL	001 perf	Pale rose	H 5-5.5 G 2.74 F easy	Dec by acids.
1.545 ^v 1.581	1.540	1.560	1.560	.020	VERMICULITE $(Mg,Fe,Al)_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$	6-8°	X ⊥ 001 el clv pos	MCL	001 perf	Green to brown	H 1.5 G 2.29 F 5	Exfoliates when heated. Dec by HCl. Fe_2O_3 4.2, FeO 1.8%.
	1.545	1.560	1.561	.016	LOVOZERITE $(Na,Ca)_3(Zr,Ti)Si_6(O,OH)_{18}$	Small	X ~ c	TRIG	---	Dark brown to black	H 5 G 2.38 F easy	Insol in acids. Poly tw.
1.546 ^v 1.569	1.551	1.560	1.562	.011	CORDIERITE $(Mg,Fe)_2Al_4Si_5O_{18}$	42°	X = c Y = b	ORTH ps hex	010 fair	Blue, green, cols	H 7 G 2.66 F 5	Partly dec by acids. Tw sectors, also lam. Pleoc, X cols, Y dark blue, Z blue. FeO 7.1, Fe_2O_3 0.2%.
	1.552	1.5605	1.561	.009	KULKEITE $Mg_8Al(Si_7Al)O_{20}(OH)_{10}$	24°	Y = a Z = b	MCL	001 perf	Cols	H 2 G 2.70	Interlayered talc-chlorite.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.536 ^v 1.588	1.526	1.561	1.561	.035	BEIDELLITE (Smectite grp) $Na_{0.33}Al_2(Si,Al)_4O_{10}(OH)_2 \cdot xH_2O$	47° (small)	X = c Z = a el cTv pos	MCL earthy	001 perf	White, reddish, gray	G 2.0 infus	Refractive indices increase when immersed in certain oils.
v ~1.585	1.553	---	1.569	.016	KARPINSKITE $(Mg,Ni)_2Si_2O_5(OH)_2$ (?) (?)	---	Z:c = 12°	MCL (?)	---	Cols to greenish-blue	H 2.5-3 G 2.6	---
	1.547	---	1.571	.024	GLUCINE $Ca_2Be_8(PO_4)_4(OH)_8 \cdot H_2O$	---	el pos ext ||	Fine needles	---	Cols	H ~ 5 G 2.23-2.40	Diss by acids. Opt char unk.
	1.547	1.562	1.567	.020	POLYHALITE $K_2Ca_2Mg(SO_4)_4 \cdot 2H_2O$	62-70°	Z':tw on $10\bar{1}$ = 28°	TCL fib b tab	$10\bar{1}$ perf parting 010	Red, yellow, cols	H 3.5 G 2.78 F 1.5	Dec by H_2O, diss by acids. Poly tw.
	1.557	1.562	1.563	.006	NACRITE $Al_2Si_2O_5(OH)_4$	40-90° r > v wk	Z = b X:c = 12°	MCL tab wedge-shaped	001 perf	White	G 2.60 infus	Insol in acids. Luster pearly.
	1.521	1.563	1.585	.064	SIDORENKITE $Na_3Mn(PO_4)(CO_3)$	63° (70±4°)	el b	MCL ps orth	100, 010 perf	Pale rose	H ~ 2 G 2.90	Diss by acids.
	1.541	1.563	1.564	.023	TANCOITE $HNa_2LiAl(PO_4)_2(OH)$	23° r < v wk	X = a Y = b	MCL	010, 001 fair	Pale pink	H 4-4.5 G 2.75	Diss by acids.
	1.560	1.563	1.515	.005	SCHODERITE $Al_2(PO_4)(VO_4) \cdot 8H_2O$	42°	X = b Y:c = 25°	MCL	---	Yellow-orange	H 2 G 1.92	Pleoc in yellow, abs Y > Z > X.
(1.548) ^v 1.584	1.535	1.564	1.565	.030	PHLOGOPITE (Mica grp) $K(Mg,Fe)_3Si_3AlO_{10}(F,OH)_2$	10° r < v wk	Y = b X ~ c el cTv pos	MCL platy	001 perf	Yellow, brown	H 2-2.5 G 2.75 F diff	Insol in acids. Pleoc, X cols, Y = Z brown, abs X < Y < Z.
	1.552	1.564	1.571	.019	JENNITE $Ca_9H_2Si_6O_{18}(OH)_8 \cdot 6H_2O$	74°	Y: el = 35-40°	TCL bladed fib	001 perf	White	G 2.32	---
1.531 ^	1.485	1.565	1.572	.087	SAPONITE (Smectite grp) $(Ca,Na)_{0.33}(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$	Small (32±5°)	X ⊥ 001	MCL plates	001 perf	Dark green	H 1.5 G 2.31 F 4	Gel with acids. Pleoc, X pale yellow, Y olive-green, Z brown-green. FeO 7.8, Fe_2O_3 7.3, Al_2O_3 9.1%.

	1.536	1.565	1.570	.034	FLUOBORITE $Mg_3BO_3(F,OH)_3$	Small	---	HEX fib	0001 indist	White	H 3.5 G 2.82	Diff diss by acids. F 15.6, H_2O 6.2%.
∨ 1.592	1.550	1.565	1.570	.020	VARISCITE $AlPO_4 \cdot 2H_2O$	Med r < v wk	X = a Z = b el cTv neg	ORTH	010 good 001 poor	Green to cols	H 4.5 G 2.57-2.75 infus	Insol in acids, but diss after being heated gently.
	1.554	1.565	1.573	.019	REEDMERGNERITE (Feldspar grp) $NaBSi_3O_8$	80°	---	TCL	001 perf	Cols	H 6-6.5 G 2.70 F 2	Insol in acids.
	1.553	1.565	1.567	.014	MORINITE $NaCa_2Al_2(PO_4)_2(OH,F)_5 \cdot 2H_2O$	40° r < v wk	Y = b	MCL	100 perf	Wine-red, cols	H 4.5 G 2.96 F easy	Insol in acids.
	1.557	1.565	1.571	.014	VIITANIEMIITE $Na(Ca,Mn)Al(PO_4)(F,OH)_3$	81°	Y = b	MCL tab	$10\overline{1}$ good	Gray, white	H 5 G 3.25	---
1.559 [] 1.569	1.560	1.565	1.566	.006	KAOLINITE $Al_2Si_2O_5(OH)_4$	24-50° r > v	Z = b X:c = 1-4°	MCL u earthy masses	001 perf	White to brownish	H 2-2.5 G 2.60 infus	Insol in acids.
⌴ 1.577	1.560	1.565	1.566	.006	ZEOPHYLLITE $Ca_4Si_3O_8(OH,F)_4 \cdot 2H_2O$	Small	Z = b el cTv pos	TRIG	0001 perf	Cols, white	G 2.75 F easy	Gel with acids. Uniax and biax segments. Exfoliates when heated.
	1.546	1.566	1.573	.027	FURONGITE $Al_2(UO_2)(PO_4)_2(OH)_2 \cdot 8H_2O$	65°	---	TCL	3 perf	Bright yellow to lemon-yellow	G 2.86	Fluor in UV. Str in yellow-green.
	1.554	1.566	1.567	.013	TOBERMORITE $Ca_5Si_6O_{16}(OH)_2 \cdot 4H_2O$	26-33°	---	ORTH	---	Cols	G 2.45	---
∨ 1.577	1.561	1.566	1.567	.006	ANTIGORITE (Serpentine grp) $(Mg,Fe)_3Si_2O_5(OH)_4$	48° r > v	X = c el cTv pos	MCL	001 perf	Green to white	H 3-4 G 2.61 infus	Dec by acids.
1.553 ≎ ~1.587	1.504	1.567	1.575	.071	ALUMOHYDROCALCITE $CaAl_2(CO_3)_2(OH)_4 \cdot 3H_2O$	46-70°	X = b ext $\overline{7}$-10°	MCL	100 perf	White	H 2.5 G 2.23 infus	Dec by hot H_2O, diss by acids with eff.
1.555 ≎ 1.577	1.542	1.567	1.570	.028	LEPIDOLITE (Mica grp) $K(Li,Fe,Al)_3(Si,Al)_4O_{10}(F,OH)_2$	34° r > v	X ~ c el cTv pos	MCL ps hex	001 perf	Cols, pink, brown	H 2.5-4 G 2.95 F 2.5	Insol in acids. Fe_2O_3 0.8, FeO 2.0, MnO 2.0, Li_2O 5.3%.
∨ 1.592	1.55	1.567	1.572	.022	URANOSPINITE (Autunite grp) $Ca(UO_2)_2(AsO_4)_2 \cdot 10H_2O$	0-62° r > v mod	X = c	TET tab	001 perf 100 dist	Lemon-yellow to green	H 2-3 G 3.45 fus	Diss by acids. Pleoc, X cols, Y and Z pale yellow.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.557	1.567	1.570	.013	OLSHANSKYITE $Ca_3B_4(OH)_{18}$	54° r > v wk	ext at 30°	MCL (?) fib	---	Cols	H 4	Diss by acids. Poly tw.
	1.520	1.568	1.591	.071	BONSHTEDTITE $NaFe^{+2}(PO_4)(CO_3)$	(68±3°)	X = b Y = c	MCL ps orth tab	010, 100 perf	Cols, rose	H 4 G 3.16	Dec by acids with eff.
	1.541	(1.568)	1.570	.029	PSEUDO-AUTUNITE $(H_3O)_4Ca_2(UO_2)_2(PO_4)_4 \cdot 5H_2O$ (?)	32° r > v dist	Y = c	ORTH ps hex plates	001 perf	Pale yellow	G 3.28	Diss by acids. Fluor bright greenish-yellow in UV.
	1.562	1.568	1.574	.012	ELPIDITE $Na_2ZrSi_6O_{15} \cdot 3H_2O$	89°	Z = a	ORTH fib	110 dist	White to tan	H 6 G 2.63	Insol in acids. U biax pos.
1.568 pos ↕ 1.577	1.563	1.568	1.573	.010	BYTOWNITE plagioclase, plutonic (Feldspar grp) $(Ca,Na)Al(Si,Al)Si_2O_8$	~ 90°	X':a on 001 = -16° 010 = -29°	TCL	001 perf 010 good	White, gray	H 6 G 2.71 infus	Insol in acids. Tw pl 010 poly. Data for An_{70}.
1.544 ↕ 1.583	1.564	1.568	1.572	.008	CELSIAN var Kasoite (Feldspar grp) $(Ba,K)Al(Si,Al)Si_2O_8$	80°	X:c on 001 = 10-13° 010 = 2-3°	MCL	001 perf 010 dist	Cols	H 5.5 G 3.00	Not tw. BaO 25.0% (Cn_{65}).
1.555 ↕ 1.638	1.562	1.568	1.570	.008	LIZARDITE (Serpentine grp) $Mg_3Si_2O_5(OH)_4$	45°	---	MCL fib	001 perf	Green	G 2.58 infus	Insol in acids. Pleoc wk, X yellow, Y and Z green.
1.560 ↕ 1.572	1.559	1.569	1.573	.014	SEKANINAITE (Cordierite grp) $(Fe,Mg)_2Al_4Si_5O_{18}$	70°	X = c Y = b	ORTH ps hex	100 fair	Blue to violet	H 7 G 2.77 F 5	Partly dec by acids. Tw pl 110, 310. Pleoc, X cols, Y and Z light blue, abs Z > Y > X. FeO 17.8%.
	1.563	1.569	1.573	.010	ARMSTRONGITE $CaZrSi_6O_{18} \cdot 2.5H_2O$	r < v	Z = b Y:c = 6°	MCL	001 perf 100 fair	Brown	H 4.5 G 2.58	Insol in acids.
1.561 ↕ 1.586	1.560	1.569	(1.570)	.010	NONTRONITE var Volchonskoite (Smectite grp) $Na_{0.33}(Fe,Cr)_2(Si,Al)_4O_{10}(OH)_2 \cdot xH_2O$	Small	Y = b	MCL earthy	001 perf	Bright green	H 2 G 2.36 infus	Dec by acids. Cr_2O_3 22.1%.

1.569 pos ◇ 1.577	1.565	1.569	1.574	.009	BYTOWNITE plagioclase, volcanic (Feldspar grp) $(Ca,Na)Al(Si,Al)Si_2O_8$	~ 90°	X':a on 001 = -23° 010 = -33°	TCL	001 perf 010 good	Cols, white	H 6 G 2.72 infus	Insol in acids. Tw poly. Data for An_{75}.
⊔ 1.572	1.567	1.569	1.570	.003	PHOSINAITE $Na_3H_2(Ca,Ce)(SiO_4)(PO_4)$	69°	X = b Y = c	ORTH colum-nar	100 perf 010, 110 imperf	Cols to rose	H 3.5 G 2.62, 3.00 F 3	Slowly diss by concd acids.
	1.536	1.570	1.571	.035	MASUTOMILITE (Mica grp) $K(Li,Mn,Al)_3(Si,Al)_4O_{10}(F,OH)_2$	28° r > v wk	Y = b Z:a = 3° el clv neg	MCL	001 perf	Pale purplish-pink	H 2.5 G 2.90	Insol in acids. Pleoc, X and Z cols to pale purple, Y purple. MnO 4.3, Li_2O 5.8%.
⊔ 1.578	1.543	1.570	1.577	.034	NOVACEKITE (Autunite grp) $Mg(UO_2)_2(AsO_4)_2\cdot12H_2O$	0-40°	X = c	TET tab	001 perf 100 dist	Yellow	H 2-2.5 G 3.23	Diss by acids. Fluor yellow in UV.
1.553 ∧	1.540	1.570	1.570	.030	TAENIOLITE (Mica grp) $KLiMg_2Si_4O_{10}F_2$	5° r < v	Y = b el clv pos	MCL ps hex	001 perf	Cols to brown	H 2.5-4 G 2.87	Insol in acids. Pleoc wk, X cols, Z yellow.
∨ 1.582	---	1.570	1.626	---	BUKOVSKYITE $Fe_2(AsO_4)(SO_4)(OH)\cdot7H_2O$	---	ext at 18°	MCL (?) acic	---	Yellow to gray-green	G 2.34	Diss by HCl. Opt char unk.
∨ 1.582	1.559	1.570	1.574	.015	SALEEITE (Autunite grp) $Mg(UO_2)_2(PO_4)_2\cdot10H_2O$	0-65° r < v str	X = c	TET tab	001 perf 010, 110 indist	Lemon-yellow	H 2-3 G 3.27	Diss by acids. Pleoc, X cols, Z greenish-yellow. Fluor lemon-yellow in UV.
	1.564	1.570	1.574	.010	TOSUDITE (interlayered-Montmorillonite-Chlorite)	59°	el pos	MCL	001 perf 010	Cols	H ~ 1 G 2.83	---
	1.543	1.571	1.577	.034	SHABYNITE $Mg_5(BO_3)(Cl,OH)_2(OH)_5\cdot4H_2O$	(49±9°)	X ‖ clv	MCL fib	---	White	H 3 G 2.32	Diss by acids.
1.564 ⊓	1.524	1.571	1.583	.059	ROEMERITE $Fe^{+2}Fe^{+3}{}_2(SO_4)_4\cdot14H_2O$	51° r > v str crossed	ext on clv = 33°	TCL tab 001	010 perf 001 good	Brown to yellow	H 3-3.5 G 2.17 F 4.5-5	Sol in H_2O. Pleoc, X reddish yellow, Y pale yellow, Z yellow-brown.
1.546 ∧	1.56	(~1.57)	1.58	.02	MANGANOPALYGORSKITE $(Mn,Mg,Al)_2Si_4O_{10}(OH)\cdot4H_2O$	Med large	Z = c	ORTH fib	---	Rose to red	G 2.62	Pleoc, X yellow, Z red-brown.
	1.546	1.572	1.576	.030	DEFERNITE $Ca_3(CO_3)_2(OH,Cl)_8\cdot H_2O$	42° r < v mod	X = c Y = b	ORTH	---	Cols	G 2.5	Diss by cold HCl with eff.
∨ 1.580	(1.533)	1.572	1.573	.040	HAIWEEITE $Ca(UO_2)_2Si_6O_{15}\cdot5H_2O$	18° r > v str	Y = b	MCL spher-ulitic	100 good	Pale yellow	H 3.5 G 3.35	Pleoc wk, Y pale yellow, Z cols. Fluor pale green in UV.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.562	(1.572)	1.583	.021	Unnamed hydrous calcium arsenate	~ 90°	Z = b Y:c = 8°	MCL (?)	---	Cols	---	Opt char unk. Am. Mineral., 53, 561 (1968).
1.566 □ 1.581	1.570	1.572	1.573	.003	ENGLISHITE $K_4Na_2Ca_9Al_{18}(PO_4)_6(PO_3OH)_{12}(OH)_{36}\cdot 8H_2O$	Small	X = c Z ~ b el cTv pos	MCL (?) plates	001 perf	Cols, white	H 2 G 2.65	---
	1.568	1.574	1.580	.012	OVERITE $CaMgAl(PO_4)_2(OH)\cdot 4H_2O$	65-85° r > v wk	X = c Y = b	ORTH	010 perf	Pale green, cols	H 4 G 2.53 F 2	Diss by hot acids.
v 1.610	1.57	1.574	1.580	.010	BASSETITE (Meta-autunite grp) $Fe(UO_2)_2(PO_4)_2\cdot 8H_2O$	62° r > v str	X = b Z:c = -4°	MCL ps tet	010 perf	Olive-green, olive-brown	H 2.5 G 3.4	Diss by acids. Pleoc, X pale yellow, Y and Z deep yellow. Does not fluor in UV.
	1.548	1.574	1.582	.034	LITIDIONITE $KNaCuSi_4O_{10}$	56°	---	TCL	---	Blue	G 2.75	---
	1.546	1.575	1.579	.033	BRAMMALLITE (Mica grp) $(Na,H_3O)(Al,Mg,Fe)(Si,Al_4)_4O_{10}[(OH)_2,H_2O]$	Small variable	X ~ c el cTv pos	MCL	001 perf	White	H 1-2 G 2.69	Dec by acids.
v 1.587	1.555	1.575	1.581	.026	TOBELITE (Mica grp) $(NH_4,K)Al_2(Si_3Al)O_{10}(OH)_2$	28° (57±10°)	el pos	MCL	001 perf	White	---	---
⊔ 1.586	1.555	1.575	1.577	.022	AUTUNITE (Autunite grp) $Ca(UO_2)_2(PO_4)_2\cdot$ $10\text{-}12H_2O$	0-53° u 10-30° r > v str	X = c	TET tab	001 perf	Lemon- to sulfur-yellow to greenish	H 2-2.5 G 3.1-3.2 fus	Diss by acids. Pleoc, X cols to pale yellow, Y and Z deep yellow. Fluor yellow-green in UV.
	1.567	1.576	1.579	.012	PANETHITE $(Na,Ca,K)(Mg,Fe,Mn)PO_4$	51°	---	MCL	---	Pale amber	G 2.95	Tw. FeO 5.3, MnO 1.7%. Meteorite mineral.
	1.558	1.576	1.593	.035	XIANGJIANGITE $(Fe^{+3},Al)(UO_2)_4(PO_4)_2(SO_4)_2(OH)\cdot 22H_2O$	(87±7°)	---	ORTH ps tet	---	Yellow	H 1-2 G 2.9-3.1	Diss by acids. Not fluor in UV. Pleoc wk in yellows.

	(1.558)	1.576	1.582	(.024)	MATULAITE $CaAl_{18}(PO_4)_{12}(OH)_{20}\cdot 20H_2O$	60° r < v very str	Y = b Z:c = 8°	MCL	100 perf	Cols, white	H 1 G 2.33	---
1.567 ^	1.548	1.577	1.579	.031	ZINNWALDITE (Mica grp) $KLiFe^{+2}Al(Si_3Al)O_{10}(F,OH)_2$	30° r > v	X ~ c el clv pos	MCL ps hex	001 perf	Brown	H 2.5-4 G 3.01 F 2.5	Insol in acids. FeO 10.4, MnO 1.7, Fe_2O_3 0.6, Li_2O 2.0%.
	1.574	(1.577)	1.577	.003	EKATERINITE $Ca_2B_4O_7(Cl,OH)_2\cdot 2H_2O$	Very small	---	HEX (?)	---	White, rose	H ~ 1 G 2.44	Diss by acids. Indices decrease in oils.
1.568 ◇ 1.584	1.571	1.577	1.583	.012	BYTOWNITE plagioclase, plutonic (Feldspar grp) $(Ca,Na)Al(Al,Si)Si_2O_8$	79°	X':a on 001 = -30° 010 = -37°	TCL	001 perf 010 good	White, gray, cols	H 6 G 2.74 infus	Insol in acids. Tw pl 010, 001 poly. Data for An_{88}.
1.569 ◇ 1.584	1.572	1.577	1.583	.011	BYTOWNITE plagioclase, volcanic (Feldspar grp) $(Ca,Na)Al(Al,Si)Si_2O_8$	81°	X':a on 001 = -34° 010 = -36°	TCL	001 perf 010 good	White	H 6 G 2.74 infus	Insol in acids. Tw pl 010, 001 poly. Data for An_{90}.
1.566 ◇ 1.603	1.567	1.577	1.578	.011	ANTIGORITE (Serpentine grp) $(Mg,Fe,Cr)_3Si_2O_5(OH)_4$	58° r < v str	X = c	MCL laths	001 perf	Lavender	H 4 G 2.6 F diff	Insol in acids. Abnorm blue interf color. Cr_2O_3 4.4%.
	1.544	1.578	1.601	.057	KROEHNKITE $Na_2Cu(SO_4)_2\cdot 2H_2O$	78° r < v inclined	Y = b X:c = 48°	MCL pris	010 perf fr conch	Blue to greenish-blue	H 2 G 2.90 F easy	Sol in H_2O. Tw 101 common.
1.576 □ 1.583	1.544	1.578	1.586	.042	TARASOVITE (Mica grp) $(Ca,Na)_{0.42}KNa(H_3O)Al_8(Si,Al)_{16}O_{40}(OH)_8\cdot 2H_2O$	23° (51±6°)	---	MCL scales	---	White	G 2.36	Interlayered mica-clay.
	1.570	---	1.584	.014	URANOSILITE $UO_3\cdot 7SiO_2$	---	el pos	ORTH acic	---	Yellow-white	G 3.25	---
	1.572	1.578	1.582	.010	MONTGOMERYITE $Ca_4MgAl_4(PO_4)_6(OH)_4\cdot 12H_2O$	75° r < v wk	Z = b X:c = 60° el clv neg	MCL laths	010 perf	Deep green to cols	H 4 G 2.53	Pleoc, X cols to pale green, Y and Z cols.
v 1.588	1.576	1.578	1.578	.003	CLINOCHLORE (Chlorite grp) $(Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	~ 0° r > v wk	X ~ c el clv pos	MCL ps hex	001 perf	Green	H 2.5 G 2.7 F diff	Dec by H_2SO_4. Abnormal blue interf colors. Pleoc, X nearly cols, Y and Z green.
	1.567	1.579	1.581	.014	AGRELLITE $NaCa_2Si_4O_{10}(F,OH)$	47°	---	TCL	$1\bar{1}0$, 110 perf 010 poor	White	H 5.5 G 2.90	---

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
⊓ ⊔	1.569	1.579	1.583	.014	SUDOITE (Chlorite grp) $Mg_2(Al,Fe)_3Si_3AlO_{10}(OH)_8$	78° r < v str	Z ~ ⊥ c el pos (?)	MCL plates	001 perf	Cols to green	H 2-3 G 2.68	Partly dec by acids. Dioctahedral chlorite.
1.572 ^	1.56	1.580	1.581	.021	HAIWEEITE $Ca(UO_2)_2Si_6O_{15}\cdot 5H_2O$	16-20° r > v str	Y = b	MCL spherulitic	110 good	Yellow	H 3.5 G 3.35	Pleoc wk, Y pale yellow, Z cols. Fluor faint green in UV.
1.474 ^	1.562	1.580	1.582	.020	HISINGERITE $Fe^{+3}{}_2Si_2O_5(OH)_4\cdot 2H_2O$	Small r > v wk	Z = c	MCL u mass	---	Brown	H 3.5 G 2.3-2.6	---
1.560 ^v 1.607	1.561	1.581	1.581	.020	VERMICULITE $(Mg,Fe,Al)_3(Si,Al)_4O_{10}(OH)_2\cdot 4H_2O$	~ 0°	X ⊥ plates el clv pos	MCL	001 perf	Green, brown	H 1.5 G 2.6 F 5	Dec by HCl. Exfoliates when heated. Fe_2O_3 7.4, FeO 1.1%.
	1.575	1.581	1.583	.008	KINGSMOUNTITE $(Ca,Mn^{+2})_4(Fe^{+2},Mn)Al_4(PO_4)_6(OH)_4\cdot 12H_2O$	62°	Z:el = 35°	MCL	---	Cols	H 2.5 G 2.51	MnO 8.1, FeO 4.1%.
⊔ 1.585	1.576	1.581	1.584	.008	SORENSENITE $Na_4SnBe_2Si_6O_{16}(OH)_4$	0-75° str, inclined	---	MCL	2 at 63°	Cols to pink	G 2.90	Anom yellow-brown and blue interference colors.
1.570 ^	---	1.582	1.631	---	BUKOVSKYITE $Fe_2(AsO_4)(SO_4)(OH)\cdot 7H_2O$	---	ext at 18°	MCL (?) acic	---	Yellow to gray-green	G 2.34	Diss by HCl. Opt char unk.
v 1.628	1.548	(1.58)	1.600	.052	LAUSENITE $(Fe,Al)_2(SO_4)_3\cdot 6H_2O$	Large	---	MCL fib	---	Cols	---	Fe/Al = 1.03.
v 1.590	1.552	1.582	1.587	.035	MUSCOVITE (Mica grp) $KAl_2(Si_3Al)O_{10}(OH)_2$	30-47° r > v	Z = b X:c ~ 0° el clv pos	MCL ps hex	001 perf	Pale brown, pale green	H 2.5-3 G 2.77 F 5.5	Insol in acids. Tw pl 001.
1.570 ^	1.565	1.582	1.585	.020	SALEEITE (Autunite grp) $Mg(UO_2)_2(PO_4)_2\cdot 10H_2O$	0-65° r < v str	X = c	TET tab	001 perf 010, 100 indist	Lemon-yellow	H 2-3 G 3.27	Diss by acids. Pleoc, X cols, Z greenish-yellow. Fluor lemon-yellow in UV.

	1.564	1.582	1.584	.020	SABUGALITE (Autunite grp) $HAl(UO_2)_4(PO_4)_4 \cdot 16H_2O$	35°	el pos	TET plates	001 perf	Bright yellow	H 2.5 G 3.20	Diss by acids. Pleoc, X cols, Y and Z pale yellow. Fluor bright lemon-yellow in UV.
	1.576	1.582	1.584	.008	TERSKITE $Na_4ZrSi_6O_{16} \cdot 2H_2O$	53° r > v wk	---	ORTH ps tet	---	Pale lilac	H 5 G 2.71	Insol in acids. Bright green in UV.
v 1.598	1.574	1.582	1.582	.008	HOPEITE $Zn_3(PO_4)_2 \cdot 4H_2O$	Small r < v wk	X = a Y = c	ORTH tab pris	010 perf 100 good	Cols to yellow	H 3.5 G 3.05 F easy	Diss by acids.
	1.576	1.582	1.584	.008	GUERINITE $Ca_5H_2(AsO_4)_4 \cdot 9H_2O$	7-15° r > v str also r < v	Z = el	MCL acic	Three clv	Cols	H 1.5 G 2.68	Diss by acids.
	1.514	1.583	1.595	.081	STRONTIODRESSERITE $(Sr,Ca)Al_2(CO_3)_2(OH)_4 \cdot H_2O$	42°	Y = el X ⊥ el	ORTH laths	---	White	G 2.71	Diss by HCl with eff.
[v] 1.603	1.554	1.583	1.583	.029	STILPNOMELANE $K(Fe^{+2},Mg,Fe^{+3},Al)_{10}Si_{12}O_{30}(OH)_{12}$	~ 0°	X = b Y ~ c	MCL also TCL	001 perf	Golden- to reddish- brown	H 3-4 G 2.74 F 4.5	Dec by acids. Pleoc, X pale yellow-brown, Y and Z dark brown. FeO 26.7, Fe_2O_3 2.1, MnO 0.4%.
	(1.573)	1.583	1.583	.010	THREADGOLDITE $Al(UO_2)_2(PO_4)_2(OH) \cdot 8H_2O$	70°	Y = b Z:c = 4° el neg	MCL tab	001, 100 010, 012	Greenish- yellow	G 3.4	Fluor green in long-wave UV.
	1.574	1.583	1.588	.014	URANOCIRCITE $Ba(UO_2)_2(PO_4)_2 \cdot 12H_2O$	60-70°	X = c	TET tab	001 perf	Yellow- green	H 2 G 3.8	Diss by acids. Pleoc wk, X nearly cols, Y and Z pale yellow. Fluor green in UV.
1.568 ◊ 1.589	1.580	1.583	1.586	.006	CELSIAN (Feldspar grp) $(Ba,K)Al(Si,Al)Si_2O_8$	74°	Z:c on $10\bar{0}$ = 33°	MCL	001 perf 010 good	Cols	H 5.5 G 3.30	Not tw (Cn_{85}).
v 1.599	1.545	1.584	1.584	.039	TALC $Mg_3Si_4O_{10}(OH,F)_2$	0-10° r > v	X ~ c Z = b el pos	TCL plates	001 perf	White to green	H 1 G 2.7 infus	Tcl polymorph. Pearly luster, greasy feel.
1.564 ◊ 1.598	1.555	1.584	1.588	.033	PHLOGOPITE (Mica grp) $K(Mg,Fe)_3Si_3AlO_{10}(F,OH)_2$	23-30° r < v wk	Y = b X ~ c el pos	MCL plates	001 perf	Brown	H 2-2.5 G 2.86 F diff	Insol in acids. Pleoc, X cols to pale yellow, Y = Z brown, abs X < Y < Z. FeO 4.2, Fe_2O_3 3.7%.
	1.568	1.584	1.585	.017	LAPLANDITE $Na_4CeTiPSi_7O_{22} \cdot 5H_2O$	Small	---	ORTH fib radi- ating	Splintery	Gray to yellowish	H 2-3 G 2.83 F 2	---

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.570	1.584	1.585	.015	TORREYITE $(Mg,Mn)_5Zn_2(SO_4)(OH)_{12}\cdot 4H_2O$	40°	X = b	MCL	010 good	White	G 2.66	Diss by acids. Poly tw.
1.577 ^	1.575	1.584	1.589	.014	ANORTHITE plagioclase, plutonic, and volcanic (Feldspar grp) $CaAl_2Si_2O_8$	77° r < v	X':a on 001 = -40° 010 = -39°	TCL	001 perf 010 good	Cols, white, pink	H 6-6.5 G 2.76	Gel with acids. Tw poly 010, 001 almost universal, other tw laws common. Data for An_{100}.
	1.582	1.584	1.584	.002	ZEKTZERITE $NaLiZrSi_6O_{15}$	~ 0° r > v wk	X = a Y = b	ORTH	100, 010 perf	Cols to pink	H 6 G 2.79	Fluor light yellow in short-wave UV.
	1.575	1.585	1.595	.020	WHITEITE-(MN) $(Mn,Ca)Mg_2(Fe,Mn)Al_2(PO_4)_4(OH)_2\cdot 8H_2O$	80-90°	X = b Y = c	MCL	001 good	Tan to brown	H 3-4 G 2.67	Diss by acids. Tw 001. FeO 7.9, MnO 7.6, MgO 10.1%.
	1.564	1.585	1.585	.021	URAMPHITE (Meta-autunite grp) $(NH_4)(UO_2)PO_4\cdot 3H_2O$	0-3°	---	---	2 dist	Bottle-green to pale green	G 3.7	Diss by acids. Fluor med yellow-green in UV. Pleoc, X cols, Y and Z pale green.
~1.562 ^	1.570	---	1.594	.024	KARPINSKITE $(Mg,Ni)_2Si_2O_5(OH)_2$	---	Z:c = 0-12° el pos	MCL(?)	---	Blue	H 2.5-3 G 2.6	Cryptocryst. NiO 2.1%.
v 1.611	1.545	1.586	1.589	.044	BANNISTERITE $(Na,K)(Mn,Fe,Al)_5(Si,Al)_6O_{15}(OH)_5\cdot 2H_2O$	Med (30+9°) r < v wk	Z ~ a	MCL	---	Brown	G 2.84	Pleoc, X nearly cols, Y and Z brown.
1.569 ^ v 1.600	1.545	1.586	1.589	.044	NONTRONITE (Smectite grp) $Na_{0.33}Fe^{+3}{}_2(Si,Al)_4O_{10}(OH)_2\cdot xH_2O$	Small to med r < v	Y = b Z ~ c	MCL u mass	001 perf	Dark brown to olive-green	H 1-2 G 2.50	Dec by acids. Pleoc, X pale yellow, Y olive-green, Z yellow green.
(v 1.600)	1.559	1.586	1.586	.027	GLAUCONITE var Skolite (Mica grp) $(K,Na)(Al,Fe,Mg)_2(Si,Al)_4O_{10}(OH)_2$	Small r < v	Y = b X:c = 10°	MCL	001 perf	Cols, blue, green	H 2 G 2.6 fus	Dec by acids. Fe_2O_3 6.4, Al_2O_3 18.2, FeO 2.6%.

1.567 ^	1.540	---	1.592	.052	ALUMOHYDROCALCITE ("Knipovichite") $Ca(Al,Cr)_2(CO_3)_2(OH)_4 \cdot 3H_2O$	---	X = b ext 7-10°	MCL fib	100 perf	Pink	H 2.5 G 2.23 infus	Diss by acids with eff. Cr_2O_3 8.8%.
v 1.590	1.52	1.587	1.613	.093	LANTHANITE $(La,Ce,Nd)_2(CO_3)_3 \cdot 8H_2O$	62° r < v wk	X = b Y = c el clv pos	ORTH platy	010 perf	Cols, pink	H 2.5-3 G 2.69 infus	Diss by acids with eff. Tw and comp pl 101.
1.575 ^	1.560	1.587	1.595	.035	TOBELITE (Mica grp) $(NH_4,K)Al_2Si_3AlO_{10}(OH)_2$	30° (56±8°)	el pos	MCL	001 perf	Yellow-green	---	---
1.571 □ 1.590	1.572	1.587	1.600	.028	ILLITE (Mica grp) $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,H_2O]$	Small to med (85±9°)	X ~ c el clv pos	MCL	001 perf	Cols, brown, green	H 1-2 G 2.7	Slightly dec by acids.
	1.574	1.587	1.599	.025	KRAUSKOPFITE $BaSi_2O_4(OH)_2 \cdot 2H_2O$	88° r > v dist	X = b Y:a = 6°	MCL	---	Cols	G 3.14 F 5	Dec by acids.
	1.578	1.587	1.595	.017	LEIGHTONITE $K_2Ca_2Cu(SO_4)_4 \cdot 2H_2O$	60° (86±13°) r > v str	X ~ b Y ~ c Z ~ a	TCL ps orth pris	---	Pale blue	H 3 G 2.95	Diss by acids. Multiple tw on 100 and 010.
	1.548	1.588	1.600	.052	GORDONITE $MgAl_2(PO_4)_2(OH)_2 \cdot 8H_2O$	Med r > v	X ~ b	TCL tab	010 perf 100 fair	White to pale green	H 3.5 G 2.23 F 3	Diss by acids. Fe^{+3} present.
	1.550	1.588	1.590	.040	COCONINOITE $Fe_2Al_2(UO_2)_2(PO_4)_4(SO_4)(OH)_2 \cdot 20H_2O$	40° (19±8°)	---	MCL (?) aggregates	---	Creamy yellow	Soft G 2.70	Diss by acids. Pleoc, X cols, Y and Z pale yellow. Not fluor in UV.
1.578 ◊ 1.619	1.583	1.588	1.589	.006	KAEMMERERITE (Chlorite grp) $(Mg,Al,Cr)_6(Si,Al)_4O_{10}(OH)_8$	8° r > v wk	X ~ c el pos	MCL	001 perf	Rose, lilac	H 2.5 G 2.72 F diff	Insol in HCl. FeO 2.0, Cr_2O_3 7.9%.
1.561 ◊ 1.600	1.559	1.588	1.588	.029	BEIDELLITE (Smectite grp) $Na_{0.33}(Al,Fe)_2(Si,Al)_4O_{10}(OH)_2 \cdot xH_2O$	Small to med	X = c Z = a	MCL earthy	001 perf	White to red	G 2.1 infus	Dec by acids.
	1.556	1.589	1.601	.045	PYROPHYLLITE $Al_2Si_4O_{10}(OH)_2$	62° r > v wk	Z = b X:c = 10° el clv pos	MCL	001 perf	White, brown, yellow	H 1-2 G 2.7-2.9 infus	Nearly insol in acids.
	1.583	1.589	1.594	.011	PHARMACOLITE $CaHAsO_4 \cdot 2H_2O$	79° r > v	Z = b X:c = -29°	MCL acic	010 perf	Cols	H 2-2.5 G 2.5-2.7 F 2.5	Diss by acids.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.583 ^v 1.589 pos	1.583	<u>1.589</u>	1.593	.010	CELSIAN (Feldspar grp) $BaAl_2Si_2O_8$	88°	Z:c on $10\bar{0}$ = 26°	MCL	001 perf 010 good	Cols	H 5.5 G 3.35	Not tw (Cn_{94}).
1.582 ^v 1.595	1.563	<u>1.590</u>	1.594	.031	MUSCOVITE var Phengite (Mica grp) $KAl_2(Si_3Al)O_{10}(OH)_2$	33° r > v	Z = <u>b</u> X ~ <u>c</u> el pos	MCL ps hex tab	001 perf	Pale brown, green	H 2.5-3 G 2.82 F 5.5	Insol in acids. Fe_2O_3 1.5, FeO 1.9, MgO 4.0%.
	1.525	<u>1.590</u>	1.593	.068	BRENKITE $Ca_2CO_3F_2$	27°	X = <u>c</u> Y = <u>a</u>	ORTH laths	---	Cols	H 5 G 3.10	Diss by HCl with eff.
(1.550) ^v (1.614)	1.57	<u>1.59</u>	1.60	.03	SAUCONITE (Smectite grp) $Na_{0.33}Zn_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$	0-20°	Y = b el cTv pos	MCL mass	001 perf	Cols	H 2 G 2.7	Dec by acids.
	1.572	<u>1.590</u>	1.601	.029	KOLBECKITE $ScPO_4 \cdot 2H_2O$	60° (75±8°) r > v wk	X = <u>c</u> Z = <u>a</u>	MCL pris	010 good fr conch	Blue-gray	H 3.5-4 G 2.39 F easy	Diss by acids.
1.587 ^	1.532	<u>1.590</u>	1.614	.082	LANTHANITE-(ND) $(Nd,La)_2(CO_3)_3 \cdot 8H_2O$	61°	X = <u>b</u> Y = <u>c</u>	ORTH	010 perf 101 good	Cols	G 2.8 infus	Diss by HCL with eff.
	1.575	<u>1.590</u>	1.601	.026	DALYITE $K_2ZrSi_6O_{15}$	72° r > v wk	X:<u>c</u> = 7°	TCL pris	101, 010 good	Cols	H 7.5 G 2.66 F 3	Gel with acids.
v 1.630	1.575	<u>1.590</u>	1.594	.019	CARPHOLITE $(Mn,Fe)Al_2Si_2O_6(OH)_4$	50° r > v str	X = <u>b</u> Z = <u>c</u> el pos	ORTH fib <u>c</u>	Pris at 68°	Pale yellow	H 5-6 G 3.04 F 3.5	Nearly insol in acids. Pleoc, X and Y pale yellow, Z cols. MnO 16.1, FeO 0.6, Fe_2O_3 2.4%.
	1.581	<u>1.590</u>	1.591	.010	TUSCANITE $K(Ca,Na)_6(Si,Al)_{10}O_{22}[SO_4,CO_3,(OH)_2] \cdot H_2O$	40°	Z = <u>b</u> X:<u>c</u> = 40°	MCL platy	100 dist	Cols	H 5.5-6 G 2.83	Compare Latiumite.
v 1.609	1.582	<u>1.590</u>	1.591	.009	LATIUMITE $(Ca,K)_8(Al,Mg,Fe)(Si,Al)_{10}O_{25}(SO_4)$	40° r > v str	Z = <u>b</u> X:<u>c</u> = 16-28°	MCL tab	100 perf	White	H 5.5-6 G 2.93 F easy	Gel with acids. Tw pl 100. Mottled extinction.
1.585 ⊓	1.572	<u>1.591</u>	1.598	.026	PRICEITE $Ca_4B_{10}O_{19} \cdot 7H_2O$	32° (62±10°)	X:plates = 65°	TCL (?) rhombic plates	110, 001 perf	White, chalky	H 3-3.5 G 2.42 F 2-3	Diss by acids.

	1.569	1.592	1.620	.051	LOKKAITE $(Y,Ca)_2(CO_3)_3 \cdot 2H_2O$	$(94 \pm 4°)$	Z = c el pos	ORTH fib	---	White	Infus	Eff in acids.
1.567 ^	1.566	1.592	1.596	.030	URANOSPINITE (Autunite grp) $Ca(UO_2)_2(AsO_4)_2 \cdot 10H_2O$	25-35° $(42 \pm 10°)$ r > v mod	X = c el pos	TET plates	001 perf 100 dist	Lemon- yellow	H 2-3 G 3.45 fus	Pleoc, X cols, Y and Z yellow. Fluor bright lemon-yellow in UV.
	1.573	1.592	1.599	.026	GAIDONNAYITE $Na_2ZrSi_3O_9 \cdot 2H_2O$	59°	X = a Y = b	ORTH	Conch	Cols	H 6 G 2.67 F 3	Gel with acids.
1.565 ◊ 1.660 pos	1.572	1.592	1.597	.025	VARISCITE, ferrian $(Al,Fe)PO_4 \cdot 2H_2O$	Med large $(55 \pm 10°)$	X = a Z = b r < v wk	ORTH	010 good 001 poor	White, green	H 4.5 G 2.57- 2.75 infus	Insol in acids but diss after heating gently.
1.586 [] 1.595	1.581	1.592	1.592	.011	TORBERNITE (Autunite grp) $Cu(UO_2)_2(PO_4)_2 \cdot 8\text{-}12H_2O$	Small r > v	X = c el pos	TET tab	001 perf	Emerald- green	H 2-2.5 G 3.22 F easy	Diss by acids. Pleoc, X cols to pale green, Y and Z pale to dark green. Not fluor in UV.
v 1.611	1.563	1.593	1.593	.030	GANOPHYLLITE $(Na,K)(Mn,Fe,Al)_5$ $(Si,Al)_6O_{15}(OH)_5 \cdot 2H_2O$	~ 0° r < v	X = c Z = b el pos	MCL	001 perf	Yellow, brown	H 4 G 2.8 F 3	Gel with acids. Pleoc wk, X yellow, Y and Z nearly cols.
	1.570	1.593	1.595	.025	LEUCOPHANITE $(Ca,Na)_2BeSi_2(O,OH,F)_7$	47°	X = c Z = b el pos	TCL ps orth tab 001	001 perf 100 dist	White to pale yellow	H 3.5-4 G 2.96 F 3	Insol in acids. Poly tw 110. Luminesces violet-blue in long-wave UV.
v 1.615	1.581	1.593	1.602	.021	TREMOLITE (Amphibole grp) $Ca_2Mg_5Si_8O_{22}(OH,F)_2$	86°	Y = b Z:c = 21° el pos	MCL	110 good	Cols	H 5.5 G 3.02	Insol in acids. Data for synth compd.
	1.520	1.594	1.595	.075	HYDRODRESSERITE $BaAl_2(CO_3)_2(OH)_4 \cdot 3H_2O$	17°	el pos	TCL radi- ating spher- ulitic	010, $2\bar{1}0$ perf	White	H 3-4 G 2.80	---
	1.572	1.595	1.614	.042	JOHANNITE $Cu(UO_2)_2(SO_4)_2(OH)_2 \cdot$ $6H_2O$	90° $(83 \pm 6°)$ r > v str	X ~ b Y:c = 5-8° disp str	TCL tab el c	100 good	Green to greenish- yellow	H 2.5 G 3.32 infus	Diss by acids. Poly tw 100. Pleoc, X cols, Y pale yellow, Z greenish-yellow. Not fluor in UV.
1.590 ◊ 1.598	1.569	1.595	1.609	.040	MUSCOVITE var Phengite (Mica grp) $K(Al,Mg,Fe)_2(Si_3Al)$ $O_{10}(OH)_2$	40° $(71 \pm 6°)$ r > v	Z = b X ~ c el pos	MCL ps hex tab	001 perf	Emerald- green	H 2.5-3 G 2.82 F 5.5	Insol in acid. Pleoc, X blue-green, Y pale yellow-green, Z bluish. F 3.4, Fe_2O_3 3.1, Cr_2O_3 3.7, MnO 3.1%.
	1.581	1.596	1.601	.020	BALIPHOLITE $BaMg_2LiAl_3Si_4O_{12}(OH)_8$	70°	X = b Y = c	ORTH fib c	010 perf 100, 110 dist	Yellow- ish-white	G 3.4	---

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.560	1.597	1.600	.032	THADEUITE $Ca(Fe^{+2},Mn)_2Mg(PO_4)_2(OH,F)_2$	33°	X = c Y = b	ORTH	010 perf	Yellow-orange	H 4 G 3.25	---
[]	1.575	1.597	1.598	.023	CHRYSOCOLLA $(Cu,Al)_2H_2Si_2O_5(OH)_4 \cdot xH_2O$	Small	---	MCL fib, u mass	---	Bluish-green, sky-blue	H 2 G 2.4 infus	Dec by acids. Optics highly variable.
	1.596	1.597	1.597	.001	EMELEUSITE (Osumilite grp) $Na_4Li_2Fe^{+3}{}_2Si_{12}O_{30}$	0-30° r > v str	X = b Y = a	ORTH tab b	---	Cols	H 5-6 G 2.76	---
v 1.605	1.516	1.598	1.621	.105	AMARANTITE $FeSO_4(OH) \cdot 3H_2O$	30° (53+3°) r < v str	X ~ ⊥ 100 Y:c = 47°	TCL acic columnar	010, 100 perf	Red to orange-red	H 2.5 G 2.19 F 4.5-5	Dec by H_2O, diss by acids. Pleoc, X cols, Y pale yellow Z reddish-brown.
1.584 ^v 1.617	1.558	1.598	1.599	.041	BIOTITE (Mica grp) $K(Mg,Fe^{+2})_3(Al,Fe^{+3})Si_3O_{10}(OH,F)_2$	10-13° r < v	Y = b X ~ c el pos	MCL plates	001 perf	Dark brown to green	H 2-2.5 G 2.95 F 3-4	Pleoc, X yellow, Y brown, Z dark brown, abs X < Y < Z. FeO 13.8, Fe_2O_3 2.1, MnO 0.4%.
1.595 ^v 1.608	1.565	1.598	1.600	.035	MUSCOVITE (Mica grp) $KAl_2(Si_3Al)O_{10}(OH)_2$	38° r > v	Z = b X ~ c el pos	MCL ps hex tab	001 perf	Pale brown, greenish, red	H 3-4 G 2.87 F diff	Insol in acids. FeO 0.9, Fe_2O_3 2.8%.
v 1.607	1.585	1.598	1.606	.021	MONTEBRASITE $LiAlPO_4(OH,F)$	77°	---	TCL	100 perf 110 good	White	H 5.5-6 G 3.10 F easy	Diff diss by acids. Li_2O 9.6, Na_2O 1.2, F 3.2%.
1.595 [] 1.600	1.586	1.598	1.605	.019	HOWLITE $Ca_2B_5SiO_9(OH)_5$	Large (74±12°)	X = b Z:a = 55°	MCL tab 100	---	White	H 3.5 G 2.58 F 2	Insol in acids.
	1.584	1.598	1.602	.018	MILLISITE $(Na,K)CaAl_6(PO_4)_4(OH)_9 \cdot 3H_2O$	Med	X = c el neg	MCL fib c	---	White, gray	H 5.5 G 2.83 F 3.5	Diss by acids.
1.582 ^	1.589	1.598	1.599	.010	HOPEITE $Zn_3(PO_4)_2 \cdot 4H_2O$	37° r < v wk	X = a Y = c	ORTH tab pris	010 perf 100 good	Cols, White	H 3.5 G 3.05-3.12 F easy	Diss by acids.

1.584 ◊ ~1.613	1.554	1.599	1.602	.048	TALC $(Mg,Fe)_3Si_4O_{10}(OH)_2$	Small r > v	X ~ c Z = b el pos	MCL	001 perf	Green	H 1 G 2.87 infus	Insol in acids. Luster pearly. FeO 13.4, Fe_2O_3 1.7%.
1.586 ◊ 1.65	1.589	1.600	1.610	.021	NONTRONITE (Smectite grp) $Na_{0.33}Fe^{+3}{}_2(Si,Al)_4$ $O_{10}(OH)_2 \cdot xH_2O$	40° r < v	Y = b X ~ c el cTv pos	MCL u mass	001 perf	Dark brown to green	H 1-2 G 2.27	Dec by acids. Pleoc in brown or green.
1.586 ◊ 1.618	1.585	(1.600)	1.600	.015	GLAUCONITE (Mica grp) $(K,Na)(Al,Fe,Mg)_2$ $(Si,Al)_4O_{10}(OH)_2$	Small r < v	Y = b X ~ c el cTv pos	MCL	001 perf	Green, blue, cols	H 2 G 2.59 fus	Dec by acids. Fe_2O_3 14.1, Al_2O_3 8.9, FeO 1.6%.
	1.518	1.601	1.601	.083	DRESSERITE $Ba_2Al_4(CO_3)_4(OH)_8 \cdot 3H_2O$	30-40°	X = a Z = c	ORTH fib	---	White	H 2.5 G 2.96 infus	Diss in acids with eff.
	1.588	1.601	1.610	.022	PARAUMBITE $K_3Zr_2HSi_6O_{18} \cdot 7H_2O$	82°	X = c Y = b	ORTH	010 mic 100 perf	Cols	H ~ 4.5 G 2.59	---
	1.595	1.601	1.604	.009	HURLBUTITE $CaBe_2(PO_4)_2$	70° r > v wk	X = b Y = c	ORTH pris	Conch	Cols to greenish-white	H 6 G 2.88 F diff	Slowly diss by acids. Striated on 110.
	1.526	1.602	1.602	.076	ANTHONYITE $Cu(OH,Cl)_2 \cdot 3H_2O$	3°	Y = b Z:c = 13°	MCL pris	100 good	Lavender	H 2 sectile	Diss by acids. Pleoc, X lavender, Y and Z deep smoky blue, abs Z = Y > X.
	1.586	1.602	1.606	.020	SPENCERITE $Zn_4(PO_4)_2(OH)_2 \cdot 3H_2O$	49° r > v mod	Z = b X ~ a el pos	MCL tab 100	100 perf 010 good 001 fair	White	H 3 G 3.14 F easy	Diss by acids. Tw and comp pl 100, poly.
v 1.622	1.596	1.602	1.603	.007	META-AUTUNITE (Meta-autunite grp) $Ca(UO_2)_2(PO_4)_2 \cdot 4\text{-}6H_2O$	0-15°	Z = c	TET tab	---	Yellow	H 2-2.5 G 3.5 fus	Diss by acids. Pleoc. X cols, Y and Z yellow. Fluor yellow-green in UV.
1.583 ◊ 1.634	1.555	1.603	1.555	.048	STILPNOMELANE $K(Fe^{+2},Mg,Fe^{+3},Al)_{10}$ $Si_{12}O_{30}(OH)_{12}$	~ 0°	X = b Y ~ c	MCL also TCL	001 perf	Golden- to reddish-brown	H 3-4 G 2.78 F 4-5	Dec by acids. Pleoc, X pale yellow, Y and Z olive-brown. FeO 21.6, Fe_2O_3 6.4, MnO 1.4%.
1.598 □ 1.605	1.571	1.603	1.606	.035	PARAGONITE (Mica grp) $NaAl_2(Si_3Al)O_{10}(OH)_2$	30° r > v	Z = b el pos	MCL ps hex plates	001 perf	Cols to green	H 2.5 G 2.87 F diff	Insol in acids.
1.598 □ 1.607	1.587	1.603	1.612	.025	BERTRANDITE $Be_4Si_2O_7(OH)_2$	70-75° r < v wk	X = a Z = c	ORTH colum-nar	110 perf 100, 010, 001 good	Cols	H 6.5 G 2.60 infus	Insol in acids. Tw 011.
	1.585	1.603	1.604	.019	WIGHTMANITE $Mg_5(BO_3)O(OH)_5 \cdot 2H_2O$	33° r < v	Z:b = 5°	MCL ps hex pris	101 perf $\bar{1}01$ good	Cols	H 5.5 G 2.59 infus	Diff sol in cold dil acids.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.596	1.603	1.606	.010	WEEKSITE $K_2(UO_2)_2Si_6O_{15}\cdot 4H_2O$	60° r > v str	X = b Y = c el c⊤v pos	ORTH ps tet	010 perf	Pale yellow-green	H 1.5 G 4.1	Pleoc, X cols, Y pale yellow-green, Z yellow-green. Not fluor in UV.
v 1.61	1.598	1.603	1.607	.009	HILLEBRANDITE $Ca_2SiO_3(OH)_2$	Med r < v str	Z = c el pos	MCL fib	110	White	H 5-6 G 2.69 F diff	Gel with acids. Ultra-blue interf colors.
1.577 ^	~1.595	1.603	1.604	~.009	ANTIGORITE (Serpentine grp) $(Mg,Fe)_3Si_2O_5(OH)_4$	Small	X = c el c⊤v pos	MCL	001 perf	Brown	H 3 G 2.4-2.6 F diff	Dec by HCl. FeO 21.0, Fe_2O_3 0.5, MnO 2.5%.
	1.582	1.604	1.609	.027	NIAHITE $(NH_4)(Mn^{+2},Mg)PO_4\cdot H_2O$	(50±11°)	---	ORTH	---	Pale orange	Soft G 2.39	---
	1.585	1.604	1.612	.027	NAKAURIITE $Cu_8(SO_4)_4(CO_3)(OH)_6\cdot 48H_2O$	(65±9°)	el pos	ORTH fib	---	Sky-blue	G 2.39	Pleoc, X cols, Y light greenish blue, Z pale sky-blue to light blue.
1.598 ^	1.51	1.605	1.611	.101	AMARANTITE $FeSO_4(OH)\cdot 3H_2O$	28° r < v str	Y:c = 47° X ~ ⊥ 100	TCL acic columnar	010, 100 perf	Red, orange-red	H 2.5 G 2.11 F 4.5-5	Dec by H_2O, diss by acids. Pleoc, X cols, Y pale yellow, Z reddish-brown.
	1.574	1.605	1.605	.031	HEINRICHITE (Autunite grp) $Ba(UO_2)_2(AsO_4)_2\cdot 10\text{-}12H_2O$	0-20°	---	TET	001 perf 100 dist	Yellow to green	H 2.5	Diss by acids. Pleoc, X cols, Y and Z pale yellow. Fluor green to yellow in UV.
	1.580	1.605	1.605	.025	MONTDORITE (Mica grp) $(K,Na)_2(Fe^{+2},Mn,Mg)_5Si_8O_{20}(F,OH)_4$	0-3°	---	MCL	001 perf	Green to brownish-green	G 3.15	---
v 1.625	1.593	1.605	1.613	.020	MAGNESIO-ANTHOPHYLLITE (Amphibole grp) $Mg_7Si_8O_{22}(OH)_2$	65° (78±12°)	Y = b Z = c el pos	ORTH	210 perf	Cols to brown	H 5.5-6 G 3.0	Insol in acids. Fe_2O_3 0.25, Al_2O_3 1.6%.
	1.598	1.605	1.608	.010	BRIANITE $Na_2CaMg(PO_4)_2$	64°	---	MCL	---	Cols	H 4-5 G 3.1	Poly tw, ext angle between lam 2-3°. Meteorite mineral.
1.581 ^v 1.648	1.560	1.607	1.607	.047	VERMICULITE $(Mg,Fe,Al)_3(Si,Al)_4O_{10}(OH)_2\cdot 4H_2O$	Small	X ⊥ plates el pos	MCL	001 perf	Green, brown	H 1.5 G 2.77 F 5	Dec by HCl. Exfoliates when heated. Fe_2O_3 4.5%.

