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THE MICROSCOPIC DETERMINATION OF THE NONOPAQUE MINERALS

SECOND EDITION

BY

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CONTENTS

ILLUSTRATIONS

NOTE TO THE SECOND EDITION

In this second edition of the bulletin on the microscopic determination of the nonopaque minerals (U. S. Geological Survey Bulletin 679) the first three chapters have been left essentially as they were in the first edition; the fourth chapter of the first edition, which contained the new data, has been omitted, as a single publication of these data seemed sufficient; and the fifth chapter of the first edition becomes the fourth in the new edition. The tables for the determination of minerals from their optical properties have been brought up to date by more than 500 new entries and 100 changes in old entries. About 250 new species and old species not given in the previous edition are included. Of these new data about 80 entries represent measurements made by the authors. Such data are indicated in the tables by an asterisk (*).

At the recommendation of several mineralogists, tables have been added assembling the data of some of the mineral groups, including the alunite, amphibole, apatite, aragonite, barite, calcite, chlorite, epidote, feldspar, garnet, melilite, mica, olivine, pyroxene, scapolite, spinel, tourmaline, vivianite, and uranite groups and the zeolites.

Other new features of this edition are the addition of a column in the main table to indicate the variability of the indices of refraction and other data given for the mineral, and the addition of the calculations of 2E immediately below 2V.

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CHAPTER 1.—INTRODUCTION

THE IMMERSION METHOD OF IDENTIFYING MINERALS

Optical methods of determining minerals with the petrographic microscope have long been used and have been carried to a high state of development in studies of the minerals in thin sections of rocks and ores, yet out of about 1,000 mineral species comparatively few can be identified readily in thin sections. A mineral whose optical properties are known can be accurately and quickly identified, however, by the immersion method—that is, by immersing its powder in liquid media whose indices of refraction are known and determining its optical constants. In this bulletin the authors give a set of tables for the systematic determination of minerals from their optical constants, describe briefly some methods for the rapid determination of optical constants, give the results of measurements of the optical constants of more than 500 species for which data were not previously available prior to the first edition, and present statistics on the optical properties of minerals.

The first tables prepared for general use in determinations of minerals by the immersion method were those of Van der Kolk,[1] published in 1900. Somewhat similar tables, prepared by A. F. Rogers,[2] were published in 1906, and an optical mineralogy containing tables and description of all minerals for which optical data were then available, prepared by N. H. and A. N. Winchell,[3] was published in 1909.

[1] Schroeder van der Kolk, J. C., Tabellen zur mikroskopischen Bestimmung der Mineralien nach ihrem Brechungsindex, Wiesbaden, 1900; 2d ed., revised and enlarged by E. H. M. Beekman, 1906.

[2] Rogers, A. F., School of Mines Quart., vol. 27, pp. 340–359, 1906.

[3] Winchell, N. H. and A. N., Elements of optical mineralogy, D. Van Nostrand Co., 1909.

NEW DATA

In attempting to employ the immersion method some years ago the senior author assembled all the data then available for its use with the petrographic microscope in determining minerals but found them so incomplete that the method was applicable to but few species. Since then he has measured the chief optical constants of about 600 mineral species for which the data were lacking or incomplete, so that such data are now lacking for only about 30 very rare species. No attempt at great accuracy was made in these measurements, and comparatively few of the specimens studied represented analyzed minerals. Only a small number of minerals of many isomorphous series were examined, in some series only a single member.

NEED OF FURTHER DATA

Much further work on the optical constants and more complete and accurate data on nearly all the minerals are needed, as well as detailed studies of isomorphous series and of the effect of solid solution. Another need is a fuller appreciation of the fact that most minerals are of variable chemical composition and therefore have variable optical and other properties. The science of mineralogy needs also good connected and consistent data on minerals. Chemical analyses, crystallographic studies, and determination of physical properties, optical constants, and paragenesis should be made on identical material. A highly accurate determination of the optical or other constants of a mineral is of comparatively little value unless the data obtained are definitely tied to a chemical analysis. Greater care should be taken in examining minerals for lack of homogeneity, whether it is due to zonal growths or to admixed or included foreign material. As few specimens of minerals are entirely free from foreign bodies and without zonal growths or other elements of heterogeneity no description of a mineral is adequate which does not show clearly that its material has been carefully examined microscopically. Every published analysis of a mineral should include a clear statement of the approximate amount and the character of the foreign material it contains and of the degree or extent of zonal growths or other elements of heterogeneity, and this statement should be the result of a careful microscopic examination of a sample of the same powder that furnished the material for the chemical analysis.

ADVANTAGES OF THE IMMERSION METHOD

For determining the nonopaque minerals the immersion method has many advantages over other methods. It appears to excel greatly the ordinary blowpipe methods in rapidity and accuracy, and the quantity of material required is less than that required for tests by any other method. One who has acquired the requisite skill can

measure the principal optical constants of a mineral in about half an hour, and most minerals can be determined by partial measurements in less time. In accuracy the method is nearly as reliable as a complete chemical analysis, for it is about as common for two or more minerals to have the same chemical composition as for two or more minerals to have the same optical constants. All the optical properties of a mineral can usually be determined from a single grain or crystal large enough to handle with a pair of delicate pincers, and in addition the material can be examined for homogeneity when the tests are made. Lack of homogeneity in material studied is one of the chief sources of error in mineralogic work.

The skill required to measure the optical constants is little if any greater than that required to do reliable blowpiping. The worker must have a good knowledge of optical mineralogy, such as may be gained by any good course in microscopic petrography, and some special training in the manipulation of immersed grains of minerals. The equipment required is a good petrographic microscope and a few inexpensive liquids whose indices of refraction are known.

OTHER SUGGESTED USES FOR THE METHOD

The optical method might be used with advantage in work done in a number of other branches of science than mineralogy and in some industries. It should be much more generally used in chemistry, especially in analyses of artificial crystalline products, to determine rapidly the exact nature of the material and its homogeneity, for artificial products have as definite optical constants as minerals. It should also be found valuable in many metallurgic processes, as well as in the cement and ceramic industries and other industries in which a knowledge of the exact nature of any material is desirable.

WORK AND ACKNOWLEDGMENTS

The senior author began his work on the tables in 1909, intending to measure the constants of only a few of the commoner minerals, but the desirability of having optical data on all the recognized species of minerals became so apparent that he afterward undertook the task of making all the measurements desired. Most of the work was done in the laboratory of the United States Geological Survey at Washington, D. C., but a considerable part was done at the University of California at Berkeley, Calif., during the winter of 1914–15. The work of preparing this new edition was done in Harvard University. To measure the optical constants of 500 selected minerals is no great task, but difficulties appeared continually as the work progressed, owing to the frequent necessity of selecting suitable material from specimens consisting largely of other minerals, to the large number of specimens that were found to be incorrectly labeled, and to the difficulty of procuring many rare minerals.

The senior author wishes to express his sincere thanks to Messrs. H. E. Merwin and Fred E. Wright, of the Geophysical Laboratory, W. T. Schaller and C. S. Ross, of the Geological Survey, and E. T. Wherry, formerly of the National Museum, for help and encouragement in the work. Thanks are due also to Messrs. Ross and Schaller for critically reading the manuscript and proof of this bulletin and offering many helpful criticisms and suggestions and for furnishing unpublished data on a number of minerals. The senior author wishes also to express his appreciation of the generosity of the officials of a number of museums and of several private collectors of minerals in furnishing specimens of many rare and valuable minerals. He is especially indebted to the late Col. Washington A. Roebling, of Trenton, N.J., who very generously placed his remarkable collection at the writers' disposal; to the late L. P. Gratacap and the American Museum of Natural History; and to Drs. Edgar T. Wherry and William F. Foshag and the United States National Museum. He is also grateful, for many valuable specimens of the rarer minerals, to Prof. W. E. Ford and Yale University; Prof. Charles Palache and Harvard University; the late Prof. A. S. Eakle and the University of California; Prof. A. H. Phillips and Princeton University; Johns Hopkins University; the late Dr. Oliver C. Farrington and the Field Museum of Natural History; Mr. F. McN. Hamilton and the California State Mining Bureau; the late Mr. F. A. Canfield, of Dover, N.J.; Dr. Per Geijer, of Stockholm, Sweden; and Prof. A. Lacroix, of Paris.

CHAPTER 2.—METHODS OF DETERMINING THE OPTICAL CONSTANTS OF MINERALS

In this chapter the writers describe briefly the special methods which they have found most satisfactory for the rapid determination of the principal optical constants of minerals by the immersion method.

The chapter is not intended to be a complete discussion of optical mineralogy, and in order to understand it properly, the reader should have an elementary knowledge of crystallography and of the methods of optical mineralogy.[4] Theoretical discussions are avoided as far as possible, and no attempt is made to describe the methods of measuring accurately the optical constants of minerals.[5]

THE CHIEF OPTICAL CONSTANTS AND THEIR INTERRELATIONS

The significant fundamental optical constants of crystals are the principal indices of refraction, the crystallographic orientation of the directions of vibration corresponding to these indices of refraction, and the amount of absorption of light vibrating in these directions, all for one or more standard wave lengths of light. For most minerals some of the constants, particularly the last, are known only in a qualitative way. The other properties commonly mentioned among the optical constants—birefringence, optical character, optic axial angle, dispersion of the optic axes, dispersion of the bisectrices, extinction angle, color, and pleochroism—are fixed by the fundamental constants and are significant only because they are often easily measured or estimated under the microscope.

Different symbols are used by different writers in referring to certain optical properties. Those used here are perhaps as commonly used as any in the textbooks listed below.[4] Refractive indices α, β, γ have directions of vibration X, Y, Z; birefringence is represented by B and equals $\gamma-\alpha$ or $\omega-\epsilon$ or $\epsilon-\omega$.

[4] Iddings, J. P., Rock minerals, John Wiley & Sons, 1911. Weinschenk-Clark, Petrographic methods, McGraw-Hill Book Co., 1912. Winchell, N. H. and A. N., Elements of optical mineralogy, 3d ed., pt. 1, John Wiley & Sons, 1928. Groth-Jackson, Optical properties of crystals, John Wiley & Sons, 1910. Dana, E. S., A textbook of mineralogy, 3d ed., John Wiley & Sons, 1921.

[5] A comprehensive treatment of the accuracy and limitations of the methods of optical mineralogy, based upon theory and checked by observations, is given by Fred. Eugene Wright in The methods of petrographic-microscopic research: Carnegie Inst. Washington Pub. 158, 1911. Albert Johannsen's Manual of petrographic methods, published by the McGraw-Hill Book Co., 1914, is an excellent compilation of the methods that have been proposed for optical measurements with the microscope. Rosenbusch's Mikroskopische Physiographie, 2d ed., Band 1, Erste Hälfte, by E. A. Wülfing, 1924; Groth's Physikalische Krystallographie, 4th ed., 1905; and Tutton, A. E. H., Crystallography and practical crystal measurement, vol. 2, London, Macmillan & Co., 1922, are valuable books of reference, as is also Duparc and Pearce's Traité de technique minéralogique et petrographique, pt. 1, 1909. The most precise treatment of the subject is given in Pockels, F., Lehrbuch der Kristalloptik, B. F. Teubner, 1906.

The relations that exist between the various optical properties are of considerable significance, and the authors believe that they are not sufficiently emphasized in the textbooks nor are they kept clearly enough in mind by workers in optical mineralogy. The best available data on over 30 mineral species, or nearly 10 per cent of those for which data were available before 1922, could be seen at a glance to be strikingly inconsistent, and this happened even where the data appeared to have a high degree of accuracy. The following examples will serve to illustrate.

Leucosphenite was said to be optically negative, but the values given for the indices of refraction ($\alpha_y = 1.6445$, $\beta_y = 1.6609$, $\gamma_y = 1.6878$) are those of an optically positive mineral. Tests by the senior author show that leucosphenite is optically positive.

Lawsonite was stated to have the following properties: $\alpha = 1.6650$, $\beta = 1.6690$, $\gamma = 1.6840$, $2V = 84° 6'$, optically +. The axial angle, as computed from the indices of refraction, is $2V = 54°$. It seems probable that the axial angle is correct and that β should be about 1.6735.

The relation between the axial angle (2V) and the indices of refraction is expressed by the equation:[6]

$$\text{Cos}^2 V_\alpha = \frac{\gamma^2(\beta^2-\alpha^2)}{\beta^2(\gamma^2-\alpha^2)} \text{ or } \tan^2 V_\gamma = \frac{\frac{1}{\alpha^2}-\frac{1}{\beta^2}}{\frac{1}{\beta^2}-\frac{1}{\gamma^2}}$$

The approximate formula [7]

$$\text{Cos}^2 V'_\alpha = \frac{\beta-\alpha}{\gamma-\alpha}.$$

holds fairly well if the axial angle is small or the birefringence not too strong. The error in V'_α, as computed from the approximate formula, is shown in Figure 1. The calculated value of V'_α is along the abscissa, and the correction to be added to this value is along the ordinate. For all the curves the value of α is 1.500, and each curve is for a particular value of $\gamma - \alpha = B$. The curves can be used to correct calculations made by the approximate formula. In the accurate equation α, β, or γ appear in the same power in both the numerator and denominator, so that the value of the equation will not be changed if they are replaced by $\frac{\alpha}{k}$, $\frac{\beta}{k}$, and $\frac{\gamma}{k}$. Hence to apply

[6] For the development of this equation see Johannsen's Manual of petrographic methods, p. 103, 1914. Rosenbusch (Wülfing), Mikroskopische Physiographie, Band 1, Erste Hälfte, pp. 119–121, 1924; Groth-Jackson, Optical properties of crystals, p. 143, 1910; Duparc and Pearce, Traité de technique minéralogique et pétrographique, pp. 78–80, 1907. For tables and a graphic solution of this equation see Wright, F. E., Graphical methods in microscopical petrography: Am. Jour. Sci., 4th ser., vol. 36, pp. 517–533, 1913.

[7] For a graphic solution of this equation see Wright, F. E., The methods of petrographic-microscopic research: Carnegie Inst. Washington Pub. 158, pl. 9, 1911.

the correction from the curves to a crystal with α different from 1.500 it is necessary to calculate $B' = \frac{1.500}{\alpha}(\gamma - \alpha)$. The value of B′ need be calculated only approximately. To get the correct value of V_α from the indices of refraction the approximate value V'_α should be found from the equation $\text{Cos}^2 V'_\alpha = \frac{\beta - \alpha}{\gamma - \alpha}$ or from the graph; then $B' = \frac{1.50}{\alpha}(\beta - \alpha)$ and from these two values the correction to be added to V'_α may be read from Figure 1.

The formulae given above indicate the value for the angle about α, which may be either the acute bisectrix (Bx_a) or the obtuse bisectrix (Bx_o). By definition, if α is the acute bisectrix (Bx_a) the

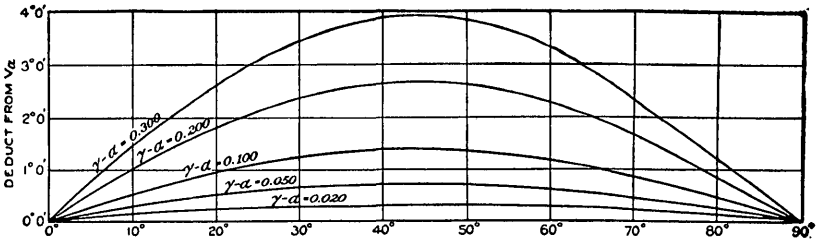

FIGURE 1.—The error in V'_α as computed from the approximate formula $\text{Cos}^2 V'_\alpha = \frac{\beta - \alpha}{\gamma - \alpha}$

mineral is optically negative and $2V_\alpha$ is less than 90° ($V_\alpha < 45°$). As tan 45°=1, a mineral is optically negative if $\frac{1}{\alpha^2} - \frac{1}{\beta^2} > \frac{1}{\beta^2} - \frac{1}{\gamma^2}$ and optically positive if $\frac{1}{\alpha^2} - \frac{1}{\beta^2} < \frac{1}{\beta^2} - \frac{1}{\gamma^2}$.

$\text{Cos } 45° = \frac{1}{\sqrt{2}}$ for an optically negative mineral from the approximate formula

$$\sqrt{\frac{\beta - \alpha}{\gamma - \alpha}} > \frac{1}{\sqrt{2}}$$

or $2(\beta - \gamma) > (\gamma - \alpha)$ approximately.

Similarly for an optically positive mineral $2(\gamma - \beta) > (\gamma - \alpha)$ approximately.

These approximations hold only where the birefringence is not too strong. The following values of α, β, and γ are for crystals where $2V = 90°$ and show the increasing error in the approximations as the birefringence increases:

$\alpha = 1.5000$	$\beta = 1.5099$	$\gamma = 1.5200$
$\alpha = 1.5000$	$\beta = 1.5244$	$\gamma = 1.5500$
$\alpha = 1.5000$	$\beta = 1.5476$	$\gamma = 1.6000$
$\alpha = 1.5000$	$\beta = 1.5906$	$\gamma = 1.7000$
$\alpha = 1.5000$	$\beta = 1.6297$	$\gamma = 1.8000$

The axial angle is commonly measured in air, and the apparent axial angle so measured (2E) has the relation to the true axial angle 2V expressed by $\sin E = \beta \sin V$, where β is the intermediate index of refraction of the mineral.[8]

In the preceding equations the values are given for light of a particular wave length. As the wave length varies the indices of refraction and consequently 2V will vary, and even the optical character may change. This variation is called the dispersion of the optic axes, and 2V may be given for different colors or it may be given for one color—commonly the yellow light of sodium—and the variation with color may be expressed by $r<v$ (or $r>v$), meaning simply that the axial angle is less (or greater) for red than for violet.

Not only do the values of the indices of refraction change with the color of light, but the positions of two of the directions X, Y, and Z in monoclinic and of all three in triclinic crystals change—that is, the extinction angles vary with the color of light. This variation is called dispersion of the bisectrices. Crossed, horizontal, and inclined dispersion are simply phenomena due to dispersion of the bisectrices as observed on the interference figure.

MEASUREMENT OF INDICES OF REFRACTION

The indices of refraction of a mineral can be measured most conveniently and accurately on a polished surface with the total refractometer or somewhat less conveniently on specially prepared and oriented prisms by the method of minimum deviation. Most minerals are not suitable for measurement by either of these methods, either because suitable plates or prisms can not be prepared or because the mineral is zoned and so differs in its optical properties at least as much as the error in the less accurate but much more rapid embedding method.

THE EMBEDDING METHOD

Fairly accurate measurements of the principal indices of refraction can be made on a very small quantity of mineral by embedding the powdered grains in media whose indices of refraction are known and comparing and matching the indices of the media with each of those of the mineral by either the method of central illumination or the method of oblique illumination. The method of oblique illumination is best used with an objective of low or moderate power and can therefore be applied to a large number of grains very quickly. The method of central illumination is best used with an objective of moderate or high power.

[8] For a graphic solution of this equation see Wright, F. E., op. cit., pls. 7 and 8, 1911.

THE METHOD OF OBLIQUE ILLUMINATION [9]

The index of refraction of a grain embedded in a liquid or other body and that of the embedding material can be quickly compared by observing their line of contact under the microscope and shading a part of the field by placing the finger or a card beneath the condenser system, by tilting the mirror, or in some other way. A number of devices have been recommended for this purpose, and some of the newer microscopes have special slides inserted. The observation is best made with a low or moderate power objective and without the condenser lens. With a low-power objective a mineral that has a decidedly higher index than the liquid will have a dark border toward the shaded side of the field and a bright border on the opposite side. If the grain has a decidedly lower index of refraction the phenomena are reversed and the bright border is on the shaded side of the field. With the moderate-power objective and the condenser lens the phenomenon depends on the position of the condenser. If the focus of the condenser is above the object, the phenomena are as stated above; if below the slide, the phenomena are reversed. It is best to check the system used by making the test on some known grain; a thin section in which orthoclase, quartz, or some other known mineral is in contact with Canada balsam is good for this purpose. At the same time the difference in index of refraction between the grain and liquid can be estimated by the relief and the amount of shading required to bring out the relief. This method is equally well adapted to thin sections and has many advantages over the Becke method or the method of central illumination, as it can be used with a low-power objective, and by it every grain in contact with the Canada balsam can be compared with balsam in a very short time.

For simplicity, the grain may be considered isotropic. If monochromatic light is used, and if the grain and liquid have the same index of refraction for that light and are clear and colorless, the grain will completely disappear. As most of the liquids commonly used have a stronger dispersion than most minerals, if the mineral and liquid have the same index for sodium light the mineral will have a higher index for the red end of the spectrum and a lower one for the blue. Hence, if white light is used there is a concentration of reddish light on one side of the grain and of bluish light on the other side. For some of the immersion materials—notably cinnamon oil—the dispersion is very great, and strongly colored borders are present even where the index for sodium light of the grain and the liquid differ in the second decimal place. The relative indices must be judged from the intensities of the colors. In order for the worker to become familiar with the color phenomena under various conditions it is well

[9] Wright, F. E., The methods of petrographic-microscopic research: Carnegie Inst. Washington Pub. 158, pp. 92–95, 1911.

to immerse grains with known indices of refraction in oils of known indices of refraction. For this purpose ω of quartz or of calcite is constant.

THE METHOD OF CENTRAL ILLUMINATION

As the immersion method is ordinarily used nearly all fragments are thinner on the edges than in the center, and if the fragments differ from the surrounding material in refractive index they will act as small imperfect lenses toward a beam of nearly parallel light emerging from the condenser. If such a lenticular fragment has a higher index of refraction than the embedding medium it tends to focus the light above its plane, and if the microscope is first focused on the grain and then raised above focus the interior of the grain will appear more highly illuminated. As the microscope tube is raised higher above focus this highly illuminated area contracts and becomes brighter—a bright line moves into the grain. If the tube is lowered below focus the grain appears less highly illuminated than the rest of the field and a highly illuminated halo surrounds it. As the tube is lowered this halo moves out from the grain.

If the grain has a lower index of refraction than the embedding medium it will have a virtual focus below its plane, the phenomena are reversed, and the grain becomes centrally illuminated as the microscope tube is lowered below focus.

In practice the test is best made with an objective of medium or high power—one with 8-millimeter focus gives good results. The condenser may be in or out. The condenser system may be lowered or the lower diaphragm closed. The most suitable arrangement for a particular microscope and lens system can best be found by testing it with grains embedded in media of known indices of refraction.

DISPERSION METHOD

The indices of refraction and the dispersion can be measured more accurately (± 0.001) by the dispersion method of Merwin.[10] The mineral is embedded in a liquid with a somewhat higher index of refraction than that of the mineral (for sodium light). The two should match for some color of light, and this color is determined by changing the color of light, using a monochromatic illuminator until the two match. The mineral is then embedded in a liquid with a somewhat lower index of refraction, and these two are matched for some other color of light. In this way the index of refraction of the mineral is determined for two or more colors of light, and as the dispersion curve of most minerals is nearly a straight line, the index of

[10] Posnjak, E., and Merwin, H. E., The system Fe_2O_3—SO_3—H_2O: Am. Chem. Soc. Jour., vol. 44, p. 1970, 1922. Tsuboi, S., A dispersion method of determining the plagioclase in cleavage flakes: Mineralog. Mag., vol. 20, pp. 108–122, 1923.

refraction of the mineral can be determined for sodium light or any other color of light from a simple plot.

Emmons [11] has recently described a method depending not only on the dispersion of immersion media but also on the variation in index of refraction of a liquid with change of temperature. By the proper manipulation of the two variables, temperature and wave length, it is possible to obtain the dispersion curve of a mineral, using only one mount. The work is facilitated by combining all the necessary instruments into a single unit.

IMMERSION MEDIA

GENERAL FEATURES

Immersion media should be nearly colorless, chemically stable, and without disagreeable odor or other objectionable properties. They should not dissolve or react with the mineral to be immersed. Low volatility and for many purposes a moderate though not too great viscosity are desirable. Each liquid should be miscible with the liquids whose indices of refraction are above and below it, and two liquids that are to be mixed should have approximately the same rate of volatilization, as otherwise the mixture may change rapidly. The index of refraction should not vary too greatly with changes of temperature. A low dispersion is desirable for accurate work, but a rather strong dispersion facilitates rapid determination.

The authors have found the set of media given in Table 1 satisfactory, and it covers the range of nearly all the minerals.

Satisfactory liquids cover the range of indices of refraction up to 1.87 and above that point low-melting mixtures that remain amorphous on cooling may be prepared which cover the range up to $n_{Li}=3.17$. The values for the indices of refraction (n) are for sodium light except where noted for the sulphur-selenium and selenium-arsenic selenide melts and are those determined by the senior author at about 20° C. for liquids purchased in the ordinary market. In the column marked $-\frac{dn}{dt}$ is given the change in the index of refraction for each degree centigrade change in the temperature. For all the media given the index of refraction decreases as the temperature increases. These values are mostly taken from the literature. The liquids are rather inexpensive, excepting methylene iodide. All the liquids, except as noted, will form suitable mixtures with those above and below in the table in all proportions. Amyl alcohol is unfortunately a solvent for a number of the minerals that have indices of refraction within its range, and measurements with it must be made rapidly.

[11] Emmons, R. C., The double dispersion method of mineral determination: Am. Mineralogist, vol. 13, pp. 504–515, 1928; The double variation method of refractive index determination: Idem, vol. 14, pp. 414–426, 441–461, 1929.

TABLE 1.—*Refractive indices of immersion media*[a]

	n at 20° C.	$-\frac{dn}{dt}$	Dispersion	Remarks
Water	1.333	Slight.		Dissolves many of the minerals with low indices.
Acetone	1.357		Slight	
Ethyl alcohol[b]	1.362	0.00040	do	Do.
Ethyl butyrate	1.381		do	
Methyl butyrate	1.386		do	
Ethyl valerate	1.393		do	
Amyl alcohol[c]	1.409	.00042	do	Dissolves many minerals with which it is used.
Kerosene	1.448	.00035	do	
Petroleum oil:[d]				
Russian alboline	1.470	.0004	do	
American alboline	1.477	.0004	do	
α Monochlornaphthalene.[e]	1.626		Moderate	
α Monobromnaphthalene.	1.658	.00048	do	
Methylene iodide	1.737 to 1.741	.00070	Rather strong.	Rather expensive. Discolors on exposure to light, but a little copper or tin in the bottle will prevent this change.
Methylene iodide saturated with sulphur.	1.778		do	
Methylene iodide, sulphur, and iodides.[f]	1.868		do	
Piperine and iodides	1.68 to 2.10			
Sulphur and selenium	1.998_{Na} to 2.716_{Li}		Very strong.	
Selenium and arsenic selenide.	2.72 to 3.17_{Li}		do	

[a] Another list of immersion media has been given by R. C. Emmons (Am. Mineralogist, vol. 14, pp. 482–483, 1929).

[b] V. T. Harrington and M. S. Buerger used petroleum distillates prepared from kerosene, gasolene, etc., for the range from 1.35 to 1.45; the liquids with the lower indices are very volatile (Immersion liquids of low refraction: Am. Mineralogist, vol. 16, pp. 45–54, 1931).

[c] Ordinary fusel oil may be used, but on mixing with kerosene it forms a milky emulsion, which settles on standing, and then the clear liquid may be decanted off.

[d] Any of the medicinal oils may be used, such as Nujol.

[e] Hallowax oil is satisfactory.

[f] To 100 grams methylene iodide add 35 grams iodoform, 10 grams sulphur, 31 grams SnI_4, 16 grams AsI_3, and 8 grams SbI_3, warm to hasten solution, allow to stand, and filter off undissolved solids. See Merwin, H. E., Media of high refraction: Washington Acad. Sci. Jour., vol. 3, pp. 35–40, 1913.

For fairly accurate work it is desirable to have a set of liquids from $n=1.400$ to $n=1.87$, differing from each other by 0.010, and a set of the solid media to carry the series up to $n=2.72$, the index of these media differing by 0.020. For less accurate work the set can be reduced to suit the requirements. The most important range is from 1.45 to 1.87, as β for about 80 per cent of all the known nonopaque minerals falls within this range. There are only about 11 minerals in which β is below 1.40 and only about 27 in which β is above 2.72. Care should be taken to prevent contamination and evaporation of the liquids. They are most conveniently kept in tall dropping bottles that have the combined ground stopper and dropper with glass cap. However, the oils with an index above about 1.75 tend to crystallize around the glass stoppers, and these keep much better in cork-stoppered bottles. A 15 cubic centimeter bottle is the smallest that is kept in stock by dealers, and even that size is larger than is required for the ordinary amount of work. It is best to keep the bottles at least half full, but with methylene iodide economy may dictate the use of a smaller amount. The bottles should never be allowed to stand without the stopper and cap in place. A convenient and easily

made case for the bottles is composed of a covered box that opens on hinges at one end. Ten bottles are kept in a 2-inch board which has 10 holes just large enough to hold the bottles. The box is made to take as many of these boards with the bottles as desired. The box should be kept closed, as light affects some of the liquids, notably methylene iodide.

With proper care a set of liquids made up as directed above will remain constant, within the limits of error required for most determinative work, for years. A set of 40 such liquids, used constantly for five years and checked once or twice a year, has rarely shown a change in any of the liquids of as much as 0.003. One or two liquids that have methylene iodide as a constituent were nearly all used up and had changed as much as 0.006. In general the liquids whose indices of refraction are above 1.75 are less constant.

The embedding media whose indices of refraction are above 1.87 are solid at ordinary temperature and are not quite so convenient nor accurate as are the liquids. They must not be heated too hot nor too long or they will change considerably. A small electric plate with three grades of heat is a convenient means for making embeddings with these melts. In practice a very small amount of the embedding medium is melted on a glass slip, a little of the powder to be examined is dusted into the melt, and a cover glass is pressed down upon it. In the highly colored melts that are rich in iodides or selenium the mineral must be powdered very fine, otherwise the thick film of the melt is nearly opaque. Borgström [11a] has prepared a series of immersion media made up of AsS and $AsBr_3$ in methylene iodide which remain liquid in the region of $n = 1.90 \pm$.

PIPERINE AND IODIDES [12]

Molten piperine dissolves the tri-iodides of arsenic and antimony and forms solutions that are fluid at slightly over 100° C. and are resinlike and amorphous when cold.

In general it has been found that the arsenic and antimony iodides available in the market are too impure to use in the preparation of the piperine-iodide melts, although they are quite satisfactory for solution in methylene iodide where impurities are filtered out. Even small proportions of impurities give a dark or even an almost opaque melt. The commercial iodides may be dissolved in hot xylene, filtered hot, and allowed to crystallize out on cooling. The cooled xylene, with part of the iodides still in solution, may then be used to dissolve a new lot of iodides. However, the same procedure may be used to make the iodides, as arsenic or antimony readily combine with iodine in hot xylene. By using iodides prepared in this way, and with proper precautions to avoid overheating during solution of the

[11a] Borgström, L. H., Ein Beitrag zur Entwicklung der Immersionmethode: Comm. géol. Finlande Bull. 87, pp. 58–63, 1929.

[12] Merwin, H. E., Media of high refraction for refractive index determinations with the microscope: Washington Acad. Sci. Jour., vol. 3, pp. 35–40, 1913.

iodides in the piperine, it is possible to procure melts of comparatively light color and perfect transparency. If overheated, the piperine decomposes, so it must be heated only slightly above the melting point but enough for complete solution of the iodides. Piperine recrystallizes readily after slight heating, but after continued heating at a proper temperature a change takes place that renders it a permanent amorphous resinlike material. It is advisable to heat the piperine for about half an hour before adding the iodides.

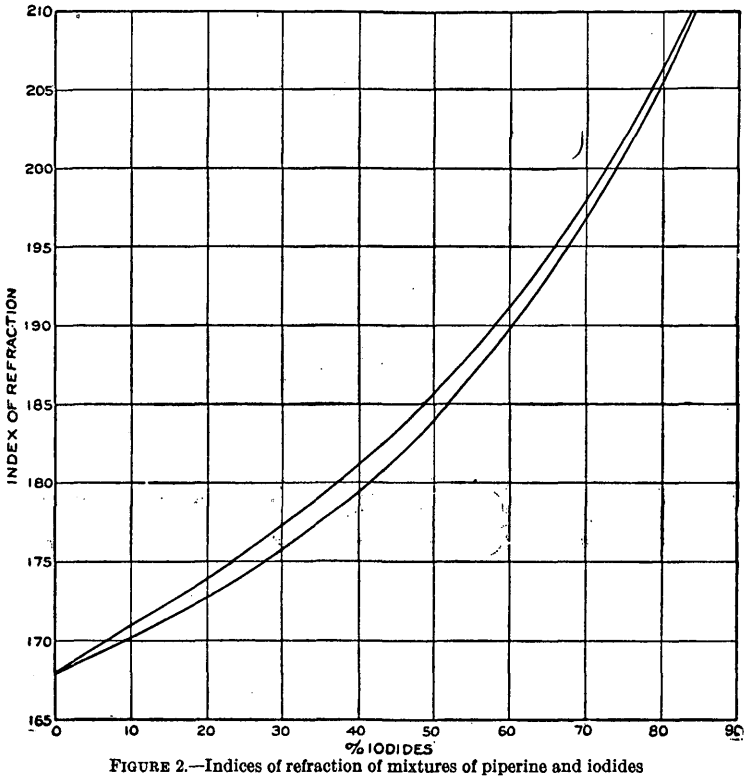

FIGURE 2.—Indices of refraction of mixtures of piperine and iodides

To make such preparations having constant indices of refraction anywhere within the range $n = 1.68$ to 2.10, mix three parts by weight of SbI_3 to one part of AsI_3, add this mixture to the piperine in the proper proportion, and heat carefully and stir in a test tube, large porcelain crucible, or glass flask just above the melting point of piperine until a homogeneous melt is obtained. A few grams of such a melt are sufficient for a large number of immersions. The heating may be done in a bath of crisco or paraffin, in an air bath, or over but not in the low flame of a bunsen burner or on an electric plate; stirring is essential to secure homogeneity. Such preparations can be standardized on the goniometer by measuring a prism molded between two pieces of cover glass, or weighted quantities of the constituents can be used and the refractive indices of the resulting preparation obtained from Figure 2. The indices of refraction of

such media increase rather rapidly on standing, and they are not entirely constant for about a month. The total increase in this time amounts to a few units in the third decimal place. After that time the indices remain constant and reheating does not affect them. In Figure 2 curve *a* shows the indices of freshly made preparations and curve *b* the indices of the preparations after they have stood until constant. The indices of refraction as measured in white light in these melts (above $n=1.70$) are almost those for sodium light.

SULPHUR-SELENIUM MELTS

Melted sulphur and selenium in any proportion readily form a homogeneous solution which has a constant index of refraction on cooling and remains amorphous long enough to allow measurements to be made. Suitable preparations with any index of refraction from 2.05 to 2.72 can be made by mixing the constituents in the proper proportion by weight and heating in a test tube just above the melting point until homogeneous. The mixture must be stirred and any sulphur that condenses on the upper part of the tube scraped back into the melt. The refractive indices for melts with different proportions of sulphur and selenium for light of different wave lengths are given in Figure 3, and preparations having approximately any index of refraction can be made by using weighed quantities of the constituents.

The indices of refraction of melts that contain more than 50 per cent of sulphur differ considerably according to the treatment, and this difference, which is probably due to the presence of λ and μ sulphur in different proportions, increases with the amount of sulphur.[13] By high heating and quenching the index of refraction may even be raised 0.05 above that obtained by cooling in air.[14] The proper treatment is to heat a small amount of the material on an object glass considerably above the melting point until the dark form of sulphur is obtained, then to add the mineral grains, press down a cover glass, and cool rather rapidly on a damp but not wet cloth or on an iron plate. It must also be remembered that sulphur is rather volatile. If the mineral to be tested is not decomposed by heating, it is well to mix the powdered embedding material and the mineral and to cover with a cover glass before heating, or to add the grains and cover before the final high heating. With proper care an accuracy of about ± 0.01 can be attained.

Indices of refraction for sodium light below about 2.20 can be readily measured in the sulphur-selenium melts, but above that point, on account of the deep-red color of the melts and the very

[13] Merwin, H. E., and Larsen, E. S., Mixtures of amorphous sulphur and selenium as immersion media for the determination of high refractive indices with the microscope: Am. Jour. Sci., 4th ser., vol. 34, pp. 42-47, 1912.

[14] The piperine-iodide melts are preferable within their range.

strong dispersion of selenium, it is best to make the measurements for the red light of lithium. This operation can be easily done by

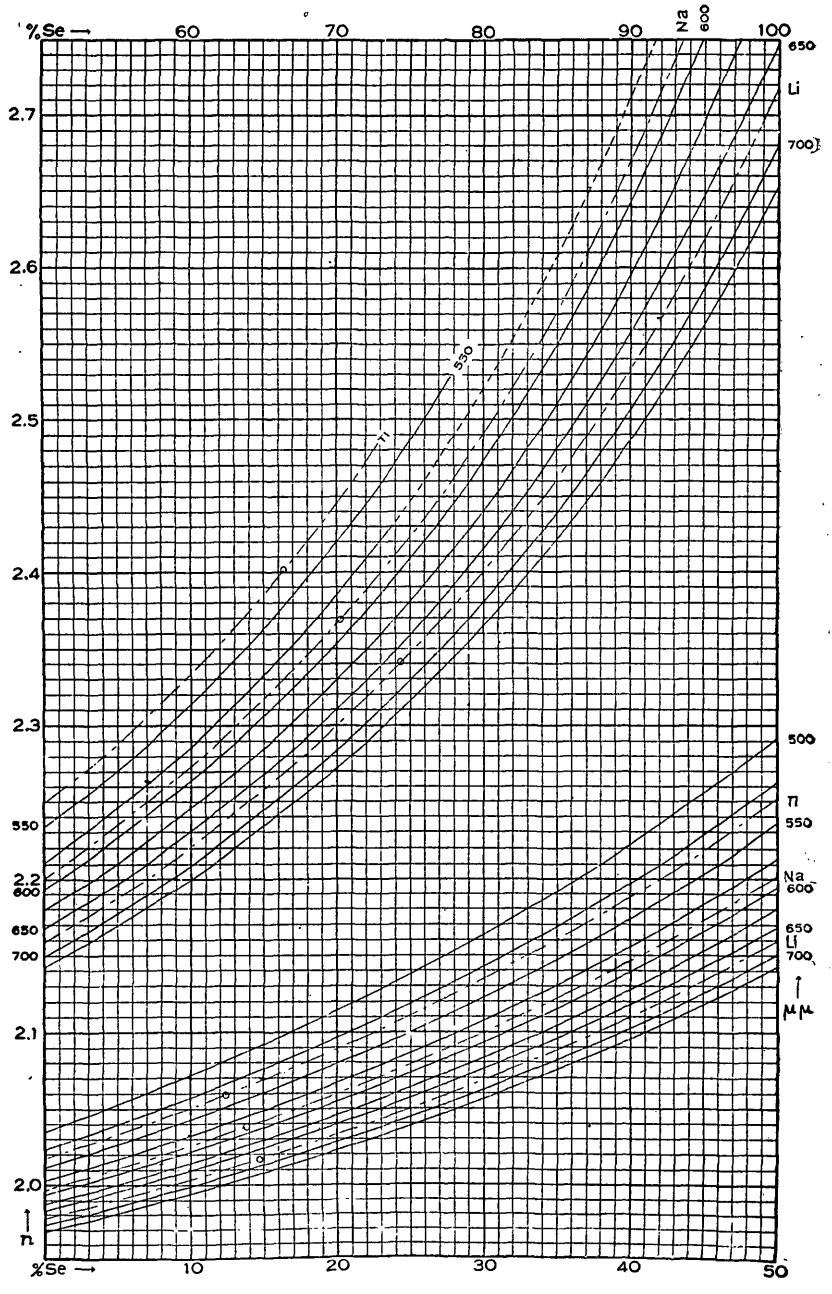

FIGURE 3.—Indices of refraction of mixtures of sulphur and selenium

placing over the eyepiece a color screen made by pressing a thin film of the melt composed of 70 per cent selenium and 30 per cent

sulphur between two glass plates, as such a film transmits chiefly light that is about equivalent to lithium light. Such a film crystallizes very slowly. Mixtures containing over 70 per cent selenium transmit chiefly lithium light, and index measurements made in such mixtures with white light give nearly the indices for lithium light.

SELENIUM AND ARSENIC SELENIDE MELTS

Dr. Merwin [15] has found that mixtures of selenium and arsenic selenide cover the range of indices of refraction from $n_{Li}=2.72$ to $n_{Li}=3.17$. These mixtures melt at rather low temperatures and are generally satisfactory, although they are deeply colored and measurements must be made for red light. Measurements can be made with these mixtures with a probable error of less than 0.02, but only under the most favorable conditions. The mixtures can be made by heating together metallic arsenic and selenium in weighed quantities or by first making As_2Se_3 and then adding the proper proportion of selenium. Thorough stirring is necessary to insure homogeneous melts. The following table gives the indices of refraction for different wave lengths of light for several mixtures of selenium and arsenic selenide.

Indices of refraction for mixtures of selenium and arsenic selenide

μμ	Se	60 per cent Se, 40 per cent As_2Se_3	22.6 per cent Se, 77.4 per cent As_2Se_3	As_2Se_3
640	2.78	2.90	----------	--------
660	2.74	2.86	3.06	--------
680	2.71	2.83	3.01	3.17
700	2.68	2.80	2.97	3.13
720	2.66	2.77	2.94	3.10
740	2.64	2.75	2.92	3.07
760	2.62	2.73	2.90	3.05

Dr. Merwin has also stated that a mixture of 10 per cent tellurium and 90 per cent As_2Se_3 gives indices of refraction 0.04 higher than the As_2Se_3 but is almost too opaque to use with an ordinary tungsten lamp. By means of direct sunlight or a "pointolite" lamp even more nearly opaque mixtures can be used.

HALOGENS OF THALLIUM

The halogen compounds of thallium, TlCl, TlBr, TlI have been suggested by Barth [16] as satisfactory immersion media of high refraction. The index range is large for mixed crystals of TlBr–TlI (2.4–2.8). These melts transmit a considerable range of the spectrum and are in that respect superior to the sulphur-selenium melts of the same index of refraction.

[15] Merwin, H. E., private communication. The data are preliminary.

[16] Barth, Tom, Some new immersion melts of high refraction: Am. Mineralogist, vol. 14, pp. 358–361, 1929.

METHODS OF STANDARDIZING MEDIA FOR MEASURING INDICES OF REFRACTION

A number of methods of standardizing the embedding media by the microscope have been devised,[17] but the method that employs the total refractometer or the method of measuring minimum deviation with a prism are much more satisfactory, and with either method accuracy to a few units in the fourth decimal place is easily attained. The Pulfrich refractometer may yield quicker results than the prism, but it can not be used with media whose indices are greater than about 1.86, and even with reasonable care it may be seriously injured by scratching or by corrosion from some of the liquids. The liquids containing methylene iodide in particular should not be allowed to remain on the hemisphere any longer than is necessary, and liquids from which crystals may separate should not be used, as the crystals may scratch the hemisphere.[18]

The Abbe refractometer is more sturdy and convenient for the ordinary range of index liquids. Daylight can be used for illumination.

The method of minimum deviation with a prism is not quite so rapid as that with the refractometer, but it can be used for the whole range of embedding media.[19] Any hollow prism can be used, but suitable prisms can be quickly made from two optically true glass plates about 5 by 20 millimeters in size by fusing them together at one corner in a blast lamp, taking care not to bend the glass, so as to form a prism that has nearly the desired angle. About one in a hundred of a good grade of petrographic object glasses is suitable. The glasses can be very quickly tested by watching the reflection on all parts of the glass of a cord in front of a window at a distance of about 10 feet. If the two surfaces are not parallel two reflections will be seen; if they are not plane surfaces, the reflections will be distorted.

The unfused end of this prism can be pressed onto a small drop of melted soft glass and a base to the prism thus made. Surface tension will keep the liquids in place. Instead of being mounted on a glass base the prism may be mounted in plaster of Paris coated with dental cement to glaze it. The glass plates should fit closely together, and it is well to cement the contact on the outside with dental cement to make a tight joint.

C. S. Ross[20] has shown that better prisms can be made by grinding a piece of glass to a rough prism of any desired angle by measuring

[17] Johannsen, Albert, Manual of petrographic methods, pp. 265–270, 1914. Wright, F. E., Measurement of the refractive index of a drop of liquid: Washington Acad. Sci. Jour., vol. 4, pp. 269–279, 1914.

[18] For a description of the crystal refractometer and its use see Rosenbusch (Wülfing), Mikroskopische Physiographie, Band 1, Erste Hälfte, pp. 650–659, 1924. Groth, Physikalische Krystallographie, pp. 704–711, 1905. Duparc and Pearce, Traité de technique minéralogique et pétrographique, pp. 385–392, Leipzig, 1907.

[19] For a description of this method see Groth, op. cit., pp. 27, 690–696, 1905; Duparc and Pearce, op. cit., pp. 26, 369–376, or any textbook on light.

[20] Private communication.

with a contact goniometer, grinding the edges of the two glass plates so that they will fit tightly together, and cementing the glass plates to the prism with bakelite so that a few millimeters of the glass plates will project above the top of the glass prism. The edges of the glass plates are also cemented with bakelite. It is convenient to have the top of the prism slope into the angle between the plates and thus make a tight receptacle for the drop of liquid.

A prism angle of about 60° is best for liquids that have moderate indices of refraction. A much smaller prism angle—one of 30° or less—must be used for liquids that have high indices of refraction. If a prism is to be used for a series of measurements a curve or a table should be constructed to show the index of refraction corresponding to any angle of minimum deviation. For the mixture of sulphur and selenium, the piperine preparations, or other solids, the prism can be molded between fragments of cover glass.

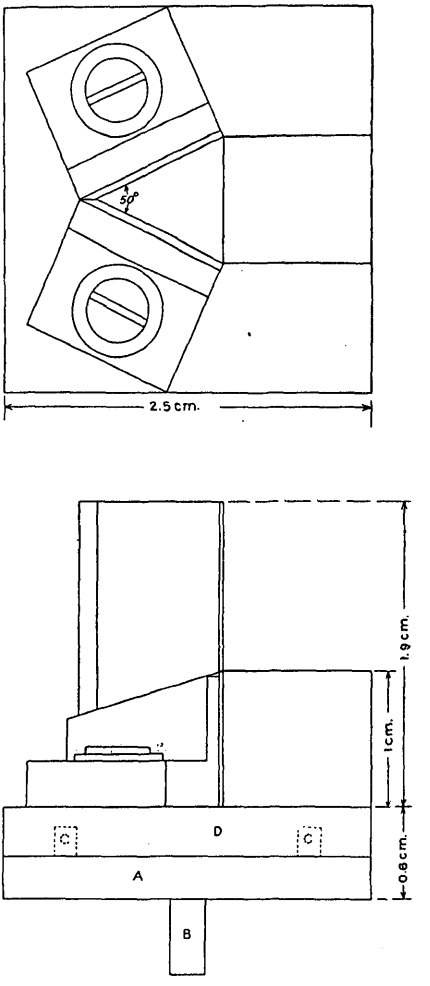

FIGURE 4.—Top and side views of brass frame for prism for determination of the refractive indices of liquids. One-third actual scale

In Figure 4 the front and side view of a prism made at the Harvard laboratory is shown. As this prism has rendered excellent service over a period of years, it is recommended as a completely satisfactory means of measuring liquids by means of the minimum deviation method. The device consists of a plate *A*, which fits into the goniometer head by means of the pin *B*. On the plane surface of *A* two guide pins, *C*, project into holes in *D*, which is carefully fitted to the lower plate. The upper portion of the prism and the plate upon which it rests are constructed of one piece of brass to prevent unnecessary movement. The upper part of the prism is cut at the desired angle, in this instrument about 50°, and sloped somewhat, as shown in the side view, so that the introduced drop

will tend to lie in the narrow portion of the prism. The glass plates, beveled to fit closely together at one end, are held in place by two brass clamps, as shown in the figure. Canada balsam or a glass cement will hold the glass plates together.

The whole top portion of the prism may be removed from the plate clamped to the goniometer, without altering the adjustment of the prism. This convenience enables one easily to clean the prism. The dimensions given are those for the prism in use at the Harvard laboratories.

MEASUREMENT OF ALL INDICES OF REFRACTION OF CRYSTALS

Most crystals have two (ω and ϵ) or three (α, β, and γ) principal indices of refraction, and for accurate work it is desirable to measure them all. If it is not necessary to measure all of the indices it is best to measure a particular one, preferably β, as otherwise any value from the lowest to the highest may be measured. If β is measured the others can be estimated from the birefringence and the axial angle.

The measurements of all the indices of refraction of a mineral can be made very quickly and within the limits of accuracy of the immersion method if the powdered grains show no marked tendency to lie on a particular face or cleavage, as do those of the micas, calcite, and many other minerals. Grains of minerals with such cleavages as the amphiboles, pyroxenes, and feldspars can generally be turned to any orientation without much difficulty. To test the lowest and the highest indices of refraction of such minerals against the embedding media a grain should be chosen that appears to show strong birefringence, both the thickness of the grain and the interference color being taken into account. The grain should be turned to extinction and tested against the embedding medium, then turned to the other extinction (or the lower nicol should be revolved 90°) and tested again. This procedure should be repeated on a number of grains, and with a little practice, unless the birefringence is extreme, many of them will show the lowest index of refraction, equal to α, or the highest index equal to γ, within the limits of error of the immersion method. For any grain or any orientation of a crystal plate β lies between the highest and the lowest values measured. Therefore β can be measured on a grain that shows no measurable birefringence. Such a grain is nearly normal to an optic axis and is suitable for observing the optical character, the size of the axial angle, and the dispersion of the optic axis. If the dispersion is considerable it will give abnormal interference colors without extinction.

Uniaxial minerals may be considered simply as a small group of biaxial minerals in which β is equal to α for a positive mineral and

to γ for a negative one. The lowest index of every grain of a uniaxial positive mineral and the highest of a uniaxial negative mineral is equal to ω and can be measured on any grain.

It may be desirable to turn the grain over. This can be done by shifting the cover glass with the point of a pencil. The movement can be controlled better with a viscous immersion medium than with one that is very fluid. Small cover glasses are more satisfactory than large ones, as they are much more easily manipulated. A cover glass 11 millimeters in diameter, divided into quarters or even ninths, is most used by the author. By turning and transferring a single small crystal to different media all the optical properties can be measured.

Some grains may be conveniently oriented by observing interference figures. A section normal to the acute bisectrix will give β normal to the plane of the optic axes, and in that plane α for a positive mineral or γ for a negative mineral. A section normal to the obtuse bisectrix gives β and γ or α; one parallel to the plane of the optic axes gives α and γ. Any section normal to the plane of the optic axes gives β.

Fibrous or prismatic fragments require a somewhat different treatment. If their extinction is nearly or quite parallel they will give one of the principal indices when turned with their length parallel to the plane of vibration of the lower nicol. The other two indices can be measured across the fibers by measuring a number of fibers, provided the mineral does not persist in lying on a particular face. In that event it may be necessary to roll a fiber, keeping it parallel to the cross hairs, and to observe the maximum or minimum index as it revolves. With a little practice this work can be done easily, unless the mineral is composed of very thin, broad laths. The face or cleavage on which a mineral tends to lie is likely to be normal to one of the principal optical directions. This tendency may be tested by an interference figure. On grains that show this tendency two of the indices of refraction can readily be measured and the other index can be obtained by turning the flake on edge. Winchell [21] proposed inclosing a fibrous or lath-shaped mineral in a capillary tube and turning the capillary.

Monoclinic minerals that are prismatic along (*c*) or (*a*) show parallel extinction for prisms that lie on any face parallel to crystal axis *b* and nearly the maximum inclined extinction if turned parallel to the face (010) which is normal to that axis. Prisms that lie on a face parallel to axis *b* will give for the ray vibrating across the prism the index of refraction (α, β, or γ) of the ray which vibrates parallel to axis *b*. Prisms that lie on the face (010) will give the other two indices of refraction and also the extinction angle, X (Y or Z) to *c* (or *a*). Triclinic fibers that have inclined extinction

[21] Winchell, A. N., Camsellite and szaibelyite: Am. Mineralogist, vol. 14, pp. 48–49, 1929.

are more difficult to measure, but with a little ingenuity measurements can usually be made. The stronger the birefringence, however, the more accurate must be the orientation to obtain accurate results.

Platy minerals, such as mica, are more difficult to manipulate, and if their birefringence is considerable they require skill and patience in order to get good results. Fortunately in nearly all such minerals the rays corresponding to one index vibrate nearly or quite normal to the plate and those corresponding to the other two vibrate in the plane of the plate and can be easily measured. The index normal to the plate can be obtained by turning the plates and keeping them on edge; this can often be done in a viscous liquid or they may be measured as they are turned. It is sometimes helpful to mix a little powdered glass with the mineral or to have grains of varying size to separate the cover glass and object glass enough so that the mineral plates can turn over. One of two plates that are differently oriented and attached together may be more easily turned on edge. Many such minerals can be cut with a knife across the plates and the resulting fragments placed on the object glass in the position desired.

MEASUREMENTS OF AXIAL ANGLES

The following methods of estimating or measuring the axial angle of mineral grains have been found most convenient by the author: (1) Observing the curvature of the hyperbola in sections cut nearly normal to an optic axis; (2) measuring or estimating the distance between the hyperbolas on a section cut nearly normal to the acute bisectrix; (3) computing the axial angle from the three indices of refraction;[22] (4) measuring on the universal stage. All observations are best made on grains immersed in a medium that has an index of refraction approximately equal to that of β for the mineral.

From the curvature of the hyperbola of an interference figure the axial angle can be measured, under favorable conditions, with an error of $\pm 3°$.[23] With a little experience a rough estimate can be made by merely inspecting the curvature of the hyperbola. If the bar appears straight, when turned to the 45° position the axial angle is nearly 90°, and as the curvature becomes greater the axial angle becomes smaller.

More accurate and rapid measurements can be made on sections approximately normal to the acute bisectrix, provided the axial angle is not so large that the hyperbolas are outside the field of the microscope. Measurements of the axial angle in air (2E), by using

[22] For an excellent discussion of measurements of axial angles, see Wright, F. E., The methods of petrographic-microscopic research: Carnegie Inst. Washington Pub. 158, pp. 147–200, 1911.

[23] Wright, F. E., op. cit., pp. 155 et seq.

a cross-grating ocular, can be made on such sections in a few minutes with a probable error of only a few degrees.[23] A grain that is not well oriented can commonly be turned by carefully touching the cover glass. The Fedorov stage can be used to measure the axial angle.

The axial angle can be computed from the values of the three indices of refraction according to the formula

$$\mathrm{Tan}^2 V_\gamma = \frac{\frac{1}{\alpha^2} - \frac{1}{\beta^2}}{\frac{1}{\beta^2} - \frac{1}{\gamma^2}}$$

or by the approximate formula [24]

$$\mathrm{Cos}^2 V'_\alpha = \frac{\beta - \alpha}{\gamma - \alpha}$$

in which $2V_\alpha$ is the axial angle about α. For a discussion of these formulae see page 6. As the error in measuring the indices of refraction by the immersion method is considerable in comparison with the birefringence of most minerals, this method is very rough unless the birefringence is considerable.

DISPERSION OF THE OPTIC AXES

The dispersion formula $r>v$ (or $r<v$) simply means that the axial angle is greater (or less) for red than for violet light. For rapid work the dispersion can best be observed on an interference figure which shows at least one optic axis well in the field of vision. For orthorhombic minerals or for monoclinic minerals in which the plane of the optic axes contains the crystal axis b both hyperbolas must show the same dispersion, but for other crystals the dispersion may be different for the two optic axes, and to determine definitely the dispersion both optic axes must be taken into account, or, better, the axial angles should be measured for different colors of light. For crystals in which both hyperbolas show the same dispersion, if $r<v$ is moderate the dark hyperbola should show on a sharp interference figure a faint but distinctly perceptible reddish color on the concave side and bluish on the convex side. These borders are reversed if $r>v$. If the dispersion is strong these borders become pronounced, and many minerals show no dark hyperbola but a series of colored ones. If the dispersion is extreme the interference figure can hardly be recognized in white light.

[23] Wright, F. E., op. cit., pp. 155 et seq.

[24] A graphic solution of this equation is given in Wright, F. E., op. cit., pl. 9.

OPTICAL CHARACTER

The optical character of a mineral can be conveniently determined on grains that show the emergence of the acute bisectrix, the obtuse bisectrix, either of the optic axes, or the optic normal (Y); it can also be determined from the values for the indices of refraction. In making any of the tests it is desirable to have the grains embedded in a medium that has an index of refraction nearly that of the β index of refraction of the mineral grain, as otherwise the interference figure will be distorted. Grains can be turned into the desired position by gently shifting the cover glass. In a viscous liquid, such as Canada balsam, even fibrous or micaceous minerals can readily be turned to any desired orientation. A few grains of powdered glass dusted through the embedding media will raise the cover glass so that the grains or fibers can be turned. Highly viscous liquids like Canada balsam, Peru balsam ($n=1.593$), bakelite varnish ($n=1.63$), or AFS mounting medium ($n=1.685$) are good media in which to turn fibers on edge. Sections that show the emergence of an optic axis are by far the most serviceable, as they can easily be recognized by their interference colors, which are low to zero, and in minerals that have moderate or strong dispersion are abnormal. Moreover, in such sections the acute and obtuse bisectrices can be distinguished, unless the axial angle is very near 90°. The tests are made in the usual way. The authors use the red of the first order for most tests, but for minerals that are deeply colored, especially if they have very strong birefringence or if the grains are embedded in a deeply colored melt, the quartz wedge is more satisfactory. It is often convenient or even necessary to determine the position of the optic plane and make the test on the grain itself by observing an edge where it wedges out. The tests can be made without a wedge or plate by observing the indices in the two directions against the embedding media, provided it is between the two or near one of them.

The optical character can be determined from the indices of refraction. If $\beta-\alpha$ is decidedly greater than $\gamma-\beta$ the mineral is optically negative; if decidedly less it is positive. (See p. 7.) This relation should be used chiefly as a check on the other data, but for some fibrous minerals whose acute bisectrix is along the fibers it may be the only means of readily determining the optical character.

OPTICAL ORIENTATION, DISPERSION OF BISECTRICES, AND CRYSTAL SYSTEM

Crystal habit and prominent cleavage, twinning, and other phenomena may be quickly observed under the microscope and their relations to the optical characters determined. By observing the interference figure the complete optic orientation of any grain, such as one lying on a cleavage or a crystal face, can be roughly made out.

This observation is especially suitable for determining the optical position that corresponds to the direction normal to the grain. The orientation in the plane of the section can best be obtained by measuring extinction angles and determining the position of the slow ray and the fast ray by means of a red of the first order or a quartz wedge, or by testing the indices against the embedding medium. The dispersion of the bisectrices can be determined by measuring extinction angles in different colors of light. For ordinary purposes it is sufficient to observe the color phenomena in ordinary daylight when the crystal is near extinction. If the dispersion is slight the extinction should be sharp; if considerable there will be no sharp extinction but abnormal interference colors over a range depending on the extent of the dispersion.

It is commonly possible to determine the crystal system to which a mineral belongs from the microscopic study. The fact that minerals such as biotite may be sensibly uniaxial or may give sensibly parallel extinction introduces some uncertainty.

Isotropic minerals are amorphous or isometric. Uniaxial minerals are tetragonal or hexagonal. Biaxial minerals with parallel or symmetrical extinction are orthorhombic. Biaxial minerals with inclined extinction for fragments normal to one principal optical direction and parallel or symmetrical for those normal to the plane of the other two are monoclinic. Biaxial minerals with inclined or unsymmetrical extinction for all orientations are triclinic.

Monoclinic minerals elongated in the direction of crystal axes *a* or *c* can be conveniently examined by rolling the fragments. When such fragments are turned so as to give parallel extinction crystal axis *b* and one principal optical direction lie across the length. When the fragments lie on a face normal to crystal axis *b* they should show approximately the maximum extinction angle. In the conoscope an interference figure should also appear in the center of the field of the microscope. Such sections will give the characteristic extinction angle X (Y or Z) $\wedge c$ (or *a*). Pleochroism can be conveniently observed at the same time.

An adequate optical orientation of triclinic minerals may be accomplished by the use of the Fedorov universal stage and the convenient accessory, the Wulff stereographic net. Recently use has been made of this method, but no uniformity in recording results has been heretofore proposed. The logical method to record an optical orientation seems to be the one wherein the optical elements are assigned coordinate values on the same projection with the crystallographic elements in the standard orientation. As an example of this method of indicating the optical positions, Figure 5, *a*, below gives the orientation of axinite, measured with *x* (111) parallel to the section—that is, the normal to *x* is at the center of projection. However, this is not the

accepted orientation for axinite, so the entire projection has been shifted until *b* (010) and *m* (110) have assumed their normal position, 90° from the center of projection. Further, by convention, the form *b* (010) is on the zero meridian; this involves one more simple shift of the projection, so that the conventional position is obtained. (See fig. 5, *b*.) The Wulff net greatly facilitates the changes required.

The data for the preparation of a table of coordinate angles, such as given below for axinite, may be read directly from the net, for the measurements made on the Fedorov stage are ordinarily not more accurate than a degree or more.

In the table the angles ϕ and ρ are those ordinarily used by crystallographers to indicate the angular positions of face poles on a projection. Thus ϕ is the angle from the zero meridian, read in a clock-

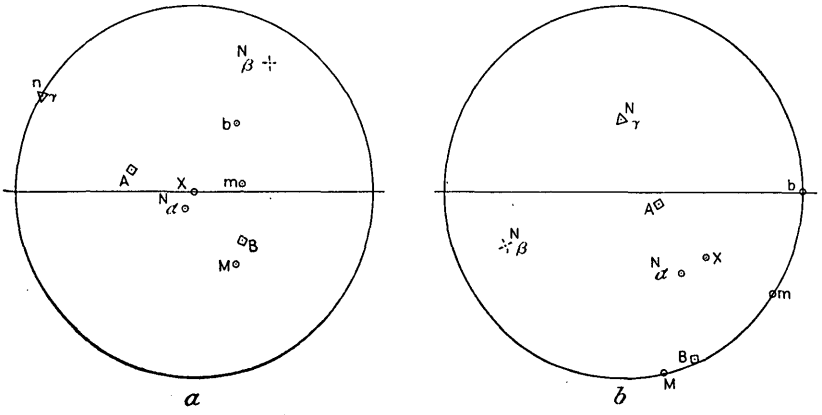

FIGURE 5.—Stereographic projection of the optical elements of a triclinic mineral (axinite). N_α, N_β, N_γ are the poles of the vibration directions of the three indices of refraction. *b*=face (010), *m*=(110), *M*=(1$\bar{1}$0), *x*=(111). A and B emergence of the two optic axes. *a*, Projection on *x*(111). *b*, Projection with the prism zone vertical

wise direction. Counterclockwise from the zero meridian the readings are negative. The angular values given are conventionally not greater than 180°. The ρ values indicate the angular inclination of the point from the center of the projection. These angles therefore do not exceed 90° in value.

Optical orientation of axinite

	ϕ	ρ		ϕ	ρ
	°	°		°	°
b (010)	0	90	Z	−93	42
X	53	55	A	18	24
Y	156	72	B	65	90

Extinction angles may be determined graphically when the positions of the axial angle are placed on the projection. The graphic method is recommended for such a determination, because, as before stated, ordinary measurements on the Fedorov stage do not justify more precise methods.

DISPERSION OF THE INDICES OF REFRACTION

The dispersion of the indices of refraction is easily measured by Merwin's dispersion method and is a significant diagnostic property. It should be used more than it is.

OTHER TESTS

The optical properties are sufficient for the accurate determination of most minerals, but the occurrence and association of the mineral should be considered, a macroscopic examination made, and such simple properties as hardness noticed. It may be desirable also to determine the fusibility and the specific gravity or to make simple chemical tests. Microchemical examinations have not received the attention from mineralogists that they deserve. X-ray photographs are valuable aids and in some determinations are indispensable.

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CHAPTER 3.—SOME STATISTICS ON THE OPTICAL PROPERTIES OF MINERALS

DISTRIBUTION OF MINERALS WITH REGARD TO OPTICAL CHARACTER

The tables in chapter 4 contain data for about 1,200 mineral species, but some species appear more than once, and there are about 1,700 entries. They are distributed as follows:

	Per cent		Per cent
Isotropic	14. 9	Biaxial+	30. 3
Uniaxial+	6. 8	Biaxial−	31. 8
Uniaxial−	13. 8	Optical character unknown	2. 4

Many of the isotropic minerals are amorphous, and some minerals that are placed under the uniaxial groups are strictly biaxial but have small axial angles or their apparent uniaxial character is due to aggregate polarization of fibers or lamellae. A few of those included in the biaxial groups are uniaxial and appear biaxial on account of strain.

The small number of uniaxial positive minerals as compared with uniaxial negative minerals is noteworthy. A significant feature of the revised edition is the lowering of the percentage of minerals entered as of optical character unknown.

DISTRIBUTION OF MINERALS WITH REGARD TO INDEX OF REFRACTION AND BIREFRINGENCE

The distribution of the minerals with regard to their intermediate index of refraction β is shown in Figure 6. For only 10 minerals, or less than 1 per cent of the total number, is β less than 1.400, and for only about 28, or about 2 per cent, is β greater than 2.70. For about 54 per cent of all the minerals β is between 1.475 and 1.700.