1.598 ^v 1.612	1.593	1.607	1.614	.021	AMBLYGONITE $(Li,Na)AlPO_4(F,OH)$	61-70° r > v	X:c = 56° Y:b = 17°	TCL	100 perf 110 good	White	H 5.5-6 G 3.05 F easy	Diff diss by acids. Li_2O 8.3, Na_2O 2.4, F 6.2%.
	1.583	1.608	1.633	.050	CHUDOBAITE $(Mg,Zn)_5H_2(AsO_4)_4\cdot 10H_2O$	79° (89±5°)	---	TCL	010, 100 good	Pink	H 2.5-3 G 2.94	---
	1.544	1.608	1.608	.064	WONESITE (Mica grp) $(Na,K)(Mg,Fe)_6(Si,Al)_8O_{20}(OH,F)_4$	0-5°	---	MCL	001 perf	Cols to brown	---	Pleoc, X pale brown, Y and Z brown.
1.598 ^v 1.609	1.571	1.608	1.611	.040	MUSCOVITE (Mica grp) $K(Al,V)_2(Si_3Al)O_{10}(OH)_2$	34° r > v	Z = b X:c = 0-5° el pos	MCL ps hex	001 mic	Green	H 3 G 2.93 F 5	Insol in acids. Pleoc, X cols, Z pale blue. V_2O_5 3.4, Cr_2O_3 0.2, FeO 0.5, MgO 1.1%.
	1.590	1.608	1.611	.021	LAWSONBAUERITE $(Mn,Mg)_9Zn_4(SO_4)_2(OH)_{22}\cdot 8H_2O$	42° r > v str	Y = b Z:c = 7°	MCL	---	Cols to white	H 4.5 G 2.87	---
	---	1.608	---	.011	MONSMEDITE $K_2O\cdot Tl_2O_3\cdot 8SO_3\cdot 15H_2O$	~ 52°	---	ORTH ps cub	cub 2	Dark green to black	G 3.00 H 2	---
1.608 ^v 1.620	1.573	1.609	1.611	.038	MUSCOVITE var Phengite (Mica grp) $K(Al,Mg)_2(Si_3Al)O_{10}(OH)_2$	31° r > v	Z = b X ~ c el pos	MCL ps hex	001 perf	Pale brown	H 3 G 2.88 F 5	Insol in acids. FeO 2.8, MgO 4.1, Fe_2O_3 4.1, TiO_2 1.0%.
	1.597	1.609	1.615	.018	MAGBASITE $KBa(Al,Sc)(Mg,Fe)_6Si_6O_{20}F_2$	70°	Z:c = 10°	Acic	---	Cols, rose-violet	H 5 G 3.41	Pleoc, X and Y cols, Z lilac.
1.590 ^	1.603	1.609	1.615	.012	LATIUMITE $(Ca,K)_8(Al,Mg,Fe)(Si,Al)_{10}O_{25}(SO_4)$	72-83° r > v str	Z = b X:c = 16-28°	MCL tab	100 perf	White	H 5-6 G 2.93 F easy	Gel with acids. Tw pl 100. Mottled extinction.
	1.596	(1.610)	1.619	.023	UMBITE $K_2ZrSi_3O_9\cdot H_2O$	80°	---	ORTH platy	010 mic 100 perf	Cols to yellowish	H 4.5 G 2.79	Dec by HCl. Weakly fluor yellow-white in UV.
v 1.626	1.600	1.610	1.616	.016	SAINFELDITE $Ca_5H_2(AsO_4)_4\cdot 4H_2O$	80°	X = b Y:c = 20°	MCL flattened on 100	---	Cols, light pink	G 3.04	Diss by acids.
1.574 ^	1.603	1.610	1.617	.014	BASSETITE (Meta-autunite grp) $Fe(UO_2)_2(PO_4)_2\cdot 8H_2O$	~ 90° r > v str	X = b Y:c = 18.5° el clv pos	MCL ps tet	010 perf	Olive-green to brownish	H 2.5 G 3.4	Diss by acids. Pleoc, X and Y yellow, Z dark olive-brown. Not fluor in UV.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.607	<u>1.610</u>	1.616	.009	BUCHWALDITE $NaCaPO_4$	---	el pos	ORTH	One clv	Cols	H < 3 G 3.21	Biax pos (?).
1.603 ^	1.605	<u>1.61</u>	1.612	.007	HILLEBRANDITE $Ca_2SiO_3(OH)_2$	51° r < v str	Z = <u>c</u> el pos	MCL fib	110	White	H 5-6 G 2.69 F diff	Gel with acids. Shows ultra-blue interf colors.
1.593 ^	1.571	<u>1.611</u>	1.612	.041	GANOPHYLLITE $(Na,K)(Mn,Fe,Al)_5$ $(Si,Al)_6O_{15}(OH)_5 \cdot 2H_2O$	~ 0° r < v	X = <u>c</u> Z = <u>b</u> el pos	MCL	001 perf	Cinnamon-brown	H 4 G 2.8 F 3	Gel with acids. Pleoc, X dark yellow-brown, Y and Z pale yellow-brown.
1.586 ^	1.574	<u>1.611</u>	1.612	.038	BANNISTERITE $(Na,K)(Mn,Fe,Al)_5$ $(Si,Al)_6O_{15}(OH)_5 \cdot 2H_2O$	22° r < v wk	Z ~ <u>a</u>	MCL	---	Brown	G 2.84	Pleoc wk, X cols, Y and Z pale yellow.
1.609 [ ] 1.620	1.592	<u>1.612</u>	1.621	.029	HERDERITE $CaBePO_4(F,OH)$	67-75° r > v inclined	Y = <u>b</u> Z:<u>c</u> = -3°	MCL pris	110 poor	Cols to yellowish	H 5-5.5 G 3.01-3.08 F diff	Diss by acids. Tw pl 001 penet.
	1.585	<u>1.612</u>	1.612	.027	SODIUM URANOSPINITE (Meta-autunite grp) $(Na_2,Ca)(UO_2)_2(AsO_4)_2 \cdot$ $5H_2O$	Small	---	TET tab	001 perf 010, 100 dist	Yellow-green to yellow	H 2.5 G 3.85	Diss by acids. Pleoc, X cols, Y and Z yellow. Fluor yellow-green in UV.
v 1.624	1.586	<u>1.612</u>	1.613	.027	MARGARITE Sodium analogue (Mica grp) $CaAl_2(Si_2Al_2)O_{10}(OH)_2$	50° r < v	Z = <u>b</u> Y:<u>a</u> = 7° el pos	MCL	001 perf	Cols	H 4 G 3.06 fus	Insol in acids. Na_2O 5.6, CaO 3.3%, Li not detd.
1.607 ^	1.598	<u>1.612</u>	1.621	.023	MONTEBRASITE $LiAlPO_4(OH,F)$	82° r > v	---	TCL	100 perf 110 good	White	H 5.5-6 G 3.05 F easy	Diff diss by acids. Li_2O 9.2, Na_2O 0.6, F 4.4%.
1.606 [ ] 1.615	1.596	<u>1.612</u>	1.615	.019	PHOSPHOPHYLLITE $Zn_2(Fe,Mn)(PO_4)_2 \cdot 4H_2O$	40-50° r > v	Z = <u>b</u> Y:<u>c</u> = 50°	MCL thick tab	001 perf 010, $\bar{1}02$ dist	Cols to bluish-green	H 3-3.5 G 3.13 F easy	Diss in acids. Tw on 100 common, sometimes poly. Fluor violet in short-wave UV.
	1.571	<u>1.613</u>	1.623	.052	KTENASITE $(Cu,Zn)_5(SO_4)_2(OH)_6 \cdot$ $6H_2O$	51°	Z = <u>b</u> X ~ <u>c</u>	MCL	---	Blue-green	H 2-2.5 G 2.97	Diss by acids and NH_4OH. Pleoc, X cols, Y bluish-green, Z light green.

1.599 ◇ ~1.630	1.580	---	1.615	.035	MINNESOTAITE $(Fe^{+2},Mg)_3Si_4O_{10}(OH)_2$	Small	el pos	MCL	001 perf	Cols to yellow-green	G 3.01	Pleoc, X pale yellow, Y and Z pale blue-green.
	1.560	1.614	1.615	.055	PREISWERKITE (Mica grp) $NaMg_2Al(Al_2Si_2)O_{10}(OH)_2$	5-7°	---	MCL	001 perf	Pale green	H 2.5 G 2.96	---
	1.585	1.614	1.614	.029	VIMSITE $CaB_2O_2(OH)_4$	28°	el pos	MCL	One clv	Cols	H 4 G 2.54	Diss by acids.
	1.586	1.614	1.621	.035	CAYSICHITE $(Y,Ca)_4Si_4O_{10}(CO_3)_3\cdot 4H_2O$	53-73°	X = b Y = a el pos	ORTH radi-ating	---	Cols to yellow	H 4.5 G 3.03	Diss by cold HCl with eff.
1.59 ^	1.575	(1.614)	1.615	.040	SAUCONITE (Smectite grp) $Na_{0.33}Zn_3(Si,Al)_4O_{10}(OH)_2\cdot 4H_2O$	0-20°	Y = b	MCL mass	001 perf	Cols, white, yellow	H 2 G 2.7	Dec by acids. ZnO 23.1, Al_2O_3 17.0%.
	1.595	1.614	1.614	.019	SEMENOVITE $(Ca,Ce,La,Na)_{10-12}(Fe,Mn)(Si,Be)_{20}(O,OH,F)_{48}$	0-40°	---	ORTH ps tet	Uneven	Cols	H 3.5-4 G 3.14	Tw 110.
	1.600	1.615	1.629	.029	LEHIITE $(Na,K)_2Ca_5Al_8(PO_4)_8(OH)_{12}\cdot 6H_2O$	Large (67±8°)	el neg	MCL fib	---	White	H 5.5 G 2.89	Diss by acids.
1.593 ◇ 1.632	1.600	1.615	1.627	.027	TREMOLITE (Actinolite ser, Amphibole grp) $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	79° (63±8°) r < v wk	Y = b Z:c = 15° el pos	MCL	110 perf at 124°	Cols to green	H 5.5-6 G 2.98	Insol in acids. FeO 0.6%.
v (1.627)	1.605	1.615	1.622	.017	RICHTERITE (Amphibole grp) $Na_2Ca(Mg,Ti,Al)_5Si_8O_{22}(OH)_2$	Med large r < v wk	Y = b Z:c = 25° el pos	MCL	110 perf at 129°	White	H 5.5-6 G 3.07	Insol in acids.
	(1.559)	1.616	1.624	(.065)	PHARALUMITE $Al_2(UO_2)_3(PO_4)_2(OH)_6\cdot 10H_2O$	40°	X = b Y ~ c	MCL pris	---	Lemon-yellow	H 3 G 3.5	Pleoc, X cols, Y and Z pale yellow. Not fluor in UV.
1.624	1.597	1.616	1.624	.027	SANBORNITE $BaSi_2O_5$	66°	Z ~ c	TCL platy	001 perf 010 imperf	White	H 5 G 4.19	Dec by acids. Poly tw on 010.
1.598 ◇ 1.640	1.575	1.617	1.621	.046	BIOTITE, var Manganophyllite (Mica grp) $K(Mg,Fe^{+2},Mn)_3(Al,Fe^{+3})Si_3O_{10}(OH,F)_2$	30° r < v	Y = b el pos	MCL plates	001 perf	Reddish-brown	H 2.5-3 G 2.98 F 3-4	Pleoc, X brown, Y and Z dark brown. Fe_2O_3 5.8, FeO 1.2, MnO 6.2%.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.600	---	1.620	.020	ALDZHANITE $CaMgB_2O_4Cl \cdot 7H_2O$ (?)	---	---	ORTH dipyram	---	Cols to rose	G 2.21	Opt char unk.
	1.606	1.617	1.620	.014	REINHARDBRAUNSITE $Ca_5(SiO_4)_2(OH,F)_2$	44-50° r > v dist	Z = b X:c = 18°	MCL	001 dist	Light pink	H 5-6 G 2.84	---
(1.600) ^v 1.634	1.597	1.618	1.619	.020	GLAUCONITE (Mica grp) $(K,Na)(Al,Fe,Mg)_2$ $(Si,Al)_4O_{10}(OH)_2$	20° r < v	Y = b X:c = 10°	MCL	001 perf	Green	H 2 G 2.7 fus	Dec by acids. Pleoc, X yellow, Y and Z bluish-green. Fe_2O_3 18.8, Al_2O_3 8.5, FeO 4.0, MgO 3.0%.
v 1.636	1.580	1.619	1.620	.040	GRANDIDIERITE $(Mg,Fe)Al_3(BO_4)(SiO_4)O_2$	24° r < v	X = a Y = c el cTv pos	ORTH	100 perf 010 poor	Blue	G 2.91 infus	Insol in acids. Pleoc, X pale blue, Y yellow-brown, Z deep blue, abs Z > X > Y.
1.588 ^v 1.637	1.605	1.619	1.619	.014	CLINOCHLORE (Chlorite grp) $(Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	~ 0° r > v	X ~ c el cTv pos	MCL	001 perf	Olive- to dark-green	H 2 G 2.8 F 5	Dec by acids. Pleoc, X pale green, Y and Z green.
	1.611	1.619	1.621	.010	CYMRITE $BaAl_2Si_2(O,OH)_8 \cdot H_2O$	0-5°	---	MCL ps hex	---	Cols, dark green, brown	H 2-3 G 3.41-3.45	Slight sol in HCl. Exfoliates when heated.
	1.583	1.62	1.633	.050	Unnamed Cu-Zn arsenate	---	---	TCL	2 pinacoidal	Light rose	---	Diss by HCl. Am. Mineral., 44, 1323 (1959).
1.609 ^	1.580	1.620	1.623	.043	MUSCOVITE, var Phengite (Mica grp) $K(Al,Fe,Mg)(Si_3Al)O_{10}(OH)_2$	35° r > v	Z = b X:c = 0-5° el pos	MCL ps hex plates	001 perf	Cols to pale green	H 5 G 2.88	Insol in acids. Fe_2O_3 8.0, FeO 2.5, MgO 1.9%.
	1.584	1.620	1.621	.037	NISSONITE $Cu_2Mg_2(PO_4)_2(OH)_2 \cdot 5H_2O$	19° r > v str	Z = b Y:c = 6°	MCL tab	100 fair	Bluish-green	H 2.5 G 2.73	Diss by acids. Pleoc, X cols, Y and Z turquoise-blue.
1.612 ^	1.604	1.620	1.629	.025	HYDROXYLHERDERITE $CaBePO_4(OH,F)$	74° r < v inclined	Y = b	MCL pris	110 poor	Cols	H 5-5.5 G 3.08	Diss by acids. Tw pl 001 penet.
	1.610	1.620	1.623	.013	SUOLUNITE $Ca_2Si_2O_5(OH)_2 \cdot H_2O$	30-35° (57±19°)	X = a Y = c	ORTH	---	White	G 2.68	Abnormal dark gray to yellowish interf colors.

∨ 1.627	1.612	1.621	1.622	.010	CARBONATE-FLUORAPATITE ("Dehrnite") (Apatite grp) $(Ca,Na,K)_5(PO_4,CO_3)_3F$	Small	X = c el c̄l̄v pos	HEX	0001 perf	Cols, yellow	H 5 G 3.04 fus	Diss by acids. Base divided into biax segments.
⊔ 1.632	1.618	1.621	1.622	.004	METATORBERNITE (Meta-autunite grp) $Cu(UO_2)_2(PO_4)_2 \cdot 8H_2O$	~ 0°	X = c	TET square tab	001 perf	Emerald- green	H 2.5 G 3.6 F easy	Diss by acids. Anom interf colors. Not fluor in UV.
1.602 ^	1.604	1.622	1.630	.026	META-AUTUNITE (Meta-autunite grp) $Ca(UO_2)_2(PO_4)_2 \cdot 4\text{-}6H_2O$	0-15°	Z = c	TET tab	---	Yellow	H 2-2.5 G 3.5 fus	Diss by acids. Pleoc, X cols, Y and Z yellow. Fluor yellow-green in UV.
	1.607	1.623	1.628	.021	VLASOVITE $Na_2ZrSi_4O_{11}$	40-56° r > v dist	Opt pl 010	MCL	010 good	Cols, brownish	H 6 G 2.97	---
1.612 ⊓	1.610	1.623	1.623	.013	META-URANOCIRCITE (Meta-autunite grp) $Ba(UO_2)_2(PO_4)_2 \cdot 8H_2O$	0-20° r > v	X = c	ORTH ps tet	001 perf 100 dist	Yellow- green	H 2-2.5 G 4.08 F 3	Diss by acids. Pleoc, X cols, Y and Z pale yellow. Poly tw. Fluor green in UV.
1.612 ◊ 1.643	1.592	1.624	1.625	.033	EPHESITE (Margarite ser, Mica grp) $NaLiAl_2(Si_2Al_2)O_{10}$ $(OH,F)_2$	18° r < v	Z = b Y:a = 7° el pos	MCL plates	001 perf	Pink to brown	H 5-7 G 2.98	Insol in acids. Na_2O 7.4, Li_2O 3.5%.
	---	1.624	1.624	---	FRAIPONTITE (Serpentine grp) $(Zn,Al)_3(Si,Al)_2O_5$ $(OH)_4$	15-20°	el pos	MCL fib	---	Yellow- ish-white	Soft fus	Gel with acids.
	---	1.625	1.645	---	Unnamed hydrous copper aluminum sulfate	Rather large	---	Radi- ating	---	Sky-blue	---	Pleoc str. Am. Mineral., 57, 1004 (1972).
	1.614	1.625	1.637	.023	PARAHOPEITE $Zn_3(PO_4)_2 \cdot 4H_2O$	~ 90° r < v perc	X ~ a	TCL	010 perf	Cols	H 3.5-4 G 3.31 F easy	Diss by acids. Poly tw common on 100.
1.605 ◊ 1.630	1.615	1.625	1.634	.019	GEDRITE (Amphibole grp) $(Mg,Fe)_5Al_2(Si_6Al_2)O_{22}$ $(OH)_2$	71° (86±12°)	Y = b Z = c el pos	ORTH	210 perf	Cols to brown	H 5.5-6 G 2.87	Insol in acids. Al_2O_3 16.1, Fe_2O_3 0.3, FeO 1.5%.
	---	1.625	---	.007	SMOLIANINOVITE $(Co,Ni,Mg,Ca)_3(Fe^{+3},$ $Al)_2(AsO_4)_4 \cdot 11H_2O$	---	el pos	ORTH fib	---	Yellow	H 2 G 2.46	Opt sign unk.
	1.605	1.626	1.633	.028	JIMTHOMPSONITE $(Mg,Fe)_5Si_6O_{16}(OH)_2$	62° r > v wk	X = a Y = b	ORTH	210 perf at 38°	Cols to light pinkish- brown	---	FeO 12.2, MnO 0.7%.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.610 ^	1.616	1.626	1.634	.018	SAINFELDITE $Ca_5H_2(AsO_4)_4 \cdot 4H_2O$	83°	X = b Y:c = 20°	MCL flattened 100	---	Cols, pink	G 3.04	Diss by acids.
	1.589	1.627	1.628	.039	CUPRORIVAITE $CaCuSi_4O_{10}$	14°	---	TET tab	001 perf	Azure-blue	H 5 G 3.08	Insol in acids. Pleoc, X pale rose, Z blue.
	1.610	1.627	1.633	.023	CLINOHOLMQUISTITE (Amphibole grp) $Li_2(Mg,Fe^{+2})_3Al_2Si_8O_{22}(OH,F)_2$	58°	Y = b Z = c X:a = 16° el pos	MCL pris	110 perf	Blue	G 3.00	---
1.615 <> 1.631	1.616	(1.627)	1.632	.016	RICHTERITE, var Magnophorite (Amphibole grp) $Na_2Ca(Mg,Fe^{+2},Ti)_5Si_8O_{22}(OH)_2$	70°	Z:c = 26° el pos	MCL pris	110 perf	Cols to brown	H 5-6 G 3.12	Insol in acids. Fe_2O_3 0.6, Al_2O_3 1.7, FeO 0.6, TiO_2 3.5%.
v 1.640	1.619	1.627	1.629	.012	FEDOROVSKITE (Roweite ser) $Ca_2(Mg,Mn)_2B_4O_7(OH)_6$	Small r < v str	Z = b Y = c el cTv pos	ORTH fib	100 perf	Cols to pink	H 4.5 G 2.65	Diss by acids. Pleoc, X cols, Z yellow. MnO 5%.
1.621 ^	1.622	1.627	1.627	.005	CARBONATE-FLUORAPATITE (Apatite grp) $Ca_5(PO_4,CO_3)_3(F,OH)$	0-25°	---	HEX u mass	0001 poor	Cols to brown	H 5 G 3.1-3.2	Diss by acids with slight eff.
(1.58) ^	1.598	1.628	1.654	.056	LAUSENITE $Fe_2(SO_4)_3 \cdot 6H_2O$	Large (64±4°)	X:c = 27°	MCL fib c	---	Cols	---	Sol in H_2O.
	1.602	1.628	1.632	.030	SWITZERITE $(Mn,Fe)_3(PO_4)_2 \cdot 4H_2O$	42°	Y = b Z:c = 10°	MCL bladed	100 perf 010 fair	Pink, brown	H 2.5 G 2.98	---
v 1.644	1.618	1.628	1.631	.013	WOLLASTONITE $CaSiO_3$	38° r > v	Y:b = 3-5°	TCL	100 perf 001, $\bar{1}02$ good	White	H 5 G 2.92 F 4	Dec by HCl. Fe_2O_3 0.2, FeO 0.1, MnO 0.1%.
	1.585	1.630	1.630	.045	TROEGERITE (Autunite grp) $(UO_2)_3(AsO_4)_2 \cdot 12H_2O$	~ 0° r > v mod	X = c Z:a = 13°	TET tab	001 perf 100 good	Lemon-yellow	H 2-3 G 3.3 F 2.5	Diss by acids. Not pleoc. Fluor yellow in UV.
~1.613 <> 1.652	1.592	---	1.632	.040	MINNESOTAITE (Talc ser) $(Fe^{+2},Mg)_3Si_4O_{10}(OH)_2$	Small	el pos	MCL	001 perf	Gray-green	G 3.03	Pleoc, X pale green, Y and Z bluish-green.

	1.610	(1.63)	1.639	.029	GATUMBAITE $CaAl_2(PO_4)_2(OH)_2 \cdot H_2O$	65°	Z = b	MCL fib	One longitudinal	White	H < 5	Diss by acids. Luster pearly.
∨ 1.643	1.606	(1.63)	1.632	.026	CELADONITE (Mica grp) $K(Mg,Fe^{+2})(Fe^{+3},Al)Si_4O_{10}(OH)_2$	Small r > v	Y = b X ~ c el c̄v pos	MCL	001 perf	Green	H 2 G 2.7 F 3	Dec by HCl. Pleoc, X yellow-green, Y and Z green. Fe_2O_3 12.0, Al_2O_3 6.7, FeO 2.1, MgO 5.8%.
1.625 ◊ 1.655	1.616	1.630	1.641	.025	ANTHOPHYLLITE (Amphibole grp) $(Mg,Fe)_7Si_8O_{22}(OH)_2$	88°	Y = b Z = c el pos	ORTH	210 perf	Brown	H 5.5-6 G 3.09	Insol in acids. Al_2O_3 0.2, Fe_2O_3 1.0, FeO 11.7%.
1.590 ◊ 1.636	1.613	1.630	1.632	.019	CARPHOLITE $(Mn,Fe)Al_2Si_2O_6(OH)_4$	50° r > v str	X = b Z = c el pos	ORTH fib c	Pris at 68°	Yellow	H 5.5-6 G 2.94 F 3.5	Insol in acids. Pleoc, X and Y pale yellow, Z cols. MnO 19.9, FeO 2.3, Fe_2O_3 2.0%.
∨ 1.644	1.620	1.630	1.635	.015	MAGNESIO-CUMMINGTONITE (Amphibole grp) $(Mg,Mn,Fe)_7Si_8O_{22}(OH)_2$	74°	Z:c = 16° Y = b el pos	MCL	110 perf	Pink	H 6.5 G 3.07	Insol in acids. Pleoc, X and Z cols, Y yellow. MgO 25.9, MnO 8.7%.
∨ (~1.66)	1.613	(1.63)	1.645	.032	SODIUM BOLTWOODITE $(H_3O)(Na,K)(UO_2)(SiO_4) \cdot H_2O$	Large	---	ORTH	010 perf 001 imperf	Pale yellow	G 4.1	Pleoc, X cols, Z pale yellow.
∨ 1.646	1.608	1.631	1.642	.034	LAZULITE $(Mg,Fe)Al_2(PO_4)_2(OH)_2$	70° r < v perc	Y = b X ~ c el c̄v neg	MCL	110 good 101	Blue	H 5-6 G 3.08 infus	Insol in HCl. Pleoc, X cols, Y and Z blue. FeO 2.6%.
(1.627) ◊ 1.699	1.617	1.631	1.637	.020	RICHTERITE (Amphibole grp) $Na_2Ca(Mg,Mn,Fe)_5Si_8O_{22}(OH)_2$	68°	Y = b Z:c = 18° el pos	MCL	110 perf at 124°	Brown	H 5-6 G 3.08	Insol in acids. Pleoc, X and Y pale yellow, Z straw-yellow. Al_2O_3 3.0, Fe_2O_3 3.7, FeO 0.6, MnO 5.4%.
∨ 1.644	1.624	1.631	1.637	.013	ECKERMANNITE (Amphibole grp) $Na_3(Mg,Fe)_4AlSi_8O_{22}(OH)_2$	72°	X:c = 49°	MCL	110 perf	Green	H 5-6 G 3.16	Insol in acids. Pleoc, X rose, Y lilac, Z light blue. Fe_2O_3 8.2, MnO 1.2%.
	1.620	1.631	1.633	.013	WOLLASTONITE-2M, Parawollastonite $CaSiO_3$	44° r > v	Y = b X:c = 34°	MCL	---	White	---	Dec by acids.
	1.589	1.632	1.634	.045	KARLITE $Mg_7(BO_3)_3(OH,Cl)_5$	24°	X = c Y = b	MCL fib	001 perf	White to light green	H 5.5 G 2.82	Insol in cold dil HCl.
	1.603	1.632	1.632	.029	CARYOPILITE (Serpentine grp) $(Mn,Mg)_3Si_2O_5(OH)_4$	~ 0°	X = c	MCL fib	001 perf	Brown	H 5.5 G 2.8-2.9 F easy	Dec by acids.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.617	<u>1.632</u>	1.640	.023	CHESTERITE $(Mg,Fe^{+2})_{17}Si_{20}O_{54}(OH)_6$	71° r > v wk	X = a Y = b	ORTH	110 perf at 45°	Cols to light pinkish-brown	---	FeO 14.1, MnO 1.0%.
1.615 ◊ 1.643	1.622	<u>1.632</u>	1.642	.020	ACTINOLITE (Amphibole grp) $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	80° r < v	Y = b Z:c = 26° el pos	MCL	110 perf at 124°	Green	H 5.5-6 G 3.18	Insol in acids. Pleoc. FeO 7.2, Fe_2O_3 2.8, Al_2O_3 2.2%.
	---	<u>1.632</u>	1.634	---	KAHLERITE (Autunite grp) $Fe(UO_2)_2(AsO_4)_2 \cdot xH_2O$	9-33°	---	TET tab	001 perf	Yellow-green	---	Diss by acids. Not fluor in UV.
	1.620	<u>1.633</u>	1.640	.020	GARRELSITE $Ba_3NaSi_2B_7O_{16}(OH)_4$	72°	Z = b	MCL bipyram	---	Cols	G 3.8	---
1.630 ⊓	1.619	<u>1.633</u>	1.635	.016	KINOSHITALITE (Mica grp) $(Ba,K,Na)(Mg,Mn,Al)_3Si_2Al_2O_{10}(OH,F)_2$	23°	el pos	MCL	001 perf	Yellow-brown	H 2.5-3 G 3.23-3.30	Pleoc wk, X very light yellow, Y and Z yellow. BaO 17.9, K_2O 3.3, MnO 7.4, Mn_2O_3 3.2%.
	1.622	<u>1.633</u>	1.638	.016	LIBERITE Li_2BeSiO_4	66°	Z:c = 41°	MCL	010 perf 100, 001 dist	Yellow to brown	H 7 G 2.69	---
⊓⊔	1.630	<u>1.633</u>	1.636	.006	DANBURITE $CaB_2Si_2O_8$	88° r < v str	X = a Z = b	ORTH el c	001 poor	Cols to yellowish	H 7 G 2.94 F diff	Insol in acids.
v 1.685	1.59	<u>~1.63</u>	~1.64	~.05	ROSCOELITE (Mica grp) $K(V,Al,Mg)_2AlSi_3O_{10}(OH)_2$	Med r < v	Z = b X ~ c el pos	MCL	001 perf	Brownish-green	H 3 G 2.8 F 3	Insol in acids. V_2O_3 17.4, Al_2O_3 21.9, FeO 1.7%.
1.603 ◊ 1.661	1.575	<u>1.634</u>	1.634	.059	STILPNOMELANE $K(Fe^{+2},Mg,Fe^{+3},Al)_{10}Si_{12}O_{30}(OH)_{12}$	~ 0°	X = b Y ~ c	MCL also tric	001 perf	Brown	H 3-4 G 2.84 F 4-5	Dec by acids. Pleoc, X pale brown, Y and Z dark brown. FeO 22.7, Fe_2O_3 12.2%.
v 1.645	1.616	<u>1.634</u>	1.646	.030	HOLMQUISTITE (Amphibole grp) $Li_2(Mg,Fe^{+2})_3Al_2Si_8O_{22}(OH)_2$	56° (78±8°) r > v wk	Z = c el pos	ORTH pris	210 perf	Violet	H 5.5-6 G 3.04	Pleoc, X and Y cols, Z lilac. FeO 7.3, Fe_2O_3 1.0, Al_2O_3 14.3, Li_2O 3.2%.

1.618 ^	1.610	1.634	1.634	.024	GLAUCONITE (Mica grp) $(K,Na)(Fe^{+3},Al,Mg,Fe^{+2})_2(Si,Al)_4O_{10}(OH)_2$	10° r < v	Y = b X ~ c	MCL	001 perf	Green	H 2 G 2.74 fus	Dec by acids. Pleoc, X yellow-green, Y and Z blue-green. Fe_2O_3 24.9, Al_2O_3 7.3, FeO 2.9%.
	1.560	1.635	1.635	.075	GILALITE $Cu_5Si_6O_{17}\cdot 7H_2O$	Small	---	MCL fib	---	Green	H 2 G 2.82	---
	1.615	1.635	1.656	.041	SKLODOWSKITE $Mg(UO_2)_2Si_2O_6(OH)_2\cdot 5H_2O$	~ 90° r > v str	Y = b = el	MCL pris b tab spher-ulitic	100 perf	Yellow	H 2-3 G 3.64	Pleoc, X cols, Y yellow, Z pale yellow. Not fluor in UV.
1.632 ⌐	1.617	1.635	1.652	.035	TILLEYITE $Ca_5Si_2O_7(CO_3)_2$	92° r > v perc	Y = b X:a = 18°	MCL	100 perf	White	G 2.84	Eff and gel with acids.
	1.611	1.635	1.643	.032	BURANGAITE $(Na,Ca)_2(Fe,Mg)_2Al_{10}(PO_4)_8(OH,O)_{12}$	58° r > v	Z = b X:c = 11°	MCL pris	100 perf	Bluish to bluish-green	H 5 G 3.05	Pleoc, X light blue, Y dark blue, Z cols. Fe_2O_3 1.1, FeO 6.3%.
v 1.651	1.624	1.635	1.654	.030	BAKERITE $Ca_4B_4(BO_4)(SiO_4)_3(OH)_3\cdot H_2O$	85° (105±8°)	Y = b X:c = 44°	MCL pris tab spher-ulitic	---	White	H 4.5 G 2.88	---
	1.615	1.635	1.638	.023	METALODEVITE (Meta-autunite grp) $Zn(UO_2)_2(AsO_4)_2\cdot 10H_2O$	27-37°	---	ORTH tab	---	Pale yellow to olive	G 4.00	Weakly fluor yellow-green in UV.
1.630 ⊏⊐ 1.640	1.619	1.635	1.642	.023	NORDITE $(La,Ce)(Sn,Ca)(Na,Mn)_3(Zn,Mg)Si_6O_{17}$	31° (66±10°)	X = a Y = b	ORTH	100 good	Light brown	H 5-6 G 3.43 F easy	Dec by acids.
v 1.644	1.627	1.635	1.639	.012	ANDALUSITE Al_2SiO_5	82° r < v	X = c Y = b el neg	ORTH	110 good 100 poor	Pink, white	H 6-6.5 G 3.14 infus	Insol in acids. Pleoc wk, X rose, Y and Z greenish-yellow. Fe_2O_3 0.8%.
	1.560	1.635	1.635	.075	GILALITE $Cu_5Si_6O_{17}\cdot 7H_2O$	Small	---	MCL	---	Green	H 2 G 2.72	---
v ~1.650	1.596	(1.636)	1.637	.041	JOLIOTITE $(UO_2)(CO_3)\cdot xH_2O$ $(x < 2)$	Small	X = a Y = b	ORTH crusts	100	Lemon-yellow	H 1-2 G 4.55 calc	Pleoc, X cols, Z yellow. Fluor wk in UV.
1.619 ^	1.602	1.636	1.639	.037	GRANDIDIERITE $(Mg,Fe)Al_3(BO_4)(SiO_4)O_2$	30° r < v str	X = a Y = c el c̄Tv pos	ORTH	100 perf 010 poor	Blue-green	G 2.99 infus	Insol in acids. Pleoc, X greenish-blue, Y cols, Z pale bluish-green.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	<u>β</u>	γ									
1.630 ⊔^ 1.644	1.621	<u>1.636</u>	1.640	.019	FERROCARPHOLITE $(Fe,Mg)Al_2Si_2O_6(OH)_4$	56° r > v str	X = <u>b</u> Z = <u>c</u> el pos	ORTH fib <u>c</u>	Pris at 68°	Yellow to green	H 5.5-6 G 3.0 F 3	Insol in acids. Pleoc, X and Y yellow-green, Z blue-green. FeO 15.5, MnO 0.1, Fe_2O_3 3.9%.
	1.624	<u>1.636</u>	1.642	.018	BERTOSSAITE $(Li,Na)_2CaAl_4(PO_4)_4(OH,F)_4$	Med r < v str	X = <u>a</u> Y = <u>c</u>	ORTH	100 good	Pink	H 6 G 3.10	Slowly diss by HNO_3.
	1.584	<u>1.637</u>	1.670	.086	USHKOVITE $MgFe^{+3}_2(PO_4)_2(OH)_2 \cdot 8H_2O$	50°	ext at 26°	TCL	010 good	Light yellow	G 3.38	Diss by acids.
	1.610	<u>1.637</u>	1.652	.042	FABIANITE $CaB_3O_5(OH)$	66° r < v wk	Y = <u>b</u> X:<u>a</u> = 22°	MCL pris	110	Cols	H 6 G 2.77	Diss by acids. Fluor brownish-yellow in UV.
1.619 ^v 1.649	1.615	<u>1.637</u>	1.638	.023	CHAMOSITE (Chlorite grp) $(Mg,Fe^{+2},Fe^{+3})_5Al(Si_3Al)O_{10}(OH,O)_8$	15°	X ⊥ <u>c</u>	MCL	001 perf	Green	H 2.5 G 3.0 F diff	Dec by acids. Pleoc, X olive-green, Y and Z brownish-yellow. FeO 22.8, Fe_2O_3 9.1, Al_2O_3 22.1%.
v 1.648	1.620	<u>1.637</u>	1.642	.022	GLAUCOPHANE (Amphibole grp) $Na_2(Mg,Fe)_3Al_2Si_8O_{22}(OH)_2$	51° r < v str	Y = <u>b</u> Z:<u>c</u> = 5° el pos	MCL pris	110 perf at 121°	Blue	H 6 G 3.13 F 3.5	Insol in acids. Pleoc, X cols, Y lavender, Z blue. FeO 10.6, Fe_2O_3 2.0, Al_2O_3 10.1%.
1.568 ^	1.623	---	1.640	.017	NEPOUITE (Serpentine grp) $(Ni,Mg)_3Si_2O_5(OH)_4$	---	---	MCL fib	001 perf	Dark green	H 6 G 3.2 infus	Insol in acids. Pleoc wk, X dark green, Z yellow-green. NiO 43.7, MgO 8.2%.
	1.596	<u>1.639</u>	1.670	.074	SUANITE $Mg_2B_2O_5$	70° (79±3°) r > v wk	X = <u>b</u> Y:<u>c</u> = 23°	MCL fib	010	White	H 5.5 G 2.91 F diff	Slowly diss by HCl.
1.636 □ 1.642	1.618	<u>1.639</u>	1.653	.035	INESITE $Ca_2Mn_7Si_{10}O_{28}(OH)_2 \cdot 5H_2O$	75° r > v wk	Ext from clv on 010 = 29° 001 = 14°	TCL pris	010 perf 100 good	Rose-red to flesh	H 5.5 G 3.02 F 3	Dec by HCl with sepn of silica.
	1.619	<u>1.639</u>	1.643	.024	TROLLEITE $Al_4(PO_4)_3(OH)_3$	49° r > v wk	---	MCL mass	---	Pale green	H 5.5 G 3.09 infus	Nearly insol in acids. Fe 2%.

⌴ 1.644	1.624	1.639	1.643	.019	ROSCHERITE $Ca(Al,Fe,Mn)_3Be_2(PO_4)_3(OH)_3 \cdot 2H_2O$ (?)	Large (54±14°) r > v str crossed	X = b Y:c = -15°	MCL pris	001 good 010 fair	Dark brown	H 4.5 G 2.93 fus	Diss by acids. Pleoc, X yellow to olive, Y yellow-brown, Z chestnut brown. Abnormal interf colors.
1.617 ↕ 1.652	1.590	1.640	1.640	.050	SIDEROPHYLLITE (Biotite ser, Mica grp) $KFe_2Al(Al_2Si_2)O_{10}(F,OH)_2$	Small r < v	Y = b el pos	MCL plates	001 perf	Dark brown	H 2.5-3 G 3.12 F 4	Pleoc, X brown, Y and Z dark brown. FeO 30.2, MnO 1.0%.
	1.624	1.640	1.650	.026	OURSINITE $(Co,Mg)(UO_2)_2Si_2O_7 \cdot 6H_2O$	(76±9°)	Y = c	ORTH	---	Pale yellow	G (3.67)	Does not fluor UV.
	1.632	---	1.646	.014	ZYKAITE $Fe^{+3}{}_4(AsO_4)_3SO_4(OH) \cdot 15H_2O$	Large	el pos	ORTH	Uneven	Gray-white, yellow-green	G 2.50	---
1.627 ↕ 1.660	1.631	1.640	1.641	.010	ROWEITE $Ca_2(Mn,Mg)_2B_4O_7(OH)_6$	20° r < v str	Z = b Y = c	ORTH tab	101 poor	Light brown	H 5 G 2.73 F 2	Diss by acids. MnO 17.9, MgO 7.6, FeO 1.2%.
	1.633	1.640	1.645	.012	Unnamed Ca_2SiO_4	57°	---	ORTH fib	clv ⊥ el	White	G 2.97 calc infus	Gel with acids. Am. Mineral., 51, 1771 (1966).
	---	1.64	---	wk	NINGYOITE $(U,Ca,Ce)_2(PO_4)_2 \cdot 1\text{-}2H_2O$	---	el pos	ORTH ps hex	---	Brown to brownish-green	---	Pleoc wk in brown. Opt char unk.
	1.583	1.641	1.648	.065	SERPIERITE $Ca(Cu,Zn)_4(SO_4)_2(OH)_6 \cdot 3H_2O$	(37±6) r > v str	Y = b X:a = 24°	MCL laths	100 perf	Sky-blue	G 3.07	Diss by acids. Pleoc, X pale green, Y and Z bluish-green.
	1.607	1.641	1.672	.065	PAPAGOITE $CaCuAlSi_2O_6(OH)_3$	78° (86±4°) r > v wk	Z = b X:c = 44°	MCL tab	100 good	Blue	H 5-5.5 G 3.25	Pleoc, X cols to pale greenish-blue, Y blue, Z deep greenish-blue.
	1.609	1.641	1.641	.032	METAHEINRICHITE (Meta-autunite grp) $Ba(UO_2)_2(AsO_4)_2 \cdot 8H_2O$	0-20°	---	TET tab	001 perf 100 dist	Yellow to green	H 2.5 G 4.04	Diss by acids. Pleoc, X cols, Y and Z pale yellow. Fluor yellow-green in UV.
	1.624	1.641	1.647	.023	ROSENHAHNITE $Ca_3Si_3O_8(OH)_2$	60-68°	On 100 Z':c = 36°	TCL laths	001 perf 100, 010 good	Cols	H 4.5-5 G 2.89 F 3	Slightly attacked by acids.
⌴ 1.646	1.635	(1.642)	1.642	.007	KILLALAITE $2Ca_3Si_2O_7 \cdot H_2O$	26°	Y = b Z:c = 16°	MCL	100 perf 010, 001 good	Cols	G 2.88 calc	Complex penet tw.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v 1.653	1.618	1.642	1.652	.034	SOUZALITE $(Mg,Fe)_3(Al,Fe)_4(PO_4)_4(OH)_6 \cdot 2H_2O$	68° r > v str	X = a el pos	MCL (?) fib	100 perf	Green	H 5.5-6 G 3.09 infus	Diff diss by HCl. Poly tw. Pleoc, X green, Y blue, Z yellow.
v 1.645	1.633	1.642	1.652	.019	MAGNESIO-HORNBLENDE (Amphibole grp) $(Ca,Na)_2(Mg,Fe)_4Al(Si_7Al)O_{22}(OH,F)_2$	88°	Y = b Z:c = 16° el pos	MCL pris	110 perf at 124°	Green	H 5-6 G 3.10	Insol in acids. Pleoc, X pale yellow, Y and Z green. FeO 8.7, Fe_2O_3 2.7, Al_2O_3 5.0%.
	1.627	1.642	1.644	.017	PALERMOITE $(Li,Na)_2(Sr,Ca)Al_4(PO_4)_4(OH)_4$	~ 20° r < v mod	Y = a X = c el neg	ORTH pris, el∘ c	100 perf 001 fair	Cols, white	H 5.5 G 3.22	---
	1.555	1.643	1.658	.103	SIBIRSKITE $CaHBO_3$	43°	---	MCL	---	Cols	---	Diss by acids.
⊔ 1.650	1.559	1.643	1.655	.096	HOHMANNITE $Fe_2(SO_4)_2(OH)_2 \cdot 7H_2O$	40° r > v str	Y:c = 23°	TCL pris	010 perf	Amaranth-red to brown	H 3 G 2.2	Diss by acids. Pleoc, X pale yellow, Y pale greenish-yellow, Z dark greenish-brown.
(1.63) ◊ (1.662)	1.612	1.643	1.643	.031	CELADONITE (Mica grp) $K(Mg,Fe^{+2})(Fe^{+3},Al)Si_4O_{10}(OH)_2$	Small r > v	Y = b X ~ c el cTv pos	MCL	001 perf	Bright green	H 2 G 2.8 F 3	Dec by HCl. Pleoc, X yellow-green, Y and Z green. Fe_2O_3 29.3, Al_2O_3 1.0, FeO 9.8, MgO 3.7%.
1.632 ◊ 1.663	1.629	1.643	1.650	.021	ACTINOLITE (Amphibole grp) $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	73° r < v	Y = b Z:c ~ 20° el pos	MCL pris	110 perf at 124°	Green	H 5.5-6 G 3.17	Insol in acids. Pleoc. FeO 8.3, Fe_2O_3 2.4%.
1.624 ◊ 1.652	1.632	1.643	1.646	.014	MARGARITE (Mica grp) $CaAl_2(Al_2Si_2)O_{10}(OH)_2$	63° r < v	Z = b Y:c = 7°	MCL	001 perf	Cols	H 4 G 3.06 F diff	BeO 1.8 to 3.3%.
	1.637	1.643	1.648	.011	KOASHVITE $Na_6(Ca,Mn)(Ti,Fe)Si_6O_{18} \cdot H_2O$	83° r > v wk	---	ORTH	Conch	Pale yellow	H 6 G 3.00 F 3	---
v 1.658	1.639	1.643	1.646	.007	HIORTDAHLITE $(Ca,Na)_3ZrSi_2O_7(O,OH,F)_2$	83° r < v	Ext on 100 = 65°	TCL tab	Pris at about 90°	Yellow, brown	H 5.5 G 3.26 F 3	Gel with acids. Poly tw, comp pl 100. Pleoc wk, X cols, Y and Z yellow.

1.630 ^v 1.665	1.630	1.644	1.652	.022	TIRODITE (Cummingtonite ser, Amphibole grp) $Mn_2(Mg,Fe^{+2})_5Si_8O_{22}(OH)_2$	73°	Z:c = 20° Y = b el pos	MCL pris	110 perf	Pink to greenish	H 5.5-6 G 3.10	Insol in acids. MnO 16.6, FeO 4.5%.
1.628 ^v (1.652)	1.631	1.644	1.646	.015	WOLLASTONITE $(Ca,Mn)SiO_3$	45° r > v	Y ~ b X:c ~ 40°	TCL	100 perf 001, $\bar{1}02$ good	White	H 5 G 3.03 F 4	Dec by HCl. MnO 6.3, FeO 0.7%.
1.635 ^	1.637	1.644	1.650	.013	ANDALUSITE Al_2SiO_5	73° r < v	X = c Y = b el neg	ORTH	110 good 100 poor	White, pink	H 6-6.5 G 3.16 infus	Insol in acids. Pleoc wk, X rose, Y and Z yellow.
1.631 ^v 1.656	1.636	1.644	1.649	.013	ECKERMANNITE (Arfvedsonite ser, Amphibole grp) $Na_3(Mg,Fe)_4AlSi_8O_{22}(OH)_2$	74°	X:c = 25° el neg	MCL pris	110 good	Bluish-green	H 6 G 3.16	Insol in acids. Pleoc, X bluish-green, Y bright blue-green, Z yellow-green. Na_2O 9.8, FeO 2.7, Fe_2O_3 8.0, MgO 9.1%.
v 1.653	1.637	1.644	1.645	.008	JEREMEJEVITE $Al_6B_5O_{15}(F,OH)_3$	18° r > v dist	X = c	HEX pris	Conch	Cols to brown	H 6.5 G 3.28 infus	Insol in acids.
	1.589	1.645	1.659)	.056	CAMPIGLIAITE $Cu_4Mn(SO_4)_2(OH)_6 \cdot 4H_2O$	52° r < v wk	Z = b X ~ a	MCL el b	---	Light blue.	---	Tw 100.
1.634 ^	1.624	1.645	1.651	.027	HOLMQUISTITE (Amphibole grp) $Li_2(Mg,Fe^{+2})_3Al_2Si_8O_{22}(OH)_2$	50° r > v wk	Z = c el pos	ORTH pris	210 perf	Blue	H 5.5-6 G 3.06	Pleoc, X grayish-yellow, Y pink-violet, Z dark bluish-violet. FeO 8.9, Fe_2O_3 2.2, Al_2O_3 13.0, Li_2O 2.4%.
1.642 ^v 1.664	1.634	1.645	1.658	.024	EDENITE (Hornblende ser, Amphibole grp) $NaCa_2(Mg,Fe)_5Si_7AlO_{22}(OH)_2$	74° (94±10°)	Y = b el pos	MCL pris	110 perf at 124°	Green	H 5-6 G 3.10	Insol in acids. Pleoc. FeO 9.0, Fe_2O_3 3.4, MnO 0.3%.
v 1.655	1.637	1.645	1.649	.012	HUREAULITE $Mn_5(PO_4)[PO_3(OH)]_2 \cdot 4H_2O$	75° r < v very str	X = b Z:c = 65°	MCL tab	100 good	Pink to brown	H 3.5 G 3.19 F 2	Diss by acids. Pleoc, X cols, Y pale pink to yellow, Z pink to brown.
	1.556	1.646	1.652	.096	DONNAYITE $Sr_3CaNaY(CO_3)_6 \cdot 3H_2O$	0-20° u 5-10°	---	TCL	001 indist to fair	Yellow to cols	H 3 G 3.35	Diss by acids with eff.
	1.558	1.646	1.648	.090	WELOGANITE $Sr_3Na_2Zr(CO_3)_6 \cdot 3H_2O$	0-15°	---	TCL ps hex el c	001 perf fr conch	Lemon-yellow to amber	H 3.5 G 3.20	Diss by acids with eff.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v (1.699)	1.575	1.646	1.650	.075	SZAIBELYITE (Sussexite ser) $MgBO_2(OH)$	~ 25° r > v	---	MCL fib	110 perf	White	H 3 G 2.65 F 3	Diss by acids. Poly tw.
1.631 ◊ 1.674	1.620	1.646	1.656	.036	LAZULITE $(Mg,Fe)Al_2(PO_4)_2(OH)_2$	67° r < v perc	Y = b X ~ c	MCL	110 good 101	Blue	H 5-6 G 3.19 infus	Insol in acids. Pleoc, X cols, Y and Z blue. FeO 8.9, Fe_2O_3 0.9%.
	1.640	(1.646)	1.651	.011	RUSTUMITE $Ca_{10}(Si_2O_7)_2SiO_4Cl_2(OH)_2$	80°	Y = b X:c = 5°	MCL tab	100 poor	Cols	G 2.9	Lam tw on 100.
	1.639	1.646	1.646	.007	KELLYITE (Kaolinite-Serpentine grp) $(Mn,Mg,Al)_3(Si,Al)_2O_5(OH)_4$	5-30° r > v mod	X = c el c̄ pos	TRIG and HEX	0001 perf	Yellow	G 3.07	Pleoc, X cols to greenish-yellow, Y and Z pale yellow to reddish-brown.
	1.637	1.647	1.647	.010	NIMITE (Chlorite grp) $(Ni,Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	15°	---	MCL	001 good	Yellow-green	H 3 G 3.16	Pleoc wk, X greenish-yellow, Z apple green. NiO 29.5, FeO 2.8, Fe_2O_3 4.4%.
1.607 ^	1.622	1.648	1.651	.029	VERMICULITE $(Mg,Ni,Fe,Al)_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$	Small	X ⊥ plates el pos	MCL	001 perf	Brownish-black	H 1.5 G 2.8 F 5	Dec by HCl. Exfoliates when heated. Fe_2O_3 19.2, FeO 5.0, MgO 13.9, NiO 8.6%.
1.637 ◊ 1.659	1.634	1.648	1.653	.019	CROSSITE (Glaucophane ser, Amphibole grp) $Na_2(Mg,Fe^{+2})_3(Al,Fe^{+3})_2Si_8O_{22}(OH)_2$	Small (61±13°)	X:c = 8° Y = b el neg	MCL pris	110 perf	Blue	H 5 G 3.14	Insol in acids. Pleoc, X yellowish, Y lavender, Z blue. FeO 7.5, Fe_2O_3 6.4, Al_2O_3 8.4%.
	1.646	1.648	1.650	.004	KILCHOANITE $Ca_3Si_2O_7$	46-54° r > v str	---	ORTH	---	Cols	G 2.99	Gel with acids. Abnormal ultrablue and brown interf colors.
	1.585	1.649	1.660	.075	DEVILLINE $CaCu_4(SO_4)_2(OH)_6 \cdot 3H_2O$	39° (44±4°)	Z = b Y ~ c	MCL tab	001 perf 110, 101 dist	Emerald- to bluish-green	H 2.5 G 3.13 F 3.5	Diss by acids. Tw 010. Pleoc, X pale green, Y Venice green, Z turquoise.

v 1.667	1.627	1.649	1.660	.033	URANOPHANE $Ca(UO_2)_2Si_2O_7 \cdot 6H_2O$	60° r > v (U r < v)	Z = b	MCL acic	100 perf	Lemon- to pale-yellow	H 2.5 G 3.3 infus	Gel with acids. Pleoc, wk in yellows. Abnormal blue interf colors.
v 1.664	1.641	1.649	1.655	.014	MONTICELLITE $Ca(Mg,Fe)SiO_4$	80° r > v	X = b Z = a	ORTH	010 poor	White, gray	H 5.5 G 3.06 F 6	Gel with acids. FeO 1.4%.
v 1.667	1.642	1.649	1.649	.007	CHLORAPATITE (Apatite grp) $Ca_5(PO_4)_3(Cl,F,OH)$	Small 5-10°	---	MCL ps hex	001 imperf	Cols	H 5 G 3.18 F 5	Diss by acids. Cl 1.31, F 0.45, H_2O 0.7%.
1.637 ^v 1.666	1.643	1.649	1.649	.006	CHAMOSITE (Chlorite grp) $(Fe^{+2},Mg,Fe^{+3})_5Al(Si_3Al)O_{10}(OH,O)_8$	~ 0°	X = c el pos	MCL	001 perf	Dark green	H 3 G 3.08	Dec by HCl. Pleoc, X pale yellow, Y and Z olive-green.
1.646	1.602	1.650	1.654	.052	VITUSITE $Na_3(Ce,La)(PO_4)_2$	30°	---	ORTH	---	Pale pink, gray	H 4.5 G 3.60-3.70	Diss by HCl. Tw.
	1.610	1.650	1.682	.072	EPISTOLITE $Na_2(Nb,Ti)_2Si_2O_9 \cdot xH_2O$	80° r < v perc	Y = b Z:c = 7°	TCL plates	001 perf 110 dist	White, gray, yellow	H 1-1.5 G 2.89	---
v 1.675	1.640	(1.650)	1.653	.013	FERROBUSTAMITE $Ca(Fe^{+2},Ca,Mn)Si_2O_6$	60°	X:c = 44°	TCL	100 perf 110, $1\bar{1}0$ good	Pink to brown	H 6 G 3.09	FeO 15.4, MnO 1.6%.
(1.636) ^	1.604	---	1.651	.047	JOLIOTITE $(UO_2)(CO_3) \cdot xH_2O$ (x = 2?)	Small	X = a Y = b	ORTH crusts	100	Lemon-yellow	H 1-2 G 4.55 calc	Pleoc, X cols, Z yellow. Fluor wk in UV.
1.600 ^	1.625	1.65	1.655	.030	NONTRONITE (Smectite grp) $Na_{0.33}Fe^{+3}{}_2(Si,Al)_4O_{10}(OH)_2 \cdot xH_2O$	33° r < v	Y = b X ~ c	MCL u mass	001 perf	Green to yellow	H 1-2 G 2.27	Dec by acids. Pleoc, X nearly cols, Y and Z yellow to greenish-yellow.
v 1.664	1.629	1.650	1.658	.029	EOSPHORITE (Childrenite ser) $(Mn,Fe)AlPO_4(OH)_2 \cdot H_2O$	45° (63±8°) r < v	X = b Z:c = 5°	MCL ps orth	001 poor	Pink to brown	H 5 G 3.10	Diss by acids. MnO 29.9, FeO 1.4%.
	1.623	1.650	1.651	.028	FRIEDELITE $(Mn,Fe)_8Si_6O_{15}(OH,Cl)_{10}$	Small	el clv pos	HEX	0001 perf	Rose-red	H 4.5-5 G 3.07 F 4	Dec by HCl. Pleoc, X cols, Y and Z greenish-yellow.
	1.610	1.650	1.650	.040	APACHITE $Cu_9Si_{10}O_{28} \cdot 11H_2O$	Small	---	MCL	---	Blue	H 2 G 2.80	---
	1.624	1.650	1.650	.026	BEMENTITE $Mn_8Si_6O_{15}(OH)_{10}$	~ 0°	X = c el clv pos	MCL	001 perf	Brown	H 5 G 2.98 F 3	Dec by acids. Pleoc, X nearly cols, Y and Z yellow.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.590	1.651	1.657	.067	BORCARITE $Ca_4MgB_4O_6(OH)_6(CO_3)_2$	30° r < v	Z = b Y:c = 28°	MCL	100 perf	Cols, greenish-blue	H 4 G 2.77	Diss by acids.
1.635 ^	1.625	1.651	1.664	.039	BAKERITE $Ca_4B_4(BO_4)(SiO_4)_3(OH)_3 \cdot H_2O$	67°	Y = b X:c = 44°	MCL pris tab spherulitic	---	White	H 4-5 G 2.88	---
	1.618	1.652	1.682	.064	SCHOONERITE $Fe^{+2}{}_2MnZnFe^{+3}(PO_4)_3(OH)_2 \cdot 9H_2O$	70-80° (85±3°)	X = b Y = c	ORTH tab 010 el 100	010 perf 001 good	Brown to red-brown	H 4 G 2.89	Diss by cold acids. Pleoc, X yellow, Y pale brown, Z brown.
	1.612	1.652	1.675	.063	LIROCONITE $Cu_2AlAsO_4(OH)_4 \cdot 4H_2O$	72° r < v mod	Y = b Z:a = 25°	MCL pris	110, 011 poor fr conch	Blue, green	H 2.5 G 2.96 F easy	Diss by acids.
1.640 ^ v 1.672	1.595	1.652	1.656	.061	BIOTITE (Mica grp) $K(Fe,Mg)_3(Al,Fe^{+3})Si_3O_{10}(OH,F)_2$	Small r < v	Y = b el pos	MCL plates	001 perf	Dark brown	H 2.5-3 G 3.05 F 4	Pleoc, X brown, Y and Z dark brown. FeO 19.9, MnO 0.4, Fe_2O_3 3.2%.
1.599 ^	1.600	1.652	(1.655)	(.055)	WILLEMSEITE (Talc ser) $(Ni,Mg)_3Si_4O_{10}(OH)_2$	27°	---	MCL	001 perf	Light to apple-green	H 2 G 3.28	Pleoc, X yellowish-green, Z bluish-green. NiO 34.5, MgO 7.1%.
1.651 pos ^ v 1.664	1.642	1.652	1.660	.018	PARGASITE (Hastingsite ser, Amphibole grp) $NaCa_2(Mg,Fe^{+2})_4Al(Si_6Al_2)O_{22}(OH)_2$	88°	Y = b Z:c = 28° el pos	MCL pris	110 perf at 124°	Brown	H 5-6 G 3.14	Insol in acids. Pleoc. $Al_2O_3$19.3, Fe_2O_3 0.9, FeO 6.1, MgO 14.3%.
1.644 ^	1.639	(1.652)	1.656	.017	WOLLASTONITE $(Ca,Fe)SiO_3$	59°	Y ~ b X:c = 3°	TCL	100 perf 001, $\bar{1}02$ good	Brown	H 5 G 3.07 F 4	Dec by HCl. FeO 8.7, MnO 2.7, Fe_2O_3 0.6%.
v 1.690	1.645	1.652	1.656	.011	LAVENITE $(Na,Ca)_3ZrSi_2O_7(O,OH,F)_2$	86° r > v wk	el pos	ORTH(?) tab 100	100	Light yellow	H 6 G 3.25	Poly tw 100. Dimorph of Lavenite at β = 1.690 (?).