The distribution of the minerals with respect to their birefringence is shown in Figure 7. Curve 1 shows that the greater number of the minerals have a birefringence of about 0.018 and that the number rapidly decreases on both sides of this value. Curves 2 to 5 show the distribution as regards birefringence of the minerals whose indices of refraction β lie between certain values. The greater number of minerals in which β is lower than 1.80 have birefringence of about 0.015. For minerals in which β lies between 1.80 and 2.00 the greatest density of distribution is for a birefringence of about 0.035, and for those in which β is greater than 2.00 there is no marked

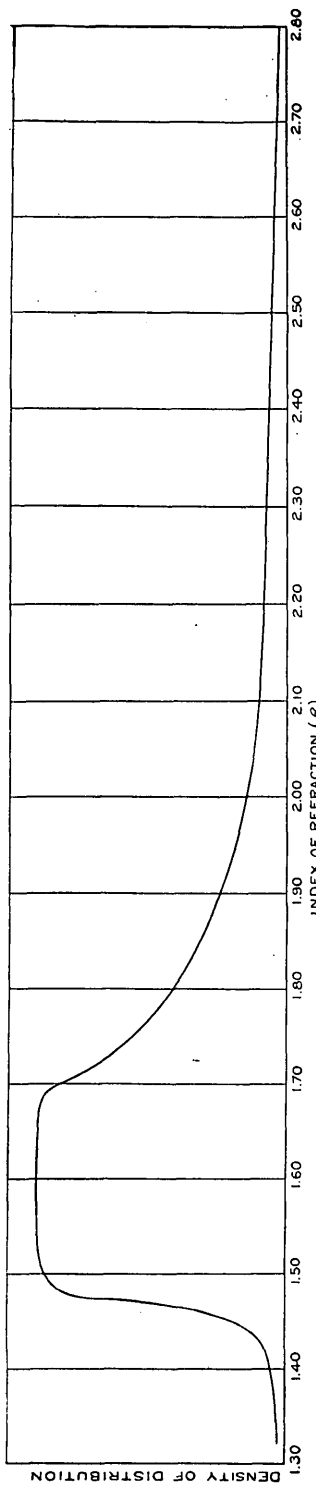

FIGURE 6.—Diagram showing density of distribution of the nonopaque minerals with respect to the intermediate index of refraction

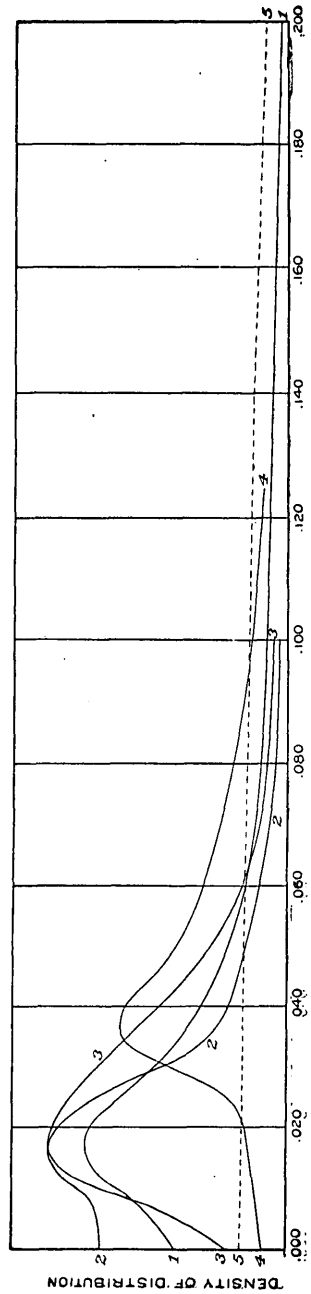

FIGURE 7.—Diagram showing density of distribution of the nonopaque minerals with respect to index of refraction and birefringence

maximum for the curve. These curves show a striking tendency for minerals which have high indices of refraction to have also strong birefringence. This tendency is equally well shown by the percentage distribution of minerals which have birefringence greater than 0.20.

Percentage of minerals with β between given values and with birefringence greater than 0.2

	Per cent		Per cent
β less than 1.80	2	β between 2.2 and 2.6	10
β between 1.80 and 2.0	11	β greater than 2.6	48
β between 2.0 and 2.2	14		

RELATION BETWEEN INDEX OF REFRACTION, DENSITY, AND CHEMICAL COMPOSITION

Gladstone and Dale long ago showed that

Every liquid has a specific refractive energy composed of the specific refractive energies of its component elements, modified by the manner of combination, and which is unaffected by changes of temperature and accompanies it when mixed with other liquids. The product of this specific refractive energy and the density is, when added to unity, the refractive index.[25]

Or,

$$\frac{n-1}{d}=\mathrm{K}, \text{ and } \mathrm{K}=k_1\frac{p_1}{100}+k_2\frac{p_2}{100}+\text{etc.},$$

where K is the specific refractive energy of any substance and k_1, k_2, p_1, p_2, etc., are the specific refractive energies and the weight percentages of the components of that substance. These components may be the elements or radicals that enter into a compound or the constituents of a solution. In general these relations hold rather accurately for varying temperature, pressure, and concentration in liquids and gases, but when applied to a substance in a different state—as liquid and gas—the formula gives errors as great as 30 per cent. On the basis of the electromagnetic theory of light Lorentz and Lorenz independently derived the formula $\frac{n^2-1}{n^2+2}\cdot\frac{1}{d}=k$. This formula holds somewhat better for substances in a different state but nevertheless gives a considerable error. Another formula recently proposed [26] is $\frac{\log n}{d}=\mathrm{K}$.

Moreover, some substances, as oxygen in some organic compounds, have two or more specific refractive energies, depending on the structure of the molecule.

[25] Gladstone, J. H., and Dale, T. P., Researches on the refraction, dispersion, and sensitiveness of liquids: Roy. Soc. London Philos. Trans., vol. 153, p. 337, 1864.

[26] Lichtenecker, K., Phys. Zeitschr., vol. 27, pp. 115–139, 1926.

When Gladstone's law is applied to crystalline substances the mean index of refraction $\frac{2\omega+\epsilon}{3}$ or $\frac{\alpha+\beta+\gamma}{3}$ must be used and the relations hold only approximately. The formula $\sqrt[3]{\omega^2\epsilon}$ or $\sqrt[3]{\alpha\beta\gamma}$, however, should be used where the birefringence is very strong. In applying these formulae to minerals, additional difficulties are introduced, as determinations of density are commonly unreliable, and the chemical composition of the material for which the indices of refraction are available may be imperfectly known. However, the values shown in Table 2 for the specific refractive energies $\left(\frac{n-1}{d}=k\right)$ of the chief constituents of minerals have been computed by taking the average as derived from a number of minerals for which the available data seemed fairly reliable.

TABLE 2.—*Specific refractive energies* $\left(\frac{n-1}{d}=k\right)$ *of the chief constituents of minerals.*

	Molecular weight	k		Molecular weight	k
H_2O	18	[a] 0.3355. [b] 0.340, [c] .354	As_2O_3	198	[g] 0.202, [h] 0.225.
Li_2O	30	.31	Y_2O_3	226	.144
$(NH_4)_2O$	52	.503	Sb_2O_3	228.4	[g] .209, [i] .232.
Na_2O	62	.181	La_2O_3	326	.149
K_2O	94	.189	Ce_2O_3	328.5	.16
Cu_2O	143	.250	Bi_2O_3	464	.163
Rb_2O	187	.129	CO_2	44	.217
Ag_2O	232	.154	SiO_2	60	.207
Cs_2O	282	.124	TiO_2	80	.397
Hg_2O	416	.169 [h]	SeO_2	111	.147
Tl_2O	424	.120	ZrO_2	122.5	.201
BeO	25	.238	SnO_2	151	.145
MgO	40.4	.200	SbO_2	152	.198
CaO	56	.225	TeO_2	159.5	[e] .200 [i]
MnO	71	[d] .191, [e] .224	ThO_2	264.5	.12
FeO	72	.187	N_2O_5	108	.240
NiO	75	.184	P_2O_5	142	.190
CoO	75	.184	Cl_2O_5	151	.218
CuO	79.6	[d] .191, [e] .253 [i]	V_2O_5	182.4	.43
ZnO	81.4	[d] .153, [e] .183	As_2O_5	230	.169
SrO	103.6	.143	Br_2O_5	240	.183
CdO	128.4	.134	Cb_2O_5	268	.295
BaO	153.4	.127	Sb_2O_5	320.4	.152, .222(?)
HgO	216	.18	I_2O_5	334	.177
PbO	223	[d] .137, [e] .175 [i]	Ta_2O_5	446	.133
B_2O_3	70	[g] .220	SO_3	80	.177
C_2O_3	72	.265	CrO_3	100	.36
Al_2O_3	102	.193, [f] .214	SeO_3	127	.165
Cr_2O_3	152	.27	MoO_3	144	.241 [i]
Mn_2O_3	158	[d] .300, [e] .304 [i]	TeO_3	175.6	.607
Fe_2O_3	160	[d] .308, [e] .36 [i]	WO_3	235	.133
			UO_3	286.5	.134

[a] Water and ice.
[b] Average.
[c] Alums, etc.
[d] Calculated from compounds containing the oxide.
[e] Calculated from the oxide.
[f] Calculated from feldspar, feldspathoids, etc..
[g] Isometric oxide.
[h] Monoclinic oxide.
[i] Orthorhombic oxide.

	Atomic weight	k		Atomic weight	k
H	1	1.256 or 1.44	S	32	[j] 0.502, [k] 1.00
C	12	.403	Cl	35.5	.303
O	16	.203	Br	80	.214
F	19	.043	I	127	.226

[j] Calculated from native sulphur.
[k] Calculated from sulphides; values vary.

These values are only approximate, but in a number of minerals selected at random the value of k as computed from n and d and as computed from that of its constituents agreed with few exceptions within 5 per cent. A very few minerals show a much greater difference.

As shown in the table for most radicals, the value of k is near 0.20. For S, $(NH_4)_2O$, TiO_2, TeO_3, and V_2O_5, it is higher, and for Cs_2O, BaO, PbO, ThO_2, UO_3, and F it is much lower. There is a tendency for the value of k in each group to decrease as the molecular weight increases, but there are many exceptions. The values of k for BaO, SrO, and CaO show why related minerals of these three oxides have about the same indices of refraction but very different densities. The values for Cb_2O_5 and Ta_2O_5 show why the columbates commonly have higher indices of refraction but lower densities than the corresponding tantalates. The extremely low value for fluorine accounts for the remarkably low indices of refraction and comparatively high densities of the fluorides.

Minerals containing any of the following radicals as essential constituents are likely to show strong dispersion: $(NH_4)_2O$, N_2O_5, UO_3, Sb_2O_5, As_2O_5, P_2O_5, V_2O_5, Fe_2O_3, Mn_2O_3, MoO_3, or TiO_2.

CHAPTER 4.—TABLES FOR THE DETERMINATION OF MINERALS FROM THEIR OPTICAL PROPERTIES

ARRANGEMENT OF THE DATA IN THE TABLES

In Table 3 the minerals are arranged in the order of their mean indices of refraction (β or ω) and the birefringence is added.

In Table 4 the minerals are divided into six groups—isotropic, uniaxial positive, uniaxial negative, biaxial positive, biaxial negative, or optical character unknown. The last group includes only a few minerals, mostly very finely crystalline. As the indices of refraction are the most characteristic and the most easily measured of the optical constants, the minerals in each group are arranged in the order of the intermediate index of refraction, β.

The data for each mineral are arranged along a horizontal line. The left-hand column shows the variability. For biaxial minerals the next three columns show the three indices of refraction in the order α, γ, β. The birefringence is not given, for it can be determined by subtracting α from γ. After the indices of refraction the name of the mineral is given, and beneath it the chemical composition. Then follows the axial angle, 2V and 2E, and beneath it the dispersion of the optic axis. 2E becomes indeterminate as it approaches 180°, and so such values are not given. Next comes the optical orientation, and beneath it the dispersion of the principal optical directions (bisectrices). The crystal system is next given, and beneath it the crystal habit. The next column shows the cleavage, and the next the color of the mineral in the hand specimen. Then follows the hardness, specific gravity, and fusibility. In the last column, under remarks, is given the group to which the mineral belongs, the solubility, the pleochroism, twinning, and other properties. For isotropic and uniaxial minerals the arrangement is the same, but some of the columns are omitted. For a few minerals only one index of refraction is known, and the birefringence (B) is then given.

The birefringence is said to be weak if it is less than 0.010, moderate if between 0.010 and 0.025, strong if between 0.025 and 0.100, very strong if between 0.100 and 0.200, and extreme if greater than 0.200. The axial angle (2V) is said to be small if it is estimated to be less than 30°, moderate if between 30° and 60°, and large if over 60°. The dispersion of the optic axis is said to be perceptible if a good interference figure shows faintly perceptible colored borders, weak if a

little more easily seen, moderate if easily seen, strong if the hyperbolas are rather broad, colored bands, and extreme if the colored hyperbolas cover much of the field of the microscope.

The attempt has not been made to describe all the phenomena observed under the microscope but rather to give the chief optical constants and any exceptional properties that are not simply manifestations of these optical constants. For example, the section {010} of a monoclinic mineral with strong dispersion of the bisectrices will not give sharp extinction in white light but a succession of abnormal interference colors over an angle whose width depends upon the strength of dispersion. Minerals that have strong dispersion of the optic axis will give abnormal interference colors in white light on sections nearly normal to an optic axis. In general, abnormal interference colors are due to strong dispersion. The positions of the optical directions with relation to cleavage or other crystal direction are easily determined, except in triclinic minerals, if the position of the cleavage and of the principal optical directions in the crystal are known. For example, gypsum has a very perfect cleavage {010} and $Y = b$; hence cleavage pieces are parallel to the plane of the optic axes and will show the emergence of Y.

Minerals for which new measurements were made for these tables are marked with an asterisk (*). Under remarks the source of the specimen examined is given. There are about 80 of these minerals, and these new data have not in general been published elsewhere.

In Tables 5 to 24 we have assembled for some of the well-known mineral groups the optical data that are most useful for distinguishing between members of the group. The groups are arranged in alphabetical order, and the arrangement within the groups is much the same as in Table 4.

COMPLETENESS OF THE DATA

In the classification and nomenclature of the minerals Dana's "System of mineralogy" has been followed with few exceptions, although that classification is now greatly in need of revision. With the exception of the opaque minerals and a few others that are noted in the index and elsewhere, all the species recognized in Dana's System, including the first three appendices, are included in the tables as well as a considerable number of minerals not considered species in the system and many subspecies of the better known groups. Some minerals whose optical properties differ in different specimens have been inserted in the tables several times. The indices of refraction of about 20 very rare minerals have been roughly estimated from the chemical composition and specific gravity, and these estimated indices have determined the position of the minerals in the tables.

It must be borne in mind that a large number of the minerals are variable in all their properties through isomorphism and solid solution. For the most species this variability is within moderate limits, and if the properties of the end members are known those of the intermediate members can be estimated. As yet only a few mineral groups have been systematically studied and for many groups the only available constants are for one or more imperfectly placed intermediate members. Where the data were available the end members are placed in the tables and, in many groups, one or more intermediate members. Ultimately it is hoped that all optical measurements will be closely tied to good chemical analyses. The data given in the tables as a rule are commonly for particular specimens, and other specimens, even from the same locality, may differ somewhat in indices of refraction and other properties. If the axial angle is large a comparatively small difference may change the optical character and such minerals should be looked for in both the optically positive and negative groups.

For more complete descriptions of the minerals the standard mineralogies should be consulted, particularly Dana's "System of mineralogy", Hintze's "Handbuch der Mineralogie", Winchell's "Elements of optical mineralogy", and Rosenbusch-Mügge's "Mikroskopische Physiographie, Band 1, Zweite Hälfte."

TABLES

TABLE 3.—*List of minerals arranged according to their intermediate indices of refraction, β, and showing their birefringences*

	β	Birefringence		β	Birefringence
Air	1.000	0.000	Gearksutite	1.454	0.008
Ice	1.309	.004	Wattevillite	1.455	.024
Malladrite	1.312	.003	Epsomite	1.455	.028
Avogadrite	1.325	.001	Sassolite	1.456	.119
Villiaumite	1.328	Very weak.	Alum	1.456	.000
Water	1.333	.000	Yttrofluorite	1.457	.000
Hieratite	1.339	.000	Mendozite	1.458	.026
Cryolite	1.339	.001	Tschermigite	1.459	.000
Cryolithionite	1.339	.000	Chrysocolla(?)	1.46±	.11
Chiolite	1.349	.007	Opal	1.46	.000
Cryptohalite	1.370	.000	Mallardite		
Sellaite	1.378	.012	Tincalconite	1.461	.013
Mirabilite	1.395	.004	Melanophlogite	1.461	.000
Chrysocolla(?)	1.40±	Moderate.	Mendozite	1.461	.014
Termierite	1.403±	.000	Lechatelierite	1.462	.000
Opal	1.406±	.000	Picromerite	1.463	.015
Pachnolite	1.413	.009	Mendozite	1.463	.012
Thomsenolite	1.414	.008	Aluminite	1.464	.011
Natron	1.425	.035	Lansfordite	1.468	.051
Ralstonite	1.427	.000 to weak.	Halloysite	1.470±	.000
Opal	1.43	.000	Hatchettite	1.47	.03
Yttrocerite	1.434	.000	Gmelinite	1.47	.004
Fluorite	1.434	.000	Tridymite	1.47	.004
Opal	1.440±	.000	Allophane	1.47±	.000
Schairerite	1.440	.005	Neotocite	1.47±	.000
Erionite	1.44	.014	Chile loeweite	1.470	.036
Hisingerite	1.44±	.000	Paraluminite	1.470	.009
Stercorite	1.441	.030	Borax	1.470	.025
Taylorite	1.448	.012	Boussingaultite	1.470	.010
Covellite	1.45		Kernite	1.472	.034
Lecontite	1.452	.013	Flokite	1.473	.002
Kalinite	1.452	.028	Gmelinite	1.474±	.001 to .008
Hexahydrite	1.453	.030	Ptilolite	1.475	.003
Sulphohalite	1.454	.000	Mordenite	1.475	.004

TABLE 3.—*List of minerals arranged according to their intermediate indices of refraction, β, and showing their birefringences*—Continued

	β	Birefringence		β	Birefringence
Carnallite	1.474	0.029	Harmotome	1.505	0.005
Laubanite	1.475	.011	Vashegyite	1.505	.000
Alunogen	1.476	.009	Mesolite	1.505	.001
Arduinite	1.476	.004	Niter	1.505	.172
Thenardite	1.477	.013	Kainite	1.505	.022
Creedite	1.478	.024	Nitromagnesite	1.506	.17
Melanterite	1.478	.015	Thermonatrite	1.506	.104
Ferrierite	1.479	.004	Parasepiolite	1.506	.011
Pisanite	1.479	.015	Thaumasite	1.507	.039
Faujasite	1.48	.000±	Sulphatic cancrinite	1.507	.007
Zebedassite	1.48	.027	Bischofite	1.507	.033
Kalicinite	1.480	.19	Tychite	1.508	.000
Chabazite	1.480±	.002	Manganese chalcanthite	1.508	.019
Boothite	1.48	.02	Ussingite	1.508	.041
Misenite	1.480	.01	Leucite	1.509	.001
Dietrichite	1.480	.013	Nocerite	1.509	.023
Phillipsite	1.48	.003	Larderellite	1.509	.068
Goslarite	1.480	.027	Pirssonite	1.510	.071
Pickeringite	1.480	.007	Phillipsite	1.51	.003
Vashegyite	1.48	.02	Petalite	1.510	.012
Hanksite	1.481	.02	Uranospathite	1.510	.03
Darapskite	1.481	.095	Epistilbite	1.510	.010
Apjohnite	1.482	.004	Inyoite	1.51	.025
Natrolite	1.482	.013	Hisingerite	1.51±	.000
Zinc-copper melanterite	1.483	.009	Pseudomesolite	1.510	.002
Sodalite	1.483	.000	Saponite	1.510	.032
Bieberite	1.483	.012	Cimolite	1.51	.000
Bloedite	1.485	.004	Brewsterite	1.512	.013
Evansite	1.485	.000	Flagstaffite	1.512	.019
Heulandite	1.485	----------	Leonhardite	1.512	.011
Cristobalite	1.486	.003	Chrysotile	1.512	.014
Cyanochroite	1.486	.018	Hydrotalcite	1.512	.014
Aphthitalite	1.487	.005	Faroelite	1.513	.006
Leonite	1.487	.007	Northupite	1.514	.000
Analcite	1.487	.001	Okenite	1.514	.003
Ammonioborite	1.487	.070	Ozocerite	1.515	.025
Tamarugite	1.487	.012	Gonnardite	1.515	.006
Hackmanite	1.487	.000	Montmorillonite	1.516	.023
Ettringite	1.488	.014	Gaylussite	1.516	.079
Halotrichite	1.488	.010	Planerite	1.517	.000
Vanthoffite	1.488	.004	Meerschaum	1.517	.000
Douglasite	1.488	.012	Syngenite	1.517	.018
Morenosite	1.489	.025	Pollucite	1.518	.000
Vashegyite	1.49±	.000	Davyne	1.518	.003
Allophane	1.49±	.000	Felsoebanyite	1.518	.017
Sylvite	1.490	.000	Leifite	1.518	.004
Hydronephelite	1.490	.012	Newberyite	1.518	.019
Loeweite	1.490	.019	Scolecite	1.519	.007
Fluellite	1.490	.038	Koenenite	1.52	.03
Aphthitalite	1.491	.008	Halloysite	1.52±	.000
Trona	1.492	.128	Bobierite	1.52	.033
Stellerite	1.492	.011	Hautefeuillite	1.52	.03
Bianchite	1.494	.030	Chlorocalcite	1.52	Weak.
Arcanite	1.494	.004	Sepiolite	1.52	.010
Kreuzbergite	1.495	.017	Carnegieite	1.52	.004
Noselite	1.495	.000	Tachhydrite	1.520	.008
Dachiardite	1.496	.008	Microsommite	1.521	.008
Bolivarite	1.496	.000	Natrodavyne	1.522	.005
Struvite	1.496	.009	Gypsum	1.523	.010
Haüynite	1.496	.000	Mascagnite	1.523	.012
Nitrocalcite	1.498	.039	Hatchettite	1.523	.070
Stilbite	1.498	.006	Cancrinite	1.524	.028
Heulandite	1.499	.007	Laumontite	1.524	.012
Levynite	1.50	Strong.	Orthoclase	1.524	.008
Wellsite	1.50	.005	Bischofite	1.524	.032
Bilinite	1.500	Weak.	Spadaite	1.525	.024
Rosiérésite	1.5	.000	Thomsonite	1.525	.013
Lazurite	1.50±	.000	Bialite	1.525	.02
Liskeardite	1.500	.010	Anorthoclase ($Ab_{65}An_{35}$)	1.525	.008
Phillipsite	1.500	.004	Kramerite	1.525	.029
Nahcolite	1.500	.206	Chalcoalumite	1.525	.009
Stevensite	1.50±	.000	Saponite	1.525	.037
Didymolite	1.501	.015	Pollucite	1.525	.000
Epidesmine	1.501	.014	Sideronatrite	1.525	.078
Nesquehonite	1.501	.114	Minasragrite	1.525	.030
Paraffin	1.502	.048	Hintzeite	1.526	.042
Antigorite	1.502±	.021	Microcline	1.526	.008
Uranothallite	1.503	.039	Hydromagnesite	1.527	.022
Prosopite	1.503	.009	Paternoite	1.528	.039
Ulexite	1.504	.029	Albite	1.529	.011
Niter	1.504	.172	Copiapite	1.529±	.066

TABLE 3.—*List of minerals arranged according to their intermediate indices of refraction, β, and showing their birefringences*—Continued

	β	Birefringence		β	Birefringence
Botryogen	1.529	0.055	Zepharovichite	1.55	0.02±
Kehoeite	1.53±	.000	Mizzonite ($Ma_{75}Me_{25}$)	1.551	.013
Tavistockite	1.530	.022	Zirklerite	1.552	Weak.
Slavikite	1.530	.024	Alumohydrocalcite	1.553	.085
Ilesite			Andesine	1.553	.007
Wapplerite	1.53	.025	Grothine	1.554	.016
Polylithionite	1.53	Low.	Lacroixite	1.554	.018
Mizzonite	1,532	.010	Bombiccite	1.555	.041
Milarite	1.532	.003	Vauxite	1.555	.011
Quetenite	1.532	.056	Lepidolite	1.555	.023
Kaliophilite	1.532	.005	Halloysite	1.555	.000
Fibroferrite	1.533	.042	Soumansite	1.555	(?)
Zinc-copper chalcanthite	1.533	.027	Saponite	1.555	.01
Searlesite	1.533	.022	Rhomboclase	1.555	.102
Langbeinite	1.533	.000	Whewellite	1.555	.159
Hydroboracite	1.534	.047	Miloschite	1.555	.007
Artinite	1.534	.068	Julienite	1.556	.089
Zinc aluminite	1.534	.020	Wapplerite	(?)	(?)
Wavellite	1.534	.027	Louderbackite	1.558	.037
Glauberite	1.535	.021	Serpentine	1.558	.000
Succinite	1.535±	.000	Paravauxite	1.558	.019
Apophyllite	1.535	.002	Ferronatrite	1.558	.053
Bromcarnallite	1.535	Very strong.	Metavariscite	1.558	.031
Kieserite	1.535	.063	Beryllonite	1.558	.009
Meyerhofferite	1.535	.060	Brucite	1.559	.021
Spadaite	1.535	.02	Anemousite	1.559	.008
Okenite	1.535	.010	Ferronatrite	1.559	.068
Coquimbite?	1.536	.036	Friedellite	1.560	.065
Iron-copper chalcanthite	1.536	.026	Trudellite	1.560	.065
Teschemacherite	1.536	.132	Polyhalite	1.560	.020
Siderotil	1.537	.015	Newtonite	1.560	.020
Apophyllite	1.537	.002	Jefferisite	1.560	.02
Chalcedony	1.537	.01	Colerainite	1.56	Weak.
Beidellite	1.537	.042	Humboldtine	1.561	.198
Chalcanthite	1.537	.029	Metavauxite	1.561	.027
Ameletite	(?)	Low.	Jezekite	1.561	.011
Cordierite	1.538	.006	Lepidolite	1.561	.025
Mellite	1.539	.028	Phlogopite	1.561	.023
Marialite (pure)	1.539	.002	Morinite	1.562	.012
Gismondite	1.539	.008	Nacrite	1.562	.006
Brugnatellite	1.540	.030	Chlorite	1.562	.014
Deweylite	1.54	(?)	Faratsihite	1.56	Moderate.
Cornuite	1.54±	.000	Scacchite		.000
Sulphoborite	1.540	.017	Cordierite	1.562	.011
Ajkaite	1.541	.000	Labradorite	1.563	.009
Gordonite	1.541	.022	Dickite	1.563	.006
Telegdite	1.542	.000	Kossmatite	1.564	Strong.
Halloysite	1.542±	.000	Anauxite	1.564	.006
Nephelite	1.542	.004	Polylithionite	1.565	.022
Stichtite	1.542	.026	Montmorillonite	1.565	.022
Dawsonite	1.542	.130	Traversoite	1.565	.000
Copiapite	1.543	.065	Pinnoite	1.565	.010
Oligoclase	1.543	.008	Zeophyllite	1.565	.005
Halite	1.544	.000	Pyroaurite	1.565±	.01
Quartz	1.544	.009	Elpidite	1.565	.014
Epididymite	1.544	.002	Kaolinite	1.565	.005
Mooreite	1.545	.014	Gibbsite	1.566	.021
Errite	1.545	.002	Radiophyllite	(?)	(?)
Anauxite	1.54	.01	Fluoborite	1.566	.038
Pholidolite	1.545	.042	Norbergite	1.567	.027
Eucryptite	1.545	Low.	Wernerite ($Ma_{50}Me_{50}$)	1.567	.022
Brushite	1.545	.012	Collophanite	1.568	.000
Hyalophane	1.545	.005	Isoclasite	1.568	.015
Eudidymite	1.546	.006	Epididymite	1.569	.004
Voglite	1.547	.023	Griffithite	1.569	.087
Copiapite	1.547	.060±	Lacroixite	1.57	
Cordierite	1.547	.010	Zaratite	1.57±	.000
Fluoborite	1.547	.025	Lawrencite	1.57	Weak.
Oxammite	1.547	.156	Phillipsite	1.57	.010
Botryogen	1.548	.028	Tengerite	1.57	.030
Centrallasite	1.548	.014	Wagnerite	1.570	.013
Gyrolite	1.549	.013	Bowlingite	1.57±	.025
Truscottite	1.549	.021	Antigorite	1.570	.011
Radiophyllite	(?)	(?)	Hoernesite	1.571	.033
Edingtonite	1.549	.016	Roemerite	1.571	.059
Cobalt chalcanthite	1.549	.021	Variscite	1.571	.022
Coquimbite	1.550	.006	Chlorite	1.572	.002
Chrysotile	1.550	.011	Beidellite	1.572	.039
Saponite	1.55	.03	Leuchtenbergite	1.572	.003
Neotocite	1.55±	.000	Englishite	1.572	.002
Ascharite	1.55	.02	Nitrobarite	1.572	.000

TABLE 3.—*List of minerals arranged according to their intermediate indices of refraction, β, and showing their birefringences*—Continued

	β	Birefringence		β	Birefringence
Manganlangbeinite	1.572	0.000	Custerite	1.59	0.012
Hisingerite	1.57±	.000	α Hopeite	1.59	.018
Alunite	1.572	.020	Nontronite	1.590	.020
Hannayite	1.572	.020	Muscovite	1.590	.033
Bytownite	1.572	.010	Metavoltaite	1.591	.018
Vermiculite	1.573	.031	Hambergite	1.591	.071
Bassetite	1.574	.02	Priceite	1.591	.022
Biotite	1.574	.033	Hiddenite	1.592	.011
Calcium hydroxide	1.574	.029	Catapleiite	1.592	.036
Phlogopite	1.574	.034	Colemanite	1.592	.028
Zinnwaldite	1.575	.030	Torbernite	1.592	.010
Anhydrite	1.575	.044	Alurgite	1.594	.04
Loewigite	1.575	.01	Astrolite	1.594	.027
Autunite	1.575	.024	Fuchsite	1.594	.04
Calcioferrite	1.575	.005	Diabantite	1.595	.040
Jurupaite	1.57	.008	Amblygonite	1.595	.020
Leuchtenbergite	1.575	.015	Crandallite	1.595	.010
Parsettensite	1.576	.030	Szmikite	1.595	.070
Ekmannite	1.576	.008	Cuspidine	1.595	.012
Penninite	1.576	.003	Leucophanite	1.595	.027
Augelite	1.576	.014	Manganophyllite	1.595	.027
Sphaerite	1.576	.026	Johannite	1.596	.036
Beryl	1.577	.006	Zunyite	1.596	.000
Kroehnkite	1.578	.057	Meionite (pure)	1.597	.037
Fichtelite	1.578	.06	Chrysocolla	1.597	.023
Penninite	1.579	.002	Cordierite	1.597	.007
Cookeite	1.579	.021	Amesite	1.597	.015
Canbyite	1.580	.020	Lepidolite	1.598	.045
Ripidolite	1.580	.009	Howlite	1.598	.019
Manandonite	(?)	.014	Beryl (high in alkalies)	1.598	.008
Cookeite	1.58±	Rather strong.	Manganophyllite	1.598	.030
			Millisite	1.598	.008
Coeruleolactite	1.580	.008	Nontronite	1.600	.021
Koninckite	1.58	.000	Muscovite	1.599	.041
Bavenite	1.581	.010	Stibiconite	1.60±	.000
Beryl (low in alkalies)	1.581	.006	Biotite	1.600	Strong.
Sheridanite	1.581	.009	Cebolite	1.60	.033
Chlorite	1.581	.010	Beidellite	1.600	.045
Muscovite	1.581	.036	Chloraluminite	1.60	.053
Beidellite	1.582	.028	Zinnwaldeite	1.60	.03
Hydrobiotite	1.582	.037	Riversideite	1.600	.008
β Hopeite	1.582	.008	Paragonite	1.60	.03
Meionite ($Ma_{25}Me_{75}$)	1.582	.031	Borickite	1.60±	.000
Chrome clinochlore	1.582	.011	Dennisonite	1.601	.010
Cacoxenite	1.582	.063	Haidingerite	1.602	.048
Uranospinite	1.582	.027	Spencerite	1.602	.020
Prochlorite	1.582	.011	Ganophyllite	1.603	.031
Alumian	1.583	.019	Fremontite	1.603	.021
Zonotlite	1.583	.012	Crestmoreite	1.603	.014
δ Mooreite	1.584	.006	Vivianite	1.603	.054
Anorthite	1.584	.012	Sarcolite	1.604	.011
Schroetterite	1.584	.000	Voltaite	1.604	.000
Natroalunite	1.585	.01	Pectolite	1.604	.032
Nontronite	1.585	.025	Prochlorite	1.605	Low.
Variscite	1.585	.029	Martinite	1.605	.02
Anthophyllite	1.585	.013	Bertrandite	1.605	.023
Volchonskite	1.585	Moderate.	Amarantite	1.605	.100
Clinochlore	1.586	.011	Hydrophilite	1.605	.000
Wardite	1.586	.009	Grodnolite	1.605	
Soumansite	1.586	.009	Chondrodite	1.606	.025
Lanthanite	1.587	.09	Scawtite	1.606	.022
Rumpfite	1.587	Low.	Phlogopite	1.606	.044
Soda niter	1.587	.251	Eudialyte	1.606	.005
Pyrophyllite	1.588	.048	Yuksporite	(?)	.017
Talc	1.589	.050	Meionite	1.607	.036
Pharmacolite	1.589	.011	Corundophilite	1.607	.006
Celsian	1.589	.010	Dahllite	1.608	.004
Rinneite	1.589	.001	Weinschenkite	1.608	.045
Zaratite	1.59±	.000	Narsarsukite	1.609	.021
Kupferite	1.590	.015	Allanite	1.61	.000
Kochite	1.590	.000	Muscovite	1.611	.043
α Catapleiite	1.590	.030	Szmolonokite	1.61	.07
Wardite	1.590	.010	Nontronite	1.61	.025
Crandallite	1.59	.01	Hillebrandite	1.61	.007
Manganbrucite	1.59	.01	Zaratite	1.61±	.000
Eggonite	1.590	(?)	Diadochite	1.61±	.000
Kornelite	1.59	.07	Gummite	1.61±	.000
Hisingerite	1.59±	.000	Montebrasite	1.611	.020
Collophanite	1.59±	.000	Meliphanite	1.612	.019
Chloromanganokalite	1.59	Very weak.	Aphrosiderite	1.612	.004
Connarite	1.59±	.03	Herderite	1.612	.029
Garnierite	1.59	Low.			

TABLE 3.—*List of minerals arranged according to their intermediate indices of refraction, β, and showing their birefringences*—Continued

	β	Birefringence		β	Birefringence
Anapaite	1.613	0.047	Richterite	1.63	0.02
Stokesite	1.613	.010	Chrysocolla (?)	1.63	.05
Soda tremolite	1.613	.017	Celadonite	1.63	.01
Monetite	1.614	.031	Lazulite	1.634	.03
Phosphophyllite	1.614	.022	Åkermanite	1.633	.006
Stilpnomelane	1.615	.069	Fluorapatite	1.633	.003
Zippeite	1.615	.012	Danburite	1.633	.006
Fluocerite	1.615	.002	Voelckerite	1.633	.004
Lehiite	1.616	.027	Melilite	1.634	.005
Tremolite	1.616	.027	Goyazite	1.635	.011
Calamine	1.617	.022	Pitticite	1.635±	.000
Cyanotrichite	1.617	.067	Tilleyite	1.635	.035
Chondrodite	1.617	.032	Dahllite	1.635	.004
Glauconite	1.618	.022	Gedrite	1.636	.021
Chalcophyllite	1.618	.066	Manganophyllite	1.636	.014
Pargasite	1.618	.022	Grandidierite	1.636	.037
Edenite	1.619	.019	Inesite	1.636	.035
Chondrodite	1.620	.036	Schizolite	1.636	.029
Delessite	1.619	.014	Clinohumite	1.636	.028
Turquoise	1.62	.04	Chlorite	1.637	.023
Nontronite	1.62	.015	Mitscherlichite	1.637	.022
Topaz	1.620	.008	Barite	1.637	.012
Churchite	1.620	.034	Cummingtonite	1.638	.022
Bisbeeite	1.620	.10	Pargasite	1.638	.019
Afwillite	1.620	.017	Anthophyllite	1.638	.019
Torbernite	1.62	.002±	Lepidomelane	1.638	.052
Gillespite	1.621	.002	Glaucophane	1.638	.017
Eucolite	1.621	.003	Sal ammoniac	1.639	.000
Zippeite	1.621	.010	Hydrothorite	1.638	.000
Lehiite	1.622	.009	Andalusite	1.639	.009
Pseudowavellite	1.622	.009	Roscherite	1.639	.019
Arakawaite	1.622	.040	Dehrnite	1.640	.009
Metatorbernite	1.623	.002	Pseudowavellite	1.64	.015
Dehrnite	1.623	.011	Picite	1.64	.000
Merrillite	1.623	.003	Thuringite	1.64±	.01
Amblygonite	1.623	.023	Jeremejevite	1.64	Moderate?
Tikhvinite	1.62	(?)	Roeblingite	1.64	.02
Uranopilite	1.623	.010	Griphite	1.64±	.000
Tremolite	1.623	.026	Lagonite	1.64±	.000
Uranocircite	1.623	.013	Homilite (altered)	1.640±	.000
Celestite	1.624	.009	Uvite	1.641	.020
Lewistonite	1.624	.011	Deltaite	1.641	.009
Soda margarite (ephesite)	1.625	.032	Anthophyllite	1.642	.024
Destinezite	1.625	.050	Sklodowskite	1.642	.046
Goyazite	1.625	.010	Serpierite	1.642	.063
Francolite	1.625	Low.	Mullite (pure)	1.642	.015
Parahopeite	1.625	.023	Hornblende	1.642	.024
Georgeixite	1.625	Weak.	Collinsite	1.642	.025
Nepouite	1.625	.037±	Ferroprehnite	1.642	.035
Roscherite	1.625	Moderate.	Ransomite	1.643	.064
Protolithionite	1.625	.033	Castanite	1.643	.104
Svanbergite	1.626	.014	Margarite	1.643	.013
Bazzite	1.626	.021	Humite	1.643	.035
Prehnite	1.626	.033	Zeunerite	1.643	.020
Actinolite	1.627	.025	Dioptase	1.644	.053
Troegerite	1.627	.045	Fairfieldite	1.644	.018
Rogersite	1.628	.056	Nontronite	1.645	.03
Carpholite	1.628	.019	Rinkolite	1.645	.018
Glauconite	1.628	.008	Holmquistite	1.645	.019
Lausenite	1.628	.056	Pargasite	1.646	.019
Prehnite	1.629	.026	Elbaite (tourmaline)	1.647	.018
Richterite	1.629	.022	Hellendite	(?)	.01
Wollastonite	1.629	.015	Biotite	1.648	.064
Mariposite	1.63±	.03	Loseyite	1.648	.039
Homilite (altered)	1.63	.02	Daphnite	1.649	.006
Chlorite	1.630	.005	Herrengrundite	1.649	.075
Collophanite	1.63±	.000	Mosandrite	1.649	.012
Biotite	1.63	.050	Phosphophyllite	1.65	.025
Anthophyllite	1.630	.021	Egueiite	1.65±	.000
Podolite	1.630	.008	Koninckite	1.65	.000
Deltaite	1.630	.010	Bementite	1.650	.026
Edenite	1.630	.023	Szaibelyite	1.650	.075
Guildite	1.630	.061	Homilite (altered)	1.650	.02
Hastingsite	1.631	.025	Krausite	1.650	.137
Ectropite	1.63	.01	Greenalite	1.65	.000
Humite	1.632	.030	Tritomite (altered)	1.65	.000
Dravite	1.632	.019	Cummingtonite	1.650	.028
Bementite	1.632	.030	Iddingsite	1.650	.047
Chalcophyllite	1.632	.057	Friedelite	1.650	.027
Picropharmacolite	1.632	.009	Chloropal	1.65	.03
			Epistolite	1.650	.072

TABLE 3.—*List of minerals arranged according to their intermediate indices of refraction, β, and showing their birefringences*—Continued

	β	Birefringence		β	Birefringence
Camsellite	1.651	0.076	Enstatite	1.669	0.009
Bityite	1.652	.011	Velardeñite	1.669	.011
Tourmaline	1.652	.024	Schorlite (tourmaline)	1.669	.031
Liroconite	1.652	.063	Hardystonite	1.669	.012
Lovchorrite	1.653	.000	Borickite	1.67±	.000
Enstatite (pure)	1.653	.008	Olivine (FeO=11.9 per cent)	1.670	.036
Messelite	1.653	.040	Siderophyllite	1.670	.052
Friedelite	1.653	.030	Lotrite	1.67	.014
Cabrerite	1.654	.07	Hibschite	1.67	.000
Hureaulite	1.654	.013	Iron åkermanite	1.670	.012
Jadeite	1.654	.029	Clinohumite	1.670	.032
Clinoenstatite	1.654	.009	Clinohedrite	1.667	.007
Dioptase	1.654	.053	Titanohydroclinohumite	1.670	.032
Phenacite	1.654	.016	Crossite	1.670	Weak.
Plumbogummite	1.654	.022	Olivine	1.670	.046
Rhabdophanite	1.654	.049	Viridine	1.671	.029
Datolite	1.654	.044	Strigovite	1.67	.02
Manganapatite	1.655	.004	Bromlite	1.671	.146
Koninckite	1.655	.010	Hinsdalite	1.671	.019
Wentzelite	1.655	.011	Diopside	1.671	.030
Wilkeite	1.655	.005	Fillowite	1.672	.004
Eosphorite	1.655	.029	Magnesium chlorophoenicite	1.672	.008
Uranochalcite	1.655	.007	Durangite	1.673	.048
Euclase	1.655	.019	Hornblende	1.673	.022
Palaite	1.656	.008	Spurrite	1.674	.039
Natrochalcite	1.656	.065	Natrophilite	1.674	.013
Chondrodite	1.656	.03	Spodiosite	1.674	.036
Reddingite	1.656	.032	Lawsonite	1.674	.019
Seybertite	1.657	.012	Butlerite	1.674	.127
Velardeñite	1.657	.004	Diopside jadeite	1.674	.022
Baldaufite	1.657	.010	Bustamite	1.674	.014
Hiortdahlite	1.658	.013	Iron anthophyllite	1.675	.022
Annabergite	1.658	.065	Plazolite	1.675	.000
Veszelyite	1.658	.055	Cummingtonite	1.675	.028
Calcite (pure)	1.658	.172	Liskeardite	1.675	.028
Jadeite	1.659	.013	Ludlamite	1.675	.044
Barrandite	1.66	.025	Pyrosmalite	1.675	.039
Hisingerite	1.66	.000	Chloromagnesite	1.675	.085
Plancheite	1.660	.070	Pharmacosiderite	1.676	.000±
Chlorite	1.660	.010	Parisite	1.676±	.081
Eosphorite	1.660	.010	Biotite	1.676	.054
Brandisite	1.660	.012	Akrochordite	1.676	.011
Tilasite	1.660	.035	Witherite	1.676	.148
Xanthophyllite	1.660	.012	Kornerupine	1.676	.012
Stewartite	1.66	.06	Soretite	1.677	.013
Salmonsite	1.66	.015	Hypersthene (10 per cent FeO)	1.678	.010
Triplite	1.660	.022	Iron reddingite	1.678	.031
Fermorite	1.660	Weak.	Childrenite	1.678	.041
Leucosphenite	1.661	.043	Clinohumite	1.678	.033
Erythrite	1.661	.073	Lithiophilite	1.679	.011
Forsterite	1.661	.040	Sincosite	1.680	.025
Cahnite	1.662	.001	Annite	1.68	.06
Monticellite	1.662	.017	Soddyite	1.68	.060
Dickinsonite	1.662	.013	Allanite	1.68±	.000
Lindackerite	1.662	.098	Florencite	1.680±	.005
Seamanite	1.663	.025	Harstigite	1.68	.005
Magnesiohastingsite	1.663	.017	Diopside	1.680	.029
Friedelite	1.664	.035	Olivine	1.681	.037
Ternovskite	1.664	.013	Erythrosiderite	----------	Strong.
Sérandite	1.664	.028	Annabergite	1.68	.05
Homilite	1.665	.02±	Dolomite (pure)	1.68	.18
Triplite	1.665±	.02	Schallerite	1.681	.038
Torendrikite	1.665	.02	Aragonite	1.682	.155
Cummingtonite	1.665	.029	Koettigite	1.683	.055
Auerlite (altered)	1.665	.020	Zinc schefferite	1.683	.029
Hornblende	1.666	.046	Barytocalcite	1.684	.161
Lithiophilite	1.666	.010	Gruenerite	1.684	.036
Spodumene	1.666	.016	Svabite	1.684	.012
Johnstrupite	1.666	.012	Ferroanthophyllite	1.685	.03
Gehlenite	1.666	.005	Thuringite	1.685	.015
Clinohedrite	1.667	.007	Axinite	1.685	.010
Chlorapatite	1.667	.003	Schroeckingerite	1.685	.032
Plumbocalcite	1.667	.177	Roscoelite	1.685	.094
Rinkolite	1.667	.019	Uranopilite	1.68	.03
Boracite	1.667	.011	Schorlite	1.685	.033
Strontianite	1.667	.147	Trichalcite	1.686	.028
Uranophane	1.667	.027	Titanoelpidite	1.686	.017
Symplesite	1.668	.068			
Rinkite	1.668	.016			
Zinkosite	1.669	.012			

TABLE 3.—*List of minerals arranged according to their intermediate indices of refraction, β, and showing their birefringences*—Continued

	β	Birefringence		β	Birefringence
Dumortierite	1.686	0.011	Merwinite	1.711	0.010
Tourmaline	1.687	.046	Hastingsite	1.711	.015
Aegirite-augite	1.687	.029	Gerhardtite	1.713	.019
Riebeckite	1.687	.005	Pigeonite	1.714	.030
Rosenbuschite	1.687	.029	Schoepite	1.714	.045
Urbanite	1.688	.031	Strengite (manganiferous)	1.714	.025
Triphylite	1.688	.004	Brandtite	1.715	.013
Zippeite	1.689	.109	Larnite	1.715	.023
Hypersthene (14 per cent FeO)	1.689	.012	Iddingsite	1.715	.044
Cenosite	1.689	.038	Delvauxite	1.716	.000
Sincosite	1.690	.018	Woehlerite	1.716	.026
Orangite (altered thorite)	1.69	.000	Ankerite	1.716	.190
Chlorophoenicite	1.690	.016	Vesuvianite	1.716	.005
Jeffersonite	1.690	.028	Glaucochroite	1.716	.050
Stilpnomelane	1.69±	.09	Clinozoisite	1.717	.004
Rhodizite	1.69	.00±	Bastnaesite	1.717	.101
Willemite	1.691	.028	Spinel (pure)	1.718	.000
Hornblende	1.691	.026	Ferroschallerite	1.718	.018
Gehlenite	1.691	.000±	Magnesium orthite	1.718	.018
Pigeonite	1.691	.021	Pigeonite	1.719	.024
Femaghastingsite	1.694	.019	Johannsenite	1.719	.028
Pharmacosiderite	1.693	.005	Bromellite	1.719	.014
Kaersutite	1.694	.032	Epidote (12 per cent iron epidote)	1.719	.007
Spangolite	1.694	.053	Ferrohastingsite	1.719	.021
Riebeckite	1.695	Low?	Allanite	1.72±	.000
Basaltic hornblende	1.695	.031	Trimerite	1.720	.010
Tarnowitzite	1.695	.161	Cyanite	1.720	.016
Triphylite	1.695	.005	Phosphuranylite	1.720	.029
Hastingsite	1.695	.025	Spinel	1.720	.000
Kempite	1.695	.014	Clinozoisite	1.720	.010
Barylite	1.696	.014	Adelite	1.721	.019
Gruenerite	1.697	.045	Xenotime	1.721	.095
Euchroite	1.698	.038	Glaucochroite	1.722	.049
Ankerite ($CaCO_3$, 52.6 per cent; $MgCO_3$, 36.7; $FeCO_3$, 10.7	1.698	.185	Diaspore	1.722	.048
Tourmaline	1.698	.040	Chloritoid	1.722	.011
Schefferite	1.699	.031	Tarapacaite	1.722	.044
Neptunite	1.699	.046	Jeffersonite	1.722	.023
Stibiconite	1.70±	.000	Lavenite	1.723	.047
Polycrase	1.70	.000	Pyrochroite	1.723	.042
Kremersite			Rhodonite	1.724	.010
Magnesite (pure)	1.700	.191	Connellite	1.724	.022
Crocidolite	1.700	.006	Basaltic hornblende	1.725	.072
Arrojadite	1.70	.007	Homilite	1.725	.023
Gadolinite	1.70	.022	Rowlandite	1.725	.000
Hainite	1.70	Low.	Phosphosiderite	1.725	.046
Plancheite	1.70	.04	Babingtonite	1.726	.033
Arfvedsonite	1.70	.021	Triploidite	1.726	.005
Ancylite	1.700	.100	Magnesite ($FeCO_3$, 15 per cent)	1.726	.199
Olivine	1.701	.040	Tyrolite	1.726	.036
Tinzenite	1.701	.011	Picrotephroite (Mg_2SiO_4, 40.4; Mn_2SiO_4, 59.6 per cent)	1.727	.029
Hudsonite	1.702	.017			
Arandisite	1.702	.000			
Triphylite	1.702	Moderate.	Hypersthene (25 per cent FeO)	1.728	.016
Hypersthene (FeO, 18 per cent)	1.702	.013	Sarcopside	1.728	.055
Zoisite	1.702	.006	Landesite	1.728	.015
Serendibite	1.703	.005	Ganophyllite	1.729	.025
Astrophyllite	1.703	.055	Clinozoisite	1.729	.010
Zoisite	1.703	.018	Mixite	1.730	.080
Schallerite	1.704	.025	Melanocerite	1.73±	.01
Augite	1.704	.025	Piedmontite	1.73	.02
Pyrope (pure)	1.705	.000	Ottrelite	1.73	.01
Tarbuttite	1.705	.053	Augite (TiO_2, 4.84 per cent)	1.73	.021
Graftonite	1.705	.024	Gruenerite	1.73	.056
Olivine	1.706	.037	Kaersutite	1.730	.068
Svabite	1.706	.008	Babingtonite	1.730	.035
Barkevikite	1.707	.021	Stibiconite (?)	1.73	.01±
Berzeliite	1.707	.000	Jeffersonite	1.731	.028
Pumpellyite	1.707	.018	Ferrohastingsite	1.731	.027
Sapphirine	1.707	.006	Chalcomenite	1.731	.022
Genevite	1.707	.009	Strengite	1.732	.032
Vesuvianite	1.708	.003	Molybdite	1.733±	.215
Diopside hedenbergite	1.708	.024	Hematolite	1.733	.019
Sussexite	1.709	.082	Hydrocyanite	1.733	.015
Uranothorite	1.710	.000	Curtisite	1.734	.51
Strengite	1.71	.035	Grossularite	1.734	.000
Zippeite (?)	1.710	.100			

TABLE 3.—*List of minerals arranged according to their intermediate indices of refraction, β, and showing their birefringences*

	β	Birefringence		β	Birefringence
Gageite	1.734	0.013	Mackintoshite	1.77	0.000
Murmanite	1.735	(?)	Melanocerite (altered)	1.77±	.000
Sicklerite	1.735	.030	Conichalcite	1.77	.041
Roselite	1.735	.01	Becquerellite	1.77	.02
Periclase	1.736	.000	Swedenborgite	1.772	.019
Grossularite (pure)	1.736	.000	Margarosanite	1.773	.078
Renardite	1.736	.024	Scorodite	1.774	.032
Hydrozincite	1.736	.110	Barthite	1.774	.013
Antlerite	1.737	.055	Palmierite	(?)	Strong.
Danalite	1.737	.000	Taramellite	1.774	.06
Thalenite	1.738	.013	Britholite	1.775	.005
Allanite	1.739	.024	Orientite	1.776	.037
Helvite	1.739	.000	Almandite	1.778±	.000
Ardennite	1.740	.021	Conichalcite	1.778	.023
Hedenbergite	1.740	.025	Brochantite	1.778	.073
Pilbarite	1.74±	.000	Allactite	1.779	.019
Caryocerite (altered)	1.74±	.000	Berzeliite	1.779	.000
Molengraaffite	1.74	.035	Stilpnomelane	1.78	.13
Vilateite	1.74	Rather strong.	Alleghanyite	1.780	.036
			Caryinite	1.780	.029
Aurichalcite	1.74	.089	Gadolinite	1.78±	.005
Staurolite	1.741	.010	Dumontite	1.78	Medium.
Pyrope	1.742	.000	Piedmontite	1.782	.082
Scorodite	1.742	.027	Shattuckite	1.782	.063
Hodgkinsonite	1.742	.022	Roepperite	1.786	.046
Epidote	1.742	.028	Lessingite	1.785	----------
Epidote (22 per cent iron epidote)	1.742	.027	Beraunite	1.786	.040
			Mesitite	1.788	.218
Adamite	1.744	.065	Olivenite	1.788	.082
Iddingsite	1.745	.042	Lossenite	1.788	.027
Pyreneite	1.745	.003	Retzian	1.788	.023
Mixite	1.745	.085	Monazite	1.788	.051
Libethenite	1.745	.087	Gahnite	1.790	.000
Freirinite	1.748	.103	Uraconite	1.79	.10
Berzeliite	1.748	.000	Molybdite	1.79±	.26±
Chrysoberyl	1.748	.010	Ardennite	1.79	.020
Ankerite	1.749	.202	Hortonolite	1.792	.035
Rutherfordine	1.75	.08	Tephroite	1.792	.034
Molybdite	1.75±	.21	Palmierite	----------	Strong.
Erythrosiderite	1.75	.08	Thortveitite	1.793	.054
Hoelite	1.75	.030	Sarkinite	1.793	.022
Danalite	1.754	.000	Scorodite	1.793	.028
Pyroxmangite	1.75	Low.	Arseniopleite	1.794	.009
Spinel	1.75±	.000	Barthite	1.795	.035
Daviesite	1.752	.016	Scorodite	1.796	.030
Mcgovernite	1.754	Very weak.	Aegirite	1.799	.050
Lamprophyllite	1.754	.035	Cronstedtite	1.80	Strong.
Caracolite	1.754	.021	Bodenbenderite	----------	.000
Arsenolite	1.754	.000	Thorite	(?)	(?)
Vegasite	1.755	.065	Spessartite (pure)	1.800	.000
Sursassite	1.755	.030	Flinkite	1.801	.050
Joaquinite	1.755	.076	Enigmatite	1.80	.006
Tritomite (altered)	1.757±	.000	Ammoniojarosite	1.80	.05
Benitoite	1.757	.047	Ferritungstite	1.80	.08
Piedmontite	1.757	.040	Glockerite	1.80	.05
Azurite	1.758	.108	Gahnite	1.805±	.000
Yttrialite	1.758	.000	Stibiconite	1.80±	.000
Stilpnomelane	1.76	.13	Hercynite	1.80±	.000
Cordylite	1.760	.183	Almandite	1.801	.000
Rhodolite	1.760	.000	Monazite	1.801	.049
Langite	1.760	.090	Sarkinite	1.807	.016
Cappelenite	(?)	Rather strong.	Acmite	1.807	.053
			Tephroite	1.807	.048
Nagatelite	1.760	.015	Olivenite	1.810	.091
Berzeliite	1.761	.000	Warwickite	1.810	.022
Gummite	1.762	.034	Hancockite	1.81	.042
Dihydrite	1.762	.086	Cornetite	1.81	.05
Dewindtite	1.763	Weak.	Arsenoklasite	1.810	.029
Epidote (57 per cent iron epidote)	1.763	.057	Spessartite	1.811	.000
			Bodenbenderite	(?)	.000
Hessonite	1.763	.000	Gadolinite	1.812	.023
Almandite	1.766	.000	Beckelite	1.812	.000
Corundum	1.768	.008	Spessartite	1.814	.000
Diopside-acmite	1.768	.044	Molybdophyllite	1.815	.054
Calcium larsenite	1.769	.009	Pascoite	1.815	.050
Nordenskiöldine	(?)	Strong.	Acmite	1.816	.060
Pleonaste	1.77±	.000	Borgstroemite	1.816	.088
Aegirite (vanadiferous)	1.770	.037	Jarosite	1.817	.105
Holdenite	1.770	.016	Rhodochrosite (pure)	1.817	.22
Rossite	1.770	.130	Leucochalcite	1.817	.032
Leucophoenicite	1.771	.031	Naegite	1.818	.000
Piedmontite	1.771	.061	Cerite	1.818	.400

TABLE 3.—*List of minerals arranged according to their intermediate indices of refraction, β, and showing their birefringences*—Continued

	β	Birefringence
Becquerite	1.820	0.095
Cornwallite	1.82	.04
Carphosiderite	1.82	.09
Rhodochrosite	1.826	.221
Malacon	1.826	.000
Romeite	1.83	.000±
Almandite	1.830	.000
Iddingsite (?)	1.83	.072
Siderite ($MgCO_3$, 24 per cent)	1.830	.234
Higgensite	1.831	.046
Knebelite	1.831	.047
Natrojarosite	1.832	.082
Chalcosiderite	1.834	.072
Manganfayalite	1.836	.041
Uvarovite	1.838	.000
Linarite	1.838	.050
Lime	1.838	.000
Tagilite	1.84	.16
Scorodite	1.84	Strong.
Rosasite	1.84	.17
Dufrenite	1.840	.055
Lautarite	1.840	.096
Dietzeite	1.842	.032
Siderite ($MnCO_3$, 16 per cent)	1.849	.234
Smithsonite	1.849	.228
Ludwigite	1.85	.17
Magnesioludwigite	1.85	.15
Beaverite	1.85	.04
Romeite	1.850	.003
Toernebohmite	1.852	.033
Hoegbomite	1.853	.050
Siderite	1.855	.242
Sphaerocobaltite	1.855	.25
Andradite	1.857	.000
Purpurite	1.86	.07
Bindheimite	1.86±	.000
Erinite	1.86	.06
Parsonsite	1.86	.01
Atacamite	1.861	.049
Fayalite	1.864	.050
Caledonite	1.866	.091
Romeite	1.87±	.000±
Chalcolamprite	1.87±	.000
Arseniosiderite	1.870	.078
Synadelphite	1.87	.04
Clinoclasite	1.870	.18
Tyuyamunite	1.870±	.225
Siderite (pure)	1.875	.242
Plumbojarosite	1.875	.089
Malachite	1.875	.254
Uvanite	1.879	.240
Hemafibrite	1.88	.06
Tscheffkinite	1.88±	.01
Arseniosiderite	1.88	.08
Chenevixite	1.88	Rather strong.
Argentojarosite	1.882	.097
Anglesite	1.882	.017
Catoptrite	(?)	.000
Dussertite	1.87	.02
Ellsworthite	1.89	.000
Dumontite	1.89	.02
Heterosite	1.89	.05
Andradite (pure)	1.895	.000
Carnotite	1.895	.20
Arseniosiderite	1.898	.083
Ianthinite	1.900	.246
Trippkeite	1.90	.22
Stibiconite	1.9±	.000
Ardennite	1.9±	.015
Titanite	1.907	.134
Schultenite	1.910	.087
Kasolite	1.910	.055
Daubreeite	1.91	.01±
Ilvaite	1.91	Strong.
Ganomalite	1.91	.035
Nasonite	1.913	.010
Hugelite	1.915	.01
Scheelite	1.918	.016
Fourmarierite	1.92	.09
Claudetite	1.92	.14
Tsumebite	1.920	0.071
Purpurite	1.92±	.04±
Betafite	1.92±	.000
Galaxite	1.923	.000
Zircon	1.923±	.045
Microlite	1.925	.000
Carnotite	1.925	.200
Zircon	1.926	.059
Corkite	1.93	Weak.
Tyuyamunite	1.93±	.20
Metarossite		Strong.
Fersmanite	1.930	.053
Nantokite	1.93	.000
Keilhauite	1.935	.115
Zircon	1.936	.055
Samirésite	1.94	.000
Melanite	1.94±	.000
Nasonite	1.945	.026
Hedyphane	1.948	.010
Manganostibiite	1.95	.04
Larsenite	1.950	.040
Catoptrite	1.95	.03
Chapmanite	1.9	.11
Durdenite	1.955	.263
Beudantite	1.96	Weak.
Zircon	1.960	.055
Neotantalite	1.96±	.000
Pyrochlore	1.96	.000
Melanovanadite	1.96	.25
Alamosite	1.961	.021
Hyalotekite	1.963	.003
Tscheffkinite	1.965	.000
Tscheffkinite (altered?)	1.97	.02
Bayldonite	1.97	.04
Dixenite	1.97	Weak.
Schaferzikite		Weak.
Calomel	1.973	.683
Powellite	1.974	.010
Walpurgite	1.975	.134
Diaboleite	1.98	
Hatchettolite	1.98	.000
Schorlomite	1.98	.000
Uranosphaerite	1.985	.10
Lanarkite	1.99	.09
Agricolite	1.99	Very low.
Stibiconite	1.99±	.000
Cassiterite	1.997	.096
Bindheimite (?)	2.0	Strong.
Wiikite	2.00	.000
Ardennite	2.0±	.015
Pyrochlore	2.00	.000
Leadhillite	2.00	.14
Walpurgite	2.00	.15
Graphite	2.00	
Lorenzenite	2.01	.12
Armangite	2.01	.02
Turanite	2.01	.02
Hydrocyanite		
Dolerophanite		
Ivaarite	2.01±	.000
Volborthite	2.01	.02
Bismite	2.01	.19
Zincite	2.013	.016
Calciosamarskite	2.015	.000
Hedyphane	2.026	.016
Mendeleyeevite	(?)	.000
Cumengeite	2.026	.061
Voltzite	2.03	Rather strong.
Pseudoboléite	2.03	.03
Kalovrotite	2.04	.09
Sulphur	2.037	.288
Uzbekite	2.04	.06
Percylite	2.05	.000
Picotite	2.05±	.000
Risorite	2.05±	.000
Boléite	2.05	.02
Fernandinite	2.05	Strong.
Eulytite	2.05	Very low.
Pyromorphite	2.050	.008
Calciovolborthite	2.05	.09

TABLE 3.—*List of minerals arranged according to their intermediate indices of refraction, β, and showing their birefringences*—Continued

	β	Birefringence
Pinakiolite	2.05	.157
Carminite	2.05	0.01
Loranskite	2.06	.000
Sipylite	2.06±	.000
Limonite	2.06±	.000
Euxenite	2.06±	.000
Duftite	2.06	.05
Cerargyrite	2.061	.000
Mosesite	2.065	.000
Chromite	2.07	.000
Barysilite	2.07	.02
Cerusite	2.076	2.74
Carnotite	2.08	.02
Senarmontite	2.087	.000±
Schneebergite	2.09	.000±
Hydrocerusite	2.09	.15
Emmonsite	2.09±	.15
Montanite	2.09±	.01
Calciosamarskite	2.095	.000
Clarkeite	2.098	.111
Trigonite	2.10	.05
Ramsayite	2.10	Weak.
Rhagite	2.10	Strong.
Metahewettite	2.10	.53
Fiedlerite	2.102	.310
Curite	2.11	.09
Phosgenite	2.114	.026
Fergusonite	2.115±	.000
Laurionite	2.116	.081
Ampangabéite	2.12	.000
Yttrocrasite	2.13±	.000
Penfieldite	2.13	.08
Bismutosphaerite	2.13	.19
Mimetite	2.135	.017
Oldhamite	2.137	.000
Blomstrandine	2.142	.000
Yttrotantalite	2.15	.000
Koppite	2.15±	.000
Embolite	2.15±	.000
Matlockite	2.15	.11
Cuprotungstite	2.15	Strong.
Goethite (impure)	2.15±	.07
Atelestite	2.15	.04
Bismutite	2.16±	.05±
Chromite	2.16±	.000
Bellite	2.16	.02
Manganosite	2.16	.000
Georgiadesite	2.17	.01
Melanotekite	2.17	.19
Fergusonite	2.175±	.000
Euxenite	2.175	.000
Kleinite (biaxial)	2.18	.02
Bunsenite	2.18_{red}	.000
Eschwegeite	2.18	.000
Uhligite	(?)	.000
Hewettite	2.18	.58
Tellurite	2.18_{Li}	.35
Iodyrite	2.182	.01
Lyndochite	2.19	.000
Zirkelite	2.19	.000
Kleinite (hexagonal)	2.19	.02
Baddeleyite	2.19	.07
Fergusonite	2.19±	.000
Euxenite	2.195±	.000
Miersite	2.20	.000
Oldhamite	----------	.000
Lewisite	2.20	.000
Bismutite	2.20±	.000
Thorianite	2.20±	.000
Iodobromite	2.20	.000
Kentrolite	2.20	.21
Tripuhyite	2.20	.14
Lepidocrocite	2.200	.57
Phoenicochroite	(?)	(?)
Eschynite	2.205	.000
Weslienite	2.21	.000±
Samarskite	2.21±	.000
Iodyrite	2.21	.01
Polymignite	2.215	.000
Cotunnite	2.217	.060
Huebnerite	2.22	.15
Vauquelinite	2.22	.11
Fervanite	2.222	.038
Goethite	2.22	0.08
Euxenite	2.24±	.000
Manganite	2.24_{Li}	.29
Thorotungstite	(?)	Strong.
Chloroxiphite	2.24	.09
Polycrase	2.248	.000
Tungstite	2.24	.17
Endlichite	2.25	.05
Samarskite	2.25±	.000
Bromyrite	2.253	.000
Manganotantalite	2.25	.07
Tantalite	2.25	.15
Descloizite	2.26	.17
Cuprodescloizite	2.26	.15
Hetaerolite	2.26	.16
Eschynite	2.26±	.00
Bismutite	2.26±	.05
Stolzite	2.269	.087
Tapiolite	2.27_{Li}	.15
Raspite	2.27	.03
Mendipite	2.27	.07
Descloizite	2.27	.17
Pyrobelonite	(?)	(?)
Goethite	2.29	.14
Manganotantalite	2.29	.08
Haematophanite	(?)	(?)
Finnemanite	2.295	.010
Monimolite	(?)	.000
Knopite	2.30	.000
Brannerite	2.30	.000
Hielmite	2.30_{Li}	.10
Plattnerite	2.3_{Li}±	(?)
Cuprodescloizite	2.31_{Li}	.12
Geikielite	2.31	.36
Tantalite	2.32	.17
Ecdemite	2.32_{Li}	.07
Wolframite	2.32_{Li}	.16
Ochrolite	(?)	(?)
Dysanalite	2.33	Weak.
Ochrolite	2.34_{Li}	.06
Hetaerolite	2.34±	.20
Marshite	2.346	.000
Goethite	2.35_{Li}	.14
Schwartzembergite	2.35	.11
Valentinite	2.35	.17
Magnesioferrite	2.35_{Li}	.000
Nadorite	2.35_{Li}	.10
Lorettoite	2.35_{Li}	.02
Vanadinite	2.354	.055
Wurtzite	2.33_{Li}	.02
	2.356_{Na}	.022
Loparite	2.36	.000
Manganoplumbite	----------	----------
Kalkowskyn	----------	Weak.
Pyrobelonite	2.36	.15
Franklinite	2.36_{Li}±	.000
Schwartzembergite	2.36_{Li}	.11
Långbanite	2.36_{Li}	.05
Wolframite	2.36_{Li}	.15
Brackebuschite	2.36_{Li}	.20
Sphalerite (pure)	2.34_{Li}	.00
	2.37_{Na}	.00
Crocoite	2.37_{Li}	.35
Perofskite	2.38	Weak.
Pseudobrookite	2.39_{Li}	.04
Trevorite	(?)	.000
Ferberite	2.40_{Li}	Strong.
Ferrocolumbite	2.40_{Li}	Extreme.
Wulfenite	2.402_{Li}	.12
Stibiotantalite	2.404	.083
Stibiocolumbite	2.419	.061
Diamond	2.419	.000
Minium	2.42_{Li}	Weak.
Greenockite	2.431_{Li}	.025
	2.506_{Na}	.023
Columbite	2.45_{Li}	Strong.
Derbylite	2.45_{Li}	.06
Hausmannite	2.46_{Li}	.31
Magnetoplumbite	(?)	(?)
Quenselite	(?)	(?)