1.643 ^ 1.655	1.643	1.652	1.654	.011	BITYITE (Margarite ser, Mica grp) $CaLiAl_2(AlBeSi_2)O_{10}(OH)_2$	Med	X = c el cTv pos	MCL	001 perf	White, yellow	H 3.5 G 3.05 F easy	Insol in HCl. Basal section divided into 6 segments.
	1.559	1.653	1.680	.121	CALLAGHANITE $Cu_2Mg_2CO_3(OH)_6\cdot 2H_2O$	55° r > v str	Z:c = 18°	MCL pyramid	111, $\bar{1}11$ perf	Azure-blue	H 3-3.5 G 2.71	Diss by acids with eff. Pleoc in blue, abs Z > Y > X.
1.649 [] 1.658	1.625	1.653	1.670	.045	DATOLITE $CaBSiO_4(OH)$	73° r > v wk	Y = b Z:a = 1-3°	MCL el c	---	Cols	H 5.5 G 3.00 F 2.5	Gel with acids.
1.642 ^	1.619	1.653	1.660	.041	GORMANITE $(Fe^{+2},Mg)_3Al_4(PO_4)_4(OH)_6\cdot 2H_2O$	53° r > v	---	TCL bladed	001 parting	Blue-green	---	Pleoc, X and Z cols, Y blue. FeO 14.7%.
1.644 ^	1.640	1.653	1.653	.013	JEREMEJEVITE $Al_6B_5O_{15}(OH)_3$	Variable 0-33°	X = c	HEX pris	Conch	Cols to brown	H 6.5 G 3.28 infus	Insol in acids. Basal section divided into 6 sections.
	1.567	1.654	1.722	.155	TATARSKITE $Ca_6Mg_2(SO_4)_2(CO_3)_2Cl_4(OH)_4\cdot 7H_2O$	(79±1°)	el pos	ORTH	---	Cols, yellow	H 2.5 G 2.34	---
v 1.705	1.618	1.654	1.655	.037	KIVUITE $(Th,Ca,Pb)H_2(UO_2)_4(PO_4)_2(OH)_8\cdot 7H_2O$ (?)	0-5° r > v	---	ORTH(?)	---	Yellow	---	Dec by HNO_3. Pleoc, X cols, Y and Z greenish-yellow.
	1.595	1.654	1.670	.075	CALCIBORITE CaB_2O_4	54°	Ext:el = 22°	MCL radiating	Conch	White	H 3.5 G 2.88	Diss by acids.
	1.650	1.654	1.661	.011	VLADIMIRITE $H_2Ca_5(AsO_4)_4\cdot 5H_2O$	70° (106±21°) r > v str	Z:c = 36°	MCL	---	Cols	H 3.5 G 3.14 F diff	Diss by acids.
1.630 ^ 1.667	1.642	1.655	1.661	.019	GEDRITE (Amphibole grp) $(Mg,Fe^{+2})_5Al_2(Si_6Al_2)O_{22}(OH)_2$	Large r > v	Y = b Z = c el pos	ORTH pris c	210 perf	Brown, gray	H 6 G 3.18 F 4	Insol in acids. FeO 9.2, Fe_2O_3 0.2, Al_2O_3 23.8%.
1.645 ^ 1.667	1.649	1.655	1.659	.010	HUREAULITE $(Mn,Fe)_5(PO_4)_2[PO_3(OH)]_2\cdot 4H_2O$	75° r < v str	X = b Z:c = 55°	MCL tab	100 good	Pink to brown	H 3.5 G 3.18 F 2	Diss by acids. Pleoc, X cols, Y pale pink or yellow, Z pink or brown.
1.644 ^ 1.683	1.645	1.656	1.661	.016	MAGNESIO-ARFVEDSONITE (Amphibole grp) $(Na,Ca)_3(Mg,Fe^{+2})_4Fe^{+3}Si_8O_{22}(OH,F)_2$	57°	Y = b Z:c = 56°	MCL	110 perf at 124°	Bluish-green	H 6 G 3.23	Insol in acids. Pleoc, X blue-green, Y green, Z pale green. Fe_2O_3 8.4, FeO 13.4, MnO 1.5, MgO 7.8, F 3.3%.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.569	1.657	1.686	.117	CALKINSITE $(Ce,La)_2(CO_3)_3 \cdot 4H_2O$	54° r < v	Y = c Z = a	ORTH platy	010 perf 101 fair	Pale yellow	H 2.5 G 3.28	Diss by acids with eff. Commonly tw 101. Pleoc wk.
	1.650	(1.657)	1.660	.010	DELLAITE $Ca_6Si_3O_{11}(OH)_2$	65°	Z':el = 20°	---	---	Cols	---	---
	1.612	1.658	1.682	.070	LAUEITE $MnFe^{+3}{}_2(PO_4)_2(OH)_2 \cdot 8H_2O$	50° (70±3°) r < v str	Z:c ~ 30°	TCL	010 perf brittle	Brown	H 3 G 2.45	Diss by acids. Pleoc wk.
	1.615	---	1.685	.070	LIKASITE $Cu_6(PO_4)(NO_3)_2(OH)_7$	---	X = a Z = b	ORTH ps hex	001 perf	Blue	G 2.97	Diss by acids. Pleoc, X green-blue, Z pale blue. Opt char unk.
	(1.640)	1.658	1.664	(.024)	JUNGITE $Ca_2Zn_4Fe^{+3}{}_8(PO_4)_9(OH)_9 \cdot 16H_2O$	~ 60° r < v str	Y = a Z = c	ORTH tab	010 perf	Yellow to yellow-green	H 1 G 2.84	---
v 1.660	1.622	1.658	1.687	.065	ANNABERGITE (Erythrite ser) $Ni_3(AsO_4)_2 \cdot 8H_2O$	84° r > v str crossed	X = b Z:c = 36° el clv pos	MCL pris acic	010 perf	Apple-green	H 2.5 G 3.07 F 4	Diss by acid. With increase of Co, becomes gray, then pink.
v 1.686	1.598	1.658	1.660	.062	HENDRICKSITE (Mica grp) $K(Zn,Mn)_3Si_3AlO_{10}(OH)_2$	8°	---	MCL	001 perf	Dark reddish-brown	H 3 G 3.4	Dec by acids. ZnO 19.8, MnO 12.5, Fe_2O_3 4.85%.
⊽ 1.695	1.639	1.658	1.670	.031	JAHNSITE $CaMn(Mg,Fe^{+2})_2Fe^{+3}{}_2(PO_4)_4(OH)_2 \cdot 8H_2O$	Large	Z = b X:c = 18° el pos	MCL pris tab	001 good	Brown to yellow	H 4 G 2.72	Diss by acids. Tw 001. Pleoc, X pale purple to brown, Y red-brown, Z cols to yellow, abs Y > Z > X.
	1.63	1.658	1.66	.03	STEWARTITE $MnFe^{+3}{}_2(PO_4)_2(OH)_2 \cdot 8H_2O$	Large r < v str	X:c = 56°	TCL	010 good	Brownish-yellow	G 2.94	Pleoc wk.
	(~1.640)	1.658	1.664	(~.024)	JUNGITE $Ca_2Zn_4Fe^{+3}{}_8(PO_4)_9(OH)_9 \cdot 16H_2O$	~ 60° r < v str	Y = a Z = c	ORTH tab	010 perf	Yellow to yellow-green	H 1 G 2.84	---
1.643 ^	1.652	1.658	1.665	.013	HIORTDAHLITE $(Ca,Na)_3ZrSi_2O_7(O,OH,F)_2$	~ 90° r < v	Ext on 100 = 65°	TCL tab	Pris at ~ 90°	Yellow, brown	H 5.5 G 3.25 F 3	Gel with acids. Poly tw pl 100. Pleoc wk, X cols, Y and Z pale brownish-yellow.

1.648 ^	1.641	1.659	1.662	.021	FERRO-GLAUCOPHANE (Amphibole grp) $Na_2(Fe^{+2},Mg)_3Al_2Si_8O_{22}(OH)_2$	42° r < v str	Y = b Z:c = 6° el pos	MCL pris	110 perf at 121°	Blue	H 6 G 3.23 F 3	Insol in acids. Pleoc, X cols, Y violet, Z blue. FeO 17.9, Fe_2O_3 4.0, Al_2O_3 10.1%.
	1.648	1.659	1.660	.012	CLINTONITE (Mica grp) $Ca(Mg,Al)_3(Al_3Si)O_{10}(OH)_2$	5-33°	Z = b el pos	MCL ps hex	001 perf	Reddish-brown	H 5 G 3.07 infus	Insol in acids. "Brittle mica." Pleoc, X cols to pale yellow, Z brown to green.
1.658 ^	1.623	1.660	1.694	.071	ERYTHRITE $Co_3(AsO_4)_2\cdot 8H_2O$	87° r > v wk	X = b Z:c = 31° el pos	MCL pris	010 perf	Pink to red	H 3 G 3.06 F 2	Diss by acids. Pleoc, X pink, Y pale violet, Z red.
	1.640	1.660	1.675	.035	TILASITE $CaMg(AsO_4)F$	83° r < v wk	Z = b X:c ~ 30°	MCL	$10\bar{1}$ good	Gray, green	H 5 G 3.77 F easy	Diss by acids. Tw 001 common.
1.640 ^	1.648	1.660	1.663	.015	ROWEITE $Ca_2(Mn,Zn)_2B_4O_7(OH)_6$	15° (53±18°) r < v str	Z = b Y = c	ORTH tab	101 poor	Light brown	H 5 G 2.92 F 1	Diss by acids. MnO 28.3, ZnO 3.1, MgO 1.7%.
(1.63) ^	1.645	(~1.66)	1.672	.027	SODIUM BOLTWOODITE $(H_3O)(Na,K)(UO_2)SiO_4\cdot H_2O$	Large	---	ORTH	010 perf 001 imperf	Pale yellow	G 4.1	Pleoc, X cols, Z pale yellow.
1.634 ^v 1.685	1.584	1.661	1.661	.077	STILPNOMELANE $K(Fe^{+2},Mg,Fe^{+3},Al)_{10}Si_{12}O_{30}(OH)_{12}$	~ 0°	Y = b X ~ c el clv pos	TCL also MCL	001 perf	Dark brown	H 3-4 G 2.80 F 4.5	Dec by acids. Pleoc, X golden yellow, Y and Z dark brown. FeO 8.9, Fe_2O_3 19.4, MnO 2.9%.
	1.640	1.661	1.663	.023	SWAMBOITE $U_3H_6(UO_2)_6(SiO_4)_6\cdot 30H_2O$	34°	---	MCL acic	---	Pale yellow	G 4.0	Pleoc, X cols, Y and Z pale yellow. Does not fluor in UV.
v 1.667	1.646	1.661	1.661	.015	PENNANTITE (Chlorite grp) $Mn_5Al(Si_3Al)O_{10}(CH)_8$	~ 0° r < v str	---	MCL	001 perf	Orange-brown	H 2-3 G 3.06	MnO 38.9, Al_2O_3 18.6, Fe_2O_3 4.4%.
	1.640	1.662	1.667	.027	VÄYRYNENITE $MnBePO_4(OH,F)$	46° r > v mod	Y = b Z:c = -31°	MCL pris	001 perf 100 good	Rose	H 5 G 3.18	---
1.643 ^	1.644	(1.662)	1.663	.019	CELADONITE (Mica grp) $K(Mg,Fe^{+2})(Fe^{+3},Al)Si_4O_{10}(OH)_2$	Small r > v	Y = b X ~ c el clv pos	MCL	001 perf	Bright green	H 2 G 2.8 F 3	Dec by HCl. Pleoc, X and Y yellow-green, Z emerald-green. FeO 9.2, Fe_2O_3 26.9, Al_2O_3 2.1%.
v 1.697	1.654	1.662	1.668	.014	MAGNESIO-RIEBECKITE (Amphibole grp) $(Na,Ca)_2(Mg,Fe^{+2})_3Fe^{+3}{}_2Si_8O_{22}(OH)_2$	Med large	Y = b X:c = 9-20° el neg	MCL pris	110 perf at 124°	Dark blue	H 5 G 3.2	Pleoc, X dark blue, Y indigo blue, Z yellow-green.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.656	<u>1.662</u>	1.668	.012	HELLANDITE $(Ca,Y)_6(Al,Fe^{+3})Si_4B_4O_{20}(OH)_4$	87°	X = <u>b</u>	MCL	100 dist	Brown	H 4.5 G 3.3 F 2-3	Gel with acids. Tw 100.
	1.640	<u>1.663</u>	1.665	.025	SEAMANITE $Mn_3BPO_4(OH)_6$	40° r < v	Y = <u>b</u> Z = <u>c</u>	ORTH acic	001 dist	Pale yellow	H 4 G 3.08 F easy	Diss by acids.
1.643 ^ 1.67	1.650	<u>1.663</u>	1.670	.020	ACTINOLITE (Amphibole grp) $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	65° r < v	Y = b Z:c = 16° el pos	MCL pris	110 perf at 124°	Green	H 5.5-6 G 3.17	Insol in acids. Pleoc. FeO 14.9, MnO 0.3, Fe_2O_3 3.9%.
	1.637	<u>1.664</u>	1.692	.055	WILHELMVIERLINGITE $CaMnFe^{+3}(PO_4)_2(OH)\cdot 2H_2O$	(90±4°)	X = <u>b</u> Y = <u>a</u>	ORTH	---	Yellow	H 4 G 2.58	Pleoc, X and Y light yellow, Z yellow. Reported to have 2V = 45° calc.
	1.640	<u>1.664</u>	1.675	.035	CYANOPHILLITE $Cu_{10}Al_4Sb^{+3}{}_6O_{25}\cdot 25H_2O$	(67±7°)	X = <u>c</u>	ORTH spher-ulitic	001 perf	Greenish-blue	H 2 G 3.10	---
	1.646	<u>1.664</u>	1.676	.030	TANEYAMALITE $Na(Mn^{+2},Mg,Fe^{+3})_{12}Si_{12}(O,OH)_{44}$	70°	el pos	TCL	010 perf	Greenish gray-yellow	H 5 G 3.30 calc	Pleoc, X and Y nearly cols, Z pale yellow.
	1.643	<u>1.664</u>	1.670	.027	RANUNCULITE $HAl(UO_2)(PO_4)(OH)_3\cdot 4H_2O$	(56±10°)	---	MCL ps orth	---	Gold-yellow	G 3.4	Pleoc, X pale greenish yellow, Y pale yellow.
1.650 ◊ 1.681	1.640	<u>1.664</u>	1.670	.030	CHILDRENITE $(Fe,Mn)AlPO_4(OH)_2\cdot H_2O$	45° r < v	X = b Z:c = 4°	MCL ps orth	001 poor	Pink to brown	H 5 G 3.14 F 4	Diss by acids. FeO 14.6, MnO 13.9%.
1.652 ◊ 1.669	1.650	<u>1.664</u>	1.671	.021	TSCHERMAKITE (Amphibole grp) $Ca_2(Mg,Fe^{+2})_3Al_2(Si_6Al_2)O_{22}(OH)_2$	81°	Y = b ext in-clined el pos	MCL pris	110 perf at 124°	Green	H 5-6 G 3.15	Insol in acids. Pleoc. FeO 9.5, Fe_2O_3 2.4, TiO_2O 2.4%.
1.652 ◊ 1.687	1.652	<u>1.664</u>	1.672	.020	MAGNESIO-HASTINGSITE (Amphibole grp) $NaCa_2(Mg,Fe^{+2})_4Fe^{+3}Si_6Al_2O_{22}(OH)_2$	80°	Y = b Z:c = 19° el pos	MCL pris	110 perf at 124°	Green	H 5-6 G 3.18	Insol in acids. Pleoc, X pale brown, Y dark brown, Z green-brown. FeO 8.7, Fe_2O_3 2.6, Al_2O_3 14.3, TiO_2 1.3%.

1.649 ^ v 1.694	1.654	1.664	1.674	.020	MONTICELLITE $Ca(Mg,Fe)SiO_4$	82° r > v	X = b Z = a	ORTH	010 poor	White, gray	H 5.5 G 3.2 F 6	Gel with acids. FeO 7.6, MnO 0.2%.
⊓ ⊔	1.646	1.664	1.664	.018	GONYERITE (Chlorite grp?) $(Mn,Mg)_5Fe^{+3}(Si_3Fe^{+3})O_{10}(OH)_8$	~ 0° r < v str	el clv pos	ORTH(?)	001 perf	Dark brown	H 2.5 G 3.01	Dec by HCl. Pleoc, X dark brown, Z light brown.
	1.654	1.664	1.666	.012	CUPROSKLODOWSKITE $Cu(UO_2)_2(SiO_3)_2(OH)_2\cdot 5H_2O$	Med r > v	X ~ a Y ~ b	TCL fib	100	Yellow-green	G 3.85	Pleoc wk, X cols, Z greenish-yellow. Not fluor in UV.
	1.638	1.665	1.676	.038	KINOITE $Ca_2Cu_2Si_3O_8(OH)_4$	68° r < v	X = b Z ~ c	MCL tab	010 perf 100, 001 dist	Azure-blue	H 5 G 3.16	Dec by HCl. Pleoc, X pale green, Y blue, Z dark blue.
1.644 ^ v 1.677	1.650	1.665	1.679	.029	GRUNERITE (Cummingtonite ser, Amphibole grp) $(Fe^{+2},Mg,Mn)_7Si_8O_{22}(OH)_2$	87° r < v	Y = b Z:c = 16° el pos	MCL pris	110 perf at 124°	Gray, brown	H 6 G 3.31 fus	Insol in acids. Pleoc, X and Y yellow, Z brownish-yellow. FeO 21.4, MnO 8.0, Fe_2O_3 0.6%.
v 1.676	1.654	1.665	1.668	.009	MAGNESIOAXINITE $Ca_2(Mg,Fe,Mn)Al_2BSi_4O_{15}(OH)$	76° r < v	X ~ ⊥ $\bar{1}11$	TCL	100 good	Brown	H 6.5 G 3.19 F 2	Insol in acids. CaO 20.3, MgO 4.2, FeO 5.2, MnO 1.4, Fe_2O_3 1.7%.
	1.638	1.666	1.682	.044	LEPERSONNITE $CaO\cdot(Gd,Dy,Y)_2O_3\cdot 24UO_3\cdot 8CO_2\cdot 4SiO_2\cdot 60H_2O$	73°	---	ORTH acic	---	Yellow	G 3.97	Pleoc, X pale yellow, Y and Z bright yellow.
	1.649	1.666	1.676	.027	UPALITE $Al(UO_2)_3(PO_4)_2(OH)_3$	(74±9°)	X = b Y = a	ORTH acic	010 dist	Amber-yellow	G 3.5	Pleoc, X cols, Y and Z yellow. Not fluor in UV.
1.649 ^ v 1.685	1.656	1.666	1.666	.010	CHAMOSITE (Chlorite grp) $(Fe^{+2},Fe^{+3},Mg)_5Al(Si_3Al)O_{10}(OH,O)_8$	~ 6°	X ~ c el pos	MCL plates	001 perf	Dark green	H 2.5 G 2.96 fus	Dec by acids. FeO 26.2, Fe_2O_3 18.8%.
v 1.686	1.520	1.667	1.668	.148	STRONTIANITE (Aragonite grp) $SrCO_3$	7° r < v wk	X = c Z = a el neg	ORTH pris	110 good	White, gray	H 3.5 G 3.68 infus	Diss by HCl with eff.
1.649 ^	1.642	1.667	1.669	.027	URANOPHANE $Ca(UO_2)_2Si_2O_7\cdot 6H_2O$	32° r < v str	Z = b	MCL acic	100 perf	Lemon- to pale-yellow	H 2.5 G 3.8 infus	Gel with acids. Pleoc wk, X cols, Y pale yellow, Z canary yellow.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.655 ◊ 1.681	1.656	1.667	1.672	.016	GEDRITE (Amphibole grp) $(Mg,Fe^{+2})_5Al_2(Si_6Al_2)O_{22}(OH)_2$	57° r > v	Y = b Z = c el pos	ORTH pris c	210 perf	Brown, gray	H 6 G 3.22 F 4	Insol in acids. FeO 17.1, Fe_2O_3 4.3, Al_2O_3 10.35%.
1.661 ^ 1.673	1.658	1.667	1.667	.009	PENNANTITE (Chlorite grp) $Mn_5Al(Si_3Al)O_{10}(OH)_8$	Small	---	MCL ps hex ro-settes	---	Dark brown	G 3.15	"Grovesite." Pleoc in browns and reds.
	1.662	1.667	1.669	.007	CLINOHEDRITE $CaZnSiO_3(OH)_2$	Med r > v	Z = b Y:c = -28° el neg	MCL	010 perf	Cols	H 5.5 G 3.33 F 4	Gel with acids.
1.649 ^	1.665	1.667	1.667	.002	CHLORAPATITE (Apatite grp) $Ca_5(PO_4)_3(Cl,F,OH)$	10°	---	MCL ps hex	---	Cols	H 5 G 3.18 F 5	Diss by acids. Cl 6.2, F 0.1, H_2O 0.9%.
1.655 ^	1.657	1.667	1.671	.014	HUREAULITE $(Mn,Fe)_5(PO_4)_2[PO_3(OH)]_2\cdot 4H_2O$	61°	X = b Z:c = 61°	MCL tab	100 good	Pink to brown	H 3.5 F 2	Diss by acids. MnO 22.4, FeO 20.7%.
	1.635	1.668	1.702	.067	SYMPLESITE $Fe_3(AsO_4)_2\cdot 8H_2O$	87° r > v str	X ⊥ 1$\bar{1}$0 Z:c = 32° el clv pos	TCL pris	1$\bar{1}$0 perf	Green to blue	H 2.5 G 3.01 infus	Diss by acids. Pleoc, X deep blue, Y cols, Z yellow-green.
	1.662	1.668	1.672	.010	ARROJADITE $(K,Ba)(Na,Ca)_5(Fe,Mn,Mg)_{14}Al(PO_4)_{12}(OH,F)$	80° r < v str	X = b Y:c = 21°	MCL u mass	001 good 201 dist	Dark green	H 5 G 3.55	Diss by acids. Pleoc, X cols, Y pale green, Z pale yellow-green.
	1.658	1.669	1.670	.012	ZINKOSITE $ZnSO_4$	Small r < v str	X = b Z = c	ORTH plates	---	White	G 3.7	Diss by H_2O. Alters on exposure. Natural occurrence doubtful.
v 1.684	1.665	1.669	1.672	.007	LITHIOPHILITE (Triphylite grp) $Li(Mn,Fe)PO_4$	80° r < v str	X = c Y = a	ORTH pris	100 perf 010 less so	Yellow-ish-brown	H 4-5 G 3.45	Diss by acids. MnO 22.6, FeO 12.8, MgO 6.3%.
1.664 ◊ 1.693	1.658	1.669	1.676	.018	FERROTSCHERMAKITE (Amphibole grp) $(Ca,Na)_2(Fe^{+2},Mg)_3Al_2(Si_6Al_2)O_{22}(OH)_2$	(77±13°)	Y = b Z:c = 7° el pos	MCL pris	110 perf at 124°	Green	H 5-6	Pleoc, X tan, Y green, Z bluish green.

1.670 pos ^	1.619	1.670	1.720	.101	STRUNZITE $MnFe^{+3}{}_2(PO_4)_2(OH)_2 \cdot 8H_2O$	Med (87±2°)	Z:c = 10°	MCL	---	Straw-yellow	G 2.52	Pleoc wk in yellows, abs Z > X > Y.
1.664 ⇕ 1.678	1.657	1.670	1.679	.022	MAGNESIO-HORNBLENDE (Amphibole grp) $Ca_2(Mg,Fe^{+2})_4Al(Si_7Al)O_{22}(OH)_2$	78°	Y = b el pos	MCL pris	110 perf at 124°	Brown	H 5-6 G 3.23	Insol in acids. Pleoc. FeO 13.2, Fe_2O_3 4.7, MnO 0.3, MgO 10.6%.
	1.526	1.671	1.672	.146	ALSTONITE $BaCa(CO_3)_2$	6° r > v wk	X = c Z = b	ORTH el c	110 imperf	Cols	H 4.5 G 3.71 F diff	Diss by acids with eff.
1.652 ^	1.624	1.672	1.672	.048	ANNITE (Biotite ser, Mica grp) $KFe^{+2}{}_3AlSi_3O_{10}(OH,F)_2$	5° r < v	Y = b el pos	MCL plates	001 perf	Dark brown	H 2.5-3 G 3.0 F 4	Pleoc, X brown, Y and Z dark brown. FeO 32.1, Fe_2O_3 3.1, TiO_2 3.2%.
	1.632	1.672	1.672	.040	Serpentine grp mineral $(Mg,Ni,Fe,Al)_3(Si,Al)_2O_5(OH)_4$	0-10°	---	MCL	001 good	Dark green	---	Species not identified. Pleoc, X yellow-green, Y and Z dark green.
	1.650	1.672	1.677	.027	PARASPURRITE $Ca_5(SiO_4)_2(CO_3)$	77° (50±11°)	X = b Z:c ~ 30°	MCL	001 poor	Cols	G 3.03 infus	Dec by HCl with eff. Poly tw.
	1.634	1.673	1.685	.051	DURANGITE $NaAl(AsO_4)F$	45° (57±5°) r > v wk	Y = b X:c = -25°	MCL pris	110 dist	Orange-red	H 5 G 4.0 F 2	Pleoc, X orange-yellow, Y pale orange, Z cols.
v 1.682	1.662	1.673	1.684	.022	TRIPLITE $(Mn,Fe,Mg,Ca)_2PO_4(F,OH)$	88°	Y = b Z:a = 42°	MCL u mass	001 good 010 fair	Dark brown	H 5-5.5 G 3.58 F easy	Diss by acids. MnO 53.8, FeO 6.7, CaO 2.2%.
1.665 ⊓	1.604	1.674	1.731	.127	BUTLERITE $Fe^{+3}SO_4(OH) \cdot 2H_2O$	Large	---	MCL pris	100 perf	Deep orange	H 2.5 G 2.55	Pleoc, X nearly cols, Y and Z pale yellow.
	1.643	1.674	1.701	.058	CLINOKURCHATOVITE $Ca(Mg,Fe,Mn)BO_5$	85°	---	MCL	010 perf	Cols	H 4.5 G 3.07	Poly tw. Diss by acids.
v 1.681	1.642	1.674	1.699	.057	KURCHATOVITE $Ca(Mg,Mn,Fe)BO_5$	82° r > v	X = b Z = c	ORTH mass	One perf 2 imperf	White	H 4.5 G 3.07	Diss by warm HCl.
1.670 □ 1.676	1.640	1.674	1.679	.039	SPURRITE $Ca_5(SiO_4)_2(CO_3)$	40° r > v wk	X = b Z ~ a	MCL pris	001 perf 100 good	Cols	H 5 G 3.01 infus	Dec by HCl with eff. Poly tw 001.
1.646 ^	1.645	1.674	1.680	.035	SCORZALITE (Lazulite ser) $(Fe,Mg)Al_2(PO_4)_2(OH)_2$	64° (48±8°) r < v	Y = b X ~ c	MCL	110 good	Dark blue	H 6 G 3.36 infus	Insol in acids. Pleoc, X cols, Y and Z dark blue. FeO 17.7, Fe_2O_3 3.0, MnO 0.5%.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v 1.696	1.660	1.674	1.675	.015	KORNERUPINE $Mg_3Al_6(Si,Al,B)_5O_{21}$ (OH)	20° r > v wk	X = c Z = b el neg	ORTH pris	110 good	Green to brownish-green	H 6.5 G 3.28 F 6	Insol in acids. Pleoc variable, X yellow to green, Y cols to pale brown, Z pale to dark green.
v 1.691	1.655	1.675	1.685	.030	DUMORTIERITE $Al_7(BO_3)(SiO_4)_3O_3$	Med r < v	X = c Z = a el neg	ORTH acic c	100 dist	Blue	H 7 G 3.25 infus	Insol in acids. Pleoc str, X deep blue, Y yellow, Z cols.
(1.650) ◊ 1.695	1.664	1.675	1.679	.015	BUSTAMITE $(Ca,Mn)_3Si_3O_9$	50-55°	X:a ~ 15° Y:b ~ 35° Z:c ~ 35°	TCL	100 perf 110, $1\bar{1}0$ good	Pink	H 6 G 3.30	MnO 27.7, CaO 24.9%.
	1.665	1.675	1.678	.013	GERSTMANNITE $(Mg,Mn)_2ZnSiO_4(OH)_2$	50-60°	X = b Y = c	ORTH pris	010 good	White to pale pink	H 4.5 G 3.68	---
	1.529	1.676	1.677	.148	WITHERITE (Aragonite grp) $BaCO_3$	16° r > v wk	X = c Z = a el neg	ORTH el c	010 dist 110 imperf	Cols, white	H 3-3.5 G 4.29 F 2.5-3	Diss by HCl. Tw pl 110 universal.
1.665 ◊ 1.681	1.670	1.676	1.681	.011	FERROAXINITE $Ca_2(Fe,Mg,Mn)Al_2BSi_4$ $O_{15}(OH)$	69°	X ~ ⊥ $\bar{1}11$	TCL	100 good	Violet	H 6.5 G 3.26 F 2	Insol in acids. CaO 19.6, FeO 8.1, MgO 2.1, MnO 1.8, Fe_2O_3 0.9%.
	1.660	1.676	1.686	.026	FERRIPYROPHYLLITE $Fe^{+3}{}_2Si_4O_{10}(OH)_2$	(76±9°)	---	MCL	---	Brownish-yellow	H 1.5-2 G 2.99	---
	1.629	1.677	1.679	.050	SAMPLEITE $NaCaCu_5(PO_4)_4Cl\cdot5H_2O$	23° r > v	X = b Y = a	ORTH	010 perf 110, 001 good	Blue	H 4 G 3.20 F 2	Diss by acids. Pleoc, X blue-green, Y and Z turquoise-blue, abs Z = Y > X.
1.665 ^ 1.677 pos v 1.682	1.660	1.677	1.693	.033	GRUNERITE (Cummingtonite ser, Amphibole grp) $(Fe^{+2},Mg)_7Si_8O_{22}(OH)_2$	87°	Y = b ext In-clined el pos	MCL pris c	110 perf at 110°	Green to brown	H 7 G 3.47	Insol in acids. Pleoc, X pale yellow, Z brown. FeO 31.2, Fe_2O_3 3.4%.
1.677 pos ◊ 1.680	1.672	1.677	1.682	.010	BRONZITE (Orthopyroxene ser, Pyroxene grp) $(Mg,Fe)_2Si_2O_6$	~ 90°	Y = a Z = c el pos	ORTH pris	210 good at 87°	Green, brown	H 5.5 G 3.3 F 5	Nearly insol in acids. Faint pleoc common.

1.670 ◊ 1.685	1.665	1.678	1.684	.019	EDENITE (Amphibole grp) $NaCa_2(Mg,Fe^{+2})_5Si_7Al$ $O_{22}(OH)_2$	65°	Y = b Z:c = 19° el pos	MCL	110 perf at 124°	Light green	H 5.5 G 3.15	Insol in acids. Pleoc, X yellow, Y pale green, Z dark green. FeO 13.4, Fe_2O_3 6.2, Al_2O_3 7.8%.
	1.569	1.679	1.708	.139	CARBOCERNAITE $(Ca,Ce,Na,Sr)CO_3$	56° (51±2°) r > v	X = b Y = a	ORTH	---	Cols to yellow	H 3 G 3.66	Diss by acids.
	1.624	1.679	1.705	.081	POSNJAKITE $Cu_4SO_4(OH)_6 \cdot H_2O$	57° (67±3°)	---	MCL	---	Dark blue	H 2-3 G 3.32 F easy	Diss by HCl. Pleoc, X bluish, Y darker blue, Z greenish blue, abs Y > Z > X.
v 1.695	1.530	1.680	1.685	.155	ARAGONITE (Aragonite grp) $CaCO_3$	18° r < v wk	X = c Z = b el neg	ORTH acic c	010 dist	Cols	H 3-4 G 2.94 infus	Diss in acids with eff. Poly tw on 110 common.
	1.648	1.680	1.716	.068	METAKOETTIGITE $(Zn,Fe^{+3},Fe^{+2})_3$ $(AsO_4)_2 \cdot 8(H_2O,OH)$	87°	---	TCL tab	$1\bar{1}0$ perf	Bluish-gray	G (3.03)	Pleoc, X deep blue, Y yellow, Z light yellow.
1.680 pos ◊ 1.704	1.661	1.680	1.697	.036	CHRYSOLITE (Olivine grp) $(Mg,Fe)_2SiO_4$	90°	X = b Z = a	ORTH	010, 001 poor	Pale green	H 7 G 3.15 infus	Gel with acids. Data for Fo_{86}.
v 1.780	1.67	1.680	1.703	.03	ALLEGHANYITE $(Mn,Zn)_5(SiO_4)_2(OH)_2$	66-86° r > v	Z = b X:c ~ 30°	MCL	fr conch	Brownish to reddish-pink	H 5 G 3.70 F 3.5	Gel with acids.
1.652 ^	1.667	1.680	1.687	.020	PARGASITE (Amphibole grp) $NaCa_2(Mg,Fe)_4Al$ $(Si_6Al_2)O_{22}(OH)_2$	74°	Y = b el pos	MCL	110 perf at 124°	Brown, green	H 5.5 G 3.22	Insol in acids. Pleoc. FeO 9.9, Fe_2O_3 4.9, TiO_2 1.9, MgO 11.6%.
	1.67	1.68	1.69	.02	METAVANMEERSSCHEITE $U(UO_2)_3(PO_4)_2(OH)_6 \cdot$ $2H_2O$	83° (92±3°)	---	ORTH tab	010 good 100 less so	Yellow	G (4.49)	Pleoc in yellow shades.
	(1.668)	1.680	1.686	(.018)	DAVREUXITE $Mn_2Al_{12}(SiO_4)_7O_3(OH)_6$	70°	el pos	MCL fib	---	Creamy white to pale rose	G 3.15	---
1.677 ◊ 1.695	1.674	1.680	1.685	.011	BRONZITE (Orthopyroxene ser, Pyroxene grp) $(Mg,Fe)_2Si_2O_6$	79° r > v	Y = a Z = c el pos	ORTH pris c	210 good at 87°	Greenish	H 5.5 G 3.3 F 5	Nearly insol in acids. Faint pleoc common. FeO 11.1, MnO 0.5%.
	---	1.680	---	weak	BALANGEROITE $(Mg,Fe^{+2},Fe^{+3},Mn)_4$ $Si_{15}(O,OH)_{90}$	---	---	ORTH fib	1 or more good	Brown	G 2.98	Pleoc, yellow brown ‖ 001, dark brown ⊥ 001. Am. Mineral., 68, 214-219 (1983).

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.674 ^	1.635	1.681	1.698	.063	KURCHATOVITE $Ca(Mg,Mn,Fe)BO_5$	66° (61+4°) r > v wk	X = b Z = c	ORTH tab mass	One perf 2 imperf	Gray to cols	H 4.5 G 3.02	Diss by acids. Fluor bright violet in long-wave UV.
1.664 ^	1.646	1.681	1.687	.041	CHILDRENITE $(Fe,Mn)AlPO_4(OH)_2 \cdot H_2O$	50° r > v	X = b Y:c = 8°	MCL ps orth	001 poor	Pink to brown	H 5 G 3.19 F 4	Diss by acids. FeO 28.6, MnO 3.1%.
1.667 ^v 1.710	1.671	1.681	1.690	.019	FERRO-GEDRITE (Amphibole grp) $(Fe^{+2},Mg)_5Al_2(Si_6Al_2)O_{22}(OH)_2$	75° (86+12°) r > v	Y = b Z = c el pos	ORTH pris c	210 perf	Brown, gray	H 6 G 3.33 F 4	Insol in acids. Pleoc. FeO 24.4, Fe_2O_3 0.9, Al_2O_3 13.7%.
1.676 ^v 1.687	1.674	1.681	1.688	.014	TINZENITE (Axinite grp) $(Ca,Mn,Fe)_3Al_2BSi_4O_{15}(OH)$	Large r < v	X ⊥ $\bar{1}$11	TCL	100 good	Yellow-green	H 6.5 G 3.28 F 2	Insol in acids. CaO 15.0, MnO 15.8, MgO 1.3, FeO 0.4%.
	(1.62)	1.682	1.688	(.070)	MUNDITE $Al(UO_2)_3(PO_4)_2(OH)_3 \cdot 5.5H_2O$	33°	el neg	ORTH	001, 100, 010 good	Pale yellow	G (4.30)	Pleoc wk.
	1.637	1.682	1.694	.057	WROEWOLFEITE $Cu_4(SO_4)(OH)_6 \cdot 2H_2O$	53°	---	MCL	010, 100, 001 perf	Deep greenish-blue	H 2.5 G 3.27	Pleoc, X light blue, Y deep greenish-blue, Z med greenish-blue, abs Y > Z >> X.
1.677 ^v 1.700	1.666	1.682	1.698	.032	DANNEMORITE (Cummingtonite ser, Amphibole grp) $Mn_2(Fe^{+2},Mg)_5Si_8O_{22}(OH)_2$	88° r < v	Y = b Z:c = 15° el pos	MCL	110 perf at 125°	Gray	H 5.5-6 G 3.50	Insol in acids. Pleoc, X red-violet, Y pale violet, Z blue. FeO 22.6, MnO 15.6%.
1.673 ^	1.671	1.682	1.690	.019	TRIPLITE $(Mn,Fe,Mg,Ca)_2PO_4(F,OH)$	Large r > v	Y = b Z:a = 42°	MCL	001 good 010 less so	Brown	H 5-5.5 G 3.8	Diss by acids.
1.656 ^v 1.695	1.667	1.683	1.692	.025	MAGNESIO-ARFVEDSONITE (manganoan) (Amphibole grp) $(Na,Ca)_3(Mg,Fe^{+2})_4Fe^{+3}Si_8O_{22}(OH,F)_2$	62° (73+9°)	Y = b Z:c = 3°	MCL	110 perf at 124°	Dark bluish-green	H 5.5-6 G 3.27	Insol in acids. Pleoc, X and Y blue-green, Z yellow-green. FeO 1.0, Fe_2O_3 9.1, MgO 11.3, MnO 7.7%.

	1.525	<u>1.684</u>	1.686	.161	BARYTOCALCITE $BaCa(CO_3)_2$	15° r > v wk	Z = <u>b</u> X:<u>c</u> = 64°	MCL el <u>c</u>	110 perf 001 poor	Cols, white	H 4 G 3.65 F diff	Diss by HCl with eff.
	1.593	<u>1.684</u>	1.698	.105	YAVAPAIITE $KFe(SO_4)_2$	30° (41+3°) r > v str	Z = <u>b</u> X:<u>c</u> = 6°	MCL	001, 100 perf 110 dist	Pink to cols	H 2.5-3 G 2.88	Dec by hot H_2O, diss by HCl.
	1.668	<u>1.684</u>	1.685	.017	WALSTROMITE $BaCa_2Si_3O_9$	30°	---	TCL	---	Cols	G 3.67	---
1.669 ◇ 1.700	1.675	<u>1.684</u>	1.685	.010	TRIPHYLITE $Li(Fe,Mg,Mn)PO_4$	25° r < v str	X = <u>c</u> Y = <u>a</u>	ORTH pris	100 perf 010 less so	Green	H 4-5 G 3.44	Diss by acids. FeO 32.9, MnO 3.1, MgO 7.4%.
~1.63 ^	1.610	<u>1.685</u>	1.704	.094	ROSCOELITE (Mica grp) $K(V,Al,Mg)_2AlSi_3O_{10}(OH)_2$	10-15° (51+3°) r < v str	Z = <u>b</u> X ~ <u>c</u> el pos	MCL plates	001 perf	Green	H 3 G 2.97 F 3	Slowly dec by HCl. Pleoc, X olive-green, Z greenish-brown. Characteristic green interf color.
1.661 ◇ 1.705	1.595	<u>1.685</u>	1.685	.090	STILPNOMELANE $K(Fe^{+2},Mg,Fe^{+3},Al)_{10}Si_{12}O_{30}(OH)_{12}$	~ 0°	Y = <u>b</u> X ~ <u>c</u> el cTv pos	TCL and MCL	001 perf	Dark brown	H 3-4 G 2.84 F 4	Dec by acids. Pleoc, X pale yellow, Y and Z dark olive-brown. FeO 13.7, Fe_2O_3 22.0%.
1.674 ⊓	1.650	<u>1.685</u>	1.712	.062	SODDYITE $(UO_2)_5Si_2O_9\cdot 6H_2O$	84°	X = <u>c</u> Y = <u>b</u>	ORTH platy	001 perf 111 good	Greenish-yellow	H 3-4 G 4.70 infus	Gel with acids. Not fluor in UV.
v 1.705	1.659	<u>1.685</u>	1.702	.043	TARBUTTITE $Zn_2(PO_4)(OH)$	50° (77+5°)	Disp str	TCL pris	001 perf	Pale green	H 3.5-4 G 4.15 F easy	Diss by acids.
1.680 [] 1.694	1.664	<u>1.685</u>	1.694	.030	URANOPHANE-BETA $Ca(UO_2)_2Si_2O_7\cdot 6H_2O$	63° r > v str crossed	X = <u>b</u> Z:<u>c</u> = 26°	MCL tab	010 good 100 poor	Yellow to yellow-green	H 2-3 G 3.8-3.9	Gel with acids. Pleoc wk, X cols, Y and Z light yellow.
v 1.710	1.672	<u>1.685</u>	1.698	.026	TALMESSITE $Ca_2Mg(AsO_4)_2\cdot 2H_2O$	~ 90°	---	TCL	---	Cols	H 5 G 3.42	"Arsenate-belovite." Diss by acids.
1.678 ◇ 1.693	1.670	<u>1.685</u>	1.693	.023	FERRO-HORNBLENDE (Amphibole grp) $Ca_2(Fe^{+2},Mg)_4Al(Si_7Al)O_{22}(OH,F)_2$	61° (72+10°)	Y = <u>b</u> Z:<u>c</u> = 18° el pos	MCL pris	110 perf at 124°	Greenish-brown	H 5-6 G 3.2	Insol in acids. Pleoc, X greenish-yellow, Y olive-green, Z bluish-green. FeO 18.1, Fe_2O_3 5.4, Al_2O_3 13.9%.
1.666 ^	1.670	<u>1.685</u>	1.685	.015	CHAMOSITE (Chlorite grp) $(Fe^{+2},Fe^{+3},Mg)_5Al(Si_3Al)O_{10}(O,OH)_8$	~ 0°	X ~ <u>c</u> el pos	MCL plates	001 perf	Dark brown	H 2.5 G 2.96 fus	Dec by acids.
	1.627	<u>1.686</u>	1.690	.063	SOBOLEVITE $Na_2Ca_2MnTi_3Si_4O_{18}\cdot 4Na_3PO_4$	29°	Y = <u>b</u> X:<u>c</u> = 32°	MCL	110 perf	Brown	H 4.5-5 G 3.03	Dec by acids. Partly dec by H_2O, alk reaction.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien- tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.666	1.686	1.694	.028	CLINOTYROLITE $Ca_2Cu_9[(As,S)O_4]_4(O,OH)_{10}\cdot 10H_2O$	66°	Y = b X:c = 7-8°	MCL silky	---	Emerald-green	G 3.22	Diss by acids.
1.667 ^	1.525	1.686	1.690	.165	STRONTIANITE (Aragonite grp) $SrCO_3$	8° ($17\pm4°$) r < v wk	X = c Z = a el neg	ORTH pris	110 good	White, gray	H 3.5 G 3.81 infus	Diss by acids with eff. CaO 1.0, BaO 3.3%.
1.658 ^	1.624	1.686	1.686	.062	HENDRICKSITE (Mica grp) $K(Zn,Mn)_3Si_3AlO_{10}(OH)_2$	2-5°	---	MCL	001 perf	Dark red-brown	H 3 G 3.41	Dec by acids. ZnO 21.4, MnO 13.9, FeO 0.7, Fe_2O_3 4.85%.
⊔ 1.691	1.640	1.686	1.702	.062	CHERNYKHITE (Mica grp) $(Ba,Na)(V^{+3},Al)_2(Si,Al)_4O_{10}(OH)_2$	11-12° ($60\pm4°$)	---	MCL	001 perf	Olive- to dark-green	H 2.5-4 G 3.15	V_2O_3 18.6, V_2O_4 5.3, BaO 9.5%.
1.682 [] 1.689	1.662	1.686	1.692	.030	KAINOSITE $Ca_2(Y,Ce)_2(SiO_4)_3(CO_3)\cdot H_2O$	40° ($53+9°$) r < v dist	X = c Y = b	ORTH	2 clv at 90°	Cols, rose, brown	H 5.5 G 3.51-3.65	Diss by acids with slight eff.
1.664 ◊ 1.709	1.676	1.687	1.695	.019	MAGNESIO-HASTINGSITE (Amphibole grp) $NaCa_2(Mg,Fe^{+2})_4(Fe^{+3},Ti)Si_6Al_2O_{22}(OH)_2$	80°	Y = b Z:c = 15° el pos	MCL pris	110 perf at 124°	Green	H 5-6 G 3.22	Insol in acids. Pleoc. FeO 6.9, Fe_2O_3 4.8, Al_2O_3 13.9, TiO_2 4.4%.
1.681 ◊ 1.693	1.678	1.687	1.692	.014	MANGANAXINITE $Ca_2(Mn,Fe)Al_2BSi_4O_{15}(OH)$	75°	X ⊥ $\bar{1}11$	TCL	100 good	Yellow-brown	H 6.5 G 3.31 F 2	Insol in acids. MnO 11.7, FeO 3.3, MgO 0.3, CaO 18.2%.
	1.658	(1.687)	1.710	.052	MAGNESIUM ASTROPHYLLITE $(K,Na)_4Mg_2(Fe,Mn)_5Ti_2Si_8O_{24}(O,OH,F)_7$	82°	Y = b Z:c = -6°	TCL	100, 010 perf	Straw yellow	---	Pleoc, X bright yellow, Z gray, Z > Y > X.
	1.632	1.688	1.738	.106	SODIUM-ZIPPEITE $Na_4(UO_2)_6(SO_4)_3(OH)_{10}\cdot 4H_2O$	80° ($84\pm2°$)	Z = c	ORTH plates	010 perf	Yellow to orange	H 2	Diss by acids. Tw common. Pleoc, X cols, Y pale yellow, Z yellow. Fluor bright yellow in UV.

	1.658	(1.688)	1.714	.056	ALVANITE $Al_6(VO_4)_2(OH)_{12}\cdot5H_2O$	80-85° r < v str	X:b = 14° el pos and neg	MCL	010 perf	Bluish-green to bluish-black	H 3-3.5 G 2.41	Diss by hot acids. Poly tw.
	1.664	1.688	(1.707)	(.043)	WEILITE $CaHAsO_4$	82°	Z:c = 20° Y:c = 27°	TCL	---	White	G 3.48	Diss by acids.
v 1.713	1.641	1.690	1.705	.064	LANGITE $Cu_4SO_4(OH)_6\cdot2H_2O$	56-70°	X = c Y = b	ORTH	001 good 010 dist	Sky-blue to blue-green	H 3 G 3.31	Diss by acids. Poly tw 110 common. Pleoc wk, abs Y > Z > X.
	1.640	1.690	1.690	.050	SHUBNIKOVITE $Ca_2Cu_8(AsO_4)_6Cl(OH)\cdot7H_2O$ (?)	Small r < v	---	ORTH(?) platy	---	Light blue	H 2 F easy	---
	1.660	1.690	1.698	.038	BERGENITE $(Ba,Ca)_2(UO_2)_3(PO_4)_2(OH)_4\cdot5.5H_2O$	> 45° (54±7°)	---	MCL tab	---	Yellow	G (4.69)	Fluor pale green in short-wave UV.
v 1.726	1.673	1.690	1.705	.032	TYROLITE $CaCu_5(AsO_4)_2(CO_3)(OH)_4\cdot6H_2O$	70° (86±7°) r > v str	X = b Z = a	ORTH laths	001 perf	Green to blue	H 1.5 G 3.1-3.2 F 2.5	Diss by HNO_3 or NH_4OH. Pleoc, X cols, Y and Z green.
	1.666	1.690	1.690	.024	CALUMETITE $Cu(Cl,OH)_2\cdot2H_2O$	2°	X = c Y = a el clv pos	ORTH	001 good	Azure-blue	H 2	Diss by acids. Pleoc wk, in blue, abs Z > Y > X.
	1.675	1.690	1.693	.018	SINCOSITE $CaV^{+4}_2(PO_4)_2(OH)_4\cdot3H_2O$	Med r > v str	---	MCL ps tet tab	001 good 100, 110 poor	Emerald-green to golden	H 3 G 2.84 fus	Diss by acids. Pleoc, X nearly cols, Z gray-green.
1.652 ↕ 1.723	1.679	1.690	1.695	.016	LAVENITE $(Na,Ca)_3ZrSi_2O_7(O,OH,F)_2$	68° r < v wk	Y = b X:c = -20°	MCL tab on 100	100 good	Yellow, brown	H 6 G 3.41 fus	Diff diss by acids. Tw pl 100, lam.
	1.682	1.690	1.697	.015	CHLOROPHOENICITE $(Mn,Zn)_5AsO_4(OH)_7$	83° r > v str	Y = b	MCL pris	100 perf	Gray-green	H 3-3.5 G 3.55 F diff	Diss by acids. Color pink, purple-red in str artificial light.
v (1.720)	1.653	(1.691)	1.691	.038	FERRI-ANNITE (Mica grp) $K(Fe^{+2},Mg)_3(Fe^{+3},Al)Si_3O_{10}(OH)_2$	0-10°	---	MCL	001 perf	Reddish-brown	---	Pleoc, X reddish-brown, Y and Z pale yellow-green. Tw common.
1.675 ↕ 1.722	1.670	1.691	1.692	.022	DUMORTIERITE $Al_7(BO_3)(SiO_4)_3O_3$	Small r < v	Z = a X = c	ORTH acic c	100 dist	Blue	H 7 G 3.3 infus	Insol in acids. Pleoc, X pale blue-violet, Y and Z nearly cols.
	1.670	1.692	1.713	.043	PARAKELDYSHITE $Na_2ZrSi_2O_7$	84°	X ~ b Y ~ c	TCL	001 perf 110, 1$\bar{1}$0 good	Cols	H 5.5-6 G 3.39	Fluor cream in short-wave UV.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.680	1.692	1.720	.040	VYUNTSPAKHKITE $Y_4Al_2AlSi_5O_{18}(OH)_5$	68°	---	MCL	---	Cols	H 6-7 G 4.02	Insol in HCl.
v 1.710	1.670	1.692	1.701	.031	KAERSUTITE (Amphibole grp) $NaCa_2(Mg,Fe^{+2})_4TiSi_6Al_2O_{22}(OH)_2$	81° (64±8°)	Y = b Z:c = 9° el pos	MCL pris	110 perf at 124°	Dark brown	H 6 G 3.3	Insol in acids. Pleoc, X yellow-brown, Y red-brown, Z dark red-brown. FeO 5.7, Fe_2O_3 3.3, Al_2O_3 14.2, TiO_2 5.7%.
	---	1.692	1.699	---	KECKITE $Ca(Mn,Zn)_2Fe^{+3}{}_3(PO_4)_4(OH)_3\cdot 2H_2O$	---	X:c = 15-22° Z = b	MCL	001, 100	Brown	H 4.5 G 2.6	Pleoc, X red-brown, Y yellow, Z bright yellow, abs X > Y > Z.
	1.672	1.693	1.710	.038	JAGOWERITE $BaAl_2(PO_4)_2(OH)_2$	100° (83±6°)	---	TCL	100, 0$\bar{1}$1 good 02$\bar{1}$ fair	Light green	H 4.5 G 4.01	Insol in acids. Fluor green-white in UV. (Reported as opt pos.)
1.685 ^	1.674	1.693	1.700	.026	FERRO-FERRI-TSCHERMAKITE (Hornblende ser, Amphibole grp) $Ca_2(Fe^{+2},Mg)_3Fe^{+3}{}_2Si_6Al_2O_{22}(OH)_2$	62°	Y = b el pos	MCL pris	110 perf at 124°	Green	H 5.5 G 3.2	Insol in acids. Pleoc. FeO 20.4, Fe_2O_3 5.5, TiO_2 1.8%.
1.687 ◇ 1.695	1.687	1.693	1.697	.010	TINZENITE (Axinite grp) $(Ca,Fe,Mn)_3Al_2BSi_4O_{15}(OH)$	Med	X ⊥ $\bar{1}$11	TCL	100 good	Yellow	H 6.5 G 3.39 F 2	Insol in acids. MnO 18.9, FeO 0.3, CaO 13.2%.
	---	1.693	---	.005	PHARMACOSIDERITE $KFe_4(AsO_4)_3(OH)_4\cdot$ 6-7H_2O	Large r > v	---	MCL ps cub	100 poor	Yellow to brown	H 2.5 G 3.0	Diss by HCl. Abnormal interf colors in blue and brown. Crystals zoned.
1.664 ◇ 1.720	1.674	1.694	1.706	.032	KIRSCHSTEINITE (Monticellite ser) $Ca(Fe,Mg)SiO_4$	65° (75±7°) r > v	X = b Y = c	ORTH	010 poor	Cols	H 5-5.5 G 3.31 F 6	Gel with acids. FeO 19.3, MnO 1.1, Fe_2O_3 1.4%.
1.680 ^	1.540	1.695	1.703	.163	ARAGONITE (Aragonite grp) $(Ca,Pb)CO_3$	23° r < v wk	X = c Z = b	ORTH acic	010 dist	Cols	H 3-4 G 3.05 infus	Diss by acids with eff. Poly tw on 110. PbO 5.2%.
v 1.718	1.620	1.695	1.730	.110	ANCYLITE $SrCe(CO_3)_2(OH)\cdot H_2O$	70° (66±2°) r < v	X = a Z = c	ORTH ps oct	---	Rose, pale yellow	H 4.5 G 3.82 infus	Diss by acids with eff.

	1.65	---	1.72	.07	OTWAYITE $Ni_2CO_3(OH)_2 \cdot H_2O$	---	X ∥ fib el neg	ORTH fib ro- settes	---	Bright green	G 3.41 infus	Diss slowly in dil HCl. Pleoc wk, abs Z > X. Opt char unk.
	1.668	1.695	1.698	.030	BOLTWOODITE $(H_3O)K(UO_2)SiO_4 \cdot H_2O$	Large (36±11°)	---	MCL ps orth fib b	010 perf 001 poor	Pale yellow	H 3.5-4 G 3.6	Abnormal blue interf colors. Fluor dull green in UV.
1.658 ^	1.682	1.695	1.707	.025	JAHNSITE $CaMn(Mg,Fe^{+2})Fe^{+3}_2$ $(PO_4)_4(OH)_2 \cdot 8H_2O$	Large	Z = b el pos	MCL pris tab	001 good	Brown to yellow	H 4 G 2.72	Diss by acids. Tw 001. Pleoc, X brown, Y red-brown, Z yellow, abs Y > Z > X. Fe_2O_3 22.8, MnO 10.2, CaO 2.6%.
	1.67	1.695	1.698	.02	MARICITE $NaFePO_4$	43° r > v wk	X = a Y = b	ORTH	---	Cols to gray to pale brown	H 4-4.5 G 3.66	---
1.680 ◇ 1.713	1.685	1.695	1.700	.015	BRONZITE (Orthopyroxene ser, Pyroxene grp) $(Mg,Fe)_2Si_2O_6$	69° r > v	Y = a Z = c el pos	ORTH pris c	210 good at 87°	Green, brown	H 5.5 G 3.43 F 5	Nearly insol in acids. Faint pleoc common. FeO 17.1, Fe_2O_3 0.95, MnO 0.4% (En_{73}).
1.675 ◇ 1.708	1.682	1.695	1.697	.015	BUSTAMITE $(Mn,Ca)_3Si_3O_9$	43°	X:a ~ 15° Y:b ~ 35° Z:c ~ 35°	TCL	100 perf 110, 1$\bar{1}$0 good	Pink	H 6 G 3.39	MnO 31.7, CaO 18.2, FeO 0.5, MgO 1.2%.
1.683 ⌃	1.685	1.695	1.698	.013	ARFVEDSONITE (Amphibole grp) $(Na,Ca)_3(Fe^{+2},Mg)_4$ $Fe^{+3}Si_8O_{22}(OH,F)_2$	69°	X:c = 29° el neg	MCL	110 perf at 124°	Dark green	H 5-6 G 3.38	Insol in acids. Pleoc, X and Z dark green, Y brown. FeO 20.6, Fe_2O_3 9.1, MnO 2.3, Na_2O 6.8, K_2O 3.6%.
	1.684	1.695	1.698	.014	KEMPITE $Mn_2Cl(OH)_3$	Med	X = c Y = b	ORTH pris	---	Emerald- green	H 3.5 G 2.94	Diss by HCl.
1.693 ◇ 1.701	1.687	1.695	1.698	.011	FERROAXINITE $Ca_2(Fe,Mn,Mg)Al_2BSi_4$ $O_{15}(OH)$	70°	X ~ ⊥ $\bar{1}$11	TCL	100 good	Brownish- blue	H 6.5 G 3.28 F 2	Insol in acids. CaO 19.4, FeO 7.7, MnO 2.3, MgO 1.7, Fe_2O_3 2.2%.
1.674 ^	1.682	1.696	1.699	.017	KORNERUPINE $Mg_3Al_6(Si,Al,B)_5O_{21}$ (OH)	48° r > v wk	X = c Z = b el neg	ORTH pris	110 good	Greenish- black	H 6.5-7 G 3.45 F 6	Insol in acids. Pleoc, X cols to green, Y yellow, Z dark green.
1.662 ⌃ 1.700	1.694	1.697	1.698	.004	RIEBECKITE (Amphibole grp) $Na_2(Fe^{+2},Mg)_3Fe^{+3}_2Si_8$ $O_{22}(OH)_2$	81°	Y = b X ~ c el neg	MCL pris	110 perf at 124°	Dark blue	H 5 G 2.94	Insol in acids. Pleoc, X and Y dark blue, Z yellow-green. FeO 9.5, Fe_2O_3 18.3, MnO 6.0%.
1.692 □ 1.704	1.669	1.698	1.705	.036	SINHALITE $MgAlBO_4$	56° disp str	---	ORTH	---	Brown to yellow	H 7 G 3.50	Insol in acids. Pleoc, X dark brown, Y green, Z pale brown.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
	1.656	1.699	1.731	.075	KUPLETSKITE $(K,Na)_3(Mn,Fe)_7(Ti,Nb)_2Si_8O_{24}(O,OH)_7$	79° r > v str	el pos	TCL	001 perf	Dark brown	H 3 G 3.22 F easy	Gel with acids. Pleoc, X orange-yellow, Z brown, abs Z > X. MnO 23.6, FeO 5.4, Fe_2O_3 7.8%.
1.646 ^v 1.713	1.639	(1.699)	1.704	.065	SUSSEXITE $(Mn,Mg)BO_2(OH)$	Small r > v	el neg	ORTH fib c	---	Brown	H 3 G 3.12 F 3	Slowly diss by acids. MnO 37.6, ZnO 3.9%.
1.631 ^	1.688	1.699	1.704	.016	FERRO-RICHTERITE (Amphibole grp) $Na_2Ca(Fe^{+2},Mg)_5Si_8O_{22}(OH)_2$	35° (68±15°) r < v	Y = b ext in-clined el pos	MCL	110 perf at 124°	Brown to dark green	H 5-6 G 3.4	Insol in acids. Pleoc. FeO 27.3, Fe_2O_3 6.2, MnO 1.1, CaO 6.1%.
v 1.724	1.660	1.700	1.701	.041	PHOSPHURANYLITE $Ca(UO_2)_3(PO_4)_2(OH)_2 \cdot 6H_2O$	5-20° r > v str	Z = c X = a	ORTH laths	100 perf 010 good	Golden-yellow	H 2.5 G 4.1	Pleoc, X cols to pale yellow, Y and Z golden-yellow. Not fluor in UV.
1.682 ^	1.679	1.700	1.719	.040	GRUNERITE (Cummingtonite ser, Amphibole grp) $(Fe,Mg)_7Si_8O_{22}(OH)_2$	86° r < v	Y = b Z:c = 14° el pos	MCL pris	110 perf at 124°	Greenish-black	H 6 G 3.4	Pleoc, X and Y cols, Z yellow to brown. FeO 45.0, MnO 0.4%.
v 1.713	1.684	1.700	1.703	.019	TARAMITE, var Mboziite (Amphibole grp) $Na_2Ca(Fe^{+2},Mg)_3Al_2(Si_6Al_2)O_{22}(OH)_2$	(46±15°)	Y = b	MCL	110 perf at 124°	Blue-green	---	Pleoc, X light yellow, Y violet gray, Z blue. FeO 13.0, Fe_2O_3 9.6, Al_2O_3 15.8%.
1.684 ^	1.696	1.700	1.702	.006	LITHIOPHILITE (Triphylite grp) $Li(Mn,Fe)PO_4$	~ 70° r < v	X = c Y = a	ORTH	100 perf	Brown, salmon	H 4-5 G 3.55 F 1.5	Diss by acids. MnO 37.3, FeO 8.6, MgO 0.7%.
1.693 ^	1.693	1.701	1.704	.011	TINZENITE (Axinite grp) $(Ca,Mn,Fe)_3Al_2BSi_4O_{15}(OH)$	63° r < v	X ⊥ $\bar{1}$11	TCL	100 good	Yellow	H 6.5-7 G 3.29	Insol in acids. MnO 21.2, CaO 12.5, Fe_2O_3 1.6%.
1.693 ⌐	1.695	1.702	1.708	.013	BARYLITE $BaBe_2Si_2O_7$	70°	X = b Y = c	ORTH	001, 100 good	White	H 7 G 4.07 infus	Insol in acids. Fluor bright blue in UV.