TABLE 3.—*List of minerals arranged according to their intermediate indices of refraction, β, and showing their birefringences*—Continued

	β	Birefringence		β	Birefringence
Kalkowskyn	(?)	(?)	Orpiment	2.81_{Li}	.6±
Sphalerite (FeS, 28 per cent)	2.47_{Na}	0.000	Cinnabar	2.819_{Li} 2.857_{Na}	0.327 .347
Pyrophanite	2.481	.271	Cuprite	2.849	.000
Eglestonite	2.49_{Li}	.000	Proustite	2.979_{Li}	.268
Strueverite	2.50_{Li}	Moderate.	Xanthoconite	3.	Extreme.
Senaite	2.50_{Li}	Low.	Livingstonite	3.	Extreme.
Montroydite	2.5_{Li}	.28	Polybasite	3.	Very strong.
Pucherite	2.50_{Li}	.10	Hematite	3.01_{Li}	.28
Anatase	2.554	.061	Pyrargyrite	3.084	.203
Smithite	2.58_{Li}	.12	Hutchinsonite	3.176_{Na}	.110
Brookite	2.586	.158	Hematite	3.22_{Li}	.28
Realgar	2.59_{Li}	.15	Smithite	3.27?	Very strong.
Trechmannite	2.6_{Li}	Extreme.	Stibnite	4.303	1.109
Koechlinite	2.61_{Li}	.15	Tetrahedrite	>2.72$_{Li}$	.000
Massicot	2.61_{Li}	.20	Tennantite	>2.72$_{Li}$	.000
Rutile	2.616	.287	Chalcophanite	>2.72$_{Li}$	Extreme.
Arizonite	2.62_{Li}	Moderate.	Vrbaite	>2.73$_{Li}$	Very strong.
Tenorite	2.63_{red}	Strong.	Kermesite	>2.72$_{Li}$	Extreme.
Moissanite	2.633_{Li} 2.654_{Na}	.040 .043	Miargyrite	>2.72$_{Li}$	Very strong.
Terlinguaite	2.64_{Li}	.32	Lorandite	>2.72$_{Li}$	Extreme.
Litharge	2.665_{Li}	.130	Dufrenoysite	>2.72$_{Li}$	Very strong.
Hauerite	2.69_{Li}	.000	Ilmenite	>2.72$_{Li}$	Very strong.
Alabandite	2.70_{Li}	.000	Sartorite	Very high.	(?)
Coccinite	2.75	.30	Pyrostilpnite	Very high.	(?)
			Frieseite	Very high.	(?)

Abbreviations used in Table 4

abs—absorption.
acic—acicular.
amor—amorphous.
anom—anomalous.
B—birefringence.
b. b—before the blowpipe.
biax—biaxial.
cleav—cleavage.
conct—concentrated.
conch—conchoidal.
decpd—decomposed.
dif—difficult; difficultly.
disp—dispersion.
dist—distinct.
dodec—dodecahedral.
elong—elongation.
ext—extinction.
extr—extreme.
F—fusibility.
fib—fibers; fibrous.
fus—fusible.
G—specific gravity.
gelat—gelatinous; gelatinize.
H—hardness.
hex—hexagonal.
imperf—imperfect.
incl—inclined.
indist—indistinct.
infus—infusible.
insol—insoluble.
isomet—isometric.
isomor—isomorphous.
isot—isotropic.
mic—micaceous.
mkd—marked.
mod—moderate.
mon—monoclinic.
oct—octahedral.
opt—optically.
orth—orthorhombic.
penet—penetration.
perf—perfect.
perc—perceptible.
pl—plane.
pleoc—pleochroism; pleochroic.
poly—polysynthetic.
pris—prismatic.
ps—pseudo.
pyram—pyramidal.
rect—rectangular.
rhomboh—rhombohedral.
sol—soluble.
sq—square.
tab—tabular.
tetrag—tetragonal.
tetrah—tetrahedrons.
tr—trace.
tric—triclinic.
trig—trigonal.
tw—twinning.
uniax—uniaxial.

The first column in Table 4 shows the extent and nature of the variability of the values for the minerals given. The symbol $\wedge$ means that an entry has been made of the same mineral or one of an isomorphous series of which this mineral is a member, having a lower mean index of refraction. The symbol $\vee$ indicates that an entry has been made of the mineral, or a related isomorphous member of the series, for which the mean index of refraction is greater. The symbol $\diamondsuit$ denotes a variability in both directions according to the above method. The symbol $\sqcup$ indicates the probable variability of a mineral entered in the tables, although no other entry has been made. The probable variability in the other direction is indicated by the symbol $\sqcap$, and the double variability by the symbol $\square$. The combination symbol $\underset{\vee}{\sqcap}$ indicates the entry of a mineral or isomorphous member of the series of higher index of refraction and the probable variability toward a mineral of lower index of refraction. The combination symbol $\overset{\wedge}{\sqcup}$ indicates the entry of a mineral of lower index of refraction and the probable variability toward a mineral of higher index of refraction.

TABLE 4.—*Data for the determination of the nonopaque minerals*

Isotropic group

[Most of the minerals of this group are isometric; a considerable number are amorphous and therefore rather variable and indefinite in their chemical composition and all their properties; a few, which are included also in the proper birefracting group, are birefracting, but their birefringence is so weak or uncertain as to make them easily mistaken for isotropic minerals]

Variability	n	Mineral name and composition	Crystal system and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.328	Villiaumite NaF	Tetrag. Ps. isomet. Massive.	{001} perf. {100} {010} dist.	Carmine-red	H=3.5 G=2.79	Sol. in H_2O. Very weak B. Uniax. −. Pleoc.: ω=carmine-red, ϵ=golden yellow.
	1.333	Water H_2O	Fluid		Colorless	G=1.00	
	1.339	Hieratite $2KF.SiF_4$	Isomet. Cubo-oct.		Gray	G=2.75	Sol. in hot H_2O.
	1.339	Cryolithionite $3NaF.3LiF.2AlF_3$	Isomet	{110} dist	do	H=2.5–3 G=2.78 F=easy	Sol. in acid.
	1.370	Cryptohalite $2NH_4F.SiF_4$(?)	Isomet. Cubo-oct.	{111} very perf		G=2.0	
⊏	1.403	Termierite $Al_2O_3.6SiO_2.18\pm H_2O$(?)	Claylike	None	White, etc	H=2 G=1.21(?) F=dif.	Slowly decpd. by HCl. Anom. B due to tension.
V	1.406±	Opal $SiO_2.nH_2O$	Amor	Conch	Varies	H=6± G=1.9–2.3	Insol. in acid; sol. in KOH.
	1.427	Ralstonite $(Na_2,Mg)F_2.3Al(F,OH)_3.2H_2O$	Oct	None	Colorless, white, yellowish.	H=4.5 G=2.61 Infus.	Decpd. by H_2SO_4. Opt. anom. Divides into birefracting octahedral segments.
^ V	1.434	Opal $SiO_2.nH_2O$	Amor		Colorless	G=1.86	12.6 per cent H_2O. In geyserite.
	1.434	Yttrocerite $(Y,Er,Ce)F_3.5CaF_2.H_2O$	Cubes	{111} perf	Violet, blue, etc.	H=4–5 G=3.36–3.63 Infus.	Sol. in acid.
	1.434	Fluorite CaF_2	do	do	Colorless, purple, etc.	H=4 G=3.18 F=1.5	Do.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Isotropic group—Continued

Variability	n	Mineral name and composition	Crystal system and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.44±	Opal $SiO_2.nH_2O$	Amor	Conch	Varies	H=6± G=2.1± Infus.	Sol. in KOH; insol. in acid.
⊓ v	1.44±	Hisingerite Fe_2O_3, MgO, FeO, SiO_2, H_2O, etc.	do	do	Brownish black	H=3.5 G=2.5 Infus.	Decpd. by acid. Opallike. In part finely crystalline.
	1.454	Sulphohalite $2Na_2O.2SO_3.NaCl.NaF$	Dodec	None	Colorless	H=3.5 G=2.49 F=1	Slowly sol. in H_2O.
	1.456	Alum $K_2O.Al_2O_3.4SO_3.24H_2O$	Oct	do	do	H=2 G=1.76 F=1	Potash alum. Sol. in H_2O.
	1.457±	Yttrofluorite $(Ca_3, Y_2)F_8$	Isomet	{111} imperf	Yellowish	H=4.5 G=3.55	Sol. in acid. Fus.
	1.459	Tschermigite $(NH_4)_2O.Al_2O_3.4SO_3.24H_2O$	Oct	None	White	H=2 G=1.64 F=1	Alum group. Sol. in H_2O. Opt. anom.
^	1.46	Opal $SiO_2.nH_2O$	Amor	Conch	Varies	H=6± G=2.2± Infus.	Sol. in KOH; insol. in acid.
	1.461	Melanophlogite Contains SiO_2, SO_3, and H_2O	Cubes		Colorless	H=6.5–7 G=2.04 Infus.	Insol. in acid.
⊓	1.462	Lechatelierite SiO_2	Amor		do		Natural fused quartz from fulgurite with SiO_2=99.0 per cent.
⊓ v	1.47±	Neotocite $MnO.SiO_2.nH_2O$	do	Conch	Brown to black	H=4 G=2.6 F=dif.	Decpd. by acid.
⊓ v	1.47±	Allophane Al_2O_3, SiO_2, nH_2O	do	Hyalinelike	Blue-green, etc.	H=3 G=1.8± Infus.	Gelat. Amorphous colloidal solid solution of Al_2O_3, SiO_2, H_2O, and occasionally of P_2O_5, with indefinite chemical composition.

⊏⊐	1.48	Faujasite $Na_2O.CaO.2Al_2O_3.10SiO_2.20H_2O$	Oct	{111} dist	White	H=5 G=1.92 F=3	Zeolite group. Decpd. by acid. Uniax. + in eight segments from loss of H_2O.
V	1.483	Sodalite $3Na_2O.3Al_2O_3.6SiO_2.2NaCl$	Dodec	{110} poor	Gray, blue, etc.	H=6 G=2.30 F=3.5–4.0	Sodalite group. Gelat. Cl=7.12, H_2O= 2.46 per cent.
⊏⊐	1.485	Evansite $3Al_2O_3.P_2O_5.18\pm H_2O$	Amor. Concretions.		Colorless	H=4 G=1.94 Infus.	Sol. only in hot H_2SO_4.
	1.486	Cristobalite SiO_2	Ps.isomet. Oct.		White	H=6–7 G=2.3 Infus.	Insol. in acid. B=0.005. Intricate tw.
	1.487	Analcite $Na_2O.Al_2O_3.4SiO_2.2H_2O$	{211}	{100} tr	Colorless	H=5 G=2.25 F=3.5	Zeolite group. Decpd. by acid. Opt. anom.
^V	1.487	Hackmanite $3\ Na_2O.3Al_2O_3.6SiO_2.2NaCl$ Some S replaces Cl_2	Dodec	{110} poor	Reddish violet, fading on exposure.	H=5 G=3.32(?) F=4	Sodalite group. Near sodalite. Gelat.
^⊐	1.49	Allophane Al_2O_3,SiO_2,nH_2O	do	Hyalinelike	Blue, green, etc.	H=3 G=1.86 Infus.	Gelat.
	1.490	Sylvite KCl	Plagihedral	Cubic perf	Colorless	H=2 G=1.99 F=1.5	Sol. in H_2O. Tastes bitter.
	1.495	Noselite $5Na_2O.3Al_2O_3.6SiO_2.2SO_3$	Dodec	{110} poor	Blue, etc.	H=6 G=2.3± F=4.5	Sodalite group. Gelat.
^V	1.496	Haüynite $5(Na_2,Ca)O.3Al_2O_3.6SiO_2.2SO_3$	do	do	do	H=6 G=2.4	Do.
⊏⊐	1.496	Bolivarite $2Al_2O_3.P_2O_5.4H_2O$	Amor		Apple-green; white powder.	Medium hardness	
^	1.50±	Lazurite $3Na_2O.3Al_2O_3.6SiO_2.2Na_2S$	Dodec	{110} poor	Azure blue	H=6 G=2.4 F=3.5	Sodalite group. Gelat.
⊏⊐	1.50±	Stevensite $3MgO.4SiO_2.nH_2O$	Amor				
⊏⊐	1.5±	Rosiérésite Hydrous phosphate of Al, Pb, and Cu	Amor. Compact, stalactitic.		Yellow	G=2.2 Infus.	Near evansite. Easily sol. in HNO_3. Blackens b. b.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Isotropic group—Continued

Variability	n	Mineral name and composition	Crystal system and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
□	*1.505	Vashegyite $3Al_2O_3.2P_2O_5.18\pm H_2O$ (about)	Amor		White, yellowish, green.	H=3.5 G=1.98 Infus.	Sol. in acid.
	1.508	Tychite $2MgO.3Na_2O.4CO_2.SO_3$	Oct	None	Colorless	H=3.5 G=2.46–2.59 F=1	Compare with northupite. Almost insol. in H_2O; sol. in acids.
	1.509	Leucite $K_2O.Al_2O_3.4SiO_2$	Ps.isomet.{211}	Imperf	do	H=5.5 G=2.47 Infus.	Decpd. by acid. Birefracting below 500° C. Twin lamellae. Symmetrical inclusions.
□	1.51	Cimolite $2Al_2O_3.9SiO_2.6H_2O$	Amor	Clay	White, etc	H=soft	
<>	1.51±	Hisingerite Fe_2O_3,MgO,FeO,SiO_2,H_2O,etc.	do	Conch	Black or brownish black.	H=3 G=2.5–3 Infus.	Decpd. by acids. Opallike. In part finely crystalline.
	1.514	Northupite $MgO.Na_2O.2CO_2.NaCl$	Oct	None	Colorless	H=4 G=2.38 F=1	Slightly sol. in H_2O; sol. in acid. Tw. common.
□	1.517	Planerite $3Al_2O_3.2P_2O_5.18\pm H_2O$	Amor	do	Green	H=1.5–5 G=2.65	Slightly sol. in acid. B. b. decrepitates. In part birefracting.
	1.517	Meerschaum $2MgO.3SiO_2.nH_2O$(?)	do	do	White	Soft	Amorphous part of sepiolite.
V	1.518	Pollucite $2Cs_2O.2Al_2O_3.9SiO_2.H_2O$	Isomet		Colorless	H=6.5 F=dif.	Decpd. by acid. From Buckfield, Me.
^	1.525	Pollucite $2Cs_2O.2Al_2O_3.9SiO_2.H_2O$	do		do	H=6.5 G=2.90 F=dif.	Decpd. by acid.
□	1.53±	Kehoeite $3(Zn,Ca)O.2Al_2O_3.P_2O_5.27\pm H_2O$	Amor., chalky		White	G=2.34 Infus.	Sol. in acid.

V	1.533	Langbeinite $K_2O.2MgO.3SO_3$	Highly modified tetrah.		Colorless	H=3-4 G=2.83 F=2	Slowly sol. in H_2O. Absorbs H_2O in air.
	1.535±	Succinite Hydrocarbon	Amor	Conch	Amber-yellow, vitreous luster.	Soft G=1.07 F=easy	Amber.
^ □	1.54±	Neotocite $MnO.SiO_2.nH_2O$	do	do	Brown to black	H=4 G=2.7 F=dif.	Decpd. by acid.
□ □	1.54±	Cornuite $mCuO.nSiO_2.H_2O$	do	None	Bluish green		Isot. chrysocolla.
	1.541_{Na}	Ajkaite A fossil resin	do		Pale yellow to red-brown.	H=2.5 G=1.05	C=80, H=10, O=9, S=1.0 per cent. Upon heating gives off H_2S. Melts to honey-like liquid, burns with sooty flame. Sol. in cajeput oil. Weakly birefracting.
	1.542	Telegdite Hydrocarbon	do			H=2.5 G=1.09	A resin. C=76.93, H=10.17, O=11.17, S=1.73 per cent. Part sol. in alcohol.
□ V	1.542±	Halloysite $Al_2O_3.2SiO_2.nH_2O$	do		White	H=2 G=2.6 Infus.	Insol. in acid. On drying at about 60° C. n increases to 1.555.
	1.544	Halite NaCl	Cubes	Cubic perf	Colorless	H=2.5 G=2.17 F=1.5	Sol. in H_2O.
^	1.555	Halloysite $Al_2O_3.2SiO_2.2H_2O$	Amor. powder		White	H=2 G=2.6 Infus.	Insol. in acid.
		Scacchite $MnCl_2$	Cubic				Deliquescent.
□ □	1.558	Serpentine, nickeliferous	Amor			Soft	Analysis: SiO_2 39.36, MgO 36.71, Al_2O_3 2.76, NiO 2.57, Fe_2O_3 2.77, H_2O+ 13.85, CaO 1.32, H_2O- 1.54 per cent.
□ □	1.565	Traversoite $2(Cu,Ca)O.Al_2O_3.2SiO_2.12H_2O$	do		Light blue		
V	1.569	Collophanite CaO,P_2O_5,H_2O,CO_2, etc.	do		White	H=3.5 G=2.6± F=5(?)	Sol. in acid.
□ V	1.57±	Zaratite $3NiO.CO_2.nH_2O(?)$	do	Conch	Emerald-green	H=3 G=2.6	Banded. n varies from 1.56 to 1.61.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Isotropic group—Continued

Variability	n	Mineral name and composition	Crystal system and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.57±	Hisingerite $Fe_2O_3,MgO,FeO,SiO_2,H_2O$,etc.	Amor	Conch	Brownish black	H=3.5 G=2.5–3 Infus.	Decpd. by acid. Opallike. In part finely crystalline.
	1.572	Nitrobarite $BaO.N_2O_5$	Isomet. Oct		Colorless	G=3.25(?) F=1	Sol. in H_2O.
^	1.572	Manganolangbeinite $2MnO.K_2O.3SO_3$	Isomet		Rose-red	G=3.02	
v	*1.58±	Koninckite $Fe_2O_3.P_2O_5.6±H_2O$	Amor.(?)		Yellow	H=3.5 G=2–3 F=3	Sol.in strong acid. Richelle.
□	1.584	Schroetterite $8Al_2O_3.3SiO_2.30±H_2O$	Amor		White	H=3–3.5 G=1.95–2.05	Uncertain clay mineral.
^ v	1.59±	Hisingerite $Fe_2O_3,MgO,FeO,SiO_2,H_2O$,etc.	do	Conch	Black or brownish black.	H=3 G=3 Infus.	Decpd. by acid. Opallike. In part finely crystalline.
^ v	1.59±	Zaratite $3NiO.CO_2+nH_2O$(?)	do	do	Emerald-green	H=3 G=2.6±	n varies from 1.56 to 1.61.
^ v	1.59±	Collophanite CaO,P_2O_5,CO_2,H_2O,etc.	do		White, etc	H=3–5 G=2.7± F=5(?)	Easily sol. in acid.
□	1.59	Garnierite $(Ni,Mg)O.SiO_2.nH_2O$	Submicroscopic		Bright green	H=2± G=2.6± Infus.	A serpentine. Decpd. by HCl.
	1.590	Kochite $2Al_2O_3.3SiO_2.5H_2O$	Isomet. Minute cubes and oct.			G=2.93	Water given off at about 750°.
v	1.596	Zunyite $Al_2O_3.SiO_2.Al(OH,F,Cl)_3$	Tetrah	{111}	Colorless	H=7 G=2.88 Infus.	Insol. in acid.

	1.60±	Stibiconite $Sb_2O_4.nH_2O$(?)	Amor	Conch	Gray, yellow, colorless.	H=4–5 G=5± Infus.	Insol. in acid. n highly variable.
	1.60±	Borickite $3CaO.7Fe_2O_3.2P_2O_5.24\pm H_2O$(?)	do	do	Reddish brown	H=3.5 G=2.7± F=3–4	Sol. in acid. n varies from 1.57 to 1.67.
	1.600	Zunyite $Al_2O_3.SiO_2.Al(OH,F,Cl)_3$	Tetrah	{111}	Colorless	H=7 G=2.88	OH:F:Cl=50:1:4. n_{Li}=1.597. n_{Tl}=1.603.
	1.602	Voltaite $5(Mg,Fe,K_2)O.2(Al,Fe)_2O_3.10SO_3.15H_2O$	Oct., etc	None	Dull oil-green, brown, black.	H=3–4 G=2.79	Partly sol. in H_2O; sol. in acid. In section oil-green. Tetragonal?
	1.605	Grodnolite $8CaO.2P_2O_5.CO_2.H_2O + \frac{1}{4}H_4Al_2Si_2O_9$			Brownish	H=5 G=2.97	Member of collophanite group?
	1.61±	Zaratite $3NiO.CO_2.nH_2O$(?)	Amor	Conch	Emerald-green	H=3 G=2.6±	n varies from 1.56 to 1.61. Some specimens weakly birefringent.
	1.61±	Diadochite $2Fe_2O_3.P_2O_5.2SO_3.2H_2O$	do		Brown, yellow	H=3 G=2.03± F=easy	Sol. in HCl.
	1.61	Allanite $4(Ca,Fe)O.3(Al,Ce,Fe,Di)_2O_3.6SiO_2.H_2O$	Ps. mon.(?)	Imperf	Brown, black	H=6 G=2.96 F=3	Epidote group. Alters to a brown birefracting form. May gelatinize.
	1.63±	Collophanite CaO,P_2O_5,H_2O,CO_2, etc.	Amor		White	H=3–5 G=2.9± F=5 (?)	Sol. in HCl.
	1.635±	Pitticite $Fe_2O_3,SO_3,As_2O_5,H_2O$, etc.	do		Brown, yellowish, white.	H=2–3 G=2.5 F=easy	Do.
	1.638	Hydrothorite $ThSiO_4.4H_2O$			Pale pinkish buff	H=1–2	Attacked by warm acids. Radioactive.
	1.639	Sal ammoniac NH_4Cl	Isomet	{111}imperf	Colorless	H=1.5–2 G=1.53 F=1	Sol. in H_2O. Volatile.
	1.64	Picite $3Fe_2O_3.2P_2O_5.10H_2O$	Amor. concretions		Dark brown	H=3–4 G=2.83	
	1.64±	Griphite MnO,P_2O_5,H_2O, with Fe, Al, Ca, etc.	Amor., resinous	Conch	Brown	H=5.5 G=3.4 F=easy	Sol. in HCl.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Isotropic group—Continued

Variability	n	Mineral name and composition	Crystal system and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
□	1.640	Homilite (altered) $3(Ca,Fe)O.B_2O_3.2SiO_2.nH_2O$(?)	Ps. mon.{Tab.001}	Conch	Black	H=5 G=3.35	
^ □	1.65±	Koninckite $Fe_2O_3.P_2O_5.6\pm H_2O$	Amor. (?)		Yellow	H=3.5 G=2–3 F=3	Sol. in strong acid.
□	1.65	Egueiite $6Fe_2O_3.CaO.5\frac{1}{2}P_2O_5.23\pm H_2O$	Amor		Yellow-brown	G=2.66 F=1	Sol. in acid.
□ v	*1.65±	Tritomite (altered) Silicate of Th, Ce, Y, Ca, etc., containing F and B	Ps. trig	Indist	Dark brown	H=5.5 G=4.2	Gelat. Långban.
□	1.65	Greenalite $FeO.SiO_2.nH_2O$	Amor		Green, yellow, brown.	G=2.8	Sol. in HCl.
	1.653	Lovchorrite $SiO_2,TiO_2,ZrO_2,Fe_2O_3,MnO,MgO,CaO$	do	Conch	Brown	H=5 G=3.32	Colloidal variety of rinkolite. Fusible. Soluble in acid. In part anisotropic.
^ □	1.66±	Hisingerite $Fe_2O_3,MgO,FeO,SiO_2,H_2O$, etc.	do	None	Brown to black	H=3 G=3 F=dif.	Decpd. by acid. Opallike. In part finely crystalline.
^ □	1.67±	Borickite $3CaO.7Fe_2O_3.2P_2O_5.24\pm H_2O$	do	Conch	Reddish brown	H=3.5 G=2.7± F=3–4	Sol. in acid. n varies from 1.57 to 1.67.
	1.67	Hibschite $CaO.Al_2O_3.2SiO_2.2H_2O$	Oct		Colorless	H=6 G=3.05 Infus.	Sol. in acid. Some crystals B and divided into sectors.
	1.675	Plazolite $3CaO.Al_2O_3.2(SiO_2,CO_2).2H_2O$	Rhombic dodec	None	do	H=6.5 G=3.13	
	1.676	Pharmacosiderite $3Fe_2O_3.2As_2O_5.3(H,K)_2O.5H_2O$	Cubes and tetrah	{100}imperf	Brown, green, etc.	H=2.5 G=3.0 F=1	Sol. in HCl. Anom. B.

^ v	1.68±	Allanite $4(Ca,Fe)O.3(Al,Ce,Fe,Di)_2O_3.6SiO_2.H_2O$	Ps. mon.(?)	Imperf.	Brown, black	H=6 G=3.4 F=3	Epidote group. Alters to a brown, birefracting form. May gelat.
	1.69	Rhodizite $4(H,Na,K,Cs,Rb)_2O.4BeO.3Al_2O_3.6B_2O_3$	Oct., etc.		Colorless	H=8 G=3.40 Infus.	Insol. in acid. Opt. anom.
□	1.69	Orangite (altered thorite) $ThO_2.SiO_2.nH_2O$	Ps. tetrag. Sq. pyramids.	{110}dist.	Black, brown, green, orange.	H=4.5–5 G=5.2–5.4 Infus.	Gelat. Isot. from alteration or inversion.
^ v	1.70±	Stibiconite $Sb_2O_4.nH_2O(?)$	Amor.	Conch.	Gray, etc.	H=4–5 G=5.00 Infus.	Insol. in acid. *n* highly variable.
□ v	1.70	Polycrase Columbate and titanate of Y, U, Th, Fe, etc.	Ps. orth. Thin pris. c. Tab.{010}	do.	Dark brown to black.	H=5–6 G=5.00 Infus.	Blomstrandine group. Decpd. by H_2SO_4.
	1.702	Arandisite $5SnO_2.3SiO_2.4H_2O$	Fib.		Apple-green	H=5 G=4.12	In part weakly birefringent; index varies.
v	1.705	Pyrope $3MgO.Al_2O_3.3SiO_2$	Isomet. {110}{211} etc.	None	Red	H=7 G=3.510 F=3.5	Garnet group. Data for pure mineral. Insol. in acid.
□ v	1.707	Berzeliite $3CaO.3(Mg,Mn)O.2As_2O_5$	Isomet.		Yellow to orange-yellow.	H=5 G=3.95 F=3	Sol. in acid. MnO=1.26 per cent.
□ □	1.710	Uranothorite ThO_2,SiO_2,UO_2,CaO, etc.				H=4.5–5 G=4.414	
□ □	1.716±	Delvauxite $2Fe_2O_3.P_2O_5.9H_2O$	Amor. concretions.		Brown	H=2.5 G=1.99(?)	Sol. in acid.
v	1.718	Spinel $MgO.Al_2O_3$	Oct.	{111}imperf.	Red, etc.	H=8 G=3.6± Infus.	Spinel group. Insol. in acid. Tw. after {111}. *n* is for the pure artificial mineral.
^ v	1.720	Spinel $(Mn,Fe,Na_2,K_2)O.(Al,Fe)_2O_3$	Isomet.	Imperf.	Dark green	H=8 G=3.683	Spinel group. Analysis: SiO_2 0.94, MgO 24.76, Al_2O_3 57.80, CaO 0.84, Fe_2O_3 3.04, Na_2O 1.38, FeO 9.62, K_2O 1.31, total 99.69 per cent.
^	1.72±	Allanite $4(Ca,Fe)O.3(Al,Ce,Fe,Di)_2O_3.6SiO_2.H_2O$	Ps. mon.(?)	do.	Brown, black	H=6 G=3.5–4.2 F=3	Epidote group. Alters to a brown, birefracting form. May gelat.
	1.725	Rowlandite $2Y_2O_3.3SiO_2$		Conch.	Drab-green to red.	H=6–7 G=4.52 Infus.	Near gadolinite. Gelat. Pale green in splinters.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Isotropic group—Continued

Variability	n	Mineral name and composition	Crystal system and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.735	Grossularite $3CaO.Al_2O_3.3SiO_2$	Isomet. {110}, {211}, etc.	None	Varies	H=6 G=3.530 F=3	Garnet group. Insol. in acid. Opt. anom. Data for pure mineral.
	1.736	Periclase MgO	Isomet. Cubes, oct.	{100} perf., {111} poor.	Colorless	H=5 G=3.6 Infus.	Sol. in acid.
	1.739	Helvite $3(Mn,Fe)O.3BeO.3SiO_2.MnS$	Isomet. Tetrah.	{111} tr	Yellow, etc.	H=6 G=3.2 F=3.	Gelat.
□	1.74±	Pilbarite $UO_2.ThO_2.PbO.2SiO_2.4H_2O$	Amor. Gumlike.			H=3 G=4.6±	Sol. in acid.
□	1.74±	Caryocerite (altered) Silicate of Y, Ce, Ca, etc., containing F and B	Ps. trig. Tab. rhombs.	Conch	Nut-brown	H=5–6 G=4.30	Near melanocerite. Sol. in hot HCl with separation of SiO_2. B. b. swells without fusing. Isotropic through alteration.
^ v	1.742	Pyrope $3(Mg,Fe)O.Al_2O_3.3SiO_2$	Isomet. {110}, {211}, etc.	None	Red	H=7 G=3.715 F=3.5	Garnet group. Insol. in acid. Data for mineral with Cr_2O_3 2.4, FeO 10.2, MgO 18.4, CaO 4.5, MnO 0.5 per cent.
^ v	1.748	Berzeliite $3CaO.3(Mg,Mn)O.2As_2O_5$	Isomet.		Yellow to orange yellow.	H=5 G=4.27 F=3	Sol. in acid. MnO=8.84 per cent.
^ v	1.75±	Spinel $(Mg,Fe)O.Al_2O_3$	Isomet. {111}, rarely {100}.		Black, green in section.	H=7.5 G=3.75± Infus.	Spinel group. Insol. in acid.
□	1.754	Danalite $3(Fe,Zn,Mn)O.3BeO.3SiO_2.(Fe,Zn)S$	Isomet. Ps. oct.		Red	H=6 G=3.43 F=3	Near helvite. Gelat.
	1.755	Arsenolite As_2O_3	Isomet. Oct.		White	H=1.5 G=3.70 F=1	Sol. in H_2O. Volatile.

	1.757±	Tritomite (altered) Silicate of Th, Ce, Y, Ca, etc., containing F and B	Ps. trig	Indist	Dark brown	H=5.5 G=4.2	Gelat.
	1.758	Yttrialite $(Y,Th)_2O_3.2SiO_2$	Ps. orth. Pris	Conch	Black, brown, olive green.	H=5–7 G=4.58 Infus.	Sol. in HCl. Pale green in section.
	1.760	Rhodolite $3(Mg,Fe)O.Al_2O_3.3SiO_2$	Isomet. {110}, {211}, etc.	None	Dark red, etc	H=7 G=3.837 Infus.	Garnet between pyrope and almandite. Insol. in acid. Data for mineral with Fe_2O_3 1.9, FeO 15.6, CaO 0.9, MgO 17.2 per cent.
	1.763	Hessonite $3CaO.(Al,Fe)_2O_3.3SiO_2$	do	do	Brown	H=6 G=3.633 F=3	Garnet group near grossularite. Insol. in acid. Data for mineral with Fe_2O_3 7.2, MnO 0.1 per cent.
	1.766	Almandite $3(Fe,Mn,Ca,Mg)O.(Al,Fe)_2O_3.3SiO_2$	Isomet. {110}, etc.	do	Red	H=7	Garnet group. Pyrope 31, andradite 3, almandite 41.5, grossularite 24.5 per cent.
	1.77±	Melanocerite (altered) Ce, Y, Ca, B, Fe, Si, etc.	Ps. trig. Tab. {0001}.	Conch	Deep brown to black.	H=5–6 G=4.13	Sol. in acid. In section reddish brown.
	1.77	Mackintoshite Silicate of U, Th, Ce, etc., containing H_2O	Ps. tetrag. Sq. prisms.		Black	H=5.5 G=5.44 Infus.	Difficultly sol. in acids. In section nearly colorless but clouded.
	1.77±	Pleonaste $(Mg,Fe)O.Al_2O_3$	Isomet. {111}, rarely {100}.	None	do	H=7.5 G=3.8± Infus.	Spinel group. Insol. in acid. Grass-green in section.
	1.779	Berzeliite $3CaO.3(Mg,Mn)O.2As_2O_5$	Isomet		Yellow to orange-yellow.	H=5 G=4.45 F=3	Sol. in acid. MnO 19.38 per cent.
	1.780±	Gadolinite $2BeO.FeO.Y_2O_3.2SiO_2$	Ps. mon	Conch	Black, greenish black.	H=6.5–7 G=4.0–4.5 Infus.	Gelat. On ignition becomes birefracting and n increases to 1.820.
	1.782	Gahnite $(Zn,Mg,Fe)O.Al_2O_3$	Isomet. Oct	None	Gray-green	H=7.5 G=4.38	Spinel group. Zn : Mg : Fe=13 : 2 : 4.
	1.789	Almandite $3(Fe,Ca,Mg)O.Al_2O_3.3SiO_2$	Isomet. {110}, {211}, etc.		Dark red, etc	H=7 G=3.917 F=3	Garnet group. Insol. in acid. Data for mineral with Fe_2O_3 2.4, MnO 0.6, CaO 4.8, MgO 7.9 per cent.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Isotropic group—Continued

Variability	n	Mineral name and composition	Crystal system and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.790	Gahnite $(Zn,Fe,Co)O.Al_2O_3$	Isomet. Oct.	{111} imperf.	Deep indigo-blue	H=7.5–8	Spinel group. Analysis: $ZnO.Al_2O_3$ 79.3, $CaO.Al_2O_3$ 4, $FeO.Al_2O_3$ 13, $MgO.Al_2O_3$ 2 per cent.
^ v	1.80±	Hercynite $FeO.Al_2O_3$	do	Imperf.	Black	H=7.5 G=3.9 Infus.	Spinel group. Insol. in acid. Grass-green in section.
^ v	1.800	Spessartite $3MnO.Al_2O_3.3SiO_2$	Isomet. {110}, {211}, etc.	Conch	Colorless, reddish	H=7 G=4.180 F=3	Garnet group. Data for pure mineral. Insol. in acid.
^ v	1.80±	Stibiconite $Sb_2O_4.nH_2O(?)$	Amor.	do	Gray, yellow, etc.	H=4–5 G=5± Infus.	Insol. in acid. n very variable.
^ v	1.801	Almandite $3FeO.Al_2O_3.3SiO_2$	Isomet. {110}, {211}, etc.	{110} poor	Dark red, etc.	H=7 G=4.093 F=3	Garnet group. Insol. in acid. Data for mineral with MnO 1.5, CaO 2.0, MgO 5.3 per cent.
^ v	1.802	Gahnite $(Zn,Fe)O.Al_2O_3$	Isomet. Oct.	None	Greenish black	H=7.5	Spinel group. Zn:Fe=15:2.
^ v	1.805	Spessartite $3(Mn,Fe,Ca)O.Al_2O_3.3SiO_2$	do	do	Pale salmon	H=7 G=4.117	Garnet group. Spessartite 61.6, almandite 32.8, grossularite 5.6 per cent.
^ v	1.805	Gahnite $ZnO.Al_2O_3$	do	{111} imperf.	Colorless, green	H=7.5–8 G=4.55 Infus.	Spinel group. Insol. in acid. Data for artificial mineral.
		Bodenbenderite $4(Mn,Ca)O.(Al,Y)_2O_3$ $3(Si,Ti)O_2$.	Isomet. Cubic		Flesh-red	G=3.3–3.5	Near beckelite.
	1.812	Beckelite $3CaO.2(Ce,La,Di)_2O_3.3SiO_2$	Isomet. Dodec. Oct.	{100} dist.	Light yellow, brown.	H=5 G=4.14 Infus.	Sol. in HCl. Large crystals are anisotropic. In section yellow.
^ v	1.815	Spessartite $3(Mn,Fe)O.Al_2O_3.3SiO_2$	do	do	Red	H=7 G=4.211	Garnet group. Spessartite 68, almandite 31 per cent.

^ v	1.818	Almandite 3(Fe,Mn)O.$Al_2O_3$3SiO_2	Isomet	None	Red, etc.	H=7	Garnet group. FeO 27.8, MnO 14.3, MgO 1.0 per cent.
□ □	1.818	Naegite ZrO_2,SiO_2, with UO_3,ThO_2, (Cb,Ta)$_2O_5$,Y_2O_3	Spheroidal aggregates. Dodecahedral.	Conch	Dark green or brown.	H=7.5 G=4.09	Probably related to zircon or malacon.
	1.82	Arandisite 5SnO_2.3SiO_2.4H_2O	Isomet.(?)		Apple-green	H=5 G=4.12	Fib. Resinous luster. Weakly birefringent in part.
□ □	1.826	Malacon ZrO_2.SiO_2.nH_2O	Sq. prisms		Colorless	H=3 G=4.0–4.3	Altered zircon.
v	1.83	Romeite 5CaO.3Sb_2O_5	Isomet. Oct	Conch	Yellow	H=5.5 G=5.04 F=dif.	Insol. in acid. Opt. anom. with low B.
^ v	1.830	Almandite 3FeO.Al_2O_3.3SiO_2	Isomet. {110}, {211}, etc.	{110} poor	Dark red, etc.	H=7 G=4.250 F=3	Garnet group. Insol. in acid. Data for pure mineral.
	1.838	Lime CaO	Isomet. Cubes	{100} perf	Colorless	H=3–4 G=3.32	Sol. in acid; somewhat sol. in H_2O. Rapidly alters on exposure to moist air.
^ v	1.838	Uvarovite 3CaO.Cr_2O_3.3SiO_2	Isomet. {110}, {211}, etc.	None	Emerald-green	H=7.5 G=3.418 Infus.	Garnet group. Opt. anom. Insol. in acid. Data for mineral with Al_2O_3 5.9, Cr_2O_3 22.5 per cent.
□ □	1.86±	Bindheimite Hydrous antimonate of Pb	Amor., opallike	Conch	Gray, green, etc.	H=4 G=4.8± F=3–4	
^ v	1.865	Andradite 3(Ca,Mg,Fe)O.Fe_2O_3.3SiO_2	Isomet. {110}, {211}, etc.	None	Varies	H=7 G=3.781 F=3.5	Garnet group. Gelat. imperfectly. Data for mineral with Al_2O_3 6.1, Fe_2O_3 25.1, FeO 0.8, CaO 33.7 per cent. Opt. anom.
^	1.87±	Romeite 5(Ca,Mn)O.3Sb_2O_5	Isomet. Oct	Conch	Yellow	H=5.5 G=5.07 F=dif.	Insol. in acid. Opt. anom. with low B.
	1.87±	Chalcolamprite 3Cb_2O_5.CaO.2SiO_2.ZrO_2.2HF	do		Grayish brown	H=5–6 G=3.77	Near pyrochlore.
□ v	1.88	Tscheffkinite Titanosilicate of Ce, Fe, etc.	Ps. mon	Conch	Velvet-black	H=5 G=4.3–4.55 F=4	Gelat. Red-brown in section. In part birefracting and opt. –.
□ □	*1.89±	Ellsworthite RO.Cb_2O_5.2H_2O	Amor.(?)	do	Dark brown to black.	H=4 G=3.6–3.9	
^ v	1.895	Andradite 3CaO.Fe_2O_3.3SiO_2	Isomet. {110}, {211}, etc.	do	Yellow, green, brown, black, etc.	H=7 G=3.750 F=3.5	Garnet group. Gelat. imperfectly. Data for pure mineral. Opt. anom.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Isotropic group—Continued

Variability	*n*	Mineral name and composition	Crystal system and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.90±	Stibiconite $Sb_2O_4.nH_2O$(?)	Amor.	Conch.	Gray, yellow, etc.	H=4–5 G=5 Infus.	Insol. in acid.
^ u	1.92±	Betafite Columbate and titanate of uranium, etc.	Isomet. Oct.	do.	Greenish black	H=5 G=4	
^ v	1.923	Galaxite $MnO.Al_2O_3$	do.	do.	Black	H=7.5 G=4.23	Mahogany-red in thin section. Data for mineral with $MnO.Al_2O_3$ 65.79, $MnO.Fe_2O_3$ 22.83, $MgO.Al_2O_3$ 5.27, $FeO.Al_2O_3$ 5.22 per cent.
u v	1.925	Microlite $6CaO.3Ta_2O_5.CbOF_3$	do.		Yellow, brown, red, etc.	H=5.5 G=5.51± Infus.	Pyrochlore group. Decpd. by H_2SO_4. On ignition *n* changes to 2.040.
	1.93	Nantokite Cu_2Cl_2	Isomet.	{100}	Colorless	H=2 G=3.93 Fus.	Sol. in H_2O. Oxidizes rapidly. Data on artificial crystals.
^ v	1.935±	Microlite CaO, Ta_2O_5, etc.	do.	None	Dark olive	H=5.5 G=5.5–5.7	
^ v	1.94	Melanite $3CaO.(Fe,Ti)_2O_3.3(Si,Ti)O_2$	Isomet. {110}, {211}, etc.	Conch.	Black	H=7 G=3.7 F=4	Garnet group. Gelat. TiO_2 8.7 per cent.
u u	1.94	Samirésite Columbate of U, etc.	Isomet. Oct.		Golden yellow	Friable G=5.24	
u u	1.96±	Neotantalite $(Fe,Mn)O$, $(Ta,Cb)_2O_5$, H_2O, etc.	do.		Clear yellow	H=5–6 G=5.19	
^ v	1.96	Pyrochlore Columbate and titanate of Ce, Ca, etc., with Th, F, etc.	do.	{111} variable	Brown	H=5 G=4.3± Infus.	Pyrochlore group. Decpd. by H_2SO_4. On ignition *n* increases to 2.000. Opt. anom.

1.965	Tscheffkinite Titanosilicate of Ce, Fe, etc.	Ps. mon	Conch	Velvet-black	H=5 G=4.3–4.55 F=4	Gelat. Red-brown in section. In part birefracting and opt.—.
1.98±	Hatchettolite Tantalocolumbate of U, Ca, etc.	Isomet. Oct		Brown	H=5 G=4.8± Infus.	Pyrochlore group. Insol. in acid.
1.98	Schorlomite $3CaO.(Fe,Ti)_2O_3.3(Si,Ti)O_2$	Isomet. {110}, {211}, etc.	Conch	Black	H=7 G=3.85± F=4	Garnet group. Gelat. TiO_2 16.9 per cent.
1.99±	Stibiconite $Sb_2O_4.nH_2O$(?)	Amor	do	Yellow, gray	H=4–5 G=5 Infus.	Insol. in acid.
1.99±	Microlite CaO, Ta_2O_5, etc.	Isomet	None	Amber-brown	H=6.0 G=5.95	
2.0±	Wiikite Columbate, titanate, and silicate of Fe and rare earths		Conch	Black	H=6 G=3.8–4.8 Infus.	
2.00	Pyrochlore Columbate and titanate of Ca, Ce, etc., with Th, F, etc.	Isomet. Oct	{111} variable	Brown, dark red	H=5 G=4.3 Infus.	Pyrochlore group. Decpd. by H_2SO_4. After ignition n=2.227.
2.01	Ivaarite Near schorlomite, etc.	Isomet. {110}, {211}, etc.	Conch	Black	H=6 G=3.7 F=4	Garnet group. Gelat. TiO_2 25 per cent.
2.015	Calciosamarskite $3(Fe,Ca,UO_2,$ etc.$)O.(Ce,Y,$ etc.$)_2O_3.3(Cb,Ta)_2O_5$	Isomet			G=4.485	Samarskite group. CaO 7.56 per cent.
	Mendelejevite Rare earths, U_3O_8, CaO, PbO, etc.	do		Grayish black, reddish-brown streak.	H=4.5 G=4.76	Betafite group. U_3O_8 23.5, CaO 15 per cent.
2.05	Percylite $PbO.CuCl_2.H_2O$	Isomet. Cubic	{100}	Pale blue	H=2 G=5.25 F=1	Sol. in HNO_3. In section sky-blue.
2.05±	Picotite $(Mg,Fe)O.(Al,Cr)_2O_3$	Isomet. Oct	None	Brown	G=4.08 Infus.	Spinel group. Nearly insol. in acid.
2.05	Eulytite $2Bi_2O_3.3SiO_2$	Isomet. Tetrah	{110} imperf	Brown, yellow, gray	H=4.5 G=6.11 F=2	Opt. anom. Uniax. —.
2.05±	Risorite $Cb_2O_5.(Y,Er)_2O_3.H_2O$; some Ta, Ti, Ce, La, etc.		Conch	Dark brown	H=5.5 G=4.18	Easily sol. in hot concd. H_2SO_4. Reddish brown in section.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Isotropic group—Continued

Variability	*n*	Mineral name and composition	Crystal system and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	2.05±	Limonite $Fe_2O_3.nH_2O$	Amor	None	Ocher-yellow	H=4± G=3.8± Infus.	Sol. in HCl. Crystallized=goethite.
^ v	2.06±	Euxenite Columbate and titanate of Y, Er, Ce, U, etc.	Ps. orth	Conch	Brownish black	H=6.5 G=4.6–5.0 Infus.	Blomstrandine group. Insol. in acid. Reddish brown in powder. After ignition n=2.22.
□	2.06±	Sipylite Columbate of Er, La, Di, U, etc.	Ps. tetrag. Oct	{111}dist. Conch	Brownish black, brownish orange.	H=6 G=4.89 Infus.	Insol. in acid. Pale red-brown in section.
□ v	2.06	Loranskite $Ta_2O_5.ZrO_2.(Y,Ce)_2O_3.CaO.FeO.H_2O$	Isomet	Conch	Black to brown	H=5 G=3.8–4.8	Euxenite group.
	2.061	Cerargyrite AgCl	Isomet. Cubes	None	Gray, etc	H=1–1.5 G=5.55 F=1	Sectile. Sol. in ammonia.
	2.065	Mosesite Hg, NH_4, Cl, SO_3, H_2O	Isomet. Oct	Conch	Pale lemon-yellow	Soft.	In part abnormally birefracting.
□ v	2.070	Chromite $FeO.Cr_2O_3$	Isomet. Oct. Massive.	do	Iron-black to brownish black.	H=5.5 G=4.5	Spinel group. Insol. in acids. Infus. in oxygen flame. Nearly opaque.
	2.087	Senarmontite Sb_2O_3	Isomet. Oct	{111}tr	Colorless	H=2 G=5.2. F=1.5	Sol. in HCl. Volatile. Anom. B.
	2.09	Schneebergite $4(Ca, Fe)O.2Sb_2O_4$	do	{111}dist	Honey-yellow	H=6.5 G=5.41 F=dif.	Insol. in acids. Opt. anom. with low B.
^ □	2.095	Calciosamarskite $3(Fe,Ca,UO_2,$ etc.$)O.(Ce,Y,$ etc.$)_2O_3.3(Cb,Ta)_2O_5$	Isomet		Black	H=5–6 G=4.738	Samarskite group. CaO 4.76 per cent.
□ v	2.115	Fergusonite $(Y, Er, Ce)_2O_3.(Cb, Ta)_2O_5$	Ps. tetrag. Pyram.	{111}imperf.Conch.	Brownish black	H=6 G=5.8 Infus.	Decpd. by H_2SO_4. After ignition becomes anisotropic with n=2.070. Brown in powder.

□	2.13	Ampangabéite Columbate of U, etc.	Ps. orth. Rectangular prisms.	Conch.	Brownish red	H=4 G=3.97–4.29 Fus.	Easily sol. in acid. Fuses to a black slag. In section red-brown.
□	2.13±	Yttrocrasite Hydrous titanate of Th, Y, etc.	Ps. orth	do	Black	H=6 G=4.80 Infus.	Sol. in H_2SO_4. In section amber. In part faintly birefracting.
	2.137	Oldhamite CaS	Isomet	{100}	Pale brown	H=4 G=2.58	Soluble in acid. Rapidly oxidizes in air.
◇	2.142	Blomstrandine Columbate and titanate of U, Th, Y, Er, Ce, etc.	Ps. orth. Tab. {010}. Elong.	Conch	do	H=5.5 G=4.8–5.0	Blomstrandine group. After ignition n=2.24.
□	2.15	Yttrotantalite $(Ca,Fe)O.(Y,Er,Ce,etc.)_2O_3.2(Ta,Cb)_2O_5.4H_2O$	Ps. orth	{010}imperf. Conch.	Black to straw-yellow.	H=5 G=5.7±	In section red-brown.
□	2.15–2.20	Eschwegeite $2Ta_2O_5.4Cb_2O_5.10TiO_2.5Y_2O_3.7H_2O$		Conch	Dark-red pebbles	H=5.5 G=5.87	
□	2.15±	Koppite $2(Ca, Ce, etc.)O.Cb_2O_5.2/5NaF$	Isomet. Dodec	do	Brown	H=5.5 G=4.5 Infus.	Pyrochlore group. Decpd. by H_2SO_4. In section red.
□	2.15±	Embolite Ag(Br, Cl)	Isomet. Cubes		Colorless	H=1–1.5 G=5.4 F=1	Sol. in ammonia. Isomorphous with cerargyrite and bromyrite. Sectile.
◇	2.16	Chromite $FeO.Cr_2O_3$	Isomet. Oct. Massive.		Iron-black to brownish black.	H=5.5 G=4.5 Infus. in oxygen flame	Spinel group. Insol. in acids.
	2.16	Manganosite MnO	Isomet. Oct	{100}	Emerald-green; nearly black in mass.	H=5–6 G=5.18 Infus.	Sol. in acid. In powder and section emerald-green.
◇	2.17	Fergusonite $(Y,Er,Ce)_2O_3.(Cb,Ta)_2O_5$	Ps. tetrag. Pyram.	{111}imperf. Conch.	Black	H=6 G=5.8± Infus.	Decpd. by H_2SO_4. After ignition becomes B. with n=2.142.
◇	2.18	Euxenite Columbate and titanate of Y, Er, Ce, U, etc.	Ps. Orth	Conch	do	H=6.5 G=4.983	$Cb_2O_5+Ta_2O_5:TiO_2$=1:3.3.
□	2.19	Lyndochite $(Cb, Ta)_2O_5$, TiO_2, $(Ce,La,Di)_2O_3$, $(Y,Er)_2O_3$, CaO, H_2O, etc.	Amor. (?)	do	Shiny black	H=6.5 G=4.9	Blomstrandine group.
		Uhligite $CaO.Al_2O_3.ZrO.2TiO_2$	Isomet. Oct	{100}imperf	Black		Near zirkelite. Translucent on thin edges.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Isotropic group—Continued

Variability	*n*	Mineral name and composition	Crystal system and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
□ □	2.19	Zirkelite $(Ce,Fe,Ca)O.2(Zr,Ti,Th)O_2$	Isomet. Oct.	Conch.	Black	H=5.5 G=4.72 Infus.	Insol. in acid. Clear reddish brown in section.
◇ ◇	2.19±	Fergusonite $(Y,Er,Ce)_2O_3.(Cb,Ta)_2O_5$	Ps. tetrag. Pyram.	do.	do.	H=5.5–6 G=5.8 Infus.	Decpd. by H_2SO_4. On ignition becomes anisotropic with n=2.090.
	2.20	Lewisite $5CaO.2TiO_2.3Sb_2O_5$	Isomet. Oct.	{111} nearly perf.	Honey-yellow; colophony-brown.	H=5.5 G=4.95 F=easy	Insol. in acids.
□ ◇	2.20±	Bismutite $Bi_2O_3.CO_2.nH_2O$	Amor. opaline	Conch.	Gray, etc.	H=4–5 G=7± F=1.5	Effervesces with acid. In part cryptocrystalline.
□ □	2.20±	Thorianite ThO_2, UO_2, etc.	Isomet. Cubes		Black	G=9.32	Nearly opaque.
	2.20	Iodobromite $2AgCl.2AgBr.AgI$	do.	{111} dist.	Colorless, yellow, etc.	H=1 G=5.7 F=1	Compare with cerargyrite, etc. So in ammonia. Sectile.
	2.20	Miersite $CuI.4AgI$	Isomet. Cubes, etc.		Yellow	H=2 G=5.64 F=1	Sol. in ammonia. Tw. pl. {111}. Sectile.
◇ ◇	2.205	Eschynite $2(Ca,Fe)O.2Ce_2O_3.8TiO_2.3Cb_2O_5$	Ps. orth.	Conch.	Brownish black	H=5.5 G=5.0± Infus.	Insol. in acid. In section reddish brown.
	2.21	Weslienite $Na_2O.FeO.3CaO.2Sb_2O_5$	Isomet. Oct.	None.	Honey-yellow	H=6.5 G=4.97	Anom. Birefracting. Långban iron deposits.
◇ ◇	2.21±	Samarskite $3(Fe,Ca,UO_2,\text{etc.})O.(Ce,Y,\text{etc.})_2O_3.3(Cb,Ta)_2O_5$	Ps. orth. Pris.	{010} imperf. Conch.	Velvet-black	H=5–6 G=5.6–5.8 F=5	Nearly insol. in acids. In section brownish to opaque. Sensibly isotropic to strongly birefracting.
	2.215	Polymignite Columbate, titanate, zirconate of Ce, etc.	do.	{100} {010} tr. Conch.	Black	H=6.5 G=4.8 Infus.	Reddish brown in section.

^ ⊔	2.24±	Euxenite Columbate, titanate of Y, Er, U, Ce, etc.	do	Conch	Brownish black	H=6.5 G=5.0± Infus.	Blomstrandine group. Insol. in acid. In section reddish brown.
^ v	2.248	Polycrase Columbate and titanate of Ce, Th, U, etc.			Dark reddish brown.		$Cb_2O_5:TiO_2=1:5.5$.
^ ⊔	2.25±	Samarskite $3(Fe,Ca,UO_2,etc.)O.(Ce,Y,etc.)_2O_3.3(Cb,Ta)_2O_5$	Ps. orth	{010} imperf. Conch.	Black	H=5–6 G=5.6–5.8 F=5	Nearly insol. in acid. In section brownish to opaque. Isotropic to strongly birefracting.
	2.18 red 2.39 blue	Bunsenite NiO	Isomet. Oct		Green or brownish black.	H=5.5 G=6.4 Infus.	Sol. in acid.
	2.253	Bromyrite AgBr	Isomet. Cubes, etc.	{110}poor	Yellow, etc	H=2 G=5.9 F=1	Sol. in ammonia. Sectile.
^	2.26±	Eschynite $2(Ca,Fe)O.2Ce_2O_3.3TiO_2.3Cb_2O_5$	Ps. orth	Conch	Brownish black	H=5 G=5.1 Infus.	Insol. in acid. Reddish brown in section. On ignition becomes birefracting with $n=2.285$.
^ ⊔	2.26±	Bismutite $Bi_2O_3.CO_2.nH_2O$(?)	Amor	Powder	Gray, yellow	H=4 G=6.9–7.7 F=1.5	Effervesces in acid.
⊔		Monimolite $3RO.Sb_2O_5$. R=Pb:Fe=3:1	Oct. or cubes	{111}dist	Yellowish or brownish green to brown or black.	H=5–6 G=6.58–7.29 Fus.	Insol. in acid. Fuses to a black slag. Weak anom. B.
	2.30	Brannerite Chiefly $TiO_3,UO_2,UO_2,ThO_2,Y_2O_3,(Ca,Fe)O$	Ps. tetrag	Conch	Black	H=4.5 G=5.1	Sol. in acid. Light reddish brown in transmitted light.
⊔ v	2.30	Knopite $(Ca,Y,Fe,Ce)O.TiO_2$	Isomet. Cubes	{100}	do	H=5 G=4.2±	Near perofskite. Brownish in powder. Anom. B. with B=low.
^ v	2.33	Dysanalite $7(Ca,Ce,Fe,Na_2)O.6TiO_2.Cb_2O_5$	do	do	Iron-black	H=5–6 G=4.13 Infus.	Near perofskite. Compare with the pyrochlore group (pp. 61, 63). Decpd. by HCl dif. Nearly opaque. In part anisotropic, with B=weak.
^ v		Trevorite $NiO.Fe_2O_3$	Isomet. Oct		Black	H=5 G=5.165	Spinel group. Practically opaque. $n=2.39$ calculated.
^ v	2.34$_{Li}$	Magnesioferrite $MgO.Fe_2O_3$	do	None	Black to dark-red in powder.	H=6–6.5 G=4.48 Infus.	Spinel group. Dif. sol. in acid. Magnetic. In transmitted light dark red.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Isotropic group—Continued

Variability	n	Mineral name and composition	Crystal system and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	2.346	Marshite Cu_2I_2	Isomet. Tetrah.	{110}	Oil-brown, etc.	H=2.5 G=5.59 F=1.5(?)	Dispersion exceeds that of diamond.
^ v	*2.36	Loparite Titanate of rare earths, Na, Ca	Cubic		Black	H=5	Related to perofskite. Complex tw. Kola.
^ u	2.36_{Li}±	Franklinite $(Zn,Fe,Mn)O.(Fe,Mn)_2O_3$	Isomet. Oct.	None	Iron-black	H=6 G=5.1 Infus.	Spinel group. Sol. in hot HCl. Nearly opaque in reddish brown.
v	2.34_{Li} 2.37_{Na}	Sphalerite ZnS (*pure*)	Isomet. Tetrah.	{110}perf.	Colorless to pale yellowish.	H=3.5–4 G=4.0 F=5	Luster resinous. Sol. in HCl. Data on pure ZnS.
^	2.38	Perofskite $CaO.TiO_2$	Cubic	{100}rather poor	Yellow, etc.	H=5.5 G=4.03 Infus.	Decpd. by acid dif. Anom. B. with complex tw.
	2.419	Diamond C	Isomet. Tetrah.	{111}highly perf.	Colorless, etc.	H=10 G=3.52 Infus.	Insol. in acid. Tw. pl. {111}.
^ v	2.428	Sphalerite (Zn,Fe)S	do	{110}perf.	Brown to black	H=3.5–4 G=4	Fe=10.35 per cent.
^ u	2.47_{Na}	Sphalerite (Zn,Fe)S	do	do	do	H=3.5–4 G=4.0 F=5	Luster resinous. Sol. in HCl. ZnS 72, FeS 28 per cent.
	2.49_{Li}	Eglestonite $Hg_2Cl_2.Hg_2O$	Isomet.	None	Yellow, darkens on exposure.	H=2–3 G=8.33	Decpd. by acid. Volatile. Anom. B.
	2.69_{Li}	Hauerite MnS_2	Isomet. Oct. pyritohedrons.	{110}imperf.	Brownish black	H=4 G=3.66 F=3	Sol. in HCl. Red in powder.

	2.70$_{Li}$	Alabandite MnS	Isomet. Cubes, dodec., etc.	{100}perf	Iron-black	H=3.5–4 G=4.0 F=3	Sol. in HCl. Streak green.
	2.849$_{Li}$	Cuprite Cu_2O	Isomet. Plagihedral.	{111}interrupted	Red	H=3.5 F=3	Streak crimson. Sol. in conc. HCl.
V	>2.72$_{Li}$	Tetrahedrite $5Cu_2S.2ZnS.2Sb_2S_3$	Isomet. Tetrah. Massive. Tw. pl. {111} and {100}.	None	Flint-gray to iron-black.	H=3 G=4.6± F=1.5	Decpd. by HNO_3. In section bright red to opaque.
^	>2.72$_{Li}$	Tennantite $5Cu_2S.2ZnS.2As_2S_3$	Isomet. Dodec., etc.		Iron-black, cherry-red in splinters.	H=3 G=4.6± F=1.5	Nearly opaque. Decpd. by HNO_3.

Uniaxial positive group

[The greater part of the minerals of this group are tetragonal or hexagonal, but some minerals that are strictly biaxial but with nearly zero axial angle are included here as well as in their proper biaxial group. A considerable proportion of these biaxial minerals with nearly uniaxial optical properties have also nearly hexagonal crystal form]

Variability	ϵ	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.313	1.309	Ice H_2O	Hex. Massive		Colorless	H=1.5 G=0.917	
	1.390	1.378	Sellaite MgF_2	Tetrag. Pris	{100}{110}perf	do	H=5 G=3.17 F=4–5	Sol. in conct. H_2SO_4. Fuses with intumescence.
□ V	B=mod.	1.40±	Chrysocolla(?) $CuO.SiO_2.nH_2O$	Fib. c. Opallike		Green	H=2± G=2 Infus.	Decpd. by acid. Pleoc. faint: ω= nearly colorless, ϵ=pale bluish green.
		1.0$_{red}$ 1.45$_{Na}$ 1.80$_{Tl}$	Covellite CuS	Hex. Plates	{0001}perf	Indigo-blue, streak nearly black.	H=1.5–2 G=4.6 F=2.5	Sol. in HNO_3. Translucent only in thinnest plates. In transmitted light green and pleochroic.
	1.445	1.440	Schairerite $Na_2SO_4.Na(F,Cl)$	Trig. Steep rhombs.	None, brittle	Clear, colorless	H=3.5 G=2.612 F=easy	Sol. in H_2O.
^ V	1.57	1.46±	Chrysocolla(?) $CuO.SiO_2.2H_2O$	Fib. c. Opallike		Beryl-blue	H=3 G=2.4 Infus.	Decpd. by acid. Pleoc. faint: ω= colorless, ϵ=pale bluish green. Values for apparent indices. They increase greatly as pores are filled with immersion media.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial positive group—Continued

Variability	ε	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.474	1.461	Tincalconite $Na_2O.2B_2O_3.5H_2O$	Rhomboh	None	Colorless, white	G=1.880	Values of indices for artificial mineral.
□	1.474	1.470	Gmelinite $Na_2O.CaO.2Al_2O_3.6SiO_2.10H_2O$	Ps. trig. Cubic	{10$\bar{1}$0}dist	White	H=4.5 G=2.1 F=3	Zeolite group. Decpd. by HCl. 2V small to 0. Tw. axis c.
	1.50	1.47	Hatchettite Hydrocarbon	Orth(?)		do	Very soft G=0.95 F=very easy	Sol. in alcohol and other organic liquids. Burns.
□	1.486	1.475	Laubanite $2CaO.Al_2O_3.5SiO_2.6H_2O$	Mon. (?) Fib. c	Pris. good	do	H=5 G=2.2 Fus.	A zeolite. Decpd. by warm conct. HCl. Fuses to a blebby glass.
□	1.482	1.480	Chabazite $Na_2O.2CaO.3Al_2O_3.18SiO_2.25H_2O$	Ps. trig. Cubic	{10$\bar{1}$1}dist	do	H=4.5 G=2.1 F=3	Zeolite group. Decpd. by HCl with separation of slimy silica. Fuses with intumescence. 2V small to 0.
□	B=weak	1.48	Faujasite $Na_2O.CaO.2Al_2O_3.10SiO_2.20H_2O$	Oct	{111}dist		H=5 G=1.92 F=3	Zeolite group. Decpd. by acid. Uniax. in eight segments from loss of H_2O.
V	1.492	1.487	Aphthitalite $(Na,K)_2O.SO_3$	Trig. Tab., rhombs.	{10$\bar{1}$0} rather dist. {0001} imperf.	White	H=3 G=2.69 F=1.5	Glaserite. Sol. in H_2O. $K_2O:Na_2O$=2:3.
	1.500	1.488	Douglasite $2KCl.FeCl_2.2H_2O$	Mon. (?)			G=2.16	Tend to lie on face normal to optic axes.
	1.502	1.490	Natrolite (hydronephelite) $2CaO.2Na_2O.3Al_2O_3.6SiO_2.7H_2O$	Hex. Fib		White	H=5 G=2.26 F=2-3.	Zeolite group. Gelat.
∧	1.496	1.490	Aphthitalite $(K,Na)_2O.SO_3$	Trig. Tab., rhombs.	{10$\bar{1}$0} rather dist. {0001}imperf.	do	H=3 G=2.69 F=1.5	Glaserite. Sol. in H_2O. $K_2O:Na_2O$=3:1.
	*1.510	1.500	Liskeardite $3(Al,Fe)_2O_3.As_2O_5.16H_2O$	Hex.? Fib. crusts		do	Soft	Liskeard.