1.680 ^ v 1.720	1.683	1.704	1.722	.039	CHRYSOLITE (Olivine grp) $(Mg,Fe)_2SiO_4$	85°	X = b Z = a	ORTH	010 fair	Green	H 7 G 3.53 infus	Gel with acids. FeO 21.6, MnO 0.3, Fe_2O_3 1.6% (Fo_{75}).
v 1.720	1.680	1.704	1.712	.032	PARNAUITE $Cu_9(AsO_4)_2(OH)_{10}\cdot 7H_2O$	60°	X = b Y = a	ORTH blades on 010	---	Green, blue, blue- green	H 2 G 3.09	Pleoc, X pale green, Y yellow-green, Z blue-green, abs Z > Y > X.
1.685 ^ v 1.735	1.596	1.705	1.705	.109	STILPNOMELANE $K(Fe^{+2},Fe^{+3},Mg,Al)_{10}$ $Si_{12}O_{30}(OH)_{12}$	~ 0°	Y = b X ~ c el clv pos	MCL or TCL	001 perf	Dark brown	H 3-4 G 2.82 F 4	Dec by acids. Pleoc, X yellow, Y and Z dark brown. FeO 13.2, Fe_2O_3 23.9%.
1.685 ^	1.660	1.705	1.713	.053	TARBUTTITE $Zn_2(PO_4)(OH)$	50°	Disp str	TCL pris	001 perf	Cols, yellow	H 4 G 4.12 F easy	Diss by acids.
1.654 ^	1.675	1.705	1.705	.030	KIVUITE $(Th,Ca,Pb)H_2(UO_2)_4$ $(PO_4)_2(OH)_8\cdot 7H_2O$	0-5° r > v	---	ORTH(?)	---	Yellow	---	Dec by HNO_3. Pleoc, X cols, Y and Z greenish-yellow.
	1.690	1.705	1.711	.021	YFTISITE $(Y,Dy,Er)_4(Ti,Sn)O$ $(SiO_4)_2(F,OH)_6$	Large r > v dist	---	ORTH	---	Yellowish	H 3.5-4 G 3.96	Abnormal blue interf color.
	1.678	1.706	1.721	.043	ERNSTITE $(Mn^{+2}{}_{1-x}Fe^{+3}{}_x)Al(PO_4)$ $(OH)_{2-x}O_x$	74° r > v	Z = b Y:c = -4°	MCL radi- ating	010, 100 good	Yellow- brown	H 3-3.5 G 3.07	Oxidation product of Eosphorite. Untw. Pleoc, X yellow-brown, Y red-brown, Z pale yellow.
	1.688	1.707	1.725	.037	LERMONTOVITE $U^{+4}(PO_4)(OH)\cdot H_2O$	(88±6°)	Z = c	ORTH fib	---	Gray- green	---	Opt sign not given.
v 1.723	1.704	1.707	1.710	.006	SAPPHIRINE $(Mg,Al)_8(Si,Al)_6O_{20}$	85° r < v str	Y = b Z:c = 12°	MCL tab	010, 100 poor	Pale blue to green	H 7.5 G 3.50 infus	Insol in acids. Pleoc, X pale greenish-blue, Y blue to dark green, Z blue to yellow-green. FeO 1.5, Fe_2O_3 0.6%.
v 1.707 pos	1.689	1.707	1.727	.038	GAITITE $Ca_2(Zn,Mg)(AsO_4)_2\cdot$ $2H_2O$	85° (92±6°)	---	TCL	010, 001, 0$\bar{1}$1 good	Cols, white	H ~ 5	Zn:Mg = 1:1.
1.695 ^	1.695	1.708	1.710	.015	BUSTAMITE $(Mn,Ca,Fe)_3Si_3O_9$	34° r < v	X:a ~ 15° Y:$\bar{b}$ ~ 35° Z:$\bar{c}$ ~ 35°	TCL	100 perf 110, 1$\bar{1}$0 good	Pink	H 6 G 3.46	MnO 30.4, CaO 12.8, FeO 6.9, MgO 1.2%.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.687 ◇ 1.731	1.688	1.709	1.714	.026	HASTINGSITE (Amphibole grp) $NaCa_2(Fe^{+2},Mg)_4Fe^{+3}Si_6Al_2O_{22}(OH)_2$	51°	Y = b Z:c = 12° el pos	MCL pris	110 perf at 124°	Dark green	H 5-6 G 3.45	Insol in acids. Pleoc, X greenish-yellow, Y dark olive, Z dark green. FeO 22.9, Fe_2O_3 5.9, Al_2O_3 11.5, TiO_2 1.7%.
1.692 ◇ 1.730	1.687	1.710	1.725	.038	KAERSUTITE (Amphibole grp) $NaCa_2(Mg,Fe^{+2})_4TiSi_6Al_2O_{22}(OH)_2$	77°	Y = b Z:c = 4° el pos	MCL pris	110 perf at 124°	Brownish-black	H 6 G 3.3	Insol in acids. Pleoc, X pale yellow-brown, Y red-brown, Z dark red-brown. FeO 4.9, Fe_2O_3 9.3, Al_2O_3 15.5, TiO_2 5.9%.
1.685 ^	1.695	1.710	1.725	.030	TALMESSITE $Ca_2(Mg,Co,Ni)(AsO_4)_2\cdot 2H_2O$	Large	---	TCL	---	Pink, green	H 5 G 3.57	"Arsenate-belovite." Diss in acids. Pink var is pleoc: cols to rose. Up to 8.5% FeO or NiO.
1.681 ^	1.694	1.710	1.722	.028	FERRO-GEDRITE (Amphibole grp) $(Fe^{+2},Mg)_5Al_2(Si_6Al_2)O_{22}(OH)_2$	82° r > v	Y = b Z = c el pos	ORTH pris c	210 perf	Green	H 6 G 3.57 F 4	Insol in acids. Pleoc, X pale green, Y brownish-green, Z bluish-green. Fe_2O_3 2.3, Al_2O_3 19.7, FeO 35.5, MnO 2.3%.
v 1.729	1.705	1.711	1.715	.010	CHLORITOID $(Fe,Mg,Mn)_2Al_4Si_2O_{10}(OH)_4$	60°	X = b Z:c = 12° el clv pos	MCL	001 perf	Greenish-gray	H 6.5 G 3.5 F diff	Dec by H_2SO_4. Pleoc, X green, Y blue, Z yellow. FeO 19.9, Fe_2O_3 4.6%.
1.708 pos ◇ 1.738	1.706	1.711	1.714	.008	ALLANITE (Epidote grp) $(Ce,Ca,Y)_2(Al,Fe)_3(SiO_4)_3(OH)$	61°	Y = b	MCL	001, 100, 110 poor	Brown to black	H 6 G 3.8 F 3	Slowly attacked by HCl, gel. Fe_2O_3 4.9, FeO 9.1, ThO_2 1.7%.
v 1.725	1.670	1.712	1.750	.080	WHITMOREITE $(Fe^{+2},Mn)Fe^{+3}{}_2(PO_4)_2(OH)_2\cdot 4H_2O$	Rather large	Y = b Z ~ c	MCL	100 fair	Brown to greenish-brown	H 3 G 2.88	Tw 100. Pleoc wk, X cols, Y pale yellow, Z yellow-green.
(1.699) ◇ 1.728	1.642	1.713	1.721	.079	SUSSEXITE $(Mn,Mg)BO_2(OH)$	37°	el neg	ORTH fib c	---	Brown	H 5 G 3.05 F 3	Slowly diss by HCl. MnO 40.4%.

1.690 ^	1.654	1.713	1.722	.068	LANGITE $Cu_4SO_4(OH)_6 \cdot 2H_2O$	~ 70° (42±5°)	X = c Y = b	ORTH	001 good 010 dist	Blue to blue-green	H 3 G 3.31	Diss by acids. Poly tw 110. Pleoc wk, abs Y > Z > X.
	1.703	1.713	1.722	.019	GERHARDTITE $Cu_2NO_3(OH)_3$	Large r > v str	X = a Z = c	ORTH horizontal striations	001 perf 100 less so	Emerald-green	H 2 G 3.40 F 2	Diss by acids. Pleoc, X and Y green, Z blue.
1.695 ⇕ 1.728	1.703	1.713	1.717	.014	HYPERSTHENE (Orthopyroxene ser, Pyroxene grp) $(Mg,Fe)_2Si_2O_6$	53°	Y = a Z = c el pos	ORTH	210 good	Green	H 5.5 G 3.53 F 5	Insol in acids. Faint pleoc common. FeO 25.7, Fe_2O_3 1.0% (En_{57}).
1.700 ^	1.705	1.713	1.715	.010	TARAMITE, var Mboziite (Amphibole grp) $Na_2Ca(Fe^{+2},Mg)_3Al_2(Si_6Al_2)O_{22}(OH)_2$	54°	Y = b Z:c = 11° el pos	MCL	110 perf at 124°	Blue-green	---	Pleoc, X yellow, Y blue-green, Z deep blue. FeO 18.7, Fe_2O_3 13.1, Al_2O_3 10.3, MnO 1.9%.
v 1.740	1.690	1.714	1.735	.045	SCHOEPITE $UO_3 \cdot 2H_2O$	85° r > v str	X = c Y = b el pos	ORTH tab	001 perf	Lemon-yellow to brownish	H 2.5 G 4.8-5.0	Diss by acids. Pleoc, X nearly cols, Y and Z lemon-yellow to bright yellow. Fluor pale green in UV.
	1.701	1.714	1.720	.019	NIOCALITE $Ca_4NbSi_2O_{10}(O,F)$	56°	X = b Z:c = 12°	MCL	Conch	Lemon-yellow	H 6 G 3.32	Tw.
	1.663	1.715	1.734	.071	RUIZITE $CaMn^{+3}Si_2O_6(OH) \cdot 2H_2O$	60° r > v str inclined	Y = b Z:c = 44°	MCL el b	---	Orange to brown	H 5 G 2.9	Diss by warm acids. Tw common 100. Pleoc, X pale orange, Y orange, Z yellow.
	1.667	(1.715)	1.737	.070	Unnamed arsenate-sulfate of Cu	Med large	---	ORTH(?)	---	Blue to blue-green	---	Pleoc, X cols, Y and Z pale green to bluish-green.
	1.665	1.715	1.715	.050	KHIBINSKITE $K_2ZrSi_2O_7$	6-16°	Z = b X:c = 34°	MCL mass	6 clv	Cols	H 4.5-5.5 G 3.35	---
	1.704	1.715	1.724	.020	XANTHOXENITE $Ca_4Fe_2(PO_4)_4(OH)_2 \cdot 3H_2O$	Large r < v str	---	Plates	---	Yellow to brown	H 2.5 G 2.97	Pleoc, X cols, Z yellow. Abnormal blue interf colors. Fe_2O_3 21.1, MnO 4.5%.
	1.704	1.715	1.718	.014	VANMEERSSCHEITE $U(UO_2)_3(PO_4)_2(OH)_6 \cdot 4H_2O$	56°	---	ORTH tab	010 good 100 less so	Yellow	G (4.67)	Pleoc in yellow.
	1.603	1.716	1.742	.139	DUNDASITE $PbAl_2(CO_3)_2(OH)_4 \cdot 2H_2O$	Large (48±2°)	X = a Y = b	ORTH aggregates	010 perf	White	H 2 G 3.55 infus	Diss by acids with eff.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien- tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
1.722	1.682	1.716	1.729	.047	GLAUCOCHROITE $CaMnSiO_4$	61° r > v	X = b Z = a	ORTH pris	---	Pale pink to violet	H 6 G 3.41 F 3	Gel with acids. MnO 32.7, FeO 4.2, MgO 2.1%.
1.779	1.695	1.716	1.725	.030	SONOLITE, zincian $(Mn,Zn)_9(SiO_4)_4(OH,F)_2$	Large	---	MCL	---	Dark brown to brownish-black	H 5.5 G 3.8	Gel with acids. Tw common 001.
	1.700	1.716	1.726	.026	WOEHLERITE $NaCa_2(Zr,Nb)Si_2O_8(O,OH,F)$	71-79° r < v dist	Z = b el c̄Tv neg	MCL tab	010 dist	Yellow-brown	H 6 G 3.42 F 3.5	Gel with HCl. Pleoc wk, X and Y cols, Z yellow.
1.748	1.703	1.716	1.721	.018	JULGOLDITE (Pumpellyite grp) $Ca_2(Fe^{+2},Mg)(Fe^{+3},Al)_2(SiO_4)(Si_2O_7)(OH)_2\cdot H_2O$	Med	---	MCL	100, 001 good	Green	H 4.5 G 3.3	Gel with hot HCl. Pleoc, X and Z pale green, Y blue-green. Tw 001.
1.739	1.709	1.716	1.723	.014	THALENITE $Y_3Si_3O_{10}(OH)$ (?)	70° (90±17°) r < v	Y:c small	MCL pris	110 perf	Reddish-black to black	H 6 G 4.16	---
1.710 1.731	1.657	1.717	1.767	.110	ZIPPEITE $K_4(UO_2)_6(SO_4)_3(OH)_{10}\cdot 4H_2O$	Large	Z = c X = b el c̄Tv pos	ORTH plates	010 perf	Yellow to orange	H 2 G 3.66	Diss by acids. Tw common. Pleoc, X cols, Y pale yellow, Z yellow. Fluor bright yellow in UV.
	1.685	1.717	1.720	.035	KOZULITE (Amphibole grp) $(Na,K)_3(Mn,Mg)_4(Fe^{+3},Al)Si_8O_{22}(OH)_2$	35° r > v wk	Y = b X:c = 25° el neg	MCL pris	110 perf	Reddish-black to black	H 5 G 3.30	Pleoc, X yellow-brown, Y red-brown, Z dark brown, abs Z > Y > X. MnO 2.8, Fe_2O_3 2.9%.
1.695 1.734	1.621	1.718	1.745	.124	ANCYLITE $SrCe(CO_3)_2(OH)\cdot H_2O$	70° (53±2°) r < v wk	X = a Z = c	ORTH	---	Yellow, pink, brown	H 4.5 G 4.00 infus	Diss by acids with eff.
	1.709	1.718	1.734	.025	METAHOHMANNITE $Fe_2(SO_4)_2(OH)_2\cdot 3H_2O$	(86±9°)	---	Mass, powdery	---	Orange	---	Diss by HCl. Pleoc, X pale yellow, Y reddish-yellow, Z reddish-brown. Reported as biax pos.

1.705 □ 1.73	1.715	<u>1.719</u>	1.720	.005	VESUVIANITE $Ca_{10}Mg_2Al_4(SiO_4)_5$ $(Si_2O_7)_2(OH)_4$	30-60°	---	TET	110 poor	Yellow, brown, green	H 6.5 G 3.4 F 3	Partly dec by HCl. Anom biax, may show abnormal interf colors in blue or brown.
	1.660	<u>1.720</u>	1.728	.068	HYDROASTROPHYLLITE $(H_3O,K,Ca)(Fe,Mn)_{5-6}$ $Ti_2Si_6(O,OH)_{31}$	40°	---	TCL	2 sets	Dark brown	G 3.15	Pleoc, X bright yellow, Y orange-yellow, Z dull yellow, abs Z > Y > X.
(1.691) ^	1.677	(<u>1.720</u>)	1.721	.044	FERRI-ANNITE (Mica grp) $K(Fe^{+2},Mg)_3(Fe^{+3},Al)$ $Si_3O_{10}(OH)_2$	Small	---	MCL	001 perf	Reddish- brown	---	Pleoc, X brownish-red, Y and Z pale greenish-brown. Tw common.
1.694 ^ 1.734	1.689	<u>1.720</u>	1.728	.039	KIRSCHSTEINITE (Monticellite ser) $Ca(Fe,Mg)SiO_4$	51° r > v	X = <u>b</u> Y = <u>c</u>	ORTH	010 poor	Gray	H 5.5 G 3.43 F 6	Gel with acids. FeO 29.3, Fe_2O_3 0.7, MgO 4.9, MnO 1.65%.
1.704 ◊ 1.733	1.698	<u>1.720</u>	1.736	.038	HYALOSIDERITE (Olivine grp) $(Mg,Fe)_2SiO_4$	80°	X = <u>b</u> Z = <u>a</u>	ORTH	010 fair	Green	H 7 G 3.60 infus	Gel with acids. FeO 27.8, Fe_2O_3 2.1, MnO 0.4% (Fo_{66}).
	1.701	<u>1.720</u>	1.734	.033	HOWIEITE $Na(Fe,Mn)_{10}(Fe^{+3},Al)_2$ $Si_{12}O_{31}(OH)_{13}$	65° (80±7°) r < v str	---	TCL	010 good 100 fair	Dark green	G 3.38	Pleoc, X pale golden yellow, Y dark lilac gray, Z dull green.
1.717 pos ◊ 1.736	1.713	<u>1.720</u>	1.727	.014	EPIDOTE (Epidote grp) $Ca_2(Al,Fe)_3Si_3O_{12}(OH)$	89° r > v str	X ~ c Y = <u>b</u> el c∧v pos	MCL el <u>b</u>	001 perf	Light green	H 7 G 3.40 F 4	Insol in acids. Fe_2O_3 6.6, FeO 0.4%.
1.704 ^	1.667	<u>1.720</u>	1.737	.070	PARNAUITE $Cu_9(AsO_4)_2(SO_4)(OH)_{10}\cdot$ $7H_2O$	60° r < v	X = <u>b</u> Y = <u>a</u>	ORTH blades	---	Green, blue	H 2 G 3.09	Pleoc, X cols, Z greenish-blue.
	1.715	<u>1.720</u>	1.725	.010	TRIMERITE $(Ca,Mn)BeSiO_4$	83°	Opt pl and X ~ ⊥ 001	TCL ps hex tab	001 dist	Cols	H 6 G 3.47 F diff	Gel with HCl. Basal section shows 3 radial segments.
	1.713	<u>1.721</u>	1.734	.021	HARADAITE $SrVSi_2O_7$	75° (103±12°) r < v str	X = <u>a</u> Y = <u>b</u>	ORTH	010 perf 100, 001 dist	Bright green	H 4.5 G 3.80	Pleoc, X cols to pale green, Y cols to light yellow-green, Z bluish-green.
1.717 □ 1.724	1.713	<u>1.721</u>	1.728	.015	KYANITE Al_2SiO_5	83° r > v wk	Z:c = -30° on 100 el pos	TCL bladed	100 perf 010 good	Bluish, greenish, cols	H 5.5-7 G 3.59 infus	Insol in acids. Pleoc wk, X cols, Y and Z pale blue. Tw pl comp face 100.
	1.687	<u>1.722</u>	1.731	.044	TARAPACAITE K_2CrO_4	52° r > v wk	X = <u>b</u> Y = <u>a</u>	ORTH ps hex	010 perf 001 good	Bright yellow	G 2.74	Sol in H_2O.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.691 ^	1.686	1.722	1.723	.037	DUMORTIERITE $Al_7(BO_3)(SiO_4)_3O_3$	13° r > v wk	Z = a X = c	ORTH acic c	100 dist	Brown	H 7 G 3.41 infus	Insol in acids. Tw pl 001. Pleoc, X black, Y deep red-brown, Z brown.
	1.716	(1.723)	1.723	.007	HATRURITE Ca_3SiO_5	Small	---	ps hex	---	Cols	---	Dec by H_2O.
	1.675	1.723	1.765	.090	CLINOCHALCOMENITE $CuSiO_3 \cdot 2H_2O$	78° (84+3°) r < v	Y = b Z:c = 10° el pos	MCL	110 perf	Bluish-green	H 2 G 3.35	Pleoc, X and Y cols, Z bluish-green.
1.690 ◊ 1.746	1.698	1.723	1.745	.047	LAVENITE $(Na,Ca)_3ZrSi_2O_7(O,OH,F)_2$	80° r < v	Y = b X:c = -20°	MCL tab on 100	100 good	Yellow, brown	H 6 G 3.5 fus	Diff diss by acids. Tw pl 100 lam. Pleoc, X cols to pale yellow, Y light yellow, Z golden yellow.
1.707 ◊ 1.741	1.720	1.723	1.725	.005	SAPPHIRINE $(Mg,Al)_8(Si,Al)_6O_{20}$	52° r < v str	Y = b Z:c = 7°	MCL tab	010, 100 poor	Pale blue to green	H 7.5 G 3.58 infus	Insol in acids. Pleoc, X nearly cols, Y and Z blue, abs Z > Y > X.
1.700 ^	1.674	1.724	1.724	.050	PHOSPHURANYLITE $Ca(UO_2)_3(PO_4)_2(OH)_2 \cdot 6H_2O$	5-10° r > v str	X = a Z = c	ORTH laths	100 perf 010 good	Golden-yellow	H 2.5 G 4.1	Diss by acids. Pleoc, X cols to pale yellow, Y and Z golden-yellow. Not fluor in UV.
1.712 ^	1.676	1.725	1.745	.069	WHITMOREITE $(Fe^{+2},Mn)Fe^{+3}_2(PO_4)_2(OH)_2 \cdot 4H_2O$	60-65°	Y = b Z ~ c	MCL	100 fair	Brown to greenish-brown	H 3 G 2.87	Tw 100. Pleoc, X and Y light greenish-brown, Z dark greenish-brown.
1.723 □ 1.728	1.692	1.725	1.738	.046	PHOSPHOSIDERITE $FePO_4 \cdot 2H_2O$	62° r > v str	Y = b X:c = 4°	MCL tab 010	010 good	Reddish-violet	H 3.5-4 G 2.76 F easy	Diss by acids. Tw 101. Pleoc, X pale rose, Y carmine-red, Z cols.
	1.700	1.725	1.730	.030	VUAGNATITE $CaAlSiO_4(OH)$	48° r < v str	X = c Y = b el neg	ORTH	---	White	G 3.22-3.42	---
1.690 ^	1.694	1.726	1.730	.036	TYROLITE $CaCu_5(AsO_4)_2(CO_3)(OH)_4 \cdot 6H_2O$	36° r > v str	X = b Z = a	ORTH laths	001 perf	Pale green to sky-blue	H 2 G 3.27 F easy	Diss by acids or NH_4OH. Pleoc, X and Z grass-green, Y yellow green.
v 1.766	1.711	1.727	1.740	.029	TEPHROITE (Olivine grp) $(Mn,Mg)_2SiO_4$	85° r > v	X = b Y = c	ORTH	001 good 010 fair	Reddish-brown to gray	H 5 G 3.72 F 3.5	Gel with acids. MnO 47.1, MgO 18.1, Fe_2O_3 0.3%.

	1.718	(~1.727)	1.728	.010	BARIUM-PHARMACOSIDERITE $Ba(Fe,Al)_4(AsO_4)_3(OH)_5\cdot 5H_2O$ (?)	0-39°	---	TET (?)	100 good	Yellow-brown	H 2-3 G 3.00	Diss by acids.
	1.681	1.728	1.769	.088	COBALTOMENITE $CoSeO_3\cdot 2H_2O$	83° r < v	Z:c = 13°	MCL	Conch	Pink	H 2.5 G 3.42	Data for synth compd. Pleoc, X and Y pink, Z red.
1.713 ^	1.670	1.728	1.732	.062	SUSSEXITE $MnBO_2(OH)$	30°	el neg	ORTH fib c	---	Brown	H 5 G 3.30 F 3	Calc for pure end members.
	1.670	1.728	1.732	.062	SARCOPSIDE $(Fe^{+2},Mn,Mg)_3(PO_4)_2$	28° r > v	---	MCL	001, 100 good 010 poor	Gray to brown	H 4 G 3.79	Diss by acids. Poly tw 001.
v 1.758	1.705	1.728	1.730	.025	HOLTITE $Al_6(Ta,Sb,Li)[(Si,As)O_4]_3(BO_3)(O,OH)_3$	27° r < v str	X = c Y = b	ORTH pris	100 good	Buff to greenish	H 8.5 G 3.90 infus	Insol in acids. Tw 110. Not pleoc.
1.713 ^ v 1.747	1.715	1.728	1.731	.016	FERROHYPERSTHENE (Orthopyroxene ser, Pyroxene grp) $(Mg,Fe)_2Si_2O_6$	51°	Y = a Z = c el pos	ORTH	210 good	Green	H 5-6 G 3.60 F 5	Insol in acids. Faint pleoc common. FeO 29.4, MnO 0.2, Fe_2O_3 2.1% (En_{45}).
	1.720	1.728	1.735	.015	LANDESITE $Mn^{+2}_3Fe^{+3}(PO_4)_2(OH)_3\cdot 3H_2O$(?)	Large	el pos	ORTH	010 perf	Reddish-brown	H 3-3.5 G 3.03	Diss by acids. Pleoc, X dark brown, Y light brown, Z yellow.
1.725	1.690	1.729	1.750	.060	BERMANITE $Mn^{+2}(Mn^{+3},Fe^{+3})_2(PO_4)_2(OH)_2\cdot 4H_2O$	72° r < v str	X = b Y:c = -36°	MCL ps orth	001 perf 010	Reddish-brown	H 3.5 G 2.85 F easy	Diss by acids. Poly tw. Pleoc, X light red, Y pale yellow, Z deep red. Mn_2O_3 30.6, Fe_2O_3 3.2, MnO 12.8%.
1.711 ^	1.725	1.729	1.730	.005	CHLORITOID $(Fe,Mg,Mn)Al_4Si_2O_{10}(OH)_4$	56°	X = b Z:c = 20° el clv neg	MCL	001 perf	Greenish-gray	H 6.5 G 3.5 F diff	Dec by H_2SO_4. Pleoc, X green, Y blue, Z yellow. FeO 22.2, Fe_2O_3 4.9, TiO_2 2.7%.
	1.605	(1.73)	1.738	.133	Unnamed barium uranyl arsenate	Small	---	ORTH(?) acic	---	Yellow	---	Pleoc, X cols, Z yellow. Not fluor in UV. Am. Mineral., 58, 561 (1973).
	1.602	1.730	1.732	.130	MCGUINNESSITE $(Mg,Cu)_2(CO_3)(OH)_2$	(very small)	X:c = 11°	MCL fib	---	Blue-green to blue	H 2.5 G 3.02-3.22	Diss by cold acids. Pleoc, X pale green, Y and Z light bluish-green.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.710 ^	1.694	1.730	1.757	.063	KAERSUTITE (Amphibole grp) $NaCa_2(Mg,Fe^{+2})_4TiSi_6Al_2O_{22}(OH)_2$	80°	Y = b Z ~ c el pos	MCL pris	110 perf at 124°	Brownish-black	H 6 G 3.3	Insol in acids. Pleoc, X yellow, Y red-brown, Z dark brown. FeO 7.7, Fe_2O_3 12.4, TiO_2 6.0%.
	(1.690)	1.730	1.749	(.059)	PHURCALITE $Ca_2(UO_2)_3(PO_4)_2(OH)_4 \cdot 4H_2O$	68°	el pos	ORTH	001, 010 perf 100	Yellow	H 3 G 4.14	Diss by acids. Pleoc, X bright yellow, Y pale yellow. Not fluor in UV.
1.717 ^	1.674	1.731	1.754	.080	ZIPPEITE $K_4(UO_2)_6(SO_4)_3(OH)_{10} \cdot 4H_2O$	45° r > v str	Z = c X = b el c̅	ORTH plates	010 perf	Yellow to orange	H 2 G 3.61	Diss by acids. Pleoc, X cols, Y and Z yellow. Fluor bright yellow in UV.
1.709 ^	1.705	1.731	1.732	.027	HASTINGSITE (Amphibole grp) $NaCa_2(Fe^{+2},Mg)_4Fe^{+3}Si_6Al_2O_{22}(OH)_2$	25°	Y = b Z:c = 13° el pos	MCL pris	110 perf at 124°	Dark green	H 5-6 G 3.43	Insol in acids. Pleoc. FeO 22.0, Fe_2O_3 11.6, Al_2O_3 11.5, MnO 0.6%.
	1.711	1.731	1.732	.021	CHALCOMENITE $CuSeO_3 \cdot 2H_2O$	Small r < v or r > v str	X = a Y = c	ORTH	None	Clear blue	H 2.5 G 3.36 fus	Diss by acids. Pleoc, X light blue, Y and Z darker blue.
	1.680	1.732	1.775	.095	Unnamed uranyl phosphate	80°	X = a Y = b el c̅Tv neg	ORTH	001 good	Yellow	---	Pleoc, X cols, Y yellow, Z yellow-gold. Fluor green in UV. Am. Mineral., 59, 212 (1974).
1.720 ^v 1.750	1.710	1.733	1.750	.040	HYALOSIDERITE (Olivine grp) $(Mg,Fe)_2SiO_4$	79°	X = b Z = a	ORTH	010 fair	Green	H 5 G 3.69 F 6	Gel with acids. FeO 32.0, Fe_2O_3 2.0, MnO 0.5% (Fo_{60}).
	1.724	1.733	1.739	.015	CHALCOCYANITE $CuSO_4$	Large r > v	X = b Y = a	ORTH tab	None	Pale green to blue	H 3.5 G 3.65	Diss by H_2O.
1.718 ^	1.656	1.734	1.776	.120	ANCYLITE $SrCe(CO_3)_2(OH) \cdot H_2O$	70° r < v wk	X = a Z = c	ORTH	---	Yellow, brown, pink	H 4.5 G 4.0 infus	Diss by acids with eff.
	1.679	1.734	1.742	.063	HUEMULITE $Na_4MgV_{10}O_{28} \cdot 24H_2O$	28° (41±5°) r > v str	---	TCL	001 perf 010 less so	Yellow-orange	H 2.5 G 2.39	Diss by cold H_2O. Not fluor in UV. Pleoc, X light yellow, Y gold, Z yellow-orange.

v 1.768	1.708	<u>1.734</u>	1.758	.050	ADAMITE (Olivenite grp) $Zn_2(AsO_4)(OH)$	87° r > v str	X = <u>a</u> Z = <u>b</u>	ORTH	101 good	Cols, green, pink	H 3.5 G 4.43	Diss by acids. CuO 0.6%.
	1.723	<u>1.734</u>	1.736	.013	GAGEITE $(Mn,Mg,Zn)_8Si_3O_{10}(OH)_8$	Med r < v str	Z = <u>c</u> el pos	ORTH acic <u>c</u>	---	Pink, brown	H 3 G 3.58 infus	Dec by HCl.
1.705 ^ 1.745	1.625	<u>1.735</u>	1.735	.110	STILPNOMELANE $K(Fe^{+2},Fe^{+3},Al)_{10}Si_{12}O_{30}(OH)_{12}$	~ 0°	Y = <u>b</u> X ~ <u>c</u> el pos	MCL or TCL	001 perf	Dark brown	H 3-4 G 2.83 F 3	Dec by acids. Pleoc, X golden yellow, Y and Z deep reddish-brown. FeO 1.3, Fe_2O_3 31.7, MnO 2.6%.
	1.707	<u>1.735</u>	1.738	.031	BERAUNITE $Fe^{+2}Fe^{+3}_5(PO_4)_4(OH)_5 \cdot 4H_2O$	25° r < v	X:<u>c</u> = 4-8°	MCL	100 perf	Green	H 3.5-4 G 2.9-3.1 F easy	Diss by acids. Pleoc, X blue-green, Y pale olive-green, Z olive-green.
v 1.771	1.715	<u>1.735</u>	1.745	.030	SICKLERITE $Li(Mn^{+2},Fe^{+3})PO_4$	Med large r > v very str	X = <u>a</u> el <u>c</u>Tv pos	ORTH	100 good	Yellow-ish- to dark brown	H 4 G 3.3 F easy	Diss by acids. Pleoc, X deep red, Y pale red, Z very pale red. MnO 33.6, Mn_2O_3 2.1, Fe_2O_3 11.3%.
	1.720	<u>1.736</u>	1.738	.018	GITTINSITE $CaZrSi_2O_7$	30°	X:<u>c</u> = 5-10°	MCL fib el <u>c</u>	---	White	H 3.5-4 G 3.6	---
1.728 ⌐	1.640	<u>1.736</u>	1.750	.110	HYDROZINCITE $Zn_5(CO_3)_2(OH)_6$	40° r < v str	X = <u>b</u> Z:<u>c</u> = 40°	MCL laths 100	100 perf	White	H 2.5 G 4.0 infus	Diss by acids with eff. Fluor pale blue in UV.
v 1.750	1.654	<u>1.736</u>	1.764	.110	LOMONOSOVITE $Na_2Ti_2Si_2O_9 \cdot Na_3PO_4$	60°	el pos	TCL	100 perf	Yellow to dark brown	H 3-4 G 3.15	Dec by H_2O. Pleoc, X yellow, Y orange-yellow, Z dark brown.
1.721 ⌐	1.715	<u>1.736</u>	1.739	.024	RENARDITE $Pb(UO_2)_4(PO_4)_2(OH)_4 \cdot 7H_2O$	~ 40° r > v	X = <u>a</u> Y = <u>c</u> el <u>c</u>Tv pos	ORTH pris	100 perf	Yellow	H 3.5 G 4.35 F easy	Pleoc, X cols, Y and Z yellow. Not fluor in UV.
1.720 ◊ 1.754	1.721	<u>1.736</u>	1.740	.019	EPIDOTE (Epidote grp) $Ca_2(Al,Fe)_3Si_3O_{12}(OH)$	78° (54+14°) r > v str	Y = <u>b</u> X ~ <u>c</u> el <u>c</u>Tv pos	MCL el <u>b</u>	001 perf	Green	H 7 G 3.44 F 4	Insol in acids. Fe_2O_3 9.5, FeO 0.8%.
	1.723	<u>1.737</u>	1.756	.043	ROSELITE-BETA $Ca_2Co(AsO_4)_2 \cdot 2H_2O$	80-90° r < v	---	TCL	010 perf	Dark rose-red	H 3.5-4 G 3.71	Pleoc, X pink, Y pale pink, Z cols.
	1.708	<u>1.738</u>	1.747	.039	ZIRCOPHYLLITE $(K,Na,Ca)_3(Mn,Fe)_7(Zr,Nb)_2Si_8O_{27}(OH)_4$	62° r > v str	Y = <u>a</u> X:<u>b</u> = 10° el neg	TCL	001 perf	Dark brown	H 4-5 G 3.34	Pleoc, X and Y dark yellow, Z brown.
1.711 ◊ 1.755	1.721	<u>1.738</u>	1.742	.021	ALLANITE (Epidote grp) $(Ce,Ca,Y)_2(Al,Fe)_3Si_3O_{12}(OH)$	Large (51+13°) r > v str	Y = <u>b</u>	MCL	001, 100, 110 poor	Brown, black	H 6 G 4.0 F 3	Gel with acids. Pleoc. Fe_2O_3 17.0, MnO 0.6, ThO 0.9%.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.716 ^	1.719	1.739	1.748	.029	THALENITE $Y_3Si_3O_{10}(OH)$ (?)	67° r < v	Y ~ c	MCL tab 100	110 perf	Reddish to black	H 6-6.5 G 4.40	---
	1.730	(1.739)	1.748	.018	SUZUKIITE $Ba_2V^{+4}{}_2O_2Si_4O_{12}$	~ 90° r < v str	X = a Y = b	ORTH	010 perf 100, 001 dist	Bright green	H 4-4.5 G 4.03	Pleoc, X pale green, Y yellowish-green, Z bluish-green, abs X < Y < Z.
	1.722	(1.739-1.740)	1.745	.023	STEIGERITE $AlVO_4 \cdot 3H_2O$	55-60°	---	MCL	010 good	Canary yellow	---	Diss by acids.
1.714 ^	1.683	1.740	1.755	.072	SCHOEPITE $UO_3 \cdot 2H_2O$	Med r > v str	X = c Y = b el pos	ORTH tab	001 perf	Yellow	H 2.5 G 4.8-5.0	Diss by acids. Pleoc, X cols, Y yellow, Z lemon-yellow. Fluor pale green in UV.
v 1.751 pos 1.756	1.720	1.740	1.757	.037	ACMITE-AUGITE (Pyroxene grp) $(Na,Ca)(Fe^{+3},Al,Mg,Fe^{+2})Si_2O_6$	82-88° r < v	Y = b X:c = 15° el neg	MCL	110 good at 87°	Dark green	H 6 G 3.40	Insol in acids. Pleoc, X bright green, Y and Z greenish-yellow. FeO 7.5, Fe_2O_3 14.0, Na_2O 5.3%.
	1.726	(1.740)	1.747	.021	STRASHIMIRITE $Cu_8(AsO_4)_4(OH)_4 \cdot 5H_2O$	70°	Z:el = 5°	MCL spherulites	---	Green	G 3.8 calc	Pleoc wk, Y very pale yellow-green, Z yellow-green.
1.723 ^	1.731	1.741	1.743	.012	SAPPHIRINE $(Mg,Al,Fe^{+3})_8(Si,Al)_6O_{20}$	40° r < v str	Y = b Z ~ c	MCL tab	010, 100 poor	Blue	H 7.5 G 3.60 infus	Insol in acids. Pleoc, X pale brown, Y and Z deep blue. FeO 3.0, Fe_2O_3 10.4%.
	1.724	1.742	1.746	.022	HODGKINSONITE $MnZn_2SiO_5 \cdot H_2O$	52° r > v str	Y = b Z:c = 38°	MCL pyram	001 good	Pale reddish-brown	H 5 G 4.01 F easy	Gel with acids. Pleoc, X and Z lavender, Y pale green.
	1.735	1.742	1.745	.010	HAGENDORFITE $(Na,Ca)Mn(Fe^{+2},Fe^{+3},Mg)_2(PO_4)_3$	68°	Z = b Y:c = -22°	MCL	---	Green	H 3.5 G 3.71	Diss by acids. Pleoc, X yellow brown, Y green, Z blue-green.
	1.720	1.743	1.748	.028	SANEROITE $Na_2(Mn^{+2},Mn^{+3})_{10}Si_{11}VO_{34}(OH)_4$	44°	el pos	TCL	2 clv perf	Deep orange	G 3.47	Pleoc, X deep orange, Y lemon-yellow, Z yellow-orange.
	1.738	1.743	1.746	.008	SURINAMITE $(Al,Mg,Fe)_3(Si,Al)_2(O,OH)_8$	68° disp str	Y = b Z:clv = 44°	MCL plates	010 perf	Blue	G > 3.3	---

ˇ 1.770	1.670	1.744	1.782	.112	MURMANITE $Na_2(Ti,Nb)_2Si_2O_9 \cdot xH_2O$	60° (68±2°) r > v	X:a small Z = b el c̄l̄v pos	TCL	100 perf	Pink to yellow-brown	H 2 G 2.8	Pleoc, X light brown, Y brown to pink, Z dark brown, abs Z > Y > X.
⊔ 1.752	1.703	1.744	1.786	.083	AHLFELDITE $NiSeO_3 \cdot 2H_2O$	87°	Z:c = 12°	MCL	Conch	Light green	H 2.5 G 3.51	Data for synth compd. Pleoc, X and Y pale green, Z green.
	---	1.74-1.75	---	---	TINTICITE $Fe_6(PO_4)_4(OH)_6 \cdot 7H_2O$	---	---	ORTH(?) earthy masses	---	Creamy white	H 5 G 2.8	---
	1.707	1.745	1.776	.069	SHCHERBAKOVITE $(K,Na,Ba)_3(Ti,Nb)_2Si_4O_{14}$	82° r < v dist	X = b Y = a el pos	ORTH	110 perf	Brown to dark brown	H 6.5 G 3.21	Pleoc, X pale yellow, Y yellow, Z brownish-yellow.
1.738 ◻ 1.752	1.658	1.746	1.751	.093	AURICHALCITE $(Zn,Cu)_5(CO_3)_2(OH)_6$	Small r < v str	X = a Y = b	ORTH fib c	010 perf	Pale green or blue	H 1-2 G 3.64 infus	Diss by acids or NH_4OH. Pleoc wk, X cols, Y and Z faint blue-green.
	1.703	1.746	1.789	.086	LIBETHENITE $Cu_2PO_4(OH)$	85-90° r > v str	X = b Y = c	ORTH short pris	100, 010 poor	Dark emerald-green	H 4-4.5 G 3.97 F 2.5	Diss by acids. Pleoc, X pale green to yellow, Y bright green to green-yellow, Z yellow to yellow-green.
1.723 ^	1.720	1.746	1.760	.040	LAVENITE $(Na,Ca)_3ZrSi_2O_7(O,OH,F)_2$	73° r < v	Y = b X:c = -20°	MCL tab	100 good	Yellow to brown	H 6 G 3.55 fus	Diss with diff by acids. Pleoc, X pale yellow, Y greenish-yellow, Z orange-yellow. TiO_2 11.3%.
1.728 ◊ 1.762	1.736	1.747	1.752	.016	EULITE (Orthopyroxene ser, Pyroxene grp) $(Fe,Mg)_2Si_2O_6$	63°	Y = a Z = c el pos	ORTH	210 good	Green	H 5-6 G 3.78 F 5	Nearly insol in acids. FeO 39.4, MnO 0.9% (En_{30}).
1.716 ◊ 1.79	1.728	1.748	1.754	.026	JULGOLDITE (Pumpellyite grp) $Ca_2(Fe^{+2},Mg)(Fe^{+3},Al)_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$	30-60°	---	MCL	100, 001 good	Greenish-black	H 4.5 G 3.31	Gel with hot HCl. Tw 001. Pleoc, X pale yellow, Y blue-green, Z yellowish-red.
	1.739	1.749	1.752	.013	PRZHEVALSKITE $Pb(UO_2)_2(PO_4)_2 \cdot 4H_2O$	30° (57±19°)	el neg	ORTH tab	001 good	Bright yellow	---	Pleoc, X cols, Y pale yellow, Z deep yellow.
1.736 ^	1.670	1.750	1.778	.108	LOMONOSOVITE $Na_2Ti_2Si_2O_9 \cdot Na_3PO_4$	~ 60°	el pos	TCL	100 perf	Dark brownish-yellow	H 3-4 G 3.15	Dec by H_2O. Pleoc, X yellow, Y orange-yellow, Z dark brown.
	1.72	1.75	1.82	.10	MAGNESIUM-ZIPPEITE $Mg_2(UO_2)_6(SO_4)_3(OH)_{10} \cdot 16H_2O$	Large	Z = c	ORTH plates	010 perf	Yellow to orange	H 2	Diss by acids. Tw common. Pleoc, X pale yellow, Y yellow, Z dark yellow. Fluor bright yellow in UV.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.733 ↕ 1.770	1.721	1.750	1.765	.044	HYALOSIDERITE (Olivine grp) $(Mg,Fe)_2SiO_4$	85° (70±5°)	X = b Z = a	ORTH	010 fair	Green	H 5 G 3.7 F 5.5	Gel with acids. FeO 36.8, MnO 0.5% (Fo_{52}).
∨ 1.776	1.733	1.750	1.762	.029	PIEMONTITE (Epidote grp) $Ca_2(Al,Mn,Fe)_3Si_3O_{12}(OH)$	78° r > v str	Y = b	MCL el b	001 perf	Reddish-brown	H 6.5 G 3.40 F 3	Pleoc, X yellow, Y pale amethyst, Z deep purplish-red. Fe_2O_3 11.3, Mn_2O_3 1.0%.
1.746 pos ↕ 1.753 pos	1.743	1.751	1.758	.015	STAUROLITE $(Fe,Mg,Zn)_2Al_9(Si,Al)_4O_{22}(OH)_2$	87° r > v wk	Z = c X ~ b el c⊥v pos	MCL ps orth	010 good	Reddish-brown	H 7 G 3.74 infus	Insol in acids. Pleoc, X cols, Y pale yellow, Z golden yellow. FeO 11.2, Fe_2O_3 2.9%. U opt pos.
	1.735	1.753	1.767	.032	SURSASSITE $Mn_5Al_4Si_5O_{21}\cdot 3H_2O$ (?)	65° (82±7°) r < v str	Y = b X:c = 55°	MCL el b	001	Brown to reddish-brown	G 3.26	Pleoc, X and Z cols to pale yellow, Y golden to reddish-brown. May show abnormal interf colors.
1.736 ↕ 1.768	1.729	1.754	1.776	.047	EPIDOTE (Epidote grp) $Ca_2(Al,Fe)_3Si_3O_{12}(OH)$	73° (85±5°) r > v str	Y = b X:c = 8° el clv pos	MCL	001 perf	Green	H 7 G 3.45 F 4	Insol in acids. Pleoc, X pale yellow, Y pale greenish-yellow, Z greenish-yellow. Fe_2O_3 14.0, FeO 1.2%.
	1.743	1.754	1.764	.021	CARACOLITE $Na_3Pb_2(SO_4)_3Cl$	Very large r > v str	---	MCL ps hex	---	Cols	H 4.5 F 2	Insol in H_2O, dec by HCl. Complex tw.
	(1.710)	1.755	1.775	(.065)	SCHUILINGITE $PbCu(Nd,Gd)(CO_3)_3(OH)\cdot 1.5H_2O$	66°	Ext 0-10°	ORTH	‖ el	Tur-quoise-to azure-blue	H 3-4 G 5.2 F diff	Diss by HNO_3 with eff.
	1.731	1.755	1.755	.024	ERICAITE $(Fe,Mn,Mg)_3B_7O_{13}Cl$	Small	---	ORTH ps trig	---	Pale red	G 3.5	Diss by acids.
1.738 ↕ 1.784	1.740	1.755	1.760	.020	ALLANITE (Epidote grp) $(Ce,Ca,Y)_2(Al,Fe)_3Si_3O_{12}(OH)$	Large r > v str	Y = b	MCL	001, 100, 110 poor	Brownish-black	H 6 G 3.90 F 3	Gel with acids. Pleoc. Fe_2O_3 3.2, FeO 10.7, MnO 1.9, TiO_2 1.7, ThO_2 0.9%.

1.740 ◇ 1.767	1.732	1.756	1.770	.038	ACMITE, manganoan, var Blanfordite (Pyroxene grp) $(Na,Ca)(Fe^{+3},Mg,Mn)Si_2O_6$	80° r > v	Y = b X:c = 9° el neg	MCL	110 good at 87°	Pink	H 6 G 3.28	Pleoc, X pink, Y pale blue, Z blue. Fe_2O_3 18.2, Al_2O_3 5.9, MnO 4.7, FeO 1.1%.
v 1.765	1.740	1.756	1.762	.022	UREYITE (Pyroxene grp) $NaCrSi_2O_6$	65°	Y = b X:c = 14°	MCL	110 good	Emerald-green	---	Insol in acids. Pleoc, X and Z dark green, Y yellow-green.
	1.692	1.757	1.800	.108	MUNIRITE $NaV^{+5}O_3 \cdot 2H_2O$	75°	X = c Y = a	ORTH	---	Greenish-white	G 2.43	Sol in H_2O.
1.728 ^	1.745	1.758	1.760	.015	HOLTITE $Al_6(Ta,Sb,Li)[(Si,As)O_4]_3(BO_3)(O,OH)_3$	52° r < v	X = c Y = b	ORTH pris	100 good	Buff, greenish to brown	H 8.5 G 3.90 infus	Insol in acids. Poly tw 110. Pleoc, X yellow, Y and Z cols. Fluor orange to yellow in UV.
	1.705	1.760	1.770	.065	PARASCHOEPITE $UO_3 \cdot 2H_2O$ (?)	46° r > v	X = c Y = b	ORTH	---	Yellow	H 2	Pleoc, X cols, Y and Z yellow.
	1.724	1.760	(1.772)	(.048)	NIOBOPHYLLITE $(K,Na)_3(Fe,Mn)_6(Nb,Ti)_2Si_8(O,OH,F)_{31}$	60°	Y = a X:b = 13°	TCL	001 perf	Brown	G 3.43	Pleoc, X and Y brownish-yellow, Z orange-red.
	1.72	1.76	1.76	.04	META-URANOPILITE $(UO_2)_6(SO_4)(OH)_{10} \cdot 5H_2O$	Small	X = b Y = c	ORTH(?) acic	---	Yellow	---	Fluor yellow-green in UV.
1.747 ◇ 1.763 pos	1.752	1.762	1.772	.020	EULITE (Orthopyroxene ser, Pyroxene grp) $(Fe,Mg)_2Si_2O_6$	87°	Y = a Z = c el pos	ORTH	210 good	Dark brown	H 5-6 G 3.84 F 4	Nearly insol in acids. FeO 44.5, Fe_2O_3 1.9%.
	1.698	1.765	1.799	.101	RICHELSDORFITE $Ca_2Cu_5Sb(AsO_4)_4Cl(OH)_6 \cdot 6H_2O$	69° r > v	Y = a Z = b	MCL	001 very good	Sky-blue to turquoise	G 3.20	Pleoc, X pale blue, Y greenish-blue, Z bright greenish-blue.
1.756 ^	1.742	1.765	1.767	.025	UREYITE (Pyroxene grp) $NaCrSi_2O_6$	34°	Y = b X:c = 22°	MCL	110 good	Emerald-green	---	Pleoc, X yellow, Y emerald-green, Z dark blue-green.
1.727 ◇ 1.802	1.750	1.766	1.779	.029	TEPHROITE (Olivine grp) $(Mn,Mg)_2SiO_4$	67° (83+8°) r > v	X = b Y = c	ORTH	001 good 010 fair	Brown, gray	H 6 G 3.87 F 3.5	Gel with acids. MnO 60.7, MgO 6.6, FeO 0.2%.
	1.705	1.767	1.769	.064	SIMPLOTITE $CaV_4O_9 \cdot 5H_2O$	25° r > v wk	X = b Z:c = -58°	MCL ps tet	010 perf	Dark green	H 1 G 2.64	Diss by acids. Pleoc, X yellow, Y and Z green.
	1.736	1.767	1.796	.060	ARTHURITE $CuFe_2(AsO_4,PO_4,SO_4)_2(O,OH)_2 \cdot 4H_2O$	~ 90°	Y = b Z:c = 10°	MCL	---	Apple green	G 3.2	Pleoc, X cols to pale green, Y gray-green, Z olive-green, abs Z > Y > X.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
1.756 ^v 1.786	1.741	1.767	1.789	.048	ACMITE-AUGITE (Pyroxene grp) $(Na,Ca)(Fe^{+3},Mg)Si_2O_6$	85° r > v	Y = b X:c = 12° el neg	MCL	110 good at 87°	Green	H 6 G 3.56	Insol in acids. Pleoc, X deep green, Y yellow-green, Z brown-green, abs X > Y = Z. Fe_2O_3 19.1, FeO 5.2, MnO 0.5%.
	1.729	1.767	1.772	.043	SHUISKITE (Pumpellyite grp) $Ca_2(Mg,Al)(Cr,Al)(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$	40-50° r < v str	el pos	MCL fib	001 perf	Dark brown	H 6 G 3.24	Pleoc, X violet blue, Y yellow green, Z dark violet. Cr_2O_3 19.3, Fe_2O_3 1.7%.
	1.761	(1.767)	1.772	.011	TADZHIKITE $Ca_3(Ce,Y)_2(Ti,Al,Fe)B_4Si_4O_{22}$	88°	---	MCL	100 good	Grayish-brown	H 6 G 3.73	---
1.754 ^v 1.784	1.740	1.768	1.787	.047	EPIDOTE (Epidote grp) $Ca_2(Al,Fe)_3Si_3O_{12}(OH)$	74° r > v str	Y = b X:c = 13° el clv pos	MCL	001 perf	Green	H 7 G 3.48 F 4	Insol in acids. Pleoc wk. Fe_2O_3 17.9, FeO 0.4, MnO 0.5%.
1.734 ^v 1.810	1.742	1.768	1.773	.031	ADAMITE (Olivenite grp) $(Zn,Cu)_2(AsO_4)(OH)$	47° r > v str	X = a Z = b	ORTH	101 good	Sea-green	H 3.5 G 4.32	Diss by acids. Pleoc, X cols, Y blue-green, Z yellow-green. ZnO 31.9, CuO 23.4, CoO 0.5%.
	1.761	1.768	1.769	.008	CORUNDUM Al_2O_3	17°	X = c	HEX	Parting 0001	Blue, gray, brown	H 9 G 4.02 infus	Anom biax. Tw common $10\bar{1}1$. Pleoc wk in blue.
v 1.831	1.730	(1.769)	1.771	.041	CONICHALCITE $CaCuAsO_4(OH)$	25° r > v very str	Z = el	ORTH	011 fr uneven	Pista-chio- to emerald-green	H 4.5 G 3.96 F 3	Diss by acids. Pleoc wk, X yellow, Y pale green, Z pale blue-green.
	1.760	1.769	1.769	.009	ESPERITE $(Ca,Pb)ZnSiO_4$	5-40°	---	MCL	010, 100 dist	White	H 5 G 4.28	Gel with acids. Fluor bright yellow in short-wave UV.
1.744 ^	1.682	1.770	1.81	.13	MURMANITE $Na_2(Ti,Nb)_2Si_2O_9 \cdot xH_2O$	57-64° r > v	X:a small Z = b el pos	TCL	100 perf	Pink to yellow-brown	H 2 G 2.8	Pleoc, X light brown, Y brown to pink, Z dark brown.

	1.72	1.77	1.81	.09	ZINC-ZIPPEITE $Zn_2(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$	Large	Z = c	ORTH plates	010 perf	Yellow	H 2	Diss by acids. Pleoc, X cols, Y pale yellow, Z yellow. Fluor yellow in UV. Data for synth compd.
	1.720	1.770	1.800	.080	MELONJOSEPHITE $CaFe^{+2}Fe^{+3}(PO_4)_2(OH)$	80-85° disp str	X = c Z = b	ORTH fib	‖ el	Dark green	H < 5 G 3.65	Diss by HCl. Pleoc, X deep brown, Y greenish-brown, Z yellow-gold.
1.750 ◊ 1.786	1.742	1.770	1.786	.044	HORTONOLITE (Olivine grp) $(Fe,Mg)_2SiO_4$	69°	X = b Z = a	ORTH	010 fair	Green	H 5 G 3.9 F 5	Gel with acids (Fo_{43}).
	1.734	1.770	1.773	.039	VINOGRADOVITE $(Na,Ca,K)_4Ti_4AlSi_6O_{23}(OH)\cdot 2H_2O$	41° r > v	Z:c = 7°	MCL	010 perf	Cols	H 4 G 2.88	Gel with acids.
	1.728	1.771	1.800	.072	BROCHANTITE $Cu_4SO_4(OH)_6$	75° r < v med	Y = b X ~ a el c̄Tv pos	MCL pris	100 perf	Emerald-green	H 3.5-4 G 3.97 F 3.5	Diss by acids or NH_4OH. Tw 100 common. Pleoc in blue-greens.
	1.727	1.771	1.798	.071	MARGAROSANITE $Pb(Ca,Mn)_2Si_3O_9$	78° (74+3°) r < v	X':010 = 42°	TCL lam	010 perf 100 good 001 fair	Cols	H 2.5-3 G 4.33	Dec by HNO_3 with sepn of silica. Fluor pink or blue in UV. F 2 in reducing flame.
	1.726	1.771	1.780	.054	PARADAMITE $Zn_2AsO_4(OH)$	50°	---	TCL	010 perf	Pale yellow	G 4.55 F 3	Diss by acids.
	1.751	1.771	1.782	.031	LEUCOPHOENICITE $Mn_7(SiO_4)_3(OH)_2$	74° r > v wk	X ⊥ clv	MCL ps orth	---	Light to deep pink	H 5.5 G 3.85 F 3	Gel with acids. Poly tw on 001.
1.735 ◊ 1.805	1.750	1.771	1.776	.026	FERRISICKLERITE $Li(Fe^{+3},Mn^{+2})PO_4$	52° r > v	X = a el c̄Tv pos	ORTH	100 good 010	Dark brown	H 4.5 G 3.30 F easy	Diss by acids.
⌴ 1.779	1.755	1.772	1.774	.019	ALLACTITE $Mn_7(AsO_4)_2(OH)_8$	Small r > v str	Y = b X:c = 51°	MCL pris	001 dist	Purplish-red	H 6.5 G 3.83 F diff	Diss by HCl. Pleoc, X blood red, Y pale yellow, Z sea-green.
	1.772	1.775	1.777	.005	BRITHOLITE $(Ce,Ca)_5(SiO_4,PO_4)_3(OH,F)$	0-44°	X = c Y = a	HEX pris	---	Brown	H 5-5.5 G 4.0-4.5	Apatite-type structure.
	1.679	1.776	1.807	.128	SAHAMALITE $(Mg,Fe)Ce_2(CO_3)_4$	57° r < v	Y = b Z:c = 29°	MCL tab	010 poor	Cols	G 4.30 infus	Diss by concd HCl with eff.
1.750 ◊ 1.803	1.746	1.776	1.793	.047	PIEMONTITE (Epidote grp) $Ca_2(Al,Mn,Fe)_3Si_3O_{12}(OH)$	87° (73+5°) r > v str	Y = b	MCL el b	001 perf	Purplish-red	H 4.5 G 3.44 F 3	Pleoc, X yellow, Y pink, Z deep pink. Fe_2O_3 11.9, Mn_2O_3 6.8%.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
	1.745	1.777	1.84	.095	NICKEL-ZIPPEITE $Ni_2(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$	Large	Z = c	ORTH plates	010 perf	Yellow to orange	H 2	Diss by acids. Pleoc, X cols, Y pale yellow, Z yellow. Fluor yellow in UV. Data for synth compd.
	1.740	1.777	1.780	.040	BELYANKINITE $Ca(Ti,Zr,Nb)_5O_{12}\cdot 9H_2O$ (?)	23°	Y = b X = c	ORTH	One perf	Cols to brown	H 2.3 G 2.36 infus	Dec by warm acids. Pleoc, X dark brown, Y and Z light brown.
	1.756	1.777	1.794	.038	ORIENTITE $Ca_2Mn^{+2}Mn^{+3}{}_2Si_3O_{10}(OH)_4$	80° r < v str	X = b Y = c	ORTH	001, 120 imperf	Deep brown	G 3.05	Dec by HCl. Pleoc, X red-brown, Y yellow, Z yellow-brown.
	1.763	1.777	1.785	.022	YOSHIMURAITE $(Ba,Sr)_2TiMn_2(SiO_4)_2(PO_4,SO_4)(OH,Cl)$	90-95° (74±11°) r < v	---	TCL	010 perf 101, $10\bar{1}$ dist	Brown	H 4.5 G 4.13	Poly tw on 010. Pleoc, X bright yellow, Y orange-brown, Z brown, abs Z > Y > X. Reported as biax pos.
	1.747	1.779	1.84	.09	COBALT-ZIPPEITE $Co_2(UO_2)_6(SO_4)_3(OH)_{10}\cdot 16H_2O$	Large	Z = c	ORTH plates	010 perf	Yellow, orange	H 2	Diss by acids. Pleoc, X cols, Y pale yellow, Z yellow. Fluor yellow in UV. Data for synth compd.
1.716 ^	1.763	1.779	1.793	.030	SONOLITE $Mn_9(SiO_4)_4(OH,F)_2$	78° r > v	X:c = 9°	MCL pris	---	Reddish-brown	H 5.5 G 3.82	Gel with acids. Tw on 001 common.
	1.67	1.78	1.78	.11	NULLAGINITE $Ni_2(OH)_2CO_3$	Small	X:c = 6°	MCL fib	---	Bright green	G 3.56 infus	---
v 1.832	1.725	1.780	1.790	.065	BILLIETITE $BaU_6O_{19}\cdot 11H_2O$	35° (45±5°) r > v str	X = c Y = a el cTv pos	ORTH ps hex	001 perf	Golden-yellow	G 5.32	Tw on 111 and 110 common. Pleoc, X pale yellow, Y and Z deep golden-yellow.
1.680 ^	1.756	1.780	1.792	.036	ALLEGHANYITE $Mn_5(SiO_4)_2(OH)_2$	72° r > v	Z = b Ext:tw pl = 22°	MCL	Conch	Pink to reddish-brown	H 5.5 G 4.02 F 2.5	Gel with acids. Poly tw on 001 common.
	1.767	1.782	1.791	.024	TEINEITE $CuTeO_3\cdot 2H_2O$	36° (75±10°)	X = a Y = b	ORTH	010 good 001, 100 poor	Blue	H 2.5 G 3.80 F 2	Pleoc, X greenish-blue, Y blue, Z indigo blue, abs Z > Y > X.

	1.720	1.783	1.842	.122	ROSSITE $CaV_2O_6 \cdot 4H_2O$	85°	Z ~ c Y:b ~ 45°	TCL pris	010 good	Yellow	H 2.5 G 2.45 F easy	Slowly diss by H_2O. Tw 100. Data for synth compd.
1.768 ^	1.751	1.784	1.797	.046	EPIDOTE (Epidote grp) $Ca_2(Al,Fe)_3Si_3O_{12}(OH)$	64° r > v str	Y = b X ~ c el cTv pos	MCL	001 perf	Green	H 7 G 3.48 F 4	Insol in acids. Fe_2O_3 17.2, FeO 0.5%.
	1.765	1.784	1.799	.034	MALAYAITE $CaSnSiO_5$	85°	---	MCL	---	Pale yellow	H 4 G 4.55	Fluor yellow-green in short-wave UV.
1.755 ◊ 1.815	1.769	1.784	1.791	.022	ALLANITE (Epidote grp) $(Ce,Ca,Y)_2(Al,Fe)_3Si_3O_{12}(OH)$	60° r > v str	Y = b	MCL	001, 100, 110 poor	Brownish-black	H 6 G 3.87 F 3	Slowly attacked by HCl, gel. Pleoc, X cols to red-brown, Y yellow-brown to pale green, Z green-brown to dark red-brown.
	1.77	1.785	1.815	.045	BARBOSALITE $Fe^{+2}Fe^{+3}{}_2(PO_4)_2(OH)_2$	64° r > v str	---	MCL ps tet tab	100	Dark blue-green	H 2 G 3.65	Slowly diss by hot HCl. Pleoc, X and Y dark blue-green, Z dark olive-green.
	1.755	1.785	1.785	.030	THEISITE $Cu_2Zn_5(As,Sb)_2O_8(OH)_{14}$	~ 0°	---	ORTH ps hex	001	Pale blue-green	H 1.5 G 4.3	Not pleoc.
1.767 ◊ 1.812	1.751	1.786	1.800	.049	ACMITE (Pyroxene grp) $(Na,Ca)(Fe^{+3},Mg,Fe^{+2})Si_2O_6$	69° r > v	Y = b X:c = 1° el neg	MCL	110 good at 87°	Green	H 6 G 3.55	Pleoc, X and Y deep green, Z yellow-brown. Fe_2O_3 25.4, FeO 3.7%.
1.770 ◊ 1.790	1.758	1.786	1.804	.046	HORTONOLITE, manganoan, zincian (Olivine grp) $(Fe,Mn,Mg,Zn)_2SiO_4$	77° r > v	X = b Z = a	ORTH	010 fair	Reddish-brown	H 6 G 4.1 F 3.5	Gel with acids. Pleoc wk. FeO 35.5, MnO 16.9, ZnO 10.7, MgO 5.6%.
	1.779	1.786	1.790	.011	KOLICITE $Mn_7Zn_4(AsO_4)_2(SiO_4)_2(OH)_8$	78° r < v str	Y = c Z = a	ORTH	---	Yellow-orange	H 4.5 G 4.17	Pleoc, X cols to pale yellow, Y yellow-orange, Z light yellow, abs Y = Z > X.
	1.749	1.790	1.821	.072	REINERITE $Zn_3(AsO_3)_2$	(80±3°)	---	ORTH	110 good 011, 111	Blue to greenish-yellow	H 5-5.5 G 4.27	Diss by cold HCl.
	1.70	1.79	1.793	.09	EPI-IANTHINITE $UO_3 \cdot xH_2O$ (?)	Small	X = c Y = b	ORTH	---	Yellow	---	Pleoc, X pale yellow, Y yellow, Z deep yellow. Stated to be Schoepite, optics are different.
1.748 ◊ 1.814	1.776	1.79	1.820	.044	JULGOLDITE (Pumpellyite grp) $Ca_2(Fe,Mg)(Fe,Al)_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$	80°	---	MCL	100, 001 good	Greenish-black	H 4.5 G 3.4	Gel with hot HCl. Pleoc, X and Y pale greenish-yellow, Z olive-green. Tw 001.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.786 ◊ 1.818	1.761	1.790	1.806	.045	HORTONOLITE (Olivine grp) $(Fe,Mg)_2SiO_4$	65° (72±5°) r > v	X = b Z = a el c̄Tv pos	ORTH	010 fair	Green to brown	H 5 G 3.90 F 5	Gel with acids (Fo_{33}).
v 1.835	1.772	1.790	1.796	.024	PSEUDOMALACHITE $Cu_5(PO_4)_2(OH)_4 \cdot H_2O$	50°	X:c = 21°	MCL pris	010 good	Dark green	H 4.5-5 G 4.35 F 2	Diss by acids. Tw 100. Pleoc wk.
	1.765	1.792	(1.82)	(.055)	VANDENBRANDEITE $Cu(UO_2)(OH)_4$	~ 90°	---	TCL tab	110 perf 2 others	Dark green	H 4 G 5.0	Diss by acids. Not fluor in UV.
1.784 □ 1.798	1.756	1.793	1.809	.053	THORTVEITITE $(Sc,Y)_2Si_2O_7$	50-70° r > v dist	Y = b	MCL pris	110 good	Gray-green	H 6.5 G 3.58 F diff	Insol in acids. Poly tw.
	1.752	1.795	1.800	.048	PUMPELLYITE-(MN) (Pumpellyite grp) $Ca_2(Mn^{+2},Mg)(Al,Mn^{+3})_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$	(37±8°)	---	MCL	001 perf	Pink to brownish-pink	H ~ 5 G 3.34	Mn_2O_3 77, Fe_2O_3 24, MnO 13.4%. Pleoc, X pale pink, Y and Z brownish-pink.
	1.773	1.795	1.815	.042	MACFALLITE $Ca_2(Mn^{+3},Al)_3(SiO_4)(Si_2O_7)(OH)_3$	(86±6°)	Z = b	MCL	001 perf	Red-brown, maroon	H > 5 G 3.43	Tw 100. Pleoc, X yellow, Y light brown, Z dark brown.
	1.780	1.795	1.805	.025	JAROSEWICHITE $Mn^{+2}{}_3Mn^{+3}(AsO_4)(OH)_6$	(78±9°)	X = a Y = b	ORTH pris	---	Bright red	G 3.66	Streak reddish-orange. Pleoc, X med brownish-red, Z dark brownish-red.
	1.758	1.796	1.810	.052	TLALOCITE $(Cu,Zn)_{16}(TeO_3)(TeO_4)_2Cl(OH)_{25} \cdot 27H_2O$	64°	---	MCL (?) spherulitic	---	Blue	H 1 sectile	Diss by HNO_3. Pleoc, X yellow-green, Y and Z blue-green, abs Z > Y > X.
	1.773	1.797	1.814	.041	BRUEGGENITE $Ca(IO_3)_2 \cdot 2H_2O$	88° (79±6°) r > v mod to str	Z = b X:a = 9° el neg	MCL	Conch	Cols to bright yellow	H 3.5 G 4.24	Slightly sol in H_2O.
	1.720	1.798	1.805	.085	GUILLEMINITE $Ba(UO_2)_3(SeO_3)_2(OH)_4 \cdot 3H_2O$	35° r > v str	X = c Y = b el c̄Tv neg	ORTH	100 perf 010 good	Canary-yellow	G 4.88	Pleoc str, X bright yellow, Y yellow, Z cols.

	1.775	1.798	1.800	.025	BOSTWICKITE $CaMn^{+3}_6Si_3O_{16}\cdot 7H_2O$	25°	r < v str	---	---	Dark red	H 1 G 2.93	Diss by HCl. Pleoc, X and Y red-brown, Z yellow-brown, abs X = Y > Z.
	<1.79	1.798	1.802	>.01	COMPREIGNACITE $K_2U_6O_{19}\cdot 11H_2O$	10-15°	X = c Y = a el clv pos	ORTH	001 perf	Yellow	G 5.03	Diss by acids. Tw 110 common. Pleoc, X cols, Y and Z yellow.
	---	1.80	---	Large	CRONSTEDTITE $(Fe^{+2},Mg)_2Fe^{+3}(SiFe^{+3})O_5(OH)_4$	~ 0°	---	MCL ps hex	001 perf	Blackish-brown	H 3.5 G 3.34 F 4	Gel with acids. Pleoc, X brown, Y and Z black.
	1.74	1.80	1.85	.11	SABINAITE $Na_9Zr_4Ti_2O_9(CO_3)_8$	85°	X ~ ⊥ plates el pos	MCL ps hex plates	001 perf	White	G 3.31	Insol cold acids, dec by hot acids.
	1.780	---	1.810	.030	Unnamed manganese silicate $(Mn,Fe^{+2})_3Si_2O_7$	60°	---	---	2 clv dist	Rose-red	---	Am. Mineral., 43, 793 (1958).
	1.787	1.800	1.805	.018	KIDWELLITE $NaFe^{+3}_9(PO_4)_6(OH)_{10}\cdot 5H_2O$	Large	Y = b	MCL acic	100 perf	Pale green to yellow	H 3 G > 3.3	---
	1.715	1.801	1.87	.155	MANDARINOITE $Fe^{+3}_2Se_3O_9\cdot 4H_2O$	85°	X = b Z:c = 2° el pos	MCL pris c	---	Light green	H 2.5 G 2.93	Tw 100. Pleoc, X cols, Y and Z pale green.
1.766 ^	1.782	1.802	1.812	.030	TEPHROITE (Olivine grp) Mn_2SiO_4	65° r > v	X = b Z = a	ORTH	010, 001 good	Reddish-brown	H 6 G 4.03	Gel with acids. Pleoc, X brown, Y and Z black.
1.776 ^ 1.810	1.768	1.803	1.843	.075	PIEMONTITE (Epidote grp) $Ca_2(Al,Mn,Fe)_3Si_3O_{12}(OH)$	68° (92±3°) r > v str	Y = b	MCL	001 perf	Purplish-red	H 6.5 G 3.52 F 3	Pleoc, X yellow, Y pink, Z deep pink. Fe_2O_3 11.0, Mn_2O_3 12.0, MnO 0.6%.
	1.775	1.803	1.812	.037	GINIITE $Fe^{+2}Fe^{+3}_4(PO_4)_4(OH)_2\cdot 2H_2O$	55°	X = c Y = b	ORTH	Conch	Blackish-green to blackish-brown	H 3-4 G 3.41	Pleoc, X light brown, Y dark brown, Z dark blue-green.
	1.793	1.803	1.808	.015	PERLOFFITE $Ba(Mn,Fe^{+2})_2Fe^{+3}_2(PO_4)_3(OH)_3$	70-80° r < v str	X = b Y:c = 42°	MCL spear-shaped	100 perf	Dark brown, greenish-brown	H 5 G 4.00	Diss by acids. Pleoc, X and Z greenish-brown, Y light greenish-brown.
v 1.835	(1.563)	1.805	1.851	(.288)	TYUYAMUNITE $Ca(UO_2)_2(VO_4)_2\cdot 5\text{-}8H_2O$	42°	X = c Y = a	ORTH	001 perf 010, 100 good	Canary-yellow	H 2 G 3.6 F easy	Pleoc wk, X cols, Y and Z greenish-yellow. Not fluor in UV.
v 1.825	1.730	1.805	1.820	.090	BECQUERELITE $CaU_6O_{19}\cdot 11H_2O$	30° (47±3°) r > v	X = c Y = b el clv pos	ORTH ps hex	001 perf	Golden- to lemon-yellow	H 2.5 G 5.3	Pleoc, X cols to pale yellow, Y and Z deep yellow.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.771 ^	1.790	1.805	1.820	.025	FERRISICKLERITE $Li(Fe^{+3},Mn^{+2})PO_4$	Very large	X = c Y = a	ORTH	010 perf 100 good	Dark brown	H 4.5 G 3.41 F easy	Diss by acids. Pleoc wk, X orange-yellow, Z gold-yellow.
	---	1.80-1.81	---	---	MUSKOXITE $Mg_7Fe^{+3}{}_4O_{13}\cdot 10H_2O$	10-40°	el pos	TRIG platy 0001	0001 perf	Dark reddish-brown	H 3 G 3.15	Not pleoc.
1.793 ⌐	1.793	1.807	1.809	.016	SARKINITE $Mn_2(AsO_4)(OH)$	83° (41±18°)	Y = b X:c = -54°	MCL tab	100 good	Flesh-red to yellow	H 3 G 3.15	---
1.768 ^	1.772	1.810	1.863	.091	OLIVENITE $Cu_2(AsO_4)(OH)$	76° (97±3°) r > v str	X = a Z = b	ORTH	101 fr conch	Olive-green	H 3 G 4.4 F easy	Diss by acids or NH_4OH. Pleoc, X pale green, Y bright green, Z pale green.
	1.74	1.81	1.81	.07	GERASIMOVSKITE $(Mn,Ca)(Nb,Ti)_5O_{12}\cdot 9H_2O$ (?)	18°	el pos	MCL (?) platy	One clv	Brown, gray	H 2 G 2.55	---
v 1.850	1.785	1.810	1.820	.035	VANDENDRIESSCHEITE $PbU_7O_{22}\cdot 12H_2O$	Med r > v str	X = c Z = a el clv pos	ORTH tab	001 perf	Orange to yellow-brown	H 3 G 4.5-5.5	Pleoc, X cols, Y and Z yellow. Not fluor in UV.
	1.787	1.810	1.816	.029	ARSENOCLASITE $Mn_5(AsO_4)_2(OH)_4$	53°	X = b Z = c el clv pos	ORTH u mass	010 perf	Red	H 5.5 G 4.16	---
v ~1.86	1.795	---	1.815	.020	PARSONSITE $Pb_2(UO_2)(PO_4)_2\cdot 2H_2O$	---	Y = b Z:c = 11-26°	TCL	010 poor fr conch	Pale lemon-yellow	H 2.5-3 G 5.73	Not fluor in UV. Opt char unk.
1.786 ^	1.770	1.812	1.830	.060	ACMITE (Pyroxene grp) $(Na,Ca)(Fe^{+3},Mg)Si_2O_6$	58° (65±4°) r > v	Y = b X:c = 6° el neg	MCL	110 good at 87°	Green	H 6 G 3.56	Insol in HCl. Pleoc, X pale yellow-green, Y yellow-green, Z emerald-green. Fe_2O_3 31.4, Al_2O_3 1.9, FeO 0.8%.
v 1.835	(1.786)	1.813	1.852	(.066)	BAFERTISITE $Ba(Fe,Mn)_2TiSi_2O_7(O,OH)_2$	80°	Y = b Z:c = 6° el clv neg	MCL	001 perf	Orange to red	H 5 G 3.97-4.25	Pleoc, X yellowish-red, Z pale yellow. FeO 10.8, MnO 12.8, Fe_2O_3 3.7%.

1.79 ^	1.776	1.814	1.836	.060	JULGOLDITE (Pumpellyite grp) $Ca_2(Fe,Mg)(Fe,Al)_2(SiO_4)(Si_2O_7)(OH)_2 \cdot H_2O$	50-70°	---	MCL	100, 001 good	Greenish-black	H 4.5 G 3.60	Gel with hot HCl. Tw 001. Pleoc, X pale brown, Y pale brownish-green, Z deep emerald-green. Fe_2O_3 29.6, FeO 8.7%.
	1.775	1.815	1.825	.050	PASCOITE $Ca_3V_{10}O_{28} \cdot 17H_2O$	50° r > v very str	X = b	MCL	010 poor	Dark red-orange	H 2.5 G 2.46 F easy	Diss in H_2O. Pleoc, X light yellow, Y yellow, Z orange.
1.784 ^v 1.857	1.791	1.815	1.822	.031	ALLANITE (Epidote grp) $(Ce,Ca,Y)_2(Al,Fe)_3Si_3O_{12}(OH)$	40° (56±8°) r > v str	Y = b X:c = 20°	MCL	001, 100, 110 poor	Brownish-black	H 6 G 3.95 F 3	Gel with HCl. Pleoc, X cols to red-brown, Y yellow-brown to pale green, Z green-brown to dark red-brown. Fe_2O_3 10.3, FeO 7.3, MnO 6.7, TiO_2 2.0, ThO_2 1.0%.
	1.715	1.817	1.820	.105	JAROSITE (Alunite grp) $KFe_3(SO_4)_2(OH)_6$	Small	---	TRIG	0001 good	Amber yellow	H 3 G 3.2	Diss by HCl. Pleoc, X pale yellow, Y and Z brownish-yellow.
1.790 ^v 1.828	1.777	1.818	1.828	.051	FERROHORTONOLITE, manganoan (Olivine grp) $(Fe,Mn)_2SiO_4$	52° r > v	X = b Z = a	ORTH	010 fair	Reddish-brown	H 6 G 4.21 F 3.5	Gel with acids. FeO 41.5, MnO 21.4, MgO 4.5, Fe_2O_3 0.7%.
v 1.85	1.770	(1.82)	1.820	.050	MITRIDATITE $Ca_3Fe^{+3}{}_4(PO_4)_4(OH)_6 \cdot 3H_2O$	Small	X ~ ⊥ 100	MCL	---	Brownish-green	G 3.24	Pleoc, X pale greenish-yellow, Y and Z deep greenish-brown.
v 1.889	1.730	1.820	1.93	.20	IRIGINITE $(UO_2)Mo_2O_7 \cdot 3H_2O$	Large	Y = b Z = c	MCL	---	Canary yellow	H 4-5 G 3.94	Diss by warm HCl. Not fluor in UV.
	1.715	1.820	1.880	.165	DOLEROPHANITE $Cu_2(SO_4)O$	105° (?) (70±2°) r > v very str, crossed	Y = b Z:c = -10°	MCL	$\bar{1}$01 perf	Chestnut-to dark brown	H 3 G 4.17 fus	Diss by acids. Pleoc, X deep brown, Y brownish-yellow, Z lemon-yellow. Reported as opt pos.
	1.762	1.820	1.825	.063	CORNETITE $Cu_3(PO_4)(OH)_3$	35° r < v str	X = a Z = b	ORTH	---	Light to dark blue	H 5 G 4.10	Diss by acids. Not pleoc.
	1.770	1.821	1.860	.090	CALCURMOLITE $Ca(UO_2)_3(MoO_4)_3(OH)_2 \cdot 11H_2O$	(80±3°)	---	ORTH pris	---	Honey-yellow	---	Pleoc, X cols, Y pale yellow, Z yellow. Fluor bright yellow-green in UV.
	1.753	1.824	1.830	.077	IIMORIITE $Y_2(SiO_4)(CO_3)$	31°	---	TCL	011 good	Gray to tan	H 5.5-6 G 4.47	---
1.805 ^	1.730	1.825	1.830	.100	BECQUERELITE $CaU_6O_{19} \cdot 11H_2O$	30° r > v	X = c Y = b el cTv pos	ORTH ps hex	001 perf	Golden-to lemon-yellow	H 2.5 G 5.1	Pleoc, X cols to pale yellow, Y and Z deep yellow.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.81 ⊓	1.788	1.825	1.830	.042	HANCOCKITE (Epidote grp) $(Pb,Ca,Sr)_2(Al,Fe)_3Si_3O_{12}(OH)$	38° r > v	Y = $\underline{b}$	MCL	001	Brownish-red	H 6.5 G 4.03 F 3	Abs Z > X.
1.818 ≎ 1.843	1.788	1.828	1.840	.052	FERROHORTONOLITE (Olivine grp) $(Fe,Mg)_2SiO_4$	58° r > v	X = $\underline{b}$ Z = $\underline{a}$	ORTH	010 fair	Reddish-brown	H 6 G 4.15 F 3.5	Gel with acids. FeO 58.6, MnO 0.85% (Fo_{17}).
	1.672	1.83	1.83	.16	ROSASITE $(Cu,Zn)_2(CO_3)(OH)_2$	Small r < v str	X = el	MCL	---	Bluish-green	G 4.09 fus	Diss by acids with eff. Pleoc, X cols, Y and Z blue.
⊔ 1.85	1.69	1.83	1.83	.14	GLAUKOSPHAERITE $(Cu,Ni)_2(CO_3)(OH)_2$	Small	X:$\underline{c}$ = 7°	MCL fib spherulitic	001 good	Green	H 3-4 G 3.78-3.96	Diss by acids with eff. Pleoc, X deep green, Y and Z apple-green.
	1.66	1.831	1.915	.255	UMOHOITE $(UO_2)MoO_4 \cdot 4H_2O$	65° r > v str	Y = $\underline{b}$ X ~ $\underline{a}$	MCL tab	---	Blue-black	H 2 G 4.6	Pleoc, X dark blue, Y light blue, Z olive-green.
(1.769) ^	1.800	1.831	1.846	.046	CONICHALCITE $CaCuAsO_4(OH)$	Large r > v str	X = $\underline{a}$ Y = $\underline{b}$	ORTH pris	011 fr uneven	Dark- to yellow-green	H 4-5 G 4.33 F 3	Diss by acids. Pleoc, X green, Y yellow-green, Z bluish-green.
1.780 ^	1.733	1.832	1.839	.106	BILLIETITE $BaU_6O_{19} \cdot 11H_2O$	35° (28±4°) r > v str	X = $\underline{c}$ Y = $\underline{a}$ el cTv pos	ORTH ps hex	001 perf	Golden-yellow	G 5.32	Tw common on 111 and 110. Pleoc, X and Z pale green, Y bright green.
1.815 ⊓	1.750	1.832	1.832	.082	NATROJAROSITE (Alunite grp) $NaFe_3(SO_4)_2(OH)_6$	Very small	X = $\underline{c}$ Y = $\underline{a}$ el cTv pos	TRIG ps orth	0001 perf	Yellow-brown	H 3 G 3.2 F 3	Diss by HCl. Pleoc, X nearly cols, Y and Z pale yellow.
	---	1.833	---	wk	RUSAKOVITE $(Fe,Al)_5(VO_4,PO_4)_2(OH)_9 \cdot 3H_2O$	---	---	Cryptocryst	---	Yellow-orange	H 1.5-2 G 2.76	Diss by acids. Opt char unk.
	1.783	1.834	1.866	.083	DELRIOITE $SrCaV_2O_6(OH)_2 \cdot 3H_2O$	Med to large	---	MCL acic	---	Yellow-green	H 2 G 3.1	Diss by H_2O. Tw common 100. Pleoc, X cols, Y pale yellow, Z deeper yellow.

1.805 ^	(1.664)	1.835	1.865	(.201)	TYUYAMUNITE $Ca(UO_2)_2(VO_4)_2 \cdot 5\text{-}8H_2O$	45° r < v wk	X = c Y = a	ORTH	001 perf 010, 100 good	Canary- to greenish-yellow	H 2 G 3.85 F easy	Pleoc wk, X cols, Y and Z greenish-yellow. Not fluor in UV.
1.813 ^	1.805	1.835	1.862	.057	BAFERTISITE $Ba(Fe,Mn)_2TiSi_2O_7(O,OH)_2$	86°	Y = b Z:c = 6° el clv neg	MCL	001 perf	Orange to red	H 5 G 3.97-4.25	Poly tw 001. Pleoc, X reddish-brown, Y yellow, Z greenish-yellow.
1.790 ◊ 1.86	1.789	1.835	1.845	.056	PSEUDOMALACHITE $Cu_5(PO_4)_2(OH)_4 \cdot H_2O$	50° r < v str	X:c = 21°	MCL pris	010 good	Dark green	H 4.5-5 G 4.35 F 2	Diss by acids. Tw 100. Pleoc wk.
	1.809	1.838	1.859	.050	LINARITE $PbCu(SO_4)(OH)_2$	80° r < v str	Z = b X:c = -24°	MCL el 010	100 perf	Deep azure-blue	H 2.5 G 5.35 F easy	Diss by HNO_3. Tw common 100, less so 001. Pleoc, X pale blue, Y clear blue, Z Prussian blue.
	1.81	---	1.84	.03	DEERITE $(Fe^{+2},Mn)_6(Fe^{+3},Al)_3Si_6O_{20}(OH)_5$	---	Z = c el pos	MCL or ORTH acic	110 good	Black	G 3.84	Opt char unk.
	1.80	---	1.87	.07	KEYITE $(Cu,Zn,Cd)_3(AsO_4)_2$	Disp str	X:c = 10° Y = b	MCL	001 good	Deep sky-blue	---	Diss by conc acids. Pleoc, X pale blue, Y greenish blue, Z deep blue. Opt char unk.
	1.760	1.840	1.870	.110	CALCIOURANOITE $(Ca,Ba,Pb)U_2O_7 \cdot 5H_2O$	(61±2°)	X = c el neg	ORTH(?)	---	Brown to orange	H 4 G 4.02-4.28	Pleoc, X and Y lemon-yellow, Z cols.
	1.775	1.840	1.844	.069	CHALCOSIDERITE $CuFe_6(PO_4)_4(OH)_8 \cdot 4H_2O$	22° r > v str crossed	---	TCL pris	001 perf 010 good	Siskin-green	H 4.5 G 3.22	Fe-analogue of Turquoise. Pleoc wk.
	1.795	1.842	1.874	.079	STRANSKIITE $Zn_2Cu(AsO_4)_2$	80°	---	TCL	010 perf 100 good	Blue	H 4 G 5.23	---
	1.825	1.842	1.857	.032	DIETZEITE $Ca_2(IO_3)_2(CrO_4)$	86° r < v very str	Y = b Z:c = 6°	MCL tab	100 poor fr conch	Golden-yellow	H 3.5 G 3.62	Diss by hot H_2O.
1.828 ◊ 1.850	1.803	1.843	1.851	.048	FAYALITE, manganoan (Olivine grp) $(Fe,Mn)_2SiO_4$	48° r > v wk	X = b Z = a	ORTH	010 good	Reddish-brown	H 6 G 4.3 F 3.5	Gel with acids. FeO 56.9, MnO 9.7, MgO 1.1, Fe_2O_3 1.2%.
---	---	1.84-1.85	---	---	ITOITE $Pb_3Ge(SO_4)_2O_2(OH)_2$	---	---	ORTH acic	---	White	G 6.7 calc	Opt char unk.
	1.65	1.85	1.90	.25	VANURALITE $Al(UO_2)_2(VO_4)_2(OH) \cdot 11H_2O$	44° r < v wk	Z = b X ~ c	MCL	001 easy	Lemon-yellow	H 2 G 3.62	Tw 001. Pleoc str, X cols, Y and Z yellow.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.77	1.85	1.89	.12	DERRIKSITE $Cu_4(UO_2)(SeO_3)_2(OH)_6 \cdot H_2O$	(68±19°)	X = a Y = b	ORTH	010 good	Green	G 4.72	----
	1.740	---	1.855	.115	SINOITE Si_2N_2O	Small	Z = c	ORTH	---	Gray	G 2.82	---
	1.79	1.85	1.89	.10	MROSEITE $CaTe^{+4}(CO_3)O_2$	74° r < v str	X = a Y = c	ORTH	---	Cols to white	H 4 G 4.35	Diss by cold acids with eff.
1.810 ^	1.780	1.850	1.860	.080	VANDENDRIESSCHEITE $PbU_7O_{22} \cdot 12H_2O$	60° (40+4°) r > v str	X = c Z = a el c∧v pos	ORTH tab	001 perf	Orange- to yellow-brown	H 3 G 4.5-5.5	Pleoc, X cols, Y and Z yellow. Not fluor in UV.
(1.82) ^	1.785	1.85	1.85	.065	MITRIDATITE $Ca_3Fe^{+3}{}_4(PO_4)_4(OH)_6 \cdot 3H_2O$	5-10°	X ~ ⊥ 100	MCL	---	Deep red to brownish-green	G 3.24	Pleoc, X pale greenish-yellow, Y and Z deep greenish-brown.
	1.82	1.85	1.85	.03	BURKHARDTITE $Pb_2(Fe^{+3},Mn^{+3})Te^{+4}AlSi_3O_{12}(OH)_2 \cdot H_2O$	Small	X = c	MCL ps hex	001 perf	Carmine- to violet-red	H 2 G 4.96	Insol in acids. Pleoc, X pale magenta, Y and Z carmine-red.
1.843 ^v 1.854	1.816	1.850	1.863	.047	FAYALITE (Olivine grp) $(Fe,Mg)_2SiO_4$	60° r > v	X = b Z = a	ORTH	010 fair	Dark brown	H 6 G 4.36 F 3.5	Gel with acids (Fo_7).
	1.847	1.850	1.850	.003	ROMEITE (Stibiconite grp) $(Ca,Fe,Mn,Na)_2(Sb,Ti)_2O_6(O,OH,F)$	Med	---	CUB oct	Conch	Brown	H 6 G 5.07 infus	Insol in acids. Opt anom. Segmented. Poly tw. Abnormal interf colors.
1.850 ^ 1.854 pos v 1.869	1.820	1.854	1.888	.068	LIEBENBERGITE (Olivine grp) $(Ni,Mg,Fe,Co)_2SiO_4$	88° r > v	X = b Z = a	ORTH	010 poor to fair 100 poor	Yellowish-green	H 6-6.5 G 4.60 calc	Pleoc, X and Y cols to pale green, Z greenish yellow. NiO 56.3, MgO 6.5, FeO 9.4, CoO 1.8%.
v 1.907	1.674	1.855	1.880	.206	STRELKINITE $Na(UO_2)(VO_4) \cdot 3H_2O$	Med	X = c Y = b el c∧v pos	ORTH plates	001 perf	Gold- to canary-yellow	H 2-2.5 G 3.70-3.91	Diss by acids. Pleoc wk, Y yellow, Z pale yellow. Fluor wk, dirty green in UV.

1.815 ^	1.813	1.857	1.891	.078	ALLANITE (Epidote grp) $(Ce,Ca,Y)_2(Al,Fe)_3Si_3O_{12}(OH)$	80° r > v str	Y = b X:c = 34°	MCL	001, 100 poor	Brownish-black	H 6 G 4.13 F 3	Pleoc, X red-yellow, Y yellow to brown, Z dark red-brown. Fe_2O_3 15.2, FeO 8.9, MnO 1.9%.
~1.81 ^	1.85	---	1.862	.01	PARSONSITE $Pb_2(UO_2)(PO_4)_2 \cdot 2H_2O$	---	Y = b Z:c = 2°	TCL	010 poor fr conch	Pale yellow	H 2.5-3 G 5.73	Not fluor in UV. Opt char unk.
1.835 ^	1.80	1.86	1.88	.080	PSEUDOMALACHITE $Cu_5(PO_4)_2(OH)_4 \cdot H_2O$	46° r < v str	X:c = 23°	MCL pris	010 good	Dark green	H 4.5-5 G 4.35 F 2	Diss by acids. Tw 100. Pleoc wk.
	1.820	1.86	1.88	.06	CORNWALLITE $Cu_5(AsO_4)_2(OH)_4 \cdot H_2O$	Small r < v med	Y = el Z ⊥ clv	MCL pris	One perf	Emerald-green	H 4.5 G 4.52 F 2.5	Diss by acids.
	1.831	1.861	1.880	.049	ATACAMITE $Cu_2Cl(OH)_3$	75° r < v str	X = b Y = a	ORTH pris tab	010 perf 101 fair	Bright green	H 3.5 G 3.76 F 3.5	Diss by acids. Pleoc, X pale green, Y yellow-green, Z grass-green.
	1.818	1.866	1.909	.091	CALEDONITE $Pb_5Cu_2(CO_3)(SO_4)_3(OH)_6$	~ 85° r < v wk	X = c Y = a	ORTH	010 perf	Bluish-green	H 2.5-3 G 5.76 fus	Commonly striated.
1.854 ^	1.827	1.869	1.879	.052	FAYALITE (Olivine grp) Fe_2SiO_4	48° r > v	X = b Z = a	ORTH	010 fair	Dark brown	H 6 G 4.22 F 3.5	Gel with acids. FeO 65.0, Fe_2O_3 0.4, MnO 1.0%.
v 1.93	1.675	1.870	1.885	.210	METATYUYAMUNITE $Ca(UO_2)_2(VO_4)_2 \cdot 3\text{-}5H_2O$	30-45° r < v	X = c Y = a	ORTH	001 perf 010, 100 good	Canary- to greenish-yellow	H 2 G 3.85 F easy	Pleoc wk, X cols, Y and Z pale yellow. Not fluor in UV.
v (1.92)	1.727	1.870	1.883	.156	ILVAITE $Ca(Fe^{+2},Mn)_2Fe^{+3}(SiO_4)_2(OH)$	20-30° r < v str	X = c Y = b	ORTH	010 good 001 dist	Brownish-black	H 5.5-6 G 3.98 F 2.5	Gel with acids. Pleoc, X dark green, Y yellow-brown to dark brown, Z dark brown, abs X > Y > Z.
	1.81	1.87	1.92	.11	BAHIANITE $Al_5Sb_3O_{14}(OH)_2$	Large r > v	---	MCL ps orth	---	Tan, brown, cols	G 4.9-5.46 (5.26 calc)	---
v 1.898	1.792	1.870	1.870	.078	ARSENIOSIDERITE $Ca_3Fe^{+3}{}_4(AsO_4)_4(OH)_6 \cdot 3H_2O$	~ 0°	el pos	MCL ps tet fib	001 perf	Yellow to brown	H 4.5 G 3.60 F 3	Diss by acids. Pleoc, X cols, Y and Z dark reddish-brown.
	1.756	1.874	1.896	.140	CLINOCLASE $Cu_3AsO_4(OH)_3$	50° (44+2°) r < v very str	Y = b Z ~ a el clv pos	MCL pris	001 perf	Greenish-blue	H 2.5-3 G 4.38	Diss by acids. Pleoc, X pale blue-green, Y light blue-green, Z blue-green.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.655	1.875	1.909	.254	MALACHITE $Cu_2CO_3(OH)_2$	44° r < v str	Y = b X:c = 23°	MCL	$20\bar{1}$ perf 010 good	Bright green	H 3.5-4 G 4.05 F 2	Diss by acids with eff. Pleoc, X nearly cols, Y yellow-green, Z deep green.
	1.786	1.875	1.875	.089	PLUMBOJAROSITE (Alunite grp) $PbFe_6(SO_4)_4(OH)_{12}$	Small	X ⊥ plates	TRIG plates	$10\bar{1}4$ fair	Brown	G 3.63	Diss by HCl. Pleoc, X golden-yellow, Y and Z brownish-red. Basal plates divided into sectors.
	1.810	1.880	1.925	.115	Unknown, labeled "Scorodite"	~ 90° (75±2°)	---	---	---	Bright green	---	Data of Larsen, 1921, p. 132.
ˇ 2.02	---	1.88	---	.10	CHEVKINITE $(Ca,Ce,Th)_4(Fe,Mg)_2(Ti,Fe^{+3})_3Si_4O_{22}$	Med	Z = b X:c = 11-26°	MCL	Fr conch	Velvet-black	H 5 G 4.3-4.6 F 4	Gel with acids. Pleoc, X nearly cols, Y pale red-brown, Z dark red-brown. In part iso-tropic, metamict.
ˇ 1.927	1.860	1.880	1.893	.033	FRONDELITE $MnFe^{+3}{}_4(PO_4)_3(OH)_5$	Med r > v str	X = c	ORTH fib	100 perf 010 good 001 poor	Brown	H 4.5 G 3.48	Pleoc, X pale yellow-brown, Y and Z orange-brown, abs Z > Y > X. Fe_2O_3 48.8, MnO 7.7%.
	---	1.88	---	---	RAUVITE $Ca(UO_2)_2V^{+5}{}_{10}O_{28}$	---	---	Mass	---	Purplish-black	---	Opt char unk.
	>1.87	---	<1.89	---	STIBIVANITE $Sb^{+3}V^{+4}O_5$	85° r > v str	X = b Z = c	MCL fib	---	Yellow-green	---	Pleoc str, X emerald-green with olive tint, Y emerald-green, Z olive-green. Sign unk.
ˇ 1.92	1.863	1.885	1.890	.027	FOURMARIERITE $PbU_4O_{13}\cdot4H_2O$	50° r > v	X = c Y = a	ORTH tab	001 perf 100 good	Reddish-orange	H 3.5 G 5.74	Pleoc, X cols, Y pale yellow, Z amber.
[ ]	1.86	1.887	1.91	.05	HETEROSITE $(Fe^{+3},Mn^{+3})PO_4$	37°	X = a	ORTH	100 good 010 poor	Deep rose to purple	H 4 G 3.3	Diss by acids. Pleoc, X greenish-gray, Y and Z eep red to purple, abs Z = Y > X. Abnormal green interf colors near optic axis.
1.820 ^	1.764	1.889	1.936	.172	IRIGINITE $(UO_2)Mo_2O_7\cdot3H_2O$	60°	Y = b Z = c	MCL	---	Canary yellow	H 4-5 G 3.84	Diss by warm HCl. Not fluor in UV.

	(1.80)	1.89	1.91	.11	WYARTITE $Ca_3U^{+4}(UO_2)_6(CO_3)_2(OH)_{18}\cdot 3\text{-}5H_2O$	48°	X = c Y = b	ORTH	001 perf and 010	Black to violet-black	H 3-4 G 4.69	Pleoc, X gray, Y violet, Z lavender-blue.
1.870 ^	1.815	1.898	1.898	.083	ARSENIOSIDERITE $Ca_3Fe^{+3}{}_4(AsO_4)_4(OH)_6\cdot 3H_2O$	~ 0°	el pos	MCL ps tet fib	001 perf	Yellow to brown	H 4.5 G 3.60 F 3	Diss by acids. Pleoc, X cols, Y and Z dark red-brown.
v 1.925	1.76	1.90	1.92	.16	CARNOTITE $K_2(UO_2)_2(VO_4)_2\cdot 3H_2O$	50° r < v	X = c Y = b Z:a = 14°	MCL	001 perf 010, 110 poor	Lemon- to bright-yellow	H soft G 4.70 F diff	Pleoc, X cols to gray, Y and Z canary- to lemon-yellow. Not fluor in UV.
	1.775	1.900	1.920	.145	XOCOMECATLITE $Cu_3(TeO_4)(OH)_4$	41±2°	---	ORTH(?) fib	---	Rich green	H 4 G 4.65	Diss by HNO_3. Pleoc in bluish-green, abs Z > X = Y.
	1.899	1.901	1.903	.004	QUEITITE $Pb_4Zn_2(SiO_4)(Si_2O_7)(SO_4)$	~ 90° r < v str	---	MCL tab	010, 001 poor	Pale yellow to cols	H 4 G 6.07	Diff sol in HNO_3.
	1.803	1.905	1.945	.142	WIDENMANNITE $Pb_2(UO_2)(CO_3)_3$	63°	X = b Y = a el pos	ORTH tab 010	010 perf	Yellow	H 2 G 6.89 calc	Diss by HNO_3 with eff. Not pleoc. Not fluor in UV.
1.895 ⌐	1.873	1.905	1.910	.037	YEATMANITE $Mn_7Zn_8Sb_2Si_4O_{28}$	49° r < v med	---	TCL	100 perf	Deep brown	H 4 G 5.02 F 4	Dec by HCl. Tw on 010.
	1.785	1.906	1.917	.132	MASUYITE $UO_2\cdot 2H_2O$ (?)	50° (32±3°) r > v	X = c Y = b	ORTH tab 001	001 perf 010 good	Reddish- to brownish-orange	G 5.08	Tw 110 and 1$\bar{3}$0 common. Pleoc, X pale yellow, Y and Z deep golden. Not fluor in UV.
1.855 ^	1.770	1.907	1.915	.145	STRELKINITE $Na_2(UO_2)_2(VO_4)_2\cdot 6H_2O$	Med (26±3°)	X = c Y = b el pos	ORTH plates	001 perf	Gold- to canary-yellow	H 2-2.5 G 3.7-3.91	Diss by acids. Pleoc wk, Y yellow, Z pale yellow. Fluor wk, dirty green in UV.
	1.685	1.91	1.93	.245	IANTHINITE $UO_2\cdot 5UO_3\cdot 10H_2O$	Large (30±15°)	X = c Y = b	ORTH acic	001 perf 100 good	Black to violet	H 2.5	Pleoc, X cols, Y purple, Z violet.
v 1.952	1.750	1.910	1.945	.195	FRANCEVILLITE $Ba(UO_2)_2(VO_4)_2\cdot 5H_2O$	46°	X = c Y = b el pos	ORTH	001 perf	Yellow	H 3 G 4.0	Pleoc, X cols, Y and Z yellow. Not fluor in UV.
	1.885	1.910	1.913	.028	BARTELKEITE $PbFe^{+2}Ge_3O_8$	35° r < v	Z = b	MCL	101 dist	Cols to pale green	H ~ 4 G (4.97)	Diss by hot HCl.
	1.820	1.920	1.955	.135	LAZARENKOITE $(Ca,Fe^{+2})Fe^{+3}As^{+3}{}_7\cdot 3H_2O$	~ 30°	el pos	ORTH fib	---	Orange	H 1 G 3.45	Diss by HCl. Pleoc, X pale yellow, Y pale brown, Z rose-brown.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.870	1.830	(1.92)	1.925	.095	ILVAITE $Ca(Fe,Mn)_2Fe^{+3}(SiO_4)_2(OH)$	20-30° r < v str	X = c Y = b	ORTH	010 good 001 dist	Brownish-black	H 5.5-6 G 3.98 F 2.5	Gel with acids. Pleoc, X dark green, Y and Z dark brown, abs X > Y > Z.
1.885	1.85	1.92	1.94	.09	FOURMARIERITE $PbU_4O_{13}\cdot 4H_2O$	Large r > v	X = c Y = a	ORTH tab	001 perf 100 good	Reddish-orange	H 3.5 G 5.74	Pleoc, X cols, Y pale yellow, Z deeper yellow.
	1.810	1.923	1.933	.123	KOLFANITE $Ca_2Fe^{+3}{}_3(AsO_4)_3O_2\cdot 2H_2O$	5-7° (24±4°)	---	MCL	One	Red to yellow	G 3.3	Pleoc, X pale yellow, Y and Z dark orange.
1.90	1.750	1.925	1.950	.200	CARNOTITE $K_2(UO_2)_2(VO_4)_2\cdot 3H_2O$	43° (38±2°) r < v	X = c Y = b Z:a = 14°	MCL	001 perf 010, 110 poor	Lemon- to bright yellow	H soft G 4.70 F diff	Pleoc, X cols, Y and Z yellow. Not fluor in UV.
	---	1.926	---	.04	Unnamed lead-zinc arsenate	~ 90° r > v	---	MCL tw	---	Yellow-brown to cols	---	Am. Mineral., 47, 418 (1962).
1.880	1.915	1.927	1.939	.024	ROCKBRIDGEITE, oxidized (Frondelite ser) $(Fe^{+2},Mn)Fe^{+3}{}_4(PO_4)_3(OH)_5$	Large r < v	---	ORTH	100 perf 010 good	Green to brown	H 4.5 G 3.48	Diss by acids. Pleoc, X pale yellow-brown, Y and Z orange-brown. Fe_2O_3 55.2, MnO 4.1%.
1.870	1.77	1.93	1.97	.20	METATYUYAMUNITE $Ca(UO_2)_2(VO_4)_2\cdot 3\text{-}5H_2O$	40-55° r < v	X = c Y = a	ORTH	001 perf 010, 100 good	Canary- to greenish-yellow	H 2 G 3.85 F easy	Pleoc, X nearly cols, Y canary yellow, Z darker yellow. Not fluor in UV.
	1.886	1.930	1.939	.053	FERSMANITE $(Ca,Ce,Na)(Nb,Ta,Ti)_2(O,OH,F)$	0-7° (48±6°)	Y = b X ~ c	MCL	---	Yellow to brown	H 5.5 G 3.44	---
1.87	---	1.93	---	wk	CORKITE $PbFe_3(PO_4)(SO_4)(OH)_6$	Med r < v very str	X = c	TRIG	0001	Olive-green to brown	H 4 G 4.20 F 4-5	Basal section divided into biax segments. Abnormal interf colors green, blue, brown.
	1.922	1.933	1.938	.016	PLUMBOTSUMITE $Pb_5Si_4O_8(OH)_{10}$	32° (68±15°) r < v	---	ORTH ps hex	001 perf	Cols	H 2 G 5.6	Diff sol hot HNO_3.

1.77	1.935	1.960	.190	SENGIERITE $Cu_2(UO_2)_2(VO_4)_2(OH)_2 \cdot 6H_2O$	38° r < v str	X = c	MCL plates	001 perf	Greenish-yellow	H 2.5 G 4.41	Diss by acids. Pleoc, X pale greenish-yellow, Y and Z greenish-yellow.
---	1.94	1.95	---	SAYRITE $Pb_2(UO_2)_5O_6(OH)_2 \cdot 4H_2O$	Large	Y = b X ~ c Z ~ a el neg	MCL	$\bar{1}$02 dist	Yellowish to reddish-orange	G (6.76)	---
1.897	1.940	1.942	..045	SCHIEFFELINITE $Pb(Te,S)O_4 \cdot H_2O$	24° r < v wk	X = b Y = c	ORTH	010 easy	Cols, white	H 2 G 4.98 F easy	---
(1.79)	1.94	1.96	(.17)	Unnamed Ca-Sr-U oxide	38°	---	ORTH ps hex	001 good	Red-orange	G 5.29	Am. Mineral., 45, 254 (1960).
1.70	1.95	2.04	.34	HYDROTUNGSTITE $H_2WO_4 \cdot H_2O$	52° r < v	Y = b	MCL plates	010 poor	Dark- to yellow-green	H 2 G 4.60	Insol in acids, diss by NH_4OH. Pleoc, X cols, Y and Z yellow-green to dark green, abs Z > Y > X.
---	1.95	1.985	---	KLEBELSBERGITE $Sb_4O_4(OH)_2SO_4$	~ 70°	X = b Y = c	ORTH	---	Yellow	G 4.62	Not pleoc.
(1.75)	1.95	1.97	.22	RAMEAUITE $K_2CaU_6O_{20} \cdot 9H_2O$	32°	X = b Z:c = 5° el clv pos	MCL ps hex	010 good	Orange	G 5.60	Tw 100.
1.89	1.95	2.02	.13	CEROTUNGSTITE $Ce_2W_2O_6(OH)_3$	(Large)	Z = b X ~ a	MCL	001 perf	Orange-yellow	H 1	Tw 001.
1.85	1.95	1.96	.11	CHAPMANITE $SbFe_2(SiO_4)_2(OH)$	Small	Z = el X ⊥ flat face	ORTH laths	Conch	Olive-green, deep yellow	H 2.5 G 3.75	Insol in acids.
1.92	1.95	1.96	.04	LARSENITE $PbZnSiO_4$	80° (?)	X = a	ORTH pris	120 good	White	H 3 G 5.90	Luster greasy.
1.92	1.95	1.96	.04	MANGANOSTIBITE $(Mn,Fe)_7SbAsO_{12}$	Small	---	ORTH fib	---	Black to reddish-brown	H 5 G 4.95 infus	Dec by HCl. Pleoc, X reddish-brown, Z nearly opaque.
1.92	1.95	1.95	.03	KATOPTRITE $(Mn,Mg,Fe)_{13}(Al,Fe)_4Sb_2Si_2O_{28}$	Small r > v str inclined	Y = b Z:a = -3°	MCL pris	001 perf	Jet black, red in thin splinters	H 5.5 G 4.56	Insol in acids. Pleoc str, reddish-yellow to reddish-brown.
---	1.95	~1.985	---	KLEBELSBERGITE $Sb_4O_4(OH)_2(SO_4)$	70°	X = b Y = a	ORTH powdery	---	Yellow to orange-yellow	G 4.62	---

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
1.910 ^v >2	1.785	<u>1.952</u>	2.002	.217	FRANCEVILLITE $(Ba,Pb)(UO_2)_2(VO_4)_2 \cdot 5H_2O$	52°	X = <u>c</u> Y = <u>b</u> el cTv pos	ORTH	001 perf	Yellow	H 3 G 4.55	Pleoc, X cols, Y and Z yellow. Not fluor in UV.
1.94 [v] 1.985	1.702	<u>1.955</u>	1.965	.263	POUGHITE $Fe_2(TeO_3)_2(SO_4) \cdot 3H_2O$	22° r > v very str	X = <u>b</u> Y = <u>a</u>	ORTH	010 perf 101 good	Greenish-yellow	H 2.5 G 3.76 fus	Diss by acids. Pleoc, X nearly cols, Y pale greenish-yellow, Z pale sulfur-yellow.
	1.946	<u>1.958</u>	1.964	.018	ALAMOSITE $PbSiO_3$	65° r < v very str	Y = <u>b</u> Z:<u>c</u> = 8°	MCL Fib	010 perf	Cols	H 4-5 G 6.49 fus	Gel with acids.
v 2.115	1.815	<u>1.960</u>	1.960	.145	TLAPALLITE $H_6(Ca,Pb)_2(Cu,Zn)_3(SO_4)(Te^{+4}O_3)(Te^{+6}O_6)$	Small	---	MCL	---	Green	H 3 G 4.7 (5.05 calc)	CuO 15.6, CaO 8.3, ZnO 0.8%.
	1.73	<u>1.96</u>	1.98	.25	MELANOVANADITE $Ca_2V^{+4}{}_4V^{+5}{}_6O_{25} \cdot xH_2O$	Med	Z = b Y:<u>c</u> = 15°	TCL pris	One perf	Black, brown	H 2.5 G 3.48 F easy	Diss by acids. Pleoc, X yellow-brown, Y dark red-brown, Z dark red-brown to opaque.
1.92 [] 1.97	1.94	<u>1.96</u>	1.96	.02	BEUDANTITE $PbFe_3(AsO_4)(SO_4)(OH)_6$	0-50° r > v	X = <u>c</u> el cTv pos	TRIG	0001 good	Yellow, brown, green	H 4 G 4.1 F 3.5	Diss by hot HNO_3. Complex tw. Base divided into biax segments. Abnormal interf colors.
	1.945	<u>1.966</u>	1.983	.038	OLSACHERITE $Pb_2(SO_4)(SeO_4)$	80°	X = <u>a</u> Y = <u>c</u>	ORTH	101 good 010 poor	Cols	H 3-3.5 G 6.55 calc	---
---	1.93	<u>1.97</u>	2.01	.08	BISMUTOFERRITE $BiFe_2(SiO_4)_2(OH)$	---	---	ORTH mass	---	Yellow-green	G 4.47	---
	1.871	<u>1.975</u>	2.005	.134	WALPURGITE $(BiO)_4(UO_2)(AsO_4)_2O_4 \cdot 3H_2O$	52°	Y:<u>c</u> = 8°	TCL tab	010 perf	Yellow to yellow-green	H 5 G 5.95 F 1.5	Tw 010. Pleoc, X pale yellow, Y and Z green.
v ~2.09	1.956	<u>1.978</u>	1.980	.024	WOELSENDORFITE $(Pb,Ca)U_2O_7 \cdot 2H_2O$	Large	---	ORTH	001 good	Orange-red	H 5 G 5.37	PbO 15.5, CaO 3.2%.
	1.78	<u>1.98</u>	2.1	.32	KARAPTITE (= Coronene) $C_{24}H_{12}$	(69±7°)	---	MCL needles	One clv	Yellow	H 1 G 1.40 F 1	Sol in benzene.

	1.89	1.98	2.02	.13	YTTROTUNGSTITE $YW_2O_6(OH)_3$	68°	Z = b X:c = 26°	MCL ps orth laths	010 perf 10$\bar{1}$ poor	Yellow	G 5.96	Tw 100.
v >2.0	(1.97)	1.98	1.99	(.02)	RICHETITE Oxide of Pb and U	Large	---	MCL ps hex tab	010 perf	Black	G 7.25	Tw common. Pleoc, X pale brown, Y and Z dull brown.
1.955 ^	1.72	1.985	1.990	.27	POUGHITE $Fe_2(TeO_3)_2(SO_4)\cdot 3H_2O$	15-20° r > v str	X = b Y = a	ORTH	010 perf 101 good	Greenish-yellow	H 2.5 G 3.76 fus	Diss by acids. Pleoc, X nearly cols, Y pale greenish-yellow, Z pale yellow.
	1.952	---	2.002	.05	KURANAKHITE $PbMn^{+4}Te^{+6}O_6$	---	---	ORTH ps hex	---	Reddish-brown to black	H 4.5	Diss by hot HCl. Opt char unk.
	1.970	1.992	2.011	.041	Unnamed arsenate analogue of Tsumebite $Pb_2Cu(AsO_4)(SO_4)(OH)$	88°	---	MCL	---	Green	---	Pleoc, X pale green, Y and Z bottle-green. Am. Mineral., 51, 258 (1966).
	1.990	1.993	1.994	.004	ELYITE $Pb_4Cu(SO_4)(OH)_8$	66°	Y = b X:c = 45°	MCL pris tab	---	Lavender	H 2 G 6.3	Pleoc str in shades of lavender, abs Z > Y > X.
	1.960	1.995	2.020	.060	JAMESITE $Pb_2Zn_2Fe^{+3}{}_5O_4(AsO_4)_5$	75° r > v	Y:a on (0$\bar{0}$1) = 5°	TCL tab	---	Reddish-brown	H ~ 3	Pleoc, X and Y pale brown, Z deep reddish-brown.
1.952 ^	---	>2	---	---	CURIENITE $Pb(UO_2)_2(VO_4)_2\cdot 5H_2O$	66°	X = c Y = b	ORTH	---	Canary yellow	G 4.88	---
	1.82	>2.0	>2.0	>.18	GRANTSITE $Na_4Ca_xV^{+4}{}_{2x}V^{+5}{}_{12-2x}O_{32}\cdot 8H_2O$	---	Z = b	MCL	---	Olive-green	H 1 G 2.94	Pleoc, X green, Y greenish-brown, Z brown, abs Z > Y > X. Mean n calc 1.965.
	1.87	2.00	2.01	.14	LEADHILLITE $Pb_4(SO_4)(CO_3)_2(OH)_2$	10° r < v str	Z = b X:c = 5° el clv pos	MCL ps hex	001 perf fr conch	Cols, gray, blue, green	H 2.5-3 G 6.55 F 1.5	Diss by HNO_3 with eff.
1.98 ^	~1.8	>2.0	<2.07	---	RICHETITE Hydrous oxide of Pb, U	Large	---	MCL (?)	010 perf	Black	G 7.25	Pleoc, X pale brown, Y and Z dull brown.
	1.797	>2.0	>2.0	>.2	BARNESITE $Na_2V_6O_{16}\cdot 3H_2O$	---	Z = b X:c = 5°	MCL bladed	---	Dark red	G 3.15 F 2	Diss by HCl. Pleoc, X yellow, Y orange-yellow, Z red. Mean refractive index 2.037.
1.986	1.930	2.002	2.020	.090	LINDGRENITE $Cu_3(MoO_4)_2(OH)_2$	71° (52±3°) r > v	Z = b X:c = -7° el clv neg	MCL tab	010 perf 001, $\bar{1}$01 poor	Apple-green	H 4.5 G 4.26 F easy	Diss by acids.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index			Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	α	β	γ									
1.99	1.928	2.007	2.036	.108	LANARKITE $Pb_2(SO_4)O$	60° r > v str inclined	Y = b Z:c = 30°	MCL el b	$\bar{2}01$ perf	Gray, greenish	H 2.5 G 6.92	Diss by KOH or warm HNO_3. Poly tw 010 rare. Fluor yellow in UV.
	(1.85)	2.01	2.06	(.21)	AGRINIERITE $(K_2,Ca,Sr)U_3O_{10}\cdot 4H_2O$	55°	X = a Y = b el c‖v neg	ORTH tab	001 good	Orange	G 5.7	Sector tw.
2.04	1.92	2.01	2.02	.10	LORENZENITE $Na_2(Ti,Zr)_2Si_2O_9$	25-49° r > v	X = a Y = b	ORTH	100 perf 110 good	Brown to black	H 6 G 3.37 F easy	Insol in acids. Pleoc, X and Y reddish-yellow, Z pale yellow.
	1.942	2.010	2.024	.082	WHERRYITE $Pb_4Cu(CO_3)(SO_4)_2(Cl,OH)_2O$	50°	Wavy ext	MCL	---	Light green	G 6.45 (7.2 calc) fus	Diss by HNO_3.
	1.96	2.01	2.04	.08	BROWNMILLERITE $Ca_2(Al,Fe)_2O_5$	75°	---	ORTH	---	Reddish-brown	G 3.76 infus	Data for synth compd. Pleoc, X and Y yellow-brown, Z dark brown.
	2.00	2.01	2.02	.02	TURANITE $Cu_5(VO_4)_2(OH)_4$ (?)	Med r > v str	---	Reni-form, radi-ating, fib	---	Olive-green	H 5	Pleoc, X and Y brown, Z green.
	2.00	2.01	2.02	.02	CALCIOVOLBORTHITE $CaCu(VO_4)(OH)$	~ 90° r < v	X = a Y = b	ORTH	010 perf 001 good	Yellow, green, brown	H 3.5 G 3.75	Diss by HCl. Pleoc wk.
	<2.01	>2.01	>2.01	---	HENDERSONITE $Ca_2V^{+4}V^{+5}{}_8O_{24}\cdot 8H_2O$	Med r > v	X = a Y = b	ORTH fib	---	Dark greenish-black	H 2.5 G 2.79	Diss by HNO_3. Pleoc, X yellow-green, Y green, Z brown. Mean n calc 2.10.
	>2.01	>2.01	>2.01	high	GERSTLEYITE $Na_2(Sb,As)_8S_{13}\cdot 2H_2O$	Large (?)	---	MCL (?)	010, $\bar{1}01$ perf	Cinnabar-red to reddish-black	H 2.5 G 3.62 F 2	Diss by alkalies. Pleoc, X salmon-red, Y and Z deep blue-red. Opt char unk.
	1.905	2.02	>2.02	>.115	NAVAJOITE $V_2O_5\cdot 3H_2O$	---	Z = b	MCL fib b	---	Dark brown	H 1 G 2.56	Pleoc, X and Y yellow-brown, Z dark brown.