□	1.550	1.502	Paraffin Hydrocarbon	Plates and fib		do	H=1 G=0.9 F=very easy	Insol. in acids. Burns. Lies on base on crushing below cover glass.
	1.509	1.508	Leucite $K_2O.Al_2O_3.4SiO_2$	Ps. isomet. {211}	{110} poor	Colorless	H=6 G=2.5 Infus.	Decpd. by acid. Inclusions characteristic. 2V small to 0. Poly. tw. lamellae.
□	1.54	1.515	Ozocerite Hydrocarbon	Orth(?). Fib		White	H=1 G=0.9 F=very easy	Insol. in acids. Burns. Elongation of fibers is −. Lie on base.
	1.522	1.518	Leifite $Na_2O.Al_2O_3.9SiO_2.2NaF$	Hex. Pris	Pris	Colorless	H=6 G=2.57 F=easy	Insol. in HCl.
□ <	1.521	1.518	Davyne $4(Na,K)_2O.CaO.4Al_2O_3.9SiO_2.3H_2O.2CO_2$?	Hex	{10$\bar{1}$0}{0001} perf		H=5.5 G=2.4± Fus.	Compare with microsommite and cancrinite. Gelat. Fuses with intumescence.
	*1.55	1.52	Koenenite $Al_2O_3.3MgO.2MgCl_2.8H_2O$	Trig. Folia	{0001} mic	Red-brown	Very soft G=1.98	Decpd. slowly by hot H_2O. Pleoc.: ω=red-brown, ϵ=colorless. Hanover.
	1.529	1.521	Microsommite $3(Na,K)_2O.4CaO.6Al_2O_3.12SiO_2.SO_3.4(Na,K)Cl$	Hex	{10$\bar{1}$0} perf. {0001} less so.	Colorless	H=6 G=2.4 F=dif.	Near cancrinite and davyne. Gelat.
> □	1.527	1.522	Natrodavyne Near davyne but with no K and much CO_2	do	{10$\bar{1}$0}{0001} perf	do	H=6 G=2.50 Fus.	Gelat. Fuses with intumescence.
	1.575	1.533	Fibroferrite $Fe_2O_3.2SO_3.10H_2O$	Orth(?). Fib. *c*		Pale yellow	H=2 G=1.86 F=4.5–5	Sol. in H_2O. Elongation +. Pleoc. feeble: ω=nearly colorless, ϵ=pale yellow.
□	1.537	1.535	Apophyllite $K_2O.8CaO.16SiO_2.16H_2O$	Tetrag	{001} perf. {110} less so.	Colorless	H=5 G=2.3 F=2	Decpd. by HCl with separation of slimy silica. Opt. anom.
<	1.572	1.536	Coquimbite(?) $2(Fe,Al)_2O_3.7SO_3.22H_2O$	Trig	Pris	Colorless to violet, transparent, vitreous.	H=2.5–3 G=2.066	Sol. in boiling H_2O.
	1.572	1.536	Ashcroftine $Na_4K_4(Ca,Mg,Mn)_5Al_{18}Si_{22}O_{80}.35½H_2O$	Tetr. Needles	{100}	White	H=5 G=2.61	Same as kalithomsonite.
	1.553	1.544	Quartz SiO_2	Trig. Hex. prisms and pyramids.	None	Colorless	H=7 G=2.66 Infus.	Insol. in acid.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial positive group—Continued

Variability	ϵ	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
∧	1.556	1.550	Coquimbite $Fe_2O_3.3SO_3.9H_2O$	Trig.	{10$\bar{1}$0}{10$\bar{1}$1}{01$\bar{1}$1} imperf.	White, yellow, violet.	H=2 G=2.1 F=4.5–5	Sol. in H_2O. Tw. pl. {0001}. Abnormal interference colors.
	1.645	1.556	Julienite Composition unknown	Tetr. Pris.		Blue	G=1.594	Very sol. in H_2O. Isomor. with connellite.
	1.627	1.559	Ferrinatrite $3Na_2O.Fe_2O_3.6SO_3.6H_2O$	Trig. Acic.	{10$\bar{1}$0}perf. {1000} less so.	White, greenish, etc.	H=2 G=2.56± F=1.5	Sol. in H_2O.
∨	1.580	1.559	Brucite $MgO.H_2O$	Trig. Tab.	{0001} eminent.	Colorless	H=2.5 G=2.4 Infus.	Flexible. Luster pearly on {0001} Sol. in acids. Opt. anom.
□	B=weak	1.56	Colerainite $4MgO.Al_2O_3.2SiO_2.5H_2O$	Hex. Plates		White	H=2.5–3 G=2.51 F=dif.	Decpd. by HCl dif.
∨	1.576	1.562	Chlorite (white) $3MgO.Al_2O_3.2SiO_2.3H_2O$	Ps. Hex.	{001} mic.	do	H=soft	Chlorite group. Data for mineral with 1.7 per cent Fe_2O_3.
	1.575	1.565	Pinnoite $MgO.B_2O_3.3H_2O$	Tetrag.		Yellowish	H=3–4 G=2.29 F=3	Sol. in acid.
∨	1.592	1.572	Alunite $K_2O.3Al_2O_3.4SO_3.6H_2O$	Trig. Tab. {0001} or cubic.	{0001} dist.	White	H=4 G=2.60 Infus.	Alunite group. Insol. in acid, but sol. in acid and partly in H_2O after ignition. Decrepitates.
∧ ∨	1.579	1.576	Penninite $5(Mg,Fe)O.Al_2O_3.3SiO_2.4H_2O$	Mon. Hex. plates.	{001} perf.	Green, etc.	H=2 G=2.7 F=5–5.5	Chlorite group. Decpd. by H_2SO_4. (See Biaxial negative group, p. 162.) Abnormal blue interference color. Pleoc.: X and Y=green, Z=nearly colorless.
□	1.584	1.576	Ekmannite $5(Fe,Mn,Mg,Ca)O.Al_2O_3.$ $Fe_2O_3.8SiO.7H_2O$	Hex.	{0001} perf.	Pitch black	G=2.671	Pleoc. strong: ω=black, ϵ=yellowish green.
□	1.588	1.580	Coeruleolactite $3Al_2O_3.2P_2O_5.10H_2O$	Fib. Crusts		Milk-white to light blue.	H=5 G=2.55–2.70 Infus.	Sol. in acid.

	1.645	1.582	Cacoxenite $2Fe_2O_3.P_2O_5.12H_2O$	Hex. Needles c		Yellow	H=3-4 G=3.38 F=2.5-3	Sol. in acid. Pleoc. considerable: ω=pale yellowish, ε=orange-yellow to canary-yellow. Abs.: ε>ω.
	1.602	1.583	Alumian $Al_2O_3.2SO_3$	Trig: Rhombs resembling cubes.	Traces	White	H=2-3 G=2.74± Infus.	Sol. in acid.
□	B=0.01	1.585±	Natroalunite $Na_2O.3Al_2O_3.4SO_3.6H_2O$	Trig. Tab. {0001} or cubic.	{0001} dist	White, etc	H=4 G=2.6 Infus.	Alunite group. Sol. in acid and partly in H_2O only after ignition. Decrepitates.
◇	B=low	1.587	Rumpfite $7MgO.8Al_2O_3.10SiO_2.14H_2O$	Mon. Scales	{001} perf	Greenish gray	H=1.5 G=2.67 F=4	Chlorite group. Slowly sol. in acid 2E=0° to 10°
	1.590	1.589	Rinneite $FeCl_2.3KCl.NaCl$	Trig	{10$\bar{1}$0}{11$\bar{2}$0}fair	Colorless, rose, yellow.	H=3 G=2.35 F=easy	Sol. in acid.
	*1.600	1.590	Wardite $Na_2O.\frac{1}{2}CaO.3Al_2O_3.2P_2O_5.8\frac{1}{2}H_2O$	Trig. (?)	{0001} perf	Clear green, colorless.	H=5 G=2.81 F=3	Dif. sol. in acid. Lewiston, Utah. Type soumansite is identical opt.
	B=very weak	1.59	Chlormanganokalite $4KCl.MnCl_2$	Trig	None	Yellow	H=2.5 G=2.31 F=easy	Deliquescent.
□	1.60	1.59	Manganbrucite $(Mg,Mn)O.H_2O$	do	{0001} perf	Light brown	H=2.5	Mg:Mn=5:1.
□	1.612	1.597	Amesite $2(Mg,Fe)O.Al_2O_3.SiO_2.2H_2O$	Ps. hex. Plates	{001} mic	Pale bluish green	H=2-3 G=2.77 Infus.	Chlorite group. Decpd. by HCl. Swells on heating. MgO: FeO= 5:1.
	1.615	1.604	Sarcolite $3CaO.Al_2O_3.3SiO_2$	Tetrag. Cubo-oct		Light rose	H=6 G=2.925 F=3	Gelat. Anom. biax.
□	1.611	1.606	Eudialyte $6Na_2O.6(Ca,Fe)O.20(Si,Zr)O_2.NaCl$	Hex	{0001} dist. {10$\bar{1}$0} poor.	Pale pink	H=5 G=3.0 F=3	Gelat. Opt. anom. Pleoc. weak. Abs.: ω>ε.
	*1.630	1.609	Narsarsukite Titanosilicate of Fe, Na, F, etc.	Tetrag. Oct	{110} perf	Honey-yellow to reddish or brownish gray.	H=7 G=2.75 F=easy	Sol. in HF. Pleoc. in thick section: ω=reddish yellow, ε=colorless. Narsarsuk.
	1.648	1.614	Pseudowollastonite $CaO.SiO_2$	Mon. Ps. hex.		White		Shows poly. tw. 2V=very small.
	B=.002	1.615	Fluocerite $(Ce,La,Di)F_3$	Hex	{0001} perf	Reddish yellow	H=4 G=5.8± Infus.	Sol. in acid.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial positive group—Continued

Variability	ϵ	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
V	*1.627	1.619	Pseudowavellite $5CaO.6Al_2O_3.4P_2O_5.18H_2O$	Trig. Fib. or plates.	{0001} perf.	Colorless, sulphur-yellow.	H=5 G=2.91 F=2.5	Dif. sol. in acid. Fuses with intumescence. Elong. of fib. —. Lewiston, Utah.
V		1.62	Tikhvinite $2SrO.3Al_2O_3.P_2O_5.SO_3.6H_2O$				H=4.5 G=3.32	Same as svanbergite?
	1.654	1.620	Churchite $3CaO.5Ce_2O_3.6P_2O_5.24H_2O$	Rectangular tablets beveled parallel to the long edge.	{001} perf.	Smoky gray tinged with red.	H=3 G=3.14 *Infus.*	Sol. in acid. Z (or ϵ) is normal to the tablets.
V	*1.631	1.622	Pseudowavellite $5CaO.6Al_2O_3.4P_2O_5.18H_2O$	Trig. Matted fib.	{0001} perf.	Colorless, yellow.	H=5 G=2.92 F=2.5	Lewiston, Utah.
	1.625	1.623	Metatorbernite $CuO.UO_3.P_2O_5.8H_2O$	Tetrag. Tab.{001}.	{001} mic.	Green, yellow, red.	H=2 G=3.68 F=3	Luster on {001} pearly. Sol. in acid.
⊏	B=weak	1.625	Georceixite $(Ba,Ca,Ce)O.2Al_2O_3.P_2O_5.5H_2O$	Trig. (?) Microcrystalline.		Brown, white.	H=6 G=3.10	Alunite group.
V	1.630 1.639 *1.646	1.620 1.629 1.635	Goyazite $2SrO.3Al_2O_3.2P_2O_5.7H_2O$	Trig. Tab.{0001}.	{0001} perf.	Colorless, etc.	H=5 G=3.20–3.26 F=4	Alunite group. Insol. in acids. Zonal growths. Basal segments commonly show anom. B. in hexagonal segments. Pleoc.: ω= red-brown, ϵ= yellow. * Data for hamlinite from Diamantina, Minas Geraes.
	*1.640	1.626	Svanbergite $2SrO.3Al_2O_3.P_2O_5.2SO_3.6H_2O$	Trig. Cubic.	do.	Colorless.	H=5 G=3.52 F=dif.	Alunite group. Nearly insol. Basal section divides into six biax. segments. Horrsjöberg.
	1.640	1.630	Deltaite $8CaO.5Al_2O_3.4P_2O_5.14H_2O$	Trig. Grains.	do.	Colorless, yellow.	H=5 G=2.95	
V	*1.640 *1.631	1.630 1.622	Pseudowavellite $5CaO.6(Al,Fe)_2O_3.4P_2O_5.18H_2O$	Trig. Matted fib.	{0001} perf.	Gray, etc.	H=5 G=2.92–2.88 F=2.5	Lewiston, Utah.

V	1.639	1.633	Åkermanite $MgO.2CaO.2SiO_2$	Tetrag	{001}, {110}	Colorless	H=5 G=3.12	Melilite group. Gelat. Data for pure mineral.
	1.670	1.654	Phenacite $2BeO.SiO_2$	Trig. Pris	{11$\bar{2}$0}dist	Colorless, yellow, rose, brown.	H=7.5 G=3.0 Infus.	Insol. in acid. Tw. pl. {10$\bar{1}$0} penet. Pleoc. faint.
□	1.676	1.654	Plumbogummite $2PbO.3Al_2O_3.2P_2O_5.7H_2O$	Hex. Gumlike		Yellow, brown	H=4–5 G=4.0–4.9 F=2(?)	Sol. in HNO_3.
□	1.703	1.654	Rhabdophanite $(Y,Er,La,Di)_2O_3.P_2O_5.2H_2O$	Fib		Brown, reddish, yellowish, white.	H=3.5 G=4.0 Infus.	Sol. in acid.
	1.708	1.655	Dioptase $CuO.SiO_2.H_2O$	Trig	{10$\bar{1}$1}perf	Emerald-green	H=5 G=3.05 Infus.	Gelat. Anom. biax. Abs. in thick section: $\omega > \epsilon$.
	1.663	1.662	Cahnite $4CaO.B_2O_3.As_2O_5.4H_2O$	Tetrag	{110}perf	Colorless	H=3 G=3.156	Twinned. Shows abnormal interference colors in brown.
□	*1.685	1.665	Auerlite (altered) Silicophosphate of Th, etc.	Ps. tetrag		Yellow	H=3 G=4.06 Infus.	A fibrous aggregate derived from a hexagonal crystal. Henderson County, N. C.
	1.757	1.676±	Parisite $2(Ce,La,Di,Th)OF.CaO.3CO_2$	Trig	None. {001}perf. on alteration.	do	H=4.5 G=4.32 Infus.	Sol. in acid. Pleoc.: ω=light-yellow, ϵ=golden-yellow.
	1.685	1.680±	Florencite $3Al_2O_3.Ce_2O_3.2P_2O_5.6H_2O$	do	{0001}rather perf	Brown, etc	H=5 G=3.59 Infus.	Alunite group. Partly sol. in HCl.
□	1.719	1.691	Willemite $2ZnO.SiO_2$	do	{0001}variable, {11$\bar{2}$0}variable.	White, green, red, brown, etc.	H=5.5 G=3.9± Infus.	Gelat. Almost pure.
□ V	1.721	1.716	Vesuvianite $2(Ca, Mn, Mg, Fe)O.(Al, Fe)(OH, F)O.2SiO_2$	Tetrag. Pris	{110}poor	Variable	H=6.5 G=3.4 F=3	Insol. in acid. Pleoc. weak: $\omega > \epsilon$. Opt. anom.
	1.818	1.717	Bastnaesite $(Ce,La,Di)FO.CO_2$	Hex. Pris	{0001}parting	Yellow, reddish, brown.	H=4 G=5.0 Infus.	Difficultly sol. in acid. Nearly colorless in powder. Feebly pleoc.
	1.733	1.719	Bromellite BeO	Hex	{10$\bar{1}$0}fair	Colorless	H=9 G=3.017	Insol.
	1.816	1.721	Xenotime $Y_2O_3.P_2O_5$	Tetrag	{110}perf	Yellow-brown, red-brown, gray.	H=4–5 G=4.59 Infus.	Insol. in HCl. Pleoc. weak: ω=pink or light yellowish brown, ϵ=brownish yellow or greenish.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial positive group—Continued

Variability	ϵ	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.746	1.724	Connellite $20CuO.SO_3.2CuCl_2.20H_2O$	Hex. Acic.		Fine blue, greenish blue.	H=3 G=3.40 F=2.5	Sol. in HCl.
	1.810	1.730	Mixite $20CuO.Bi_2O_3.5As_2O_5.22H_2O$	Acic.		Emerald-green, blue-green.	H=3–4 G=3.79 F=2	In section pale green and nonpleochroic.
	1.765	1.75±	Buttgenbachite $16CuO.2CuCl_2.Cu(NO_3)_2.19H_2O$	Hex. Prism. to needles.		Sky-blue	G=3.33	Same as connellite?
□	B=very weak	1.754	Mcgovernite $2I(Mn,Mg,Zn)O.3SiO_2.\frac{1}{2}As_2O_3.As_2O_5.10H_2O$	Hex.(?)	{0001}mic.	Brownish red in section.	H=3 G=3.719	
	1.804	1.757	Benitoite $BaO.TiO_2.3SiO_2$	Hex. Pyram. or tab.	{10$\bar{1}$1}imperf.	Blue	H=6 G=3.65 F=3	Sol. in HF. Pleoc.: ω=colorless, ϵ=purple-blue, etc.
□	1.801	1.778	Conichalcite $4(Cu,Ca)O.As_2O_5.1\frac{1}{2}H_2O$	Fib.		Pistachio-green to emerald-green.	H=4.5 G=4.13 F=3	In section pale green and nonpleochroic. Usually biaxial.
□	1.803	1.794	Arseniopleite $9(Mn,Ca,Pb,Mg)O.(Mn,Fe)_2O_3.3As_2O_5.3H_2O$	Trig.		Brownish red		In section apricot orange and nonpleochroic.
		High	Thorite $ThO_2.SiO_2$	Tetrag. Sq. pyramids.	{110} dist.	Black, reddish-brown, orange.	H=5 G=5.3 Infus.	Gelat. before calcination? Commonly isot. from alteration.
	2.12	1.90	Trippkeite Arsenate of Cu	Tetrag. Oct.	{100} highly perf. {110} less perf.	Bluish green	Soft F=easy	Easily sol. in acid. Crystals break up into flexible, asbestoslike pieces. Bluish-green in section and nonpleochroic.
	1.945	1.910	Ganomalite $6PbO.4(Ca,Mn)O.6SiO_2.H_2O$	Hex. Tab.{0001}.	{0001}, {10$\bar{1}$0} perf.	Gray	H=3 G=5.74 F=3?	Gelat. Anom. biax. B is variable.

V	1.923	1.913	Nasonite $5PbO.4CaO.PbCl_2.6SiO_2$	Hex. Pris.	{0001}, {10$\bar{1}$0} imperf.	White	H=4 G=5.43 F=easy	
V	1.934	1.918	Scheelite $CaO.WO_3$	Tetrag. Oct. or tab.	{111} dist.	White, yellow, brown, gray.	H=5 G=6.12 F=5	Decpd. by HCl. Tw. pl. {100}. G=6.12 for pure mineral, but decreases to 5.94 for mineral with 8 per cent MoO_3. Gives a deep-blue color when powder is boiled with HCl and again boiled after zinc or tin is added.
^ V	1.985	1.926	Zircon $ZrO_2.SiO_2$	Tetrag.	{110} rare.	Colorless, yellow, etc.	H=7.5 G=4.583	Analysis: ZrO_2 71.80, SiO_2 28.45 per cent.
^ V	1.991	1.936	Zircon $ZrO_2.SiO_2$	do.	do.	Brown	H=7.5 G=4.658	Analysis: ZrO_2 67.02, SiO_2 32.51 per cent. The ZrO_2 includes about 1 per cent HfO_2.
^	1.971	1.945	Nasonite $5PbO.4CaO.PbCl_2.6SiO_2$	Hex. Pris.	{0001}, {10$\bar{1}$0} imperf.	White	H=3 G=5.43 F=easy	
□ V	*1.958	1.948	Hedyphane $4½PbO.4½(Ca,Ba)O.3P_2O_5.PbCl_2$	Hex.	Two.	do.	H=4 G=5.7 F=1	Sol. in HNO_3. Both Långban and Franklin.
□ □	B=weak	(?)	Schafarzikite $nFeO.P_2O_5$	Tetrag. Pyramids.		Red to red-brown.	H=3.5 G=4.3	Pleoch.: ω=straw-yellow. ε=brownish yellow.
	B=weak	1.96	Dixenite $5MnO.SiO_2.As_2O_3.H_2O$	Hex. Plates.	{0001} mic.	Dark brown.	H=3–4 G=4.20	Decpd. in HCl. Glowing red in transmitted light.
	2.656_{Na} 2.601_{Li}	1.973_{Na}	Calomel Hg_2Cl_2	Tetrag.	{100} {111} rather dist.	Colorless.	H=1–2 G=6.48	Sectile. Insol. in H_2O. Volatilizes at 1.
^	1.984	1.974	Powellite $CaO.(Mo,W)O_3$	Tetrag. Pyramids.	None.	Pale greenish yellow.	H=3.5 G=4.35–4.53 F=4	Decpd. by acid. Artificial mineral. Data for 570 A units.
	2.093	1.997	Cassiterite SnO_2	do.	{100}{111 }imperf.	Brown, black, gray, white.	H=6–7 G=6.8–7.1 Infus.	Insol. in acid. Tw. {110} poly. Anom. 2E. Becomes coated with metallic tin when embedded in granulated zinc and HCl.
	2.029	2.013	Zincite ZnO	Hex.	{0001} perf.	Deep red.	H=4 G=5.68 Infus.	Sol. in acid. Streak orange-yellow. Section deep red, nonpleochroic. Data for pure ZnO.
	B=rather strong	2.03±	Voltzite $ZnO.4ZnS$	Hex. Spherical globules.		Yellowish, reddish, brownish.	H=4 G=3.7 Infus.	Decpd. by acids.

163287—34——6

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial positive group—Continued

Variability	ϵ	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	2.140	2.114	Phosgenite $PbO.PbCl_2.CO_2$	Tetrag. Pris. tab.	{110}{100} dist.	White, gray, yellow.	H=3 G=6.0–6.3 F=1	Sol. in dilute HNO_3, with effervescence.
	2.21	2.13	Penfieldite $PbO.2PbCl_2$	Hex. Prisms	{0001} dist.	White	F=1	Sol. in HNO_3.
V	B=0.01	2.182	Iodyrite AgI	Hex. Thin plates.	{0001} perf.	Yellowish, greenish, brownish.	H=1–1.5 G=5.6 F=1	Sectile. Sol. in NH_4OH. Becomes isotropic at 146° C. Abnormal green interference colors.
	2.21	2.19	Kleinite Hg, NH_4, Cl, SO_4, etc.	Hex. Short prisms.	{0001} good.	Yellow, orange	H=3.5 G=7.98	Sol. in acid. Biax. — at ordinary temperature.
^	2.22	2.21	Iodyrite AgI	Hex. Thin plates.	{0001} perf.	Yellowish, greenish, brownish.	H=1–1.5 G=5.6 Fus.	Sectile. Sol. in NH_4OH. Isotropic at 146° C. Abnormal green interference colors. Anom. 2V small.
□	2.42_{Li}	2.27_{Li}	Tapiolite $FeO.(Ta,Cb)_2O_5$	Tetrag. Oct.		Black	H=6 G=7.3–7.8 Infus.	Red brown in section. Pleoc. very strong: ω=pale yellowish or reddish brown, ϵ=nearly opaque. Indices for mineral with G=7.4.
□	2.4_{Li}	2.30_{Li}	Hielmite Stannotantalate and columbate of Y, Fe, Mn, Ce, etc.	Ps. orth.		do	H=5 G=5.82 Infus.	Pleoc. very strong: ω=yellowish brown, ϵ=nearly opaque.
	2.378_{Na} 2.35_{Li}	2.356_{Na} 2.33_{Li}	Wurtzite ZnS	Hex. Short prisms. Lamellar {0001}.	{11$\bar{2}$0} easy, {0001} dif.	Varies	H=4 G=3.98 F=very dif.	Sol. in acids. Feebly pleoc.
	2.51_{Li}	2.45_{Li}	Derbylite $6FeO.Sb_2O_3.5TiO_2$	Orth. Pris. c		Black	H=5 G=4.53 Infus.	Insol. in acid. Nearly opaque. Nonpleochroic. See Biax.
□	B=mod.	2.50_{Li}	Strueverite $FeO.(Ta,Cb)_2O_5.4TiO_2$	Tetrag.		Iron-black	H=6 G=5.56	Pleoc. very strong: ω=brown, ϵ= green and nearly opaque. May be opt. —.
	2.529_{Na} 2.456_{Li}	2.506_{Na} 2.431_{Li}	Greenockite CdS	Hex. Short prisms. Crusts.	{11$\bar{2}$0} dist., {0001} indist.	Varies	H=3–3.5 G=5.0 Infus.	Sol. in HCl. Data for pure artificial crystals.

	2.903	2.616	Rutile TiO_2	Tetrag. Pris	{100}{110}dist	Yellow, red, brown, etc.	H=6 G=4.24 Infus.	Insol. in acid. Pleoc. faint.
	2.673$_{Li}$ 2.697$_{Na}$ 2.721$_{Tl}$	2.633$_{Li}$ 2.654$_{Na}$ 2.675$_{Tl}$	Moissanite CSi	Hex. Plates{0001}		Green to black	H=9.5 G=3.1 Infus.	Insol. in acid. Pleoc.: ω=light blue, ϵ=deep indigo blue. Data for artificial product.
	3.201 3.146$_{Li}$	2.854 2.819$_{Li}$	Cinnabar HgS	Hex	{10$\bar{1}$0}perf	Cochineal-red	H=2 G=8.1	Volatilizes at 1.5. Disp. very great. Circular polarization. Streak scarlet.

Uniaxial negative group

[The greater part of the minerals of this group are tetragonal or hexagonal, but some minerals that are strictly biaxial, though their axial angle is nearly zero, are included here a well as in their proper biaxial group. Many of these biaxial minerals which have nearly uniaxial optical properties have also nearly hexagonal crystal form]

	1.309	1.312	Malladrite $2NaF.SiF_4$	Ps. hex. Orth. Pris.		Colorless	G=2.75	
	B=very weak	1.328	Villiaumite NaF	Tetrag. Ps. isomet.	{001}perf. {100}, {010}dist.	Carmine-red, etc.	H=3.5 G=2.79	Sol. in H_2O. Pleoc.: ω=carmine-red, ϵ=golden-yellow.
	1.342	1.349	Chiolite $2NaF.AlF_3$	Tetrag. Sq. prisms.	{001}perf. {111}, good.	White	H=3.5–4 G=3.00 F=1.5	Sol. in acid.
	1.432	1.458	Mendozite $Na_2O.Al_2O_3.4SO_3.24H_2O$	Fib		do	H=3 G=1.73 F=1	Sol. in H_2O. May be biax.
	1.464	1.465	Gmelinite $CaO.Na_2O.2Al_2O_3.6SiO_2.10H_2O$	Trig. Cubic	{10$\bar{1}$0}easy	Colorless	H=4.5 G=2.1 F=3	Zeolite group. Decpd. by acid. Opt. anom. 2V=small. Tw. axis c.
	1.434	1.470	Chile loeweite $K_2Na_4Mg_2(SO_4)_5.5H_2O$.	Tetrag			G=2.153	
	1.478	1.480	Chabazite $Na_2O.2CaO.3Al_2O_3.18SiO_2.25H_2O$	Trig. Cubic	{10$\bar{1}$0}dist	White	H=4.5 G=2.1 F=3	Zeolite group.
	1.461	1.481	Hanksite $11Na_2O.9SO_3.2CO_2.KCl$	Hex. Short prisms.	{0001}dist	do	H=3 G=2.56 F=1.5	Readily sol. in H_2O.
	1.484	1.487	Cristobalite SiO_2	Tetrag.? Ps. isomet. Oct.		Colorless	H=6–7 G=2.3 Infus.	Insol. in acid. May be biax.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial negative group—Continued

Variability	ε	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.486	1.487	Analcite $Na_2O.Al_2O_3.4SiO_2.2H_2O$	Ps. isomet.{211}	Cubic tr	Colorless	H=5 G=2.25 F=3.5	Zeolite group. Decpd. by acid. Often biax.
	1.474	1.488	Ettringite $6CaO.Al_2O_3.3SO_3.33H_2O$	Hex. Acic. c	{10$\bar{1}$0}perf	White	H=2–2.5 G=1.75 F=3	Sol. in HCl.
∧	1.471	1.490	Loeweite $MgO.Na_2O.2SO_3.2½H_2O$	Tetrag	{001}dist	do	H=3.5 G=2.37 F=1.5	Sol. in H_2O. Opt. anom.
□	1.491	1.496	Levynite $CaO.Al_2O_3.3SiO_2.5H_2O$	Trig	{02$\bar{2}$1}dist	do	H=4 G=2.1 F=2–2.5	Zeolite group. Gelat.
	1.468	1.507	Thaumasite $3CaO.CO_2.SO_3.SiO_2.15H_2O$	Hex. Fib., etc	Tr	do	H=3.5 G=1.87 Infus.	Decpd. by acids.
□	1.500	1.507	Sulphatic cancrinite $4Na_2O.CaO.4Al_2O_3.CO_2.SO_3.9SiO_2.3H_2O$	Hex	{10$\bar{1}$0}perf	Colorless	H=5 G=2.44 F=2	Gelat. Data for mineral with CO_2 3.13, SO_3 4.65 per cent.
	1.486	1.509	Nocerite $2MgO.MgF_2.3CaF_2$	Hex. Acic		White	G=2.96	
∨	1.498	1.512	Hydrotalcite $6MgO.Al_2O_3.CO_2.12H_2O$	Hex. Plates	{0001}mic	White. Pearly luster.	H=2 G=2.06 Infus.	Hydrotalcite group. Sol. in acids.
	1.470	1.516±	Beidellite $Al_2O_3.3±SiO_2.3±H_2O$	Basal plates	{001}mic	White, green, yellow, brown.	H=1.5 G=2.6 Infus.	On standing in oils ω increases to 1.536. Becomes plastic in water. Loses its H_2O below 200° C.
	1.512	1.520	Tachhydrite $CaCl_2.2MgCl_2.12H_2O$	Trig	{10$\bar{1}$1}good	Wax to honey-yellow.	H=2 G=1.67(?) F=1	Very deliquescent. Loses much water on heating.
∧	1.496	1.524	Cancrinite $4Na_2O.CaO.4Al_2O_3.2CO_2.9SiO_2.3H_2O$	Hex	{10$\bar{1}$0}perf	Colorless, gray, yellow.	H=5–6 G=2.45 F=2	Gelat.

	1.506	1.530	Slavikite $(Na,K)_2O.5Fe_2O_3.13SO_3.66H_2O$	Trig. Flat tab. to base.		Yellowish green	G=1.905	Abs. $\omega>\epsilon$. Pleoch.: ω=lemon-yellow, ϵ=almost colorless.
V	1.522	1.532	Mizzonite Scapolite	Tetrag	{100}perf. {110}less so.	Colorless	H=6	Scapolite group. Analysis: SiO_2 54.89, Al_2O_3 22.72, FeO .08, CaO 6.32, MgO 0.14, Na_2O 7.12, K_2O 4.25, Cl 1.01, CO_2 2.00, H_2O 3.14 per cent.
V	1.527	1.532	Kaliophilite $K_2O.Al_2O_3.2SiO_2$	Hex. Prisms	{10$\bar{1}$0}dist	do	H=6 G=2.49–2.60 F=3.5	Nephelite group. Gelat Analysis: SiO_2 39.04, Al_2O_3 31.96, K_2O 22.84, Na_2O 3.89 per cent.
	1.529	1.532	Milarite $K_2O.4CaO.Al_2O_3.4BeO.24SiO_2.H_2O$	Ps. hex		Pale green	H=5.5–6 G=2.57 F=3	Insol. in acid. Basal section shows six biax. segments. Uniax. at a high temp.
	1.514	1.534	Zinc aluminite $6ZnO.3Al_2O_3.2SO_3.18H_2O$	Hex. Plates		White	H=2.5–3 G=2.26 Infus.	Sol. in acid.
[ ]	1.535	1.537	Apophyllite $K_2O.8CaO.16SiO_2.16H_2O$	Tetrag	{001} highly perf. {110}less so.	Colorless, rose, etc.	H=5 G=2.35 F=1.5	Decpd. by acid. Opt. anom.
	1.511	1.539	Mellite $Al_2O_3.C_{12}O_9.18H_2O$	Tetrag. Sq. pyramids.	{111}indist	Honey-yellow, red-brown, white.	H=2.5 G=1.6	Sol. in HNO_3. Decpd. by boiling H_2O. 2E reaches 8°.
V	1.535	1.539	Nephelite $(Na,K,Ca)_8(Al,Si)_{16}O_{32}$	Hex	{10$\bar{1}$0}dist. {0001} imperf.	Colorless	H=6 G=2.63 F=3.5	Gelat. Luster greasy. Refr. index increases with K content. Na: K:Ca=30:6:1; Al:Si=19:21.
	Low biref.		Ameletite $NaAlSiO_4.NaCl$?	do				Stains violet with $AgNO_3$ solution.
> [ ]	1.510	1.540	Brugnatellite $6MgO.Fe_2O_3.CO_2.12H_2O$	Hex. Tab.{0001}	{0001}mic	White, etc. Pearly luster	H=2–3 G=2.07 Infus.	Near pyroaurite. Hydrotalcite group. Sol. in acids. Pleoc.: ω=yellow red, ϵ=colorless.
>	1.538	1.542	Nephelite $Na_2O.Al_2O_3.2SiO_2$	Hex	{10$\bar{1}$0}dist. {0001} imperf.	Colorless	H=6 G=2.6 F=3.5	Nephelite group. Gelat. Luster greasy.
> [ ]	1.516	1.542	Stichtite $6MgO.Cr_2O_3.CO_2.12H_2O$	Hex. Plates{0001}	{0001}mic	Lilac	H=1.75 G=2.16 Infus.	Hydrotalcite group. Sol. in acid. Anom. biax. Pleoc. weak. Abs.: $\omega>\epsilon$.
	B=low	1.545	Eucryptite $Li_2O.Al_2O_3.2SiO_2$	Hex	{0001}dist		G=2.67	Nephelite group. Gelat.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial negative group—Continued

Variability	ε	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
□	1.503	1.545	Pholidolite $K_2O.12(Mg,Fe)O.Al_2O_3.13SiO_2.5H_2O$	Mon. Hex. scales	{001}mic	Grayish yellow	H=4 G=2.41	Nearly colorless in section. Biax. with 2V small.
V	1.522	1.547	Fluoborite $6MgO.B_2O_3.3(F_2,H_2O)$	Hex. Fib		White	H=3 G=2.92	Dif. sol. in acid. $H_2O:F_2$=2:3. Sterling Hill.
□	1.536	1.549	Gyrolite $4CaO.6SiO_2.5(H,Na,K)_2O$	Trig. Fib. lamellae.	{0001}mic	White, etc.	H=3–4 G=2.39 F=dif.	Zeolite group. Decpd. by HCl.
^ V	1.538	1.551	Mizzonite Scapolite.	Tetrag	{100}rather perf. {110}less so.	Colorless	H=6 G=2.61 F=3	Scapolite group. Data for $Ma_{75}Me_{25}$, low in CO_2. Insol. in acid. CO_2 increases the birefringence.
	B=0.01	1.555	Saponite MgO,Al_2O_3,SiO_2,H_2O	Minute scales		Greasy white	Soft G=2.26±	
□	1.54	1.560	Jefferisite $10(Mg,Fe)O.4(Al,Fe)_2O_3.10SiO_2.7H_2O$	Ps. hex	{0001}mic	White, green, brown, etc.	H=1.5 G=2.30	A vermiculite. Altered mica. Decpd. by HCl. When heated at 300° C. it exfoliates very remarkably; on higher heating it becomes pearly white and ultimately fuses to a dark-gray mass.
	1.495	1.560	Trudellite $4AlCl_3.3Al_2O_3.3SO_3.36H_2O$	Trig	{10$\bar{1}$1}perf.	Amber-yellow	H=2.5 G=1.93 Infus.	Deliquescent.
	1.560	1.565	Zeophyllite $3CaO.CaF_2.3SiO_2.2H_2O$	do	{0001}mic	Colorless, white	H=3 G=2.76 F=very easy	Zeolite group. Gelat. Biaxial borders. 2V=0° to 27½° and disp. $r<v$.
		(?)	Radiophyllite $CaO.SiO_2.H_2O$	Spherical aggregate of radiating scales.		White	H=2–3 G=2.53	Decomposed by HCl with separation of powdery silica.
^ V	B=0.01	1.565±	Pyroaurite $6MgO.Fe_2O_3.CO_2.12H_2O$	Hex. Tab. {0001} Fib.	{0001}mic	White, etc. Pearly	H=2–3 G=2.07 Infus.	Hydrotalcite group. Sol. in acid. Pleoc.: ω=yellow red, ϵ=colorless.
^	1.528	1.566	Fluoborite $6MgO.B_2O_3.3(H_2O, F_2)$	Hex. Pris.		Colorless	H=3.5 G=2.89	Sol. in H_2SO_4. $H_2O:F_2$=12:5.

◇ ◇	1.545	1.567	Wernerite Scapolite	Tetrag.	{100} rather perf. {110} less so.	do	H=5–6 G=2.65 F=3	Scapolite group. Data for Ma_{50} Me_{50}, low in carbonate. Insol. in acid. The carbonate scapolite has a stronger birefringence.
□ ◇	1.564	1.568	Beryl $3BeO.Al_2O_3.6SiO_2$	Hex. Pris.	{0001} imperf.	Colorless, green, blue, etc.	H=8 G=2.66 Infus.	Insol. in acid. Pleoc. variable. Data for mineral with Na_2O= 0.43.
	B=weak	1.57	Lawrencite $FeCl_2$	Hex. Tablets.		Green or brown		Not stable.
	1.57	1.575	Calcioferrite $6CaO.3Fe_2O_3.4P_2O_5.19H_2O$	Mon. (?) Scales, nodules.	{001} very perf.	Yellow-green	H=2.5 G=2.53 F=easy	Easily decpd. by HCl.
	1.546	1.576	Parsettensite $3MnO.4SiO_2.4H_2O$	Ps. hex.		Copper-red	G=2.59 Fus.	Decpd. by acid. Vein filling. ω= greenish yellow. ε=nearly colorless.
□	1.577	1.579	Penninite $5(Mg,Fe)O.Al_2O_3.3SiO_2.4H_2O$	Mon. Hex. plates and shreds.	{001} perf.	Green, etc.	H=2 G=2.7 F=dif.	Chlorite group. Decpd. by H_2SO_4. Biax. with 2V=0°±. Pleoc.: X nearly colorless, Y and Z green. Abnormal blue interference color.
◇ ◇	1.575	1.581	Beryl $3BeO.Al_2O_3.6SiO_2$	Hex. Pris.	{001} imperf.	Colorless, green, blue, yellow.	H=8 G=2.714 Infus.	Insol. in acid. Pleoc. variable. Data for mineral low in alkalies.
◇ ◇	1.545	1.582	Meionite Scapolite	Tetrag.	{100} perf. {110} less so.		H=5–6 G=2.690	Scapolite group. Ma_{29} Me_{71}. Analysis: CO_2 3.54, H_2O 1.56, CaO 17.42, Na_2O 3.50 per cent.
	1.560	1.586	Uranospinite $CaO.2UO_3.As_2O_5.8H_2O$	Tetrag. Ps. orth. Rect. tablets.	{001}	Yellow	H=2–3 G=3.45 Fus.	Sol. in acid. See Biaxial negative group, p. 163. Pleoc.: ω=pale yellow, ε=colorless.
	1.336	1.587	Soda niter $Na_2O.N_2O_5$	Trig.	{10$\bar{1}$1} perf.	White	H=2 G=2.27 F=1	Tastes cooling. Soluble in H_2O. Deflagrates on heating.
	1.56	1.59±	Connarite $2NiO_2.3SiO_2.2H_2O$	Hex.	{0001} perf.	Yellow-green	H=2.5–3 G=2.5	Faintly pleoc.
	1.573	1.591	Metavoltine $5(K_2,Na_2,Fe)O.3Fe_2O_3.12SO_3.18H_2O$	Hex. Scales.		Yellow	H=2.5 G=2.53 F=5	Sol. in acid. Partly sol. in H_2O. Pleoc.: ω=yellow, ε=green to nearly colorless.
	1.582	1.592	Torbernite $CuO.2UO_3.P_2O_5.12H_2O$	Tetrag. or Mon. Tab. {001}.	{001} mic.	Green	H=2 G=3.5 F=3	Luster on {001} pearly. Sol. in acid.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial negative group—Continued

Variability	ε	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^	1.590	1.598	Beryl $3(Be,Na_2)O.Al_2O_3.6SiO_2$	Hex. Prisms	{0001}imperf	Colorless, pink, etc.	H=8 G=2.80 Infus.	Insol. in acid. Pleoc. variable. Data on mineral high in alkalies.
□	B=strong	1.600	Biotite $K_2O.4(Mg,Fe)O.2(Al,Fe)_2O_3.6SiO_2.H_2O$	Mon. Hex. plates	{001}mic	Brown, black, green.	H=3 G=2.7–3.1 F=dif.	Mica group. Decpd. by H_2SO_4. Pleoc. marked in brown or green. Abs: X<Y and Z.
	1.55±	1.60±	Chloralluminite $AlCl_3.6H_2O$	Rhomb		Colorless, white, or yellow.		Vesuvius.
	1.591	1.601	Dennisonite $6CaO.Al_2O_3.2P_2O_5.5H_2O$	Hex. (?) Fib	{0001}perf	Colorless	H=4.5 G=2.85	From Lewiston, Utah.
v	1.598	1.603	Dahllite $4CaO.P_2O_5.(H_2O,CO_2)$	Hex. Spherules		Yellow	H=5	Sol. in HCl with slight effervescence. $CO_2:H_2O$=1:3.
	1.571	1.607	Meionite $Ma_{12}Me_{88}$	Tetrag	{100}perf. {110} less so.	Colorless	H=5.5 G=2.7± F=4	Scapolite group. Analysis: Cl 0.22, SO_3 0.27, CO_2 4.07 per cent. Decpd. by acid.
	1.593	1.612	Meliphanite $2CaO.2BeO.3SiO_2.NaF$	Tetrag. Obtuse pyramids.	{001}dist	Yellow	H=5 G=3.01	Insol. Fuses with intumescence. Anom. biax. Related to melilite.
	1.607	1.613	Fluocerite $(Ce,La,Di)F_3$	Hex	{0001}perf	Wax-yellow	H=4.5–5 G=5.6–6.1 Infus.	Insol. in acid.
	1.552	1.618	Chalcophyllite $20CuO.Al_2O_3.2As_2O_5.3SO_3.25H_2O$	Hex. Tab. {0001}	do	Deep emerald-green.	H=2 G=2.5 F=2–2.5	Luster on {0001} pearly. Related to tyrolite. Sol. in HNO_3 and NH_4OH. Pleoc.: ω=bluish green, ε=almost colorless. Data for fresh mineral. Loses H_2O below 100° C. with increase of indices.
^ v	1.609	1.620±	Dahllite $7CaO.2P_2O_5.CO_2.½H_2O$	Hex. Fib		Colorless	H=5 G=2.87–3.05 Infus.	Apatite group. Sol. in acid.
	1.619	1.621	Gillespite $BaO.FeO.4SiO_2$	Tetrag. Platy	Basal mic	Rose-red	H=3 G=3.33 F=very easy	Decpd. by HCl. Pleoc. strong: ω=very pale pink, ε=deep rose red.

□ □	1.618	1.621	Eucolite $6Na_2O.6(Ca,Fe)O.20(Si,Zr)O_2.NaCl$	Trig	{0001}imperf.{11$\bar{2}$0} poor.	Colorless, brown, red, etc.	H=5 G=3.1 F=2.5	Gelat.
	1.620	1.623	Merrillite $Na_2O.3CaO.P_2O_5$	Hex. (?)	None	Colorless	H=(?) G=3.10	Sol. in acid. Found only in meteorites.
	1.613	1.624	Lewistonite $15CaO.(Na,K)_2O.4P_2O_5.8H_2O$	Pris	{0001} perf	Colorless, yellow	H=5 G=3.05	Sol. in acid. Also biax. with $2V=42°\pm$.
^ v	B=low	1.625	Francolite $10CaO.3P_2O_5.CO_2.CaF_2.H_2O$	Ps. hex. Fib			H=4.5 G=3.1 F=easy	Apatite group. Sol. in HNO_3. Basal section shows six biax. segments.
	1.605±	1.626	Bazzite Silicate of Sc, etc.	Hex. Barrel shapes		Bright azure-blue	H=6.5 G=2.8 Infus.	Insol. in acids. Becomes dark and opaque b. b. Pleoc.: ω=very pale greenish yellow, ϵ=intense azure-blue.
	1.582	1.627	Troegerite $3UO_3.As_2O_5.12H_2O$	Tetrag.? Sq. tablets {001}.	{001} perf., {100} good.	Lemon-yellow	Soft G=3.3 F=2.5	Sol. in acid.
^ v	1.626	1.632	Melilite $(Ca,Na)_2(Mg,Al)(Al,Si)_2O_7$	Tetrag	{001} dist	Colorless	H=5 G=2.98 F=3	*Melilite group. Gelat. Data for* mineral with åkermanite 46, gehlenite 31, soda melilite 13, *submelilite* 10 per cent. (See table 16, p. 238.)
v	1.602	1.632	Bementite $8MnO.7SiO_2.5H_2O$	Stalactitic. Fib		Brown	H=4–6 G=2.90	Tend to lie on base. Weakly pleoc.: $\omega > \epsilon$.
□	1.575	1.632	Chalcophyllite (altered) $7CuO.As_2O_5.14H_2O$(?)	Trig. Hex. tablets	{0001} highly perf. {10$\bar{1}$1} traces.	Emerald-green	H=2 G=2.5 F=2–2.5	Luster on {0001} pearly. Related to tyrolite. Sol. in HNO_3 and NH_4OH.
	1.629	1.633	Voelckerite $10CaO.3P_2O_5$	Hex	None	White	Infus.	Apatite group. Sol. in HCl.
^ v	1.630	1.633±	Fluorapatite $9CaO.3P_2O_5.CaF_2$	Hex. Pris	{0001}imperf	Colorless	H=5 G=3.2 F=5	Apatite group. ω increases with Cl. Sol in acid. Pleoc. rare. Abs.: $\epsilon > \omega$. Data for pure artificial mineral.
^	1.631	1.635	Dahllite $7CaO.2P_2O_5.CO_2$	Hex. Fib	None		H=3 G=3.08 Infus.	Apatite group. Sol. in HCl. Optical anom. in hex. segments.
v	1.613	1.636	Dravite (tourmaline) $Na_2O.6MgO.6Al_2O_3.3B_2O_3.12SiO_2.4H_2O$	Rhomb. Pris	do	Brown, gray	H=7 G=3.038	Tourmaline group. Magnesium member. Insol.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial negative group—Continued

Variability	ϵ	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.615	1.637	Mitscherlichite $2KCl.CuCl_2.2H_2O$	Tetrag. Tw. on {111}.		Green, blue	G=2.418	Data for artificial mineral. Pleoc.: X=sky-blue, Z=grass-green. Some specimens orth. and biax.; tw. on {110}.
^ v	B=0.05	1.64	Lepidomelane Biotite rich in ferric iron	Mon. Scales	{001}mic	Black	H=3 G=3.1± F=4.5–5	Mica group. Gelat. Green, etc., in section and strongly pleoc. Abs. $\omega > \epsilon$.
	*1.614 *1.633	1.622 1.640	Dehrnite $7CaO.Na_2O.2P_2O_5.H_2O$	Ps. hex. Pris	{0001} perf	Colorless, yellow	H=5 G=3.05 F=2	Sol. in acid. From Lewiston, Utah, and Dehrn.
	B=mod.?	1.640	Jeremejevite $Al_2O_3.B_2O_3$	do	None	Colorless	H=6.5 G=3.28 Infus.	Resembles beryl. Sol. in KOH. Divided into six sectors. 2E variable.
^ v	1.621	1.641	Uvite (tourmaline) $2CaO.6MgO.6Al_2O_3.3B_2O_3.12SiO_2.3H_2O$	Rhomb. Pris	do		H=7 G=3.054	Tourmaline group. Calcium member. Insol.
	1.623	1.643	Zeunerite $CuO.2UO_3.As_2O_5.8H_2O$?	Tetrag. Rect. Tab. {001}.	{001}perf	Grass, apple, or emerald green.	H=2–2.5 G=3.2 F=3	Sol. in HNO_3. Pale green in section.
^ v	1.625	1.646	Indicolite (tourmaline) $NaR_3Al_6B_3Si_6O_{28}(OH,F)_3$	Rhomb. Pris	None	Bluish green	H=7 G=3.086	Tourmaline group. R=Li:Fe'': Mg:Al=5:8:2:15. (OH):F=5:1.
^ v	1.636	1.647	Gehlenite $(Ca, Na)_2(Mg,Al)(Al,Si)_2O_7$	Tetrag. Platy {001}.	{001} imperf	Brown to honey-yellow.		Melilite group. Gehlenite 51, åkermanite 37, soda melilite 12 per cent.
^ v	1.625	1.648	Rubellite (tourmaline) $NaR_3Al_6B_3Si_6O_{28}(OH,F)_3$	Rhomb. Pris	None	Red	H=7 G=3.135	Tourmaline group. R=Li:Mn: Al=1:2:3.
	1.644	1.649	Apatite $9CaO.3P_2O_5.Ca[F_2,(OH)_2,CO_3,Cl_2]$	Hex. Pris	{0001} imperf	Colorless	H=5 G=3.16 F=5	Sol. in acid. Abs. $\epsilon > \omega$. Contains F 3.31, Cl 0.37, H_2O 0.71, CO_2 0.57 per cent.
^ v	1.643	1.649	Daphnite $27FeO.10Al_2O_3.18SiO_2.28H_2O$	Mon. Plates and fib.	{001} perf	Dark green	Soft.	Chlorite group. Decpd. by warm HCl. Pleoc. ω=olive-green, ϵ=pale yellowish.

^	1.624	1.650	Bementite $8MnO.7SiO_2.5H_2O$	Orth. Plates {100}, fibers.	{100} mic., {010}, {001} perf.	Pale yellow. Pearly.	H=6 G=3.11 F=3.5	Decpd. by acid.
	1.575	1.650	Szaibelyite $10MgO.6B_2O_3.3H_2O$	Acic. Nodular		White, yellow	H=3–4 G=2.76 Fus.	Dif. sol. in acid. Related to camsellite.
⊓ v	*1.623	1.653	Friedelite $9(Mn,Fe)O.8SiO_2.MnCl_2.7H_2O$	Trig. Tab. {0001}	{0001} perf. {10$\bar{1}$0} imperf.	Colorless, pink	H=4 G=3.07 F=4	Decpd. in acid. Fuses to a black glass. Opt. anom. with small 2V. Franklin and Westerwald.
^ v	1.633	1.655	Tourmaline $(Na, Ca)R_3Al_6B_3Si_6O_{29}(OH)_2$	Rhomb. Pris.	None	Black	G=3.089	Na:Ca=2:1. R=Mg:Fe″:Al=3:1:2. Pleoc.: ϵ=buff; ω=honey-yellow.
	1.650	1.655	Wilkeite $20CaO.3P_2O_5.CO_2.3SiO_2.3SO_3$	do	do	Pale rose-red, etc.	H=5 G=3.23 F=5.5	Apatite group. Sol. in acid.
^ v	1.651	1.655	Manganapatite $9(Ca,Mn)O.3P_2O_5.Ca(F,OH)_2$	Hex. Pris.	{0001} imperf.	Green	H=5 G=3.257 F=5	Near apatite. Sol. in acid. Fluorapatite with 3.1 per cent MnO and ½ F replaced by OH.
	*1.645	1.655	Koninckite $Fe_2O_3.P_2O_5.6H_2O$	Fib		Yellow-green	H=3 G=2.3–2.5 F=2.5–3	Sol. in strong acid. Richelle.
^ v	1.653	1.657	Velardeñite (gehlenite) $(Ca,Na)_2(Mg,Al)(Al,Si)_2O_7$	Tetrag. Rect.	{001} imperf.	Dull olive-green	H=6±	Melilite group. Data for gehlenite 71 per cent, åkermanite 29 per cent.
v	1.486	1.658	Calcite $CaO.CO_2$	Trig.	{10$\bar{1}$1} perf.	Colorless	H=3 G=2.715 Infus.	Effervesces in acid. Data on pure $CaCO_3$.
⊔	B=weak	1.660	Fermorite $9(Ca,Sr)O.(P,As)_2O_5.Ca(OH,F)_2$	Hex.	None		H=5 G=3.52 Infus.	Apatite group. Luster greasy. Sol. in acids.
^ v	1.636	1.662	Tourmaline $(Na, Ca)R_3Al_6B_3Si_6O_{28}(OH)_3$	Rhomb. Pris.	do	Black	H=7 G=3.00	Na:Ca=7:3. R=Mg:Fe″:Fe‴=7:3:2. Pleoc.: ω=buff; ϵ=neutral gray.
^ v	B=low	1.664	Apatite $9CaO.3(P,As)_2O_5.Ca(F,OH)_2$	Hex.	{0001} imperf.	White	H=5 G=3.446	Contains P_2O_5 28, As_2O_5 16 per cent.
^ v	1.629	1.664	Friedelite $9(Mn,Fe)O.8SiO_2.MnCl_2.7H_2O$	Trig. Tab. {0001}	{0001} perf. {10$\bar{1}$0} imperf.	Colorless, pink	H=4 G=3.07 F=4	Decpd. in acid. Fuses to a black glass. Nearly colorless in section. Thick plates pleoc. Abs.: ω>ϵ. Opt. anom. with small 2V and optic plane {11$\bar{2}$0}.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial negative group—Continued

Variability	ϵ	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.664	1.667	Chlorapatite $9CaO.3P_2O_5.CaCl_2$	Hex. Pris	{0001} imperf	Colorless	H=5 G=3.20 F=5	ω decreases with F. Sol. in acid. Pleoc. rare. Abs.: $\epsilon>\omega$. Data for pure artificial mineral.
^ u	1.490	1.667	Plumbocalcite $(Ca,Pb)O.CO_2$	Trig	{10$\bar{1}$1}perf	do	H=3 Infus.	Effervesces in acid. $PbCO_3$ 1.9 per cent.
^ v	1.658	1.669	Velardeñite (gehlenite) $2CaO.Al_2O_3.SiO_2$	Tetrag. Rect	{001}imperf	do	H=6 G=3.04 F=6	Melilite group. Gelat. Data for pure artificial mineral.
^ v	1.657	1.669	Hardystonite $2CaO.ZnO.2SiO_2$	Tetrag. Granular	{001}good, {100}, {110}rare.	White	H=3 G=3.4 F=dif.	Gelat. Melilite group.
^ v	1.658	1.670	Iron åkermanite $2CaO.FeO.2SiO_2$	Tetrag	{001}imperf	Colorless	H=5.5 G=3.23	Melilite group. Artificial product.
^ v	1.636	1.675	Pyrosmalite $9(Fe,Mn)O.8SiO_2.FeCl_2.7H_2O$	Trig	{0001} perf. {10$\bar{1}$0} poor.	Colorless, green, brownish.	H=4 G=3.1 F=3	Decpd. by acid. Fuses to a black glass. Nearly colorless in section. Thick plates pleoc. Abs.: $\epsilon>\omega$.
	1.59	1.675	Chloromagnesite $MgCl_2$	Hex. plates		Colorless	Soft F=1	Very deliquescent.
	1.655	1.680	Sincosite $V_2O_4.CaO.P_2O_5.5H_2O$	Tetrag. Basal plates.	{001}good	Leek-green	Soft G=2.84	Sol. in dilute acid giving blue sol. Pleoc.: ω=gray-green, ϵ=nearly colorless. Tw. {110}. Alters to biax. hydrate.
v	1.500	1.681	Dolomite $CaO.MgO.2CO_2$	Trig. Rhombs	{10$\bar{1}$1}perf	White	H=4 G=2.87 Infus.	Does not effervesce in cold dilute acid. Data for pure mineral.
v	1.643	1.681	Schallerite $8MnO.6SiO_2.½As_2O_3.4H_2O$	Rhomb. (?)	{0001}perf	Brown	H=4 G=3.339	Friedelite group.
^ v	1.672	1.684	Svabite $9CaO.3(As_2O_5.P_2O_5)$, $Ca(F,OH)_2$	Hex		Green, greasy luster.	H=4± G=3.542	Apatite group, intermediate between svabite and apatite; svabite, 63½ per cent, apatite 36½ per cent.

^ v	1.641	1.687	Chromium tourmaline $(Ca,Na)R_3Al_6B_3Si_6O_{27}(OH)_4$	Hex. Pris.	None	Black	H=7 G=3.3	Insol. in acid. Pleoc. strong: ω=green to bluish green, ϵ=yellow. R=Cr:Mg:Fe″=7:6:2. Na:Ca=2:1.
^ v	1.60	1.69	Stilpnomelane $2(Fe,Mg)O.(Fe,Al)_2O_3.5SiO_2.3H_2O$	Plates. Mon.	{001}mic.	do.	H=3.5 G=2.85 F=4.5	Chalcodite. Chlorite group. Decpd. by acid. Strongly pleoc.: ω=dark brown and nearly opaque, ϵ=yellowish.
^	1.691	1.691	Gehlenite (fuggarite) $(Ca,Na)_2(Al,Mg)(Al,Si)_2O_7$	Tetrag.	{001}imperf.	Colorless.	H=6.0 G=3.0 F=dif.	Melilite group. Gelat. Isot. in yellow light. Abnormal interference colors. Gehlenite 56, åkermanite 35, soda melilite 9 per cent.
	1.641	1.694	Spangolite $AlClO.6CuO.SO_3.9H_2O$	Trig. Tab.	{0001}perf.	Dark green, bluish green.	H=2 on{0001} 3 on pyramids. G=3.14 F=3	Pleoc.: ω=green, ϵ=bluish green.
^	1.658	1.698	Tourmaline $Na_2O.8FeO.8Al_2O_3.4B_2O_3.16SiO_2.5H_2O$	Rhomb. Pris.	None		H=7	
^ v	1.518	1.698	Ankerite $CaO.(Mg,Fe)O.2CO_2$	Trig.	{10$\bar{1}$1}perf.	Colorless.	H=3 G=2.95 Infus.	Data for mineral with $CaCO_3$ 52.6, $MgCO_3$ 36.7, $FeCO_3$ 10.7 per cent. Sol. in acid.
v	1.509	1.700	Magnesite $MgO.CO_2$	Trig. Massive.	do.	Colorless, white, etc.	H=3.5–4 G=2.96 Infus.	Sol. in hot acid. Data for pure $MgCO_3$.
^ v	1.679	1.704	Schallerite $12MnO.9SiO_2.As_2O_3.7H_2O$	Hex.(?)	{0001}perf.	Red-brown.	H=4.5 G=3.37 F=dif.	Decpd. by HCl slowly.
^ v	1.698	1.706	Svabite $9CaO.3As_2O_5.CaF_2$	Hex. Pris. Fib.	None	Colorless.	H=5 G=3.5–3.8 F=5	Apatite group. Sol. in acid.
^	1.698	1.707	Genevite $CaO,MgO,FeO,Al_2O_3,Fe_2O_3,SiO_2$	Tetrag.	{100} {001}	do.	G=3.16 F=3	Melilite group? Easily attacked by hot HCl.
^ v	1.700	1.712	Vesuvianite (beryllium bearing) $2RO.6CaO.4BeO.Al_2O_3.6SiO_2$	do.	{110}poor.	Brown.	H=6± G=3.385	R=Mg:Mn:Zn=8:7:6. Abs. in brown.
⊏	B=strong	1.712	Palmierite $3(K,Na)_2O.4PbO.7SO_3$	Mic. Hex. plates.		Colorless, with pearly luster.	G=3.33 F=easy	Sol. in HNO_3. Decpd. in boiling H_2O.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial negative group—Continued

Variability	ϵ	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.705	1.713	Vesuvianite (cyprine)	Tetrag. Massive	{110}poor	Greenish blue	H=6±	Contains about 1 per cent of CuO.
^ v	1.526	1.716	Ankerite $CaO.(Mg,Fe)O.2CO_2$	Trig. Rhombs	{10$\bar{1}$1}perf	White, etc	H=4 G=2.97 Infus.	Sol. in acid. Data for mineral with $CaCO_3$ 52, $MgCO_3$ 26, $FeCO_3$ 22 per cent.
^ □	*1.700	1.718	Ferroschallerite $12(Mn,Fe)O.9SiO_2.As_2O_3.7H_2O$	Hex. (?)	{0001}perf	Brown	H=4± G=?	Some specimens biaxial. MnO:FeO=2:1.
^	1.715	1.719	Vesuvianite $4CaO.Al_2O_3.4SiO_2.H_2O$	Tetrag	{110}poor	Olive-green	H=6± G=3.36	Al:Fe'''=8:1. MgO 2.45 per cent.
^ v	1.534	1.721	Calcite (manganese bearing) $(Ca,Mn)O.CO_2$	Trig	{10$\bar{1}$1}perf	Pink	H=3 G=3.143	Data for mineral with $MnCO_3$ 42.17, $CaCO_3$ 57.83 per cent.
	1.681	1.723	Pyrochroite $MnO.H_2O$	do	{0001}mic	White	H=2.5 G=3.26 Infus.	Difficultly sol. in acid. Abs.: $\omega > \epsilon$ Luster pearly. Darkens on exposure.
^ □	1.527	1.726	Magnesite $(Mg,Fe)O.CO_2$	Trig. Rhombs	{10$\bar{1}$1}perf	do	H=4 G=3.09 Infus.	Sol. in hot acid. Data for mineral with $MgCO_3$ 85, $FeCO_3$ 15 per cent.
□ □	1.72	1.73±	Melanocerite Silicate of Ce,Y,Ca, etc., containing fluorine and boron	Trig. Tab.{0001}	Conch	Deep brown to black.	H=5–6. G=4.13 Infus.	Decpd. by acid. Very pale yellow in section.
	1.714	1.733	Hematolite $8MnO.(Al,Mn)_2O_3.As_2O_5.8H_2O$	Trig	{0001}perf	Brown, red, etc	H=3.5 G=3.416 Infus.	Sol. in acid. Luster greasy. In section yellowish to brown. Opt. anom. 2V small.
□ □	1.645	1.748	Freirinite $6(Cu,Ca)O.3Na_2O.2As_2O_5.6H_2O$	Tet. Flakes	{001}perf. {100} imperf.	Greenish blue	G=3.3 F=easy	Easily sol. in HCl. Fuses with intumescence. Pleoc.: ω=light greenish blue, ϵ=deep greenish blue. Cu:Ca=4:1.
^ □	1.547	1.749	Ankerite $CaO.(Fe,Mg)O.2CO_2$	Trig. Rhombs	{10$\bar{1}$1}perf	White	H=4 G=3.12 Infus.	Sol. in acid. Data for mineral with $CaCO_3$ 48.3, $MgCO_3$ 11.3, $FeCO_3$ 37.9, $MnCO_3$ 2.5 per cent.

^ □	1.63	1.76	Stilpnomelane $2(Fe,Mg)O.(Fe,Al)_2O_3.5SiO_2.3H_2O$	Mon. Hex. plates	{001}mic	Black	H=3–4 G=3 F=4.5	Chlorite group. Decpd. by HCl. Strongly pleoc.: X=Yellowish, Y and Z=dark brown and nearly opaque.
	1.577	1.760	Cordylite $Ce_2O_3.3CO_2.BaF_2$	Hex. Pyram	{0001}perf	Wax-yellow	H=4.5 G=4.31	Sol. in HCl. B. b. decrepitates and becomes brown. Pleoc.: ω=greenish yellow, ϵ=brownish yellow.
	B=rather strong	1.76	Cappelenite Borosilicate of Y and Ba	Hex	None	Green-brown	H=6–6.5 G=4.41 F=dif.	Sol. in HCl.
	1.760	1.768	Corundum Al_2O_3	Trig	{0001}perf. parting	Red, blue, etc.	H=9 G=4.0 Infus.	Insol. in acid. Pleoc.: ω=green, ϵ=blue, etc. Anom., 2V up to 58°.
	B=strong	1.77	Nordenskioeldine $CaO.SnO_2.B_2O_3$	do	{0001}perf	Sulphur-yellow	H=5.5–6 G=4.20 Infus.	Imperfectly decpd. by HCl. Sinters.
	1.770	1.772	Swedenborgite $Na_2O.2Al_2O_3.Sb_2O_5$	Hex. Pris	{0001}dist	Colorless to wine-yellow.	H=8 G=4.29	Insol. in acid.
□	1.570	1.788	Mesitite $(Fe,Mg)O.CO_2$	Trig. Rhombs	{10$\bar{1}$1}perf	White	H=4 G=3.43 Infus.	Sol. in hot acid. Data for mineral with $FeCO_3$ 50, $MgCO_3$ 50 per cent.
	1.72	1.80	Ferritungstite $Fe_2O_3.WO_3.6H_2O$	Hex. Plates and fib.		Pale yellow		Decpd. by acid. Elongation of fib.+.
^	B=strong	1.80	Cronstedtite $7(Fe,Mg)O.3Fe_2O_3.4SiO_2.8H_2O$	Trig.(?) Tapering hex. pyramids.	{0001}mic	Black	H=3.5 G=3.34 F=4	Chlorite group. Gelat. Pleoc. marked: Dark reddish brown to nearly opaque.
	1.75	1.80	Ammoniojarosite $(NH_4)_2O.3Fe_2O_3.4SO_3.6H_2O$	Hex.(?) Flattened grains.	{0001}dist	Pale ocher, yellow		Member of the alunite group.
□	1.761	1.815	Molybdophyllite $2(Pb,Mg)O.SiO_2.H_2O$	Hex. Lamellar	{0001}perf	Pale green, colorless.	H=3–4 G=4.72 F=dif.	In section colorless.
	*1.728	1.816	Borgstroemite $3Fe_2O_3.4SO_3.9H_2O$	Trig. Rhombs. Earthy.		Yellow		Sol. in acid. Pleoc.: ω=dark yellow, ϵ=light yellow.
^ v	1.597	1.817	Rhodochrosite $MnO.CO_2$	Trig	{10$\bar{1}$1}perf	Pink	H=4 G=3.70 Infus.	Sol. in acid. Turns black on heating. Data for mineral composed of pure $MnCO_3$.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial negative group—Continued

Variability	ϵ	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.715	1.820	Jarosite $K_2O.3Fe_2O_3.4SO_3.6H_2O$	Trig. Rhombs. Tablets.	{0001}dist.	Yellow	H=3 G=3.2 F=4.5	Alunite group. Sol. in acid. Base divided into six biax. segments. Pleoc.: ω=yellowish, ϵ=colorless.
^ v	1.605	1.826	Rhodochrosite $(Mn,Fe)O.CO_2$	Trig. Rhombs.	{10$\bar{1}$1}perf.	Pink	H=4 G=3.74 Infus.	Sol. in acid. Turns black on heating. Data for mineral with $MnCO_3$ 79.3, $FeCO_3$ 19.9, $CaCO_3$ 0.8 per cent.
□ v	1.596	1.830	Siderite $(Fe, Mg)\ O.CO_2$	Trig.	do	Colorless to brown	H=4 G=3.64 Infus.	Sol. in HCl. Data for mineral with $FeCO_3$ 73.2, $MnCO_3$ 2.2, $MgCO_3$ 23.3, $CaCO_3$ 1.3 per cent.
	1.750	1.832	Natrojarosite $Na_2O.3Fe_2O_3.4SO_3.6H_2O$	Trig. Hex. plates.	{0001}dist.	Yellow, brown	H=3 G=3.2 F=4.5	Alunite group. Sol. in acid. Faintly pleoc.: ω=pale yellowish, ϵ=colorless.
^ v	1.615	1.849	Siderite $(Fe,Mn)O.CO_2$	Trig.	{10$\bar{1}$1}perf.	Colorless	H=4 G=3.80 Infus.	Sol. in acid. Data for mineral with $FeCO_3$ 77.2, $MnCO_3$ 15.8, $MgCO_3$ 6.6, $CaCO_3$ 0.4 per cent.
^ v	1.621	1.849	Smithsonite $ZnO.CO_2$	do	do	do	H=4.4 G=4.398 Infus.	Sol. in acid. Data for mineral with $ZnCO_3$ 97, $(Fe, Ca, Mg)CO_3$ 3 per cent. Indices for sodium light.
	B=0.04±	1.85	Beaverite $CuO.PbO.Fe_2O_3.2SO_3.4H_2O$	Hex. plates		Yellow	G=4.36	
□ v	1.803	1.853	Hoegbomite $MgO.2(Al,Fe)_2O_3$, some TiO_2	do	None	do	H=6.5 G=3.81 Infus.	Insol. in acid. Pleoc. strong. ω=dark brown, ϵ=light yellow-brown. Alteration of pleonaste.
^ v	1.613	1.855	Siderite $FeO.CO_2$	Trig.	{10$\bar{1}$1} perf.	Colorless	H=4 G=3.78 Infus.	Sol. in acid. Data for mineral with $FeCO_3$ 90, $MgCO_3$ 5, $CaCO_3$ 5 per cent.
^ v	1.60	1.855	Sphaerocobaltite $CoO.CO_2$	Hex. plates	do	Rose-red, black	H=3-4 G=4.1 Infus.	Sol. in acid. Colorless in section.

V	1.792	1.870	Arseniosiderite $6CaO.4Fe_2O_3.3As_2O_5.9H_2O$(?)	Orth.? Fib., tab. {001}.	{001} perf.	Yellow, brown	H=1–2 G=3.5–3.9 F=3	Sol. in acid. Pleoc. in brownish red. Abs.: $\omega>\epsilon$.
	*1.85	1.87	Dussertite $3CaO.1\frac{1}{2}Fe_2O_3.As_2O_5.4\frac{1}{2}H_2O$	Hex.	{0001}	Yellowish-green in section.	H=3.5 G=3.75	Sol. in acid. Nonpleochroic.
^	1.633	1.875	Siderite $FeO.CO_2$	Trig.	{10$\bar{1}$1} highly perf.	Gray, yellow, brown.	H=4 G=3.89 Infus.	Sol. in acid. Data for pure $FeCO_3$.
	1.784	1.875	Plumbojarosite $PbO.3Fe_2O_3.4SO_3.6H_2O$	Trig. Hex. plates. Powder.	{10$\bar{1}$1}	Brown	G=3.63	Alunite group. Sol. in HCl. Pleoc.: ω=dark brownish red, ϵ=pale golden yellow.
	1.785	1.882	Argentojarosite $Ag_2O.3Fe_2O_3.4SO_3.6H_2O$	Hex. plates	{0001}	Yellow-brown	G=3.65	Alunite group. $\omega>\epsilon$ abs. in yellow.
^	1.815	1.898	Arseniosiderite $3CaO.2Fe_2O_3.2As_2O_5.6H_2O$(?)	Orth. Pris		Black; blood-red in splinters.	H=4.5 G=3.57 F=2–3?	Variety mazapilite. Sol. in acid. Pleoc.: ω=dark reddish brown, ϵ=nearly colorless.
	B=low	1.93	Corkite $2PbO.3Fe_2O_3.P_2O_5.2SO_3.6H_2O$	Trig. Rect.	{0001} easy	Olive, yellow, etc.	H=4 G=4.2±	Alunite group. Sol. in HCl. Abnormal green interference colors. Base divided into six biax. segments.
	B=mod. or low	1.96	Beudantite $2PbO.3Fe_2O_3.As_2O_5.2SO_3.6H_2O$	Trig. Acute rhombs.	do	Olive, yellow, brown, black.	H=4 G=4.1± F=3.5	Do.
	*B=very faint	1.97	Dixenite $5MnO.SiO_2.As_2O_3.H_2O$	Hex.(?) Mic. plates	{0001} mic.	Black	H=3–4 G=4.20	Decpd. in HCl. Glowing red in transmitted light. Långban.
		1.98	Diaboleite $2Pb(OH)_2.CuO$	Tetrag. Tab. {001}	{001} perf.	Sky-blue	H=2.5 G=6.41 F=easy	Sol. in HNO_3. Pleoc. ω=deep blue, ϵ=nearly colorless. In mendipite.
		2.0±	Graphite C	Trig. Platy	{0001} perf.	Black	H=1–2 G=2.2 Infus.	Insol. Transmits greenish light in extremely thin layers.
	*1.99	2.01	Armangite $3MnO.As_2O_3$	Trig.	{0001} poor	do	H=4 G=4.23 F=easy	Sol. in HCl. Streak brown. Not pleochroic. Långban.
	1.82	2.01	Bismite $Bi_2O_3.3H_2O$(?)	Hex. tablets	{0001} perf.	White powder	Soft G=3.36	Sol. in HNO_3. Nevada.
^	2.010	2.026	Hedyphane $4\frac{1}{2}PbO.4\frac{1}{2}(Ca,Ba)O.3P_2O_5.PbCl_2$	Hex.	Two	White	H=4 G=5.7 F=1	Sol. in HNO_3. Apatite group.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial negative group—Continued

Variability	ε	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	2.00	2.03	Pseudoboléite $5PbCl_2.4CuO.6H_2O$	Tetrag.	{001} perf., {101} perf.	Indigo-blue	H=2.5 G=4.85 F=1	Sol. in warm dilute HNO_3. Luster on cleavage pearly.
	1.926	2.041	Cumengéite $4PbCl_2.4CuO.5H_2O$	do	{101} very good, {110} good.	do	H=2.5 G=4.8 F=1	Sol. in warm dilute HNO_3. In section it is purer blue than the boléite and pseudoboléite with which it is intergrown.
	2.03	2.05	Boléite $9PbCl_2.8CuO.3AgCl.9H_2O$	Tetrag. Cubic	{100} perf.	do	H=2.5 G=5.08 F=1	Sol. in warm dilute HNO_3. Luster on cleavage pearly. Trillings on {001} of three individuals form pseudocubic faces.
	B=very low	2.05	Eulytite $2Bi_2O_3.3SiO_2$	Ps. isomet. Tetrah.	{110} imperf.	Grayish, etc.	H=4.5 G=6.11 F=2	Gelat.
	2.042	2.050	Pyromorphite $9PbO.3P_2O_5.PbCl_2$	Hex. Pris.	{10$\bar{1}$0}{10$\bar{1}$1} traces	Green, yellow, etc.	H=4 G=7.0± F=1.5	Sol. in HNO_3. Resinous. Pleoc.: ω = green, ε = greenish-yellow. Biaxial.
	2.05	2.07	Barysilite $3PbO.2SiO_2$	Trig. Tab. {0001}	{0001} dist.	Gray, white	H=3 G=6.72 F=2.5	Gelat.
	1.94	2.09	Hydrocerusite $3PbO.2CO_2.H_2O$	Hex. plates	{0001} perf.	Colorless	H=3.5 G=6.33 F=1.5	Sol. in acids. The data given are for the artificial product.
	1.94	2.13	Bismutosphaerite $Bi_2O_3.CO_2$	Fib. concretions, basal tablets.		Yellow, green, brown.	H=3-3.5 G=7.3-7.4 F=1.5	Sol. in acid.
	2.118	2.135	Mimetite $9PbO.3As_2O_5.PbCl_2$	Hex.	{10$\bar{1}$1} imperf.	Yellow, brown, colorless, etc.	H=3.5 G=7.1 F=1	Sol. in HNO_3. Biax. in sections.
	2.04	2.15	Matlockite $PbO.PbCl_2$	Tetrag.	{001} perf.	Yellow, greenish, etc.	H=3 G=7.21 F=1	Sol. in warm dilute HNO_3. Biax.

	2.14	2.16	Bellite PbO, Cr_2O_3, As_2O_3, etc.	Hex. Velvety coatings. Acic. c.		Bright crimson, yellow, orange.	H=2.5 G=5.5 F=easy	Faintly pleoc. in pale pink. Abs.: $\omega > \epsilon$.
⌐	2.20	2.25	Endlichite $9PbO.3(As, V)_2O_5.PbCl_2$	Hex. Pris.		Yellow	H=3 G=7 F=1.5	Between vanadinite and mimetite. Decpd. by HCl.
V	2.10	2.26±	Hetaerolite $2ZnO.2Mn_2O_3.H_2O$	Tetrag. Fib. c.	{001}perf	Yellowish black	H=6 G=4.55 Infus.	Zinc hausmannite. Sol. in HCl giving Cl gas. Pleoc. faint: ω=red-brown, ϵ=nearly opaque.
	2.182	2.269	Stolzite $PbO.WO_3$	Tetrag. Pyram.	{001}{111}imperf	Green, gray, brown, etc.	H=3 G=8± F=2	Isomor. with scheelite. Decpd. by HNO_3.
	2.285	2.295	Finnemanite $9PbO.3As_2O_3.PbCl_2$	Hex. Pris.	{10$\bar{1}$1}	Olive-green	H=2-3 G=7.27	
			Haematophanite $Pb(Cl, OH)_2.4PbO.2Fe_2O_3$	Tetrag.		Dark reddish brown.	H=2-3 G=7.70	Easily sol. in acid.
		2.3±Li	Plattnerite PbO_2	do	{110}	Black	H=5-5.5 G=8.5 F=2	Sol. in HCl. Streak chestnut-brown. Nearly opaque. Basal section shows six biax. segments.
	1.95	2.31	Geikielite $(Mg, Fe)O.TiO_2$	Trig. Rhombs.	{10$\bar{1}$1}perf	do	H=6 G=3.98 Infus.	Slowly sol. in HCl. Pleoc. faint in red-brown or purple. Abs.: $\omega > \epsilon$.
	2.25Li	2.32Li	Ecdemite $4PbO.As_2O_3.2PbCl_2$	Tetrag. Tab. {001}. Crusts.	{001}nearly perf.	Yellow, green	H=2.5-3 G=6.9-7.1 F=1.5(?)	Heliophyllite. Sol. in HNO_3. In part biax.
^	2.14	2.34±	Hetaerolite $ZnO.Mn_2O_3$	Tetrag. Fib. c.	{001}perf	Black	H=6 G=4.85 Infus.	Zinc hausmannite. Sol. in HCl giving Cl gas. Red-brown in section and faintly pleoc.: $\omega < \epsilon$.
	2.33Li	2.35Li	Lorettoite $6PbO.PbCl_2$	Massive	{001}highly perf.	Orange-yellow	H=3 G=7.4-7.6 F=1	Sol. in acid.
	2.299	2.354	Vanadinite $9PbO.3V_2O_5.PbCl_2$	Hex. Pris.		Red, yellow, brown.	H=3 G=7± F=1.5	Resinous. Decpd. by HCl.
	2.25Li	2.36Li	Schwartzembergite $7PbO.I_2O_5.3PbCl_2$	Tetrag. or ps. tetrag.	{001}dist.	Honey to straw yellow, reddish.	H=2-2.5 G=6.3 F=1	Sol. in dilute HNO_3. Anom. 2V.
	2.31Li	2.36Li	Langbanite $Sb_2O_3, Fe_2O_3, Mn_2O_3, SiO_3$	Trig.	None	Iron-black	H=6.5 G=4.6-4.8 Infus.	Dif. sol. in HCl. Pleoc. faint in dark, reddish brown. Abs.: $\omega > \epsilon$.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Uniaxial negative group—Continued

Variability	ϵ	ω	Mineral name and composition	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	2.28	2.40	Wulfenite $PbO.MoO_3$	Tetrag. Tab	{111}perf., {001}{115}less so.	Colorless, yellow, orange, greenish.	H=3 G=6.9 F=2	Decpd. by HCl.
⊐	2.15_{Li}	2.46_{Li}	Hausmannite Mn_3O_4	Tetrag. Oct	{001}nearly perf	Brownish black	H=5–5.5 G=4.72–4.86 Infus.	Sol. in HCl with evolution of Cl. In section dark reddish brown and nonpleoc.
	2.210	2.481	Pyrophanite $MnO.TiO_2$	Trig. Scaly	{02$\bar{2}$1}perf., {10$\bar{1}$2}less so.	Deep blood-red	H=5 G=4.54 Infus.	Sol. in HCl. Streak ocher-yellow. In section yellow-red and not pleoc.
⊐ ⊐	B=mod.	2.50_{Li}	Strueverite $FeO.(Ta,Cb)_2O_5.4TiO_2$	Tetrag		Iron-black	H=6 G=5.57	Very strongly pleoc.: ω=nearly opaque, greenish in very thin splinters, ϵ=brown.
⊐ ⊐	B=low or mod.	2.50_{Li}	Senaite $(Fe, Mn, Pb)O.TiO_2$	Trig	None	Black	H=6 G=5.30	Nearly opaque and nonpleoc. Tw. pl. {11$\bar{2}$0} common.
	2.493	2.554	Anatase TiO_2	Tetrag. Oct	{001}{111}perf	Brown, etc	H=6 G=3.84 Infus.	Insol. in acid. Pleoc. in thick section: ω=pale blue or yellowish, ϵ=dark blue or orange.
	B=extr.	2.6_{Li}	Trechmannite $Ag_2S.As_2S_3$	Trig	{10$\bar{1}$1}good, {0001}dist.	Scarlet, vermilion	H=1.5–2	Brittle. Streak scarlet. Pleoc.: ω=pale reddish, ϵ=clear and colorless. On heating moderately inverts to a biax. form, probably smithite.
	2.535_{Li}	2.665_{Li}	Litharge PbO	Tetrag. Tab.{001}	{110}perf	Reddish	H=2 G=9.13 F=1.5	Sol. in HNO_3. Fuses to a yellow glass. Borders crystals of massicot.
⊐	B=extr. Near 2.72_{Li}	Greater than 2.72_{Li}	Chalcophanite $(Mn,Zn)O.2MnO_2.2H_2O$	Trig. Tab.{0001}	{0001}perf	Black	H=2.5 G=3.91 Infus.	Sol. in HCl with evolution of Cl. Strikingly pleoc.: ω=nearly opaque, ϵ=deep red.
V	2.711_{Li}	2.979_{Li}	Proustite $3Ag_2S.As_2S_3$	Trig	{10$\bar{1}$1}dist	Scarlet	H=2 G=5.6 F=1	Decpd. by HNO_3. Streak scarlet. In section bright red. Pleoc. weak: ϵ=cochineal-red, ω=blood-red.

V	2.78$_{Li}$	3.01$_{Li}$	Hematite Fe_2O_3	do	{0001}parting	Red to black	H=5 G=5.2 Infus.	Sol. in acid. Streak red. The data given are for the artificial product.
∧	2.881$_{Li}$	3.084$_{Li}$	Pyrargyrite $3Ag_2S.Sb_2S_3$	do	{10$\bar{1}$1}dist	do	H=2.5 G=5.8 F=1	Decpd. by HNO_3. Tw. pl. {11$\bar{2}$0}. Composition pl. {0001}. Tw. pl. {10$\bar{1}$4}. Streak purplish-red. In section red.
∧	2.94$_{Na}$	3.22$_{Na}$	Hematite Fe_2O_3	do	{0001}parting	do	H=5 G=5.2 Infus.	Sol. in acid. Streak red. Abs. $\omega > \epsilon$.

Biaxial positive group

[The minerals of this group are chiefly orthorhombic, monoclinic, or triclinic]

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	B=.001		1.339	Cryolite $3NaF.AlF_3$	2V=43° 2E=59° $r<v$.	X=b Z∧c=−44°.	Mon. Rect.	{001}perf. {110}, {101} good.	White, reddish, brownish.	H=2.5 G=3.0 F=2	Sol. in H_2SO_4. Tw. {110}, lamellar.
	*1.411	1.420	1.413	Pachnolite $NaF.CaF_2.AlF_3.H_2O$	2V=76° 2E=120° $r<v$ weak.	X=b Z∧c=69°. Disp. strong.	Mon.	{001}dist.	White	H=3 G=2.98 F=1.5	Alteration of cryolite. Tw. pl. {100}. Greenland.
□	1.438	1.452	1.44	Erionite $CaO.(Na,K)_2O.2Al_2O_3.12SiO_2.12H_2O$		Z=elong.	Orth. Woolly.		do	G=2.00 F=easy	Zeolite group.
	1.439	1.469	1.441	Stercorite $Na_2O.(NH_4)_2O.P_2O_5.9H_2O$	2V=36° 2E=53° $r>v$ rather strong.	Z=b Y∧c=30°. Disp. strong.	Mon. (?)	None	Colorless	H=2 G=1.574 F=1	Sol. in H_2O. Section {010}shows two sets of poly. tw. lamellae at about 90°.
	1.447	1.459	1.448	Taylorite $5K_2O.(NH_4)_2O.6SO_3$	2V=36° 2E=53° $r>v$ rather strong.		Concretions		do	H=2 F=1.5(?)	Sol. in H_2O.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.461	1.476	1.463	Picromerite $MgO.K_2O.2SO_3.6H_2O$	$2V=48°$ $2E=73°$. $r>v$ mod.	$Y=b$ $X\wedge c=-1°$.	Mon. Crusts.	{$\bar{2}01$}perf.	White	H=2.5 G=2.1 F=2	Sol. in H_2O.
	1.459	1.470	1.464	Aluminite $Al_2O_3.SO_3.9H_2O$	Large	X=elong	Mon. Fib Earthy.		do	H=1–2 G=1.66 Infus.	Insol. in H_2O. Sol. in acid.
	1.456	1.507	1.468	Lansfordite $MgO.CO_2.5H_2O$	$2V=61°$ $2E=97°$.	Z near c X=b.	Mon. Tab.	{001}perf.	Colorless	H=2.5 G=1.73 Infus.	Sol. in acid. Alters on exposure to air to nesquehonite.
	1.469	1.479	1.470	Boussingaultite $(NH_4)_2O.MgO.2SO_3.6H_2O$	$2V=50°$ $2E=77°$. $r>v$ slight.	$Y=b$ $Z\wedge c=95°$.	Mon	None	do	H=2 G=1.68–1.72 F=1	Sol. in H_2O.
	1.469	1.473	1.47	Tridymite SiO_2	Large	X=b Z=c.	Orth. Ps. hex. Tab. {0001}.	Indistinct	do	H=6.5 G=2.30 Infus.	Sol.in boiling Na_2CO_3.
	1.467	1.496	1.474	Carnallite $KCl.MgCl_2.6H_2O$	$2V=70°$ $2E=116°$. $r<v$.	Z=a X=c.	Orth		White, reddish, etc.	H=2.7 G=1.60 F=1–1.5	Deliquescent.
	1.472	1.476	1.474	Mordenite $(Ca,Na_2)O.Al_2O_3.9SiO_2.6H_2O$	Large	$Z=b$ $X\wedge c=4°$.	Mon. Tab. {010}. Fib. c.	{010}perf.	Yellow, pink, etc.	H=3–4 G=2.15 F=4–5	Zeolite group. Partly decomposed by acid.
	1.474	1.483	1.476	Alunogen $Al_2O_3.3SO_3.16H_2O$	$2V=69°$ $2E=114°$.	X=b $Z\wedge c=42°$.	Mon. Tab. {010}. Fib. c.		White	H=1.5 G=1.64–1.67 Infus.	Keramohalite. Sol. in H_2O.
	1.474	1.478	1.476	Arduinite $CaO.Na_2O.2Al_2O_3.3SiO_2.5H_2O$	Near 90°	Pl. opt. axes // cleav.	Orth(?). Radially fib. aggregates.	One perfect	White, colored by inclusions of (Fe_2O_3)?	G=2.26 Infus.	Zeolite group. Does not gelatinize.
	1.471	1.484	1.477	Thenardite $Na_2O.SO_3$	$2V=84°$ $2E=162°$. $r>v$ weak.	X=b Y=c.	Orth	{001}dist.	White, brown.	H=2–3 G=2.69 F=1.5–2	Very sol. in H_2O.

	1.471	1.486	1.478	Melanterite $FeO.SO_3.7H_2O$	2V=86° $r>v$ weak.	Y=b Z∧c= −61°.	Mon. Elong. c.	{001}perf.{110} good.	Green (when fresh), yellow.	H=2 G=1.90 F=easy	Sol. in H_2O. Tastes astringent. Alters on exposure to dry air.
	1.478	1.482	1.479	Ferrierite $2RO.Al_2O_3.5SiO_2$ R=Mg:Na_2:H_2 =1:1:1	2V=50° 2E=78°.	Y=b Z=c.	Orth. Blades {100}. Elong. c.	{100}perf.	White	H=3–3.25 G=2.15 F=3–3.5.	Insol. in HCl.
	1.472	1.487	1.479	Pisanite $(Fe,Cu)O.SO_3.7H_2O$	Very large Disp. weak.	Y=b X near c.	Mon.	{001}easy	Blue	H=2–3 G=1.9 F=easy	Sol. in H_2O. Alters readily by dehydration.
	1.47	1.49	1.48	Boothite $CuO.SO_3.7H_2O$	Large	Y=b X near c.	Mon. Fib. c.	{001}imperf.	do	H=2.5 G=1.94 Fus.	Sol. in H_2O. Colorless in section. Decomposes to chalcanthite on exposure to dry air. Opt. character doubtful.
	1.475	1.487	1.480	Misenite $K_2O.2SO_3.H_2O$	do	Z∧elong.=33°	Mon.? Silky fib.		White	F=easy	Sol. in H_2O.
	1.475	1.488	1.480	Dietrichite $(Zn,Fe,Mn)O.Al_2O_3.4SO_3.22H_2O$	do	X=b Z∧c=29°±.	Mon. Fib. c.		do	H=2 Infus.	Do.
	B=weak		1.480	Faujasite $Na_2O.CaO.2Al_2O_3.10SiO_2.20H_2O$	Near 0°		Oct.	{111}dist.	do	H=5 G=1.92 F=3	Zeolite group. Decpd. by acid. Uniax. +. In eight segments from loss of H_2O.
	B=0.001 to 0.009		1.481	Gmelinite $Na_2O.CaO.2Al_2O_3.6SiO_2.10H_2O$	do		Ps. trig.	{10$\bar{1}$0}easy	Colorless, yellowish, greenish.	H=4 G=2.17 F=3.	Zeolite group. Decpd. by acid. Tw. axis c.
	*1.480	1.507	1.48	Zebedassite $5MgO.Al_2O_3.6SiO_2.4H_2O$	Small	Z=elong.	Fib.		White	H=2 G=2.19 Infus.	Gelat. May be uniax. or opt.−. Zebedassi.
	1.480	1.493	1.482	Natrolite $Na_2O.Al_2O_3.3SiO_2.2H_2O$	2V=63° 2E=101°. $r<v$ weak.	X=a Z=c.	Orth. Needles c.	{110}perf.{010} imperf.	do	H=5 G=2.25 F=2	Zeolite group. Gelat. Tw. pl.{110} {100}, rarely {301}.
	1.481	1.486	1.482	Ashtonite $(Ca,Na_2,K_2)O.Al_2O_3.9SiO_2.5H_2O$	Large		Radiating crystals.		White to brick-red.		A zeolite.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.479	1.488	1.483	Zinc-copper melanterite. $CuO.ZnO.2SO_3.14H_2O$	Large. Disp. weak.	$Z=b$. $Y\wedge$elong. large.	Mon.? Fib.		Light blue-green.	H=2 G=2.02 F=easy	Sol. in H_2O. Decomposes to the pentahydrate on exposure to dry air.
[ ]	1.485	1.488	1.485	Chabazite. $(Ca,Na_2)O.Al_2O_3.2SiO_2.6H_2O$?	Small.		Ps. trig.	{10$\bar{1}$1}dist.	Colorless, white, red, etc.	H=4–5 G=2.1 F=3	Zeolite group. Decpd. by acid. Tw. pl. {10$\bar{1}$1}. (See Uniaxial group, p. 77.)
V	1.482	1.489	1.485	Heulandite. $(Ca,K_2,Na_2)O.Al_2O_3.7SiO_2.5H_2O$	2V=52°. 2E=82°. $r>v$.	$Z=b$. $Y\wedge c=35°$.	Mon. Tab. {010}.	{010}perf.	White.	H=4 G=2.2 F=2	Zeolite group. Decpd. by HCl. Y in some=b. Mineral with Na_2O 4.48, CaO 3.60 per cent.
	1.484	1.502	1.486	Cyanochroite. $K_2O.CuO.2SO_3.6H_2O$	2V=47°. 2E=72°. $r<v$ strong.	$Y=b$. $X\wedge c=19°$.	Mon. Crusts.	{$\bar{2}$01}perf.	Clear blue.	G=2.228 F=1(?)	Isomor. with picromerite. Sol. in H_2O.
	1.484	1.496	1.487	Tamarugite. $Na_2O.Al_2O_3.4SO_3.12H_2O$	2V=60° 2E=96°. Disp. slight.	Z near b. $Y\wedge c=30°\pm$.	Mon. or tric. Laths {100}. Fib. c.		Colorless.	H=1 G=2.03 Fus.	Sol. in H_2O. Poly. tw.
	1.470	1.540	1.487	Ammonioborite. $(NH_4)_2O.5B_2O_3.5H_2O$	2V=59°. 2E=94°.	X $\perp$ plates.	Mon. or tric.		White.	Soft	Mostly granular. Slowly soluble in cold water.
	1.473	1.511	1.490	Fluellite. $AlF_3.H_2O$	2V=85°. $r<v$ rather strong.	$Y=a$. $Z=c$.	Orth.	{111}indist.	do.	H=3 G=2.17 Infus.	Insol. in acid.
	1.493	1.497	1.494	Arcanite. $K_2O.SO_3$	2V=67°. 2E=111°. $r>v$ mod.	$X=b$. $Z=c$.	do.	{010}{001}good		G=2.67	Sol. in H_2O. Artificial.
[ ]	*1.489	1.506	1.495	Kreuzbergite. Phosphate of Al, Fe, etc., H_2O	Large. $r<v$ perc.		do.		White, yellow.	G=2.139	Kreuzberg.

	1.495	1.504	1.496	Struvite $(NH_4)_2O.2MgO.P_2O_5.12H_2O$	2V=37°. 2E=57°. $r<v$ strong.	Z=b X=a.	do	{001}perf.{010} good.	Colorless, yellow.	H=2 G=1.72 F=3	Sol. in acids.
□	1.492	1.500	1.496	Dachiardite $3(Ca,Na_2,K_2)O.2Al_2O_3.18SiO_2.14H_2O$	2V=65°. 2E=107°.	X=b Z∧c=35°.	Mon	{100}{001} perf.	White	H=4–4.5 G=2.165 Fus.	Zeolite group. Decpd. by acid. Mimetic tw. {110}. Hex.
□	1.498	1.505	1.499	Heulandite $CaO.Al_2O_3.6SiO_2.5H_2O$	2V=34°±. 2E=52°. $r>v$.	Z=b Y∧c=6°±.	Mon. T a b. {010}.	{010} perf.	do	H=4 G=2.2 F=2	Zeolite group near stilbite. Decpd. by HCl. Opt. pl. sometimes//{010}.
	*1.498	1.503	1.500	Phillipsite $(Na,K)_2O.CaO.2Al_2O_3.6SiO_2.8H_2O$	2V=70°+. 2E=119°. $r<v$ medium.	Y=b Z∧a=19°.	Mon. Fib. a.	{001} {010} rather dist.	do	H=4 G=2.2 F=3	Zeolite group. Gelat. Tw. pl. {001} and {011} penet. simulating orth. or tetrag. forms. Vesuvius. From Isle of Flanders, Annerode, and Habuhlswald are essentially the same.
□	1.498	1.503	1.50	Wellsite $BaO.K_2O.2Al_2O_3.6SiO_2.8H_2O$	2V=39°±. 2E=60°.	Z=b X∧c=−52°.	Mon	None	Colorless	H=4–4.5 G=2.28–2.37 F=3	Zeolite group. Decpd. by acid. Complex tw.
	1.499	1.538	1.503	Uranothallite $2CaO.UO_2.4CO_2.10H_2O$	2V=42°. 2E=65°. $r>v$=perc.	X=a	Orth. Crusts.	{100} perf.	Siskin-green	H=2.5–3 Infus.	Sol. in acid.
□	1.501	1.510	1.503	Prosopite $CaF_2.2Al(F,OH)_3.H_2O$	2V=63°. 2E=103°. $r>v$ strong.	Y=b Z∧c=−50°.	Mon. or tricl. Tab. {010}.	{211} dist.	Colorless	H=4.5 G=2.88 Infus.	Decpd. by H_2SO_4.
<	1.493	1.517	1.504	Chrysotile $3MgO.2SiO_2.2H_2O$	Large	Z=c X=b.	Orth. Elong. c.	{010} perf.	Light brown	H=4 G=2.5	FeO 0.3 per cent.
	1.491	1.520	1.504	Ulexite $Na_2O.2CaO.5B_2O_3.16H_2O$	Moderate	X=b Y∧c=23°–0°.	Mon. Fib. c. "Cotton balls."		White	H=1 G=1.65 F=1	Sol. in acids. Slightly sol. in H_2O.
□	1.503	1.508	1.505	Harmotome $2BaO.K_2O.3Al_2O_3.26SiO_2.20H_2O$	2V=43°. 2E=67.°	Z=b Y∧a=23½°.	Mon. Pris. a.	{010}easy{001} less so.	do	H=4.5 G=2.5 F=3.5	Zeolite group. Decpd. by HCl. Tw. pl. {001} cruciform.
□	1.505	1.506	1.505	Mesolite $Na_2O.2CaO.3Al_2O_3.9SiO_2.8H_2O$	2V=86°. $r>v$ strong.	Z near c. Y=b.	Mon. Elong. b.	{101}{$\bar{1}$01} perf.	White, gray	H=5 G=2.27 F=easy	Zeolite group. Gelat. Tw. pl. {100} common. 2V changes rapidly with temperature.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity and fusibility	Remarks
	1.494	1.528	1.507	Bischofite $MgCl_2.6H_2O$	2V=79° 2E=152°. $r>v$.	X=*b* Y∧*c*=9½°.	Mon. Fib.		Colorless	H=1.5 G=1.591 Fus.	Sol. in H_2O.
	1.504	1.545	1.508	Ussingite $2Na_2O.Al_2O_3.6SiO_2.H_2O$	2V=39° 2E=60°.	Z=*c*?	Tric.	{001} perf. or lamellar tw.		H=6–7 G=2.50 F=easy	Gelat. in acid.
	B=0.001		1.508	Leucite $K_2O.Al_2O_3.4SiO_2$	Small	Z=*a*	Orth. Ps. isomet.		Colorless	H=6 G=2.5 Infus.	Decpd. by acid.
	1.493	1.561	1.509	Larderellite $(NH_4)_2O.5B_2O_3.5H_2O$	2V=60°± 2E=99°.	X=*b* Y near *a*. Z∧*c*=large.	Mon. Tab. {100} with rhombic outline and angle 66°.	{001} perf.	do	Soft	Cleaved rhombs resemble hexagonal plates.
	1.504	1.575	1.510	Pirssonite $CaO.Na_2O.2CO_2.2H_2O$	2V=33° 2E=51°.	X=*a* Z=*b*.	Orth. Elong *c*. Tab.{010}.	None	do	H=3 G=2.35 F=1.5	Effervesces in acid. Slightly sol. in H_2O.
	1.504	1.516	1.510	Petalite $Li_2O.Al_2O_3.8SiO_2$	2V=84° $r>v$ small.	Z=*b* X∧*a*=−8°.	Mon	{001} perf. {201}.	Colorless, white, pink.	H=6 G=2.4 F=5	Insol. in acid.
	B=0.002		1.510	Pseudomesolite $2CaO.Na_2O.3Al_2O_3.9SiO_2.8H_2O$	Very small	Z∧*c*=20°	Tric. Fib. *c*	{110} {1$\bar{1}$0} perf.	White	H=5 G=2.22 F=2	Near mesolite. Gelat. X and Y are // to diagonals of rhombs in cross sections.
□	*1.510	1.523	1.512	Brewsterite (Sr,Ba,Ca)O. $Al_2O_3.6SiO_2.5H_2O$	2V=50°± 2E=90. $r>v$=weak.	Z=*b* X∧*c*=22°.	Mon. Elong. *c*.	{010} perf. {100}.	do	H=5 G=2.45 F=3	Zeolite group. Decpd. by acids. Strontian.
◇	1.508	1.522	1.512	Chrysotile $3MgO.2SiO_2.2H_2O$	Large	Z=*c* X=*b*.	Orth. Elong. *c*.	{010} perf.	Green, brown, yellow.	H=4 G=2.5 F=6	Serpentine. Decpd. by acid. Pleoc.: faint. Z>Y>X.

	1.505	1.524	1.512	Flagstaffite $H_{20}C_{10}O_2.H_2O$	2V=77° 2E=140°. $r>v$.	Opt. pl.={010} Z=a. X=c.	Orth. Pris.	{110} imperf.	Colorless	Very soft G=1.09 F=116° C.	Sol. in warm alcohol.
V	1.511	1.518	1.513	Thomsonite $(Na,Ca)_5(Al,Si)_{20}O_{40}.12H_2O$	2V=75°	X=a Z=b.	do	{010}perf.{100} good.	White	H=5 G=2.33 F=2	Zeolite. Gelat. Ca:Na=1:1; Si:Al=11:9.
	1.512	1.518	1.513	Faroelite $Na_2O.3CaO.4Al_2O_3.9SiO_2.9H_2O$	Medium	X=a Z=b.	Orth. Fib. c.	do		H=5 G=2.30 F=2	Related to thomsonite. Zeolite group. Gelat.
	1.514	1.533	1.518	Newberyite $2MgO.P_2O_5.7H_2O$	2V=45° 2E=71°. $r<v$.	X=a Z=c.	Orth. Tab. {100}.	{010} perf. {001} imperf.	White	H=3 G=2.10	Sol. in HNO_3.
	1.516	1.533	1.518	Felsoebanyite $2Al_2O_3.SO_3.10H_2O$	2V=48° 2E=76°. $r>v$ perc.	Z=c X=elong.	Orth. Scales {001}.	{001} perf.	Colorless	H=1.5 G=2.33 Infus.	Sol. in acid. Lath-shaped cleavage pieces.
V	1.510	1.543	1.520	Bobierite $3MgO.P_2O_5.8H_2O$	2V=71° 2E=124°. $r<v$ weak.	Y=b Z∧c=29°.	Mon. Needles c.	{010}	do	H=1-2 G=2.41 Fus.	Sol. in acid.
	B=0.03		1.52	Hautefeuillite $3(Mg,Ca)O.P_2O_5.8H_2O$	2V=55° 2E=89°. $r<v$.	Y=b Z∧c=45°. Disp.strong.	Mon. Lamellar. Radiated c.	{010} perf.	do	H=2.5 G=2.44 Fus.	Near bobierite. Dif. sol. in acid.
	1.520	1.530	1.523	Gypsum $CaO.SO_3.2H_2O$	2V=58° 2E=95°. $r>v$ perc.	Y=b X∧c=37½°. Disp.strong.	Mon. Tab. {010}.	{010} perf. {111}, {100} imperf.	White	H=1.5-2 G=2.32 F=2.5-3	Sol. in HCl. Tw. and comp. pl. {100}.
	1.521	1.533	1.523	Mascagnite $(NH_4)_2O.SO_3$	2V=52° 2E=84°. $r>v$ feeble.	Z=a X=c.	Orth. Elong. c.	{001} dist.	Colorless, yellowish, greenish.	H=2 G=1.76 F=1	Sol. in H_2O. Tastes pungent and bitter. Volatile. Tw. pl. {110}.
	1.518	1.588	1.523	Hatchettite $C_{38}H_{78}$	2V=33°± 2E=51°. $r<v$ rather strong.	Z=c	Orth	{001}	White	H=1. G=0.96 Fuses at 80° C.	Sol. in oils but not in acids.
	1.515	1.544	1.525	Probertite $Na_2O.2CaO.5B_2O_3.10H_2O$	2V=73° 2E=130°. $r>v$.	Y=b Z∧c=12½ Elong. +.	Mon. Pris.	{110}	do	H=2.5 G=2.141	Same as kramerite.
	1.508	1.586	1.525	Sideronatrite $2Na_2O.Fe_2O_3.4SO_3.7H_2O$	2V=58° 2E=95°. $r>v$ strong.	Z=c Y=b.	Orth. Fib. c.	{100} perf.	Orange to straw-yellow.	H=2-2.5 G=2.15-2.36 F=2	Sol. in acid. Pleoc.: X=colorless, Y=very pale amber-yellow, Z=pale amber-yellow.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.520	1.540	1.525	Thomsonite $Na_2O.4CaO.5Al_2O_3.10SiO_2.12H_2O$	$2V=48°\pm$ $2E=76°$. $r>v$ easily perc.	X=*a*. Z=*b*.	Orth. Fib. *c*. Lamellar {010}.	{010}perf.{100} good.	White	H=5 G=2.36 F=2	Zeolite group. Gelat.
	1.521	1.545	1.525	Spadaite $MgO.SiO_2.2H_2O$	Small to medium.	Elong. +. Ext. // or nearly so.	Orth.? Felted. Columnar.		Cream-colored to pink.	G=2.2 Fus. b.b.	Sol. in acid, yielding sandy silica.
⊏ ⊐	B=0.02		1.525	Bialite CaO,MgO,P_2O_5,H_2O		Z=*c*. Y=*a*.	Orth. Acic. *c*.	{100} good.	White		Dif. sol. in acid. Magnesian variety of tavistockite?
	1.523	1.532	1.525	Chalcoalumite $CuO.2Al_2O_3.SO_3.9H_2O$	Rather small. $r>v$ strong.	On flat face ext.=40°.	Tric. (?). Fibrous crusts.	Perf.	Nile blue	H=2.5 G=2.29 F=5	Sol. in hot HCl. Tw. pl. // elong.
	1.508	1.550	1.526	Kaliborite $K_2O.4MgO.11B_2O_3.18H_2O$	$2V=81°$ $2E=165°$. Disp. not perc.	Y=*b*. $Z\wedge c=65°$.	Mon.	{100}{001} perf.	White	H=4.5 G=2.13 F=1	Sol. in acid.
	1.523	1.545	1.527	Hydromagnesite $4MgO.3CO_2.4H_2O$	Medium large.	Z=*b*. $Y\wedge c=43°$.	Mon. Tufts. Fib. *c*. Tab. {100}.	{010} perf.	do	H=3.5 G=2.152 Infus.	Dif. sol. in acid. Tw. pl. {100} poly. and invariable.
⊏	1.509	1.548	1.528	Paternoite $MgO.5B_2O_3.5H_2O$	Large.	X=*b*. $Z\wedge c=71°$.	Mon. Tab. // {100}. with rhombic outline and angle of 62°.	{001} perf.	Colorless in section.		Related to larderellite. Sol. in acid. Cleavage pieces have hex. aspect on {100}.
v	1.507	1.573	1.529	Copiapite $RO.2Fe_2O_3.6SO_3.22\pm H_2O$	$2V=73°\pm$ $2E=130°$. $r>v$ rather strong.	Z bisects acute angle.	Orth. Rhombic tablet {001} with angle 77½°.	{001} perf.	Sulphur to citron yellow.	H=2.5 G=2.10 F=4.5–5	Sol. in acid. Pleoc. X=yellowish green, Y=very pale yellow, Z=sulphur-yellow.

V	1.525	1.536	1.529	Albite $Na_2O.Al_2O_3.6SiO_2$	2V=74° 2E=134°. r<v weak.	On {010}X′∧{001}=24°. On {001}X′∧{010}=3½°.	Tric.	{010}{001}perf.	Colorless	H=6 G=2.605 F=4	Feldspar group. Data for $Ab_{100}An_0$. Insol. Poly. tw. {010} almost universal. Other laws common.
	1.522	1.577	1.529	Botryogen $2MgO.Fe_2O_3.4SO_3.15H_2O$	2V=41° 2E=65°. r>v rather strong.	X=b Z∧c=−12°.	Mon. Reniform.	{110}dist.{010}perf.	Red to yellow	H=2 G=2.1 F=4.5–5	Partly sol. in boiling H_2O. Sol. in acid. Pleoc.: X=bright yellow, Y=pale red, Z=deep orange-red.
	1.522	1.544	1.530	Tavistockite $3CaO.Al_2O_3.P_2O_5.2H_2O$?	2V=74°± 2E=135°. Disp. not perc.	Z=c Y=a.	Orth. Acic.c.	{100}perf.	White	Infus.	Dif. sol. in acid.
∧ V	1.528	1.545	1.531	Thomsonite $(Na,Ca)_6(Al,Si)_{20}O_{40}.12H_2O$	2V=54° 2E=87°.	X=a Z=b.	Orth. Pris.	{010}perf. and {100}good.	do	H=5 G=2.364 F=2	Zeolite. Gelat. Ca:Na=2:1; Al:Si=1:1.
	1.520	1.584	1.533	Kieserite $MgO.SO_3.H_2O$	2V=57° 2E=94°. r>v mod.	Y=b Z∧c=76.5°. Disp.dist.	Mon.	{$\bar{1}$11}{$\bar{1}$13}perf. {101}{012} {111}good.	do	H=3.5 G=2.57 F=2–3	Slowly sol. in H_2O.
	1.533	1.575	1.534	Fibroferrite $Fe_2O_3.2SO_3.10H_2O$	Nearly 0°	Z // elong.	Orth. Fib. c.		Pale yellow	H=2 G=1.86 F=4.5–5.	Sol. in H_2O. Pleoc.: X and Y nearly colorless, Z = pale yellow.
	1.523	1.570	1.534	Hydroboracite $CaO.MgO.3B_2O_3.6H_2O$	Rather large r<v perc.	Y=b X∧c=33°.	Mon. Tab. {010}elong.c.	{010}perf.	White	H=2 G=2.167 F=2	Sol. in acid.
⊏	1.525	1.552	1.534	Wavellite $3Al_2O_3.2P_2O_5.13(H_2O,HF)$	2V=72° 2E=128°. r>v small.	Z=c X=b.	Orth. Radiating fib. c.	{101} {010} rather perf.	White, yellow, green.	H=3–4 G=2.3–2.5 Infus.	Sol. in HCl.
	*1.534	1.558	1.543	Gordonite $MgO.Al_2O_3.P_2O_5.9H_2O$	2V=73° 2E=133°. r<v perc.	X=b Z∧c=30°.	Mon. Laths. Elong. c. Tab.{010}	{100}perf.	Colorless	H=3½ F=3 G=2.28	Lewiston, Utah.
∧ V	1.530	1.595	1.543	Copiapite $RO.2Fe_2O_3.6SO_3.22H_2O$	Mod r>v rather strong.	X=c Z bisects acute angle.	Orth. Rhombic tablets {001}, 77½. Elong. a.	{001}perf.	Yellow, reddish, violet.	H=2.5 G=2.10 F=4.5–5	Sol. in acid. Pleoc.: X=yellowish green, Y=very pale yellow, Z=sulphur-yellow.
	1.544	1.546	1.544	Epididymite $Na_2O.2BeO.6SiO_2.H_2O$	2V=23° r>v.	Z=b Y=c.	Orth. Plates //{001}.	{001}perf., {010}perf.	Colorless	H=5.5 G=2.55 F=3	Twinning on {001}(?). Nearly insol. in acid.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.539	1.551	1.545	Brushite $2CaO.P_2O_5.5H_2O$	$2V=86°$	$Z=b$ $X_{Li}\wedge c=9.2°$. $X_{Tl}\wedge c=11.2°$.	Mon. Flattened {010} Elong. c.	{010} perf., {$\bar{3}$01} perf.	White	H=2 G=2.25± F=3	Sol. in dilute acids.
	1.545	1.551	1.546	Eudidymite $Na_2O.2BeO.6SiO_2.H_2O$	$2V=30°$ $2E=47°$. $r>v$ dist.	$Y=b$ $Z\wedge c=-58½°$.	Mon. Tab. {001}.	{001} perf., {551} imperf.	do	H=6 G=2.55 F=2.5–3	Insol. in acid. Tw. pl. {001} lamellar always present.
	1.541	1.564	1.547	Voglite Hydrous carbonate of U, Ca, Cu	$2V=60°$ $2E=101°$. $r<v$ very strong.	Ext. on plates Z' to elong. 33°. X nearly ⊥ plates.	Tric. (?). Scales.		Emerald-green.	Soft	Poly. tw. lamellae plates. Pleoc. strong: X and Y= deep bluish green, Z=pale yellowish.
∧ ⊔	1.546	1.557	1.550	Chrysotile $3MgO.2SiO_2.2H_2O$	Small to medium.	$Z=c$ $X=a$.	Orth. Fib. c.	{010}	Green, brown, yellow.	H=4 G=2.5 F=6	Serpentine. Decpd. by acids. Pleoc. faint. Abs.: Z>Y>X.
∧	1.530	1.592	1.550	Copiapite $RO.2Fe_2O_3.6SO_3.22±H_2O$	$2V=69°$ $2E=122°$. $r>v$ rather strong.	$X=b$	Mon. Tab. {010}. Fib.	{010} perf., {100} less so.	Yellow, reddish violet.	H=2.5 G=2.21 F=4.5–5	Sol. in H_2O. Pleoc.: X=yellowish green, Y=very pale yellow, Z=sulphur-yellow.
∧ ∨	1.550	1.557	1.553	Andesine Ab_3An_2	$2V=88°$	On {010} $X'\wedge$ {001}=8°. On {001} $X'\wedge$ {010}=2°.	Tric.	{001}{010} perf.	Colorless	H=6 G=2.676 F=4–4.5	Feldspar group. Ab_{60} An_{40}. Insol. in acid. Poly. tw. {010} almost universal. Other laws common.
	B=0.016		1.554	Grothine Silicate of Ca, Al, Fe	Medium $r<v$.	$Y=c$ $Z=a$.	Orth. Tab. {010}.		do	G=3.09 Infus.	Easily decomposed by H_2SO_4.
	1.533	1.635	1.555	Rhomboclase $Fe_2O_3.4SO_3.9H_2O$	Small	$Z=b$ $X=c$.	Rhombic plates.	{001}	do		

	1.491	1.650	1.555	Whewellite $CaO.C_2O_3.H_2O$	$2V=84°$ $r<v$ weak.	$X=b$ $Z\wedge c=31°$.	Mon.	{001}{010}{110}{101}.	do.	H=2.5 G=2.23 Infus.	Sol. in acid. Tw. pl. {$\bar{1}$01} heart-shaped.
	*1.546	1.587	1.555	Bombiccite C_7HO_{13}	Medium large $r>v$ easily perc.		Tric.		White.	H=0.5–1 G=1.06 F=easy	Sol. in ether and alcohol. "Valdamo, Toscane."
	1.551	1.562	1.555	Vauxite $FeO.Al_2O_3.P_2O_5.6H_2O$	$2V=32°$ $2E=50°$. $r>v$ mod.	Z emerges on {010}.	Tric. Tab.	None.	Sky-blue to venetian blue.	H=3.5 G=2.45	Pleoc. strong. Blue to colorless. On wavellite.
	1.554	1.573	1.558	Paravauxite $FeO.Al_2O_3.P_2O_5.5H_2O$	Medium.	Opt. axis emerges from {010}.	Tric. Pris.	{010} perf.	Colorless.	H=3 G=2.30	
[ ]	1.544	1.581	1.558	Louderbackite $2FeO.3(Fe,Al)_2O_3.10SO_3.35H_2O$	do.		Orth.	Pinacoidal.	Pale chestnut-brown.	H=2.5–3 G=2.185	Nonpleoc. Sol. in cold water.
	1.551	1.582	1.558	Metavariscite $Al_2O_3.P_2O_5.4H_2O$	$2V=55°$ $2E=92°$. $r<v$ slight.	$X=c$	Orth. Laths {010}, elong. c.		Green.	H=4 G=2.54 Infus.	Sol. in HCl after ignition. On gentle heating changes to deep lavender. Pleoc. faint: X=colorless, Y and Z=pale green.
<>	1.555	1.563	1.559	Anemousite Feldspar.	Very large $r>v$ slight.	On {001} $X'\wedge a=1°$ to 5°. On {010} $X'\wedge a=2°$ to 11°. Z=near $\perp$ {001}. Y=near $\perp$ {001}	Tric.	{001}{010}perf.	Colorless.	H=6	Feldspar group, $Ab_8An_{10}Cg$.
	1.550	1.577	1.561	Metavauxite $FeO.Al_2O_3.P_2O_5.4H_2O$	Large.	$X=b$ $Z\wedge c=17°$.	Mon. Acic., radiating fibers.		do.	H=3 G=2.34	
	1.494	1.692	1.561	Humboldtine $FeO.C_2O_3.2H_2O$	do.	$X=a$ $Z=c$.	Orth. Pris.	{110} very perf. {100} {010} less so.	Yellow.	H=2 G=2.28	Sol. in acids. Pleoc.: X=very pale yellowish green, Y=pale greenish yellow, Z=intense yellow.
[ ]	1.561	1.567	1.563	Dickite $Al_2O_3.2SiO_2.2H_2O$	Large $r<v$ strong.	$Z=b$ $Y\wedge a=16°$.	Mon. Hex. plates {001}.	{001}perf.	White.	H=2 G=2.6 Infus.	Kaolin group. Insol. in acid.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
∧ ∨	1.559	1.568	1.563	Labradorite Ab_2An_3	$2V=79°$ $2E=172°$.	On {010} $X' \wedge$ {001} $=21°$. On {001} $X' \wedge$ {010} $=9°$.	Tric.	{001}{010}perf.	Colorless	H=6 G=2.70 Infus.	Feldspar group, Ab_{40} An_{60}. Insol. in acid. Poly. tw. {010} almost universal. Other laws common.
□	1.560		1.564	Kosmatite $3MgO.7CaO.$ $3Al_2O_3.7SiO_2$ $9H_2O$. Some F	$2V=9°$ $2E=14°$.			{001} mic.		H=2-2.5 F=dif.	Brittle mica.
	1.560	1.574	1.565	Elpidite $Na_2O.ZrO_2.6SiO_2.$ $3H_2O$	$2V=75°$ $2E=144°$. $r<v$ dist.	$X=c$ $Z=a$.	Orth. Elong. c.		White to brick-red.	H=7 G=2.58	
∨	1.560	1.581	1.566	Humite (?) $6MgO.3SiO_2.$ $Mg(F,OH)_2$	Medium $r<v$ perc.	$X=a$ $Z=b$.	Orth. Tab. {001}.	{001}perf.	Colorless, yellow, brown.	H=6 G=3.1 Infus.	Gelat. Pleoc.: X= faint yellow, Y and Z=colorless. Sjögren orientation.
	1.566	1.587	1.566	Gibbsite $Al_2O_3.3H_2O$	Small (varies). $r>v$ dist. or $r<v$ dist.	$Y=b$ $Z \wedge c=-25° \pm$ or $X=b$.	Mon. Hex. tab. {001}. Fib.	{001}eminent.	White, greenish, etc.	H=3 G=2.35± Infus.	Sol. in H_2SO_4.
	1.563	1.590	1.567	Norbergite $3MgO.SiO_2.H_2O$, some F	$2V=50°$ $2E=83°$.		Orth.		Brown, yellow-brown, etc.	H=6 G=3.14	Decpd. by acid. Humite group.
	1.565	1.580	1.568	Isoclasite $4CaO.P_2O_5.5H_2O$	Medium	$X=b$ $Z \wedge c=$small.	Mon. Acic. c.	Clinodiagonal, perf.	White	H=1.5 G=2.92 Fus.	Sol. in HCl.
	1.555	1.585	1.57	Tengerite Y, Be, CO_3	Large	X=elong.	Fib. Powder.		do		Sol. in acid.
	1.569	1.582	1.570	Wagnerite $3MgO.P_2O_5.MgF_2$	$2V=26° \pm$ $2E=41°$. $r>v$ perc.	$Z \wedge c=21½°$ $Y=b$. Disp. weak.	Mon.	{100}{110}imperf.	Colorless, yellow, flesh-red, greenish.	H=5 G=3.0 F=4	Do.

V	1.571	1.576	1.571	Clinochlore $5MgO.(Al, Cr)_2O_3.3SiO_2.4H_2O$	Small	Z near c	do	{001}mic	Green	H=3± G=2.657	Chlorite group. Ant_1 At_1. Cr:Al=1:33.
	1.563	1.596	1.571	Hoernesite $3MgO.As_2O_5.8H_2O$	2V=60° 2E=103°.	X=b Z∧c=31°±.	Mon. Tab. {010}, elong. c.	{010}perf.	White	H=1 G=2.60 F=2-3?	Sol. in acid.
< □	1.575	1.590	1.575	Leuchtenbergite $12MgO.3Al_2O_3.7SiO_2.10H_2O$	2V=18° 2E=28°.	Z near c	Hex. Plates	{001}mic	Colorless	H=3.5 G=2.74	Contains: SiO_2 30.3, Al_2O_3 12.17, FeO 0.6, MgO 34.6, H_2O 13.3 per cent.
	1.570	1.614	1.575	Anhydrite $CaO.SO_3$	2V=42° 2E=68°. $r<v$.	X=c Z=a.	Orth	{001}very perf. {010} perf. {100}less so.	do	H=3 G=2.93 F=3	Sol. in HCl.
< >	1.576	1.579	1.576	Penninite $5(Mg, Fe)O.Al_2O_3.3SiO_2.4H_2O$	0°± $r<v$ strong.	Z∧c=0°± Y=b.	Mon. Plates {001}.	{001}mic	Green	H=2.5 G=2.7± F=dif.	Decpd. by H_2SO_4. Pleoc.: Z=nearly colorless, X and Y green. Abnormal blue interference colors without extinction.
	1.574	1.588	1.576	Augelite $2Al_2O_3.P_2O_5.3H_2O$	2V=51° 2E=85°.	Y=b Z∧c=−34°.	Mon. Tab. {001}.	{110}perf{$\bar{1}$01} good.	Colorless	H=5 G=2.70 Infus.	Nearly insol. in acid.
	1.54	1.60±	1.578	Fichtelite $C_{18}H_{32}$	2V=87°	Opt. pl.={010} Z∧c=+13°.	Mon. Tab. to base or elong. b.	{001}perf {$\bar{1}$01}dist.	White	H=1	Sol. in ether. Tw. on {001}.
□	1.576	1.597	1.579	Cookeite $(Li,Na)_2O.3Al_2O_3.4SiO_2.6H_2O$	2V=0°-80°	Z=near c X // edge.	Mon. Tab. {001}.	{001}mic	Pink, etc	H=2.5 G=2.68	Fuses and exfoliates b. b. Base is divided into six biax. segments with uniax. center.
< >	1.579	1.584	1.579	Clinochlore $5MgO.(Al, Cr)_2O_3.3SiO_2.4H_2O$	2V=0°±	Z near c	Mon. Plates	do	Violet	H=3± G=2.675	Chlorite group. Ant_1 At_1. Cr:Al=1:5.
< >	1.578	1.586	1.580	Sheridanite $9MgO.3Al_2O_3.5SiO_2.8H_2O$	2V=13° 2E=20°.	do	Mon. Spherulites.	do	Green	H=2.5± G=2.680	Chlorite group. Ant_1 At_3.
	1.567	1.638	1.581	Kornelite $Fe_2O_3.3SO_3.8H_2O$	2V=49°-62° 2E=83°-110°. $r>v$ perc.	Z=b X∧c=17°±.	Mon. Pris. Spherical aggregates.	{100} good {010}good.	Colorless, brown, amethystine. Silky luster.	G=2.31	Poly. tw. on {100}. B. b. turns brown and assumes worm-like shape. Sol. in acid. Very slowly sol. in cold water.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
∧ ∨	1.578	1.588	1.581	Chlorite $9MgO.3Al_2O_3.5SiO_2.8H_2O$	$2V=12°$ $2E=20°$.	$Z=b$ $X\wedge c=17°\pm$.	Mon. Minute spherulites.	{001}mic	White, pearly on cleav.	H=2.5 G=2.67	Chlorite group. Ant_1 At_3. Fe:Mg=1:40.
	1.583	1.595	1.583	Zonotlite $5CaO.5SiO_2.H_2O$	Very small	$Z=c$ $X=b$.	Orth. (?) Fib. Mottled fib., needles c.	{010}perf	Colorless to pink.	H=6.5 G=2.70 F=2.5	Easily sol. in acid with separation of flaky silica.
	1.583	1.590	1.585	Bavenite $BeO.4CaO.Al_2O_3.9SiO_2.H_2O$	$2V=50°$	$Z=b$ $Y=a$.	Orth Flattened {100}. Fib.	{010}good {001}fair.	Colorless	H=5.5 G=2.74	A zeolite? Apparent tw. on {100}.
∨	1.578	1.591	1.585	Anthophyllite $7MgO.8SiO_2.H_2O$	Large	$Z=c$ $X=a$.	Orth. Pris. c.	{110}perf. at 0°.	do	G=2.86	Amphibole group. Data on pure artificial mineral.
	*1.586	1.595	1.586	Wardite $2Na_2O.CaO.6Al_2O_3.4P_2O_5.17H_2O$	$2V=0°$–$70°$ $2E=0°$–$131°$.	$Z=c$	Ps. tetrag. Oct.		do	H=4.5 G=2.87 Nearly infus.	Sol. in acid. Basal section divides into four segments. Type soumansite.
∧ ∨	B=low		1.587	Rumpfite $7MgO.8Al_2O_3.10SiO_2.14H_2O$	$2V=0°$–$10°$ $2E=0°$–$16°$.	$X\wedge c=0°$	Scales	{001}mic	Greenish-white.	H=1.5 G=2.68 Infus.	Chlorite group. Insol. in acid.
∧ ∨	1.588	1.599	1.589	Prochlorite $12(Mg,Fe)O.3Al_2O_3.7SiO_2.10H_2O$	$2V=29°$ $2E=46°$.	Z near c	Mon. Hex. plates.	do	Green	H=2± G=2.713	Chlorite group. Fe‴: Al=1:20; Fe″: Mg=1:15.
∧	1.584	1.594	1.589	Celsian $BaO.Al_2O_3.2SiO_2$	$2V=87°$	$Y=b$ $Z\wedge a=28°$.	Mon	{001}perf. {010}good.	Colorless	H=6 G=3.37 Infus.	Barium feldspar. Sol. in HCl.
	*1.59	1.60	1.59	Crandallite $CaO.2Al_2O_3.P_2O_5.6H_2O$	Medium	$X=c$ $Z=a$.	Orth.(?) Elong. c.	{100}perf	do	H=4 F=2–3	Dif. sol. in acid. Dehrn.
⊐	B=low.		1.59	Garnierite $(Ni,Mg)O.SiO_2.nH_2O$	Small	$Z=c$	do		Apple-green	H=3 G=2.5± Infus.	Serpentine group. Decpd. by HCl.

	1.586	1.598	1.59	Custerite $3CaO.CaF_2.2SiO_2.H_2O$	$2V=60°$ $2E=105°$. $r>v$ strong.	$X=b$ $Y\wedge a=6°$.	Mon.	Basal and pris.	White	H=5 G=2.96 F=dif.	Separates gelat. silica. Poly. tw. {001}.
	1.587	1.597	1.590	Bulfonteinite $Ca_2SiO_2(OH,F)_4$	$2V=70°$ $r>v$.	Ext. on {010} to {100} = 45°; on {100} to {001} = 28°.	Tric. Spherulites.	{010}, {100} fairly good.	Pink	H=4.5 G=2.73	Sol. in acid. Ca dissolved out by acid. Poly. tw.
	1.560	1.631	1.591	Hambergite $4BeO.B_2O_3.H_2O$	$2V=88°$ $r>v$ weak.	$X=a$ $Z=c$.	Orth. Pris. c.	{010} perf. {100} good.	White	H=7.5 G=2.35 Infus.	Insol. except in HF.
	1.591	1.627	1.592	Catapleiite $(Na_2,Ca)O.ZrO_2.3SiO_2.2H_2O$	$2V=0°$–$25°$ $2E=0°$–$40°$. $r<v$ slight.	Ax. pl. nearly $\perp$ edge {10$\bar{1}$0}.	Mon. Hex. tab.	{10$\bar{1}$0} perf. {10$\bar{1}$1}{10$\bar{1}$2} imperf.	Yellow, brownish, bluish.	H=6 G=2.75 F=3	Gelat. Section {0001} shows trillings and very complex tw. grating. Hex. above 120° to 200° C.
	1.586	1.614	1.592	Colemanite $2CaO.3B_2O_3.5H_2O$	$2V=56°$ $2E=96°$. $r>v$ weak.	$X=b$ $Z\wedge c=83.7°$.	Mon.	{010} perf. {001} dist.	Colorless	H=4 G=2.42 F=1.5	Sol. in hot HCl.
	1.590	1.602	1.595	Cuspidine $3CaO.CaF_2.2SiO_2$	$2V=62°$ $2E=110°$. $r>v$.	$Y=b$ $Z\wedge c=5\frac{1}{2}°$. Disp. marked.	Mon. Spear-shaped.	{001} dist.	Pale rose-red, colorless.	H=5–6 G=2.86–2.98. F=dif.	Sol. in HNO_3. Tw. pl. {100}.
	1.562	1.632	1.595	Szmikite $MnO.SO_3.H_2O$	Near $90°$	$Z=b$	Mon. (?) Fib. or plates.	One perf. (?)	White, rose, chalky.	H=1.5 G=3.15 Infus.	Sol. in HCl and H_2O.
	*1.577	1.616	1.596	Johannite $RO.UO_3.SO_3.4H_2O$ R=Cu, Fe, Na_2	Very large $r<v$ very strong.	X near b Ext. {010}. Y to tw. = $5\frac{1}{2}°$. Disp. strong.	Tric. Laths {010}. Elong. c.		Yellow, green.	H=2–2.5 G=3.9 Infus.	Sol. in acid. Poly. tw. {100}. Faintly pleoc. in greenish yellow. Abs.: Z>Y>X. Joachimsthal mineral same as "gilpinite."
	1.597	1.612	1.597	Amesite $2(Mg,Fe)O.Al_2O_3.SiO_2.2H_2O$	Very small	Z near c	Mon. Hex. plates.	{001} mic.	Pale bluish green.	H=2–3 G=2.77 Infus.	A chlorite. Decpd. by HCl. Mg:Fe = 5:1.
	1.595	1.628	1.60	Cebollite $5(Ca,Na_2)O.Al_2O_3.3SiO_2.2H_2O$	$2V=58°$ $2E=103°$.		Orth. (?) Fib. Arborescent.		White	H=5 G=2.96 F=5	Alteration of melilite. Gelat.
	B=0.014		1.6±	Manandonite $2Li_2O.7Al_2O_3.2B_2O_3.6SiO_2.12H_2O$	$2V=16°$–$18°$ $2E=25°$–$30°$.	Z sensibly $\perp$ cleav.	Ps. hex.	{0001} mic.	Colorless	G=2.89 F=easy	Decpd. by H_2SO_4. Basal section divides into six segments with the opt. pl. parallel to the hex. edge.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.590	1.638	1.602	Haidingerite $2CaO.As_2O_5.3H_2O$	$2V=58°$ $2E=103°$. $r>v$.	$X=b$ $Z=c$.	Orth. Crusts. Tab.{010}.	{010} highly perf.	Colorless	H=1.5–2.5 G=2.85 F=2.5	Sol. in acid.
∧	1.594	1.615	1.603	Fremontite $Na_2O.Al_2O_3.P_2O_5.H_2O$	Very large	$Z\wedge$tw.lamellae $=29°$.	Mon.(?)			H=5.5 G=3.04	A soda amblygonite. Poly. tw.
	1.579	1.633	1.603	Vivianite $3FeO.P_2O_5.8H_2O$	$2V=83°\pm$ $r<v$ small.	$X=b$ $Z\wedge c=28.5°$. Disp. strong.	Mon	{010}perf	Colorless, green, blue.	H=2 G=2.6 F=1.5	Sol. in HCl. Colorless if fresh, but the colorless mineral on powdering rapidly changes to deep blue and becomes strongly pleoc. with X= dark cobalt-blue. Y= nearly colorless, Z=very pale olive-green to brownish.
∨	1.595	1.633	1.604	Pectolite $Na_2O.4CaO.6SiO_2.H_2O$	$2V=60°$ $2E=106°$. $r>v$ slight.	$Z=b$ $X\wedge c=19°$.	Mon. Acic. b	{100}{001}perf.	Colorless	H=4.5–5 G=2.74–2.88 F=2.	Partly decpd. by HCl.
	1.600	1.613	1.605	Hydrophilite $CaCl_2$			Prob. orth. Ps. tetrag.		White	G=2.2	Artificial mineral. Shows lamellar twinning. Deliquescent. Sol. in H_2O.
	1.599	1.621	1.606	Scawtite $4CaO.3SiO_2.2CO_2$	$2V=74°$ $2E=146°$.	$Y=b$ $Z\wedge$cleav. 29°	Mon. Flattened //{001}.	{001}	Colorless	H=4.5–5 G=2.77	Effervesces, leaving a gelatinous residue.
∧ ∨	1.606	1.610	1.606	Prochlorite $2FeO.2MgO.Al_2O_3.2SiO_2.2H_2O$	Very small $r<v$ perc.	Z near c	Mon. Plates {001}. Vermicular.	{001}mic	Green	Soft G=2.9 F=5–5.5	Chlorite group. Decpd. by hot conct. H_2SO_4. Pleoc.: X and Y=nearly colorless, Z=greenish or brownish.