2.01 □ 2.04	1.96	2.02	2.06	.10	PERRIERITE $(Ca,Ce,Th)_4(Mg,Fe)_2(Ti,Fe)_3Si_4O_{22}$	63° r > v str	Z = b X:a = 24°	MCL	---	Brownish-black	H 6 G 4.3-4.45 F 4	Pleoc, X yellow-brown, Y deep reddish-brown, Z dark brown to opaque, abs Z > Y > X.
1.88 ^	1.97	2.02	2.05	.08	CHEVKINITE $(Ca,Ce,Th)_4(Fe,Mg)_2(Ti,Fe)_3Si_4O_{22}$	Large	Z = b X:c = 11-26°	MCL	Conch	Brown to black	H 5.5 G 4.63 F 4	Tw 001. Pleoc, X dark brown, Y and Z nearly opaque.
	2.018	2.023	2.025	.007	SONORAITE $FeTeO_3(OH)\cdot H_2O$	23°	---	MCL plates	---	Yellowish green	H 3 G 3.95	Diss by acids.
v 2.24	1.82	(2.03)	2.04	.22	TUNGSTITE $WO_3\cdot H_2O$	27° r < v	X = c Y = b el c̄ℓv pos	ORTH	001 perf	Dark to light yellow	H 1.5 G 5.52	Diss by NH_4OH, insol in HCl.
	1.990	2.030	2.035	.045	ARSENDESCLOIZITE $PbZn(AsO_4)(OH)$	~ 30° r > v	X = b Y = a	ORTH tab 001	---	Pale yellow	H ~ 4 G (6.57)	---
	1.98	2.04	2.10	.12	FIEDLERITE $Pb_3Cl_4(OH)_2$	Large r < v	Z = b Y:c = -34°	MCL tab 100	100 good	Cols	H 3.5 G 5.88	Diss by HNO_3. Tw on 100 common.
2.01 ^	1.95	2.04	2.06	.11	LORENZENITE $Na_2Ti_2Si_2O_9$	37-41° r > v	X = a Y = b	ORTH	100 perf 110 good	Brown to black	H 6 G 3.43 F easy	Insol in acids. Pleoc, X and Y pale reddish-yellow, Z pale yellow.
v 2.129	2.01	2.04	2.04	.07	VESIGNIEITE $BaCu_3(VO_4)_2(OH)_2$	60°	Ext:tw pl = 10°	MCL ps hex	001 good	Yellow- to olive-green	H 3.5 G 4.05	Poly tw.
2.01 □ 2.05	2.01	2.04	2.07	.06	VOLBORTHITE $Cu_3(VO_4)_2\cdot 3H_2O$	Large r < v str	---	MCL	001 perf	Yellow to dark green	H 3.8 G 3.42	Tw. Diss by acids. Pleoc, X and Y yellow, Z yellow-green.
	(1.91)	2.05	2.15	(.24)	SCHMITTERITE $(UO_2)TeO_3$	75°	X = c Y = b	ORTH	100	Light yellow	H 1 G 6.9	---
	1.908	2.05	2.065	.157	PINAKIOLITE $(Mg,Mn^{+2})_2Mn^{+3}BO_5$	32°	X = b Z = a el c̄ℓv pos	MCL	010 perf	Black	H 6 G 3.88 F 5	Diss by HCl. Pleoc in red-browns.
	---	2.05	---	str	FERNANDINITE $CaV^{+4}{}_2V^{+5}{}_{10}O_{30}\cdot 14H_2O$	---	---	Crypto-cryst	---	Dull green	---	Diss by acids. Not pleoc. Opt char unk.
⌴ 2.061	2.042	2.050	2.050	.008	PYROMORPHITE (Apatite grp) $Pb_5(PO_4)_3Cl$	~ 0°	X = c	HEX pris	$10\bar{1}0$	Green, brown, yellow	H 4 G 7.05 F 1.5	Diss by HNO_3. Pleoc, X greenish-yellow, Z green.
	1.96	---	>2.10	>.14	KARIBIBITE $Fe^{+3}{}_2As^{+3}{}_4(O,OH)_9$	Large	---	ORTH fib	---	Brownish-yellow	Soft G 4.07	Pleoc wk, straw-yellow to brownish-yellow.
⌴ 2.08	2.03	2.06	2.08	.05	DUFTITE $PbCuAsO_4(OH)$	Large r > v	---	ORTH	X = c Y = b	Canary yellow	G 4.88	---

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	1.786	2.070	2.075	.289	SALESITE $Cu(IO_3)(OH)$	0-5° (12±2°) r > v extr	X = a Y = b el pos	ORTH	110 perf	Green	H 3 G 4.77	Diss by HNO_3. Pleoc, X cols, Y light bluish-green, Z bluish-green.
	1.804	2.074	2.076	.272	CERUSSITE (Aragonite grp) $PbCO_3$	9° r > v str	X = c Y = b	ORTH	110, 021 good	Cols, white	H 3.5 G 6.55 F easy	Diss in dil HNO_3 with eff. Tw on 110 common.
	1.95	2.08	2.11	.16	CAFETITE $Ca(Fe,Al)_2Ti_4O_{12}\cdot 4H_2O$	Med	Z:c = 3° el pos	MCL fib c	Pris	Pale yellow to cols	H 4.5 G 3.28 F easy	Insol in acids.
	1.96	2.09	2.10	.14	EMMONSITE $Fe_2Te_3O_9\cdot 2H_2O$	20° r > v str	Y = b	TCL fib	010 perf	Yellow-green	H 5 G 4.59	Tw. Pleoc, X light green, Z darker green.
1.978 ^	2.05	---	2.09	.04	WOELSENDORFITE $PbU_2O_7\cdot 2H_2O$	---	---	ORTH	001 good	Orange-red	G 6.08	PbO 23.1, CaO 1.2%.
	---	~2.09	---	.01	MONTANITE $Bi_2TeO_6\cdot 2H_2O$	Small r < v extr	---	MCL (?) fib	---	Yellowish white to grayish-yellow	Soft G 3.79 F 1.5	Diss by acids. Abnormal green interf colors.
	1.982	2.095	2.19	.208	CARLFRIESITE $CaTe^{+4}{}_2Te^{+6}O_8$	80°	Y = b X:c = 28°	MCL	010 fair	Bright yellow	H 3.5 G 6.3	Diss by hot dil HCl. Pleoc wk in yellows, abs Z > X = Y.
	2.01	---	---	---	SANTAFEITE $Na_2(Mn,Ca,Sr)_6Mn^{+4}{}_3(V,As)_6O_{28}\cdot 8H_2O$	---	X = c	ORTH ro-settes	010 perf 110 dist	Brownish-black	G 3.38 F easy	Diss by HCl. Pleoc, yellow-brown to dark red-brown, abs X > Y > Z. Opt char unk.
	1.70_{Li}	2.10_{Li}	2.23_{Li}	.53	METAHEWETTITE $CaV_6O_{16}\cdot 9H_2O$	52°	Z = b	MCL laths	---	Deep red	Soft G 2.51-2.94	Diss by acids. Pleoc, X light orange-yellow, Y and Z deep red.
	>2.10	>2.10	>2.10	---	NAMIBITE $CuBi_2VO_6$	Mod for red, small for blue light	Z = b X:a = 12°	MCL tw	100 good	Dark green	H 4.5-5 G 6.86	Diss by acids. Pleoc, X yellow-green, Y pistachio green, Z dark green, abs Z > Y > X.
	>2.09	>2.09	>2.09	---	MOUNANAITE $PbFe_2(VO_4)_2(OH)_2$	---	Ext:c = 38° on (010)	TCL el c	---	Brownish-red	G 4.85	Tw common. Pleoc, brownish-yellow to brownish-red. Opt char unk.

	2.00	2.10	2.11	.11	CLARKEITE $(Na,Ca,Pb)_2U_2(O,OH)_7$	40° r < v	---	ORTH(?)	Conch	Dark brown	H 4.5 G 6.3	Pleoc wk in deep orange.
	2.07	2.10	2.12	.05	TRIGONITE $Pb_3Mn(AsO_3)_2(AsO_2OH)$	Large r < v	Y = b ext:c = 45°	MCL domatic	010 perf 101 good	Bright yellow to brownish	H 2.5 G 6.5 F 2	Diss by acids.
2.07 ⊓	2.06	2.11	2.15	.09	CURITE $Pb_2U_5O_{17}{\cdot}4H_2O$	Large r > v str	X = b Y = a	ORTH	100 perf	Deep orange-red	H 4.5 G 7.26	Diss by acids. Pleoc, X pale yellow, Y orange, Z red-brown. Not fluor in UV.
	2.08	2.11	---	---	DUHAMELITE $Pb_2Cu_4Bi(VO_4)(OH)_3{\cdot}8H_2O$	---	---	ORTH	---	Yellow-green	H 3 G 5.80	Sign unk. Pleoc wk in yellow. Diss by acids.
1.960 ^	1.915	2.115	2.115	.200	TLAPALLITE $H_6(Ca,Pb)_2(Cu,Zn)_3SO_4(Te^{+4}O_3)(Te^{+6}O_6)$	---	---	MCL	---	Green	H 3 G 5.38	PbO 13.6, CaO 4.3, CuO 15.8, ZnO 0.7%.
	2.08	2.12	2.16	.08	LAURIONITE $PbCl(OH)$	Large	X = c Y = a	ORTH tab	101 perf	Cols, white	H 3.5 G 6.14 F 1	Diss by HNO_3.
2.04 ^	2.053	2.129	2.133	.08	VESIGNIEITE $BaCu_3(VO_4)_2(OH)_2$	---	Ext:tw pl = 10°	MCL	001 good	Yellow, olive	H 3.5 G 4.3-4.6	Poly tw.
	1.95	2.13	2.21	.26	KASSITE $CaTi_2O_4(OH)_2$	58° r > v very str	X = c Z = b	ORTH	010 perf 101 dist	Pale yellow	G 3.42	Pleoc wk, cols to pale yellow.
⊔ 2.18	2.12	2.13	2.135	.015	MIMETITE (Apatite grp) $Pb_5(AsO_4)_3Cl$	29°	X = c	MCL ps hex	---	Yellow, green	H 3.5 G 7.1 F 1	Diss by HNO_3. Basal section in 6 segments. Tw.
	2.13	2.137	2.142	.012	YTTROCRASITE $(Y,Th,Ca,U)(Ti,Fe)_2(O,OH)_6$	60-70°	---	ORTH pris	---	Greenish brown	H 5.5-6 G 5.32	Pleoc, X cols to pale brown, Y brown, Z brown to greenish-brown, abs Z > Y > X.
	2.06	2.14	2.17	.11	Unnamed lead oxychloride	Large (?)	Ext:tw = 30° el pos	MCL (?)	010 dist	White	H 3	Poly tw. Am. Mineral., 59, 211 (1974).
	2.12	2.14	~2.15	~.03	MOLYBDOMENITE $PbSeO_3$	~ 80°	el pos	MCL	001 perf	Cols to yellowish	H 3.5 G 7.07	Diss by HNO_3.
	2.14	---	2.15	.01	EZTLITE $Pb_2Fe^{+3}{}_6(Te^{+4}O_3)_3(Te^{+6}O_6)(OH)_{10}{\cdot}8H_2O$	---	Z:c = 3°	---	001	Deep orange	---	Sign unk. Not pleoc.
	---	2.15	---	str	CUPROTUNGSTITE $Cu_2WO_4(OH)_2$	---	---	Crypto-cryst	---	Green	fus	Dec by HCl. Opt char unk.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien- tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	2.05	2.15	2.20	.15	PARALAURIONITE PbCl(OH)	Med large r < v str	Y = b Z:c = 25°	MCL tab	001 perf	Cols, white	Soft G 6.12 F 1	Diss by HNO_3. Tw 100 very common.
	2.01	2.15	2.15	.14	MATLOCKITE PbFCl	~ 0°	X = c el cTv pos	TET	001 perf	Yellow	H 3 G 7.12 F 1	Diss by HNO_3. Anom biax.
	2.13	2.16	2.195	.065	PREISINGERITE $Bi_3(AsO_4)_2O(OH)$	90°	---	TCL tab	---	White to gray	G (7.24)	---
v 2.36	---	2.16	---	.05	BISMUTITE $Bi_2(CO_3)O_2{+}xH_2O$	Small to med	X = c el pos	ORTH platy	---	Yellow, dark gray	H 3.5 G 7.0 F 1.5	Diss by acids with eff. Striated 100.
	>2.1	---	<2.2	<0.1	RODALQUILARITE $H_3Fe^{+3}{}_2(TeO_3)_4Cl$	38°	---	TCL	One good	Emerald-green	H 2-3 G 5.1	Not pleoc.
	2.11	2.18	2.22	.11	BALYAKINITE $CuTeO_3$	100° (72±22°)	X = a Y = b	ORTH	---	Gray-green, bluish-green	G 5.6	Reported as opt pos.
	2.04 1.77_{Li}	--- 2.18_{Li}	2.18 2.35_{Li}	.14(?) $.58_{Li}$	HEWETTITE $CaV_6O_{16}\cdot 9H_2O$	Med $(55{\pm}4)_{Li}$	Z = b	MCL	---	Deep red	---	Diss by acids. Pleoc, X and Y light orange-yellow, Z dark red.
	2.00_{Li}	2.18_{Li}	2.35_{Li}	$.35_{Li}$	TELLURITE TeO_2	~ 90° r > v mod	X = b Z = c el cTv pos	ORTH	010 perf	White	H 2 G 5.90 fus	Diss by HCl. Flexible.
	2.16	2.18	2.18	.02	KLEINITE $Hg_2N(Cl,SO_4)\cdot xH_2O$	Small r < v very str	---	HEX pris	0001 good	Yellow to orange	H 3.5-4 G 8.0 volat	Diss by acids. Uniax pos above 130°C. Poly tw.
v 2.38	2.13	2.19	2.20	.07	BADDELEYITE ZrO_2	30° r > v str	Y = b X:c = 13°	MCL pris	001 perf 010 good	Cols, brown, black	H 6.5 G 5.74 infus	Insol in acids. Poly tw on 100, 110. Pleoc wk, abs X > Y > Z.
	1.94	2.20	2.51	.57	LEPIDOCROCITE FeO(OH)	83°	X = b Y = c	ORTH tab	010 perf 100 good 001 fair	Ruby red	H 5 G 4.09 infus	Diss by HCl. Pleoc, X yellow, Y reddish-orange, Z dark red orange, abs Z > Y > X.
	2.14	---	2.315	.175	VIGEZZITE $(Ca,Ce)(Nb,Ta,Ti)_2O_6$	Large	X = c Z = a	ORTH prism	100 dist	Orange-yellow	G (5.54)	Sign unk. Not pleoc.

	2.12	2.20	2.23	.11	NATRONIOBITE $NaNbO_3$	10-30° (61±22°) r < v	X':c = 10-15°	MCL	---	Yellow to black	H 5.5-6 G 4.40	---
2.27	2.11	2.22	2.22	.11	VAUQUELINITE $Pb_2Cu(CrO_4)(PO_4)(OH)$	~ 0°	X = el	MCL wedge-shaped	Uneven	Green, brown	H 2.5-3 G 6.06 F 2	Diss by HNO_3. Pleoc, X pale green, Y and Z pale brown.
2.41	2.15	2.22	2.23	.08	GOETHITE FeO(OH)	Small r > v str	X = b Y = c	ORTH	010 perf 100 good	Yellow-brown, reddish-brown	H 5 G 3.8-4.2 infus	Diss by HCl. Pleoc, X clear yellow, Y brownish-yellow, Z orange-yellow, abs Z > Y > X.
	2.186	2.222	2.224	.038	FERVANITE $Fe^{+3}_4(VO_4)_4 \cdot 5H_2O$	~ 0°	---	MCL (?) fib c	---	Golden-brown	---	Diss by acids.
	2.10	---	2.30	.20	ROOSEVELTITE $BiAsO_4$	---	---	MCL	Conch	Gray to yellow	H 4-4.5 G 6.9-7.1 F 2-3	Diss by acids. Opt char unk.
	---	<2.23 >2.18	<2.26 >2.23	---	ONORATOITE $Sb_8O_{11}Cl_2$	---	X:c = 12° Y:a = 8°	TCL ps mcl acic	---	White	G 5.3	Diss by HCl.
	>2.11	>2.11	>2.11	---	MOCTEZUMITE $Pb(UO_2)(TeO_3)_2$	5-10°	---	MCL	100 perf	Bright orange	H 3 G 5.73	Diss by HCl or NaOH.
(2.03)	2.09	2.24	2.26	.17	TUNGSTITE $WO_3 \cdot H_2O$	27° r < v	X = c Y = b	ORTH	001 perf 010 good	Light- to greenish-yellow	H 1.5 G 5.52	Insol in acids, diss by NH_4OH.
	2.16	2.24	2.25	.09	CHLOROXIPHITE $Pb_3CuCl_2(OH)_2O_2$	70° r > v str	X = c Z = b	MCL bladed	$\bar{1}01$ perf 100 good	Olive-green	H 2.5 G 6.93 F easy	Diss by HNO_3. Pleoc, X pale yellow-brown, Y brown, Z green.
	2.24	---	2.26	.02	OBOYERITE $Pb_6H_6(TeO_3)_3(TeO_6)_2 \cdot 2H_2O$	---	---	TCL fib	---	White	H 1.5 G 6.46	Opt sign unk.
2.19 2.28	2.24	---	2.26	.02	FERGUSONITE-BETA $YNbO_4$	Small to 34°	---	MCL ps tet	Conch	Black	H 5.6 G 5.2-5.8 infus	Dec by H_2SO_4.
	2.17 2.21_{Li}	2.26 2.31_{Li}	2.32 2.33_{Li}	.15 $.12_{Li}$	MOTTRAMITE $Pb(Cu,Zn)(VO_4)(OH)$	73° r > v str	X = c Y = b	ORTH	Conch	Brownish-red to black, green	H 3.5 G 5.9 F 1.5	Diss by HNO_3. Pleoc, X pale yellow, Y and Z deep reddish-brown.
	2.18	2.27	2.35	.17	DESCLOIZITE $Pb(Zn,Cu)(VO_4)(OH)$	~ 90° r > v str	X = c Y = b	ORTH	Conch	Red, brown, black	H 3.5 G 6.2 F 1.5	Diss by HNO_3. Pleoc, X yellow, Y and Z deep reddish-brown.
2.30	---	2.25	2.40	---	IRANITE $Pb_{10}Cu(CrO_4)_6(SiO_4)_2(F,OH)_2$	---	Ext:el = 5°	TCL	---	Saffron-yellow	---	Pleoc, brownish-orange to yellow-orange.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orientation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
v (2.37)	---	2.29	---	str	FERROCOLUMBITE $(Fe,Mn)(Nb,Ta)_2O_6$	82°	X = a Y = b	ORTH	010 perf 100 good	Black	H 6 G 5.3 infus	Insol in acids. Tw pl 201.
2.27 □ 2.35	---	2.30	---	up to .025	LUESHITE $NaNbO_3$	46-80°	---	ORTH ps cub	---	Reddish-brown	H 5.5 G 4.35-4.52	Insol in acids.
	2.28	2.31	2.34	.06	MACQUARTITE $Pb_3Cu(CrO_4)SiO_3(OH)_4 \cdot 2H_2O$	85°	Y = b X:c = +35°	MCL	100 good	Orange	H 3.5 G 5.49	Dec by concd HCl.
	2.10	2.32	2.65	.55	HEMIHEDRITE $Pb_{10}Zn(CrO_4)_6(SiO_4)_2F_2$	88° horizontal disp	X:110 = 30°	TCL tab	110 poor	Bright orange to brown	H 3-3.5 G 6.42	Diss by HNO_3. Tw common $2\bar{2}3$ by reflection, less common $0\bar{1}0$.
	2.12	2.32	2.32	.20	SEELIGERITE $Pb_3(IO_3)Cl_3O$	4°	---	ORTH ps tet plates	001 perf 110 good	Bright yellow	G 6.8	---
2.30 pos ^	2.27	2.32	2.34	.07	NIOBO-AESCHYNITE $(Ce,Ca,Th)(Nb,Ti)_2(O,OH)_6$	85°	X = a Y = b	ORTH	Conch	Black	H 5-5.5 G 5.04	---
	2.30_{Li}	2.34_{Li}	2.36_{Li}	.06	NADORITE $PbSbO_2Cl$	~ 90°	X = b Y = c el cTv pos	ORTH tab	010 perf	Brown to yellow	H 3.5-4 G 7.02 F 1.5	Diss by HNO_3. Tw pl 101.
	2.31	2.35	2.4	.1	ASHANITE $(Nb,Ta,U,Fe,Mn)_4O_8$	70-75°	X = b Y = a	ORTH	Conch	Brownish-black	G 6.61	Pleoc, brownish-yellow to reddish-brown, abs Z > X.
	2.18	2.35	2.35	.17	VALENTINITE Sb_2O_3	Very small r < v	X = a Y = b el pos	ORTH pris	110 perf 010 poor	Cols to yellow	H 2.5 G 5.76 F 1.5	Diss by HCl. Prism faces commonly striated 001.
	2.25_{Li}	2.35_{Li}	2.36_{Li}	$.11_{Li}$	SCHWARTZEMBERGITE $Pb_6(IO_3)_2Cl_4O_2(OH)_2$	Small disp wk	---	ORTH ps tet	001 good	Honey-yellow to reddish-brown	H 2 G 7.39 F 1	Diss by acids. Crystals divided into biax sectors.
	2.20	2.36	2.36	.16	EMBREYITE $Pb_5(CrO_4)_2(PO_4)_2 \cdot H_2O$	0-11°	Y = b	MCL tab	Conch	Orange	H 3.5 G 6.45	Pleoc, X honey-yellow, Y and Z amber.
2.16 ^	2.30	2.36	2.38	.08	BISMUTITE $Bi_2(CO_3)O_2$	45°	X = c el pos	ORTH platy	---	Yellow to dark gray	H 3.5 G 8.11 F 1.5	Diss by acids. Striated 100.

	2.32	<u>2.36</u>	2.37	.05	PYROBELONITE $PbMn(VO_4)(OH)$	29° r > v	X = <u>a</u> Y = <u>c</u>	ORTH acic	Conch	Bright red	H 3.5 G 6.45	Pleoc in reddish-brown, abs Y > X and Z.
2.29 ◊ (2.41)	2.34	(<u>2.37</u>)	2.40	.06	MAGNOCOLUMBITE $(Mg,Fe,Mn)(Nb,Ti)_2O_6$	80°	X = <u>a</u> Y = <u>b</u>	ORTH	010, 100	Black to brownish-black	H 6 G 5.2 infus	Insol in acids. Pleoc, X brownish-yellow, Z brownish-red.
2.19 ^	2.21	<u>2.38</u>	2.41	.20	BADDELEYITE ZrO_2	31° r > v str	Y = <u>b</u> X:<u>c</u> = 13°	MCL pris	001 perf 010 good	Cols, brown, black	H 6.5 G 5.62 infus	Insol in acids. Poly tw on 100 and 110. Pleoc wk, abs X > Y > Z.
	2.37	(<u>2.38</u>)	2.39	.02	LANDAUITE $NaMnZn_2(Ti,Fe)_6Ti_{12}O_{38}$	60° r > v wk	---	MCL	Conch	Black to greenish-brown	H 7.5 G 4.42	Pleoc, X and Z bottle green, Y green, abs Z > Y > X.
2.27 [] 2.40	---	<u>2.38</u>	---	wk	PEROVSKITE $CaTiO_3$	~ 90° r > v	X = <u>a</u> Y = <u>c</u>	ORTH ps cub	100 poor fr sub-conch	Brown to black	H 5.5 G 4.0-4.3 infus	Dec by hot H_2SO_4. Penet or poly tw on 001.
	2.25	<u>2.382</u>	2.41	.16	CHERVETITE $Pb_2V_2O_7$	50° disp wk inclined	---	MCL	100, 010 (?)	Cols, gray, brown	H < 3 G 6.31	Tw 100.
2.22 ^	2.275	<u>2.41</u>	2.415	.140	GOETHITE $FeO(OH)$	Small r > v str	X = <u>b</u> Y = <u>c</u>	ORTH pris	010 perf 100 good	Yellow-brown, reddish-brown	H 5.5 G 4.28 infus	Diss by HCl. Pleoc, X clear yellow, Y brownish-yellow, Z orange-yellow, abs Z > Y > X.
(2.37) ^	2.36	(<u>2.41</u>)	2.44	.08	MANGANOCOLUMBITE $(Mn,Mg,Fe)(Nb,Ta)_2O_6$	80°	X = <u>a</u> Y = <u>b</u>	ORTH	010 perf 100 good	Reddish-brown to black	H 6 G 5.4 infus	Insol in acids. Tw pl 201. Pleoc, X yellow-brown, Z red-brown. MnO 11.8, FeO 7.9%.
	>2.42	---	>2.42	---	BISMITE Bi_2O_3	Disp str	---	MCL mass	---	Gray, green, yellow	H 4.5 G 8.6	Opt char unk.
	2.44	<u>2.47</u>	2.48	.04	GIRDITE $Pb_3H_2(TeO_3)TeO_6$	70° r > v str	Z = <u>b</u> X:<u>c</u> = 34°	MCL spher	---	Cols	H 2 G 5.5 fus	Diss by HNO_3.
	<1.83	<u>2.49</u>	>2.70	>.87	MARGARITASITE $(Cs,K,H_3O)_2(UO_2)_2(VO_4)_2 \cdot H_2O$	45.5°	---	MCL	---	Yellow	G 5.41	Data for synth Cs compd.
	2.41_{Li}	<u>2.50_{Li}</u>	2.51_{Li}	$.10_{Li}$	PUCHERITE $BiVO_4$	19° r < v	X = <u>c</u> Y = <u>a</u> el c̄lv pos	ORTH tab	001 perf	Reddish-brown	H 4 G 6.57 F 2	Diss by acids.
	2.45_{Li}	<u>2.55_{Li}</u>	2.55_{Li}	$.10_{Li}$	HEMATITE, var Turgite (impure) $Fe_2O_3{+}xH_2O$	~ 0°	---	TRIG mass compact	Subconch	Red to brownish-black	H 5.5 G 5 infus	Diff diss by HCl. Pleoc wk in reds.

Table 7. Biaxial negative minerals (continued)

Other entries	Refractive index α	β	γ	Biref	MINERAL NAME and formula	$2V_x$ ($2V_x$ calc) disp	Optical orien-tation	SYSTEM and habit	CLEAVAGE or fracture	Color	Hardness, specific gravity, and fusibility	Remarks
	2.52_{Li}	2.61_{Li}	2.67_{Li}	$.15_{Li}$	KOECHLINITE Bi_2MoO_6	Large r < v str	X = c Y = a el clv neg	ORTH plates	010 perf	Greenish-yellow	G 8.3 fus	Diss by HCl. Contact and penet tw 101. Striated 010.
	---	2.63 calc	---	---	CLINOBISVANITE $BiVO_4$	Disp str	---	MCL	010 perf	Orange to yellow	G 6.95 calc	Opt char unk.
	---	2.63 red 3.17 blue	---	str	TENORITE CuO	---	Y = b Z ~ c	MCL	In zones perp 011, $0\bar{1}1$	Steel-gray to black	H 3.5 G 6.45	Diss by HCl. Tw common on 011. Pleoc in browns. Opt char unk.
	2.35_{Li}	2.64_{Li}	2.66_{Li}	$.31_{Li}$	TERLINGUAITE Hg_2ClO	20° (Li) r < v	---	MCL pris	$\bar{1}01$ perf	Sulfur- to greenish-yellow	H 2.5 G 8.73	Volat when heated.
	2.538 2.46_{Li}	2.684 2.59_{Li}	2.704 2.61_{Li}	.166 $.15_{Li}$	REALGAR AsS	41° r < v	Y = b X:c = -11°	MCL pris	010 good $\bar{1}01$, 100 120 poor	Red to orange-yellow	H 2 G 3.51 F 1	Dec by HNO_3. Contact tw 100. Striated 001.
	---	>2.72_{Li}	---	very str	DUFRENOYSITE $Pb_2As_2S_5$	---	---	MCL	010 perf	Lead gray	H 3 G 5.53 fus	Opt char unk.
	---	>2.72	---	very str	POLYBASITE $(Ag,Cu)_{16}Sb_2S_{11}$	22°	X = c Y = a	MCL ps hex tab	001 poor fr un-even	Black	H 2.5 G 6.31 F 1	Dec by HNO_3. Tw pl 110.
	---	>2.72	---	very str	MIARGYRITE $AgSbS_2$	Med	---	MCL	010 poor	Black	H 2.5 G 5.25 fus	Red in thin splinters.
	2.4_{Li}	2.81_{Li}	3.02_{Li}	$.62_{Li}$	ORPIMENT As_2S_3	76° r > v str	X = b Z:c = 2° el clv pos	MCL ps orth orth pris	010 perf sectile	Lemon- to brownish-yellow	H 2 G 3.49 volat	Tw pl 100. Pleoc, Y yellow, Z greenish-yellow.
	---	~3	---	extr	XANTHOCONITE Ag_3AsS_3	34° r < v	X = a Z = b el clv pos	MCL ps orth tab	100 perf	Red, orange, yellow	H 2.5 G 5.5 F 1	Dec by HNO_3. Tw 100.
	---	~3	---	extr	LIVINGSTONITE $HgSb_4S_8$	---	---	MCL acic	100 perf	Lead gray	H 2 G 4.81 F 1	Volat when heated. Pleoc wk in reds.

2.78_{Li} 3.08_{Na}	3.06_{Li} 3.18_{Na}	3.07_{Li} 3.19_{Na}	$.29_{Li}$ $.11_{Na}$	HUTCHINSONITE $(Pb,Tl)_2As_5S_9$	20° Li 37° Na r < v extr	X = a Y = b	ORTH pris	010 good fr conch	Deep cherry- red	H 2 G 4.6 fus	Pleoc wk in reds.
---	3.27	---	very str	SMITHITE $AgAsS_2$	65°	Y = b Z:c = 6° el clv pos	MCL	100 perf	Pale red	H 2 G 4.88 F 1	Dec by HNO_3.
3.19_{Li}	4.05_{Li}	4.30_{Li}	1.11_{Li}	STIBNITE Sb_2S_3	26° Li (46±2°)	X = c Y = a el clv neg	ORTH pris	010 perf 100, 110 poor	Lead gray	H 2 G 4.63 F 1	---

CHAPTER IV. MINERAL GROUPS (TABLES 8–38)

For these tables, the minerals are arranged in groups according to the chemical and physical characteristics they hold in common, following the terminology of Fleischer (1983). For each group, a brief statement of these common characteristics is given, followed by representative examples in tabular form. These are arranged in order of increasing refractive index, similar to the arrangement in the identification tables above but omitting in most cases those properties that are the same or nearly the same for all members of the group.

Not included are several groups, notably the chlorite, kaolinite-serpentine, and montmorillonite groups, mainly because of difficulties of nomenclature and lack of reliable criteria for distinguishing between the members under the microscope.

Table 8. Alunite group

The minerals of this group have the general formula $AB_6(SO_4)_4(OH)_{12}$, in which A may be K_2, Na_2, $(NH_4)_2$, Ag_2, $(H_3O)_2$, Ca (the hydronium ion), and Pb; B may be Al and Fe^{+3}. In beaverite and osarizawaite, A = Pb, B = Cu_2Al_4 or $Cu_2(Fe^{+3},Al)_4$.

Alunite	$KAl_3(SO_4)_2(OH)_6$
Alunite	$(K,Na)Al_3(SO_4)_2(OH)_6$
Ammoniojarosite	$(NH_4)Fe_3(SO_4)_2(OH)_6$
Argentojarosite	$AgFe_3(SO_4)_2(OH)_6$
Beaverite	$PbCu(Fe,Al)_2(SO_4)_2(OH)_6$
Hydronium Jarosite	$(H_3O)Fe_3(SO_4)_2(OH)_6$
Jarosite	$KFe_3(SO_4)_2(OH)_6$
Natroalunite	$NaAl_3(SO_4)_2(OH)_6$
Natroalunite	$(Na,K)Al_3(SO_4)_2(OH)_6$
Natrojarosite	$NaFe_3(SO_4)_2(OH)_6$
Osarizawaite	$PbCuAl_2(SO_4)_2(OH)_6$
Plumbojarosite	$PbFe_6(SO_4)_4(OH)_{12}$

These minerals are trigonal (pseudo-cubic), space group R3m (except plumbojarosite, $R\bar{3}m$). Distinct to perfect basal cleavage is characteristic, with hardness between 2 and 4. Optically, they are uniaxial, although some samples of jarosite are anomalously biaxial. The minerals of this group are closely related to those of the beudantite and plumbogummite groups.

Table 8. Alunite group (continued)

Refractive index		Biref	NAME	G
ω	ε			
1.572	1.592	(+).020	ALUNITE	2.6
1.574	1.590	(+).016	NATROALUNITE	2.78
1.583	1.595	(+).012	ALUNITE	2.7
1.603	1.611	(+).008	NATROALUNITE	2.8
1.714	1.731	(+).017	OSARIZAWAITE	4.04
1.791	1.705	(-).086	JAROSITE	2.9-3.2
1.800	1.750	(-).050	AMMONIOJAROSITE	3.11
1.815	1.740	(-).075	NATROJAROSITE	3.18
1.816	1.728	(-).088	HYDRONIUM JAROSITE	3.1-3.2 calc.
1.820	1.715	(-).105	JAROSITE	3.2
1.832	1.750	(-).082	NATROJAROSITE	3.18
1.85	(1.81)	(-).04	BEAVERITE	4.08-4.36
1.875	1.785	(-).090	PLUMBOJAROSITE	3.63
1.882	1.785	(-).097	ARGENTOJAROSITE	3.66

Table 9. Amphibole group

The amphiboles form a complex group of double-chain silicates having the general formula $A_{0-1}B_2C_5T_8O_{22}(OH,F,Cl)_2$, in which A may be Ca, Na, and K; B may be Fe^{+2}, Mg, Mn, and Li; C may be Al, Cr, Fe^{+2}, Fe^{+3}, Mg, and Mn; T may be mainly Si and Al but may have Cr, Fe^{+3}, and Ti. The nomenclature used here generally follows that recommended by the International Mineralogical Association (Leake, 1978).

		$\frac{Mg}{Mg + Fe^{+2}}$
A. Fe-Mg-Mn AMPHIBOLES		
1. Orthorhombic forms		
Anthophyllite	$(Mg,Fe^{+2})_7Si_8O_{22}(OH)_2$	0.1-0.9
Magnesio-anthophyllite		0.9-1.0
Gedrite	$(Mg,Fe^{+2})_5Al_2Si_6Al_2O_{22}(OH)_2$	0.1-0.9
Magnesio-gedrite		
Ferro-gedrite		0.9-1.0
Holmquistite	$Li_2(Mg,Fe^{+2})_3Al_2Si_8O_{22}(OH,F)_2$	0.1-0.9
2. Monoclinic forms		
Cummingtonite	$(Mg,Fe^{+2})_7Si_8O_{22}(OH)_2$	0.3-0.7
Grunerite		0.0-0.3
Tirodite	$Mn_2^{+2}(Mg,Fe^{+2})_5Si_8O_{22}(OH)_2$	0.5-1.0
Dannemorite		0.0-0.5
Clinoholmquistite	$Li_2(Mg,Fe^{+2})_3Al_2Si_8O_{22}(OH)_2$	0.1-0.9
B. CALCIC AMPHIBOLES		$Mg + Fe^{+2}$
Tremolite	$Ca_2(Mg,Fe^{+2})_5Si_8O_{22}(OH)_2$	0.9-1.0
Actinolite		0.5-0.9
Ferro-actinolite		0.0-0.5
Edenite	$NaCa_2(Mg,Fe^{+2})_5Si_7AlO_{22}(OH)_2$	0.5-1.0

Table 9. Amphibole group (continued)

		Mg
B. CALCIC AMPHIBOLES (continued)		
Hastingsite	$NaCa_2(Mg,Fe^{+2})_4Fe^{+3}Si_6Al_2O_{22}(OH)_2$	0.0-0.3
Magnesio-hastingsite		0.7-1.0
(Hornblende)		
Magnesio-hornblende	$Ca_2(Mg,Fe^{+2})_4AlSi_7AlO_{22}(OH,F)_2$	0.5-1.0
Ferro-hornblende		0.0-0.5
Kaersutite	$NaCa_2(Mg,Fe^{+2})_4TiSi_6Al_2O_{22}(OH)_2$	0.5-1.0
Pargasite	$NaCa_2(Mg,Fe^{+2})_4AlSi_6Al_2O_{22}(OH)_2$	0.3-1.0
Tschermakite	$Ca_2(Mg,Fe^{+2})_3Al_2Si_6O_{22}(OH)_2$	0.5-1.0
Ferrotschermakite		0.0-0.5
Ferro-ferri-tschermakite	$Ca_2(Fe^{+2},Mg)_5Fe_2^{+3}Si_6Al_2O_{22}(OH)_2$	
C. SODIC-CALCIC AMPHIBOLES		
Richterite	$Na_2Ca(Mg,Fe^{+2})_5Si_8O_{22}(OH)_2$	0.5-1.0
Ferro-richterite		0.0-0.5
Taramite	$Na_2Ca(Fe^{+2},Mg)_3Al_2Si_6Al_2O_{22}(OH)_2$	0.0-0.5
D. ALKALI AMPHIBOLES		$Mg + Fe^{+2}$
Arfvedsonite	$Na_3(Mg,Fe^{+2})_4Fe^{+3}Si_8O_{22}(OH,F)_2$	0.0-0.5
Magnesio-arfvedsonite		0.5-1.0

		Mg
D. ALKALI AMPHIBOLES (continued)		
Eckermannite Kozulite	$Na_3(Mg,Li,Fe^{+2})_4(Al,Fe^{+3})Si_8O_{22}(OH)_2$	0.5-1.0
Glaucophane	$Na_2(Mg,Fe^{+2})_3Al_2Si_8O_{22}(OH)_2$	0.5-1.0
Ferro-glaucophane		0.0-0.5
Crossite	$Na_2(Mg,Fe^{+2})_3(Al,Fe^{+3})_2Si_8O_{22}(OH)_2$	
Riebeckite	$Na_2(Mg,Fe^{+2})_3Fe_2^{+3}Si_8O_{22}(OH)_2$	0.0-0.5
Magnesio-riebeckite		0.5-0.1

Members of this group may be orthorhombic, space group Pnma, or monoclinic, space group C2/m (also $P2_1/m$). They are generally prismatic with perfect cleavage on {210} at 124-126°. The orthorhombic amphiboles have orientation Y=b and Z=c; most monoclinic amphiboles have Y=b and Z:c=4-26°, thus with positive elongation. Some alkali amphiboles, such as riebeckite, eckermannite, and crossite, have Z:c > 45°, therefore with negative elongation. All amphiboles have hardness from 4.5 to 6.5 and are insoluble in all acids except HF. In general, the refractive indices increase with increasing content of iron and titanium, but the substitutions are so complex that it is difficult to deduce chemical composition from refractive indices alone.

Table 9. Amphibole group (continued)

A. Fe-Mg-Mn AMPHIBOLES

1. Orthorhombic forms

Refractive index			NAME	2V	Wt. pct. selected oxides			Remarks
α	β	γ			Al_2O_3	Fe_2O_3	FeO	
1.593	1.605	1.613	MAGNESIO-ANTHOPHYLLITE	(-)65°	1.6	0.3	---	
1.613	1.625	1.634	MAGNESIO-GEDRITE	(-)71° (86±12°)	16.1	0.3	1.5	
1.616	1.628	1.641	ANTHOPHYLLITE	(+)79° (88±9°)	1.9	---	11.1	
1.616	1.630	1.641	ANTHOPHYLLITE	(-)88°	0.2	1.0	11.7	
1.616	1.634	1.646	HOLMQUISTITE	(-)56° r > v wk	14.3	1.0	7.3	Li_2O_3 3.2%. Pleoc, X and Y cols, Z lilac.
1.624	1.645	1.651	HOLMQUISTITE	(-)50° r > v wk	13.0	2.2	8.9	Li_2O 2.4%. Pleoc, X grayish-yellow, Y lavender, Z blue.
1.645	1.649	1.661	ANTHOPHYLLITE	(+)59°	1.8	1.8	20.5	
1.648	1.655	1.662	GEDRITE	(+)87°	13.3	1.3	14.6	
1.654	1.660	1.667	ANTHOPHYLLITE	(+)81°	8.1	2.2	18.4	
1.657	1.667	1.678	GEDRITE	(+)87°	17.8	1.0	18.3	

Table 9. Amphibole group (continued)

A. Fe-Mg-Mn AMPHIBOLES (continued)

1. Orthorhombic forms (continued)

Refractive index			NAME	2V	Wt. pct. selected oxides			Remarks
α	β	γ			Al_2O_3	Fe_2O_3	FeO	
1.671	1.681	1.690	FERRO-GEDRITE	(-)75°	18.7	0.9	24.4	
1.680	1.688	1.700	FERRO-GEDRITE	(+)83°	17.7	3.6	26.2	
1.694	1.710	1.722	FERRO-GEDRITE	(-)82°	19.7	2.3	33.5	MnO 2.3%, Pleoc, X pale green, Y brown-green, Z bluish green.

2. Monoclinic forms

Refractive index			NAME	2V	Z:c	Wt. pct. selected oxides				Remarks
α	β	γ				Al_2O_3	Fe_2O_3	FeO	MnO	
1.610	1.627	1.633	CLINOHOLMQUISTITE	(-)58°	(X:a= 16°)	13.5	0.4	5.9	0.5	
1.630	1.640	1.655	CUMMINGTONITE	(+)78° r > v	20°	2.8	1.9	16.8	0.8	Pleoc wk, X cols, Y and Z pale green.
1.630	1.644	1.652	TIRODITE	(+)73°	20°	---	---	5.0	16.6	

Table 9. Amphibole group (continued)

A. Fe-Mg-Mn AMPHIBOLES (continued)

2. Monoclinic forms (continued)

Refractive index			NAME	2V	Z:c	Wt. pct. selected oxides				Remarks
α	β	γ				Al_2O_3	Fe_2O_3	FeO	MnO	
1.638	1.651	1.665	TIRODITE	(+)89° r > v	19°	---	---	11.1	13.2	Pleoc wk in green.
1.651	1.664	1.678	CUMMINGTONITE	(+)86° r > v	17°	2.4	---	28.0	1.0	Pleoc in green.
1.650	1.665	1.679	GRUNERITE	(-)87° r < v	16°	---	0.6	21.9	8.0	Pleoc, X and Y yellow, Z brownish yellow.
1.660	1.677	1.693	GRUNERITE	(-)large r < v	---	---	3.4	31.2	---	Pleoc, X pale yellow, Z brown.
1.666	1.682	1.698	DANNEMORITE	(-)88° r < v	15°	---	---	22.6	15.6	Pleoc, X red-violet, Y pale violet, Z blue.
1.679	1.700	1.719	GRUNERITE	(-)86° r < v	14°	---	---	45.0	0.4	Pleoc, X and Y cols, Z yellow to brown.

Table 9. Amphibole group (continued)

B. CALCIC AMPHIBOLES

Refractive index			NAME	2V	Z:c	Wt. pct. selected oxides						Remarks
α	β	γ				Al_2O_3	Fe_2O_3	FeO	MnO	CaO	Na_2O	
1.581	1.593	1.602	TREMOLITE	(-)86°	21°	---	---	---	---	---	---	Synthetic fluor-tremorite.
1.600	1.615	1.627	TREMOLITE	(-)79° (63±8°) r < v wk	15°	---	---	0.6	---	---	---	
1.613	1.618	1.635	PARGASITE	(+)61°	26°	11.1	0.7	1.7	---	12.5	2.5	K_2O 1.2%.
1.622	1.632	1.642	ACTINOLITE	(-)80°	26°	2.2	2.8	7.2	---	---	---	
1.632	1.634	1.651	PARGASITE	(+)64°	17°	13.3	---	4.0	---	10.2	2.6	
1.633	1.642	1.652	MAGNESIO-HORNBLENDE	(-)88°	16°	5.0	2.7	8.7	---	---	---	Pleoc, X yellow, Y and Z green.
1.629	1.643	1.650	ACTINOLITE	(-)73° r < v	---	---	2.4	0.8	---	---	---	
1.634	1.645	1.658	EDENITE	(-)74° (94±10°)	---	---	3.4	9.0	0.3	---	---	
1.641	1.651	1.664	PARGASITE	(+)82°	18°	15.3	1.1	8.9	---	12.2	---	

Table 9. Amphibole group (continued)

B. CALCIC AMPHIBOLES (continued)

Refractive index			NAME	2V	Z:c	Wt. pct. selected oxides						Remarks
α	β	γ				Al_2O_3	Fe_2O_3	FeO	MnO	CaO	Na_2O	
1.642	1.652	1.660	PARGASITE	(-)88°	---	19.3	0.9	6.1	---	---	---	MgO 14.3%.
1.650	1.663	1.670	ACTINOLITE	(-)65°	---	---	3.9	14.9	0.3	---	---	
1.650	1.664	1.671	TSCHERMAKITE	(-)81°	---	---	2.4	9.5	---	---	---	TiO_2 2.4%.
1.652	1.664	1.672	MAGNESIO-HASTINGSITE	(-)80°	19°	14.3	2.6	8.7	---	---	---	TiO_2 1.3%. Pleoc, X pale brown, Y dark brown, Z greenish-brown.
1.657	1.670	1.679	MAGNESIO-HORNBLENDE	(-)78°	---	---	4.7	13.2	0.3	---	---	MgO 10.6%.
1.660	1.671	1.687	FERROTSCHERMAKITE	(+)78°	18°	11.2	9.3	15.8	---	10.2	1.3	
1.665	1.678	1.684	EDENITE	(-)65°	19°	7.8	6.2	13.4	---	---	---	Pleoc, X yellow, Y pale green, Z dark green.
1.667	1.680	1.687	PARGASITE	(-)74°	---	---	4.9	9.9	---	---	---	MgO 11.6, TiO_2 1.9%.
1.670	1.685	1.693	FERRO-HORNBLENDE	(-)61° (72±10°)	18°	13.9	5.4	18.1	---	---	---	Pleoc, X greenish-yellow, Y olive-green, Z bluish-green.

Table 9. Amphibole group (continued)

B. CALCIC AMPHIBOLES (continued)

Refractive index			NAME	2V	Z:c	Wt. pct. selected oxides						Remarks
α	β	γ				Al_2O_3	Fe_2O_3	FeO	MnO	CaO	Na_2O	
1.676	1.687	1.695	MAGNESIO-HASTINGSITE	(-)80°	15°	13.9	4.8	6.9	---	---	---	TiO_2 4.4%.
1.670	1.692	1.701	KAERSUTITE	(-)81° (64±8°)	9°	14.2	3.3	5.7	---	---	---	TiO_2 5.7%. Pleoc, X yellow-brown, Y red-brown, Z dark red-brown.
1.674	1.693	1.700	FERRO-FERRI-TSCHERMAKITE	(-)62°	---	---	5.5	20.4	---	---	---	Ti_2 1.8%.
1.688	1.709	1.714	HASTINGSITE	(-)51°	12°	11.5	5.9	22.9	---	---	---	TiO_2 1.7%. Pleoc, X greenish-yellow, Y dark olive, Z dark green.
1.687	1.710	1.725	KAERSUTITE	(-)77°	4°	15.5	9.3	4.9	---	---	---	TiO_2 5.9%.
1.694	1.730	1.757	KAERSUTITE	(-)80°	small	---	12.4	7.7	---	---	---	TiO_2 6.0%.
1.705	1.731	1.732	HASTINGSITE	(-)25°	13°	11.5	11.6	22.0	0.6	---	---	

Table 9. Amphibole group (continued)

C. SODIC-CALCIC AMPHIBOLES

Refractive index			NAME	2V	Z:c	Wt. pct. selected oxides					Remarks
α	β	γ				Al_2O_3	Fe_2O_3	FeO	MnO	CaO	
1.605	1.615	1.622	RICHTERITE	med large r < v wk	25°	---	---	---	---	---	
1.616	(1.627)	1.632	RICHTERITE	(-)70°	26°	1.7	0.6	0.6	---	---	TiO_2 3.5%.
1.617	1.631	1.637	RICHTERITE	(-)68°	18°	3.0	3.7	0.6	5.4	---	
1.688	1.699	1.704	FERRO-RICHTERITE	(-)35° (68±15°) r < v	---	---	6.2	27.3	1.1	6.1	
1.684	1.700	1.703	TARAMITE	(-) (46±15°)	---	15.8	9.6	13.0	---	---	Pleoc, X greenish-yellow, Y dark olive, Z dark green.
1.705	1.713	1.715	TARAMITE	(-)54°	11°	10.3	13.1	18.7	1.9	---	Pleoc, X yellow, Y blue-green, Z deep blue.

Table 9. Amphibole group (continued)

D. ALKALI AMPHIBOLES

Refractive index			NAME	2V	Z:c	Wt. pct. selected oxides						Remarks
α	β	γ				Al_2O_3	Fe_2O_3	FeO	MnO	CaO	Na_2O	
1.624	1.631	1.637	ECKERMANNITE	(-)72°	41°	1.2	8.2	---	1.2	---	---	TiO_2 0.3%. Pleoc, X rose, Y lilac, Z pale blue.
1.620	1.637	1.642	GLAUCOPHANE	(-)51° r < v str	5°	10.1	2.0	10.6	---	---	---	Pleoc, X cols, Y lavender, Z blue.
1.638	1.643	1.650	MAGNESIO-ARFEDSONITE	(+)80°	39°	---	---	8.3	6.0	---	---	
1.636	1.644	1.649	ECKERMANNITE	(-)74°	65°	---	9.5	1.9	---	---	---	Pleoc, X and Y bluish-green, yellow-green.
1.634	1.648	1.653	CROSSITE	(-)small (61±13°)	82°	8.4	6.4	7.5	---	---	---	Pleoc, X yellow, Y lavender, Z blue.
1.645	1.656	1.661	MAGNESIO-ARFEDSONITE	(-)57°	56°	---	8.4	13.4	1.5	---	---	MgO 7.8, F 3.3%. Pleoc, X blue-green, Y green, Z pale green.
1.641	1.659	1.662	FERRO-GLAUCOPHANE	(-)42° r < v str	6°	10.1	4.0	17.9	---	---	---	Pleoc, X cols, Y violet, Z blue.
1.654	1.662	1.668	MAGNESIO-RIEBECKITE	(-)med large	81°	0.4	15.9	3.6	0.1	---	4.5	Pleoc, X dark blue, Y indigo blue, Z yellow-green.

Table 9. Amphibole group (continued)

D. ALKALI AMPHIBOLES (continued)

Refractive index			NAME	2V	Z:c	Wt. pct. selected oxides						Remarks
α	β	γ				Al_2O_3	Fe_2O_3	FeO	MnO	CaO	Na_2O	
1.667	1.683	1.692	MANGANOAN MAGNESIO-ARFEDSONITE	(-)6° (72±9°)	3°	---	9.1	1.0	7.7	---	9.0	Pleoc, X and Y blue-green, Z yellow-green.
1.694	1.697	1.698	RIEBECKITE	(-)81°	X~c	---	18.3	9.5	6.0	---	---	Pleoc, X and Y dark blue, Z yellow-green.
1.685	1.717	1.720	KOZULITE	(-)35° r > v wk	65°	1.7	2.9	0.0	28.0	1.1	8.4	Pleoc, X yellow-brown, Y reddish brown, Z dark brown.

Table 10. Apatite group

This group includes phosphates, arsenates, and vanadates of general formula $A_5(XO_4)_3(F,Cl,OH)$, in which A may be Ba, Ca, Ce, K, Na, Pb, Sr, and Y; X may be As, C, P, S, Si, and V. Whereas the silicates britholite, britholite-(Y), ellestadite, and hydroxylellestadite are not, strictly speaking, members of the apatite group, they are included here because they intergrade with the phosphates of the apatite group.

Alforsite	$Ba_5(PO_4)_3Cl$
Apatite-britholite	$(Ca,Ce)_5(PO_4,SiO_4)_3F$
Belovite	$(Sr,Ce,Na,Ca)_5(PO_4)_3(OH)$
Britholite	$(Ce,Ca,Y)_5(SiO_4)_3(OH,F)$
Britholite-(Y)	$(Y,Ca,Ce)_5(SiO_4,PO_4)_3(OH,F)$
Carbonate-fluorapatite	$Ca_5(PO_4,CO_3)(F,OH)$
Carbonate-hydroxylapatite	$Ca_5(PO_4,CO_3)_3(OH,F)$
Chlorapatite	$Ca_5(PO_4)_3(Cl,F,OH)$
Ellestadite	$Ca_5[(Si,S,P)O_4]_3(F,OH,Cl)$
Fermorite	$(Ca,Sr)_5(PO_4,AsO_4)(OH,F)$
Fluorapatite	$Ca_5(PO_4)_3F$
Hedyphane	$(Ca,Pb)_5(AsO_4)_3Cl$
Hydroxylapatite	$Ca_5(PO_4)_3(OH,F)$
Hydroxyl-ellestadite	$Ca_5[(Si,S)O_4]_5(OH,Cl,F)$
Johnbaumite	$Ca_5(AsO_4)_3(OH)$
Mimetite	$Pb_5(AsO_4)_3Cl$
Morelandite	$(Ba,Ca,Pb)_5(AsO_4)_3Cl$
Pyromorphite	$Pb_5(PO_4)_5Cl$
Strontium-apatite	$(Sr,Ca,Ba)_5(PO_4)_3(F,OH)$
Svabite	$Ca_5(AsO_4,PO_4)_3(F,OH)$
Vanadinite	$Pb_5(VO_4)_3Cl$

These minerals are hexagonal or monoclinic (pseudohexagonal). They are infusible to difficultly fusible, except for the lead members, which fuse easily. All are readily attacked by HNO_3; britholite gels and britholite-(Y) is decomposed. Optically they are uniaxial or biaxial with small optic angle. All except vanadinite have low birefringence.

Refractive index			Biref	NAME	2V	G	Remarks
α or ε	β or ω	γ or ε					
	1.569			CARBONATE-FLUORAPATITE		2.6	Isotropic.
	1.59			CARBONATE-FLUORAPATITE		2.6-2.7	Isotropic.
1.598	1.603		.005	CARBONATE-HYDROXYL-APATITE	(-)0°	2.9	
1.612	1.621	1.622	.010	CARBONATE-FLUORAPATITE	(-)small	3.04	
1.614	1.622		.008	CARBONATE-FLUORAPATITE	(-)0°	3.05	
1.622	1.627	1.627	.005	CARBONATE-FLUORAPATITE	(-)0-25°	3.1-3.2	
	1.63			CARBONATE-FLUORAPATITE		2.7	Isotropic.
1.630	1.633		.003	FLUORAPATITE	(-)0°	3.2	
1.634	1.638		.004	FLUORAPATITE	(-)0°	3.32	
1.633	1.640		.007	CARBONATE-FLUORAPATITE	(-)0°	3.05	
1.638	1.644		.006	FLUORAPATITE	(-)0°	3.26	
1.642	1.649	1.649	.007	CHLORAPATITE	(-)5-10°	3.18	
1.637	1.651		.014	STRONTIUM-APATITE	(-)0°	3.84	
1.644	1.651		.007	HYDROXYL-APATITE	(-)0°	3.21	F 0.16, H_2O 1.86%.

Table 10. Apatite group (continued)

Refractive index			Biref	NAME	2V	G	Remarks
α or ε	β or ω	γ or ε					
1.650	1.654		.004	HYDROXYL-ELLESTADITE	(-)0°	3.02	
1.650	1.655		.005	ELLESTADITE	(-)0°	3.1-3.2	SiO_2 17.3, SO_3 20.7, P_2O_5 3.1%.
1.653	1.658		.005	CHLORAPATITE	(-)0°	3.18	
1.640	1.660		.020	BELOVITE	(-)0°	4.18	
	1.66		wk	FERMORITE	(-)0°	3.52	
1.660	1.666		.006	CHLORAPATITE	(-)0°	3.2	
1.665	1.667	1.667	.002	CHLORAPATITE	(-)10°	3.18	
1.672	1.684		.012	SVABITE	(-)0°	3.54	P_2O_5 12.5, F 1.4%.
1.684	1.687		.003	JOHNBAUMITE	(-)0°	3.68	
1.694	1.696		.002	ALFORSITE	(-)0°	4.80	
1.699	1.703		.004	APATITE-BRITHOLITE	(-)0°	3.83	P_2O_5 17.3, SiO_2 12.9, Ce_2O_3 12.9%.
	1.72		.000	BRITHOLITE	---	3.85	Isotropic.
	1.728	1.730	.002	BRITHOLITE-(Y)	(+)0°	4.25	
	1.75		.000	BRITHOLITE	---	3.85	Isotropic.
1.748	1.752		.004	BRITHOLITE	(-)0°	4.1-4.4	
1.772	1.775	1.777	.005	BRITHOLITE	(-)0-44°	4.0-4.5	
	1.780	1.783	.003	BRITHOLITE-(Y)	(+)0°	4.35	
	1.81		.000	BRITHOLITE	---	4.1	Isotropic.

Table 10. Apatite group (continued)

Refractive index			Biref	NAME	2V	G	Remarks
α or ε	β or ω	γ or ε					
	1.880	1.884	.004	MORELANDITE	(+)0°	5.33	
	1.948	1.958	.010	HEDYPHANE	(+)0°	5.7	
2.010	2.026		.016	HEDYPHANE	(-)0°	5.82	
2.042	2.050	2.050	.008	PYROMORPHITE	(-)small	7.05	
2.046	2.057		.011	PYROMORPHITE	(-)0°	7.0-7.1	Anom biax. Pleoc, O green, E greenish yellow.
2.12	2.13	2.135	.015	MIMETITE	(-)29°	7.1	
2.12	2.135		.01	MIMETITE	(-)0°	7.1-7.24	
2.20	2.25		.05	VANADINITE	(-)0°	7.0	Arsenatian var.
2.37	2.43		.06	VANADINITE	(-)0°	6.65-6.98	

Table 11. Aragonite group

Minerals of this group have the general formula RCO_3, in which R may be Ca, Sr, Ba, and Pb. They are orthorhombic, space group Pmcn, with twinning on {110} very common, giving pseudo-hexagonal aggregates. Hardness is 3 to 4. The minerals are soluble in HCl with effervescense. All are biaxial negative, with very high birefringence and small optic angle.

Refractive index			Biref	NAME and formula	(-)2V	G	Remarks
α	β	γ					
1.520	1.667	1.668	.148	STRONTIANITE $SrCO_3$	7°	3.68	
1.529	1.676	1.677	.148	WITHERITE $BaCO_3$	16°	4.29	
1.530	1.680	1.685	.155	ARAGONITE $CaCO_3$	18°	3.32	
1.525	1.686	1.690	.165	STRONTIANITE $(Sr,Ba,Ca)CO_3$	8°	3.81	BaO 3.3, CaO 1.0%.
1.540	1.695	1.703	.163	ARAGONITE $(Ca,Pb)CO_3$	23°	3.05	Pb 5.2%.
1.804	2.074	2.076	.272	CERUSSITE $PbCO_3$	9°	6.55	

Table 12. Autunite group

The minerals of this group have the general formula $A(UO_2)_2(XO_4)_2 \cdot 8\text{-}12H_2O$, in which A may be Ba, Ca, Cu, Fe^{+2}, 1/2 (HAl), Mg, Mn, Na_2, and (UO_2), and X may be As, P, and V. The water is of zeolitic character, and the minerals are readily transformed reversibly into the respective lower hydrates of the meta-autunite group (which see).

Autunite	$Ca(UO_2)_2(PO_4)_2 \cdot 10\text{-}12H_2O$
Heinrichite	$Ba(UO_2)_2(AsO_4)_2 \cdot 10\text{-}12H_2O$
Kahlerit	$Fe(UO_2)_2(AsO_4)_2 \cdot 10\text{-}12H_2O$
Novacekite	$Mg(UO_2)_2(AsO_4)_2 \cdot 10\text{-}12H_2O$
Sabugalite	$HAl(UO_2)_4(PO_4)_4 \cdot 16H_2O$
Saleeite	$Mg(UO_2)_2(PO_4)_2 \cdot 10H_2O$
Sodium autunite	$Na_2(UO_2)_2(PO_4)_2 \cdot 8H_2O$
Torbernite	$Cu(UO_2)_2(PO_4)_2 \cdot 10\text{-}12H_2O$
Troegerite	$(UO_2)(UO_2)_2(AsO_4)_2 \cdot 12H_2O$
Unnamed analogue of Troegerite	
Uranocircite	$Ba(UO_2)(PO_4)_2 \cdot 12H_2O$
Uranospinite	$Ba(UO_2)(AsO_4)_2 \cdot 8H_2O$
Zeunerite	$Cu(UO_2)(AsO_4)_2 \cdot 10\text{-}12H_2O$

These minerals are tetragonal, space group I4/mmm. Crystals are typically square tabular in form with yellow to green color. Optically the members have negative sign, mostly uniaxial, but often showing anomalous biaxial character. Most show moderate to weak birefringence with pleochroism in shades of yellow or green. All except those containing Fe or Cu fluoresce under ultraviolet light.

Refractive index			Biref	NAME	(-)2V	G
α or ε	β or ω	γ				
1.55	1.567	1.572	.022	URANOSPINITE	62°	3.45
1.543	1.570	1.577	.034	NOVACEKITE	40°	3.23
1.559	1.570	1.574	.015	SALEEITE	65°	3.27

Table 12. Alunite group (continued)

Refractive index			Biref	NAME	(-)2V	G
α or ε	β or ω	γ				
1.552	1.574		.022	Unnamed analogue of TROEGERITE	0°	3.76
1.559	1.574		.015	SALEEITE	0°	3.27
1.572	1.575		.003	AUTUNITE	0°	3.2
1.555	1.575	1.577	.022	AUTUNITE	53°	3.1-3.2
1.548	1.578		.030	NOVACEKITE	0°	3.23
1.559	1.578		.019	SODIUM AUTUNITE	0°	3.58
1.564	1.582		.018	SABUGALITE	0°	3.20
1.565	1.582	1.585	.020	SALEEITE	65°	3.27
1.564	1.582	1.584	.020	SABUGALITE	35°	3.20
1.574	1.583	1.588	.014	URANOCIRCITE	60-70°	---
1.560	1.586		.026	URANOSPINITE	0°	3.45
e 1.578	1.586		.008	AUTUNITE	0°	3.2
1.582	1.592		.010	TORBERNITE	0°	3.22
1.566	1.592	1.596	.030	URANOSPINITE	25-35°	3.45
1.581	1.592	1.592	.011	TORBERNITE	small	3.22
1.574	1.605		.031	HEINRICHITE	0°	---
1.585	1.613		.028	ZEUNERITE	0°	3.4
1.582	1.627		.045	TROEGERITE	0°	3.3
---	1.632	1.634	---	KAHLERITE	9-33°	---

Table 13. Barite group

Members of this group are sulfates with the general formula XSO_4, in which X may be Ba, Sr, and Pb. They are orthorhombic, space group Pnma, with perfect cleavage on {001}. Optically they are biaxial positive, with X=c, Y=b, dispersion r < v.

Refractive index			Biref	NAME and formula	(+)2V	G
α	β	γ				
1.622	1.624	1.631	.009	CELESTITE $SrSO_4$	51°	3.96
1.636	1.637	1.648	.012	BARITE $BaSO_4$	37°	4.50
1.693	(1.697)	1.718	.025	BARITE $(Ba,Pb)SO_4$	~ 50°	~ 5
1.877	1.883	1.894	.017	ANGLESITE $PbSO_4$	68-75°	6.38

Table 14. Beudantite group

The minerals of this group have the general formula $AB_3(SO_4)(XO_4)(OH)_6$, in which A may be Ba, Ca, Pb, and Sr; B may be Al and Fe^{+3}; X may be P and As, with the ratio SO_4:XO_4 varying somewhat from 1. The minerals of this group are closely related to the sulfates of the alunite group and the phosphates of the plumbogummite group.

Beudantite	$PbFe_3(AsO_4,SO_4)_2(OH)_6$
Corkite	$PbFe_3(PO_4)(SO_4)(OH)_6$
Hidalgoite	$PbAl_3(AsO_4)(SO_4)(OH)_6$
Hinsdalite	$PbAl_3(PO_4)(SO_4)(OH)_6$
Kemmlitzite	$(Sr,Ce)Al_3(AsO_4)(SO_4,PO_4)(OH)_6$
Svanbergite	$SrAl_3(PO_4)(SO_4)(OH)_6$
Weilerite	$BaAl_3(AsO_4)(SO_4)(OH)_6$
Woodhousite	$CaAl_3(PO_4)(SO_4)(OH)_6$

Table 14. Beudantite group (continued)

They are trigonal, pseudo-cubic, space group $R\bar{3}m$. Distinct to perfect basal cleavage and low birefringence are characteristic, with anomalous biaxial samples not uncommon.

Refractive index			Biref	NAME	2V	G
α or ε	β or ω	γ or ε				
	1.626	1.640	.014	SVANBERGITE	(+)0°	2.98-3.22
	1.636	1.647	.011	WOODHOUSEITE	(+)0°	3.01
	1.639	1.646	.007	SVANBERGITE	(+)0°	2.98-3.22
	1.662	1.669	.007	WOODHOUSEITE	(+)0°	2.9-3.0
	1.67	1.70	.03	HINSDALITE	(+)0°	3.65
	1.671	1.689	.019	HINSDALITE	(+)0-30°	3.65
	1.688	1.698	.010	WEILERITE	(+)0°	---
	1.688	1.697	.009	HINSDALITE	(+)0°	3.65
	1.701	1.707	.006	KEMMLITZITE	(+)0°	3.63
	1.71	---	.005	HIDALGOITE	(+)0°	3.96
	1.730	1.735	.005	HIDALGOITE	(+)0°	3.95
1.909	1.916		.007	BEUDANTITE	(-)0°	4.0-4.3
---	1.93		wk	CORKITE	(-)0°	4.2-4.3
---	1.93	---	wk	CORKITE	(-)med	4.20
1.943	1.957		.014	BEUDANTITE	(-)0°	4.0-4.3
1.94	1.96	1.96	.02	BEUDANTITE	(-)6-50°	4.1

Table 15. Calcite group

The calcite group minerals have the general formula RCO_3, in which R may be Ca, Cd, Co, Fe^{+2}, Mg, Mn, Ni, and Zn. Complete solid solution exists between Ca and Cd, Ca and Mn, Mn and Fe, and Mg and Fe, probably also between (Mg,Fe^{+2}) and (Zn,Co), although not many representatives are known.

Calcite	$CaCO_3$
Gaspeite	$(Ni,Mg)CO_3$
Magnesite	$(Mg,Fe)CO_3$
Otavite	$(Cd,Ca)CO_3$
Rhodochrosite	$(Mn,Ca)CO_3$
Siderite	$(Fe,Mg)CO_3$
Smithsonite	$(Zn,Mg)CO_3$
Sphaerocobaltite	$CoCO_3$

These minerals are trigonal, space group $R\bar{3}c$, with perfect rhombohedral cleavage, hardness 3 to 5. Optically they are uniaxial negative with very high birefringence (compare the related dolomite group).

Refractive index		Biref (-)	NAME	G	Weight %			
ω	ε				MnO	FeO	MgO	Other
1.658	1.486	.172	CALCITE	2.71	---	---	---	end member
1.672	1.501	.171	CALCITE	2.82	4.2	2.1	1.3	
1.700	1.509	.191	MAGNESITE	2.96	---	---	47.8	end member
1.710	1.523	.189	CALCITE	---	---	---	---	CdO 20.1
1.711	1.519	.192	MAGNESITE	3.15	---	---	---	NiO 13.55
1.713	1.519	.194	CALCITE	3.02	20.1	---	---	ZnO 0.4
1.726	1.528	.198	MAGNESITE	3.10	---	9.5	---	
1.731	(1.55)	.18	RHODOCHROSITE	3.05	33.4	2.7	2.2	CaO 21.0
1.753	1.560	.193	RHODOCHROSITE	3.3	44.3	0.8	2.3	CaO 13.4

Table 15. Calcite group (continued)

Refractive index		Biref (-)	NAME	G	Weight %			
ω	ε				MnO	FeO	MgO	Other
1.788	1.570	.218	MAGNESITE	3.43	---	(35.9)	(20.1)	Mg/Fe = 1
1.803	1.584	.219	RHODOCHROSITE	3.65	---	3.8	0.6	CaO 1.3
1.81	1.58	.23	GASPEITE	3.6	---	4.3	14.8	NiO 36.8
1.815	1.601	.214	SMITHSONITE	---	---	---	7.6	ZnO 53.2 CaO 1.1
1.816	1.592	.224	SIDERITE	3.59	5.9	---	11.8	CaO 1.4
1.816	1.597	.219	RHODOCHROSITE	3.70	61.7	---	---	end member
1.830	1.605	.225	OTAVITE	~4.8	---	---	---	CdO 67.8
1.836	(1.61)	.226	RHODOCHROSITE	3.76	29.8	13.9	---	{ZnO 14.9 CaO 3.1
1.840	1.615	.225	RHODOCHROSITE	3.72	35.4	26.1	---	
1.84	(1.62)	.22	GASPEITE	3.7	---	0.1	3.3	NiO 55.5
1.849	1.615	.234	SIDERITE	3.81	9.5	47.9	3.2	
1.850	1.623	.227	SMITHSONITE	4.42	0.5	0.4	---	
1.855	1.60	.225	SPHAERO-COBALTITE	4.1	---	---	---	
1.860	1.625	.235	SIDERITE	3.92	14.7	36.4	0.3	ZnO 11.55
1.875	1.633	.242	SIDERITE	3.89	---	62.0	---	end member

Table 16. Cancrinite group

The cancrinite group consists of hexagonal silicates of Ca, Na, and K, also containing carbonate (cancrinite), sulfate (vishnevite), or chloride. Davyne, microsommite, and afghanite are polytypes with nearly the same composition but with different unit cells. They are characterized by low to moderate birefringence and perfect prismatic cleavage.

Afghanite	$(Na,Ca,K)_8(Si,Al)_{12}O_{24}(Cl,SO_4,CO_3)_3 \cdot H_2O$
Cancrinite	$(Na,Ca)_{7-8}(Si_6Al_6)O_{24}(CO_3,SO_4)_{1-2} \cdot 2H_2O$
Davyne	$(Na,Ca,K)_{7-8}(Si,Al)_{12}O_{24}(Cl,SO_4,CO_3)_{2-3}$
Franzinite	$(Na,Ca)_7(Si,Al)_{12}O_{24}(SO_4,CO_3)_3 \cdot H_2O$
Giuseppettite	$(Na,K,Ca)_{7-8}(Si,Al)_{12}O_{24}(SO_4,Cl)_{1-2}$
Liottite	$(Ca,Na,K)_8(Si,Al)_{12}O_{24}(SO_4,CO_3,OH,Cl)_4 \cdot H_2O$
Microsommite	$(Na,Ca,K)_{7-8}(Si,Al)_{12}O_{24}(Cl,SO_4,CO_3)_{2-3}$
Sacrofanite	$(Na,Ca,K)_9(Si,Al)_{12}O_{24}[(OH)_2,SO_4,CO_3,Cl_2]_3 \cdot xH_2O$
Vishnevite	$(Na,Ca,K)_{6-7}Si_6Al_6O_{24}(SO_4,CO_3)_{1-2} \cdot H_2O$

Refractive index		Biref	NAME	Weight %					
ω	ε			SO_3	CO_2	Cl	Na_2O	K_2O	CaO
1.491	1.507	(+).016	GIUSEPPETTITE	---	---	---	---	---	---
1.499	1.493	(-).006	VISHNEVITE	4.7	2.2	0.4	20.8	1.0	1.1
1.505	1.486	(-).019	SACROFANITE	---	---	---	---	---	---
1.510	1.512	(+).002	FRANZINITE	10.7	1.5	0.4	11.5	4.2	12.1
1.515	1.496	(-).019	CANCRINITE	1.4	7.0	0.4	18.7	0.6	4.8
1.518	1.521	(+).003	DAVYNE	---	---	---	---	---	---
1.521	1.529	(+).008	MICROSOMMITE	---	---	---	---	---	---
1.523	1.529	(+).006	AFGHANITE	8.5	0.4	4.6	12.6	2.7	16.5
1.528	1.533	(+).005	AFGHANITE	9.7	0.8	4.5	12.4	0.9	12.3

Table 16. Cancrinite group (continued)

Refractive index		Biref	NAME	Weight %					
ω	ε			SO_3	CO_2	Cl	Na_2O	K_2O	CaO
1.528	1.503	(-).025	CANCRINITE	0.2	6.2	0.1	9.8	1.2	11.7
1.530	1.528	(-).002	LIOTTITE	8.7	2.1	2.6	8.0	5.0	16.7

Table 17. Chalcanthite group

The minerals of this group are hydrous sulfates of the general formula $ASO_4 \cdot 5H_2O$, in which A may be Cu, Fe^{+2}, Mg, Mn, and Zn. They are triclinic, optically biaxial negative, with moderate 2V, r < v. Hardness and specific gravity are low. All are soluble in water and on heating lose water but do not fuse.

Refractive index			Biref	NAME and formula	(-)2V	Color	Remarks
α	β	γ					
1.482	1.492	1.493	.011	PENTAHYDRITE $MgSO_4 \cdot 5H_2O$	45°	Cols	
1.498	1.510	1.517	.019	JOKOKUITE $MnSO_4 \cdot 5H_2O$	70-80°	Pale pink	
1.495	1.512	1.518	.023	PENTAHYDRITE $(Mg,Cu,Zn)SO_4 \cdot 5H_2O$	55°	Blue	CuO 9.0, ZnO 5.6, FeO 1.4%.
1.513	(1.526)	1.534	.021	SIDEROTIL $(Fe,Cu)SO_4 \cdot 5H_2O$	60°	Pale green to blue	
1.501	1.537	1.539	.038	CHALCANTHITE $CuSO_4 \cdot 5H_2O$	56°	Dark blue	

Table 18. Copiapite group

Minerals of this group are sulfates having the general formula $AFe_4^{+3}(SO_4)_6 \cdot 20H_2O$ or $BFe_4^{+3}(SO_4)_6O(OH) \cdot 20H_2O$, in which A may be Ca, Cu, Fe^{+2}, Mg, and Zn; B may be Al and Fe^{+3}. All are triclinic with perfect {010} cleavage, low hardness and density. They are optically biaxial positive with moderate 2V, r > v strong, X near b, and pleochroic in yellows or greens. Optical data are not available for calcio-copiapite. All are dissolved by acids.

Refractive index			Biref	NAME and formula	(+)2V	Pleochroism
α	β	γ				
1.507	1.529	1.573	.067	MAGNESIOCOPIAPITE $MgFe_4^{+3}(SO_4)_6(OH)_2 \cdot 20H_2O$	73°	X yellow-green, Y yellow, Z yellow to yellow-green.
1.520	1.535	1.578	.058	COPIAPITE $Fe^{+2}Fe_4^{+3}(SO_4)_6(OH)_2 \cdot 20H_2O$	70°	X, Y pale yellow, Z yellow.
1.525	1.540	1.590	.065	ALUMINOCOPIAPITE $AlFe_4^{+3}(SO_4)_6O(OH) \cdot 20H_2O$	med	Yellows.
1.525	1.545	1.595	.070	MAGNESIOCOPIAPITE $(Mg,Fe^{+2})Fe_4^{+3}(SO_4)_6(OH)_2 \cdot 20H_2O$	66°	X, Y very pale yellow, Z deep yellow.
1.530	1.550	1.592	.062	FERRICOPIAPITE $Fe^{+3}Fe_4^{+3}(SO_4)_6O(OH) \cdot 20H_2O$	69°	Yellows.
1.534	1.554	1.586	.052	ZINCOCOPIAPITE $ZnFe_4^{+3}(SO_4)_6(OH)_2 \cdot 20H_2O$	(78±5°)	Strong in shades of yellow.
1.558	1.575	1.620	.062	CUPROCOPIAPITE $CuFe_4^{+3}(SO_4)_6(OH)_2 \cdot 20H_2O$	63°	Greens, abs X and Z > Y.

Table 19. Crandallite (Plumbogummite) group

The minerals of this group have the general formula $AB_3(XO_4)_2(OH)_5 \cdot H_2O$ or $AB_3(XO_4)_2(OH)_6$, in which A may be Ba, Ca, Ce, Nd, Pb, Sr, and Th; B may be Al and Fe^{+3}; X may be P and As. Minerals of this group are closely related to those of the alunite and beudantite groups.

Arsenocrandallite	$(Ca,Sr)Al_3[(As,P)O_4]_2(OH)_5 \cdot H_2O$
Crandallite	$CaAl_3(PO_4)_2(OH)_5 \cdot H_2O$
Dussertite	$BaFe^{+3}_3(AsO_4)_2(OH)_5 \cdot H_2O$
Eylettersite	$(Th,Pb)Al_3(PO_4)_2(OH)_6$
Florencite	$CeAl_3(PO_4)_2(OH)_6$
Gorceixite	$(Ba,Ca,Ce)Al_3(PO_4)_2(OH)_5 \cdot H_2O$
Goyazite	$SrAl_3(PO_4)_2(OH)_5 \cdot H_2O$
Lusungite	$(Sr,Pb)Fe^{+3}_3(PO_4)_2(OH)_5 \cdot H_2O$ (?)
Philipsbornite	$PbAl_3(AsO_4)_2(OH)_5 \cdot H_2O$
Plumbogummite	$PbAl_3(PO_4)_2(OH)_5 \cdot H_2O$
Unnamed	$PbFe^{+3}_3(AsO_4)_2(OH)_5 \cdot H_2O$
Zairite	$Bi(Fe^{+3},Al)_3(PO_4)_2(OH)_6$

These minerals are trigonal, pseudocubic, space group R3m or R$\bar{3}$m. Distinct to perfect basal cleavage and low birefringence (except for lusungite) are characteristic. An unnamed triclinic (?) dimorph of crandallite with β=1.607 (see table 7) is also included in this group. Optical data on waylandite have not been recorded, other than that it is uniaxial negative.

Refractive index		Biref	NAME	H	G	Remarks
ω	ε					
1.610	1.620	(+).010	GORCEIXITE	6	3.1-3.3	
1.613	1.622	(+).009	CRANDALLITE	5	2.8	

Table 19. Crandallite (Plumbogummite) group (continued)

Refractive index		Biref	NAME	H	G	Remarks
ω	ε					
1.620	1.630	(+).010	GOYAZITE	4.5-5	3.15-3.26	Anom biax. Pleoc, O red-brown, E yellow.
1.623	1.634	(+).011	CRANDALLITE	5	2.8	
1.625	---	low	ARSENO-CRANDALLITE	5.5	3.25	
1.625	---	(+)low	GORCEIXITE	6	3.09-3.32	
1.635	---	(-)low	EYLETTERSITE	---	3.4	Fluor wk greenish-yellow in UV.
1.640	1.651	(+).011	GOYAZITE	4.5-5	3.15	Anom biax, 2V 0-20°.
1.653	1.675	(+).022	PLUMBOGUMMITE	4-5	4.0	
1.653	1.661	(+).008	FLORENCITE	5	3.46	
1.678	1.684	(+).006	FLORENCITE	5-6	3.46	
1.680	1.698	(+).018	PLUMBOGUMMITE	4.5	4.0-4.9	
1.695	1.705	(+).010	FLORENCITE	6	3.69	
1.713	1.719	(+).006	FLORENCITE	6	3.4-3.6	
1.77	---	(+).03-.04	LUSUNGITE	---	---	
1.790	---	Isotropic	PHILIPSBORNITE	4.5	4.33	
1.82-1.83	---	---	ZAIRITE	---	4.37	
1.855	---	(+).03-.04	LUSUNGITE	---	---	
1.870	1.845	(-).025	DUSSERTITE	3.5	3.75	
1.99	---	(-)mod	Unnamed	---	---	Anom biax, 2V 0-50°.

Table 20. Dolomite group

The minerals of this group have the general formula $AB(CO_3)_2$, in which A may be Ca and Ba, and B may be Mg, Fe^{+2}, Mn^{+2}, and Zn. Dolomite, Ankerite, and Kutnohorite probably form a complete series of solid solutions.

Ankerite	$CaFe(CO_3)_2$
Dolomite	$CaMg(CO_3)_2$
Kutnohorite	$CaMn(CO_3)_2$
Minrecordite	$CaZn(CO_3)_2$
Norsethite	$BaMg(CO_3)_2$

The minerals are trigonal, space group $R\bar{3}$. All are optically uniaxial negative and, like the members of the calcite group, are characterized by very high birefringence and perfect rhombohedral cleavage. All are infusible and difficulty soluble in dilute acids (compare the related calcite group).

Refractive index		Biref	NAME	G	Weight %		
ω	ε				FeO	MnO	Others
1.680	1.501	.179	DOLOMITE	2.865	0.5	---	
1.694	1.510	.184	DOLOMITE	2.92	8.4	1.1	SrO 0.4
1.694	1.519	.175	NORSETHITE	3.74-3.84	---	---	
1.700	1.521	.179	DOLOMITE	2.95	2.2	---	ZnO 8.3, PbO 1.1
1.710	1.519	.191	KUTNOHORITE	3.00	1.3	17.6	MgO 10.0
1.711	1.520	.191	DOLOMITE	3.01	12.6	1.2	
1.712	1.512	.200	NORSETHITE	3.88	3.6	0.8	
1.734	1.542	.192	MINRECORDITE	3.32			
1.740	1.547	.193	KUTNOHORITE	3.14	0.8	31.8	ZnO 1.4, MgO 0.5
1.741	1.536	.205	ANKERITE	3.12	24.0	1.6	
1.750	1.550	.200	MINRECORDITE	3.45			

Table 21. Epidote group

The minerals of the epidote group are silicates having AlO_6- and $AlO_4(OH)_2$-chains linked by independent SiO_4- and Si_2O_7-groups. The general formula is $A_2B_3(Si_2O_7)(SiO_4)O(OH)$ or $A_2B_3(Si_3O_{12})(OH)$, in which A may be Ca, Ce, La, Y, Pb, and Sr, and B may be Al, Fe^{+3}, and V.

Allanite	$(Ca,Ce,La,Y)_2(Al,Fe^{+3},Fe^{+2})_3Si_3O_{12}(OH)$
Clinozoisite	$Ca_2Al_3(Si_3O_{12})(OH)$
Epidote	$Ca_2(Al,Fe)_3(Si_3O_{12})(OH)$
Hancockite	$(Pb,Ca,Sr)_2(Al,Fe)_3(Si_3O_{12})(OH)$
Mukhinite	$Ca_2(Al,V)_3(Si_3O_{12})(OH)$
Piemontite	$Ca_2(Al,Mn^{+3},Fe^{+3})_3(Si_3O_{12})(OH)$
Zoisite	$Ca_2Al_3(Si_3O_{12})(OH)$

All are monoclinic, except orthorhombic zoisite, and all have perfect {001} cleavage, except allanite and zoisite. They are optically biaxial with moderate to large optic angle, most with strong dispersion and X = or ~ c, Y=b. Refractive indices and birefringence increase with increase in iron or manganese content. Pleochroism is marked in piemontite, mukhinite, and in the higher-iron epidotes.

Many allanites are isotropic metamict because of the presence of U and Th. In this state, refractive index and density are highly variable: n 1.61 to 1.75; G 2.96 to 3.74. Data for such metamict varieties are not listed here but are included in the table for isotropic minerals (table 3).

Refractive index α	β	γ	Biref	NAME	2V	Orientation	Remarks
1.691	1.692	1.700	.009	ZOISITE	(+)54° r > v str	X = c	Abn interf colors. Pleoc u wk, X violet, Y deep blue, Z yellow-green.
1.700	1.703	1.708	.008	ZOISITE	(+)71° r < v or r > v	X = c	Abn interf colors. Fe_2O_3 3.1, FeO 1.3, MnO 0.3%.
1.700	1.703	1.706	.006	CLINO-ZOISITE	~ 90° r < v str	X ~ c	Abn interf colors. Fe_2O_3 3.2, FeO 0.6%.

Table 21. Epidote group (continued)

Refractive index			Biref	NAME	2V	Orientation	Remarks
α	β	γ					
1.704	1.708	1.714	.006	ALLANITE	(+)70-80° r > v	X:c = 5-40°	U neg. Slowly gel in HCl.
1.706	1.711	1.714	.008	ALLANITE	(-)61°		Slowly gel in HCl. Fe_2O_3 4.9, FeO 9.1, ThO_2 1.7%.
1.715	1.717	1.721	.006	CLINO-ZOISITE	~ 90° r < v str	X ~ c	Abn interf colors. Fe_2O_3 3.0, FeO 0.8%.
1.713	1.720	1.727	.014	EPIDOTE	(-)89° r > v str		Fe_2O_3 6.6, FeO 0.4%.
1.723	1.733	1.755	.032	MUKHINITE	(+)88° (69±8°)	Z:a = 32°	Pleoc str, X
1.721	1.736	1.740	.019	EPIDOTE	(-)78° (54±14°) r > v str	X ~ c	Fe_2O_3 9.5, FeO 0.8%.
1.721	1.738	1.742	.021	ALLANITE	(-)Large (51±13°) r > v str		Gel with acids. Fe_2O_3 17.0, MnO 0.6, ThO_2 0.9%.
1.738	1.744	1.753	.015	ALLANITE	(+)70-80° r > v	X ~ c = 5-40°	Pleoc in brown and red.
1.732	1.750	1.778	.046	PIEMONTITE	(+)Large	X:c = -5°	Pleoc str, X buff, Y deep lavender, Z pink. Fe_2O_3 3.8, Mn_2O_3 11.8%.

Table 21. Epidote group (continued)

Refractive index			Biref	NAME	2V	Orientation	Remarks
α	β	γ					
1.733	1.750	1.762	.029	PIEMONTITE	(-)78° r > v str		Pleoc, X yellow, Y pale amethyst, Z deep purplish red. Fe_2O_3 11.3, Mn_2O_3 1.0%.
1.729	1.754	1.776	.047	EPIDOTE	(-)73° (85°±5°) r > v str	X:c = 8°	Pleoc, X pale yellow, Y pale greenish yellow, Z greenish yellow. Fe_2O_3 14.0, FeO 1.2%.
1.740	1.755	1.760	.020	ALLANITE	(-)Large r > v str		Gel with acids. Fe_2O_3 3.2, FeO 10.7, MnO 1.9, TiO_2 1.7, ThO_2 0.9%.
1.763	1.768	1.788	.025	ALLANITE	(+)57° r > v	X:c = 5-40°	Slowly gel with HCl. Fe_2O_3 3.8, FeO 10.4%.
1.740	1.768	1.787	.047	EPIDOTE	(-)74° r > v str	X:c = 13°	Fe_2O_3 17.9, FeO 0.4, MnO 0.5%.
1.754	1.772	1.795	.041	PIEMONTITE	(+)85° r < v	X:c = -6°	Pleoc str, X yellow, Y violet, Z red.
1.746	1.776	1.793	.047	PIEMONTITE	(-)87° r > v str		Pleoc, X yellow, Y pink, Z deep pink. Fe_2O_3 11.9, Mn_2O_3 6.8%.
1.751	1.784	1.797	.046	EPIDOTE	(-)64° r > v str		Fe_2O_3 17.2, FeO 0.5%.

Table 21. Epidote group (continued)

Refractive index			Biref	NAME	2V	Orienta-tion	Remarks
α	β	γ					
1.769	1.784	1.791	.022	ALLANITE	(-)60° r > v str		Slowly gel with HCl.
1.756	1.788	1.829	.073	PIEMONTITE	(+)86° r < v	X:c = -9°	Pleoc str, X yellow, Y violet, Z red.
1.788	1.825	1.830	.042	HANCOCKITE	38° r > v	Y = b	Abs Z > X.

Table 22. Feldspar group

Minerals of the feldspar group are framework silicates of the general formula $XAlSi_3O_8$ or $Y(Z,Si)Si_2O_8$, in which X may be K and Na, less commonly NH_4; Y may be Ca, less commonly Ba and Sr; Z may be Al, less commonly B and Fe^{+3}. Two subgroups of wide occurrence and importance in the classification of igneous rocks are the alkali feldspars and the plagioclases. The barium, strontium, boron, and NH_4 feldspars occur only infrequently or rarely.

Alkali feldspars	$(K,Na)AlSi_3O_8$
Microcline	
Orthoclase	
Anorthoclase	
Sanidine-High Albite	
Plagioclase	$(Na,Ca)Al(Al,Si)Si_2O_8$
Albite	An 0-10
Oligoclase	An 10-30
Andesine	An 30-50
Labradorite	An 50-70

Table 22. Feldspar group (continued)

Bytownite	An 70-90
Anorthite	An 90-100
Barium feldspars	
Banalsite	$BaNa_2Al_4Si_4O_{16}$
Celsian	$(Ba,K)Al(Al,Si)Si_2O_8$
Hyalophane	$(K,Ba)Al(Al,Si)Si_2O_8$
Buddingtonite	$(NH_4)AlSi_3O_8$
Reedmergnerite	$NaBSi_3O_8$
Slawsonite	$(Sr,Ca)Al_2Si_2O_8$

Minerals of the feldspar group may also be divided on the basis of thermal history. Alkali feldspars that have been rapidly quenched from magmatic temperatures form the sanidine-high albite series. Those that have cooled slowly (annealed) under plutonic conditions or have formed at low temperatures include microcline and orthoclase. Anorthoclases may be an intermediate type. Similarly, the plagioclase series may be divided into quenched types (labeled "volcanic" in tables 6 and 7), annealed types ("plutonic"), and intermediate types. If the aim is to infer thermal history, advantage may be taken of the differences in lattice structure seen in optical orientation or in X-ray. If, on the other hand, the aim is only to infer anorthite content, a convenient approach is to determine the α-refractive index on cleavage flakes (Tsuboi, 1923; Morse, 1968). Useful mineralogical and petrographic discussions of the feldspars are given by Deer, Howie, and Zussman (1963, v. 4), Tröger (1967, pt. 2), and Smith (1974).

The feldspars are monoclinic or triclinic. The space groups are microcline and anorthoclase, C1; orthoclase and sanidine-high albite, C2/m; low albite, C1; anorthite, P1; and celsian, I2/c. They have good to perfect {010} and {001} cleavages, and hardness 5.5 to 6. Simple twins are common, with polysynthetic twinning especially prominent in the plutonic feldspars, less so in the volcanic plagioclases. Except for those high in barium and calcium, the feldspars are essentially unaffected by HCl. All are dissolved by HF.

Table 22. Feldspar group (continued)

Refractive index			Biref	NAME and composition	2V	X':a on		Poly tw	System
α	β	γ				{001}	{010}		
1.519	1.522	1.524	.005	ANORTHOCLASE Or 21, Ab 73, An 6 (?)	(-)51° r > v wk	2°	8°	fine grating	TCL
1.519	1.523	1.525	.006	MICROCLINE Or 85, Ab 14, An 1	(-)76°	10-15°	7.5°	coarse grating	TCL
1.519	1.524	1.525	.006	ORTHOCLASE Or 84, Ab 14, An 2	(-)46°	0°	6°	---	MCL
1.520	1.525	1.525	.005	SANIDINE Or 78, Ab 22	(-)24°	0°	5-8°	---	MCL
1.523	1.529	1.530	.007	SANIDINE Or 41, Ab 58, An 1	(-)33°	0°	---	---	MCL
1.530	1.531	1.534	.004	BUDDINGTONITE $(NH_4)AlSi_3O_8$	(+)	0°	4°	---	MCL
1.525	1.531	1.532	.007	ANORTHOCLASE Or 22, Ab 76, An 2	(-)47°	---	---	fine grating	TCL
1.528	1.532	1.539	.011	ALBITE, plutonic plagioclase, An 0	(+)74° r < v wk	3°	20°	{010}	TCL
1.527	1.534	1.535	.008	ALBITE, volcanic plagioclase, An 0	(-)50°	3°	23°	less common	TCL
1.536	1.539	1.541	.005	ANORTHOCLASE Or 19, Ab 63, An 18	(-)62°	---	3°	fine grating	TCL
1.536	1.541	1.546	.010	OLIGOCLASE, plutonic plagioclase, An 18	~ 90°	1°	7°	{010}	TCL

Table 22. Feldspar group (continued)

Refractive index			Biref	NAME and composition	2V	X':a on		Poly tw	System
α	β	γ				{001}	{010}		
1.538	1.543	1.546	.008	OLIGOCLASE, volcanic plagioclase, An 20	(-)65°	3°	4°	less common	TCL
1.542	1.544	1.546	.004	HYALOPHANE Cn 37	(-)75°	0°	-18°	---	MCL
1.541	1.546	1.550	.009	OLIGOCLASE, plutonic plagioclase, An 25	(-)78°	1°	2°	{010}	TCL
1.546	1.550	1.554	.008	ANDESINE, plutonic plagioclase, An 33	~ 90°	0°	-5°	{010}	TCL
1.549	1.552	1.556	.00	ANDESINE, volcanic plagioclase, An 36	~ 90°	2°	-4°	less common	TCL
1.555	1.558	1.562	.007	LABRADORITE, plutonic plagioclase, An 50	(+)78°	-6°	-17°	{010}	TCL
1.558	1.562	1.566	.008	LABRADORITE, volcanic plagioclase, An 58	(+)76°	-15°	-26°	less common	TCL
1.570	1.571	1.578	.008	BANALSITE	41°				ORTH
1.554	1.565	1.573	.019	REEDMERGNERITE	(-)80°	---	---	---	TCL
1.564	1.568	1.572	.008	CELSIAN, var Kasoite, Cn 35	(-)80°	10-13°	2-3°	untw	MCL

Table 22. Feldspar group (continued)

Refractive index			Biref	NAME and composition	2V	X':a on		Poly tw	System
α	β	γ				{001}	{010}		
1.563	1.568	1.573	.010	BYTOWNITE, plutonic plagioclase, An 70	~ 90°	-16°	-29°	{010}, pericline	TCL
1.565	1.569	1.574	.009	BYTOWNITE, volcanic plagioclase, An 75	~ 90°	-23°	-33°	less common	TCL
1.571	1.577	1.583	.012	BYTOWNITE, plutonic plagioclase, An 88	(-)79°	-30°	-37°	{010}, pericline	TCL
1.572	1.577	1.583	.011	BYTOWNITE, volcanic plagioclase, An 90	(-)81°	-34°	-36°	less common	TCL
1.573	1.581	1.585	.012	SLAWSONITE $(Sr,Ca)Al_2Si_2O_8$	(+)82° r < v	Z = b X:c = 11°		---	MCL
1.580	1.583	1.586	.006	CELSIAN, Cn 85	(-)74°	Z:c on $\{\bar{1}00\}$ = 33°		untw	MCL
1.575	1.584	1.589	.014	ANORTHITE, plagioclase, An 100	(-)77°	-40°	-39°	{010}, pericline	TCL
1.583	1.589	1.593	.010	CELSIAN, Cn 94	(-)88°	Z:c on $\{\bar{1}00\}$ = 26°		untw	MCL
1.593	1.599	1.608	.015	CELSIAN, Cn 94	(+)85°	Y = b		---	MCL

Table 23. Garnet group

The minerals of this group are orthosilicates having the general formula $X_3Y_2(SiO_4)_3$, in which X may be Fe^{+2}, Mn^{+2}, and Mg; Y may be Al, Fe^{+3}, Cr, less commonly V, Ti, Mn^{+3}, and Zr. Substitution is common among the end members listed below, with complete solid solution between some.

Almandine	(Al)	$Fe_3^{+2}Al_2(SiO_4)_3$
Andradite	(An)	$Ca_3Fe_2^{+3}(SiO_4)_3$
Melanite		$Ca_3(Fe^{+3},Ti)_2(SiO_4)_3$
Schorlomite		$Ca_3(Fe^{+3},Ti)_2[(Si,Ti)O_4]_3^{=}$
Calderite	(Ca)	$Mn_3Fe_2^{+3}(SiO_4)_3$
Goldmanite	(Go)	$Ca_3V_2(SiO_4)_3$
Grossular	(Gr)	$Ca_3Al_2(SiO_4)_3$
Henritermierite		$Ca_3(Mn^{+3},Al)_2(SiO_4)_2(OH)_4$
Hydrogrossular		$Ca_3Al_2(SiO_4)_{3-x}(OH)_{4x}$
Kimzeyite		$Ca_3(Zr,Ti)_2Al_2SiO_{12}$
Knorringite	(Kn)	$Mg_3Cr_2(SiO_4)_3$
Pyrope	(Py)	$Mg_3Al_2(SiO_4)_3$
Spessartine	(Sp)	$Mn_3Al_2(SiO_4)_3$
Uvarovite	(Uv)	$Ca_3Cr_2(SiO_4)_3$

The garnets are cubic, space group Ia3d, except for henritermierite, which is tetragonal. Their fracture is subconchoidal, hardness 6 to 7.5, specific gravity 3.35 to 4.32; and, except for hydrogrossular and henritermierite, they are nearly insoluble in HCl and only slowly attacked by cold HF.

Optically garnets have very high refractive index and are usually isotropic, but some, especially the andradites, grossulars, and uvarovites, may show low birefringence with complex grating twinning. Because of the many possible substitutions in the solid solution series, refractive index alone is not a sufficient basis on which to infer chemical composition but is helpful together with density and the length of a_0 of the unit cell. The overlaps in the following tabulation dictate caution in deducing composition from physical properties. If a garnet is known to be in the series Gr-An, however, the composition may be inferred from refractive index, specific gravity, or the length of the cell edge. In the Al-Sp-Py series, refractive index and Mn-content will usually give an approximate determination of the composition.

Relations between composition and physical properties were discussed by Ford (1915), Fleischer (1937), and Winchell (1958), and properties of synthesized garnets are described by Skinner (1956), whose data are included in the tabulation below. Graphs showing these relations are given by Sriramadas (1957). Types of occurrence are discussed by Wright (1938), and Deer, Howie, and Zussman (1962, v. 1, p. 77-112).

Refractive index	NAME	G	Cell edge $\underline{a}_0$ (Å)	Composition					Remarks
				Al	An	Gr	Py	Sp	
1.670	HYDROGROSSULAR	---	---	---	---	---	---	---	H_2O 9.3%.
1.702	HYDROGROSSULAR	3.35	---	---	---	---	---	---	H_2O 4.6%.
1.714	PYROPE	3.582	11.459	---	---	---	100	---	Synth.
1.734	GROSSULAR	3.594	11.851	---	---	100	---	---	Synth.
1.737	GROSSULAR	---	---	27	---	53	20	---	
1.741	PYROPE-ALMANDINE	3.72	---	20	2	11	66	0.6	
1.752	GROSSULAR-ANDRADITE	3.57	---	---	13	85	1	---	
1.766	PYROPE-ALMANDINE	3.88	11.580	41	6	8	43	1.5	
1.773	GROSSULAR-SPESSARTINE	3.80	---	11	7	56	---	25	
1.782	ALMANDINE-PYROPE	4.02	---	55	---	14	27	3	
1.796	GROSSULAR-UVAROVITE	3.68	---	---	8	52	1	---	Uv 39.
1.797	ALMANDINE	4.10	---	60	---	7	18	15	
1.800	SPESSARTINE	4.190	11.621	---	---	---	---	100	Synth.
1.801	GROSSULAR-ANDRADITE	3.71	11.94	4	42	52	---	2	
1.803	KNORRINGITE	3.85	---	14	3	19	10	1	Kn 53.
1.805	SPESSARTINE	4.20	---	17	---	---	2	80	
1.808	ALMANDINE	4.15	---	74	---	11	11	5	

Table 23. Garnet group (continued)

Refractive index	NAME	G	Cell edge $\underline{a}_0$ (Å)	Composition					Remarks
				Al	An	Gr	Py	Sp	
1.814	SPESSARTINE-ALMANDINE	4.23	---	45	---	1	1	53	
1.818	ALMANDINE-SPESSARTINE	4.25	---	74	---	1	5	20	
1.821	GOLDMANITE	3.74	12.011	---	17	20	3	---	Go 60.
1.825	UVAROVITE-GROSSULAR	3.81	---	---	1	26	1	---	Uv 72.
1.827	ANDRADITE-GROSSULAR	3.77	---	57	5	32	3	3	
1.830	ALMANDINE	4.318	11.526	100	---	---	---	---	Synth.
1.834	GOLDMANITE	3.765	---	---	---	---	---	---	Go 100, synth.
1.855	UVAROVITE	3.77	---	1	---	6	2	---	Uv 91.
1.855	GOLDMANITE	3.91	11.974	---	---	---	---	---	V_2O_3 24.9%.
1.863	ANDRADITE	3.72	11.996	5	79	12	---	4	
1.875	CALDERITE-GROSSULAR	4.05	---	---	---	---	---	---	
1.887	ANDRADITE	3.859	12.048	---	100	---	---	---	Synth.
1.890	CALDERITE-ANDRADITE	4.07	---	---	---	---	---	---	
1.893	ANDRADITE-SPESSARTINE	3.98	---	1	71	---	---	28	
1.94	MELANITE	3.79	---	---	---	---	---	---	TiO_2 9.4%.
1.94	KIMZEYITE	3.94	12.46	---	---	---	---	---	TiO_2 5.6, ZrO_2 29.9%.
1.98	SCHORLOMITE	3.85	---	---	---	---	---	---	TiO_2 16.9%.

Table 24. Humite group

Minerals of this group are morphotrophic orthosilicates with the general formula $nXSiO_4 \cdot Y(OH,F)_2$ in which n may be 1, 2, 3, or 4; X may be Mg, Fe, and Mn; Y may be Mg and Mn. The site of the Ti, present in some clinohumites, has not been clearly established.

Alleghanyite	$2Mn_2SiO_4 \cdot Mn(OH)_2$
Chondrodite	$2(Mg,Fe)_2SiO_4 \cdot Mg(OH,F)_2$
Clinohumite	$4(Mg,Fe)_2SiO_4 \cdot Mg(OH,F)_2$
Humite	$3(Mg,Fe)_2SiO_4 \cdot Mg(OH,F)_2$
Leucophoenicite	$3Mn_2SiO_4 \cdot Mn(OH)_2$
Manganhumite	$3Mn_2SiO_4 \cdot Mn(OH)_2$
Norbergite	$(Mg,Fe)_2SiO_4 \cdot Mg(OH,F)_2$
Sonolite	$4Mn_2SiO_4 \cdot Mn(OH,F)_2$

The orthorhombic members have space group Pbnm; the monoclinic members, $P2_1/c$, commonly with polysynthetic twinning on {001}. Cleavage of the orthorhombic members is perfect {001}; that of the monoclinic members is poor or lacking. Hardness is 5 to 6; specific gravity, 3.2 to 4.0. All gelatinize in HCl.

Optically the members of this group are biaxial with moderately strong birefringence and Z parallel to the b crystallographic axis. The Mg-Fe members are optically positive, colorless to yellow; the Mn members (except Manganhumite) are optically negative, pink to reddish brown.

Table 24. Humite group (continued)

Refractive index			Biref	NAME	2V	System	Orientation	Remarks
α	β	γ						
1.548	1.552	1.570	.022	NORBERGITE	(+)33° (51±13°)	ORTH	X = a	Synth Mg-F compd.
1.565	1.570	1.591	.026	NORBERGITE	(+)49°	ORTH	X = a	
1.593	1.603	1.623	.030	CHONDRODITE	(+)71° r > v wk	MCL	X:c = 27°	Poly tw {001}. Pleoc, X yellow, Y and Z nearly cols. FeO 2.8, F 7.9%.
1.598	1.606	1.630	.032	HUMITE	(+)59° r > v wk	ORTH	X = a	Synth Mg-F compd.
1.607	1.617	1.639	.032	CHONDRODITE	(+)80° (69±8°) r > v wk	MCL	X:c = 28°	Poly tw {001}. Pleoc, X yellow, Y and Z pale yellow. FeO 5.0, Fe_2O_3 0.8%.
1.608	1.618	1.636	.028	CLINOHUMITE	(+)59° (79±8°) r < v	MCL	X:c = 9°	Synth Mg-F compd.
1.607	1.623	1.643	.036	HUMITE	(+)81° r > v wk	ORTH	X = a	Pleoc, X and Z pale yellow, Y nearly cols. FeO 5.4, Fe_2O_3 0.5, F 5.4%.
1.619	1.632	1.653	.034	CHONDRODITE	(+)80° r > v wk	MCL	X:c = 27°	Pleoc, X yellow, Y and Z pale yellow. FeO 10.5, MnO 1.2, F 5.4%.

Table 24. Humite group (continued)

Refractive index			Biref	NAME	2V	System	Orientation	Remarks
α	β	γ						
1.628	1.638	1.655	.027	HUMITE	(+)76° r > v wk	ORTH	X = a	Pleoc, X and Z pale yellow, Y nearly cols. FeO 7.9, Fe_2O_3 1.0, MnO 1.7, F 5.0%.
1.632	1.643	1.664	.032	CLINOHUMITE	(+)74° r < v	MCL	X ~ c	FeO 6.6, MnO 1.7, F 3.2%.
1.643	1.653	1.675	.032	HUMITE	(+)68° r > v wk	ORTH	X = a	Pleoc, X and Z golden yellow, Y pale yellow. FeO 7.8, MnO 0.7, Fe_2O_3 2.7%.
1.668	1.679	1.700	.032	CLINOHUMITE	(+)Med r < v	MCL	X ~ c	FeO 9.9, MnO 0.3, Fe_2O_3 1.0, F 1.8%.
1.67	1.680	1.703	.033	ALLEGHANYITE	(-)66-86° r > v	MCL	X:a = ~ 30°	
1.707	1.712	1.732	.025	MANGANHUMITE	(+)37° r > v	ORTH	X = a	MnO 57.1, MgO 14.2, FeO 1.0%.
1.707	1.714	1.734	.027	CLINOHUMITE	(+)56° r < v	MCL	X ~ c	FeO 10.2, Fe_2O_3 1.2, TiO_2 5.1, F 0.1%.
1.695	1.716	1.725	.030	SONOLITE	(-)Large	MCL	---	Tw {001} common zincian var.
1.751	1.771	1.782	.031	LEUCOPHOENICITE	(-)74° r > v wk	MCL, ps orth	X ⊥ clv	Poly tw on {001}.

Table 24. Humite group (continued)

Refractive index			Biref	NAME	2V	System	Orientation	Remarks
α	β	γ						
(1.761)	1.772	1.781	.020	MANGANHUMITE	(+)84°	ORTH	X = a	MnO ~ 69, Fe ~ 1.0, MgO ~ 0.8%.
1.763	1.779	1.793	.030	SONOLITE	(-)78° r > v	MCL, pris	X:c = 9°	Tw {001} common.
1.756	1.780	1.792	.036	ALLEGHANYITE	(-)72° r > v	MCL	Ext to tw plane = 22°	Poly tw on {001} common.

Table 25. Melilite group

This group consists of silicates with the general formula $A_2YZ_2(O,OH,F)_7$, in which A may be Ca and Na; Y may be Mg, Al, Fe, Be, and Zn; and Z may be Si and Al. The mineral melilite is commonly formulated in terms of its end members akermanite (Ak) and gehlenite (Ge), neglecting the presence of Na.

Akermanite	(Ak)	$Ca_2MgSi_2O_7$
Gehlenite	(Ge)	$Ca_2Al(SiAl)O_7$
Hardystonite		$Ca_2ZnSi_2O_7$
Melilite		$(Ca,Na)(Mg,Al,Fe)(Si,Al)_2O_7$
Meliphanite		$(Ca,Na)Be(Si,Al)_2(O,OH,F)_7$

These minerals are tetragonal, space group $\underline{P\bar{4}2_1m}$, with distinct basal cleavage and hardness 5 to 6. They are optically uniaxial and, except for meliphanite, have low birefringence, ranging from optically positive for akermanite to negative for gehlenite.

A related mineral, leucophanite, $(Ca,Na)_2BeSi_2(O,OH,F)_7$, is triclinic, pseudo-orthorhombic. It is biaxial negative with β=1.593 (table 7).

Refractive index ω	Refractive index ε	Biref	NAME	G	Remarks
1.611	1.592	(-).019	MELIPHANITE	3.01	
1.629	1.624	(-).005	MELILITE	2.98	Al_2O_3 6.9, Fe_2O_3 1.2, FeO 2.1, MgO 8.2, Na_2O 3.2%.
1.630	1.637	(+).007	MELILITE	2.96-3.05	Al_2O_3 6.9, Fe_2O_3 1.9, FeO 3.1, MgO 8.2, Na_2O 3.2%.
1.632	1.639	(+).007	AKERMANITE	2.961	Synth, Ak 100.
1.648	1.649	(+).001	MELILITE	2.9-3.1	Synth, Ak 60, Ge 40.
1.65	1.65	.00	MELILITE	3.0	Ak 50, Ge 50.
1.653	1.652	(-).001	MELILITE	3.0	Synth, Ak 50, Ge 50.
1.664	1.672	(+).019	MELIPHANITE	3.03	

Table 25. Melilite group (continued)

Refractive index		Biref	NAME	G	Remarks
ω	ε				
1.669	1.657	(-).012	HARDYSTONITE	3.4	
1.669	1.658	(-).011	GEHLENITE	3.04	
1.672	1.661	(-).011	MELILITE	3.1	Al_2O_3 8.4, Fe_2O_3 8.4, FeO 1.1, MgO 4.7, Na_2O 3.8%.

Table 26. Meta-autunite group

The minerals of this group, many of which are lower hydrates of respective members of the autunite group, have the general formula $A(UO_2)_2(XO_4)_2 \cdot 4\text{-}8H_2O$, in which A may be K_2, $(NH_4)_2$, Ca, Ba, Mg, Fe^{+2}, Co, Cu, and Zn; X may be P and As.

Abernathyite	$K_2(UO_2)_2(AsO_4)_2 \cdot 8H_2O$
Bassetite	$Fe(UO_2)_2(PO_4)_2 \cdot 8H_2O$
Meta-ankoleite	$(K,Ba,Ca)(UO_2)_2(PO_4)_2 \cdot 6H_2O$
Meta-autunite	$Ca(UO_2)_2(PO_4)_2 \cdot 6H_2O$
Metaheinrichite	$Ba(UO_2)_2(AsO_4)_2 \cdot 8H_2O$
Metakahlerite	$Fe(UO_2)_2(AsO_4)_2 \cdot 8H_2O$
Metakirchheimerite	$Co(UO_2)_2(AsO_4)_2 \cdot 8H_2O$
Metalodevite	$Zn(UO_2)_2(AsO_4)_2 \cdot 10H_2O$
Metanovacekite	$Mg(UO_2)_2(AsO_4)_2 \cdot 8H_2O$
Metatorbernite	$Cu(UO_2)_2(PO_4)_2 \cdot 4\text{-}8H_2O$
Meta-uranocircite	$Ba(UO_2)_2(PO_4)_2 \cdot 6H_2O$
Metazeunerite	$Cu(UO_2)_2(AsO_4)_2 \cdot 8H_2O$
Sodium Uranospinite	$(Na_2,Ca)(UO_2)_2(AsO_4)_2 \cdot 5H_2O$
Uramphite	$(NH_4)_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$

Table 26. Meta-autunite group (continued)

These minerals are tetragonal, orthorhombic, or monoclinic, with square tabular form and perfect basal cleavage. Optically they are uniaxial or biaxial, mostly negative, with low to medium birefringence, weakly to moderately pleochroic in yellow or green. All except those containing Fe, Cu, or Co fluoresce under UV light.

Refractive index			Biref	NAME	2V	System	G
α or ε	β or ω	γ or ε					
1.57	1.574	1.580	.006	BASSETITE	(-)62°	MCL	3.4
---	1.581		---	META-ANKOLEITE	(-)0°	TET	3.54
1.564	1.585	1.585	.021	URAMPHITE	(-)3°	ORTH(?)	3.7
1.570	1.597		.027	ABERNATHYITE	(-)0°	TET	3.74
1.598	1.600		.002	META-AUTUNITE	(-)0°	TET	3.5
1.596	1.602	1.603	.007	META-AUTUNITE	(-)15°	TET	3.5
1.603	1.610	1.617	.014	BASSETITE	~ 90°	MCL	3.4
1.594	1.611		.017	META-AUTUNITE	(-)0°	TET	3.5
1.585	1.612		.027	SODIUM URANOSPINITE	(-)0°	TET	3.85
1.618	1.621	1.622	.004	METATORBERNITE	(-)0°	TET	3.6
1.604	1.622	1.630	.026	META-AUTUNITE	(-)15°	TET	3.5
1.603	1.622		.019	META-URANOCIRCITE	(-)0°	TET	4.0
1.610	1.623	1.623	.013	META-URANOCIRCITE	(-)20°	ORTH	4.08
	1.626	1.627	.001	METATORBERNITE	(+)0°	TET	3.6-3.8
1.628	1.631		.003	METATORBERNITE	(-)0°	TET	3.7-3.8
1.619	1.635	1.638	.019	METALODEVITE	(-)27-37°	ORTH	(4.0)
1.620	1.637		.017	METANOVACEKITE	(-)0°	TET	3.66

Table 26. Meta-autunite group (continued)

Refractive index			Biref	NAME	2V	System	G
α or ε	β or ω	γ or ε					
1.609	1.641		.032	METAHEINRICHITE	(-)0°	TET	4.04
1.608	1.642		.034	METAKAHLERITE	(-)0°	TET	---
1.617	1.644		.027	METAKIRCH-HEIMERITE	(-)0°	TET	---
1.624	1.648		.024	METAZEUNERITE	(-)0°	TET	3.67

Table 27. Mica group

The minerals of this group are silicates having the general formula $XY_{2-3}Z_4O_{10}(OH,F)_2$, in which X may be K, Na, Ca, Ba, and H_3O; Y may be Al, Fe^{+3}, Cr, V^{+3}, Mg, Fe^{+2}, Mn, Zn, and Li; Z may be Si, Al, and Be. The so-called brittle micas and the hydromicas are included here.

Anandite	$(Ba,K)(Fe,Mg)_3(Si,Al,Fe)_4O_{10}(O,OH)_2$
Annite	$K(Fe^{+2},Fe^{+3},Ti)_3(Si,Al)_4O_{10}(OH,F)_2$
Biotite	$K(Mg,Fe)_3(Si_3Al)O_{10}(OH,F)_2$
Bityite	$CaLiAl_2(AlBeSi_2)O_{10}(OH)_2$
Brammallite	$(Na,H_3O)(Al,Mg)_2(Si,Al)_4O_{10}(OH)_2 \cdot nH_2O$
Celadonite	$(K,Na)(Al,Fe,Mg)_2(Si,Al)_4O_{10}(OH)_2$
Chernykhite	$(Ba,Na)(V,Al)_2(Si,Al)_4O_{10}(OH)_2$
Clintonite	$Ca(Mg,Al)_3(Si,Al)_4O_{10}(OH)_2$
Ephesite	$Na(LiAl_2)(Si_2Al_2)O_{10}(OH,F)_2$
Ferri-annite	$K(Fe^{+2},Mg)_3(Fe^{+3},Al)Si_3O_{10}(OH)_2$
Glauconite	$(K,Na)(Al,Fe,Mg)_2(Si,Al)_4O_{10}(OH)_2$
Hendricksite	$K(Zn,Mn)_3(Si_3Al)O_{10}(OH,F)_2$
Illite	$(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}(OH)_2 \cdot nH_2O$

Table 27. Mica group (continued)

Kinoshitalite	$(Ba,K,Na)(Mg,Mn,Al)_3(Si,Al)_4O_{10}(OH,F)_2$
Lepidolite	$K(Li,Fe,Al)_3(Si,Al)_4O_{10}(F,OH)_2$
Margarite	$CaAl_2(Al_2Si_2)O_{10}(OH)_2$
Masutomilite	$K(Li,Mn,Al,Fe)_3(Si,Al)_4O_{10}(F,OH)_2$
Montdorite	$(K,Na)_2(Fe^{+2},Mn,Mg)_5(Si,Al)_8O_{20}(F,OH)_4$
Muscovite	$KAl_2(Si_3Al)O_{10}(OH,F)_2$
Paragonite	$NaAl_2(Si_3Al)O_{10}(OH,F)_2$
Phlogopite	$K(Mg,Fe)_3(Si_3Al)O_{10}(F,OH)_2$
Preiswerkite	$NaMg_2Al(Al_2Si_2)O_{10}(OH)_2$
Roscoelite	$K(V,Al)_2(Si_3Al)O_{10}(OH,F)_2$
Siderophyllite	$K(Fe,Mg)_3(Si_3Al)O_{10}(F,OH)_2$
Sodium phlogopite	$NaMg_3(Si_3Al)O_{10}(OH)_2$
Taeniolite	$KLiMg_2Si_4O_{10}F_2$
Tarasovite	$(K,Na,H_3O)Al_2(Si,Al)_4O_{10}(OH)_2 \cdot nH_2O$
Tobelite	$(NH_4,K)Al_2(Si_3Al)O_{10}(OH)_2$
Wonesite	$(Na,K)(Mg,Fe)_6(Si,Al)_8O_{20}(OH,F)_4$
Zinnwaldite	$K(Li,Fe^{+2},Al)_3(Si_3Al)O_{10}(F,OH)_2$

These minerals are monoclinic but show complex polytypic relations. Nearly all are biaxial negative, but optic angle may be near 0°, so that some have been listed also in table 5 (uniaxial negative) as well as table 7. The acute bisectric (X) is nearly normal to the plane of the basal cleavage, which is perfect ("micaceous"). Y=b in most of the group, but Z=b in muscovite, paragonite, and in the brittle micas margarite, ephesite, and clintonite. The birefringence is mostly 0.03-0.04, less for glauconite, celadonite, and the brittle micas, higher for those of high index, the latter also showing greater pleochroism.