	B=0.02		1.606	Martinite $5CaO.2P_2O_5.1\frac{1}{2}H_2O$	Medium large.	$Y=b$ and bisects obtuse angle of rhombs. Z emerges from plates.	Mon. (?) Rhombic tablets (65°).		Colorless.	G=2.89 Infus.	Sol. in dilute acid.
^ v	1.605	1.613	1.607	Corundophilite $11(Fe,Mg)O.4Al_2O_3.6SiO_2.10H_2O$	Medium $r<v$ rather strong.	$X\wedge$cleav.=8°.	Mon. Platy	{001}mic.	Green	Soft G=2.9 F=dif.	Chlorite group. Decp. by H_2SO_4. Pleoc.: X and Y=bright green, Z=nearly colorless.
	1.600	1.645	1.608	Weinschenkite $(Y,Er)_2O_3.P_2O_5.4H_2O$	Medium small.	$X=b$ $Z\wedge c=30°\pm$.	Mon. Laths // {010} elong. c.		White		Easily sol. in acid. Related to scorodite group (?).
	B=.017		(?)	Yuksporite $5(Na_2,K_2,Ca)O.6SiO_2.H_2O$	2V=46°–75°		Fib. or scales		Red	H=5± F=easy	Sol. in hot acid. Pleoc.: X=pale yellow-rose, Y and Z=rose-yellow.
^ v	1.612	1.616	1.612	Aphrosiderite $6(Fe,Mg)O.2(Al,Fe)_2O_3.4SiO_2.5H_2O$	Small	$Z=c$	Mon. Fib. and plates {001}.	{001} mic.	Green	Soft G=2.96 F=dif.	Chlorite group. Gelat. Pleoc.: X and Y=olive-green, Z=colorless.
	1.602	1.649	1.613	Anapaite $2CaO.FeO.P_2O_5.4H_2O$	2V=53°± 2E=92°. $r>v$ perc.	On {100} 15° to c	Tric. Elong. c. Radiating.	{101}{010}	Greenish white.	H=3.5 G=2.81	Easily sol. in cold acid.
	1.609	1.619	1.613	Stokesite $CaO.SnO_2.3SiO_2.2H_2O$	2V=70° 2E=134°. $r<v$.	$Z=c$ $Y=b$.	Orth. Pyram.	{110}perf. {010}imperf.	Colorless	H=6 G=3.19	
v	1.606	1.623	1.613	Soda tremolite $CaO.Na_2O.5MgO.8SiO_2.H_2O$	Large	$Z=c$ (or near c).	Orth.? Fib.	{110}perf. at 124°.	White to gray.		Amphibole group. Described as "soda anthophyllite." Pleoc.: X and Y=colorless, Z=pale yellow-green.
v	1.603	1.626	1.613	Amblygonite $Al_2O_3.P_2O_5.2LiF$	2V=55°. 2E=98°. $r<v$.		Tric.	{001}perf. {$\bar{1}$00}less so, {0$\bar{2}$1}rare.	White	H=6 G=3.02 F=2	Sol. in H_2SO_4. Poly. tw. in two directions at 90°.
	1.600	1.631	1.614	Monetite $2CaO.P_2O_5.H_2O$	Large $r>v$ weak.		Tric. Rhombs.	Three pinacoidal.	Pale yellow-white.	H=3.5 G=2.75	

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
V	*1.612	1.624	1.615	Zippeite $2UO_3.SO_3.4H_2O$	Medium large $r>v$ extr.	$Z=b$ $Y\wedge c=23°$. Disp. strong.	Mon. Laths.		Yellow	H=3	Abn. interference colors. Pleoc.: X=pale canary-yellow. Y=canary-yellow. Z=deep canary-yellow. Type material.
	1.614	1.636	1.617	Calamine $2ZnO.SiO_2.H_2O$	$2V=46°$ $2E=78°$. $r>v$ strong.	$X=b$ $Z=c$.	Orth. Elong. c.	{110}perf {101}less so.	Colorless	H=5 G=3.45 F=6	Gelat.
	1.588	1.655	1.617	Cyanotrichite $4CuO.Al_2O_3.SO_3.8H_2O$	$2V=82°$ $r<v$ strong.	$Z=c$	Orth. Velvet-like. Needles c.		Bright blue	G=2.74± F=3	Sol. in acid. Strongly pleoc.: X=nearly colorless, Y=pale blue, Z=bright blue. Lettsomite.
V	*1.604	1.636	1.617	Chondrodite $4MgO.2SiO_2.Mg(F,OH)_2$	$2V=72°$ or more. $2E=143°+$. $r>v$ weak.	$X\wedge a=27°$ $Z=b$. Disp.	Mon. Tab. {010}.	{100}poor	Yellow, red	H=6 G=3.1 Infus.	Humite group. Gelat. Poly. tw. {001}. Pleoc.: X=yellow, Y and Z=nearly colorless. Kaveltorp. Analyzed by Penfield and Howe.
∧	1.618	1.621	1.618	Ripidolite $7(Mg,Fe)O.2Al_2O_3.4SiO_2.6H_2O$	$2V=0°\pm$	Z near c	Mon. Ps. hex.	{001}perf	Green	H=2±	Chlorite group: Ant_1 At_2. Mg:Fe=2:1, Al:Fe=20:1. Pleoc.: X=Y=olive-green, Z=clear olive-green.
⊓ V	1.614	1.633	1.619	Edenite $8CaO.2Na_2O.18MgO.4Al_2O_3.26SiO_2.H_2O.3F_2$	$2V=58°$ $2E=104°$.	$Y=b$ $Z\wedge c=27$.	Mon. Pris. c.	{110}perf. at 124°.	Brown	H=6 G=3.095	Amphibole group.

	B = very weak.		1.62	Metatorbernite $CuO.2UO_3.P_2O_5.8H_2O$	Near 0° Disp. very strong.	$Z=c$	Ps. tetrag Sq. tablets {001}.		Emerald-green to grass-green.	H=2-2.5 G=3.5	Sol. in HNO_3. Abnormal blue to red interference colors.
	1.61	1.65	1.62	Turquoise $CuO.3Al_2O_3.2P_2O_5.9H_2O$	2V=40° 2E=67°. $r<v$ strong.	On {1$\bar{1}$0}=12°. On other cleav.=5° and 34°. Disp. mkd.	Tric	{1$\bar{1}$0}	Sky-blue, bluish green.	H=5 G=2.84 Infus.	Sol. in acid only after ignition. Turns brown b. b. Pleoc.: Colorless to pale bluish.
□	1.610	1.625	1.62	Nontronite $(Ca,Mg)O.Fe_2O_3.2SiO_2.2(\pm)H_2O$	Large	X⊥cleav. Z// fib.	Orth. (?) Plates and fib.	One mic	Yellowish green.	Soft G=2.50	Gelat. Pleoc.: X=yellow-brown, Z=pale yellow. Data from somewhat altered mineral.
□	1.619	1.627	1.620	Topaz $2(AlF)O.SiO_2$	2V=49°-66° 2E=84°-124°. $r>v$ dist.	X=a Z=c.	Orth. Elong. c	{001}perf	Colorless, yellow, etc.	H=8 G=3.58 Infus.	Slightly attacked by H_2SO_4.
	1.620	1.654	1.620	Churchite $3CaO.5Ce_2O_3.6P_2O_5.24H_2O$	2V=0°± Slight.	Z⊥plates	Orth. (?) Rectangular tablets with the long edge beveled.		Colorless	H=3-3.5 G=3.14 Infus.	Sol. in acid.
	1.61	1.71	1.62	Bisbeeite $CuO.SiO_2.H_2O$	Small	Z// elong. Y (or X)⊥ laths.	Orth. Very thin laths.		White, cotton-like.	Soft	Abs: Z>X and Y.
	1.617	1.634	1.620	Afwillite $3CaO.2SiO_2.3H_2O$	2V=55° 2E=97°. $r<v$ perc.	Y=b X∧c=30.6° sodium. Disp. strong.	Mon. Pris. b	{001}perf. {100} imp.	Colorless	H=4 G=2.63 F=dif.	Sol. in HCl.
◇ ◇	1.616	1.635	1.621	Pargasite $4CaO.Na_2O.9(Mg,Fe)O.2Al_2O_3.13SiO_2.H_2O.F_2$	2V=59° 2E=108°.	Z∧c=27°	Mon. Elong. c	{110}perf. at 124°.	Light green	H=6 G=3.095	Amphibole group. Mg/Fe=23; Al/Fe=21.
◇	*1.620	1.630	1.621	Zippeite $2UO_3.SO_3.4H_2O$	Medium $r<v$ extr. Disp. strong.	Y∧c=22° Z=b.	Mon.(?). Minute laths {010}, earthy.		Lemon-yellow	Powder. H=3	Sol. in acid. Plates lying on {010} gives sharp extinction in white light. Others give very abnormal blue interference colors. Pleoc.: X=colorless, Y and Z=canary-yellow. Cornwall. (Joachimsthal, from Prof. Slavik, of Prague, had β=1.615, Y∧c=23°.)

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.618	1.658	1.622	Arakawaite $4CuO.2ZnO.P_2O_5.6½H_2O$	$2V=38½°$ $2E=64°$.	$Y=b$ $Z\wedge c=36°$.	Mon. Pris	{011}	Dark bluish green.	H=3.5 G=3.09	Near veszelyite and kipushite. Oxidized zone of copper ores.
∧	1.613	1.636	1.623	Amblygonite $Al_2O_3.P_2O_5.2LiF$	$2V=55°$ $2E=98°$.		Tric	{001} perf., {$\bar{1}$00} less so, {0$\bar{2}$1} rare.	White	H=6 G=3.02 F=2	Sol. in H_2SO_4. Poly. tw. in two directions at 90°.
	1.592	1.665	1.624	Szomolnokite $FeO.SO_3.H_2O$	$2V=70°–80°$.	$Y=b$	Mon. Pyram		Honey-yellow to brown.	H=3.5 G=3.186 F=easy	Slowly sol. in water. Isomorphous with kieserite. Turns black on heating in tube.
⊔	1.622	1.631	1.624	Celestite $SrO.SO_3$	$2V=51°$ $2E=80°$. $r<v$.	$X=c$ $Z=a$.	Orth. Tab. {001}.	{001} perf {110} nearly so, {010} less so.	Colorless	H=3.5 G=3.96 F=3	Insol. in acids.
∨	1.615	1.645	1.625	Prehnite $2CaO.Al_2O_3.3SiO_2.H_2O$	Large $r>v$ weak.	$X=a$ $Z=c$.	Orth	{001} dist	White	H=6 G=2.9± F=2	Sol. in HCl slowly. Luster on {001} pearly.
	1.615	1.665	1.625	Destinezite $2Fe_2O_3.P_2O_5.2SO_3.13H_2O$	Small $r>v$ rather strong.	X inclined to ⊥ plates, Z to elong. 16°.	Tric.(?) Minute six-sided tablets.		White powder. Yellow.	H=3 G=2.1 F=dif.	Sol. in HCl.
	1.614	1.637	1.625	Parahopeite $3ZnO.P_2O_5.4H_2O$	$2V$=nearly 90° $r<v$ perc.	Ext. {100} $Y\wedge c=30°$ Ext. {010}= 0°–25°. X near a.	Tric. Tab. {100}.	{010} perf	Colorless	H=3.5–4 G=3.31 F=easy	Sol. in HCl. Tw. pl. {100} multiple and common.
⊏⊐	B=weak		1.625	Georceixite (Ba, Ca, Ce)O. $2Al_2O_3.P_2O_5.5H_2O$			Microcrystalline.		Brown, white, etc.	H=6 G=3.10	Alunite group.
∧ ∨	1.626	1.652	1.629	Prehnite $2CaO.Al_2O_3.3SiO_2.H_2O$	Medium $r>v$ mod.	$X=a$ $Z=c$.	Orth	{001} dist	White, etc	H=6 G=2.9 F=2	Sol. in HCl. Luster on {001} pearly. Fe_2O_3 2.10 per cent.

V	B=0.02±		1.63±	Homilite (altered) $3(Ca,Fe)O.B_2O_3.2SiO_2.nH_2O$(?)	Medium large $r<v$ very strong.		Ps. mon.	Imperf.	Yellow	H=5 G=3 F=2	Altered homilite. Gelat.
^ V	1.630	1.635	1.630	Chlorite $9(Mg,Fe)O.3Al_2O_3.5SiO_2.7H_2O$	Very small	Z near c	Mon. Platy	{001} mic.	Green	H=3	Pleoc.: X and Y=deep green, Z=greenish brown. Mineral with SiO_2 24.8, Al_2O_3 22.9, FeO 28.7, MgO 13.5, H_2O 10.1 per cent.
^ V	1.622	1.645	1.630	Edenite $4CaO.Na_2O.10(Mg,Fe)O.(Al,Fe)_2O_3.14SiO_2.H_2O.F_2$	$2V=60°\pm$ $2E=118°$. $r<v$.	$Y=b$ $Z\wedge c=27°$.	Mon. Pris. c.	{110} perf.	Brownish green.	H=6	Amphibole group. Mg/Fe=13; Al/Fe=16. Pleoc.: X=colorless, Y=light violet-blue, Z=violet-blue.
□	1.623	1.684	1.630	Guildite $3(Cu,Fe)O.2(Fe,Al)_2O_3.7SO_3.17H_2O$	Small		Mon.	{100} perf., {001} perf.	Chestnut-brown.	H=2.5 G=2.725	Brittle. Pleoc.: X and Y=pale yellow, Z=greenish yellow.
^ V	*1.622	1.652	1.632	Humite $6MgO.3SiO_2.Mg(F,OH)_2$	$2V=68°\pm$ $2E=132°$. $r>v$ weak.	$X=a$ $Z=b$.	Orth. Tab. {010}.	{001} perf.	Colorless, yellow, brown.	H=6 G=3.1 Infus.	Gelat. Pleoc.: X=golden-yellow, Y and Z=nearly colorless. Monte Somma. Analyzed by Penfield and Howe. Sjögren orientation.
□	1.631	1.640	1.632	Picropharmacolite $3(Ca,Mg)O.As_2O_5.6H_2O$	$2V=40°$ $2E=67°$. $r<v$ rather strong.	$Y=b$ $X\wedge c=37°\pm$.	Mon. Aggregates.	{010}{100}	White	Soft G=2.58	
^ □	1.633	1.634	1.633	Ripidolite $15(Mg,Fe)O.5Al_2O_3.9SiO_2.13H_2O$	$2V=0°\pm$	Z near c	Mon. Plates ps. hex.	{001} mic.	Green		Chlorite group: Ant_2At_3. Fe:Mg=4:5; Fe:Al=1:8. Pleoc.: X and Y=olive-green, Z=light yellow-green.
	1.617	1.652	1.635	Tilleyite $3CaO.SiO_2.CO_2$	$2V=90°\pm$ $r<v$ perc.	$X\wedge a=18°$	Mon.		White	G=2.823	Effervesces and gelat.
	1.613	1.657	1.635	Sklodowskite $MgO.2UO_3.2SiO_2.7H_2O$	Large $r<v$ very strong.	Y=elong.	Orth. Needles.		Yellow	G=3.7	Pleoc.: X=colorless, Y=pale yellow, Z=yellow.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
□	1.631	1.660	1.636	Schizolite $Na_2O.4(Ca,Mn)O.6SiO_2.H_2O$	$2V=47°$ $2E=81°$. $r<v$ rather strong.	Z near b $Y\wedge a=9°$.	Tric. Pris. b.	{001}{100}perf.	Light red altering to brown.	H=5–5.5 G=2.97–3.13	
◇	*1.623	1.651	1.636	Clinohumite $8MgO.4SiO_2.Mg(F,OH)_2$	$2V=$near 90° $r<v$.	$Z=b$ $X\wedge a=9°\pm$.	Mon.	{001}poor.	Yellow to reddish brown.	H=6 G=3.1 Infus.	Humite group. Gelat. Pleoc.: X=yellow, Y and Z=nearly colorless. Monte Somma. Analyzed by Penfield and Howe.
	1.636	1.648	1.637	Barite $BaO.SO_3$	$2V=37½°$ $2E=63°$. $r<v$ weak.	$X=c$ $Z=a$.	Orth. Tab. {001}.	{001}{110}perf. {010}imperf.	White.	H=3 G=4.5 F=3	Insol. in acids. Tw. {110} lamellar.
◇	1.633	1.652	1.638	Anthophyllite $7(Mg,Fe)O.8SiO_2.H_2O$	$2V=66°$ $2E=127°$.	$Y=b$ $Z=c$.	Orth. Pris. c.	{110} perf. at 126°.	Colorless.	H=6 G=3.157	Amphibole group. Mg/Fe=2.7.
◇	1.633	1.652	1.638	Pargasite $4CaO.Na_2O.9(Mg,Fe)O.2Al_2O_3.13SiO_2.H_2O.F_2$	$2V=63°$ $2E=118°$.	$Z\wedge c=26°$	Mon. Pris. c.	{110}perf.		H=6 G=3.186	Amphibole group. Mg/Fe=6.2.
□	1.64	1.66	1.64	Roeblingite $7CaO.2PbO.6SiO_2.2SO_3.5H_2O$	Small.	Elong.—			Colorless.	H=3 G=3.43 F=3	Gelat. Ca:Pb:Mn:Sr=12:4:1:1.
□	1.640	1.657	1.640	Sarcolite $3(Ca,Na_2)O.Al_2O_3.3SiO_2$	do $r>v$ strong.		Ps. tetrag. Cubo-oct.		Reddish white, flesh-red.	H=6 G=2.7± F=2.5–3 (?).	Gelat. Anom. biax.
◇	1.638	1.653	1.642	Mullite $3Al_2O_3.2SiO_2$.	$2V=20°\pm$ $2E=33°$. $r>v$ perc.	$X=b$ $Z=c$.	Orth. Prisms and needles //c.	{100}very perf.	Colorless, gray.	H=6–7 G=3.23 Infus.	Insol. in acid. Data for artificial mineral.

⊓ ◇	1.632	1.657	1.642	Collinsite $2CaO.(Mg,Fe)O.P_2O_5.2\frac{1}{2}H_2O$	$2V=80°$	$Y\wedge c_1=150°$, $Y\wedge c_2=66°$, $Y\wedge c_3=44°$. Elong. +.	Tric. Elongated blades.	Pinacoidal c_1, c_2, c_3.	Light brown, silky luster.	H=3.5 G=2.95 F=3	Member of roselite group. Easily sol: Near messelite.
◇ ⊓	1.632	1.665	1.642	Ferriprehnite $2CaO.(Al,Fe)_2O_3.3SiO_2.H_2O$	$2V=68°$ $2E=133°$.	$Y=b$ or a	Orth		Apple-green	H=6 G=2.924	Prehnite with 6.89 per cent of Fe_2O_3.
	1.631	1.695	1.643	Ransomite $CuO.(Fe,Al)_2O_3.4SO_3.7H_2O$	Medium		Orth. Radiating crystals. Elong. c.	One perfect	Sky-blue	H=2.5 G=2.632	
	1.640	1.647	1.642	Juanite $10CaO.4MgO.Al_2O_3.11SiO_2.4H_2O$	$2V=50°\pm$ $2E=88°\pm$.	Elong. (+) // ext.	Orth.? Fibrous		White	G=3.01 F=3	An altered melilite. Fuses b. b. to a translucent glass. Decpd. by acid.
	1.636	1.654	1.644	Fairfieldite $2CaO.MnO.P_2O_5.2H_2O$	Very large $r>v$.	Ext. on $\{100\}=40°$ to c, on $\{010\}=10°$. Disp. perc.	Tric. Pris., foliated, fib.	$\{010\}$ highly perf., $\{100\}$ good.	Nearly colorless. Luster on $\{010\}$ pearly.	H=3.5 G=3.1 F=4	Sol. in acids.
⊓	B=0.01			Hellandite $2CaO.3(Al,Fe,Mn,Ce)_2O_3.4SiO_2.3H_2O$	$2V=80°$	$X=b$ $Z\wedge c=-43\frac{1}{2}°$.	Mon. Pris. c. Tab. $\{010\}$.		Nut-brown to brownish red	H=7.5 G=3.35–3.70 F=easy	Sol. in HCl. Tw. pl. $\{001\}$ contact, $\{100\}$ lamellar. Commonly altered; optical properties vary and finally the mineral becomes isotropic.
◇ ◇	1.643 (1.662)	1.651 (1.681)	1.645 (1.667)	Rinkolite Titanosilicate of rare earths and Na, Sr, Ca	$2V=45°$–$88°$ $r>v$.	$Y=b$ $X\wedge c=1.5°$–$3.5°$.	Mon. Bladed crystals.	$\{100\}$ $\{010\}$ poor.	Yellowish green.	H=5 G=3.40	Related to rinkite. Easily sol. in acid. Abs.: $Z>Y>X$. Indices vary.
⊓	1.637	1.676	1.648	Loseyite $7(Mn,Zn,Mg)O.2CO_2.5H_2O$	$2V=64°$ $2E=122°$. $r>v$.	$Y=b$	Mon. Elong. b.		Bluish white	H=3± G=3.27	MnO:ZnO:MgO=5:4:1. Related to hydrozincite?
	1.646	1.658	1.649	Mosandrite Contains Ti, Si, Ce, Ca, Na, Zr, O, etc.	$2V=74°\pm$ $2E=166°$. $r>v$ strong.	$X\wedge c=2°\pm$ $Y=b$.	Mon.(?) Elong. c.	$\{100\}$dist	Reddish brown	H=4 G=3.0 F=3	Near johnstrupite. Sol. in HCl.
◇ ◇	B=0.02±		1.65±	Homilite (altered) $3(Ca,Fe)O.B_2O_3.SiO_2+nH_2O(?)$	$2V=0°\pm$ $r\lesssim v$ very strong.		Ps. mon	Imperf	Yellow	H=5 G=3.4 F=2	Alteration of homilite. Gelat.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.588	1.722	1.650	Krausite $K_2O.Fe_2O_3.4SO_3.2H_2O$	Large	$Z=b$ $X \wedge c=35°$.	Mon. Pris. and also flat tab. to {001}.	{001}perf.,{100} good.	Yellowish green.	H=2.5 G=2.840	Sol. in acid. Pleoc.: weak: X=colorless, Y and Z=pale yellow.
◇	1.639	1.667	1.650	Cummingtonite $7(Mg,Fe)O.8SiO_2.H_2O$	2V=84° $r>v$.	$Y=b$ $Z \wedge c=19½°$.	Mon. Pris. c	{110} perf. at 124°.	Gray-brown	H=6 G=3.25 Fus.	Amphibole group. Mg/Fe=1.3. Insol. in HCl. Pleoc.: X and Y=yellow; Z=brown-yellow.
□	1.640	1.660	1.650	Fairfieldite $2CaO.(Mn,Fe)O.P_2O_5.2H_2O$	2V=86° $r>v$.	Ext. on {100} to c axis = 40°; on {010} to c axis=10°.	Tric. Platy // b.	{010}perf.{100} good.	White, luster on {010} pearly.	H=3.5 G=3.016 F=4	Mn:Fe=3:1. Sol. in acid.
∨	1.636	1.669	1.651	Forsterite $2MgO.SiO_2$	2V=85° $r<v$.	$X=b$ $Y=c$.	Orth. Equant.	{010} and {001} dist.	Colorless	H=7 G=3.216 Infus.	Olivine group. Data for pure artificial mineral. Gelat.
∨	1.650	1.658	1.653	Enstatite $MgO.SiO_2$	2V=31° 2E=52°. $r<v$.	$Z=c$ $Y=b$.	Orth. Pris. c	{110} perf. at 87°.	do	H=5–6 G=3.18 F=6	Pyroxene group. Data for pure artificial mineral. Insol. in acid. 2V, index, and B increase with FeO content.
∧	1.651	1.668	----------	Mullite $3Al_2O_3.2SiO_2$	Small	$X=b$ $Z=c$.	do	{100} very perf.	Pink, etc.	H=6 G=3.2. Infus.	Insol. in acid. Faintly pleoc. Data for mineral with 1.3 per cent TiO_2.
⌓	1.640	1.680	1.653	Messelite $2CaO.(Fe,Mg)O.P_2O_5.2½H_2O$.	Medium Slight.	Ext. on {100} 20° to c.	Tric. Tab. {100}.	One good	Colorless, brownish.	H=3–3.5 G=3	
	B=0.053	----------	1.654	Dioptase $CuO.SiO_2.H_2O$	2V=43° 2E=74°.	----------	Trig	{10$\bar{1}$1} perf.	Emerald-green	H=5 G=3.05 Infus.	Gelat. Pleoc. faint. Abs.: X>Y and Z.

V	1.651	1.660	1.654	Clinoenstatite $MgO.SiO_2$	$2V=54°$. $2E=96°$. Slight.	$X=b$. $Z\wedge c=22°$.	Mon. Elong. c.	{110} perf.	Colorless	G=3.28 Infus.	Pyroxene group. Insol. in acid. Data on artificial mineral. Poly. tw. {100} characteristic.
	1.655	1.662	1.655	Uranochalcite UO_3, CuO, CaO, SO_3, H_2O	Small	$Z=c$.	Matted. Fib. c.		Grass-green to apple-green.	H=2–2.5	Sol. in acid. Abnormal interference colors. Faintly colored and pleoc.: X and Y=very pale yellowish green, Z=pale greenish yellow.
V	1.648	1.662	1.655	Dickinsonite $7(Mn,Fe)O.2(Na_2,K_2,Ca)O.3P_2O_5.H_2O$	$2V$=nearly 90°. $r>v$.	$X=b$. $Y=c$.	Mon. Tab. foliated {001}.	{001} perf.	Epidote-green	H=4± G=3.27	Pleoc. in green. Mn: Fe=3:1.
	1.653	1.673	1.656	Euclase $2BeO.Al_2O_3.2SiO_2.H_2O$	$2V=47°$. $2E=82°$. $r>v$.	$Y=b$. $Z\wedge c=42.3°$.	Mon. Elong. c.	{010} perf. {100} {001}. poor.	Colorless, pale blue.	H=7.5 G=3.1 F=5.5	Insol. in acid.
	1.649	1.714	1.656	Natrochalcite $Na_2O.4CuO.3SO_3.3H_2O$	$2V=37°$. $2E=63°$. $r<v$ strong.	$Y=b$. $Z\wedge c=-12°$. Disp. strong.	Mon. Elong. c.	{001} perf.	Emerald-green	H=4.5 G=2.33 F=easy	Sol. in H_2O slowly. Dispersion of bisectrices strong. $Z\wedge c$ for red is greater than for blue.
V	1.651	1.683	1.656	Reddingite $3MnO.P_2O_5.3H_2O$	$2V=41°$. $2E=71°$. $r>v$ strong.		Orth. Oct.	One dist.	Pink, violet, red-brown.	H=3–3.5 G=3.10 F=2.5–3	Sol. in acid.
□	*1.652	1.665	1.658	Hiortdahlite $(Na_2,Ca)O.FeO.2(Si,Zr)O_2$	Near 90°. $r>v$ perc.	Opt. pl. nearly {111}. Ext. on {100}=65°.	Tric. Tab. {100}.	Pris. at nearly 90° dist.	Bright yellow, yellow-brown.	H=5.5 G=3.27 F=3(?)	Gelat. Pleoc.: X=colorless, Y=yellowish white, Z=wine-yellow. Poly. tw. Composition pl. {110}. Langesund.
□	1.640	1.695	1.658	Veszelyite $7(Zn,Cu)O.(P,As)_2O_5.9H_2O$	$2V=71°$. $2E=148°$. $r<v$ very strong.		Mon. or tric. Incrustations.		Greenish blue	H=3.5–4 G=3.53 Fus.	Pale greenish blue and nonpleoc. in section.
^ V	1.654	1.667	1.659	Jadeite $Na_2O.Al_2O_3.4SiO_2$	$2V=70°$. $2E=144°$. $r<v$ weak.	$Y=b$. $Z\wedge c=34°$. Disp.	Mon. Fib. c.	{110} perf. at 88° Parting {100}.	Green, etc.	H=6.3 G=3.4 F=2.5	Pyroxene. Insol. in acid. In section colorless. Mineral with 2 per cent diopside.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.655	1.670	1.66	Salmonsite $Fe_2O_3.9MnO.4P_2O_5.14H_2O$	Very large $r<v$ strong.	Z // fibers	Orth. Massive	Two at 90° dist.	Yellowish	H=4 G=2.88	Pleoc.: X=nearly colorless, Z=orange-yellow.
V	1.650	1.672	1.660	Triplite $3MnO.P_2O_5.MnF_2$	Very large $r>v$ strong.	Y=b Z∧a=42°.	Mon.	{100}perf {010}poor.	Pale salmon	H=4–4.5 G=3.79 F=2.5	Sol. in acids. Data on mineral with 1.7 per cent FeO. Abs.: X>Y≧Z.
□	1.650	1.680	1.660	Barrandite $(Al,Fe)_2O_3.P_2O_5.4H_2O$	Medium large $r>v$ strong.	Z=c	Orth. Fib. c		Gray, etc	H=4.5 G=2.6± Fus.	Sol. in acid.
V	1.645	1.715	1.660	Plancheite $2CuO.2SiO_2.H_2O$	Medium	Z near elong X ⊥ cleav.	Mon. Fib		Blue	H=5.5 G=3.36	Dif. sol. in acid. Pleoc.: in blue tints. Abs.: Z>X.
	1.659	1.680	1.660	Sillimanite $Al_2O_3.SiO_2$	2V=20° 2E=33°. $r>v$ perc.	X=b Z=c.	Orth. Acic. c	{100}perf	White	H=6 G=3.23 Infus.	Insol. in acid. May be pleoc.
	1.626	1.699	1.661	Erythrite $3CoO.As_2O_5.8H_2O$	2V=90°± $r<v$ weak.	X=b Z∧c=31°.	Mon. Laths {010} elong. c.	{010} highly perf.	Crimson to gray.	H=1.5–2.5 G=2.95 F=2	Sol. in HCl. Strongly pleoc.: X=pale pinkish, Y=very pale violet, Z=red. Colors vary.
	1.645	1.688	1.661	Leucosphenite $2Na_2O.BaO.2TiO_2.10SiO_2$	2V=77° $r>v$ rather strong.	Z=b Y∧c=3°.	Mon. Elong. c	{010}dist	White, gray-blue.	H=6.5 G=3.05 F=dif.	Tw. pl.{001}.
^ V	1.640	1.680	1.661	Forsterite $2MgO.SiO_2$	2V=90°± $r<v$ slight.	X=b Z=a.	Orth. Equant	do	Colorless, etc	H=7 G=3.2 Infus.	Olivine group. Gelat. Mg/Fe=19.
^ □	1.658	1.671	1.662	Dickinsonite $3(Mn,Fe,Na_2)O.P_2O_5.\frac{1}{2}H_2O$	Medium $r>v$ strong.	X=b Y near c.	Mon. Tab Foliated{001}	{001}perf	Olive-green, etc.	H=3.5–4 G=3.34 F=2.5–3	Sol. in acids. Pleoc. in green. Abs. X>Y>Z.

	1.629	1.727	1.662	Lindackerite $3NiO.6CuO.SO_3.2As_2O_5.7H_2O$	$2V=73°$ $2E=162°$. $r<v$ strong.	$X\wedge$elong. $26°$. $Y=b$.	Mon.? Oblong rhombic tablets {010}. Fib.	{010}perf.	Apple-green	H=2-2.5 G=2.0-2.5 F=2-3(?)	
< >	1.655	1.683	1.662	Reddingite $3(Mn,Fe)O.P_2O_5.3H_2O$	$2V=65°$ $2E=126°$. $r>v$ perc.		Orth. Oct.	One distinct.	Red-brown	H=3±	Mn:Fe=3:1.
□	1.660	1.688	1.664	Sérandite $(Mn,Ca,K,Na)\ Si(O,OH)_3$	$2V=36°$ $2E=57°$.	$Z=b$. $X\wedge c=57°$.	Mon. Elong. b.	Two cleav. in orthozone.	Rose-red	G=3.22	A manganese pectolite. Mn: Ca=2.2:1.
< >	B=0.02±		1.665	Homilite (altered) $3(Ca,Fe)O.B_2O_3.2SiO_2+nH_2O(?)$	Small $r>v$ very strong.		Ps. mon.	Imperf.	Yellow	H=5 G=3.38 F=2	Gelat.
□	1.661	1.673	1.666	Johnstrupite $Na_2O.3CaO.(Ti,Zr)O_2.5SiO_2.Ce(F,OH)_3$	$2V=70°$ $2E=146°$. $r>v$ strong.	$X\wedge c=2°$ $Y=b$.	Mon.	{100}dist.	Brownish green	H=4 G=3.29 F=3	Sol. in HCl. Poly. tw. {100}. In section colorless.
□ < >	1.663	1.673	1.666	Lithiophilite $Li_2O.2MnO.P_2O_5$	Large	$X=a$ $Z=b$.	Orth. Elong. c.	{001}perf{010} nearly so.	Pale-pink	H=5 G=3.5 F=1.5	Isom. with triphylite. Sol. in acid. Data for mineral with 2.94 per cent FeO. Pleoc.: X=deep pink, Y=pale yellowish, Z=pale pink. With increase of FeO β increases, 2V and B decrease.
	1.660	1.676	1.666	Spodumene $Li_2O.Al_2O_3.4SiO_2$	$2V=58°\pm$ $2E=108°$. $r<v$.	$Y=b$ $Z\wedge c=24°$.	Mon. Pris. c.	{110}perf. at 88° {010}parting. {100}parting rare.	White, yellow, green, violet, etc.	H=6.5 G=3.2 F=3.5	Pyroxene group. Insol. in acids. Abs.: X>Y>Z.
<	1.644	1.716	1.667	Plancheite $2CuO.2SiO_2.H_2O$	Medium	Z elong. $Bx_o\perp$ laths.			Pale blue	H=5.5 G=3.36	Z slightly more blue than X and Y.
	1.662	1.673	1.667	Boracite $5MgO.7B_2O_3.MgCl_2$	Very large		Orth. Ps. isomet.	{111}traces	White, etc.	H=7 G=2.95 F=2	Sol. in acid. Isomet. above 265° C.
□	1.665	1.681	1.668	Rinkite $Na_2O.3CaO.(Ti,Zr)O_2.3SiO_2.Ce(F,OH)_3$	$2V=43°\pm$ $2E=75°$. $r<v$ strong.	$Y\wedge c=-7.5°$ $X=b$. Disp. dist.	Mon. Elong. c.	{100}dist.	Yellowish brown, straw yellow.	H=5 G=3.46 Fus.	Decpd. by dilute acids. Tw. pl. {100} poly. Abs.: Z>Y>X. Near colorless in section.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
∧ ∨	1.665	1.674	1.669	Enstatite (Mg,Fe)O.SiO_2	2V=80° $r<v$ weak.	Z=*c* X=*a*.	Orth. Pris. *c*.	{110} perf. at 88°.	Green	H=5.5 G=3.2 F=6	Pyroxene group. Data for mineral with 7 per cent FeO=9 per cent (molecular) $FeSiO_3$. Insol. in HCl. 2V, index, and B increase with iron.
□	B=0.014		1.67	Lotrite $2(Al,Fe)_2O_3$. $3(Ca,Mg)O$. $4SiO_2.2H_2O$	2V=18° 2E=30°.	Z=*b* Y∧cleav. 28°	Massive	Parallel to length perf.		H=7.5 G=3.23	
∧	1.658	1.690	1.670	Titanohydroclinohumite. $8MgO.4SiO_2$. Some TiO_2, $Mg(OH)_2$	2V=76° $r>v$ weak.	Z=*b* X∧*a*=9°± Disp. perc.	Mon	{001}poor	Yellow to reddish brown.	H=6 G=3.1 Infus.	Humite group or titanolivine? Gelat. Pleoc.: X=yellow, Y and Z=nearly colorless. Poly. tw. {001}. Contains 1.92 per cent TiO_2.
∧ ∨	1.653	1.689	1.670	Olivine $2(Mg,Fe)O.SiO_2$	2V=88° $r<v$.	X=*b* Z=*a*.	Orth. Equant.	{010}dist {100}less so.	Grass-green	H=7 G=3.341 F=dif.	Olivine group. Gelat. Habit characteristic alters to serpentine and iddingsite. Mineral with 11.9 per cent FeO+MnO =12 per cent (molecular) $2FeO.SiO_2$.
□	1.662	1.691	1.671	Viridine $(Al, Fe, Mn)_2O_3$. SiO_2	2V=71° 2E=152°. $r<v$.	X=*a* Y=*b*.	Orth	{001}good		H=6.5 G=3.22	Pleoc.: X=light yellow, Y=grass-green, Z=dark yellow. Contains 5 to 7 per cent Mn_2O_3.

	1.670	1.689	1.671	Hinsdalite $2PbO.3Al_2O_3.2SO_3.P_2O_5.6H_2O$	2V=0°–30° 2E=0°–51°.	Z=c	Ps. hex. Tab. {0001}. Rhombs.	{0001}perf.	White, gray	H=4.5 G=3.65 Infus.	Alunite group. Insol. in HCl. Basal section divided into 6 segments and opt. pl. of each is ⊥hex. edge.
◇ ◇	1.664	1.694	1.671	Diopside $CaO.MgO.2SiO_2$	2V=59° 2E=110°. r>v weak.	Z∧c=38½° Y=b.	Mon. Pris. c.	{110} at 87° perf.	Colorless	H=5–6 G=3.28 Infus.	Pyroxene group. Data on pure artificial mineral. Insol. in acid.
◇	*1.669	1.677	1.672	Magnesium chlorophoenicite. $10(Mg,Mn)O.As_2O_5.7H_2O$	Small r<v strong.	Y=b	Mon. Fib. // b.	{100}good	White	H=3–3.5 G=3.37	Mg:Mn=4:1. See Chlorophoenicite, p. 126.
□ □	1.672	1.676	1.672	Fillowite $3(Mn,Fe,Na_2)O.P_2O_5.H_2O$	Small		Mon. Ps. rhomboh.	{001}nearly perf.	Yellow, reddish brown, colorless.	H=4.5 G=3.43 F=1.5	Sol. in acid.
◇ ◇	1.665	1.682	1.673	Triplite $3MnO.P_2O_5.MnF_2$	Near 90° r>v strong.	Y=b Z∧a=42°.	Mon	{100}perf. {010}perf.	Pale salmon	H=3.5 G=3.58 F=2.5	Sol. in acid. Data for mineral with FeO 4.95, CaO 3.18, MgO 0.58 per cent. Pleoc.: in brown.
	1.671	1.684	1.674	Natrophilite $Na_2O.2MnO.P_2O_5$	Large r<v strong.	Z=b X=a.	Orth	{001}perf. {010}good.	Deep wine-yellow.	H=4.5–5 G=3.41 F=2–2.5	Sol. in acid.
□ □	1.663	1.699	1.674	Spodiosite $3(Ca,Mg)O.P_2O_5.$ Some CaF_2	2V=69°± 2E=142°. r>v rather strong.	Ext. on cleav. 38° to other cleav.	Tric.? Flattened prisms.	{010}dist. {001}indist.	Ash-gray, brown.	H=5 G=2.94(?) F=dif.	Do.
	1.665	1.684	1.674	Lawsonite $CaO.Al_2O_3.2SiO_2.2H_2O$	2V=84° r>v strong.	X=a Z=c.	Orth. Tab. {001}.	{010}perf. {001} rather perf. {110}less so.	Colorless, bluish.	H=8 G=3.09 F=4.	Insol. in acid. Pleoc. in thick plates: X= blue, Y=yellowish, Z=colorless.
◇ ◇	1.666	1.688	1.674	Diopside-jadeite $Na_2O,CaO,MgO,Al_2O_3,SiO_2$	2V=70–80°	Y=b Z∧c=43°–47°.	Mon. Pris. c.	{110} perf. at 87°.	Green	H=6.5 G=3.27	Pyroxene group. Data for mineral about midway between diopside and jadeite.
◇ ◇	1.666	1.688	1.675	Iron anthophyllite $7(Fe,Mg)O.8SiO_2.H_2O$	2V=81° r>v perc.		Orth.	{110}perf. at 120°.	Dark green	H=6 G=3.85	Amphibole group. Data for mineral with MgO 4.68, MnO 3.49 per cent.

163287—34——9

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.653	1.697	1.675	Ludlamite $7FeO.2P_2O_5.9H_2O$	$2V=82°$ $r>v$ weak.	$Y=b$ $Z\wedge c=-67°$.	Mon. Tab. {001}.	{001}highly perf. {100}dist.	Bright green	H=3–4 G=3.72 F=2–2.5	Sol. in acid.
V	B=weak		1.676	Pharmacosiderite $3Fe_2O_3.2As_2O_5.13H_2O$	Large $r<v$ very strong. Disp. strong.	Large ext	Mon.? Ps.iso-met. Cubes, tetrah.	{100}imperf	Olive-green, yellow-brown, etc.	H=2.5 G=3.0 F=1.5–2	Sol. in acids. Poly. tw.
	*1.672	1.683	1.676	Akrochordite $4MnO.MgO.As_2O_5.6H_2O$	Medium $r<v$ fairly strong.	$X=b$ $Y\wedge c=45°$.	Mon. Radial aggregates, tab. $\perp$ {010}.	{010}poor	Yellowish brown.	H=3.5 G=3.194	
^	*1.669	1.700	1.678	Iron reddingite $9RO.4P_2O_5.3H_2O$. Some F. R=Fe, Ca, Mg, Mn	Medium large $r>v$ easily perc.				White, yellow, pale green.	H=4–5 G=3.16	Sol. in acid. Hagendorf.
^ v	1.673	1.683	1.678	Hypersthene $(Mg,Fe)O.SiO_2$	$2V=90°$	$X=a$ $Z=c$.	Orth. Pris. c.	{110}perf. at 88°	Green, etc	H=5.5 G=3.3 F=6	Pyroxene group. Insol. in HCl. Data for mineral with 10 per cent FeO=14 per cent (molecular) $FeSiO_3$.
^ v	1.676	1.687	1.679	Lithiophilite $Li_2O.2(Mn,Fe)O.P_2O_5$	$2V=63°$ $2E=123°$. $r<v$ strong.	$X=a$ $Z=b$.	Orth. Elong. c.	{001}perf. {010}nearly so.	Pale pink, liver-brown.	H=5 G=3.5 F=1.5	Isomor. with triphylite. Data for mineral with 9.42 per cent FeO. Sol. in acid. Pleoc.: X=deep pink, Y=pale yellowish green, Z=pale pink. With increase of FeO β increases, 2V and B decrease.
	1.678	1.683	1.68	Harstigite $6CaO.2MnO.Al_2O_3.6SiO_2.2H_2O$	$2V=52°$ $2E=95°$. $r<v$ weak.	$X=c$ $Z=a$.	Orth. Pris. c. with {010} {011}.		Colorless	H=5.5 G=3.05	After ignition easily sol. in HCl.

	1.679	1.692	1.680	Pumpellyite $Ca_4R_6Si_6O_{23}(OH)_3 \cdot 2H_2O$	$2V=40°$ $2E=72°$.	$Y=b$ $X \wedge a=12°$.	Mon. Elong. b. Fib.	{001}, {100}, imperf.	Green to brown	H=5.5	Twinned on {001}. Pleoc.: X=colorless, Y=pale green, Z=colorless. R=Al: Fe‴: Fe″: Mg=50:1:4:4.
◇ ◇	1.663	1.700	1.681	Olivine $2(Mg,Fe)O \cdot SiO_2$	$2V=90°$ $r<v$.	$X=b$ $Z=a$.	Orth. Equant.	{010}dist. {100}less so.	Green, brownish, etc.	H=7 G=3.404 F=dif.	Olivine group. Gelat. Habit characteristic. Alters to serpentine and iddingsite. FeO+MnO+NiO=15.5 per cent=16.2 per cent (molecular) Fe_2SiO_4.
◇ ⊔	1.675	1.692	1.683	Triplite $3(Mn,Fe)O \cdot P_2O_5 \cdot MnF_2$	$2V=80°$ $r>v$.	$Y=b$ $X \wedge a=42°$.	Mon	{100}perf. {010}poor.	Salmon	H=3.5 G=3.87 F=2.5	Sol. in acids. Fe: Mn=49:33. F: OH=4:1.
	1.662	1.717	1.683	Koettigite $3ZnO \cdot As_2O_5 \cdot 8H_2O$	$2V=77°$ $r<v$ rather strong.	$Z \wedge c=37°$ $X=b$.	Mon. Fib. c.	{010}perf.	Carmine	H=2.5–3 G=3. ± F=3(?)	Sol. in acid. Pale pink in section and nonpleoc.
◇ ◇	1.676	1.705	1.683	Zinc schefferite $(Mg, Mn, Zn)O \cdot CaO \cdot 2SiO_2$	$2V=60°$ $2E=114°$. $r>v$.	$Z \wedge c=5°\pm$	Mon	{110}	Light to deep brown.	H=5.5 G=3.3–3.39	Pyroxene group: ZnO 3.5, MnO 6.5 per cent.
◇	1.681	1.698	1.686	Titanoelpidite $Na_2O \cdot (Ti, Zr)O_2 \cdot 6SiO_2 \cdot 3H_2O$	Medium $r>v$.	$X=b$ $Y=c$.	Orth. pris. Elong. c.	{100}	Brown	H=6.5 G=2.55 F=dif.	Insol. Pleoc.: X=yellow, Y=colorless.
◇ ◇	B=0.005	----------	1.687	Riebeckite $Na_2O \cdot Fe_2O_3 \cdot FeO \cdot 5SiO_2 \cdot H_2O$	Very large Disp. strong.	$Y=b$ $X \wedge c=1°–8°$.	Mon. Pris. c.	{110} perf. at 124°.	Blue to black	H=4 G=3.44 F=3?	Amphibole group. Insol. in acid. Pleoc.: X=deep-blue Y=lighter blue, Z=yellow-green.
◇ ◇	1.682	1.711	1.687	Rosenbuschite $Na_2O \cdot 3CaO \cdot 4(Si,Ti,Zr)O_2$	$2V=60°$ $2E=115°$.	$X=b$ $Z \wedge c=13°$.	Mon. Elong. b.	{001}perf.	Orange or gray	H=5–6 G=3.3 F=easy.	Zirconium pectolite? Sol. in HCl. Pleoc. faint in pale yellow. Abs.: Z>Y>X.
◇ ◇	1.679	1.710	1.688	Urbanite $Na_2O \cdot 2Fe_2O_3 \cdot (Ca, Mg)O \cdot 4SiO_2$	$2V=65°$ $2E=130°$. $r<v$ perc.	$Y=b$ $X \wedge c=20°$.	Mon. Pris. c.	{110}perf. at 87°	Brownish black.	H=5–6 G=3.52 F=dif.	Pyroxene between diopside and aegirite. Slightly sol. in HCl. Fuses to a black magnetic slag.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
∧ ∨	1.688	1.692	1.688	Triphylite $Li_2O.2(Fe,Mn)O.P_2O_5$	$2V=0°\pm$ $r<v$ very strong.	$Z=b$	Orth. Elong. c.	{001}perf. {010}dist.	Greenish or bluish.	H=5 F=2	Isomor. with lithiophilite. Data for mineral with 26.58 per cent FeO. Sol. in acid. With increases of FeO β increases and X=a. B decreases and passes through 0 and mineral becomes opt. −.
	1.682	1.698	1.690	Chlorophoenicite $10(Mn,Zn)O.As_2O_5.7H_2O$	Very large $r<v$ strong.	$Y=b$ Opt. axis nearly ⊥{100}	Mon. Elong. b.	{100} good	Greenish, etc.		Usually Bx. − with $r>v$.
∧ ∨	1.682	1.710	1.690	Jeffersonite $(Mn,Zn,Fe,Mg)O.CaO.2SiO_2$	$2V=72°\pm$ $2E=167°$. $r>v$ perc.	$Y=b$ $Z\wedge c=54°$.	Mon. Pris.	{110}perf. at 87°	Brown, green, black.	H=4.5 G=3.39 F=dif.	Pyroxene group. Data for mineral with MnO 7.4, ZnO 3.3, CaO 23.7, MgO 12.6 per cent. Insol. in acid.
∧ ∨	1.690	1.711	1.691	Pigeonite $(Mg,Fe,Ca)O.SiO_2$	$2V=13°$–$67°$ $2E=22°$–$138°$.	$Y=b$ $Z\wedge c=46°\pm$.	Mon. Pris. c.	{110}perf. at 88°		H=6 G=3.42 Infus.	Pyroxene group. Insol. in acid. Pleoc. faint: X=yellowish green, Y=brownish red, Z=greenish white.
∧	B=0.005		1.693	Pharmacosiderite $3Fe_2O_3.2As_2O_5.13H_2O$	Large $r<v$ very strong.	Ext. large $Y=b$? Disp. strong.	Mon.? Ps. isomet. Cubic.	{100}imperf.	Green, brown, yellow.	H=2.5 G=2.9–3.0 F=1.5–2	Sol. in acid. Cubes divided into segments and these show poly. tw. Very abnormal interference colors.

	1.691	1.703	1.696	Barylite $2BeO.BaO.2SiO_2$	2V=81° $r>v$ weak.	Y=a X=b.	Orth. Pris. c. Tab.{001}.	{100}good	Colorless	H=7 G=4.03 Infus.	Insol. in acid. Greasy luster.
	1.695	1.733	1.698	Euchroite $4CuO.As_2O_5.7H_2O$	2V=29° 2E=50°. $r>v$ mod.	X=b Z=c.	Orth. Pris. c.	{110}{011}tr	Emerald to leek green.	H=3.5–4 G=3.39 F=2–2.5	Sol. in HNO_3. Bright bluish green in section and faintly or nonpleoc.
⊏ <	1.690	1.736	1.699	Neptunite $(Na,K)_2O.(Fe,Mn)O.TiO_2.4SiO_2$	2V=49° 2E=89°. $r<v$ extr.	Y=b Z∧c=16°±. Disp. extr.	Mon. Pris. c.	{110}perf. at 80°	Black; in splinters deep red.	H=5–6 G=3.19 F=2.5	Insol. in HCl. Pleoc. strong: X=pale yellow, Y=yellowish red, Z=deep ocherous yellow to brownish red.
⊏	1.690	1.721	1.699	Schefferite $(Mg,Mn)O.CaO.2SiO_2$	2V=60° 2E=116°. $r>v$ weak.	Y=b Z∧c=43°.	Mon	{110}perf	Brown	H=6±	Pyroxene group. Analysis: SiO_2 51.20, CaO 21.09, MgO 12.70, MnO 9.96, FeO 1.65, Al_2O_3 0.27, Fe_2O_3 1.50, H_2O 1.3, Na_2O 0.09, F 0.32 per cent, Mg/Mn=2.
◇	*1.697	1.703	1.700	Riebeckite (crocidolite) $Na_2O.2FeO.Fe_2O_3.6SiO_2$	Large	Z=b Y∧c=0±.	Mon. (?) Fib. c.	{110}perf. at 60°	Lavender, blue, light green.	H=5–6 G=3.2 F=3.5	Amphibole group. Insol. in acid. Pleoc.: X=pure yellow, Y=deep violet, Z=deep bluish violet. Keikamspoort, South Africa.
⊏ <	*1.695	1.722	1.70	Gadolinite $2BeO.FeO.2Y_2O_3.2SiO_2$	do	X=b Z∧c=4°–13°.	Mon. Pris	Conch	Black, brown.	H=7 G=3.6 Infus.	Gelat. in part. Pale green and nonpleoc. Kingman, Ariz.
	0.012		1.7±	Hainite Na,Ca,Ce,Zr,Ti,Si, O, etc.	do $r>v$.	Z=nearly ⊥ {010}. Ext. {100} nearly //. Ext. {010} =4°. Disp. very strong.	Tric. Acic. c.	{010} rather perf. {100} indist.	Wine or honey yellow to colorless.	H=5 G=3.18	Near hiortdahlite. Pleoc.: X=colorless, Y=faint yellow, Z=wine-yellow.
◇	1.696	1.714	1.702	Augite $Ca(Mg,Fe,Al)(Al,Si)_2O_6$	2V=59° 2E=114°.	Y=b Z∧c=44°.	Mon	{110} perf	Black	H=6± G=3.228	Pyroxene group. Analysis: SiO_2 49.63, TiO_2 1.08, Al_2O_3 14.59, Fe_2O_3 1.14, FeO 6.17, MnO 0.21, MgO 6.37, CaO 18.48, Na_2O 0.57, K_2O 0.58, H_2O 0.88 per cent.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
r > v	1.700	1.706	1.702	Zoisite $4CaO.3Al_2O_3.6SiO_2.H_2O$	$2V=0°–60°$, $2E=0°–116°$. $r<v$ strong or $r>v$ strong.	$X=c$ and $Y=b$, or $X=b$ and $Y=c$.	Orth. Pris. *c*. Grains.	{010} very perf.	Gray, brown, greenish, rose.	H=6 G=3.3 F=3.5	Epidote group. Insol. in acid. Gelat. after ignition. Pleoc. faint. Abnormal interference colors.
r > v	1.701	1.706	1.703	Serendibite $2CaO.4MgO.3Al_2O_3.B_2O_3.4SiO_2$	Near 90°. $r<v$ strong.	Sections ⊥ tw. lamellae and nearly ⊥ Z have ext. of 35°–40°.	Tric. (?) Six-sided plates.	None	Sky to indigo blue.	H=6.5 G=3.42 Infus.	Nearly insol. in acid. Pleoc.: Y and X= yellow to green or brownish yellow to colorless, Z=blue. Tw. poly. resembling plagioclase.
r > v	1.700	1.718	1.703	Zoisite $4CaO.3Al_2O_3.6SiO_2.H_2O$	Medium small $r<v$.	$X=c$ $Z=a$.	Orth			H=6	Analysis: SiO_2 39.20, CaO 23.90, Al_2O_3 33.22, MgO 0.16, Fe_2O_3 2.14, H_2O 2.04 per cent.
	1.700	1.724	1.705	Graftonite $3(Fe,Mn,Ca)O.P_2O_5$	$2V=55°±$ $2E=104°$. $r>v$ rather strong.	$X=b$ Disp. dist.	Mon		Salmon pink, darkens on exposure.	H=5 G=3.67 F=2	Readily sol. in acid. Colorless in section.
	1.691	1.735	1.705	Astrophyllite $(K,Na,Ca,Mn)_7(Fe'',Fe''',Al,Ti)_{10}Si_{10}O_{35}(OH,F,Cl)_4$	$2V=72°±$ $r>v$.	X near *b* Z near *a*.	Mon. or tric.	{010} perf. {001} imperf.	Bronze-yellow,	H=3 G=3.4 F=2.5–3	Decpd. by HCl. Pleoc.: X=deep orange, Y=lemon-yellow, Z=orange. K:Na:Ca:Mn=2:2:1:2. Fe'':(Fe'''+Al):Ti=5:2:3.
r > v	1.700	1.724	1.706	Augite $CaO.2(Mg,Fe)O.(Al,Fe)_2O_3.3SiO_2$	$2V=60°$ $2E=116°$. $r>v$ weak.	$Y=b$ $Z\wedge c=48°$. Disp. dist.	Mon. Pris. *c*.	{110} perf. at 90°.	Green, etc.	H=6 G=3.4 F=about 3	Pyroxene group. Insol. in acid. Tw. pl. {100}{001}. Colorless in section. Data for mineral with SiO_2 47.7, Al_2O_3 6.8, Fe_2O_3 3.6, FeO 4.6, MgO 13.3, CaO 11.4, Na_2O 0.7, TiO_2 1.9 per cent.

	1.700	1.718	1.707	Pumpellyite $6CaO.3Al_2O_3.7SiO_2.4H_2O$	$2V=75°–80°$. $r<v$ strong.	$Z\wedge c=31°$. $Y=b$.	Mon. Elong. b.	{001} perf. {100} imperf.	Bluish-green	H=5.5 G=3.2	Pleoc.: X and Z=colorless, Y=bluish-green.
> <	1.702	1.726	1.708	Diopside hedenbergite $CaO.(Mg,Fe)O.2SiO_2$	$2V=61°$. $2E=119°$. $r>v$ weak.	$Y=b$. $Z\wedge c=43°$.	Mon. Pris. c.	{110} perf. at 87°.	Green	H=6 G=3.6 F=4	Pyroxene group. Insol. in HCl. Data for mineral with equal parts of $MgSiO_3$ and $FeSiO_3$ by weight.
<	1.708	1.745	1.708	Strengite $Fe_2O_3.P_2O_5.4H_2O$	Small. $r>v$ strong.	$Z=c$. $Y=a$.	Orth. Fib. c.	{100} imperf.	Pink, blue, etc.	H=3–4 G=2.87 F=2.5–3	Compare scorodite. Sol. in HCl but not in H_2SO_4. Pleoc.: X=very pale rose, Y=colorless, Z=pale rose. Blue contains Mn.
	*1.702	1.741	1.709	Legrandite $2ZnO.9As_2O_5.25H_2O$	$2V=36°\pm$. $2E=65°$. $r<v$ dist.	$X=b$. $Z\wedge c=36°–40°$.	Mon. Radiating pris.	{100} fair	Canary-yellow	G=4.01	Pleoc.: X and Y=light yellow, Z=yellow. Our data in part.
	1.708	1.718	1.711	Merwinite $MgO.3CaO.2SiO_2$	$2V=67°$. $2E=142°$. $r>v$ weak.	$Z=b$. $X\wedge c=36°$.	Mon. Grains.	{010}	Colorless	H=6 G=3.15 Fus.	Gelat. Poly. tw. very common. Tw. axis c, composition pl. {110} with angle 43° between sets. Less common tw. pl. and composition pl. {100}.
	1.709	1.724	1.711	Brandtite $2CaO.MnO.As_2O_5.2H_2O$	$2V=23°$. $2E=40°$. $r<v$ rather strong.	$X=b$. $Y\wedge c=8°$.	Mon. Pris. b, Tab. {001}.	{010} good	do	H=5–5.5 G=3.67 F=2.5–3	Sol. in HCl. Tw. common {100}.
	1.703	1.722	1.713	Gerhardtite $4CuO.N_2O_5.3H_2O$	Large. $r>v$ very strong.	$X=a$. $Z=c$.	Orth. Striated horizontally.	{001} highly perf. {100} less so.	Emerald-green	H=2 G=3.40 F=2	Sol. in dil. acids. Pleoc.: X and Y=green, Z=blue.
> <	1.714	1.744	1.714	Pigeonite SiO_2, FeO, MgO, CaO, etc.	$2V=0°$	$Z\wedge c=40°\pm$	Mon. Pris.	{110} perf.		H=6 G=3.42	Pyroxene group. Analysis: SiO_2 49.72, TiO_2 0.85, Al_2O_3 0.90, Fe_2O_3 1.72, FeO 27.77, MnO 0.98, MgO 12.69, CaO 3.80, Na_2O 0.23, K_2O 0.12, H_2O 1.35 per cent.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.707	1.730	1.715	Larnite $2CaO.SiO_2$	Large	$Y=b$ $X\wedge c=14°$.	Mon. Tw. on {100}.	{100} and {010}?	White		Gelat. with acids.
v	1.715	1.719	1.717	Clinozoisite $4CaO.3Al_2O_3.6SiO_2.H_2O$	$2V=66°$ $2E=138°$. $r<v$ strong.	$Y=b$ $Z\wedge a=32°$.	Mon. Elong. b.	{001}perf. {100}imperf.	Pale green, brown.	H=6.5 G=3.21 F=3	Epidote group. Insol. in acid. Abnormal interference colors.
r v	1.715	1.733	1.718	Magnesium orthite $7(RO+R_2O_3).6SiO_2.H_2O$	$2V=50°\pm$. $2E=93°$.		Fib. aggregate		Brown	G=3.90	Weakly pleoc. in pink to brown. RO=MgO, FeO, CaO, etc. R_2O_3= Fe, Al, Ce, Nd, La, etc., some F.
> v	1.699	1.742	1.718	Augite $CaO.2(Mg,Fe)O.(Al,Fe)_2O_3.3SiO_2$	$2V=65°$–$67°$ $2E=136°$–$143°$. $r>v$.	$Y=b$ $Z\wedge c=46°$–$51°$.	Mon. Pris.	{110}perf.		H=6± G=3.410	Pyroxene group. Analysis: SiO_2 46.16, TiO_2 2.86, Al_2O_3 4.92, Fe_2O_3 5.89, FeO 3.93, MgO 11.29, MnO 0.19, CaO 23.56 per cent, etc.
> v	1.717	1.741	1.719	Pigeonite $(Mg,Fe,Ca)SiO_3$ etc.	$2V=23°$–$40°$ $2E=40°$–$72°$.	$Y=b$ $Z\wedge c=45°$.	do	do		H=6± G=3.46	Pyroxene group. Analysis: SiO_2 50.36, TiO_2 0.80, Al_2O_3 2.49, Fe_2O_3 2.35, FeO 18.15, MnO 0.56, NiO 0.04, MgO 11.37, CaO 13.97, Na_2O 0.26, K_2O 0.19, H_2O 0.55, total 101.99 per cent.
r	1.710	1.738	1.719	Johannsenite $MnO.CaO.2SiO_2$	$2V=70°$ $r>v$.	$Y=b$ $Z\wedge c=45°\pm$.	Mon. Pris. Columnar, radiated.	{110}	Gray, brown	H=6 G=3.4 F=4	Pyroxene group. Indices calculated for pure compound. Fuses b. b. to brown globule.
> v	1.715	1.737	1.719	Chloritoid $(Fe,Mg)O.Al_2O_3.SiO_2.H_2O$	$2V=50°$ $2E=94°$. $r>v$ strong.		Mon	{001}perf.		G=3.371	Fe:Mg=3:1. Pleoc.: X=blue-green, Y= blue, Z=light blue.

	1.70	1.74	1.72	Iddingsite $MgO.Fe_2O_3.3SiO_2.4H_2O$	Large $r>v$ strong.		Orth.	{100}{010}{001} perf. {101} less so.	Reddish brown.	H=2.5 G=2.7 Infus.	Decpd. by HCl. Pleoc. in brown and yellow.
<	1.715	1.725	1.720	Clinozoisite $4CaO.3Al_2O_3.6SiO_2.H_2O$	2V=90° $r<v$ strong.	Y=*b*. X∧*c*=0°	Mon. Elong. *b*.	{001}perf. {100}imperf.	Green, pale rose, etc.	H=6.5 G=3.36 F=3	Epidote group. Insol. in acid. Abnormal interference colors. Data for mineral with 8 per cent iron epidote.
>	1.716	1.728	1.720	Rhodonite $(Mn,Mg,Fe,Ca)MnSi_2O_6$	2V=75°	Ext. on {010} $Z' \wedge c = 9°$; on {1$\bar{1}$0} $Z' \wedge c = 20°$; on {110} $Z' \wedge c = 30°$.	Tric.	{0$\bar{1}$0}, {1$\bar{1}$0} perf. {001} poor.	Pink	H=6 G=3.58	Mn:Fe:Mg:Ca = 70:4:6:20. Lamellar tw. {1$\bar{1}$0}.
	1.712	1.731	1.721	Adelite $2MgO.2CaO.As_2O_5.H_2O$	Very large $r<v$ perc.	Y=*b*. Z∧*c*=39°.	Mon. Tab. {001} or Pris. *c*.	None	Gray	H=5 G=3.75 F=easy	Sol. in HNO_3.
	1.702	1.750	1.722	Diaspore $Al_2O_3.H_2O$	2V=84° $r<v$ weak.	Z=*a*. X=*c*.	Orth. Blades {010}. Elong. *c*.	{010}eminent {210}less so.	Pink to dark red.	H=7 G=3.328 Infus.	Insol. in acid. Luster pearly. Pleoc.: Reddish brown to nearly colorless. Mn_2O_2 4.32, Fe_2O_3 1.96 per cent.
< >	1.713	1.745	1.722	Jeffersonite A pyroxene	2V=74° $r<v$ easily perc.	Y=*b*. Z∧*c*=55°.	Mon	{110}perf.	Brown-green		Pyroxene group Pleoc.: X and Y= olive-green, Z= brown-green.
< >	1.720	1.731	1.722	Chloritoid $(Fe, Mg)O.Al_2O_3.SiO_2.H_2O$	2V=36°–60° 2E=64°–118° $r>v$ strong.	X=*b*. Z∧*c*=20°±. Disp. strong.	Mon. or tric. Plates{001}.	{001}perf. {110}imperf.	Gray, green	H=6.5 G=3.55 Nearly infus.	A brittle mica. Decpd. by H_2SO_4. Pleoc.: X=colorless to pale greenish-yellow. Y=plum to indigo blue, Z=yellow to colorless. Contains Fe_2O_3 3.0, FeO 25.4, CaO 0.9, MgO 2.0 per cent.
< >	1.715	1.738	1.725	Homilite $3(Ca, Fe)O.B_2O_3.2SiO_2$	2V=80° $r>v$ rather strong.	Y∧*c*=0°±. Z=*b*. Disp. dist.	Mon. Tab. {001}.	Indist.	Black to dark brown.	H=5 G=3.36 F=2	Gelat. Pleoc.: X= bluish green, Y= deep brownish red, Z=deep smoky gray to brownish yellow.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
∧	1.724	1.737	1.726	Chloritoid $2MgO.3Al_2O_3.3SiO_2.2H_2O$	$2V=63°$ $2E=130°$. $r>v$ strong.	$Z\wedge c=21°$	Mon. Platy	{001}perf		H=6.5 G=3.358	Mg:Fe: (Na+K) 1:3:2. Pleoc.: X=greenish brown, Y=deep blue, Z=light yellow-green.
⊐	1.725	1.730	1.726	Triploidite $4(Mn,Fe)O.P_2O_5.H_2O$	Medium $r>v$ extr.	$X=b$ $Z\wedge c=0°\pm$. Disp. mkd.	Mon. Pris	{100}perf	Yellowish to reddish brown.	H=5 G=3.43 F=1.5	Sol. in acid. Colorless in section.
∧ ∨	1.725	1.737	1.728	Iron rhodonite $(Mn,Fe,Mg,Ca)MnSi_2O_6$	$2V=70°$	Ext. on {001} $X'\wedge$ edge {110}{001}=40°; on {001} $X'\wedge a=7°$; on $\{1\bar{1}0\}Z'\wedge c=27°$; on $\{110\}Z'\wedge c=39°$.	Tric	{110} $\{1\bar{1}0\}$ perf. {001} poor.	Brown	H=6 G=3.653	Mn:Fe:Mg:Ca=53:26:6:15.
⊐	1.717	1.752	1.730	Babingtonite $4CaO.2FeO.Fe_2O_3.10SiO_2.H_2O$	$2V=76°$ $2E=126°$. $r>v$ strong.	Opt. pl. nearly $//\{110\}$ and $\{1\bar{1}0\}$. Ext. on {100}=44° with c. Ext. on {010}=31°. Ext. on {001}=35° to tr. {010}.	Tric. Pris. c	{001}perf {010}{100} less so.	Greenish to brownish black.	H=5.5–6 G=3.36 F=3	Insol. in acid. Pleoc.: X=strong emerald-green or dark blue-green, Y=pale violet-brown or claret, Z=deep brown or pale brown. Mg:Mn:Fe=3:3:14. Fe:Al=7:2.
⊐	1.718	1.751	1.730	Roselite $3(Ca,Co,Mg)O.As_2O_5.2H_2O$	Medium large $r<v$ easily perc.	X near b Ext. on cleav. $Y\wedge$tw. lamellae=3°. Z near a.	Tric	{010}perf	Rose-red	H=3.5 G=3.5–3.6 F=3	Sol. in acid. Faintly pleoc.: X and Y=pale rose-red, Z=nearly colorless. Lamellar tw. Zonal growths. Dana position.