Table 27. Mica group (continued)

Refractive index			Biref	NAME	(-)2V	Weight %			
α	β	γ				FeO	MnO	Fe_2O_3	Other
1.522	(1.548)	1.549	.027	PHLOGOPITE, synth F	14°	---	---	---	
1.529	1.548	1.553	.024	LEPIDOLITE	39°	0.1	0.7	0.2	
1.522	1.553	1.553	.031	TAENIOLITE	0-5°	---	---	---	
1.537	1.555	1.559	.022	LEPIDOLITE	38°	.07	.09	1.1	
1.535	1.564	1.565	.030	PHLOGOPITE	10°	---	---	---	
1.542	1.567	1.570	.028	LEPIDOLITE	34°	2.0	2.0	0.8	
1.534	1.568	1.570	.036	MASUTOMILITE	30°	1.5	8.1	0.4	Li_2O 4.5
1.540	1.570	1.570	.030	TAENIOLITE	5°	---	---	---	
1.546	1.575	1.579	.033	BRAMMALITE	small	---	---	---	
1.555	1.575	1.581	.026	TOBELITE	28°			0.6	$(NH_4)_2O$ 3.5, K_2O 2.3
1.548	1.577	1.579	.031	ZINNWALDITE	30°	10.4	1.7	0.6	
1.544	1.578	1.586	.042	TARASOVITE	23°	---	---	---	
1.552	1.582	1.587	.035	MUSCOVITE	30-47°	---	---	---	
1.555	1.584	1.588	.033	PHLOGOPITE	23-30°	4.2	---	3.7	TiO_2 0.4
1.559	1.586	1.586	.027	GLAUCONITE, var Skolite	small	2.6	---	6.4	Al_2O_3 18.2
1.560	1.587	1.595	.035	TOBELITE	30°			1.0	$(NH_4)_2O$ 3.85, K_2O 3.25
1.572	1.587	1.600	.028	ILLITE	small to med	---	---	---	
1.555	1.590	1.590	.035	MUSCOVITE	0-15°	---	---	---	
1.563	1.590	1.594	.031	MUSCOVITE, var Phengite	33°	1.9	---	1.5	MgO 4.0

Table 27. Mica group (continued)

Refractive index			Biref	NAME	(-)2V	Weight %			
α	β	γ				FeO	MnO	Fe_2O_3	Other
1.569	1.595	1.609	.040	MUSCOVITE, var Phengite	40°	3.4	3.9	3.1	MgO 3.1, Cr_2O_3 3.6
1.558	1.598	1.599	.041	BIOTITE	10-13°	13.9	0.4	2.1	
1.565	1.598	1.600	.035	MUSCOVITE	38°	0.9	---	2.8	
1.585	(~1.60)	1.600	.015	GLAUCONITE	small	1.6	---	14.1	Al_2O_3 8.9
1.571	1.603	1.606	.035	PARAGONITE	30°	---	---	---	
1.580	1.605	1.605	.025	MONTDORITE	3°	17.1	9.9	---	MgO 4.3, Al_2O_3 5.0
1.544	1.608	1.611	.040	WONESITE	0-5°	---	---	---	
1.571	1.608	1.611	.040	MUSCOVITE	34°	0.5	---	---	MgO 1.1, Cr_2O_3 0.2
1.573	1.609	1.615	.042	MUSCOVITE, var Phengite	31°	2.8	---	4.1	MgO 4.1, TiO_2 1.0
1.586	1.612	1.613	.027	MARGARITE (Sodium analogue)	50°	---	---	---	
1.560	1.614	1.615	.055	PREISWERKITE	5-7°	---	---	---	
1.575	1.617	1.621	.046	BIOTITE, var Mangano-phyllite	30°	1.2	6.2	5.8	
1.597	1.618	1.619	.020	GLAUCONITE	20°	4.0	---	18.8	Al_2O_3 8.5, MgO 3.6
1.580	1.620	1.623	.043	MUSCOVITE, var Phengite	35°	2.5	---	8.0	MgO 1.9
1.592	1.624	1.625	.033	EPHESITE	18°	---	---	---	Na_2O 7.4, Li_2O 3.5
1.606	(1.630)	1.632	.026	CELADONITE	small	2.1	---	12.4	MgO 5.8, Al_2O_3 6.7
1.60	1.63	1.63	.03	MUSCOVITE, var Mariposite	~ 0°	---	---	---	

Table 27. Mica group (continued)

Refractive index			Biref	NAME	(-)2V	Weight %			
α	β	γ				FeO	MnO	Fe_2O_3	Other
1.619	1.633	1.635	.016	KINOSHITALITE	23°	---	7.4	0.7	BaO 17.8, Mn_2O_3 3.2
1.59	>1.63	>1.64	>.05	ROSCOELITE	med	1.7	---	---	Al_2O_3 21.9, V_2O_3 17.4
1.610	1.634	1.634	.024	GLAUCONITE	10°	2.9	---	24.9	Al_2O_3 7.3
1.590	1.640	1.640	.050	SIDERO-PHYLLITE	small	30.2	1.0	---	
1.612	1.643	1.643	.031	CELADONITE	small	9.8	---	24.3	MgO 3.7
1.632	1.643	1.646	.014	MARGARITE	63°	---	---	---	
1.595	1.652	1.656	.061	BIOTITE	small	19.9	0.4	3.2	
1.643	1.652	1.654	.011	BITYITE	med	---	---	---	
1.598	1.658	1.660	.062	HENDRICKSITE	8°	---	12.5	4.8	ZnO 19.8
1.648	1.659	1.660	.012	CLINTONITE	5-33°	---	---	---	
1.644	---	1.663	.019	CELADONITE	small	9.2	---	26.9	Al_2O_3 2.1
1.624	1.672	1.672	.048	ANNITE	5°	32.1	---	3.1	TiO_2 3.6
1.610	1.676	1.676	.066	PHLOGOPITE (titanian)	19°	4.7	0.2	6.7	TiO_2 4.4
1.610	1.685	1.704	.094	ROSCOELITE	10-15°	---	---	---	
1.624	1.686	1.686	.062	HENDRICKSITE	2-5°	0.7	13.9	4.8	ZnO 21.4
1.640	1.686	1.702	.062	CHERNYKHITE	11-12°	---	---	---	
1.653	(1.691)	1.691	.038	FERRI-ANNITE	0-10°	24.5	---	8	Al_2O_3 5.5
1.660	(1.720)	1.728	.068	FERRI-ANNITE	40°	29.9	---	13.2	Al_2O_3 1.4
---	1.855	>1.88	>.025	ANANDITE	(+)?	33.1	0.7	7.0	BaO 20.4

Table 28. Monticellite group

This group, sometimes considered to be a subgroup of the olivine group, includes minerals having the general formula $CaXSiO_4$, in which X may be Mg, Fe^{+2}, and Mn. All members are orthorhombic, space group Pmcn. Optically they are biaxial negative, with medium to large optic angle, $r > v$, X=b, Z=a. All gelatinize with HCl.

Refractive index			Biref	NAME and formula	(-)2V	Weight %		
α	β	γ				FeO	Fe_2O_3	MnO
1.641	1.649	1.655	.014	MONTICELLITE $CaMgSiO_4$	80°	1.4	---	---
1.654	1.664	1.674	.020	MONTICELLITE $Ca(Mg,Fe)SiO_4$	82°	7.6	---	0.2
1.674	1.694	1.706	.032	KIRSCHSTEINITE $Ca(Fe,Mg)SiO_4$	65°	19.3	1.4	1.1
1.695	1.716	1.725	.030	GLAUCOCHROITE $Ca(Mn,Fe)SiO_4$	61°	4.2	---	32.7
1.689	1.720	1.728	.039	KIRSCHSTEINITE $Ca(Fe,Mg)SiO_4$	51°	29.3	0.7	1.6

Table 29. Olivine group

Minerals of this group have the general formula X_2SiO_4, in which X may be Mg, Fe, Mn, Ni, and rarely Zn. There is a complete solid solution series from Fe to Mg, referred to as the olivine series.

Liebenbergite	$(Ni,Mg,Fe)_2SiO_4$
Olivine series	$(Mg,Fe)_2SiO_4$
Forsterite	Fo 90-100
Chrysolite	Fo 70-90
Hyalosiderite	Fo 50-70
Hortonolite	Fo 30-50
Ferrohortonolite	Fo 10-30
Fayalite	Fo 0-10
Tephroite	$(Mn,Mg)_2SiO_4$

The members are orthorhombic, space group Pmcn (except liebenbergite, possibly Pbnm), with distinct {010} cleavage, hardness 6.5 to 7, high specific gravity. Optically they are biaxial, with X=b, Z=a, moderate to high birefringence, refractive indices increasing with Fe-content (compare the monticellite group).

Refractive index			Biref	NAME	2V	Weight %			
α	β	γ				FeO	Fe_2O_3	MnO	MgO
1.636	1.651	1.669	.033	FORSTERITE (synthetic) Fo 100	(+)85°	---	---	---	57.3
1.653	1.664	1.686	.033	FORSTERITE Fo 93	(+)87°	8.6	0.4	0.2	---
1.656	1.674	1.695	.039	CHRYSOLITE Fo 88	(+)89°	10.8	1.7	0.2	46.5
1.661	1.680	1.697	.036	CHRYSOLITE Fo 86	~ 90°	---	---	---	---
1.683	1.704	1.722	.039	CHRYSOLITE Fo 76	(-)85°	21.6	1.6	0.3	---

Table 29. Olivine group (continued)

Refractive index			Biref	NAME	2V	Weight %			
α	β	γ				FeO	Fe_2O_3	MnO	MgO
1.698	1.720	1.736	.038	HYALOSIDERITE Fo 65	(-)80°	27.8	2.1	0.4	---
1.711	1.727	1.740	.029	TEPHROITE	(-)85°	---	0.3	47.1	18.1
1.710	1.733	1.750	.040	HYALOSIDERITE Fo 63	(-)79°	32.0	2.0	0.5	31.0
1.721	1.750	1.765	.044	HYALOSIDERITE Fo 60	(-)85°	36.8	---	0.5	27.0
1.750	1.766	1.779	.029	TEPHROITE	(-)67°	0.2	---	60.7	6.6
1.742	1.770	1.786	.044	HORTONOLITE Fo 43	(-)69°	---	---	---	---
1.758	1.786	1.804	.046	HORTONOLITE, zincian	(-)77°	35.5	(ZnO 10.7)	16.9	5.6
1.761	1.790	1.806	.045	HORTONOLITE Fo 33	(-)65°	---	---	---	---
1.782	1.802	1.812	.030	TEPHROITE	(-)65°	0.9	---	65.1	2.5
1.777	1.818	1.828	.051	FERRO-HORTONOLITE, manganoan	(-)52°	41.5	0.7	21.4	4.5
1.788	1.828	1.840	.052	FERRO-HORTONOLITE Fo 20	(-)58°	58.6	---	0.8	---
1.803	1.843	1.851	.048	FERRO-HORTONOLITE, manganoan	(-)48°	56.9	1.2	9.7	1.1
1.816	1.850	1.863	.047	FAYALITE Fo 7	(-)60°	---	---	---	---
1.820	1.854	1.888	.068	LIEBENBERGITE	(-)88°	4.4	(NiO 56.3)	(CaO 1.8)	6.5
1.827	1.869	1.879	.052	FAYALITE	(-)48°	65.0	0.4	1.0	---

Table 30. Osumilite group

This group consists of silicates with double rings of $(Si,Al)_{12}O_{30}$. The general formula is $A_{1-2}B_{2-3}C_3Z_{12}O_{30}\cdot nH_2O$, in which A may be Ba, Ca, K, and Na; B may be Fe^{+2}, LI, Mg, Mn, and Na; C may be Al, Be, Fe^{+2}, Fe^{+3}, Li, Mg, Sn, Ti, Zn, and Zr; Z may be Al and Si. The minerals are hexagonal, space group P6/mcc, or pseudohexagonal. Optically they are uniaxial or nearly so, with low birefringence.

Brannockite	$KLi_2Sn_3Si_{12}O_{30}$
Darapiosite	$KNa_2Li(Mn,Zn)_2ZrSi_{12}O_{30}$
Eifelite	$KNa_4Mg_9Si_{24}O_{60}$
Emeleusite	$Na_4Li_2Fe_2^{+3}Si_{12}O_{30}$
Merrihueite	$(K,Na)_2(Fe^{+2},Mg)_5Si_{12}O_{30}$
Milarite	$KCa_2AlBe_2Si_{12}O_{30}\cdot 0.5H_2O$
Osumilite	$(K,Na)(Fe^{+2},Mg)_2(Al,Fe)_3(Si,Al)_{12}O_{30}$
Osumilite-(Mg)	$(K,Na)(Mg,Fe^{+2})_2(Al,Fe)_3(Si,Al)_{12}O_{30}\cdot H_2O$
Roedderite	$(Na,K)_2(Mg,Fe^{+2})_5Si_{12}O_{30}$
Sogdianite	$(K,Na)Li_2(Li,Fe^{+2})_2ZrSi_{12}O_{30}$
Sugilite	$(K,Na)(Na,Fe^{+3})_2(Li_2Fe^{+3})Si_{12}O_{30}$
Yagiite	$(Na,K)_{1-2}Mg_2(Al,Mg)_3(Si,Al)_{12}O_{30}$

(Armenite, $BaCa_2Al_6Si_9O_{30}\cdot H_2O$, may belong to this group.)

Refractive index		Biref	NAME	Weight %				Remarks
ω	ε			MgO	FeO	Na_2O	K_2O	
1.532	1.529	(-).003	MILARITE	---	---	---	---	
1.536	1.543	(+).006	ROEDDERITE	19.0	0.4	5.3	3.8	$2V_z$ = 5-8°.
1.536	1.544	(+).008	YAGIITE	10.5	2.4	3.7	1.4	
1.537	1.542	(+).005	ROEDDERITE	19.5	2.0	4.0	3.3	
1.540	1.546	(+).006	OSUMILITE-Mg	9.5	2.2	0.3	4.0	

Table 30. Osumilite group (continued)

Refractive index		Biref	NAME	Weight %				Remarks
ω	ε			MgO	FeO	Na_2O	K_2O	
1.541	1.547	(+).006	OSUMILITE-Mg	7.5	4.0	---	4.1	$2V_z$ = 5-15°.
1.543	1.545	(+).002	EIFELITE	---	---	---	---	
1.546	1.550	(+).004	OSUMILITE	6.7	10.0	1.0	1.4	Fe_2O_3 2.0%.
1.553	1.549	(-).004	MILARITE	---	---	---	---	
1.559	---	---	MERRIHUEITE	---	10.5	---	---	
1.567	1.566	(-).001	BRANNOCKITE	---	---	0.7	3.5-4.5	SnO_2 28.2, Li_2O_3 3.7%. Fluor in UV.
1.580	1.575	(-).005	DARAPIOSITE	---	---	3.0	5.1	2V = 5°, ZrO_2 5.0, MnO 8.2, ZnO 7.8%.
1.592	---	---	MERRIHUEITE	---	24.9	---	---	
1.597	1.596	(-).001	EMELEUSITE	0.1	---	12.0	---	2V = 0-30°, r > v str. Fe_2O_3 12.1, Li_2O 2.8%.
1.606	1.608	(+).002	SOGDIANITE	---	1.2	2.8	4.8	TiO_2 2.9, Fe_2O_3 4.6, ZrO_2 9.8, Li_2O 3.7%. Violet.
1.610	1.607	(-).003	SUGILITE	---	0.2	4.4	3.8	Fe_2O_3 12.8, Li_2O 3.1%.

Table 31. Pyrochlore group

The minerals of this group are complex oxides having the general formula $A_{1-2}B_2O_6(O,OH,F)$, in which A may be Ba, Bi, Ca, Ce, K, Na, Pb, Sb^{+3}, Sn, Sr, Th, U, Y, and Zr; B may be Nb, Ta, and Ti. Jixianite is a related mineral with W and Fe^{+3}.

In the Pyrochlore subgroup, Nb > Ta, and Nb + Ta > 2Ti.

In the Microlite subgroup, Ta > Nb, and Nb + Ta > 2Ti.

In the Betafite subgroup, Nb + Ta < 2Ti.

Bariopyrochlore	$(Ba,Sr)_2(Nb,Ti)_2(O,OH)_7$
Betafite	$(Ca,Na,U)_2(Ti,Nb,Ta)_2O_6(OH)$
Bismutomicrolite	$(Bi,Ca)(Ta,Nb)_2O_6(OH)$
Jixianite	$Pb(W,Fe^{+3})_2(O,OH)_7$
Microlite	$(Ca,Na)_2(Ta,Nb)_2O_6(OH)$
Plumbopyrochlore	$(Pb,Y)(Nb,Ta)_2(O,OH)_7$
Pyrochlore	$(Na,Ca)_2(Nb,Ta)_2O_6(OH,F)$
Stibiobetafite	$(Ca,Sb^{+3})(Ti,Nb,Ta)_2(O,OH)_7$
Uranmicrolite	$(Ca,Na,U)_2(Ta,Nb,Ti)_2O_6(OH)$
Uranpyrochlore	$(Ca,Na,U)_2(Nb,Ta,Ti)_2(O,OH)_7$
Yttropyrochlore	$(Y,Na,Ca,U)_{1-2}(Nb,Ta,Ti)_2(O,OH)_7$
Zirkelite	$(Ca,Zr,Th)_2(Ti,Nb)_2O_7$

These minerals are cubic, space group <u>Fd3m</u>, commonly occurring as octahedra, with conchoidal fracture. Nearly all are infusible. Optically they are isotropic with high refractive index.

Refractive index	NAME	H	G	Color	Action in acid
1.83	YTTROPYROCHLORE	4.5-5	3.7	Dark brown	Insol.
1.87	PYROCHLORE	5-6	3.77	Brown, yellow	Dec by H_2SO_4.
1.915	BETAFITE	5	4.0	Greenish black	Dec by H_2SO_4.
1.925	MICROLITE	5.5	5.5	Yellow, brown	Dec by H_2SO_4.

Table 31. Pyrochlore group (continued)

Refractive index	NAME	H	G	Color	Action in acid
1.94	BETAFITE	5	5.2	Black, brown, yellow	Dec by H_2SO_4.
1.97	URANMICROLITE	5.5	5.8	Brown, black	Dec by H_2SO_4.
1.98	URANPYROCHLORE	5	4.8	Brown	Insol.
2.0	PYROCHLORE	5	4.1-4.3	Brown, red	Dec by H_2SO_4.
>2.00	BISMUTOMICROLITE	5	6.5-7.2	Yellow, brown	Insol.
2.02	BETAFITE	4.5	4.76	Black	Dec by H_2SO_4.
2.023	MICROLITE	6	6.42	Brown, yellow	
2.06	ZIRKELITE	6	4.02	Brown, black	Dec by hot HCl.
2.07	MICROLITE	6	5.95	Brown, yellow	Insol.
2.08	BARIOPYROCHLORE	4-4.5	3.7-4.0	Yellow, gray	Insol.
2.08	PLUMBOPYROCHLORE	---	6.34	Green-yellow to brown	---
2.18	PYROCHLORE	5	4.1-4.3	Brownish red	Dec by H_2SO_4.
2.18	ZIRKELITE	5-6	4.3-4.7	Black to dark brown	Insol.
2.2	STIBIOBETAFITE	~ 5	5.30	Brownish black	---
2.26	JIXIANITE	5	5.30	Brownish black	---
2.28	ZIRKELITE	5-6	4.3-4.7	Black to dark brown	Insol.
2.315	JIXIANITE	5	5.30	Brownish black	---

Table 32. Pyroxene group

The minerals of the pyroxene group are single-chain silicates with the general formula $(W)_{1-p}(X,Y)_{1+p}Z_2O_6$. One subgroup is orthorhombic, in which p=1 and X may be mainly Mg and Fe^{+2}. Another subgroup includes the monclinic members, in which p ranges from 0 to 1, and W may be Ca and Na; X may be Mg, Fe^{+2}, Mn, Ni, and Li; Y may be Al, Fe^{+3}, Cr, and Ti; Z may be Si and Al. A discussion of nomenclature is given by Deer, Howie, and Zussman (1978, v. 2A).

Orthopyroxenes	$(Mg,Fe)_2Si_2O_6$
Enstatite	En 100-87
Bronzite	En 87-70
Hypersthene	En 70-50
Ferrohypersthene	En 50-30
Eulite	En 30-10
(Orthoferrosilite	En 10-0)
Clinopyroxenes	
Acmite	$NaFe^{+3}Si_2O_6$
Aegirine-augite	$(Na,Ca)(Fe^{+3},Mg,Al)(Si,Al)_2O_6$
Augite	$(Ca,Na)(Mg,Fe,Al,Ti)(Si,Al)_2O_6$
Clinoenstatite	$Mg_2Si_2O_6$
Clinohypersthene	$(Mg,Fe)_2Si_2O_6$
Diopside	$CaMgSi_2O_6$
Fassaite	$Ca(Mg,Fe^{+3},Al)(Si,Al)_2O_6$
Ferroaugite	$(Ca,Na)(Fe,Mg,Al,Ti)(Si,Al)_2O_6$
Ferrosalite	$Ca(Fe,Mg)Si_2O_6$
Hedenbergite	$CaFe^{+2}Si_2O_6$
Jadeite	$NaAlSi_2O_6$
Johannsenite	$CaMnSi_2O_6$
Kanoite	$(Mn,Mg)_2Si_2O_6$
Omphacite	$(Ca,Na)(Mg,Fe^{+2},Fe^{+3},Al)Si_2O_6$

Clinopyroxenes (continued)

Pigeonite	$(Mg,Fe^{+2},Ca)(Mg,Fe^{+2})Si_2O_6$
Salite	$Ca(Mg,Fe)Si_2O_6$
Spodumene	$LiAlSi_2O_6$
Ureyite	$NaCrSi_2O_6$

The orthorhombic pyroxenes, space group Pbca, form a solid solution series from enstatite through eulite, with no natural occurrences of the theoretical iron end member, orthoferrosilite. Crystals are commonly prismatic, cleavage is good {210} at 87-88°, hardness 5 to 6. All members are insoluble in or only slightly attacked by acids. Birefringence is low, refractive indices increase with increasing iron content, with optic sign changing from positive to negative at about β 1.68 and back to positive at about β 1.76. All members of the series have X=b, Z=c, positive elongation. Although the enstatite end member is not pleochroic, many intermediate members show weak pleochroism, X pink, Y yellow, Z pale green.

The monoclinic pyroxenes have space group P2/c (except pigeonite, $P2_1/c$), good cleavage on {110} at about 87°, hardness 5 to 6. All are insoluble in or only very slightly attacked by acids. Optically, they are biaxial, with refractive indices increasing with increasing iron and titanium content; Y=b (except clinoenstatite, clinohypersthene, and some pigeonites, where X=b). Minerals of the series diopside-hedenbergite-johannsenite along with the augites are optically positive, with moderate 2V and birefringence, Z:c=40-50°. Pigeonite, a Ca-poor member, is characterized by low 2V. The series jadeite to aegirine to aegirine-augite has high 2V (60-90°), with indices and birefringence increasing with increase in Fe-content. For aegirines, Z:c=75-89°.

Table 32. Pyroxene group (continued)

Refractive index α	β	γ	Biref	NAME	2V	Opt orientation	System	Weight % FeO	MnO	Fe_2O_3	Al_2O_3	Remarks
1.640	1.645	1.652	.012	JADEITE	(+)67°	Y = b Z:c = 22°	MCL	---	---	---	---	
1.650	1.653	1.658	.008	ENSTATITE En 100	(+)59° r < v	X = b Z = c	ORTH	---	---	---	---	Synth.
1.651	1.654	1.660	.009	CLINO- ENSTATITE En 100	(+)54°	X = b Z:c = 22°	MCL	---	---	---	---	Synth.
1.654	1.657	1.666	.012	JADEITE	(+)70° r > v med	Y = b Z:c = 34°	MCL	---	---	0.4	---	
1.653	1.659	1.677	.024	SPODUMENE	(+)66° r < v	Y = b Z:c = 25°	MCL	---	---	---	---	
1.665	1.669	1.674	.009	ENSTATITE En 91	(+)80° r < v wk	X = b Z = c	ORTH	7.0	---	---	---	
1.664	1.670	1.685	.021	OMPHACITE	(+)66° r < v med	Y = b Z:c = 35°	MCL	2.8	---	1.8	---	Pleoc, wk greens.
1.662	1.670	1.682	.020	JADEITE	(+)70° r > v med	Y = b Z:c = 35°	MCL	0.5	---	3.2	---	
1.668	1.671	1.682	.014	SPODUMENE	(+)65° r < v	Y = b Z:c = 24°	MCL	---	---	0.7	---	

Table 32. Pyroxene group (continued)

Refractive index			Biref	NAME	2V	Opt orien-tation	System	Weight %				Remarks
α	β	γ						FeO	MnO	Fe_2O_3	Al_2O_3	
1.665	1.672	1.695	.030	DIOPSIDE	(+)57° r > v wk	Y = b Z:c = 39°	MCL	1.5	0.1	0.6	---	
1.673	1.678	1.705	.032	DIOPSIDE	(+)48° r > v	Y = b Z:c = 42°	MCL	8.2	0.3	1.4	4.5	TiO_2 1.1%.
1.675	1.678	1.688	.013	CLINO-HYPERSTHENE	(+)57°	X = b Z:c = 36°	MCL	12.6	0.5	---	0.5	
1.674	1.680	1.685	.011	BRONZITE	(-)79°	X = b Z = c	ORTH	11.1	0.5	---	---	
1.673	1.681	1.695	.022	OMPHACITE	(+)70° r < v med	Y = b Z:c = 41°	MCL	2.7	---	1.3	8.3	Pleoc, wk greens.
1.679	1.681	1.685	.006	JADEITE	(+)64° r > v med	Y = b Z:c = 38°	MCL	1.1	---	5.7	---	
1.676	1.683	1.705	.029	DIOPSIDE, manganoan	(+)1.0° r > v	Y = b Z:c = 5°	MCL	---	7.4	0.4	0.4	ZnO 3.3%.
1.684	1.684	1.707	.023	PIGEONITE	(+)18-26°	Y = b Z:c = 40°	MCL	20.1	0.4	3.5	---	CaO 5.5%.
1.677	1.685	1.708	.031	DIOPSIDE	(+)59° r > v wk	Y = b Z:c = 39°	MCL	5.6	0.5	3.2	2.2	

Table 32. Pyroxene group (continued)

Refractive index			Biref	NAME	2V	Opt orien- tation	System	Weight %				Remarks
α	β	γ						FeO	MnO	Fe_2O_3	Al_2O_3	
1.687	1.692	1.715	.028	DIOPSIDE	(+)51°	Y = b Z:c = 42°	MCL	9.5	0.2	1.6	2.3	
1.686	1.693	1.719	.028	FASSAITE	(+)56° r > v med	Y = b Z:c = 43°	MCL	3.1	---	2.1	13.4	TiO_2 0.5%.
1.685	1.695	1.700	.015	BRONZITE En 73	(-)69° r > v	X = b Z = c	ORTH	17.1	0.4	1.0	---	
1.696	1.698	1.721	.025	PIGEONITE	(+)25°	Y = b Z:c = 41°	MCL	21.4	0.4	0.8	---	CaO 5.5%.
1.690	1.699	1.721	.031	DIOPSIDE, manganoan	(+)60° r > v wk	Y = b Z:c = 43°	MCL	1.7	10.0	1.5	0.3	
1.689	1.699	1.718	.029	OMPHACITE	(+)64° r < v med	Y = b Z:c = 40°	MCL	5.9	---	3.8	6.1	
1.695	1.700	1.720	.025	AUGITE	(+)50°	Y = b Z:c = 43°	MCL	14.1	0.2	1.3	2.9	MgO 10.5%.
1.700	1.707	1.724	.024	SALITE	(+)52°	Y = b Z:c = 44°	MCL	9.8	0.3	1.8	2.8	TiO_2 1.3%.
1.700	1.710	1.733	.033	JOHANNSENITE	(+)60° r > v	Y = b Z:c = 49°	MCL	1.5	22.6	0.8	---	
1.703	1.713	1.717	.014	HYPERSTHENE En 57	(-)53°	X = b Z = c	ORTH	25.7	---	1.0	---	

Table 32. Pyroxene group (continued)

Refractive index			Biref	NAME	2V	Opt orien-tation	System	Weight %				Remarks
α	β	γ						FeO	MnO	Fe_2O_3	Al_2O_3	
1.708	1.714	1.736	.028	FERROSALITE	(+)70° r > v wk	Y = b Z = c	MCL	18.6	0.2	0.5	1.1	
1.714	1.714	1.742	.028	PIGEONITE	(+)0-12°	Y = b Z:c = 41°	MCL	27.8	1.0	1.7	0.9	CaO 3.8%.
1.710	1.716	1.736	.028	FERROAUGITE	(+)52°	Y = b Z:c = 49°	MCL	20.2	1.1	3.5	0.9	TiO_2 1.2%.
1.715	1.717	1.728	.013	KANOITE	(+)41°	Y = b Z:c = 48°	MCL	3.1	31.2	---	---	MgO 15.1%.
1.710	1.719	1.738	.028	JOHANNSENITE	(+)70°	Y = b Z:c = 48°	MCL	1.0	26.8	0.3	---	
1.712	1.719	1.736	.024	FASSAITE	(+)55° r > v	Y = b Z:c = 46°	MCL	0.2	---	6.1	15.8	CaO 25.3%.
1.714	1.723	1.774	.060	AUGITE, zincian	(+)74° (47±5°)	Y = b Z:c = 55°	MCL	3.7	7.2	4.2	1.2	ZnO 7.7%.
1.715	1.728	1.731	.016	FERROHYPER-STHENE En 45	(-)51°	X = b Z = c	ORTH	29.4	0.2	2.1	---	
1.725	1.730	1.750	.025	AUGITE, titanian	(+)40°	Y = b Z:c = 45°	MCL	5.0	0.2	4.4	7.4	TiO_2 5.5%.
1.726	1.732	1.753	.027	HEDENBERGITE	(+)49° r > v wk	Y = b Z:c = 44°	MCL	24.7	0.7	1.9	---	Pleoc, X pale green, Z dark green.

Table 32. Pyroxene group (continued)

Refractive index α	β	γ	Biref	NAME	2V	Opt orien-tation	System	Weight % FeO	MnO	Fe_2O_3	Al_2O_3	Remarks
1.727	1.736	1.751	.024	FASSAITE	(+)49° r > v	Y = b Z:c ≡ 48°	MCL	1.2	---	6.2	12.9	TiO_2 3.0%.
1.720	1.740	1.757	.037	AEGIRINE-AUGITE	(-)85° r < v	Y = b Z:c ≡ 75°	MCL	7.5	0.6	14.0	2.2	Pleoc, X bright green, Y and Z greenish yellow. Na_2O 5.3%.
1.735	1.741	1.761	.026	FERROAUGITE	(+)51°	Y = b Z:c = 40°	MCL	24.0	0.4	1.2	4.1	TiO_2 1.6%.
1.736	1.747	1.752	.016	EULITE En 30	(-)63°	X = b Z = c	ORTH	39.4	0.9	---	---	
1.741	1.751	1.774	.033	ACMITE	(+)mod	Y = b Z:c ≡ 60°	MCL	1.4	7.2	12.9	---	Zn 8.8%.
1.745	1.753	1.771	.026	HEDENBERGITE	(+)52° r > v wk	Y = b Z:c ≡ 41°	MCL	29.7	0.9	1.4	---	
1.732	1.756	1.770	.038	ACMITE	(-)80° r > v	Y = b Z:c ≡ 81°	MCL	1.1	4.7	18.2	5.9	Pleoc, X pink, Y pale blue, Z blue. TiO_2 0.6%.
1.740	1.756	1.762	.022	UREYITE	(-)65°	Y = b Z:c ≡ 76°	MCL	---	---	---	---	
1.752	1.762	1.772	.020	EULITE En ~ 11	(-)87° r < v str	X = b Z = c	ORTH	44.5	---	1.9	---	Dark brown.

Table 32. Pyroxene group (continued)

Refractive index			Biref	NAME	2V	Opt orien-tation	System	Weight %				Remarks
α	β	γ						FeO	MnO	Fe_2O_3	Al_2O_3	
1.741	1.767	1.789	.048	AEGIRINE-AUGITE	(-)85° r > v	Y = b Z:c = 78°	MCL	5.2	0.5	19.1	1.3	Pleoc, X deep green, Y yellow-green, Z brown-green, abs X > Y = Z. Na_2O 7.2, TiO_2 1.6%.
1.751	1.786	1.800	.049	ACMITE	(-)69° r > v	Y = b Z:c = 89°	MCL	3.7	0.2	25.4	2.9	Pleoc, X and Y deep green, Z yellow-brown. Na_2O 11.7, TiO_2 0.7%.
1.770	1.812	1.830	.060	ACMITE	(-)58° r > v	Y = b Z:c = 84°	MCL	0.8	---	31.4	1.9	Pleoc, X pale yellow-green, Y yellow-green, Z emerald green, TiO_2 0.8%.

Table 33. Scapolite group

The minerals of this group are solid solutions of the end-members marialite, $Na_8(AlSi_3O_8)_6(Cl_2,SO_4,CO_3)$, and meionite, $Ca_8(Al_2Si_2O_8)_6(CO_3,Cl_2,SO_4)$, which themselves are not found as such in nature. The composition and paragenetic relations of the scapolites have been reviewed in detail by Shaw (1960).

Minerals of this group are tetragonal, space group P4/m, with cleavages {100} perfect, {110} less so, hardness 5 to 6. Optically they are uniaxial negative, refractive indices and birefringence increasing with Ca-content.

Refractive index		Biref	NAME	Weight %					
ω	ε			Na_2O	K_2O	CaO	Cl	CO_2	SO_3
1.532	1.522	(-).010	MARIALITE	7.1	4.3	6.3	1.0	2.0	---
1.546	1.542	(-).004	MARIALITE Me 19	10.5	1.2	4.8	3.0	1.1	0.03
1.561	1.546	(-).015	SCAPOLITE Me 33	8.6	1.1	8.3	2.2	1.7	0.4
1.574	1.549	(-).025	SCAPOLITE Me 54	5.4	1.0	12.5	1.4	2.9	0.1
1.587	1.555	(-).032	MEIONITE Me 70	2.4	2.4	15.8	0.1	2.9	0.9
1.607	1.571	(-).036	MEIONITE Me 84	2.0	0.3	20.4	0.2	4.1	0.3

Table 34. Sodalite group

The minerals of this group are sodium- and calcium-aluminosilicates having the general formula $(Na,Ca)_{6-8}Al_6Si_6(O,S)_{24}[SO_4,Cl_2,(OH)_2]_{1-2}$.

Hauyne	$(Na,Ca)_{6-8}Al_6Si_6(O,S)_{24}(SO_4,Cl_2)_{1-2}$
Lazurite	$(Na,Ca)_{7-8}(Al,Si)_{12}(O,S)_{24}[SO_4,Cl_2(OH)_2]$
Nosean	$Na_8Al_6Si_6O_{24}(SO_4)$
Sodalite	$Na_8Al_6Si_6O_{24}Cl_2$

These minerals are cubic, space group $P\bar{4}3m$ or $P\bar{4}3n$, habit dodecahedral, color blue or white, cleavage {110} poor, hardness 5 to 6. They fuse at 3.5-4.5, gelatinize with HCl. Optically they are isotropic, with refractive index increasing with Ca-content. The group is discussed by Taylor (1967) and by Hogarth and Griffin (1976).

Refractive index	NAME	G	Weight %				
			Na_2O	CaO	SO_3	Cl	Other
1.470	NOSEAN	2.32	20.7	1.7	8.8	0.7	
1.483	SODALITE	2.30	---	---	---	7.1	H_2O 2.5%.
1.487	SODALITE var. Hackmanite	2.2-2.3	---	---	---	---	
1.494	HAUYNE	2.40	19.9	4.9	9.8	1.3	
1.495	NOSEAN	2.3-2.4	---	---	---	---	
1.500	LAZURITE	2.4	---	---	---	---	
1.509	HAUYNE	2.51	13.2	10.1	---	---	K_2O 2.8%.
1.522	LAZURITE	2.4	---	---	---	---	

Table 35. Spinel group

Minerals of this group have the general formula AB_2O_4, in which A may be Mg, Fe^{+2}, Zn, Mn^{+2}, rarely Ni, Cu, Co, Ti, and Ge; B may be Al, Fe^{+3}, Cr, Mn^{+3}, rarely Fe^{+2} and V^{+3}. Common end members are spinel (Mg-Al), hercynite (Fe-Al), gahnite (Zn-Al), magnesiochromite (Mg-Cr), chromite (Fe-Cr), magnesioferrite (Mg-Fe), magnetite (Fe-Fe), and jacobsite (Mn-Fe).

Chromite	$(Fe^{+2},Mg)(Cr,Al,Fe^{+3})_2O_4$
Franklinite	$(Zn,Mn^{+2},Fe^{+2})(Mn^{+3},Fe^{+3})_2O_4$
Gahnite	$Zn(Al,Fe^{+3})_2O_4$
Galaxite	$(Mn,Fe^{+2})(Al,Fe^{+3})_2O_4$
Hercynite	$(Fe^{+2},Mg)(Al,Fe^{+3})_2O_4$
Jacobsite	$(Mn,Fe^{+2},Mg)Fe_2^{+3}O_4$
Magnesiochromite	$(Mg,Fe^{+2})(Cr,Al,Fe^{+3})O_4$
Magnesioferrite	$(Mg,Fe^{+2})Fe^{+3}O_4$
Magnetite	$Fe^{+2}Fe_2^{+3}O_4$
Spinel	$(Mg,Fe^{+2})Al_2O_4$
Trevorite	$NiFe_2O_4$

Rare minerals of the group include coulsonite (Fe-V), cuprospinel (Cu-Fe), ulvöspinel ($TiFe_2^{+2}O_4$), and its germanium analogue brunogeierite, $GeFe_2O_4$. Ringwoodite, $(Mg,Fe)_2SiO_4$, has spinel-type structure (n=1.768).

These minerals are cubic, commonly octahedral, space group Fd3m. They are characterized by high refractive index and specific gravity, lack of cleavage, hardness 7.5 to 8, and infusibility. Those members high in Fe^{+3} or V^{+3} (magnetite, coulsonite, ulvöspinel, brunogeierite) are opaque or nearly so. The aluminum and chromium end-members are insoluble in acids; those with dominant Fe^{+3} are dissolved by HCl.

Table 35. Spinel group (continued)

Refractive index	NAME	G	Weight %					Remarks
			Cr_2O_3	Fe_2O_3	FeO	MnO	MgO	
1.714	SPINEL	3.58	---	---	---	---	---	Synth end member.
1.738	SPINEL	3.62	---	1.5	5.6	0.1	---	
1.747	SPINEL, zincian	3.97	---	---	1.9	---	16.8	ZnO 18.2.
1.776	HERCYNITE	4.20	---	11.7	23.3	---	10.8	"Pleonaste"
1.782	GAHNITE	4.38	---	---	8.5	---	2.4	ZnO 31.4.
1.798	SPINEL, chromian	3.94	19.6	---	9.8	---	19.5	Al_2O_3 48.3.
1.805	GAHNITE	4.61	---	---	---	---	---	Synth end member.
1.818	GAHNITE	4.60	---	2.9	1.7	---	---	
1.833	SPINEL, chromian	3.93	16.8	5.8	11.7	---	19.3	Al_2O_3 45.4.
1.835	HERCYNITE	4.40	---	---	---	---	---	Synth end member.
1.856	GALAXITE	---	---	6.4	2.3	33.1	---	
1.90	MAGNESIO-CHROMITE	4.39	---	---	---	---	---	Synth end member.
1.923	GALAXITE	4.23	---	---	16.4	34.0	1.5	
1.97	MAGNESIO-CHROMITE	4.67	43.6	4.0	11.1	---	16.0	Al_2O_3 24.4.
2.10	CHROMITE	4.65	49.7	8.1	8.7	9.3	2.4	Al_2O_3 17.6, ZnO 4.1.
2.12	CHROMITE	5.22	---	---	---	---	---	Synth end member.
2.30	JACOBSITE	4.84	---	---	---	---	---	Wk magn.

Table 35. Spinel group (continued)

Refractive index	NAME	G	Weight %					Remarks
			Cr_2O_3	Fe_2O_3	FeO	MnO	MgO	
2.3 (?)	TREVORITE	5.2	---	---	---	---	---	Str magn, n(calc) = 2.39.
2.38 Na 2.34 Li	MAGNESIO-FERRITE	4.5-4.7	---	---	---	---	---	Str magn.
2.36 Li	FRANKLINITE	5.2	---	---	---	---	---	Wk magn.
2.42 Na	MAGNETITE	5.17	---	---	---	---	---	Str magn.
2.45 Na 2.41 Li	FRANKLINITE	5.2	---	---	---	---	---	Wk magn.
2.585 Na 2.535 Li	JACOBSITE	4	---	---	---	---	---	Wk-mod magn.

Table 36. Stibiconite group

Minerals of this group have the general formula $A_{1-2}B_2O_6(O,OH,F)$, in which A may be Bi^{+3}, Ca, Na, Pb, Sb^{+3}, Ag, K, Fe, and Mn; B may be Sb^{+5} and Ti.

Bindheimite	$Pb_2Sb_2O_6(O,OH)$
Bismutostibiconite	$(Bi,Fe)Sb_2O_7$
Romeite	$(Ca,Na,Fe,Mn)_2(Sb,Ti)_2O_6(O,OH)$
Stetefeldite	$Ag_2Sb_2(O,OH)_7$ (?)
Stibiconite	$SbSb_2O_6(O,OH)$

These minerals are cubic, space group Fd3m, isostructural with those of the pyrochlore group. They are commonly massive, fine-grained, and highly variable in physical properties. Specific gravity is high; optically isotropic.

Table 36. Stibiconite group (continued)

Refractive index	NAME	G	Remarks
1.60	STIBICONITE	5.1-5.6	Insol in acids. Infus.
1.70	STIBICONITE	5.1-5.6	Insol in acids. Infus.
1.72	BINDHEIMITE	4.6-5.6	Dec by HCl. F 3-4.
1.74	STIBICONITE	5.2-5.6	Insol in acids. Infus.
1.79	BINDHEIMITE	4.6-5.6	Dec by HCl. F 3-4.
1.80	STIBICONITE	5.2-5.6	Insol in acids. Infus.
1.817	ROMEITE	4.7-5.4	Insol in acids. F diff.
1.84	BINDHEIMITE	4.6-5.4	Dec by HCl. F 3-4.
1.87	ROMEITE	4.7-5.4	Insol in acids. F 4.5.
1.90	STIBICONITE	5.2-5.6	Insol in acids. Infus.
1.94	BINDHEIMITE	5.0-5.6	Dec by HCl. F 3-4.
1.95	STETEFELDITE	4.1-4.6	
2.05	STIBICONITE	5.2-5.6	Insol in acids. Infus.
2.09	BISMUTOSTIBICONITE	7.38	
2.09	ROMEITE, var Schneebergite	5.41	Insol in acids. F diff. Anom biref.
2.20	ROMEITE, var Lewisite	4.95	Insol in acids. Fus. Anom biref.

Table 37. Tourmaline group

Minerals of this group are borosilicates having the general formula $AX_3Y_6(BO_3)_3Si_6O_{18}(OH,F)_4$, in which A may be Ca, Na, and K; X may be Al, Fe^{+2}, Fe^{+3}, Li, Mg, Mn^{+2}, and V^{+3}; Y is mainly Al, but may also be Cr^{+3}, Fe^{+3}, and V^{+3}.

Buergerite	$NaFe^{+3}Al_6(BO_3)_3Si_6O_{18}(O,OH,F)_4$
Chromdravite	$Na(Mg,V,Al)_3(Cr,Fe^{+3})_6(BO_3)_3Si_6O_{18}(OH)_4$
Dravite	$(Na,Ca)(Mg,Fe)_3Al_6(BO_3)_3Si_6O_{18}(OH,F)_4$
Elbaite	$Na(Al,Li,Fe)_3Al_6(BO_3)_3Si_6O_{18}(OH,F)_4$
Ferridravite	$(Na,K)(Mg,Fe^{+2})_3(Fe^{+3},Al)_6(BO_3)_3Si_6O_{18}(O,OH)_3$
Liddicoatite	$Ca(Li,Al)_3Al_6(BO_3)_3Si_6O_{18}(O,OH,F)_4$
Schorl	$(Na,Ca)(Mg,Fe)_3(Al,Fe^{+3})_6(BO_3)_3Si_6O_{18}(OH)_4$
Uvite	$Ca(Mg,Fe)_3Al_5Mg(BO_3)_3Si_6O_{18}(OH)_4$

These minerals are trigonal, space group R3m, with characteristic prismatic habit, lack of cleavage (except buergerite), specific gravite 3.0-3.3. All have hardness of 7 and are insoluble in acids. Optically they are uniaxial negative with moderate to strong birefringence and negative elongation. Absorption in the pleochroic members is O > E.

Table 37. Tourmaline group (continued)

Refractive index		Biref (-)	NAME	Pleochroism		Weight %					
ω	ε			O	E	Fe_2O_3	FeO	MgO	CaO	Na_2O	Other
1.634	1.612	.022	DRAVITE	---	---	---	.02	8.4	---	1.9	
1.635	1.618	.017	ELBAITE	---	---	.03	---	---	0.4	2.4	Li_2O 1.9.
1.637	1.621	.016	LIDDICOATITE	Dark brown	Pale brown	---	---	---	4.2	0.9	Li_2O 2.5, F 1.7.
1.638	1.619	.019	UVITE	Dark	Light	---	0.5	15.4	5.5	0.2	
1.646	1.625	.021	ELBAITE	---	---	---	4.9	---	---	2.5	Li_2O 1.2, MnO 0.7.
1.653	1.637	.016	DRAVITE	Dark olive green	Pale brown	2.2	3.6	9.3	1.6	1.9	
1.660	1.639	.021	UVITE	Dark	Light	2.7	5.8	11.0	7.9	---	
1.661	1.632	.029	SCHORL	---	---	0.8	8.7	5.6	---	2.3	
1.675	1.643	.032	DRAVITE	Red-brown	Pale green	---	1.3	6.3	---	---	V_2O_3 8.0.
1.693	1.659	.034	SCHORL	---	---	9.2	0.6	7.3	1.5	2.6	TiO_2 2.2.
1.710	1.664	.046	DRAVITE, chromian	---	---	1.8	1.8	---	---	---	Cr_2O_3 17.8.
1.735	1.625	.110	BUERGERITE	Yellow-brown	Pale yellow	17.6	1.3	---	0.7	2.5	

Table 37. Tourmaline group (continued)

Refractive index		Biref (-)	NAME	Pleochroism		Weight %					
ω	ε			O	E	Fe_2O_3	FeO	MgO	CaO	Na_2O	Other
1.778	1.772	.006	CHROMDRAVITE	Dark green	Yellow-green	7.65	---	9.05	0.16	2.66	Cr_2O_3 31.6, V_2O_3 1.46.
1.800	1.743	.057	FERRIDRAVITE	Very dark brown	Light brown	38.4	7.5	5.6	---	2.2	K_2O 1.0.

Table 38. Zeolite group

The zeolite minerals form a complex group of hydrated aluminosilicates with ratio O:(Si+Al)=2. They have the general formula $A(XO_2)_n \cdot mH_2O$, in which A may be Na, Ca, and K, and less commonly Ba, Sr, Mg, Li(?), and Cs; X may be Si and Al. They are characterized by ready loss of their water, which can be restored, at least in part, and by their ability to exchange basic cations.

Amicite	$K_2Na_2Al_4Si_4O_{16} \cdot 5H_2O$
Analcime	$(Na,K,Cs)AlSi_2O_6 \cdot H_2O$
Barrerite	$(Na,K,Ca)_2Al_2Si_7O_{18} \cdot 7H_2O$
Brewsterite	$(Sr,Ba,Ca)Al_2Si_6O_{16} \cdot 5H_2O$
Chabazite	$(Ca,Na_2)Al_2Si_4O_{12} \cdot 6H_2O$
Clinoptilolite	$(Na_2,K_2,Ca)_{2-3}Al_3(Al,Si)_2Si_{13}O_{36} \cdot 12H_2O$
Cowlesite	$CaAl_2Si_3O_{10} \cdot 6H_2O$
Dachiardite	$(Ca,Na_2,K_2)_5Al_{10}Si_{38}O_{96} \cdot 25H_2O$
Edingtonite	$BaAl_2Si_3O_{10} \cdot 4H_2O$
Epistilbite	$CaAl_2Si_6O_{16} \cdot 5H_2O$
Erionite	$(Ca,Na_2,K_2)Al_2Si_6O_{16} \cdot 6H_2O$
Faujasite	$Na_2CaAl_4Si_{10}O_{28} \cdot 20H_2O$
Ferrierite	$(Na,K)_2MgAl_3Si_{15}O_{36}(OH) \cdot 9H_2O$
Garronite	$Na_2Ca_5Al_{12}Si_{20}O_{64} \cdot 27H_2O$
Gismondine	$CaAl_2Si_2O_8 \cdot 4H_2O$
Gmelinite	$(Na_2,Ca)Al_2Si_4O_{12} \cdot 6H_2O$
Gobbinsite	$Na_4(Ca,K_2)Al_6Si_{10}O_{32} \cdot 12H_2O$
Gonnardite	$Na_2CaAl_4Si_6O_{20} \cdot 7H_2O$
Goosecreekite	$CeAl_2Si_6O_{16} \cdot 5H_2O$
Harmotome	$(Ba,K_2)_{1-2}(Al,Si)_iO_{16} \cdot 6H_2O$
Herschelite	$(Na_2,Ca,K_2)AlSi_2O_6 \cdot 3H_2O$
Heulandite	$(Na,K)_{2-3}Al_3(Al,Si)_2Si_{13}O_{36} \cdot 12H_2O$
Laumontite	$CaAl_2Si_4O_{12} \cdot 4H_2O$

Levyne	$CaAl_2Si_3O_{10}\cdot 5H_2O$
Mazzite	$(K_2,Na_2,Ca)_6Mg_3Al_{13}Si_{27}O_{80}\cdot 16H_2O$ (?)
Merlinoite	$(K,Ca,Na)_7Si_{23}Al_9O_{64}\cdot 23H_2O$
Mesolite	$Na_2CaAl_6Si_9O_{30}\cdot 8H_2O$
Mordenite	$(Ca,Na_2,K_2)Al_2Si_{10}O_{24}\cdot 7H_2O$
Natrolite	$(Na_2,Ca)Al_2Si_3O_{10}\cdot 2H_2O$
Offretite	$(K_2,Ca)_3Al_5Si_{13}O_{36}\cdot 14H_2O$
Paulingite	
Phillipsite	$(K_2,Na_2,Ca)_{1-2}(Al,Si)_8O_{16}\cdot 6H_2O$
Pollucite	$(Cs,Na)AlSi_2O_6\cdot mH_2O$
Scolecite	$CaAl_2Si_3O_{10}\cdot 3H_2O$
Sodium dachiardite	$(Na_2,Ca,K)_{4-5}Al_8Si_{40}O_{96}\cdot 26H_2O$
Stellerite	$CaAl_2Si_9O_{18}\cdot 7H_2O$
Stilbite	$NaCa_2Al_5Si_{13}O_{36}\cdot 14H_2O$
Tetranatrolite	$Na_2Al_2Si_3O_{10}\cdot 2H_2O$
Thomsonite	$NaCa_2Al_5Si_5O_{20}\cdot 6H_2O$
Wairakite	$CaAl_2Si_4O_{12}\cdot 2H_2O$
Wellsite	$(Ba,Ca,K_2)Al_2Si_3O_{10}\cdot 3H_2O$
Yugawaralite	$CaAl_2Si_6O_{16}\cdot 4H_2O$

The basic structure of zeolite minerals is an open framework of $(Si,Al)O_4$ tetrahedra, which accounts for their cation exchange and absorption capacity and for the ability of water molecules to move out of and into the framework. In the zeolite group are representatives of every crystal system except triclinic. Hardness is 3.5 to 5, specific gravity is low (mostly 2.0-2.3), cleavage is good to perfect. Most are gelatinized or otherwise decomposed by acids.

These minerals vary in optical character but typically have low refractive index and low to very low birefringence. Depending on the degree of dehydration of a given species, the optic angle may vary widely, even to changing optic sign and orientation. This, together with the overlap of properties and the lack of adequate documentation of some of the examples, makes it difficult to distinguish between members of this group by optical means.

Table 38. Zeolite group (continued)

Refractive index			Biref	NAME	2V	System	Remarks
α or ε	β, ω, or n	γ or ε					
---	1.461	1.465	.004	CHABAZITE	(+)0°	TRIG	
1.460	1.462	---	.001	CHABAZITE	(-)0°	TRIG	Anom biax.
---	1.468	1.473	.008	ERIONITE	(+)0°	HEX	Diff dec by acids. El pos.
1.468	1.470	1.473	.005	ERIONITE	(+)0°	HEX	Diff dec by acids.
---	1.470	1.474	.004	GMELINITE	(+)0°	TRIG	Tw. 2V 0° to small.
---	1.471	1.474	.003	HERSCHELITE	(+)0°	TRIG	
---	1.473	---	.000	PAULINGITE	---	CUB	
1.470	1.474	---	.004	HERSCHELITE	(-)0°	TRIG	
1.471	1.475	1.476	.005	SODIUM-DACHIARDITE	(-)88-92°	MCL	Z:c = 18°.
1.472	1.475	1.477	.005	MORDENITE	(-)80°	ORTH	X = a, Z = c
---	1.477	1.480	.003	ERIONITE	(+)0°	HEX	Diff dec by HCl. El pos.
1.475	1.477	---	.002	GMELINITE	(-)0°	TRIG	Anom biax. Tw.
1.476	1.479	1.479	.003	CLINOPTILOLITE	(-)small	MCL	X = b?, Z:a = 15°.
1.478	1.479	1.481	.003	CLINOPTILOLITE	(+)40°	MCL	X = b, el clv pos.
1.478	1.479	1.482	.004	FERRIERITE	(+)50°	ORTH	Insol in HCl. X = a, Y = b.

Table 38. Zeolite group (continued)

Refractive index			Biref	NAME	2V	System	Remarks
α or ε	β, ω, or n	γ or ε					
---	1.479	---	.000	ANALCIME	---	CUB	Opt anom.
---	1.480	1.493	.013	TETRANATROLITE	(+)0°	TET	
1.477	1.480	1.490	.013	NATROLITE	(+)63°	ORTH	X = a, Z = c, el pos.
---	1.48	---	wk	FAUJASITE	---	CUB	On losing H_2O, becomes uniax pos.
1.480	(1.480)	1.485	.005	CHABAZITE	(+)small	TRIG	
---	1.481	1.483	.002	LEVYNE	(+)0°	TRIG	
---	1.482	(1.484-1.490)	.002-.008	GMELINITE	(+) ~ 0°	HEX	
1.481	1.482	1.486	.005	MORDENITE	(+)large	ORTH	Partly dec by HCl. X = c, Y = a.
1.481	1.484	1.486	.005	CLINOPTILOLITE	(-)large	MCL	X = b (?), Z:c = 15°.
1.483	1.485	1.487	.004	PHILLIPSITE	(+)63°	MCL	X = b, Z:c = 19°
1.479	1.485	1.489	.010	BARRERITE	(-78°)	ORTH	X = a, Y = b.
1.485	1.485	1.488	.003	CHABAZITE	(+)med	TRIG	Tw.
1.483	1.486	1.495	.012	NATROLITE	(+)med	ORTH	X = a, Z = c, tw.
1.484	1.486	1.487	.003	PHILLIPSITE	(-)med	MCL	Penet tw.
---	1.487	1.489	.002	CHABAZITE	(+)0°	TRIG	Anom biax.
1.486	1.487	---	.001	ANALCIME	(-)small	CUB	Anom biax, lam tw.

Table 38. Zeolite group (continued)

Refractive index			Biref	NAME	2V	System	Remarks
α or ε	β, ω, or n	γ or ε					
1.488	1.488	1.489	.001	HEULANDITE	(+)70°	MCL	El clv neg.
1.484	(1.488)	1.490	.006	CHABAZITE	(-)60-70°	TRIG	Anom biax, tw.
1.482	1.489	1.496	.014	STILBITE	(-)43°	MCL	Y = b, X:a = 2-9°, el neg. Cruciform penet tw.
1.489	1.489	1.492	.003	FERRIERITE	(+)small	ORTH	Insol in HCl. El pos.
1.486	1.489	---	.003	OFFRETITE	(-)0°	HEX	El pos.
1.486	1.489	---	.003	CHABAZITE	(-)0°	TRIG	Anom biax.
1.487	1.489	---	.002	LEVYNE	(-)0°	TRIG	
1.490	1.490	1.502	.012	NATROLITE	(+)0°	ORTH	El pos.
1.485	1.490	1.494	.009	AMICITE	(-)82°	MCL	
1.491	1.492	1.494	.003	CHABAZITE	(+)58°	TRIG	Tw.
1.491	1.493	1.497	.006	CLINOPTILOLITE	(+)72°	MCL	El clv pos.
---	1.493	---	.000	ANALCIME	---	CUB	
1.486	1.494	1.496	.010	STELLERITE	(-)38-48°	ORTH	X = a, Y = c, el clv neg.
1.489	1.494	---	.005	GOBBINSITE	(-)0°	TET	El neg.
1.493	1.496	1.500	.007	DACHIARDITE	(+)69°	MCL	Mimetic tw.
1.495	1.497	1.504	.009	YUGAWARALITE	(+)78°	MCL	Insol in acids. U opt neg.
1.495	1.498	1.502	.007	GOOSECREEKITE	(-)82°	MCL	Y = b, Z:c = 46°.

Table 38. Zeolite group (continued)

Refractive index			Biref	NAME	2V	System	Remarks
α or ε	β, ω, or n	γ or ε					
1.497	(1.498)	1.499	.002	GONNARDITE	(+)med to large	ORTH	
1.496	1.498	1.504	.008	HEULANDITE	(+)35°	MCL	El clv neg.
1.499	1.500	1.502	.003	WAIRAKITE	(+)med	MCL	
---	1.500	1.502	.002	GARRONITE	(+)0°	TET	
1.499	1.500	1.501	.002	MERLINOITE	(-)56°	ORTH	X = b, Z = a, el pos.
1.498	(1.501)	1.502	.004	WAIRAKITE	(-)75°	MCL	X ~ b, Z ~ c. U biax pos.
1.500	1.501	1.504	.004	WELLSITE	(+)39°	MCL	Complex tw.
1.494	1.502	1.507	.013	STILBITE	(-)30-50°	MCL	Y = b, X:a = 2-9°, el neg. Cruciform penet tw.
1.498	1.503	1.506	.008	HARMOTOME	(-)75-82°	MCL	Z = b, Y:c = 28°
---	1.503	1.507	.004	CHABAZITE	(+)0°	TRIG	2V small
1.500	1.503	1.510	.010	PHILLIPSITE	(+)med	MCL	Tw.
1.501	1.504	1.509	.008	HARMOTOME	(+)78°	MCL	Cruciform tw.
1.504	1.505	1.507	.003	MESOLITE	(+)large	MCL	
---	1.505	---	.000	ANALCIME	---	CUB	Diff dec by acids. Cs_2O 14.9%.
1.499	1.506	---	.007	MAZZITE	(-)0°	HEX	
1.505	1.507	1.507	.002	GARRONITE	(-)0°	ORTH, ps tet	

Table 38. Zeolite group (continued)

Refractive index			Biref	NAME	2V	System	Remarks
α or ε	β, ω, or n	γ or ε					
1.504	1.507	1.515	.011	HEULANDITE	(-)10-40°	MCL	El clv neg.
---	1.507	---	.000	POLLUCITE	---	CUB	F diff.
1.505	1.509	1.509	.004	COWLESITE	(-)30°	ORTH	X = a, Y = b, el pos.
1.505	1.509	1.513	.008	HARMOTOME	~ 90°	MCL	Cruciform tw.
1.505	1.509	1.511	.006	PHILLILPSITE	(-)med	MCL	Penet tw.
1.508	1.510	1.513	.005	GONNARDITE	(+)large	ORTH	
1.502	1.510	---	.008	LEVYNE	(-)0°	TRIG	
1.508	1.511	1.523	.015	BREWSTERITE	(+)55°	MCL	El clv neg.
1.508	1.511	1.512	.004	GARRONITE	(-)0-30°	ORTH	
1.500	1.511	1.513	.013	EPISTILBITE	(-)40°	MCL	X = b, Z:c = 9°
1.504	1.512	1.516	.012	LAUMONTITE	(-)44°	MCL	Y = b, Z:c = 30°
1.511	1.513	1.518	.007	THOMSONITE	(+)75°	ORTH	X = a, Z = b
1.512	1.515	1.517	.005	COWLESITE	(-)44-53°	ORTH	X = a, Z = c, el pos.
1.512	1.515	1.515	.003	GARRONITE	(-)0°	ORTH, ps tet	
1.512	1.516	1.518	.006	GISMONDINE	(-)large	MCL	X = b, Y ~ c. Tw.
1.512	1.518	1.519	.007	SCOLECITE	(-)35°	MCL	Z = b, X:c = 18°, el neg.
1.515	1.518	---	.003	CHABAZITE	(-)0°	TRIG	Anom biax.

Table 38. Zeolite group (continued)

Refractive index			Biref	NAME	2V	System	Remarks
α or ε	β, ω, or n	γ or ε					
1.513	1.524	1.525	.012	LAUMONTITE	(-)25°	MCL	Y = b, Z:c = 20-30°.
1.523	1.525	1.532	.009	THOMSONITE	(+)48°	ORTH	X = a, Z = b
---	1.525	---	.000	POLLUCITE	---	CUB	
1.522	1.528	1.530	.008	GISMONDINE	(-)15-90°	MCL	X = b, Y ~ c. Tw.
1.530	1.533	1.542	.012	THOMSONITE	(+)52°	ORTH	X = a, Z = b
1.538	1.543	1.548	.010	GISMONDINE	(-)15-90°	MCL	X = b, Y ~ c. Tw.
1.541	1.553	1.557	.016	EDINGTONITE	(-)54°	ORTH	X = c, Z = a, el neg.

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INDEX

INDEX