∧ ∨	1.725	1.746	1.73	Augite (titaniferous). $CaO.2(Mg,Fe)O.(Al,Fe)_2O_3.3(Si,Ti)O_2$	2V=33°. 2E=59°.	Z∧c=42°	Mon. Pris. c.	{110}perf.at 87°	Black	H=6 G=3.39	Pyroxene group. Contains 4.84 per cent TiO_2. Pleoc.: X=reddish or pinkish brown with a violet shade, Y=reddish or pinkish brown with a violet shade, Z=pale bright yellow with a brownish shade.
□	B=0.01		1.73	Ottrelite. $(Fe,Mn)O.Al_2O_3.3SiO_2.H_2O$	Variable. r>v.	Y∧b=0°±. Z∧c=25°±. Disp. strong.	Mon. or Tric.	{001}perf.		H=7 G=3.3 Nearly infus.	Brittle mica. Near chloritoid. Decpd. by H_2SO_4. Pleoc.: X=olive-green, Y=blue, Z=yellow-green.
	1.730	1.762	1.732	Strengite. $Fe_2O_3.P_2O_5.4H_2O$	2V=29°. 2E=51°. r<v very strong.	X=a(?) Z=b(?).	Orth.	Two at 90°, good.	Pale, pink, etc.	H=3-4 G=2.87 F=2.5-3	Compare with scorodite. Sol. in HCl. Pleoc. faint in pale rose to colorless.
∨	1.726	1.751	1.732	Hedenbergite. $CaO.FeO.2SiO_2$	2V=70°. 2E=120°. r>v weak.	Y=b. Z∧c=48°.	Mon. Pris. c.	{110}at 90°good.	Green, etc.	H=6 G=3.7 F=3.5-4	Pyroxene group. Insol. in HCl. Pleoc.: X=pale green, Y=yellowish green, Z=dark green. Data for mineral with 10 per cent $CaO.MgO.2SiO_2$.
∨	1.720	1.935	1.733	Molybdite. $Fe_2O_3.MoO_3.7\frac{1}{2}H_2O$	2V=28°. 2E=49°. r<v mkd.	Y=a. Z=c.	Orth. Fib. c.	{001}dist.	Sulphur - yellow.	H=1-2 G=4.50 F=easy	Sol. in acids and decpd. by NH_4OH. Pleoc.: X and Y=clear, Z=dirty gray to canary-yellow.
	1.557	2.07	1.734	Curtisite. $C_{60}H_{40}O$	2V=83½°. r>v slight.	Z=c. Y=a.	Orth. (?)	{001}perf. {100}poor.	Yellow to greenish.	Soft G=1.21	Melts above 350°. Pleoc.: X=pale yellow, Y and Z=yellow. Abs.: Z>X>Y.
□			1.735	Murmanite. $2Na_2O.(Fe,Mg,Ca)O.4SiO_2.4(Ti,Zr)O_2.4H_2O$		X ⊥ cleav.		One mic.	Violet.	H=2-3	Analysis: SiO_2 29.13, TiO_2 37.33. ZrO_2 2.00, FeO 1.84, MgO 0.75, CaO 2.10, Na_2O 14.94, H_2O 8.92, MnO 2.92, total 99.93 per cent.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
∧	1.733	1.747	1.737	Rhodonite (Mn,Ca) $MnSi_2O_6$	$2V=61°$	Ext. on {110} $Z' \wedge c = 17°$; on {1$\bar{1}$0} $Z' \wedge c = 14°$; on {010} $Z' \wedge c = 2°$.	Tric.	{110}{1$\bar{1}$0}perf. {001} poor.	Pink	H=6 G=3.70	Mn:Mg:Ca=95:2:3. Lamellar tw. {1$\bar{1}$0}.
	1.726	1.789	1.738	Antlerite $3CuO.SO_3.2H_2O$	$2V=53°$ $2E=102°$. $r<v$ very strong.	$X=b$ $Y=c$.	Orth. Pris. c.	{010}highly perf.	Light green	H=3 G=3.9	Pleoc. strong: X=yellowish green, Y=bluish green, Z=green.
∧	*1.739	1.760	1.740	Ardennite $8MnO.4Al_2O_3.(As,V)_2O_5.8SiO_2.5H_2O$	$2V=0°$ to small, $r>v$ perc. or $r<v$ rather strong.	$Z=a$ X or $Y=c$.	Orth. Pris. c.	{010}perf. {110}dist. {001}parting.	Yellow to brown.	H=6-7 G=3.6 F=2-2.5	Nearly insol. in acid. Pleoc.: X=deep brownish-yellow, Y=golden yellow, Z=pale-yellow. Salm Chateau.
∧	1.732	1.757	1.740	Hedenbergite $FeO.CaO.2SiO_2$	$2V=70°$ $r>v$.	$Y=b$ $Z \wedge c = 45° \pm$.	Mon. Pris.	{110}	Dark green	H=6 G=3.6 F=4	Pyroxene group. Indices calculated for pure compound. Fuses b.b. to black magnetic globule.
⊏	B=strong to weak		1.74	Allanite $4(Ca,Fe)O.3(Al,Ce,Fe,Di)_2O_3.6SiO_2.H_2O$	Variable Strong.	$Y=b$	Mon.	{0 0 1}{1 0 0} {110}imperf.	Brown, black	H=6 G=3.5-4.2 F=3	Epidote group. Commonly opt. —. May gelat.
	1.736	1.746	1.741	Staurolite $2FeO.5Al_2O_3.4SiO_2.H_2O$	$2V=88° \pm$ $r>v$ weak.	$X=b$ $Z=c$.	Orth. Short prisms // c.	{010}dist. {110}imperf.	Yellow, red-brown, brownish black.	H=7 G=3.7 Infus.	Slowly attacked by H_2SO_4. Cruciform tw. Pleoc. in yellows and reds. Abs.: X<Y<Z.
∨	1.738	1.765	1.742	Scorodite $Fe_2O_3.As_2O_5.4H_2O$	Medium $r>v$ strong.	$Z=c$	Orth. Oct. Pris. c.	{110}imperf.	Leek-green to liver-brown.	H=3.5-4 G=3.1-3.3 F=easy	Sol. in acid. Data for mineral with 48. per cent P_2O_5.

	B=0.003		1.745	Pyreneite $3CaO.Al_2O_3.3SiO_2$	2V=56° 2E=109°. $r<v$.		Ps. isomet. Dodec.	None	Colorless, etc.	H=7 G=3.5 F=3	Insol. in acid. Birefracting grossularite.
	1.745	1.830	1.745	Mixite $20CuO.Bi_2O_3.5As_2O_5.22H_2O$	2V=0°±	Z=c	Acic. c		Emerald-green	H=3-4 G=3.79 F=2	In section pale green and nonpleoc.
	*1.744	1.773	1.747	Molengraaffite Na_2O, CaO, Al_2O_3, SiO_2, TiO_2, etc.	2V=30° 2E=52°.	X=b Z∧c=6°. Y near a.	Mon. Plates // to {100}.	{100}perf. {011}good.	Yellowish brown.	H=4-5 G=3.49	Pleoc. weak: X=colorless to light brown, Y=light yellow, Z=yellowish brown. Tw. pl. {100} poly.
	1.747	1.757	1.748	Chrysoberyl $BeO.Al_2O_3$	2V=45° 2E=84°. $r>v$.	X=a Y=b.	Orth. Tab. {100}. Ps. hex. from tw.	{011}dist. {100}imperf. {010}poor.	Green, yellow, red.	H=8.5 G=3.64 Infus.	Insol. Tw. pl. {031}. Pleoc.: X=columbine-red, Y=orange-yellow, Z=emerald-green.
∧∨	1.74	1.95	1.75±	Molybdite $Fe_2O_3.3MoO_3.7½H_2O$	Small $r<v$ mkd.	Y=a Z=c.	Orth. Fib. c	{001}dist.	Sulphur - yellow.	H=1 G=4.50 F=easy	Sol. in acid and decpd by NH_4OH. Pleoc.: X and Y clear, Z=dirty gray to canary-yellow.
∧	B=low		1.75	Pyroxmangite $(Mn,Fe)O.SiO_2$	2V=30° 2E=54°.	On{010}=5° On {100} Z'∧c=45°.	Tric.	Pris.	Amber to black.	H=5.5-6 G=3.80 F=3	Insol. in acid.
	1.715	1.80	1.75	Erythrosiderite $2KCl.FeCl_3.H_2O$	2V=62° 2E=130°. $r>v$ strong.	X=a Z=b.	Orth. Tab. {100}.		Yellow in section.		
⊏	*1.745	1.780	1.754	Lamprophyllite Contains SiO_2, Ti, Fe, Mn, Na	2V=50°± 2E=96°. $r>v$ medium strong.	X=b Z∧a=30°±.	Mon.? Platy	One perf., other less so.	Bronze to brown.	H=4± G=3.45	Pleoc.: X=light brown, Y=greenish brown, Z=brown. Related to astrophyllite.
	1.730	1.838	1.758	Azurite $3CuO.2CO_2.H_2O$	2V=68° 2E=158°. $r>v$ rather strong.	X=b Z∧c=−13°. Disp. dist.	Mon.	{021}imperf.	Azure blue.	H=3.5-4 G=3.80 F=3	Sol. in acid. Pleoc. moderate in Prussian blue. Abs.: X and Y<Z.
	1.719	1.805	1.762	Dihydrite $5CuO.P_2O_5.2H_2O$	Near 90° $r<v$ strong.	X∧c=22° Z near b.	Mon. or tric. Crystals and crusts. Fib. b.	{010}imperf.	Dark emerald-green.	H=4.5-5 G=4.0-4.4 F=2	Sol. in HCl. Pleoc.: X=bluish green, Y=yellowish green, Z=deep bluish green.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.762	1.765	1.763	Dewindtite $3PbO.5UO_3.2P_2O_5.12H_2O$	Large $r<v$ extr.	$Y=c$ $Z=a$.	Orth. Sq. tablets.	{100}perf.	Yellow	G=4.9	Sol. in acid. Weakly pleoc. in yellow. Abnormal interference colors.
∧ ∨	1.746	1.806	1.764	Piedmontite $4CaO.3(Al,Fe,Mn)_2O_3.6SiO_2.H_2O$	$2V=68°$ $2E=135°$. $r<v$.	$Y=b$ $X\wedge c=-6°$.	Mon. Elong. b.	{001} good {100}{010}.	Black	H=6 G=3.447	Epidote group. Al:Fe:Mn=6:1:2. Abs. for yellow $Z>Y>X$. Strong pleoc. Tw. pl. {100}. Data for sodium light.
	1.748	1.823	1.767	Joaquinite $3Na_2O.6BaO.5TiO_2.16SiO_2$	$2V=50°\pm$ $2E=91°$. $r<v$.	$X=a$ $Y=b$.	Orth. equant.		Light brown	H=6 G=3.89 F=2.5	Insol. Fuses with intumescence to brown glass.
□	1.769	1.785	1.770	Holdenite $8MnO.4ZnO.As_2O_5.5H_2O$	$2V=30°$ $2E=54°$. $r>v$ dist.	$X=c$ $Z=a$.	Orth.	{010}indist.	Reddish brown.	H=4 G=4.07	
	1.710	1.840	1.770	Rossite $CaO.V_2O_5.4H_2O$	Large Disp. strong	$Z=c$	Tric. Pris. or tab. tw. {100}.	{010}good	Clear glassy yellow.	H=2-3 G=2.45	Sol. in H_2O.
∧ ∨	1.765	1.797	1.774	Scorodite(?) $Fe_2O_3.As_2O_5.4H_2O$	$2V=62°$ $2E=131°$. $r>v$ rather strong.	$X=b$ $Z=c$.	Orth. Oct.	{120}imperf.	Leek-green, etc.	H=3.5-4 G=3.1-3.3 F=2-2.5	Sol. in HCl. Pleoc. in thick sections.
∨	1.770	1.783	1.774	Barthite $3ZnO.CuO.3As_2O_5.2H_2O$	Mod $r>v$ slight.		Mon.? Equant	None?	Grass-green	H=3 G=4.19	Nearly colorless in section. Data for core of type material.
	1.770	1.83	1.774	Taramellite $4BaO.FeO.2Fe_2O_3.10SiO_2$	$2V=40°$ $2E=74°$. $r>v$ strong.	$X=a$ $Z=c$.	Orth. Pris. c.	{100}perf.	Brown-red	H=5.5 G=3.92 F=very easy	Insol. Pleoc. Intense: X and Y=pale flesh red with a touch of yellow, Z=nearly opaque.

	1.758	1.795	1.776	Orientite $4CaO.2Mn_2O_3.5SiO_2.4H_2O$	$2V=67°$ $2E=155°$. $r<v$ very strong.	$X=a$ $Y=c$.	Orth. Pris. *c*. Tab. {010}.	{110}imperf.	Dark brown	H=4.8 G=3.05 F=dif.	Sol. in hot HCl. Pleoc.: X=red-brown. Y=yellow, Z=brownish yellow.
	1.778	1.801	1.78	Conichalcite $2CuO.2CaO.As_2O_5.1½H_2O$	$2V=25°$ $2E=45°$.	$X=c$ $Y=b$.	Orth. Fib		Pistachio to emerald-green.	H=4.5 G=4.15 F=2.5–3	Sol. in acid. In section pale green and nonpleochroic.
	1.77	1.80	1.78	Vandenbrandeite $2CuO.2UO_3.5H_2O$	Medium large.	Opt. axis almost ⊥ to {001}. Ext. 35° with cleav. edge.	Tric.	{001}and pris.	Dark green to black.	H=4 G=4.96	Sol. in hot acid. Pleoc.: Green to colorless.
□	1.776	1.805	1.780	Caryinite $10(Pb,Mn,Ca,Mg)O.3As_2O_5$	$2V=41°$ $2E=77°$. $r>v$ slight.	$Y=a$ $Z=b$.	Orth.	{110}{010}	Nut-brown	H=3–3.5 G=4.25 F=2.5	Not pleoc.
◇	1.78	1.785	1.78±	Gadolinite $2BeO.FeO.2Y_2O_3.2SiO_2$	Medium $r<v$ strong.	$Y=b$ $Z\wedge c=4°$ to 13°.	Mon.	Conch	Black	H=7 G=4.3 Infus.	Gelat. in part. Pale green in section and nonpleoc.
□	1.752	1.815	1.782	Shattuckite $2CuO.2SiO_2.H_2O$	Large.	$X=b$ $Z\wedge c=$small.	Mon. Fib.		Green, blue		Pleoc: X=very pale blue, Y=pale blue, Z=deep blue.
◇	1.750	1.832	1.782	Piedmontite $4(Ca,Mn)O.3(Al,Fe,Mn)_2O_3.6SiO_2.H_2O$	$2V=81°$ $r<v$.	$Y=b$ $X\wedge c=-7°$.	Mon. elong. *b*.	{001}perf.{100}	Black	G=3.453	Epidote group. Pleoc. in yellow and red. Abs. for red $Y>Z>X$, for yellow $Z>Y>X$. Ca:Mn=10:1; Al:Fe:Mn=7:2:3.
	1.775	1.815	1.786	Beraunite $3Fe_2O_3.2P_2O_5.8H_2O$	Medium large. $r>v$ mkd.	$Z=b$ $Y\wedge c=1½°$.	Mon. Tab. {100}.	{100}dist.	Reddish brown to hyacinth-red.	H=2 G=2.87–2.98 F=3	Variety eleonorite. Sol. in acid. Strongly pleoc.: X=nearly colorless, Y=pale flesh-color, Z=carnelian red. Tw. pl. {100}.
◇	1.747	1.829	1.788±	Olivenite $4CuO.As_2O_5.H_2O$	Nearly 90° $r<v$ strong.	$X=b$ $Z=a$.	Orth. Acic. *c*.	Traces	Olive-green to dark yellow-brown.	H=3 G=4.3 F=2–2.5	Sol. in HCl. In part opt. —. Pale green in section and nonpleoc.
	1.783	1.818	1.788	Lossenite $4PbO.9Fe_2O_3.6As_2O_5.4SO_3.33H_2O$	$2V=51°$ $2E=101°$. $r>v$ strong.	$Y=a$ $Z=c$.	Orth. Acute pyramids.		Brownish red	H=3–4 F=2–2.5	Sol. in acid.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.777	1.800	1.788	Retzian Arsenate of Y, Mn, Ca, etc., and H_2O	Large $r<v$ weak.	$Y=b$	Orth. Pris. or tab.{010}.	None	Chocolate-brown to chestnut-brown.	H=4 G=4.15 Infus.	Sol. in acids. Pleoc.: X=colorless, Y=pale yellowish brown, Z=reddish brown.
□	1.786	1.837	1.788	Monazite $(Ce,La,Di)_2O_3$. P_2O_5	$2V=14°$ $2E=25°$. $r<v$ weak.	$X=b$ $Z\wedge c=2°\pm$.	Mon.	{001}perf {100}dist. {010}difficult	Red, brown	H=5 G=5.1± Infus.	Difficultly sol. in HCl. Pleoc. faint: X=light yellow, Y=dark yellow, Z=greenish yellow. Abs.: Y>X and Z. Tw. pl.{100}.
□	1.756	1.829	1.789	Piedmontite 4CaO. $3(Al,Fe,Mn)_2O_3$. $6SiO_2.H_2O$	$2V=86°$ $r<v$.	$Y=b$ $X\wedge c=-4°$.	Mon. Elong. b.	{001}perf {100}.	Black	H=6 G=3.470	Epidote group. Pleoc. in yellow and red. Abs. for red: Y>Z>X. Al:Fe:Mn=1:6:7. Na_2O 2.96 per cent.
>	1.78	2.04±	1.79±	Molybdite $Fe_2O_3.3MoO_3$. $7\frac{1}{2}H_2O$	Small $r<v$ mkd.	$Y=a$ $Z=c$.	Orth. Fib. c.	{001}dist	Sulphur - yellow.	H=1–2 G=4.50 F=easy	Sol. in acid and decpd. NH_4OH. Pleoc.: X and Y=clear, Z=dirty gray to canary yellow.
	1.75	1.85	1.79	Uraconite SO_3,UO_3,H_2O, etc.	Medium $r<v$ strong.	$Z=c$. $X=a$.	Orth. Minute laths {100}, elong. c.		Lemon-yellow, earthy.	Soft	Sol. in acid.
<>	B=0.020		1.79±	Ardennite $8MnO.4Al_2O_3$. $(As,V)_2O_5.8SiO_2$. $5H_2O$	$2V=36°\pm$ $2E=67°$. $r>v$ very strong.	$Y=b$ $Z=a$ or c.	Orth. Pris. c.	{010}perf {110}dist. {001}parting.	Yellow to brown.	H=6–7 G=3.62 F=2–2.5	Nearly insol. in acid. Pleoc.: X=deep brownish yellow, Y=golden yellow, Z=pale yellow.
□	1.794	1.803	1.794	Arseniopleite $9(Ca,Mn,Pb,Mg)O$. $(Mn,Fe)_2O_3$. $6As_2O_5.3H_2O$	$2V=0°\pm$		Trig.? Massive		Brownish red		Anom. biax. In section apricot-orange to blood-red.

^	1.780	1.815	1.795	Barthite $3ZnO.CuO.3As_2O_5.2H_2O$?	Nearly 90° $r<v$ mod.		Mon. Equant.	None?	Grass-green	H=3 G=4.19	Yellowish green in section and faintly pleoc. Data for border of type material.
^v	1.784	1.814	1.796	Scorodite $Fe_2O_3.As_2O_5.4H_2O$	2V=54°. 2E=109°. $r>v$.	X=b. Z=c.	Orth. Oct.		Pea-green	H=3.5± G=3.413	Disp. of indices=0.03.
^v	B=0.015		1.8±	Ardennite $8MnO.4Al_2O_3.8SiO_2.(As,V)_2O_5.5H_2O$	2V=0°-50°. 2E=99°. $r>v$ very strong.	Z=b. X=c.	Orth.	{010}perf. {110}dist.	Yellow, brown	H=6-7 G=6.3 F=2-2.5	Nearly insol. in acids. Pleoc.: X=deep brownish yellow, Y=golden yellow, Z=pale yellow.
	B=0.006		1.80	Enigmatite $2Na_2O.9FeO.(Al,Fe)_2O_3.12(Si,Ti)O_2$	2V=32°. 2E=59°. $r<v$(?).	Y near b. $Z\wedge c=45°$.	Tric.	{110} {1$\bar{1}$0} at 66° dist.	Black	H=5.5 G=3.80 F=3	Insol. in acid. Pleoc. mkd.: X=clear red-brown, Y=deep chestnut - brown, Z=brownish black.
^	1.800	1.849	1.801	Monazite $(Ce,La,Di)_2O_3.P_2O_5$. Some $ThO_2.SiO_2$	$2V_{Na}=11°$. 2E=19°. $r<v$.	Y=b. $Z\wedge c=10°$.	Mon.	{001} perf. {100} dist. {010} diffuse.		H=5 G=5.27	Pleoc. in brown and red. Analysis: ThO_2 11.23, Ce_2O_3 26.95, $(La,Di)_2O_3$ 32.60, P_2O_5 25.90 per cent.
	1.783	1.834	1.801	Flinkite $Mn_2O_3.4MnO.As_2O_5.4H_2O$	Large. Disp. slight.	Z=a. X=b.	Orth. Tab. {001}.	Not prominent	Greenish brown.	H=4-4.5 G=3.87 F=easy	Readily sol. in acid. Pleoc.: X=yellowish or brownish green, Y=yellowish green, Z=orange-brown.
	1.79	1.84	1.807	Leucochalcite $4CuO.As_2O_5.3H_2O$	Large. $r<v$ strong.	Y=c.	Orth. Acic. c.		White silky	F=2-2.5	
^	1.772	1.863	1.810	Olivenite $4CuO.As_2O_5.H_2O$	2V=82°. $r<v$ strong.	X=b. Z=a.	Orth. Acic.	Traces.	Olive-green	H=3 G=4.1-4.4 F=2-2.5	Sol. in HCl. In part opt.—. Pale green in section and non-pleoc.
[ ]	1.808	1.830	1.810±	Warwickite $3(Mg,Fe)O.TiO_2.B_2O_3$	2V=59°. 2E=126°.	X=c. Z=a.	Orth. Pris. c.	{100}perf.	Dark brownish to dull black.	H=3-4 G=3.4 F=5.5	Insol. in acid. Pleoc. strong: X=clear. yellowish brown, Y=reddish brown, Z=brown.
^ [ ]	1.801	1.824	1.812	Gadolinite $2BeO.FeO.2Y_2O_3.2SiO_2$	Very large. $r<v$ strong.	Y=b. $Z\wedge c=4°-13°$.	Mon.	Conch.	Black	H=7 G=4.3 Infus.	Gelat. in part. X=olive-green, Y and Z=grass-green.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
[ ]	1.817	1.821	1.818	Cerite $2(Ca,Fe)O.3Ce_2O_3.6SiO_2.3H_2O$	$2V=25°$ $2E=46°$. $r<v$ very strong.		Orth.		Clove-brown, red-gray.	H=5.5 G=4.86–4.91 Infus.	Gelat. Pleoc. faint: X and Y=nearly colorless, Z=pale reddish.
	1.81	1.85	1.82±	Cornwallite $5CuO.As_2O_5.3H_2O$	Small	Elong.+ or−	Fib.		Emerald-green.	H=4.5 G=4.16 F=2–2.5	
∧	B=strong		1.84	Scorodite $Fe_2O_3.As_2O_5.4H_2O$	$2V=58°$ $2E=126°$. $r>v$ strong.	$Z=c$ $X=b$.	Orth. Oct. or pris.	{120}imperf.	Leek-green, brown, etc.	H=4 G=3.2 F=2–2.5	Sol. in HCl. Pleoc. faint: X=bluish green, Z=colorless to pink.
	1.792	1.888	1.840	Lautarite $CaO.I_2O_5$	Nearly 90° $r>v$ perc.	$Y=b$ $X\wedge c=25°$.	Mon. Pris.	{011} rather perf.	Light wine-yellow to colorless.	H=4 G=4.59 F=1.5	Slightly sol. in H_2O, Sol. in HCl with evolution of Cl.
	1.830	1.885	1.840±	Dufrenite $2Fe_2O_3.P_2O_5.3H_2O$	$2V°=0°$–$90°$ Disp. extr.	$Z=b$	Mon.(?) Fib.	{010}perf.	Dull leek-green.	H=3.5–4 G=3.2–3.4 F=2.5	Sol. in acid. Pleoc. strong. When $r<v$, X=pale yellowish, Y=rather dark reddish brown, Z=dark reddish brown and Y // fibers. When $r>v$, X=bright-green, Y=pale yellowish, Z=dark reddish brown and X // fibers.
[ ]	1.85	2.02	1.85±	Ludwigite $4(Mg,Fe)O.Fe_2O_3.B_2O_3$	Small $r>v$ extr.	$Z=c$	Orth. Fib. c		Blackish green	H=5 G=4.0 F=4.5	Sol. in acid. Pleoc.: X and Y=greenish, Z=reddish brown. Nearly opaque in all directions.

	1.845	1.878	1.852	Toernebohmite $3R_2O_3.4SiO_2.H_2O$ R=Ce, La, Di, Al	$2V=26°$ $2E=49°$. $r<v$ rather strong.				Light green to olive.	H=4.5 G=4.94	Slowly sol. in hot conc. acid. Pleoc.: X=light rose to greenish yellow, Y=bluish green, Z=light rose.
	B=0.07±		1.86±	Purpurite $(Mn,Fe)_2O_3.P_2O_5.H_2O$	Medium	X=a	Orth	{100} rather perf. {010} less so.	Deep red or purple.	H=4–4.5 G=3.4 F=easy	Sol. in acid. Pleoc. strong: X=dark brownish gray, Y=scarlet, Z=purple.
	1.86	1.90	1.87	Synadelphite $(Al,Mn)_2O_3.5MnO.As_2O_5.5H_2O$	Small	$X \wedge c=45°$ Z=b.	Mon. Pris.		Brownish, black.	H=4.5 G=3.45–3.50 F=2 (?)	Sol. in HCl with evolution of Cl. Feebly pleoc. in dark brown.
	1.817	2.057	1.879	Uvanite $2UO_3.3V_2O_5.15H_2O$	$2V=52°$ $2E=110°$.		Orth	Two pinacoidal.	Brownish yellow.		Readily sol. in ammonium carbonate solution. Pleoc.: X=light brown to yellow, Y=dark brown, Z=greenish yellow.
	1.87	1.93	1.88	Hemafibrite $6MnO.As_2O_5.5H_2O$	$2V=35°$ $2E=69°$. $r>v$.	X=b Z=c.	Orth. Pris. fib.	{010} dist.	Brownish to garnet-red, alters black.	H=3 G=3.6 F=2(?)	Sol. in HCl with evolution of Cl. Red-brown in section and nonpleoc.
	1.877	1.894	1.882	Anglesite $PbO.SO_3$	$2V=60°–75°$ $r<v$ strong.	X=c Z=a.	Orth	{001}{110} dist.	Colorless	H=3 G=6.3 F=1.5	Slowly sol. in HNO_3.
	1.88		1.89	Dumontite $2PbO.3UO_3.P_2O_5.5H_2O$	Large $r<v$.	Y=elong	do		Yellow		X=pale yellow. Y=yellow.
	B=0.015		1.9±	Ardennite $8MnO.4Al_2O_3.8SiO_2.V_2O_5.5H_2O$	$2V=0°–50°$ $2E=0°–107°$. $r>v$ very strong.	Z=b X=c.	Orth. Pris. c.	{010} perf. {110} dist.	Yellow to brown.	H=6–7 G=3.62 F=2–2.5	Nearly insol. in acids. Pleoc.: X=deep brownish yellow, Y=golden yellow, Z=pale yellow.
	1.900	2.034	1.907±	Titanite $CaO.TiO_2.SiO_2$	$2V=27°±$ $2E=53°$. $r>v$ strong.	Y=b $Z \wedge c=51°$.	Mon. Wedge-shaped, flattened {001}, etc.	{110} rather dist.	Yellow, brown, colorless, etc.	H=5 G=3.5 F=3	Sol. in H_2SO_4. Pleoc.: X=nearly colorless Y=pale greenish, etc., Z=yellow, red, or pink.
	1.910	1.945	1.91	Ganomalite $6PbO.4CaO.6SiO_2.H_2O$	Small		Hex	{10$\bar{1}$0} perf. {0001} less so.	Gray	H=3 G=5.74 F=3.2	Gelat. with HNO_3. Anom. biax.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	*1.895 ○	1.950	1.910	Kasolite $3PbO.3UO_3.3SiO_2.4H_2O$	Medium large. Disp. not strong.	$X=b$ $Y\wedge c=11°$.	Mon. Tab. {001} elong. *a*.	{001} very perf. {010} perf.	Ocher-yellow	H=4–5 G=5.96	Gelat. Katanga.
	1.890	1.977	1.910	Schultenite $2PbO.As_2O_5.H_2O$	$2V=58°$ $2E=136°$. Disp. strong.	$X=b$ $Z\wedge c=+66°$.	Mon. Thin plates // {010}.	{010}	Colorless	H=2.5 G=5.943	
	B=0.01		1.915	Huegelite Vanadate of Pb, Zn, and H_2O	$2V=0°$ for red-orange. $r<v$ extr.	Y=near *c* Z nearly ⊥ laths Disp. extr.	Mon. Laths		Orange-yellow, yellow-brown.	H=5	Crystals lying on lath face (nearly ⊥ X) show sharp, parallel extinction in white light but have abnormal green interference colors. Other sections give no extinction in white light but abnormal colors. Pleoc. faint: X=very pale greenish yellow, Y=pale orange.
	1.871	2.01	1.92	Claudetite As_2O_3	$2V=58°$ $2E=137°$. $r>v$ strong.	$Y=b$ $Z\wedge c=5½°$.	Mon. Thin tablets {010}.	{010} perf.	Colorless	H=2.5 G=3.85–4.15	Slightly sol. in hot H_2O. Volatile at 1. Tw. {100} penet.
[ ]	1.885	1.956	1.920	Tsumebite $4PbO.2CuO.P_2O_5.nH_2O$	$2V=89°$ $r<v$ strong.		Orth. or mon. tab.			H=3.5 G=6	Faintly pleoc. in green. Abs.: Z>X.
^	B=0.04±		1.92±	Purpurite $(Mn,Fe)_2O_3.P_2O_5.H_2O$	$2V=38°±$ $2E=77°$.	X=*a*	Orth. (?)	{100} rather perf., {010} less so.	Deep red or purple.	H=4–4.5 G=3.4 F=easy	Sol. in acid. Pleoc. intense: X=grayish, Y and Z deep blood-red.
[ ]	1.93±	1.97	1.93±	Zircon $ZrO_2.SiO_2$	$2V=10°±$ $2E=19°$.		Tetrag. Short prisms with pyramids.	{110} rare	Colorless, pink, brown, etc.	H=7.5 G=4.7 Infus.	Insol. in acid. Abnormally biax. (See Uniaxial group, p. 75.)

⊓	1.915	2.03	1.935	Keilhauite $15CaO.(Al,Fe,Y)_2O_3.15TiO_2.16SiO_2$	$2V=50°$ $2E=110°$. $r>v$ strong.	$Y=b$	Mon.	{111}dist.	Brownish black.	H=6.5 G=3.52–3.77 F=4–4.5	Insol. in acid.
⊓	1.963	1.966	1.963	Hyalotekite $9(Pb,Ba,Ca)O.B_2O_3.12SiO_2$(?)	Small $r<v$ strong.	Opt.pl. ⊥cleav.	Orth.	Two at 90°	Colorless	H=5–5.5 G=3.80 F=3(?)	Insol.
⊓	1.95	1.99	1.97	Bayldonite $4(Pb,Cu)O.As_2O_5.2H_2O$	Large $r<v$ strong(?)	$X=b$ $Y\wedge$elong. $45°\pm$.	Mon.(?) Fib.c.		Grass-green	H=4.5 G=5.35 F=2–3(?)	Sol. in HNO_3.
	1.955	2.05	1.985	Uranosphaerite $Bi_2O_3.2UO_3.3H_2O$	Very large $r<v$ strong.	$X=a$ $Z=c$.	Orth.(?).Spherulites. Elong. c.	{100}perf.	Orange-yellow; brick-red.	H=2–3 G=6.36	On heating decrepitates.
	B = very low		1.99	Agricolite $2Bi_2O_3.3SiO_2$	Large		Mon. Fib.		Yellow-brown	H=3(?) G=6 F=2	Gelat.
∧	B=0.015		2.0±	Ardennite $MnO.4Al_2O_3.3SiO_2.V_2O_5.5H_2O$	$2V=0°$–$50°$ $2E=0°$–$116°$. $r>v$ very strong.	$Z=b$ $X=c$.	Orth.	{010}perf. {110}dist.	Yellow to brown.	H=6–7 G=3.65 F=2–2.5	Nearly insol. in acids, Pleoc.: X = deep brownish yellow, Y=golden yellow, Z=pale yellow.
∨	2.00	2.02	2.01	Volborthite $6(Cu,Ca,Ba)O.V_2O_5.15H_2O$	Large to small. $r>v$ very strong.	Z nearly ⊥ plates. Disp. very strong.	Mon.(?). Six-sided tablets.	One perf.	Olive-green, citron-yellow.	H=3 G=3.55 F=1.5(?)	
	B = high 1.840			Metarossite $CaO.V_2O_5.2H_2O$	Large	Opt. axes emerge from cleav.		One perf.	Dull yellow	Soft F.=easy	Sol. in H_2O. Sol. in HCl, turning solution mahogany red.
	1.957	2.245	2.037	Sulphur S	$2V=69°$ $r<v$.	$X=a$ $Z=c$.	Orth. Pris. granular.	{001}{110}{111} imperf.	Yellow	H=2 G=2.06 F=1	Insol. in acids. Burns with a blue flame to fumes of SO_2. Pleoc. Tw. pl. {101}.
	*2.05	2.06	2.05	Carminite $3PbO.5Fe_2O_3.6As_2O_5$	Medium $r>v$ extr.	$X=c$	Orth. Needles.	// rhombic prism.	Carmine to lilac.	H=2.5 G=4.11 F=easy	Sol. in HNO_3. Pleoc. faint in red-brown. Abs.: X<Y+Z. Cornwall.
∧ ∨	2.01	2.10	2.05	Calciovolborthite $4(Cu,Ca)O.V_2O_5.H_2O$	$2V_{Li}=68°$ $2V_{Na}=83°$. $2V_{Tl}=89°$. Disp. extr.		Mon.(?) Rosettes and hex. scales.	(?)	Yellow-green	H=3.5 G=3.5–3.9 F=1.5–3	Opt.– for violet light.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	B=weak	----	2.087	Senarmontite Sb_2O_3	----	----	Ps. isomet. Oct.	{111}tr	Colorless	H=2 G=5.2 F=1.5 volatile	Sol. in HCl. Anom. biref.
	2.14	2.18	2.15	Atelestite $3Bi_2O_3.As_2O_5.2H_2O$	2V=44° 2E=107°. $r<v$ rather strong.	----	Mon	{001}indist	Sulphur-yellow.	H=3-4.5 G=6.4 F=1.5	
	*2.17	2.18	2.17	Georgiadesite $3PbO.3PbCl_2.As_2O_5$	Very large $r<v$ strong.	Y=a Z=c.	Orth. Hex. outline.	----	White	H=3.5 G=7.1 F=easy	Sol. in HNO_3. Laurium.
	2.12	2.31	2.17	Melanotekite $3PbO.2Fe_2O_3.3SiO_2$	2V=67° $r<v$ rather strong.	----	Orth. Pris	Two	Black	H=6.5 G=5.73 F=2-2.5	Decpd. by HNO_3. Pleoc. intense: X=nearly colorless, Y=pale reddish brown, Z=deep reddish brown.
	2.00_{Li}	2.35_{Li}	2.18_{Li}	Tellurite TeO_2	2V=90° $r<v$ mod.	X=b Z=c.	Orth. Acic. c or tab.{010}.	{010}very perf.	Colorless	H=2 G=5.90 Fus.	May be opt.—. Flexible.
	2.10	2.31	2.20	Kentrolite $3PbO.2Mn_2O_3.3SiO_2$	2V=88° $r<v$ strong.	X=a Y=b.	Orth. Pris	{110}dist	Dark reddish brown.	H=5 G=6.19 F=2-2.5	Sol. in HCl. Pleoc. in red. Abs.: Z>Y>X.
	2.19	2.33	2.20	Tripuhyite $2FeO.Sb_2O_5$	Small $r<v$ very strong.	----	Microcrystalline.	----	Dull greenish yellow.	G=5.82 F=4-5(?)	
	1.94_{Na}	2.51_{Na}	2.20_{Na}	Lepidocrocite $Fe_2O_3.H_2O$	2V=90° Disp. not strong.	X=a Y=c.	Orth. Blades {100}, elong c.	{100}very perf. {010}perf. {001}fair.	Red. Streak red.	H=4 G=4.09	Pleoc. strong: X=yellow, Y=deep red, Z=deeper red. Abs.: X<Y<Z.
	B=weak		2.21	Weslienite $Na_2O.FeO.3CaO.2Sb_2O_5$	Large	----	Ps. oct	None	Wax-yellow	H=6.5 G=4.97	Undulatory ext., and abnormal violet interference colors,

	2.200	2.260	2.217	Cotunnite $PbCl_2$	2V=67°	Z=*a* X=*c*.	Orth. Acic. *a*.	{001}perf.	White, yellowish, greenish.	Fragile G=5.84 F=1	Sol. in hot water.
V	2.17	2.32	2.22	Huebnerite $MnO.WO_3$	2V=73°	X=*b* Z∧*c*=19°.	Mon. Tab. {100}blades *c*.	{010}very perf.	Brownish red.	H=5–5.5 G=6.7–7.3 F=4	Isomor. with wolframite. Decpd. by HCl. Pleoc. weak: X=nearly colorless, Y=yellow-brown, Z=green.
	2.24_{Li}	2.53_{Li}	2.24_{Li}	Manganite $Mn_2O_3.H_2O$	Small *r*>*v* (?) very strong.	Y=*b* Z=*c*.	Orth	{010}very perf. {110}perf.	Black	H=4 G=4.3 Infus.	Sol. in HCl. Red-brown and nearly opaque in section. Abs. faint: X and Y<Z.
⊏ >	2.22	2.29	2.25	Manganotantalite $MnO.(Ta,Cb)_2O_5$	Large *r*<*v* strong.	Y=*a* Z=*c*.	do	{010}perf.	Dark reddish brown to black.	H=4.5 G=6.6± Infus.	Nearly insol. in acid. Yellow in section and nonpleoc. Indices for mineral with G=6.6.
> >	2.19	2.34	2.25	Tantalite $(Fe,Mn)O.(Ta,Cb)_2O_5$	Very large *r*<*v* mod.	Y=*a* Z=*c*.	do	do	Dark reddish brown.	H=4.5 G=6.5± Infus.	Nearly insol. in acid. Strongly pleoc.: X=very pale red, Z=blood-red. Abs.: X<Y<Z.
⊏	2.18	2.35	2.26	Descloizite $4(Pb,Zn,etc.)O.V_2O_5.H_2O$	2V=90°± *r*>*v* rather strong.	X=*c* Z=*a*.	Orth. Short prisms.	None	Cherry-red, brown, black.	H=3.5 G=5.9–6.2 F=1.5	
	2.27	2.30	2.27	Raspite $PbO.WO_3$	2V=0°±	Y=*b* X∧*c* large.	Mon Tab.{100}, elong. *b*.	{100}perf.	Brownish yellow.	H=2.5 F=2.5 to 3	Decpd. by HCl. Abs.: X and Y>Z.
	2.24	2.31	2.27	Mendipite $2PbO.PbCl_2$	2V=90°± *r*<*v* very strong.	Z=*c* X=*a*.	Orth. Fib. *c*.	{110} highly perf. {100} {010} less perf.	White	H=2.5–3 G=7.24 F=1	Sol. in HNO_3.
> >	2.26	2.34	2.29	Manganotantalite $(Fe,Mn)O.(Cb,Ta)_2O_5$	Large *r*<*v* strong.		Orth	{100} rather dist. {010} less so.	Nearly black.	H=6 G=6± Infus.	Isomor. with columbite. Nearly insol. in acid. Streak dark red to black. Nearly opaque.
>	2.26	2.43	2.32	Tantalite $(Fe,Mn)O.(Ta,Cb)_2O_5$	Large		do	{100} rather dist.	Black	H=6 G=6± Infus.	Nearly insol. in acid. Pleoc. strong: X=nearly colorless, Y=red-brown, Z=dark red-brown. Tw. pl. {021}.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
⟨ ⟩	2.26_{Li}	2.42_{Li}	2.32_{Li}	Wolframite (Fe,Mn)O.WO_3	Large		Mon. Tab.{100}.	{010}very perf.	Brownish black.	H=5–5.5 G=7.2–7.5 F=3	Isomor. with huebnerite and ferberite. Sol. in conct. H_2SO_4. Strongly pleoc. Abs.: X>Y>Z.
[ ]	B=weak		2.33	Dysanalite 7(Ca,Ce,Fe,Na_2)O. 6TiO_2.Cb_2O_5	2V=90°±	Z=*b*. X=*a*.	Orth. Ps. isomet. Cubes.	{110} good {100}less so.	Iron-black	H=5–6 G=4.13 Infus.	Pleoc. weak: X=light gray-green, Z=dark gray-green.
	2.30_{Li}	2.40_{Li}	2.35_{Li}	Nadorite PbO.Sb_2O_3.$PbCl_2$	Very large *r*>*v* strong.	Y=*b*. Z=*c*.	Orth. Tab. {100}. Pris. c.	{100}very perf.	Smoky brown, brown-yellow.	H=4 G=7.02 F=1.5	Sol. in HCl. Tw. pl. {010}crosses at about 90°.
⟨ ⟩	2.31_{Li}	2.46_{Li}	2.36_{Li}	Wolframite (Fe,Mn)O.WO_3	Large		Mon. Tab. {100}.	{010}very perf.	Brownish black.	H=5–5.5 G=7.2–7.5 F=3	Sol. in conct. H_2SO_4. Nearly opaque. Abs.: X>Y>Z.
[ ]	2.28_{Li}	2.48_{Li}	2.36_{Li}	Brackebuschite 3(Pb,Mn,Fe)O. V_2O_5.H_2O(?)	do. *r*>*v* rather strong.		Mon.(?) Pris.		Black	F=1.5(?)	Pleoc. very strong: X=nearly colorless, Y=clouded reddish brown, Z=clear reddish brown.
	2.31_{Li}	2.66_{Li}	2.37_{Li}	Crocoite PbO.CrO_3	2V=54° *r*>*v* very strong.	Y=*b*. Z∧*c*=−5½°. Disp. very strong.	Mon.	{110} rather distinct.	Hyacinth-red	H=2–3 G=6.0 F=1.5	
	2.34	2.65	2.38	Phoenicochroite 3PbO.2CrO_3	Medium *r*>*v* strong.		Orth. Tab.	One perf.	Cochineal to hyacinth red.	H=3–3.5 G=5.75 F=easy	Sol. in HCl. Same as crocoite?
	B=very weak		2.38	Perofskite CaO.TiO_2	2V=90°±	Z=*a*. Y=*b*.	Orth. Ps. isomet.	{100} poor.	Yellow, black, etc.	H=5.5 G=4.03 Infus.	Decpd. by H_2SO_4. May be −. Complex interlaced tw.
	2.38_{Li}	2.42_{Li}	2.39_{Li}	Pseudobrookite Fe_2O_3.TiO_2	2V=50°±	Z=*a*. X=*c*.	Orth. Tab. {100}.	{001} dist.	Dark brown to black.	H=6 G=4.4–5.0 Infus.	Insol. in acid. Weakly pleoc. in reddish brown. Abs.: X<Y>Z.

V	2.374	2.457	2.404	Stibiotantalite $Sb_2O_3.(Ta,Cb)_2O_5$	$2V=75°$ $r<v$ strong.	$X=a$ $Z=c$.	Orth. Flattened {100}.	{100}very perf.		H=5 G=6.6–7.9 F=4	Isomor. with stibiocolumbite. Insol. except in HF. Data for mineral with G=6.82, Ta_2O_5 39 per cent. β and disp. increase with Cb; B and G decrease.
^	2.398	2.459	2.419	Stibiocolumbite $Sb_2O_3.(Cb,Ta)_2O_5$	$2V=73°$ $r<v$ strong.	$Y=b$ $Z=c$.	Orth. Tab. {100}.	do		H=5 G=5.6–6.6 F=4	Insol. in acid. Data for mineral with G=6.30, Ta_2O_5=22.5 per cent. β and disp. increase with Cb; B and G decrease.
	2.45_{Li}	2.51_{Li}	2.45_{Li}	Derbylite $6FeO.Sb_2O_3.5TiO_2$	Near 0°		Orth. Pris. c.		Black	H=5 G=4.53 Infus.	Insol. in acid. In section dark brown and nonpleoc.
	2.37	2.65	2.5	Montroydite HgO	Large	$Y\perp$cleav.(?) Z=elong.	Orth. Pris.	{010}very perf.	Deep red, orange, brown.	H=2–3	Sol. in acid. Volatile.
	2.583	2.741	2.586	Brookite TiO_2	$2V_{Na}=30°$ 0° for yellow-green. Disp. very strong.	$X_{red}=b$ $X_{blue}=c$. $Z=a$.	Orth	{110}indist.	Brown, black	H=6 G=3.9 Infus.	Insol. even in HF. Pleoc. weak.
	2.51_{Li}	2.71_{Li}	2.61_{Li}	Massicot PbO	$2V=90°\pm$ Disp. strong.	$Y=a$?	Orth. Tab. {100}.	{100}perf.	Yellow	Soft G=9.29 F=1.5	Sol. in acid. Commonly bordered by litharge. Pleoc.: Y=light sulphur-yellow, Z=deep yellow. Opt −for blue.
	*B=very strong.		>2.72	Vrbaite $TlAs_2SbS_5$	Large $r>v$ strong.		Orth	{010}easy	Brownish-gray to reddish.	H=3.5 G=5.30 F=easy	Sol. in HCl.
	2.74	B = extreme.	$>2.72_{Li}$	Kermesite $Sb_2O_3.2Sb_2S_3$	Small (?)	Elong.+	Mon. Pris.	{100}perf.	Cherry-red	H=1–1.5 G=4.5 F=1	Volatile.
	B=very strong.		$>2.72_{Li}$	Miargyrite $Ag_2S.Sb_2S_3$	Medium		Mon	{010}tr	Iron-black, Streak cherry-red.	H=2–2.5 G=5.2 F=1	Decpd. by HNO_3. In section blood-red.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial positive group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	>2.72	B = extreme.	>2.72$_{Li}$	Lorandite $Tl_2S.As_2S_3$	Large $r>v$ strong.	Z//elong. (>b) Y=a.	Elong.+	{100}perf.	Cochineal-red	H=2–2.5 G=5.53 F=1	Sol. in HNO_3 with separation of S. Deep red in powder. Faintly pleoc. Y=purple-red, Z=orange-red.
			Extreme	Pyrostilpnite $3Ag_2S.Sb_2S_3$		Ext. on {010}=8° to 11°.	Mon. or tric.	{010} perf.	Hyacinth-red	H=2 G=4.2 F=1	Tw. pl. {100}. Absorption.

Biaxial negative group

[The minerals of this group are chiefly orthorhombic, monoclinic, or triclinic]

	1.3239	1.3247	1.3245	Avogadrite KBF_4 + 10 per cent $CsBF_4$	Very large	X=c	Orth. Tab. //{001}elong. b (also a).		Yellowish to reddish sublimate.	G=2.617	
	1.393	1.397	1.395	Mirabilite $Na_2O.SO_3.10H_2O$	2V=76° 2E=118°. $r<v$.	X=b or Y=b. Z$\wedge c$=30°. Disp. strong.	Mon. Near pyroxene habit.	{100}perf. {001}{010}tr.	White	H=2 G=1.481 F=1.5	Sol. in H_2O. Effloresces rapidly.
	1.407	1.415	1.414	Thomsenolite $NaF.CaF_2.AlF_3.H_2O$	2V=50° 2E=73°. $r<v$ weak.	X$\wedge c$=−52° Z=b.	Mon. Cubic.	{001}perf. {110}less so.	Colorless	H=2 G=2.98 F=1.5	Decpd. by H_2SO_4. Alteration of cryolite.
	1.405	1.440	1.425	Natron $Na_2O.CO_2.10H_2O$	2V=71° 2E=112°. $r<v$ perc.	X=b	Mon	{100}good {010}imperf.	White	H=1 G=1.46 F=1	Very sol. in H_2O. Rapidly loses H_2O on exposure to air.
	1.440	1.453	1.452	Lecontite $(Na,NH_4,K)_2O.SO_3.2H_2O$	2V=40° 2E=59°. $r<v$ rather strong.		Orth. Pris.		Colorless	H=2–2.5 F=1	Sol. in H_2O.

1.430	1.458	1.452	Kalinite $K_2O.Al_2O_3.4SO_3.24H_2O$	2V=52° 2E=79°. Disp. weak.	Z=*b*. Y∧*c*=13°.	Mon.(?). Fib. *c*.		White	H=2-2.5 G=1.75 F=1	Do.
1.426	1.456	1.453	Hexahydrite $MgO.SO_3.6H_2O$	2V=38°± 2E=56°.	Y=*b*. X∧*c*=−25°. X nearly ⊥ {$\bar{1}$02}.	Mon. Tab. {001}.	{100}perf.		G=1.75 Infus.	Exfoliates. Twinned on {001} and {110}.
1.448	1.456	1.454	Gearksutite $CaF_2.Al(F,OH)_3.H_2O$	Medium	X=*b*. Y∧*c*=very large.	Mon. Needles *c*. Powder.		White, chalky.	H=2 G=2.77 F=1.5-2	Sol. in acid.
1.435	1.459	1.455	Wattevillite $Na_2O.CaO.2SO_3.4H_2O$	2V=48° 2E=72°. Disp. slight.		Mon. Hair-like.		Colorless	G=1.81 F=1.5-2	Sol. in HCl.
1.433	1.461	1.455	Epsomite $MgO.SO_3.7H_2O$	2V=52° 2E=80°. *r*<*v* weak.	X=*a*. Z=*b*.	Orth. Elong. *c*.	{010}very perf. {011}less perf.	White	H=2 G=1.68 F=1	Sol. in H_2O. Tastes bitter and salty.
1.340	1.459	1.456	Sassolite $B_2O_3.3H_2O$	2V=7° 2E=10°.	X nearly ⊥ {001}. Ax. pl. nearly// to *b*.	Tric. Tab. {001}.	{001}perf.	White, pearly.	H=1 G=1.48 F=0.5	Sol. in H_2O. Tastes acidulous, saline, and bitter.
1.432	1.458	1.457	Mendozite $Na_2O.Al_2O_3.4SO_3.22H_2O$	Very small Disp. slight.	Elong.−	Mon.(?) Fib		White	H=3 G=1.88 F=1	Soda alum. Sol. in H_2O.
1.449	1.463	1.461	Mendozite $Na_2O.Al_2O_3.4SO_3.22H_2O$	2V=56° 2E=87°. Disp. slight.	X=*b*. Y∧*c*=30°.	Mon. Laths {100}, elong. *c*.	{010}perf.	do	H=3 G=1.73 F=1	Artificial. Sol. in H_2O. Alters in air to tamarugite.
1.462	1.471	1.470	Paraluminite $2Al_2O_3.SO_3.15H_2O$	Small	X=elong	Massive. Fib.		White, chalky.	Soft	
1.447	1.472	1.470	Borax $Na_2O.2B_2O_3.10H_2O$	2V=39° 2E=59°. *r*>*v* strong.	X=*b*. Z∧*c*=−56.9° Disp. strong.	Mon	{100} perf. {110} less perf.	White	H=2 G=1.70 F=1-1.5	Very sol. in H_2O. Tw. pl. {100}.
1.454	1.488	1.472	Kernite $Na_2O.2B_2O_3.4H_2O$	2V=80° 2E=143°. *r*>*v*.	Z=*b*. X∧*c*=70°.	Mon	{001}{100} perf. {$\bar{1}$01} fair.	White to colorless.	H=2.5 G=1.91	Fuses to clear glass after swelling. Very slowly sol. in cold H_2O.
B=0.001 to 0.008		1.474	Gmelinite $(Na_2,Ca)O.Al_2O_3.4SiO_2.6H_2O$	Small		Ps. trig	{10$\bar{1}$0} easy	do	H=4.5 G=2.1 F=3	Zeolite group. (See Uniaxial group, p. 77.) Decpd. by acid. Tw. axis *c*.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
[ ]	1.474	1.477	1.475	Ptilolite $(Ca,Na_2,K_2)O.Al_2O_3.10SiO_2.7H_2O$	$2V=57°\pm$ $2E=89°$.	$X=c$ $Y=a$.	Orth. Slender laths. Elong *c*. Flattened {100}.	{100} perf. {010} dist.	Colorless, white.	H=5 G=2.11 F=3–4	Zeolite group. Insol. in acid. Cottonlike aggregates. On heating becomes+ 120° and on cooling again becomes −.
[ ]	1.472	1.476	1.475	Mordenite $(Ca,Na_2,K_2)O.Al_2O_3.9SiO_2.6H_2O$	Large	$Z=b$ $X\wedge c=4°$.	Mon. or tric. Tab.{010}. Fib. *c*.	{010} perf.	Yellow, pink, etc.	H=3–4 G=2.15 F=4–5	Zeolite group. Partly decpd. by acid. Mineral with CaO 3.5, Na_2O 3.5, K_2O 0.6 per cent.
[ ]	1.461	1.485	1.478	Creedite $CaO.2CaF_2.2Al(F,OH)_3.SO_3.2H_2O$	$2V=63°$ $2E=101°$. $r>v$ slight.	$Z\wedge c=41°$ $Y=b$.	Mon. Pris. *c*. Rhombic cross section.	{100} perf.	Colorless.	H=3.5 G=2.73 F=dif.	Sol. in acid.
	1.476	1.479	1.479	Clinoptilolite $(Ca,Na_2,K_2)O.Al_2O_3.10SiO_2.7H_2O$	Very small. $r<v$ strong.	$X=b$? $Z\wedge a=15°$.	Mon.	{010}			Zeolite group.
	1.457	1.484	1.480	Goslarite $ZnO.SO_3.7H_2O$	$2V=46°$ $2E=71°$. $r>v$ weak.	$X=b$ $Z=a$.	Orth. Acic. *c*.	{010} perf.	Colorless, yellowish, bluish, etc.	H=2 G=2.2 Infus.	Sol. in H_2O. Taste astringent. Alters on exposure to dry air.
	1.476	1.483	1.480	Pickeringite $MgO.Al_2O_3.4SO_3.22\pm H_2O$	Medium	$Y=b$ $Z\wedge c=37°$.	Mon. Fib.		Colorless, yellow, reddish.	H=1 G=1.85 F=easy	Sol. in H_2O. Tastes astringent.
	1.38	1.57	1.480	Kalicinite $K_2O.2CO_2.H_2O$	$2V=82\frac{1}{2}°$ $2E=153°$.	$Y=b$ $X\wedge c=30°$.	Mon. Elong. *b*.	{100}{001}{101}.	White.	G=2.16 F=easy	Sol. in H_2O.
	1.47	1.49	1.48	Boothite $CuO.SO_3.7H_2O$	Large	$Y=b$ X near *c*.	Mon. Fib. *c*.	{001} imp.	White, silky.	H=2.5 G=1.94 Fus.	Sol. in H_2O. Colorless in section. Decpd. to chalcanthite on exposure to dry air. Opt. character doubtful.

1.391	1.486	1.481	Darapskite $3Na_2O.N_2O_5.2SO_3.2H_2O$	$2V=25°$ $2E=39°$. $r>v$ rather strong.	$X=b$ $Z\wedge c=12°$.	Mon.?	{100}{010}perf.	Colorless	H=2.3 G=2.20 F=1(?)	Sol. in H_2O. Poly. tw. {100} similar to those of plagioclase.
1.478	1.482	1.482	Apjohnite $MnO.Al_2O_3.4SO_3.22\pm H_2O$	Rather small	$Y=b$ $Z\wedge c=29°$.	Mon. Fib. c		White, silky	H=1.5 G=1.78–2.3 Infus.	Sol. in H_2O. Tend to lie on {010}and{100}.
1.477	1.489	1.483	Bieberite $CoO.SO_3.7H_2O$	Near 90° Disp. slight.	$Z=b$	Mon.(?)		Carmine	H=2 G=1.96 F=easy	Sol. in H_2O. Decpd. to the pentahydrate on exposure to air.
1.483	1.487	1.486	Bloedite $Na_2O.MgO.2SO_3.4H_2O$	$2V=71°$ $2E=119°$. $r<v$ strong.	$Y=b$ $X\wedge c=41.1°$.	Mon. Tab. {001}. Simulates quartz.	None	Colorless	H=3 G=2.23 F=1.5	Sol. in H_2O.
1.483	1.490	1.487	Leonite $K_2O.MgO.2SO_3.4H_2O$	$2V=86°$ $r<v$.	$Y=b$ $Z\wedge c=$small.	Mon		do	H=3 G=2.25 F=easy	Sol. in H_2O.
B=0.001		1.487	Analcite $Na_2O.Al_2O_3.4SiO_2.2H_2O$	Very small		Ps. isomet. Trapezohedrons.	{100}imperf	do	H=5 G=2.25 F=2.5	Decpd. by HCl. Tw. grating. (See isotropic group, p. 49.)
*1.480	1.490	1.488	Halotrichite $FeO.Al_2O_3.4SO_3.24H_2O$	Medium small	$Z\wedge c=38°$ $Y=b$.	Mon. Fib. c		do	H=2 G=1.89–2.04 F=4.5–5	Near alunogen. Sol. in H_2O. Tastes astringent.
1.485	1.489	1.488	Vanthoffite $3Na_2O.MgO.4SO_3$	$2V=84°$ $2E=170°$. $r<v$.		Mon.(?)		do	H=4 G=2.69 Fus.	Sol. in H_2O.
1.467	1.492	1.489	Morenosite $NiO.SO_3.7H_2O$	$2V=42°$ $2E=64°$. $r>v$ strong.	$X=b$ $Z=a$.	Orth. Acic. c	{010}perf	Apple-green, etc.	H=2 G=2.00 Infus.	Sol. in H_2O. Tastes astringent.
*1.484	1.495	1.492	Stellerite $CaO.Al_2O_3.7SiO_2.7H_2O$	$2V=44°$ $2E=68°$. $r<v$ weak.	$X=c$ $Z=a$.	Orth. Tab.	{010}highly perf. {100} less so.	Light flesh-red	H=4 G=2.12	Zeolite group. Commander Islands.
1.412	1.540	1.492	Trona $3Na_2O.4CO_2.5H_2O$	$2V=72°$ $2E=122°$. $r<v$ rather strong.	$X=b$ $Z\wedge c=83°$.	Mon. Elong. b	{100}perf	White, gray	H=3 G=2.13 F=1.5	Sol. in H_2O.
1.465	1.495	1.494	Bianchite $FeO.2ZnO.3SO_3.18H_2O$	$2V=10°\pm$ $2E=15°$. $r>v$ weak.		Mon		White		Sol. in cold H_2O.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
□	1.465	1.504	1.498	Nitrocalcite $CaO.N_2O_5.nH_2O$	$2V=50°$ $2E=78°$. Disp. slight.	$X \perp$cleav	Silky tufts	One perf	Colorless	Soft. F=easy	Very hygroscopic.
□	1.494	1.500	1.498	Stilbite $2CaO.Na_2O.3Al_2O_3.26SiO_2.20H_2O$	$2V=33\pm$ $2E=50°$.	$Y=b$ $X \wedge a=5°$.	Mon. Acic. a	{010}perf {001}tr.	White, etc	H=4 G=2.2 F=3	Zeolite. Decpd. by HCl. Tw. pl. {001} cruciform penet.
∨	1.478	1.549	1.500	Montmorillonite $MgO.Al_2O_3.4SiO_2.nH_2O$	$2V=10°$–$16°$ $2E=16°$–$26°$.			{001} perf			Member of montmorillonite-beidellite series.
	1.380	1.586	1.500	Nahcolite $Na_2O.2CO_2.H_2O$	$2V=75°$ $2E=132°$. $r>v$.	$Y=b$ $X \wedge c=+20°$.	Mon	{101}perf. {111} dist. {100} imperf.	White	G=2.22	Data for artificial sodium bicarbonate.
□	1.493	1.507	1.501	Epidesmine $CaO.Al_2O_3.6SiO_2.6H_2O$	$2V=40°$ $2E=61°$.	$X=c$ $Y=a$.	Orth	{100}perf {010}less so.		G=2.16	Zeolite group. Gelat. Fuses with intumescence to a white enamel.
✓	1.493	1.508	1.501	Didymolite $2CaO.3Al_2O_3.9SiO_2$	$2V=81°$ $2E=155°$. $r>v$.	$Y=b$ $X \wedge c=40°$.	Mon	{010}{110}fair	Dark gray	H=5 G=2.71 F=dif.	Insol. in acid. Tw. pl. {110} universal, {010} less common.
	1.412	1.526	1.501	Nesquehonite $MgO.CO_2.3H_2O$	$2V=53°$ $2E=84°$. $r<v$ weak.	$X=a$ $Z=b$.	Orth. Elong. c	{110}perf {001}imperf.	Colorless	H=2.5 G=1.84 Infus.	Sol. in cold dilute HCl.
∨	1.490	1.511	1.502±	Antigorite $3MgO.2SiO_2.2H_2O$	Large	$Z=b$ $X=c$.	Orth. Fib		Green	H=4-5 G=2.6± F=dif.	Serpentine. Decpd. by HCl. Faintly pleoc.
	1.332	1.504	1.504	Niter $K_2O.N_2O_5$	$2V=7°$ $2E=10°$. $r<v$ weak.	$X=c$ $Z=b$.	Orth. Equant or elong. c.	{011}perf {010}{110} imperf.	Colorless	H=2 G=2.1 F=1	Sol. in H_2O. Tastes saline.
	1.494	1.516	1.505	Kainite $MgO.SO_3.KCl.3H_2O$	$2V=85°$ $r>v$ small.	$Y=b$ $X \wedge c=-8°$. Disp. dist.	Mon. Tab. {001}.	{100}very dist. {110}dist.	do	H=3 G=2.13 F=1.5–2	Sol. in H_2O.

	1.495	1.520	1.505±	Inyoite $2CaO.3B_2O_3.13H_2O$	2V=70° 2E=120°. r<v slight.	Y=b X oblique to c.	Mon. Rhombic tablets {001}.	{001}good	do	H=2 G=1.87	Easily sol. in acid. Decrepitates and fuses b. b. with much intumescence. Alters to meyerhofferite.
	1.420	1.524	1.506	Thermonatrite $Na_2O.CO_2.H_2O$	2V=48° 2E=75°. r<v weak.	X=a Z=b.	Orth. Flat {001} or {100}	{010}dif.	White	H=1.5 G=1.55 F=1.5	Sol. in H_2O.
	1.344	1.506	1.506	Nitromagnesite $MgO.N_2O_5.nH_2O$	2V=5° 2E=7°. r<v perc.				Colorless	F=easy	Sol. in H_2O. Tastes bitter.
	1.498	1.508	1.506	Parasepiolite $2MgO.3SiO_2.4H_2O$	2V=50° 2E=79°.	Z=elong	Orth. Fib		White	Soft	α sepiolite. Separates gelat. SiO_2 in acid.
	B=0.002		1.508	Gonnardite $Ca_2Na_4Al_8Si_{12}O_{40}.14H_2O$	2V=50° or less	X=c	Fib		do	G=2.26	Zeolite.
	1.495	1.514	1.508	Manganese chalcanthite $MnO.SO_3.5H_2O$	Medium large r>v.		Tric		Pale pink	H=2-3 G=2.10 F=3	Sol. in H_2O. Near chalcanthite.
	1.502	1.512	1.510	Epistilbite $CaO.Al_2O_3.6SiO_2.5H_2O$	2V=44° 2E=69°. r<v strong.	Y=b Z∧c=9°.	Mon. Elong.c	{010}perf.	Colorless	H=4 G=2.25 F=3	Zeolite. Decpd. by acid.
	*1.479	1.511	1.510	Saponite $Al_2O_3.9MgO.10SiO_2.16H_2O$	Medium small	X=scales Z=elong.	Mon.(?) Scales laths.			Soft F=dif.	Michigan.
	1.49	1.521	1.510	Uranospathite $CaO.2UO_3.P_2O_5.nH_2O$	2V=69° 2E=118°.	X=c	Orth. Ps. tetrag.	{001}perf. {100}good.	Yellow to pale green.	G=2.50	Pleoc.: X=pale yellow, Y and Z=deep yellow. Becomes uniax. in a desiccator.
	1.506	1.517	1.512	Leonhardite $CaO.Al_2O_3.4SiO_2.H_2O$		Ext. to c=44°					Zeolite related to laumontite. H_2O 12.97 per cent.
	1.512	1.515	1.514	Okenite $CaO.2SiO_2.2H_2O$	Large	Z=c	Orth. Fib. c		White, etc.	H=5 G=2.17-2.36 F=2.5	Gelat.
	1.444	1.523	1.516	Gaylussite $Na_2O.CaO.2CO_2.5H_2O$	2V=34° 2E=52°. r<v strong.	X=b Z∧c=−14°. Disp. large.	Mon. Elong.a.	{110}perf. {001}imperf.	Colorless	H=2-3 G=1.991 F=1.5	Slightly sol. in H_2O. Sol. in acids.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
◇	1.493	1.516	1.516	Montmorillonite $(Mg,Ca)O.Al_2O_3.5SiO_2.nH_2O$	$2V=15°\pm$ $2E=22°$.			{001}mic.	Colorless, etc.	Soft	Member of montmorillonite-beidellite series. Properties variable. Loses H_2O at a low temperature.
	1.500	1.518	1.517	Syngenite $K_2O.CaO.2SO_3.H_2O$	$2V=27°$ $2E=41°$. $r<v$ very strong.	$Z=b$ $Y\wedge c=-2.3°$.	Mon. Laths {100}. Elong. *c*.	{110}{100}perf.	White	$H=2.5$ $G=2.60$ $F=1.5–2$	Partly sol. in H_2O. Tw. pl. {100} common.
	1.508	1.522	1.518	Ilesite $MnO.SO_3.4H_2O$	Medium large.	$Y=b$ $Z\wedge c=5°$.	Mon. (?) Tab. {100}, elong. *c*.				Artificial product. Sol. in H_2O.
□	1.512	1.519	1.519	Scolecite $CaO.Al_2O_3.3SiO_2.3H_2O$	$2V=36°\pm$ $2E=56°$. $r<v$ strong.	$Z=b$ $X\wedge c=17°$.	Mon. Elong. *c*.	{110}perf.	White	$H=5$ $G=2.3$ $F=2$	Zeolite. Gelat.
	1.501	1.526		Letovicite $H(NH_4)_3(SO_4)_2$		$Y=b$	Tab. {001}	{001} poor	Colorless to cloudy.	$G=1.81$	Easily sol. in H_2O. Easily volatile. Tw. lamellae.
	B=slight.		1.52	Chlorocalcite $KCl.CaCl_2$			Cubes	Cubic		$H=2.5–3$	Strongly hygroscopic. Twinned.
	1.519	1.529	1.52	Sepiolite $2MgO.3SiO_2.2H_2O$		$Z=c$	Orth. Fib. *c*.		White	$H=2–2.5$ $G=2$	β sepiolite. Does not gelat. with acid.
	1.516	1.520	1.52	Carnegieite $Na_2O.Al_2O_3.2SiO_2$	$2V=36°$ $2E=56°$.	Rhomb. section. $Z\wedge tw.=44°$.	Tric.		Colorless	$G=2.57$	Feldspar group. Artificial. Tw. as microcline. Also at 60°.
◇ □	1.513	1.525	1.524	Laumontite $CaO.Al_2O_3.4SiO_2.4H_2O$	$2V=25°\pm$ $2E=38°$. $r<v$ strong.	$Y=b$ $Z\wedge c=20°$ to 30°.	Mon. Elong. *c*.	{010}{110}very perf. {100} imperf.	White, etc.	$H=4$ $G=2.28$ $F=2$	Zeolite. Gelat. Tw. pl. {100}.

	1.518	1.526	1.524	Orthoclase $K_2O.Al_2O_3.6SiO_2$	2V=0°–70°. 2E=0°–122°. Disp. weak.	Y or Z=*b*. X∧*a*=5°.	Mon.	{010}{001}perf.	White, colorless, pink, etc.	H=6 G=2.56 F=5	Insol. in acids. Tw. ax. *c* and composition pl. {010}, others less common.
>	1.519	1.527	1.525	Anorthoclase $(Na,K)_2O.Al_2O_3.6SiO_2$. $Ab_{65}Or_{35}$	2V=45°. 2E=71°. *r*>*v* weak.	Ext. on {001}=3°±. Ext. on {010}=10.6°.	Tric.	do.	White, etc.	H=6 G=2.58 Infus.	Feldspar group. Insol. in acids. Tw. pl. {010}, also {100}, both poly., giving a very fine grating.
<>	1.503	1.527	1.526	Montmorillonite $MgO.Al_2O_3.4SiO_2.nH_2O$	Small			{001} perf.	Pink		Type material. Montmorillon, France.
<	1.522	1.530	1.526	Microcline $K_2O.Al_2O_3.6SiO_2$	2V=83°. *r*>*v* weak.	Ext. on {001}=15°. Ext. on {010}=5° to 6°.	Tric.	{010}{001}perf.	White, pink, etc.	H=6 G=2.56 Infus.	Feldspar group. Insol. in acids. Tw. pl. {010}, also {100}, both poly., giving a very fine grating.
[ ]	*1.490	1.527	1.527	Saponite $Al_2O_3.9MgO.10SiO_2.15H_2O$	Medium to small.	X⊥scales. Z=elong.	Scales, laths.		Colorless	Soft F=dif.	
	1.518	1.542	1.530	Minasragrite $V_2O_4.3SO_3.16H_2O$	Large	X=*b*. Z∧fib. 12°.	Mon. Fib. Rhombs.	{010}perf.	Blue	F=easy	Very sol. in cold H_2O. Pleoc. strong: X=deep blue, Y=pale blue, Z=nearly colorless.
[ ]	B=0.003		1.532	Milarite $K_2O.4CaO.4BeO.Al_2O_3.24SiO_2.H_2O$	Small	Z=*c*.	Ps. hex.		Pale green, etc.	H=6 G=2.57 F=3	Insol. in acid. Basal section shows six biax. segments. Uniax. at high temperatures.
	1.513	1.535	1.533	Searlesite $Na_2O.B_2O_3.4SiO_2.2H_2O$	Large (?)	X∧*c*=30°. Z=*b*.	Mon. Pris.*c*.	{100}perf.	White	H=soft G=2.45 F=easy	Sol. in acid. Appreciably sol. in H_2O.
	1.489	1.557	1.534	Artinite $2MgO.CO_2.4H_2O$	Large	Y usually // fibers.	Orth. Fib.		do.	H=2 G=2.03	
>	1.514	1.541	1.534	Zinc-copper chalcanthite $ZnO.CuO.2SO_3.10H_2O$	Mod.		Tric.		Pale blue	H=2–3 G=2.1	Sol. in H_2O. Nearly colorless in section. Near chalcanthite.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.500	1.560	1.535	Meyerhofferite $2CaO.3B_2O_3.7H_2O$	$2V=79°$ $2E=155°$. $r>v$ perc.	Ext. on {100} $Z'\wedge c=25°$. Ext. on {010}. $X'\wedge c=33°$.	Tric. Pris. c. Tab. {100}.	{010} perf.	Colorless	H=2 G=2.12 F=easy	Readily sol. in acid. Fuses with intumescence to an opaque enamel. Alteration of inyoite.
	1.515	1.536	1.535	Glauberite $Na_2O.CaO.2SO_3$	$2V=7°$ $2E=10°$. $r>v$ strong.	$Z=b$ $Y\wedge c=12°$. Disp. strong.	Mon. Tab. {001}.	{001} perf.	do	H=3 G=2.83 F=1.5–2	Slightly sol. in H_2O. Sol. in HCl.
□	1.530	1.540	1.535	Okenite $CaO.2SiO_2.2H_2O$	Very large	$Z\wedge c$=small Ext. on {100} =32°.	Tric. Fib. c. Tab. {010}.	{010} perf.	White	H=5 G=2.33 F=2.5	Gelat. Very tough.
^ v	1.494	1.536	1.535	Beidellite $Al_2O_3.3SiO_2.nH_2O$	Small			{001} perf.			Member of montmorillonite-beidellite-nontronite series.
^ v	1.517	1.543	1.536	Iron-copper chalcanthite. $FeO.CuO.2SO_3.10H_2O$	Mod		Tric.		Pale blue	H=2–3 G=2.2	Sol. in H_2O. Near chalcanthite.
	1.423	1.555	1.536	Teschemacherite $(NH_4)_2O.2CO_2.H_2O$	$2V=42°$ $2E=66°$. $r<v$ slight.	$X=a$ $Y=b$.	Orth.	{110} very perf. at 68°±.	Yellowish, white.	H=1.5 G=1.573–1.45 F=5.5	Sol. in H_2O.
^	1.495	1.537	1.537	Beidellite $Al_2O_3.3SiO_2.nH_2O$	Small	$X=c$	Orth.(?). Mic.	{001} mic.	Colorless	Soft Infus.	Member of montmorillonite-beidellite-nontronite series. On standing in oil n increases. Loses most of H_2O at low temperature.
	1.528	1.543	1.537	Siderotil $FeO.SO_3.5H_2O$	Mod $r>v$ weak.		Tric.		Pale green, white.	H=2–3 G=2.2 F=3	Sol. in H_2O.

∧ ∨	1.514	1.543	1.537	Chalcanthite $CuO.SO_3.5H_2O$	$2V=56°$ $2E=92°$. $r<v$ perc.		do		Berlin-blue to sky-blue.	H=2.5 G=2.2 F=3	Sol. in H_2O. Nearly colorless in section.
⊏ ∨	1.534	1.540	1.538	Cordierite $4(Mg,Fe)O.4Al_2O_3.10SiO_2.H_2O$	$2V=78°\pm$ $2E=151°$. $r<v$ weak.	$X=c$ $Z=b$.	Orth. Elong. c.	{010}dist.	Blue, green-blue.	H=7 G=2.58± F=5.5	Partly decpd. by acid. Pleoc. sometimes present: X=clear yellow, Y=dark violet. Z=clear.
	B=0.008		1.539	Gismondite $CaO.Al_2O_3.4SiO_2.4H_2O$	$2V=83°$ $r<v$ weak.	$X=b$ $Y\wedge c$=small	Mon. Tetrag. bipyramids. Ps. tetrag. by tw.	None	Colorless	H=4.5–5 G=2.27 F=3	Gelat. Section {001} shows four segments with opposite segments alike and ext. inclined at 5°.
	1.527	1.544	1.540	Sulphoborite $6MgO.2B_2O_3.2SO_3.9H_2O$	$2V=70°\pm$ $2E=124°$.	$X=c$ $Z=a$.	Orth. Pris.	{110}dist. {001}indist.	do	H=4 G=2.4 Fus.	Sol. in H_2O.
	1.520	1.545	1.541	Lueneburgite $3MgO.B_2O_3.P_2O_5.8H_2O$	Medium	$Y=b$ X and Z to length nearly 45°.	Mon. Laths with b across.		do	G=2.05 Fus.	Sol. in acid.
	1.466	1.596	1.542	Dawsonite $Na_2O.Al_2O_3.2CO_2.2H_2O$	$2V=77°$ $2E=148°$. $r<v$ weak.	$Y=c$ $X=a$.	Orth. Acic. c.	{110}perf.	White	H=3 G=2.40 F=4.5–5	Sol. in HCl.
∧ ∨	1.539	1.547	1.543	Oligoclase Ab_4An	$2V=86°$ $r<v$ weak.	On {010} $X'\wedge$ {001}=6°. On {001} $X'\wedge$ {010}=1°.	Tric.	{001}perf. {010}less so.	Colorless	H=6 G=2.64 Infus.	Feldspar group. Ab_{80} An_{20}. Insol. in acid Tw. pl. {010} poly. almost universal, also other laws.
⊐	1.503	1.545	1.545	Pholidolite $K_2O.12(Fe,Mg)O.Al_2O_3.13SiO_2.5H_2O$	$2V=0°$–$20°$ $2E=0°$–$31°$.	$X=c$	Mon. Hex. scales.	{001}mic.	Green	H=4 G=2.41	Nearly colorless in section.
∧	1.542	1.547	1.545	Hyalophane $(K_2,Ba)O.Al_2O_3.4SiO_2(?)$	$2V=79°\pm$ $2E=148°$. $r>v$.	$Z=b$ $Y\wedge c=5°$–$24°$.	Mon.	{010}{001}perf.	Colorless	H=6 G=2.80 F=dif.	Feldspar group. Ba orthoclase. Insol. in acids. Tw. axis c and composition pl. {010}; and other laws.
	1.533	1.547	1.545	Mooreite $8(Mg,Mn,Zn)O.SO_3.11H_2O$	$2V=50°\pm$ $2E=82°$. $r>v$ perc.	$X=b$ $Z\wedge c=44°$.	Mon. Tab.// {010}.	{010}perf.	White to colorless.	H=3 G=2.470	Easily sol. in acid. $MgO:MnO:ZnO=4:1:2$.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.539	1.551	1.546	Brushite $2CaO.P_2O_5.5H_2O$	Very large	$Z=b$ $Y \wedge a=15\frac{1}{2}°$.	Mon. Flattened {010}.	{010}perf {301}perf.	Colorless, pearly.	H=2 G=2.21 F=3	Sol. in dilute acid.
r > v	1.520	1.572	1.547	Copiapite $RO.2Fe_2O_3.6SO_3.22H_2O$	$2V=90°\pm$ $r<v$ medium.	$X=c$ Z bisects acute angle.	Orth. Tab. {001}. Scales, crusts.	{001}	Sulphur-yellow.	H=2.5 G=2.10 F=4.5–5	Janosite. Sol. in acid. Pleoc. in thick plates: yellow to colorless.
	1.439	1.595	1.547	Oxammite $(NH_4)_2O.C_2O_3.H_2O$	$2V=60°$ $2E=102°$. $r<v$.	$X=c$ $Y=a$.	Orth. Acic. c Tab. {100}.	{001}imperf	White	H=soft G=1.46–1.50 F=easy	Sol. in H_2O.
r > v	1.540	1.550	1.547	Cordierite $CaO.6MgO.6(Al,Fe)_2O_3.15SiO_2.3H_2O$	Large	$X=c$ $Z=b$.	Orth	{010}	Blue, etc	H=7	Al:Fe‴=5:1, Mg:Fe″=3:2, Ca:Na=2:3.
v	1.535	1.549	1.548	Centrallasite $4CaO.7SiO_2.3H_2O$	Small	X emerges from cleav.	Plates radiating.	One. Mic	White	H=2.5 G=2.51 F=easy	Decpd. by HCl. Replaces quartz in pegmatite.
	1.528	1.549	1.549	Truscottite $4(Ca,Mg)O.7SiO_2.3H_2O$	Very small	do		do	do	Soft G=2.47	Cf. centrallasite. CaO:MgO=4:1.
	1.531	1.552	1.549	Cobalt chalcanthite $CoO.SO_3.5H_2O$	Mod Not strong.		Tric		Rose-pink	H=2–3 G=2.2 F=3	Near chalcanthite. Sol. in H_2O.
	1.538	1.554	1.549	Edingtonite $BaO.Al_2O_3.3SiO_2.3H_2O$	$2V=53°$ $2E=88°$. $r<v$ weak.	$X=c$ $Z=a$.	Orth. Ps. tetrag. Sphenoidal.	{110}perf	White	H=4 G=2.7 F=5	Gelat.
r > v	*B=0.03		1.55	Saponite $Al_2O_3.9MgO.10SiO_2.15H_2O$	Medium to small.	$X \perp$ scales Z=elong.	Scales, laths		Colorless	Soft F=dif.	
	1.53	1.55	1.55	Ascharite $2MgO.B_2O_3.H_2O$	Small	Elong.−	Fib		White	G=2.69	

	1.485	1.570	1.553	Alumohydrocalcite $CaO.Al_2O_3.2CO_2.5H_2O$	2V=50°-55° 2E=81°-91°.	X=*b*. Ext.=7°-10°.	Mon.	{100}perf. {010}less so.	Chalky white to pale blue.	G=2.231 Infus.	Dawsonite group. Sol. in acid with effervescence.
V	1.530	1.556	1.553	Lepidolite $2K_2O.3Li_2O.4Al_2O_3.14SiO_2.H_2O.2F_2$	2V=46° 2E=75°.	X near *c*.	Mon. Ps. hex.	{001}mic.		G=2.820	Mica group. Fe_2O_3 1.30 per cent.
□	*1.545	1.565	1.554	Lacroixite $2Na(F,OH).2(Mn,Ca)O.Al_2O_3.P_2O_5.H_2O$	Near 90° Disp. slight.	Ext. large.	Mon. (?)		Colorless.	H=4.5 G=3.13	Ehrensfriedensdorf.
^ v	1.532	1.555	1.555	Lepidolite $K_2O.Li_2O.2Al_2O_3.6SiO_2.2H_2O$	2V=0°		Mon. Hex. plates.	{001}mic.	Pale purple-brown.	G=2.85 and 2.75 F=2.5	Mica group. Nearly insol. in acid. Li_2O 6 per cent.
^ v	1.552	1.559	1.555	Miloschite $(Al,Cr)_2O_3.2SiO_2.2H_2O$	2V=90°±	Inclined. Ext.	Mon. Clay-like. Tabular.	Traces.	Pale greenish blue.	H=2.5 G=2.1 Infus.	A chromiferous kaolinite. Almost insol. in HCl. Color under microscope pale bluish green.
	1.552	1.561	1.558	Beryllonite $Na_2O.2BeO.P_2O_5$	2V=68° 2E=120°. $r<v$ weak.	X=*c*. Z=*b*.	Orth. Short prisms *b* or tablets{001}.	{001} highly perf., {100}good, {110}poor.	Colorless to yellowish.	H=6 G=2.85 F=3	Sol. in acid. Luster on {001}pearly.
	*1.547	1.567	1.560	Polyhalite $2CaO.MgO.K_2O.4SO_3.2H_2O$	2V=62° 2E=107°.	On best cleav. shows tw. with ext. Z′∧ composition pl.=28°. On other cleav. shows two sets of tw. at about 90° and ext. X′∧ composition pl. of commoner tw.=28°.	Tric. Fib. *b*. Tab.{010}.	In two directions.	Flesh-red, yellow, etc.	H=3 G=2.78 F=1.5	Partly sol. in H_2O. Poly. tw. after two laws. Texas.
□ v	1.54	1.560	1.560	Jefferisite $5(Mg,Fe)O.2(Al,Fe)_2O_3.5SiO_2.14H_2O$	2V=0°±	X ⊥ plates.	Mic.	{001}mic.	White, green, brown, etc.	H=1.5 G=2.30	Vermiculite. Alteration of mica. Decpd. by HCl. Heated at 300° C., exfoliates very remarkably. On higher heating fuses.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
□ □	B=mod.	----------	1.56	Faratsihite $(Al,Fe)_2O_3.2SiO_2.2H_2O$	----------	----------	Mon. Hex. plates. Scales	----------	Pale yellow	Soft G=2.+ F=dif.	Between kaolinite and nontronite. Decpd. by HCl.
□ □	*1.551	1.562	1.561	Jezekite $CaO.Al_2O_3.2(Na,Li)F.2(Na,Li)(OH).P_2O_5$	Medium small. $r<v$ perc.	$Y=b$ $X\wedge a=29°$.	Mon. Pris	{100}perf {001}imperf.	Colorless	H=4.5 G=2.94	See morinite, below.
	*1.551	1.563	1.562	Morinite $3Al_2O_3.2Na_2O.4P_2O_5.6CaF_2.18H_2O$	$2V=38°\pm$ $2E=61°$. $r<v$ easily perc.	$Y=b$ Ext. 30° in obtuse angle β.	Mon	{100}perf	Wine-red, white.	H=4 G=2.94 F=easy	Insol. in acid. Montebras. The type jezekite has $\beta=1.561$ and is otherwise similar.
∧ ∨	1.552	1.563	1.562	Cordierite $4(Mg,Fe)O.4Al_2O_3.10SiO_2.H_2O$	$2V=40°\pm$ $2E=64°$. $r<v$ weak.	$X=c$ $Z=b$.	Orth. Elong. c.	{010}dist	Blue, etc	H=7 G=2.66 F=5.5.	Partly decpd. by acids. Pleoc. sometimes present: X= clear yellow, Y= dark violet, Z= clear.
	1.557	1.563	1.562	Nacrite $Al_2O_3.2SiO_2.2H_2O$	$2V=40°-90°$ $r>v$.	$Z=b$ $X\wedge c=12°\pm$.	Mon. Tab	{001}perf	White, pearly luster.	----------	Kaolin group. Not readily stained by dyes.
∨	1.559	1.565	1.564	Anauxite $5H_2O.2Al_2O_3.6SiO_2$ or $2H_2O.Al_2O_3.3SiO_2$	$2V=18°-31°$ $2E=28°-49°$. $r>v$ slight.	$X\perp\{001\}$. Slightly inclined ext. $Y=a$. $Z=b$.	Mon. Aggregates of plates hex. in section.	do	White	----------	Probably member kaolinite-anauxite series. Slightly pleoc.
∧ ∨	1.485	1.572	1.565	Griffithite $4(Mg,Fe,Ca)O.(Al,Fe)_2O_3.5SiO_2.7H_2O$	Small	$X\perp$cleav	Mon.? Plates {001}, shreds.	{001}mic	Dark green	Soft G=2.31 F=4	Chlorite group. Gelat. Pleoc.: X=pale yellowish, Y=olive-green, Z=brownish green. Fe/Mg=¼; Al/Fe=2.

	1.543	1.565	1.565	Potash clay $(Mg,Ca)O.Al_2O_3.5SiO_2.nH_2O$. Rich in K_2O	2V=20°± 2E=32°.	X near *c*	Orth. Mic	do	Colorless	Soft Infus.	Insol. Properties variable. Loses much H_2O at a low temperature.
	*1.544	1.566	1.565	Polylithionite $(Na,K)_3Li_5Al_2Si_8O_{22}F_2$	2V=40°± 2E=65°.	do	Mon	do	Pale green	H=2 G=2.9 F=2	Mica group. Kangerdluarsuk.
^ v	1.561	1.566	1.565	Kaolinite $Al_2O_3.2SiO_2.2H_2O$	2V=10°–57° 2E=15°–96°. *r*>*v*.	X nearly ⊥ {001}. Ext.=3.5°.	Mon. Minute hex. plates {001}.	{001}perf	White	H=2 G=2.6 Infus.	Insol. in acids.
^ v	B= 0.025±		1.57±	Bowlingite Silicate of Fe, Mg, Al, H_2O	2V=0°–40° 2E=65°.	X=*a* Z=*c*.	Orth.(?) Tab. {001}.	{100}perf		G=2.3 F=dif.	Serpentine. Easily sol. in HCl. Pleoc.: X and Y=green or yellow, Z=green or dark red-yellow.
^ v	1.560	1.571	1.570	Antigorite $3MgO.2SiO_2.2H_2O$	2V=27°± 2E=43°.	X=*b* Z=*c*.	Orth. Fib. *c*	{010}	Green	H=4–5 G=2.6±	Serpentine. Decpd. by HCl or H_2SO_4. Faintly pleoc.
^ v	1.523	1.572	1.570	Beidellite $Al_2O_3.3SiO_2.nH_2O$	Small	X=*c*		{001} mic	Colorless	Soft Infus.	Member beidellite-nontronite series. Fe_2O_3 18.54, Al_2O_3 12.22 percent. Insol. Properties variable. Loses much H_2O at a low temperature.
	1.524	1.583	1.571	Roemerite $FeO.Fe_2O_3.4SO_3.14H_2O$	2V=52° 2E=87°. *r*>*v* very strong crossed.	On {101} ax. pl. bisects obtuse angle between {100} {010} X or Z∧*c*=33°. Disp. mkd.	Tric. Tab. {001}.	{010}perf	Chestnut-brown.	H=3–3.5 G=2.15± F=4.5–5.	Sol. in H_2O. Very pronounced abnormal interference colors in some sections. Pleoc.: X=reddish yellow, Y=pale yellow, Z=yellow-brown.
v	1.554	1.576	1.571	Variscite $Al_2O_3.P_2O_5.4H_2O$	Medium large *r*>*v* perc.	Z=elong	Orth. Oct. Fib.	None	Green	H=5 G=2.52 Infus.	Sol. in acid after ignition.
	1.555	1.575	1.572	Hannayite $3MgO.(NH_4)_2O.2P_2O_5.10H_2O$	2V=42° 2E=68°. Disp. slight.	X=sensibly normal to perf. cleav. Y∧elong.=33°.	Tric. Slender prisms. Plates.	{0 0 1}{1 1 0} {1$\bar{1}$0}{130}.	Yellowish	H=soft G=1.89	
^ v	1.566	1.576	1.572	Bytownite $AbAn_4$	2V=82°	On {010}X′∧{001}=33°. On {001}X′∧{010}=22°.	Tric	{100}perf. {010} good.	Colorless	H=6 G=2.73 F=5	Feldspar group. $Ab_{20}An_{80}$. Gelat. Tw. {010}. poly., almost universal. Other tw. laws common.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	*1.570	1.572	1.572	Englishite $4CaO.K_2O.4Al_2O_3.4P_2O_5.14H_2O$	Small	$X=c$	Orth.(?) Plates.	{001} mic	Colorless	H=3 G=2.65	Lewiston, Utah.
⊐ ⊂	1.542	1.573	1.573	Vermiculite $4(Mg,Ni)O.Al_2O_3.4SiO_2.6½H_2O$	$2V=0°$–$8°$ $2E=0°$–$12°$. $r>v$ weak.	X near c	Mon. Hex. plates.	{001}perf	Green	H=1	Pleoc.: X=pale green, Y and Z=pale brownish green. NiO 11.25, MgO 18.18 per cent.
∧ ∨	1.540	1.574	1.574	Phlogopite $K_2O.6MgO.Al_2O_3.6SiO_2.2H_2O$	$2V=5°$ $2E=8°$. $r>v$ weak.	$X\wedge c$=small $Y=b$.	Mon	{001}mic	Pale brown or green.	H=3 G=2.85 F=dif.	Mica group. Decpd. by acid. Pleoc. faint. Data for mineral with Fe_2O_3 0.9, FeO 1.7, F 3.2 per cent.
	1.568	1.576		Jurupaite $7CaO.MgO.8SiO_2.4H_2O$		$Z\wedge$elong.=31°	Mon. Fib		White	H=4 G=2.75 F=2	Sol. in HCl. Contact deposit.
	1.56	1.580	1.574	Bassetite $CaO.2UO_3.P_2O_5.8H_2O$(?)	$2V=62°$ $2E=108°$.	$X=b$	Mon	{010}{100}{001}	Yellow	G=3.10	Pleoc.: X=pale yellow, Y and Z=deep yellow.
	1.553	1.577	1.575	Autunite $CaO.2UO_3.P_2O_5.8H_2O$	$2V=30°$ $2E=48°$. $r>v$ perc.	$X=c$ $Z=a$.	Orth. Thin tablets{001}. Nearly tetrag.	{001}eminent	Citron to sulphur yellow.	H=2 G=3.1 F=3	Sol. in acid. Luster on {001} pearly.
	1.562	1.588	1.576	Sphaerite $5Al_2O_3.2P_2O_5.16H_2O$	Large	$Z=c$	Orth. Concretions. Fib.c.	One dist	Gray to blue	H=4 G=2.54	
∧ ∨	1.576	1.579	1.578	Penninite $5(Mg,Fe)O.Al_2O_3.3SiO_2.4H_2O$	$2V=0°\pm$ $r>v$ perc.	$X\wedge c=0°\pm$	Mon. Shreds	{001}mic	Green	H=2.5 G=2.7 F=dif.	Chlorite group. Decpd. by H_2SO_4. Abnormal blue interference colors without ext. Pleoc.: X=nearly colorless, Y and Z=green.

^ v	1.551	1.581	1.578	Zinnwaldite $K_2O.Li_2O.2FeO.2Al_2O_3.6SiO_2.H_2O.F_2$	2V=30° 2E=47°.	X near *c*	Mon. Hex. plates.	do	Brown, etc.	H=3± G=2.987	Mica group. MnO 1.73 per cent.
	1.544	1.601	1.578	Kroehnkite $CuO.Na_2O.2SO_3.2H_2O$	2V=79° *r*<*v* weak.	Y=*b* X∧*c*=−48°. Disp. red >blue.	Mon. Fib. *c*	{010}perf.{011} dist.	Azure-blue	H=2.5 G=2.0 F=1	Sol. in H_2O. Tw. pl. {001}.
^ u	B=0.03		1.58	Cryophyllite $3(Li,K)_2O.2FeO.4Al_2O_3.2OSiO_2.3H_2O.8(Li,K)F$			Mon	{001}perf	Dark green	Fus.	Mica group. Variety zinnwaldite. Dif. sol. in acid. Pleoc.: X=emerald-green, Y and Z=brownish red.
u u	1.562	1.582	1.580	Canbyite $Fe_2O_3.2SiO_2.4H_2O$	Small *r*>*v* (?) perc.	Z ⊥ cleav	One perf		Amber-brown		α ranges from 1.55 to 1.60.
^ v	1.551	1.587	1.581	Muscovite $K_2O.3Al_2O_3.6SiO_2.2H_2O$	2V=48°± 2E=80°. *r*>*v* perc.	Z=*b* X∧*c*=0°±.	Mon. Hex. tablets{001}.	{001}mic	Colorless	H=2 G=2.80 F=5.7	Mica group. Insol. in acid. Tw. pl.{001}.
^ v	1.545	1.582	1.582	Hydrobiotite $2K_2O.10MgO.3Al_2O_3.12SiO_2.6H_2O$.	2V=0°± *r*<*v*.	X near *c*	Mon. Hex. plates.	do		H=3± G=2.783	Mica group.
	1.560	1.587	1.582	Uranospinite $CaO.2UO_3.As_2O_5.8H_2O$	2V=46° 2E=76°. *r*>*v* rather strong.	X=*c* Z=long direction.	Orth. Rect. plates{001}.	{001}perf	Pale yellow, etc.	H=2-3 G=3.45 Fus.	Sol. in acid. Pleoc.: X=colorless, Y and Z=pale canary-yellow.
	1.574	1.582	1.582	β hopeite $3ZnO.P_2O_5.4H_2O$	2V=0°± Disp. weak.	X=*b* Y=*a* or *c*.	Orth. Elong. *c*	{100}perf.{010} dist.	Grayish	H=3 G=3.03 F=5	Sol. in acids.
^	1.566	1.593	1.584	Variscite $(Al,Fe)_2O_3.P_2O_5.4H_2O$	2V=49°-54° 2E=82°-92°. *r*<*v*.	Z=elong	Orth	None	Colorless	H=5 G=2.597	Al:Fe‴=6:1.
^	1.576	1.588	1.584	Anorthite $CaO.Al_2O_3.2SiO_2$	2V=77° 2E=163°. *r*<*v*.	On{010}X′∧{001}=−37°. On{001}X′∧{010}=−40°.	Tric	{010}{001}perf	White	H=6 G=2.765 F=5	Feldspar group. Ab_0An_{100}. Gelat. Poly. tw. {010}. Almost universal. Other laws common.
	1.579	1.585	1.584	δ-Mooreite $7(Mg,Mn,Zn)O.SO_3.10H_2O$	Small		Mon	{010}dist	Bluish-white	H=3 G=2.665	Easily sol. in acid. MgO:MnO:ZnO=5:3:4.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
□	B=mod.	----------	1.585	Volchonskoite $(Cr,Fe,Al)_2O_3.2SiO_2.2H_2O$	----------	----------	Mon.(?)	----------	Green	H=2.5 G=2.2–2.3 Infus.	A chromium kaolinite. Gelat. with HCl.
< >	1.56	1.585	1.585	Nontronite $(Ca,Mg)O.2Fe_2O_3.8SiO_2.7\pm H_2O$	Small $r<v$ perc.	X⊥cleav Z // elong.	----------	One mic	Dark olive-green to yellow or orange	Soft G=2.50	Member of beidellite-nontronite series. Gelat. Pleoc.: X=pale yellow, Y=olive-green, Z=yellowish to bright green. When wet it is claylike. Alters to a yellow or orange type with higher index of refraction.
	1.52	1.613	1.587	Lanthanite $La_2O_3.3CO_2.9H_2O$	2V=62° 2E=110°. $r<v$ weak.	X=c Z=b.	Orth. Thin plates{001}.	{001}mic	White	H=3 G=2.60–2.74 Infus.	Sol. in acid.
	1.552	1.600	1.588	Pyrophyllite $Al_2O_3.4SiO_2.H_2O$	2V=57° 2E=98°. $r>v$ weak.	X=c Z // length.	Orth. Tab. {001}. Blades and fib.	{001}eminent	White, gray, apple-green, etc. Pearly.	H=1–2 G=2.8–2.9 F=dif.	Dif. sol. in H_2SO_4.
	1.539	1.589	1.589	Talc $3MgO.4SiO_2.H_2O$	2V=6°–30° 2E=9°–48°. $r>v$ perc.	X=c	Mon.(?) Orth.(?)	{001}mic	White, greenish.	H=1 G=2.7 F=6	Insol. in acid. Pearly luster.
	1.583	1.594	1.589	Pharmacolite $2CaO.As_2O_5.5H_2O$	2V=77° 2E=164°. $r<v$ strong.	Z=b X∧c=70°.	Mon. Pris. a	{010}perf	White	H=2 G=2.754 F=2.5	Sol. in acids. Luster on {010} pearly.
□	1.575	1.605	1.590	Catapleiite $(Na_2,Ca)O.ZrO_2.2SiO_2.2H_2O$	Large	X=c Z=b.	Orth	----------	Colorless	H=6 G=2.658 F=3	Gelat.
			1.590	Eggonite $Al_2O_3.P_2O_5.4H_2O$	2V=60° 2E=106°. $r>v$.	X=a Y=b.	do	{100}	White	----------	See variscite, p. 163.

	1.572	1.59	1.591	α Hopeite $3ZnO.P_2O_5.4H_2O$	2V=36°± 2E=59°. r<v weak.	X=b Y=c.	Orth. Elong. c.	{100}perf. {010} dist.	Grayish	H=3 G=3.03 F=5	Sol. in acid.
	1.572	1.594	1.591	Priceite $4CaO.5B_2O_3.7H_2O$	2V=32° 2E=52°. r<v rather strong.	X to normal to plates 25°±. Ext. on plates Y′ to bisectrix of acute angle of rhombs=14°±.	Tric. Minute rhombic plates, angle 58°.		Snow-white chalky.	H=3 G=2.4	Do.
	1.582	1.592	1.592	Torbernite $CuO.2UO_3.P_2O_5.12H_2O$	Very small r>v.	X=c	Orth. Ps. tetrah.	{001}perf	Green	H=2 G=3.4–3.6 F=2.5	Do.
◇	1.585	1.608	1.593	Nontronite $(Fe,Al)_2O_3.2SiO_2.2H_2O$	2V=26° 2E=42°.	X ⊥ cleav		One mic	Yellow, green	H=soft G=2.289	Member of beidellite-nontronite series. Fe:Al=10:1. Also MgO 3.98 per cent.
□	1.55	1.594	1.594	Alurgite $6(H,K)_2O.2(Mg,Mn)O.3Al_2O_3.12SiO_2$	2V=0°–57° 2E=0°–98°. r>v weak.	X=c	Plates and scales.	{001}mic	Copper-red, purple, etc.	H=3 G=2.84 F=3	Mica group. Insol. in acid. Pleoc. slight.
□	1.570	1.597	1.594	Astrolite $(Na,K)_2O.FeO.(Al,Fe)_2O_3.5SiO_2.H_2O$	2V=30° 2E=49°. r>v perc.	X⊥plates	Orth. Radiating globules, plates, and fibers.	Lamellar	Greenish yellow.	H=3.5 G=2.78 F=3.5	Insol. in acid. Pleoc.: X=nearly colorless, Y and Z=siskin-green.
◇	B=0.04		1.594	Fuchsite Chromium mica.	2V=40° 2E=66°. r>v strong.	X=c	Mon. Plates.	{001}mic	Green	H=2.5 G=2.86 F=5	Mica group. Near muscovite. Insol. in acid. Pleoc.: X=robin's-egg blue, Y=yellowish green, Z=chrome green.
◇	1.584	1.594	1.594	Clinochlore $13(Mg,Fe)O.3Al_2O_3.8SiO_2.11H_2O$	2V=0°±	X near c	do	do	do	H=2±	Chlorite group. Fe:Mg=1:12.
◇	1.578	1.598	1.595	Amblygonite $Al_2O_3.P_2O_5.2LiF$	2V=52–90° r>v small.	Ax. pl. 12½° to {100}, 67° to {011}. X to edge {100}{001} is 11.8°. Disp. strong.	Tric.	{001}perf {100}less so. {021}rare.	White	H=6 G=3.10 F=2	Sol. in H_2SO_4. Poly. tw. in two directions at 90°.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.572	1.614	1.595	Johannite $RO.UO_3.SO_3.4H_2O$ R=Cu, Fe, Na_2	2V=87° $r>v$ strong.	X near b Y∧c=7°. Disp. strong.	Tric(?) Laths {010}. Elong. c.		Yellow	H=2–2.5 G=3.9± Infus.	Sol. in HCl. Pleoc.: X=colorless, Y=pale yellow, Z=canary-yellow. Poly. tw. {100}.
◇	1.555	1.595	1.595	Diabantite $5(Mg,Fe)O.Al_2O_3.4SiO_2.4H_2O$	Near 0°	X=c Z // fibers.	Mon. Plates {001}. Fib.	{001} mic	Green to black	H=2 G=2.79	Chlorite group. Pleoc.: X=pale yellow, Y and Z=olive-green.
◇	1.558	1.601	1.595	Muscovite $(K,Na)_2O.3Al_2O_3.6SiO_2.2H_2O$	2V=42° 2E=68°.	X near c	Mon. Plates	do	Greenish, etc.	H=3–4	Mica group. K:Na=5:1.
	1.571	1.598	1.595	Leucophanite $BeO.CaO.2SiO_2.NaF$	2V=39° 2E=64°. $r>v$ weak.	X=c Z=b.	Orth. Tab. {001}.	{001} perf. {021} {201} {100} {010} dist.	Green to pale yellow.	H=4 G=2.96 F=3	Insol. in acids. Tw. pl. {110} (or {001}?) common.
□	1.592	1.599	1.597	Cordierite $4(Mg,Fe)O.4Al_2O_3.10SiO_2.H_2O$	2V=70° 2E=132°. $r<v$ weak.	X=c Z=b.	Orth	{010} dist	Blue, etc.	H=7 G=2.66± F=5.5	Partly decpd. by HCl. Pleoc. at times: X=clear yellow, Y=dark violet, Z=clear.
□	1.575	1.598	1.597	Chrysocolla $CuO.SiO_2.nH_2O$(?)	Small		Fib		Green	H=2± G=2.4± Infus.	Decpd. by acid. Faintly pleoc.
◇	1.551	1.598	1.598	Phlogopite $2K_2O.10(Mg,Fe)O.3Al_2O_3.12SiO_2.3H_2O$	2V=3° 2E=5°.	X near c	Mon. Hex. plates.	{001} mic	Brown, etc.	H=3–4	Mica group. FeO 2.72, Na_2O 1.49, F 0.58 per cent.
◇	1.568	1.598	1.598	Manganophyllite $K_2O.6(Mg,Mn)O.(Al,Fe,Mn)_2O_3.6SiO_2.2H_2O$	2V=4° 2E=6°.	do	do	do	Reddish brown, etc.	H=3–4 G=2.760	Mica group. Pleoc.: X=dark red; Y and Z=light red. Mg: Mn=4:1, Al: Fe‴: Mn‴=3:1:1.

1.584	1.602	1.598	Millisite $2CaO.Na_2O.6Al_2O_3.4P_2O_5$	Mod	$X=c$	Mon(?). Fib. c.		Colorless	H=5.5 G=2.83	Lewiston, Utah.
1.586	1.605	1.598	Howlite $4CaO.5B_2O_3.2SiO_2.5H_2O$	Large	$X=b$ $Z\wedge c=44°\pm$.	Mon. Tab. {100}. Elong. c.		White	H=3.5 G=2.58 F=2	Insol. in HCl.
1.556	1.602	1.599	Muscovite $2K_2O.MgO.5Al_2O_3.13SiO_2.4H_2O$	$2V=29°$ $2E=48°$.	X near c	Mon. Hex. plates.	{001}mic	Green	H=3-4	Mica group. Al : Fe =15 : 1; K : Na=6 : 1.
B=0.03		1.60	Paragonite $Na_2O.3Al_2O_3.6SiO_2.2H_2O$	$2V=40°\pm$ $2E=66°$.	$X\wedge\perp\{001\}=0°$–$2°$.	Mon. Hex. plates, {001}.	{001}mic	Colorless	H=3 G=2.8 F=dif.	Mica group. Insol. in HCl.
1.589	1.610	1.600	Nontronite $(Fe,Al)_2O_3.2SiO_2.2H_2O$	$2V=40°$ $2E=66°$.	$X\perp$ cleav		One mic	Yellowish green	H=soft G=2.27	Fe‴ : Al=4 : 1. Also FeO 1.11, CaO 1.78 per cent.
1.586	1.606	1.602	Spencerite $4ZnO.P_2O_5.4H_2O$	$2V=49°$ $2E=83°$. $r>v$ mod.	$Z=b$ X near a.	Mon. Tab. {100}.	{100}very perf. {010} perf. {111}less so. The three are nearly at 90°.	White	H=3 G=3.14 F=readily	Sol. in acid. Tw. and composition face {100}, lamellar. Ext. against lamellae 6°.
1.597	1.605	1.603	Foshagite $5CaO.3SiO_2.3H_2O$	$2V=60°\pm$ $2E=108°$. $r>v$.	$X=a$? $Z=c$.	Orth. Fib. c.	Cleav. // fib	do	G=2.67	Probably the same as hillebrandite.
*1.573	1.604	1.603	Ganophyllite $7MnO.Al_2O_3.8SiO_2.6H_2O$	$2V=26°$ $2E=42°$. $r<v$ easily perc.	$X\wedge c$=small $Y=b$.	Mon. Tab. {001}.	{001}mic. {100} perf.	Brown	H=4 G=2.84 F=3	Gelat. Pleoc. weak. X=yellow-brown, Y and Z=colorless. Pajsberg.
1.591	1.614	1.605	Bertrandite $4BeO.2SiO_2.H_2O$	$2V=75°$ $2E=156°$. $r<v$ weak.	$X=a$ $Z=c$.	Orth. Tab. {001}. Rhombic in outline.	{110}perf. {100} {001} {010}.	Pale yellow to colorless.	H=6.5 G=2.6 Infus.	Insol. in acids. Heart-shaped tw.
1.51	1.611	1.605	Amarantite $Fe_2O_3.2SO_3.7H_2O$	$2V=28°$ $2E=45°$. $r<v$ strong.	Ext. on {100}. Axial pl. is 38° to c. X nearly $\perp$ {100}.	Tric. Blades, fib.	{100}{010}perf.	Amaranth-red.	H=2.5 G=2.11 F=4.5-5	Sol. in HCl. Pleoc.: X=nearly colorless, Y=pale orange-yellow, Z=orange-yellow.
*1.592	1.617	1.606	Chondrodite $4MgO.2SiO_2.Mg(F,OH)_2$	Large $r<v$ perc.	$X\wedge a=26°$–$30°$. $Z=b$. Disp.	Mon. Tab. {010}.	{001}poor	Yellow, red, green.	H=6 G=3.1 Infus.	Humite group. Gelat. Poly. tw. {001}. Pleoc.: X=yellow, Z=colorless, Y=pale yellow. Franklin.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.562	1.606	1.606	Phlogopite $K_2O.6MgO.Al_2O_3.6SiO_2.2H_2O$	$2V=0°-35°$ $2E=57°$. $r<v$ weak.	$X \wedge c=0°\pm$ $Y=b$.	Mon.	{001}mic.	Brown, green, pale.	H=3 G=2.8 F=dif.	Mica group. Decpd. by H_2SO_4. Pleoc. faint: X=yellow, Y=brownish green, Z=brownish red. Abs: X<Y<Z.
	1.605	1.612	1.61	Hillebrandite $2CaO.SiO_2.H_2O$	$2V=70°(?)$ $2E=135°$.	$Z=c$ $Y=b(?)$.	Orth.(?) Fib.	Pris.	White.	H=5.5 G=2.69 F=dif.	Sol. in HCl.
^ v	1.572	1.615	1.611	Muscovite $K_2O.3(Al,Fe)_2O_3.6SiO_2.2H_2O$	$2V=30°$ $2E=49°$. $r>v$ perc.	$Z=b$ $X \wedge c=0°\pm$.	Mon. Hex. Tab. {001}.	{001}mic.	Colorless, pale green, or brown.	H=3–4 G=2.885 F=5	Mica group. Insol. in acid. Tw. pl. {001}. Al : Fe=10 : 1.
^	1.600	1.620	1.611	Montebrasite $Al_2O_3.P_2O_5.2Li(OH,F)$	Large.	Axial pl. to {001} is 23°; to {100} is 82°. X nearly // {100}{001}.	Tric.	{001}perf. {100} less so.	White.	H=6 G=3 F=2.	Variety of amblygonite. Sol. in H_2SO_4.
□	1.592	1.621	1.612	Herderite $CaO.2BeO.P_2O_5.Ca(F,OH)_2$	$2V=74°$ $2E=152°$. $r>v$.	$Y=b$ $Z \wedge c=2.5°$. Disp. dist.	Mon. Short prisms *a*.	{110}poor.	Yellowish to greenish.	H=5 G=3.01 F=dif.	Sol. in HCl. Tw. pl. {001}penet.
	1.593	1.613	1.613	Meliphanite $2CaO.2BeO.3SiO_2.NaF$	Small.	$X=c$	Ps. tetrag.	{001}dist.	Yellow, red, black.	H=5 G=3.0 Fus.	Insol. in HCl. Pleoc. in thick plates: X=green-yellow, Z=brownish yellow to honey-yellow.
□	1,594	1.616	1.614	Phosphophyllite $3(Zn,Fe,Mn)O.P_2O_5.4H_2O$	$2V=50°$ $2E=86°$. $r>v$ perc.	$Z=b$ $Y \wedge a=50°$.	Mon. Tab. {102}.	{100}perf. {102} {010}.	Colorless to pale blue-green.	H=3–4 G=3.08	Sol. in acid. Related to hopeite.

⊓ ⊔	1.590	1.615	1.614	Glauconite SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, K_2O, H_2O	2V=24° 2E=38°.	X∧c=3°	Mon. Platy // {001}.	{001} perf	Pale green		
∧ ∨	1.546	1.615	1.615	Stilpnomelane 2(Fe,Mg)O. $(Fe,Al)_2O_3$.5SiO_2. 3H_2O	Very small	X∧c=small	Mon. Plates	{001}mic	Black, green	H=3–4 G=2.88 F=4.5	Mica group. Decpd. by HCl. Strongly pleoc.: X=yellowish, Y and Z=dark brown or green. Data for mineral with FeO 20, Fe_2O_3 11.6 per cent.
∨	1.605	1.622	1.615	Soda tremolite 4CaO.4Na_2O. 18(Mg,Fe)O. $(Al,Fe)_2O_3$. 32SiO_2.3H_2O	Medium large	Z∧c=25°	Mon	{110}perf. at 129°.	White	H=6± G=3.066	Amphibole group. Mg/Fe=1.5; Al/Fe =0.17.
	1.597	1.624	1.616	Sanbornite BaO.2SiO_2	2V=66° 2E=124°.	Z nearly ⊥ {001}. Y nearly ⊥ {100}.	Tric. Platy	{001} mic {010} imperf.	do	H=5 G=4.19	Polysynthetic tw. on {010}. Decpd. by HCl with swelling of plates.
∧ ∨	1.600	1.627	1.616	Tremolite 2CaO.5MgO.8SiO_2 H_2O	2V=80°	Y=b Z∧c=15°.	Mon. Pris	{110} perf. at 124°.	Colorless	H=6 G=2.980	Amphibole group.
	1.602	1.629	1.616	Lehiite 5CaO.Na_2O.4P_2O_5. 4Al_2O_3.12H_2O	Large		Mon		White	H=5.5 G=2.89	Lewiston, Utah.
∧ ∨	1.597	1.619	1.618	Glauconite SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, K_2O, H_2O	2V=20° 2E=33°. $r>v$.	X near c	Mon. Platy // {001}.	{001} perf	Green		X=dark bluish green, Y and Z=lemon-yellow. SiO_2 48.66, Al_2O_3 8.46, Fe_2O_3 18.80, FeO 3.98, MgO 3.56, CaO 0.62, K_2O 8.31, H_2O 6.56 per cent. SiO_2: K_2O=1:9. Other bases variable.
∧ ∨	1.605	1.619	1.619	Delessite 4(Mg,Fe)O.2Al_2O_3. 4SiO_2.5H_2O	2V=0°±	X=⊥{001}	Mon. Spherulites.	{001}mic	Olive-green, etc.	H=2 G=2.8± F=dif.	Chlorite group. Easily sol. in acids. Pleoc.: X=pale green to colorless or pale yellow to colorless, Y and Z=green or pink.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	B=very weak	----------	1.62	Metatorbernite $CuO.2UO_3.P_2O_5.8H_2O$	Near 0°. Disp. very strong.	X=*c*	Ps. tetrag. Sq. tablets {001}.	{001} perf	Emerald-green to grass-green.	H=2–2.5 G=3.5	Sol. in HNO_3. Abnormal blue and red interference colors.
	1.573	1.620	1.620	Biotite $(K,Na,Cs)_2(Fe,Mg,Al)_6Al_2Si_6O_{20}(OH,F)_2$	Very small	X near *c*	Mon. Hex. plates {001}.	do	Black	H=3 G=3.10	Mica group. Contains SiO_2 36.97, TiO_2 2.64, Fe_2O_3 2.26, Al_2O_3 17.51, FeO 14.81, MgO 8.45, Li_2O 0.65, K_2O 8.04, Cs_2O 3.14, H_2O 2.48, F 3.17 per cent.
^ v	1.609	1.622	1.622	Glauconite $SiO_2,Al_2O_3,Fe_2O_3,FeO,MgO,K_2O,H_2O$	2V=0°–15°. 2E=0°–24°. *r*>*v*.	X near *c*	Mon. Plates // {001}.	{001}	Green		Pleoc: X=pale yellowish green, Y and Z=grass-green. K:Na=4:1, Fe:Mg=1:2, Fe:Al=1:1.
^ v	1.598	----------	1.623	Anthophyllite $7(Mg,Mn)O.8SiO_2.H_2O$	----------	Z=*c*. Y=*b*.	Orth. Thin lamellar.	{110} and {010} perf.	Light yellow	H=6 G=3.06	Amphibole group. Mg:Mn=21:1.
	1.610	1.623	1.623	Uranocircite $BaO.2UO_3.P_2O_5.8H_2O$	2V=10°. 2E=16°.	X=*c*. Z=*a*.	Orth. Thin tab. {001}.	{001} perf. {100} {010} dist.	Yellow-green	H=2 G=3.5 F=3(?)	Luster on {001} pearly. Sol. in HCl. Pleoc.: X=colorless, Y and Z=pale canary-yellow. Poly. tw.
	1.614	1.624	1.623	Dehrnite $6CaO.Na_2O.2P_2O_5H_2O$	Medium	X=*c*. Z∧edge=12°.	Ps. hex. Pris.	{001} perf	Colorless, yellow.	G=3.04	Base is divided into six segments. Lewiston, Utah.
	B=small	1.625	----------	Francolite $10CaO.3P_2O_5.CO_2.CaF_2.H_2O$	Small	X=*c*	Ps. hex	----------	Colorless	H=4 G=3.1	Basal section shows six segments, with opt. pl. // hex. sides.
⊐ v	1.595	1.627	1.625	Soda margarite (ephesite). $(Na,Li,Ca)_2,Al_4Si_2O_{10}(O,OH,F)_2$	2V=43°. 2E=73°. *r*<*v*.	Y=*b*. X∧*c*=small.	Mon. Plates // {001}.	{001} perf	Pale pink to brown.	H=5–7 G=3.00	Brittle mica, lamellar twinning on base. Li_2O 1.5, CaO 1.4 per cent.

◇◇	1.592	1.625	1.625	Protolithionite $K_2O.Li_2O.2Al_2O_3.3Fe,O.6SiO_2.2H_2O$	0°±	X near c Z=b.	Mon. Hex. tab.{001}.	{001}mic		H=3 G=3.305	Mica group. Decpd. by acid.
[ ]	B=0.037±	1.625		Nepouite $3(Ni,Mg)O.2SiO_2.2H_2O$	Small	X=c	Ps. hex. Plates {001}.	{001}perf. Also one // opt. pl.	Pale to deep brown.	H=2-2.5 G=2.47-3.24	Pleoc.: X=green, Y and Z=yellow green.
	*1.611	1.630	1.628	Carpholite $MnO.Al_2O_3.2SiO_2.2H_2O$	2V=50° 2E=87°. $r>v$ rather strong.	X=b Z=c.	Orth. Laths {010} elong. c.	Pris. at 68.5°	Straw-yellow	H=5.5 G=2.94 F=3.5	Nearly insol. in HCl. Silky. Pleoc.: X and Y=pale yellow, Z=colorless. Schlaggenwald.
	1.598	1.654	1.628	Lausenite $Fe_2O_3.3SO_3.6H_2O$	Large	X∧c=27°	Mon. Elong. c.		White, silky fib.		
◇◇	1.609	1.628	1.628	Glauconite $SiO_2,Al_2O_3,Fe_2O_3,FeO,MgO,K_2O,H_2O$	Medium	X near c	Mon. Plates //{001}.	{001}			K:Na=5:2,Fe:Mg=2:1, Fe:Al=1:1.
◇◇	1.615	1.637	1.629	Richterite $Ca_3Na_2(Mg,Mn)_{10}Si_{16}O_{44}(OH)_4$	2V=69° 2E=135°.	Y=b Z∧c=17°.	Mon	{110}perf at 124°.		H=6± G=3.044	Amphibole group. Mg:Mn=6.4:1.
◇◇	1.60	1.63	1.63±	Mariposite Chromiferous mica	2V=0°±	X=c	Mon. Hex. Plates {001}.	{001} mic	Light apple-green.	H=5 G=2.79 F=3	Mica group. Near alurgite. Insol. in acid. Pleoc.: Z<Y and X.
	1.585	1.630	1.630	Troegerite $3UO_3.As_2O_5.12H_2O$	2V=0°±	do	Mon.? Ps. tetrag. Tab. {001}.	{001}perf{100} good.	Lemon-yellow	Soft G=3.23 F=2.5	Sol. in HCl.
◇◇	1.580	1.630	1.63	Biotite $K_2O.4(Mg,Fe)O.2(Al,Fe)_2O_3.6SiO_2.H_2O$	Small	X∧c=small Y=b.	Mon. Hex. pris.	{001}eminent	Brown, black	H=3 G=3.02 F=dif.	Mica group. Decpd. by H_2SO_4. Strongly pleoc. in brown and green. X<Y and Z. Data for mineral with FeO and Fe_2O_3 15.2 and MgO 16.6 per cent.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.625	1.638	1.63	Celadonite $R_2O_3.3(RO,R_2O).8SiO_2.5H_2O$		Elong.+	Earthy. Fib.	Mic.	Green	H=1± G=2.7± F=3	Sol. in HCl. Alteration product in igneous rocks. Pleoc.: X=light yellow-green, Y and Z=dark green.
^ v	1.603	1.630	1.630	Glauconite $SiO_2,Al_2O_3,Fe_2O_3,FeO,MgO,K_2O,H_2O$	Small	X near c	Mon.	{001}		H=2 G=2.2-2.8	K: Na=5:1, Fe: Mg=1:2, Fe: Al=4:3.
^ v	1.614	1.641	1.630	Actinolite $2CaO.5(Mg,Fe)O.8SiO_2.H_2O$	2V=80°	Y=b Z∧c=16°.	Mon. Pris. c.	{110} perf. at 124°.	Green	H=6± G=3.044	Amphibole group. Mg/Fe=7.4.
^ v	1.619	1.640	1.630	Anthophyllite $7(Mg,Fe)O.8SiO_2.H_2O$	2V=89° r>v.	Y=b Z=c.	Orth. Pris. c.	{110} perf. at 124°. {010} good.	Gray, green, brown.	H=6 G=3.09 F=dif.	Amphibole group. Insol. in acid. Data for mineral with FeO+MnO=10.7 per cent.
□ v	*1.622	1.630	1.630	Podolite $10CaO.3P_2O_5.CO_2$	Small	Z=c	Ps. hex. Elong. c.		Colorless	H=5 G=3.08	Apatite group. Sector distribution on base. Hourglass structure. See Dahllite, p. 83. Podalia.
^ v	1.618	1.642	1.631	Hastingsite $8CaO.Na_2O.16(Mg,Fe)O.3(Al,Fe)_2O_3.30SiO_2.2H_2O$	2V=90°±	Y=b Z∧c=16°.	Mon. Pris. c.	{110} perf. at 124°.	Green	H=6± G=3.147	Amphibole group. Mn/Fe=5.1, Al/Fe=5.5.
^ v	1.622	1.641	1.632	Pargasite $4CaO.Na_2O.8(Mg,Fe)O.3(Al,Fe)_2O_3.12SiO_2.½H_2O.3F$	Large	Z∧c=18°	do.	do.	Black	H=6± G=3.163	Amphibole group. Mg/Fe=10, Al/Fe=12.

V	1.602	1.632	1.632	Bementite $8MnO.7SiO_2.5H_2O$	2V=0°±	X=c Z or Y= elong.	Orth. Fib., plates{001}.	{001}perf.	Brown	H=5.5 G=2.83–3.11 F=easy	Decpd. by acid. Faintly pleoc. Abs.: X and Y<Z.
⊐	1.620	1.634	1.632	Wollastonite $CaO.SiO_2$	2V=39° 2E=65°. r>v perc.	Y near b X∧c=32°.	Tric.	{100}perf. {$\bar{1}$02} and {001}less so; {101} and {$\bar{1}$01} poor.	Colorless	H=5 G=2.9 F=4	Crestmore, Calif. Decpd. by HCl. Tw. pl. {100}. Y almost // to elong.
	1.630	1.636	1.633	Danburite $CaO.2SiO_2.B_2O_3$	2V=88° r<v strong.	X=b Z=a.	Orth. Elong. c.	{001}poor	Colorless,wine-yellow.	H=7 G=3.0 F=dif.	Insol. in HCl.
⊏	1.612	1.643	1.634	Lazulite $(Mg,Fe)O.Al_2O_3.P_2O_5.H_2O$	Large r<v perc.	Y=b X∧c=−9°–10°.	Mon.		Blue	H=5–6 G=3.08 Infus.	Insol. in HCl. Pleoc.: X=colorless, Y=light blue, Z=blue. Mg: Fe=8:1.
	1.617	1.652	1.635	Tilleyite $3CaO.SiO_2.CO_2$	2V=90°± r>v perc.	X∧a=18°	do		White	G=2.823	Effervesces and gelat. Also opt.+.
^ V	1.629	1.640	1.635	Anthophyllite $7(Mg,Fe)O.8SiO_2.H_2O$	2V=87° r>v.	Y=b Z=c.	Orth. Pris. c.	{110} and {010} perf. {100}poor.	Clove-brown	H=6 G=3.093	Amphibole group. Mg: Fe=5:1. Opt. + for red light.
^ V	1.622	1.636	1.636	Manganophyllite $K_2O.6(Mg,Mn)O.Fe_2O_3.6SiO_2.2H_2O$	2V=14° 2E=22°. r>v.	X near c	Mon. Hex. plates.	{001} mic.	Dark brownish red.	G=2.953	Mica group. MnO 4.52 per cent. X=dark red, Y and Z=lighter red.
⊐	1.602	1.639	1.636	Grandidierite $2Na_2O.4FeO.8(Fe,Al,B)_2O_3.5SiO_2$	2V=30° 2E=50°. r<v strong.	X=a Z=b.	Orth	{100}{010} unequal.	Blue-green	G=2.99 Infus.	Insol. in HCl. Pleoc.: X=greenish blue, Y=colorless, Z=pale bluish green.
⊐	1.609	1.644	1.636	Inesite $2(Mn,Ca)O.2SiO_2.H_2O$	2V=60° 2E=110°. r>v perc.	X nearly ⊥ {010}. Ext. on {010}. Z∧cleav.=50°.	Tric. Pris.	{010}perf.{100} less so.	Rose-red to flesh-red.	H=6 G=3.03 F=3	Decpd. by HCl.
^ V	1.623	1.644	1.636	Gedrite $(Mg,Fe,Al)_7(Al,Si)_8O_{22}(OH)_2$	2V=78°± r>v.	X=a Z=c.	Orth. Pris. c.	{110} perf. at 124°.	Grayish, yellow, pinkish brown.	H=6 G=3.1 F=3–4	Amphibole group. Insol. in acid.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.615	1.638	1.637	Chlorite $4RO.R_2O_3.3SiO_2.4H_2O$	$2V=15°$ $2E=25°$.	$X \perp \{001\}$	Mon.	{001} mic.	Green	H=2.5 G=? F=dif.	Unnamed chlorite from Challis, Wash. Sol. in acid. X=olive-green, Y and Z=brownish-yellow. SiO_2 30.8, Al_2O_3 12.10, Fe_2O_3 9.1, FeO 22.80, MgO 12.4, H_2O 11.6 per cent.
^ v	1.621	1.638	1.638	Glaucophane $Na_2O.2(Fe,Ca,Mg)O.Al_2O_3.6SiO_2$?	$2V=45°\pm$ $2E=77°$. $r<v$ strong.	$Y=b$ $Z \wedge c=5°\pm$.	Mon. Pris. c.	{110} perf. at 121°.	Blue to bluish black.	H=6 G=3.1 F=3–3.5	Amphibole group. Insol. in acid. Pleoc.: X=yellowish, Y=violet-blue, Z=dark blue.
□ □	1.634	1.643	1.639	Andalusite $Al_2O_3.SiO_2$	$2V=85°$ $r>v$ faint.	$X=c$ $Z=a$.	Orth. Needles. Fib. c.	{110} perf.	Colorless, red, etc.	H=7.5 G=3.15 Infus.	Insol. in acid. Pleoc. common: X=rose-red, Y and Z=nearly colorless. Fe_2O_3 1.56 per cent.
□ □	*1.624	1.643	1.639	Roscherite $2FeO.3MnO.3CaO.2Al_2O_3.4P_2O_5.10H_2O$	Large $r>v$ very strong. Crossed disp.	$X=b$ $Y \wedge c=-15°$.	Mon. Tab. {001}.	{001} perf. {010} fair.	Brown	H=4.5 G=2.92 Infus.	Pleoc.: X=yellow to olive-green, Y=yellow-brown, slightly greenish, Z=chestnut-brown. Complex tw. Abnormal interference colors. Grupenstein.
	B=mod.?		1.64	Jeremejevite $Al_2O_3.B_2O_3$	Small, variable.	$X=c$	Ps. hex. Pris.	None	Colorless	H=6.5 G=3.28 Infus.	Insol. in acid. Basal section divided into six segments.
^ v	B=0.01		1.64±	Thuringite $8FeO.4(Al,Fe)_2O_3.6SiO_2.9H_2O$	Small	do	Mon. Hex. plates {001}.	{001} mic.	Olive to pistachio green.	H=2.5 G=3.13–3.19 F=4	Chlorite group. Gelat.

⊏	1.584	1.647	1.642	Serpierite $(Cu,Zn,Ca)O.SO_3.H_2O$	$2V=34^a$ $2E=57°$. $r>v$ strong.	$X=c$ $Z=b$.	Orth. Tab	{001} very perf.	Bluish		Pleoc.: X=pale greenish, Y and Z=deep greenish-blue.
	1.611	1.657	1.642	Sklodowskite $MgO.2UO_3.2SiO_2.7H_2O$	Medium large $r>v$ very strong.	$Y=c$	Orth. Pris. c		Yellow	G=3.54	Easily sol. in acid. Pleoc.: X=colorless, Y and Z=canary-yellow.
> <	1.632	1.645	1.643	Margarite $CaO.2Al_2O_3.2SiO_2.H_2O$	$2V=0°$–$67°$ $2E=0°$–$130°$. $r<v$.	$Z=b$ $X\wedge c=6°\pm$.	Mon. Hex. tablets {001}.	{001} highly perf.	Gray, etc.	H=4 G=3.0 F=dif.	Brittle mica. Partly decpd. by H_2SO_4. Luster on base pearly.
	1.553	1.653	1.643	Castanite $Fe_2O_3.2SO_3.8H_2O$	Medium Large disp.	X near b on {010}. $Y\wedge c$ (trace) $=22°$.	Tric. Pris. and massive.	{010} perf. {110} and {1$\bar{1}$0} less perf.	Burnt orange to brown.	G=2.2 F=5	Decpd. by hot H_2O. Sol. in HCl. B.b. changes color from orange to brown to black. Pleoc.: Y=yellow, Z=brown-red.
> ⊏	1.612	1.644	1.643	Glauconite $SiO_2,Al_2O_3,Fe_2O_3,FeO,MgO,K_2O,H_2O$	$2V=19°$ $2E=33°$.	X near c	Mon. plates {001}.	{001} perf.	Dark gray-green.		
> <	1.625	1.654	1.645	Holmquistite $2CaO.3(Li,Na)_2O.12(Mg,Fe)O.5Al_2O_3.30SiO_2.4H_2O$	$2V=51°$ $2E=92°$. $r>v$ weak.	$Y=b$ $Z\wedge c=0°\pm$.	Mon. Pris. c	{110} perf. at 124°.	Blue	H=6± G=3.111	Amphibole group. Mg/Fe=2, Li/Na=4. Pleoc.: X=light yellow, Y=violet, Z=purple.
<	1.639	1.653	1.646	Monticellite $MgO.CaO.SiO_2$	$2V=90°$ $r>v$.	$X=b$ $Z=a$.	Orth	{010} poor	White	H=5–5.5 F=6	Artificial product. Olivine group. Gelat. Iron-free.
> <	1.634	1.652	1.647	Hornblende $Ca_3Na_2(Mg,Fe)_9(Al,Fe)_2Si_{15}O_{44}(OH)_4$	$2V=62°$ $2E=116°$.	$Z\wedge c=21°$	Mon. Pris. c	{110} at 124°		H=6±	Amphibole group. Mg/Fe=3.6, Al/Fe=0.4, Na/K=7. Pleoc.: X=light bluish green, Y=deep green, Z=deep bluish green.
> ⊏	1.624	1.647	1.647	Bementite $8MnO\ 7SiO_2.5H_2O$	Near 0°	$X=c$	Orth. Plates {001}, fib.	{001} mic. {010} {100} perf.	Gray to brown, weathers darker.	H=6 G=3.11 F=easy	Decpd. by acid.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.584	1.648	1.648	Biotite $K_2O.4(Fe,Mg)O.2(Al,Fe)_2O_3.6SiO_2.H_2O$	Small	X∧c=small Y=*b*.	Mon. Hex. pris.	{001} eminent.	Brown, black, green.	H=3 G=3.12 F=dif.	Mica group. Decpd. by H_2SO_4. Strongly pleoc.: X<Y and Z. Data for mineral with FeO and Fe_2O_3 21.6, TiO_2 4.3 per cent.
	1.643	1.649	1.649	Daphnite $3FeO.Al_2O_3.2SiO_2.3H_2O$	do	X=*c*	Mon. Fib. and plates.	{001} mic.	Dark green	H=3	Chlorite group. Decpd. by hot HCl. Pleoc.: X=pale yellowish, Y and Z=olive-green.
	1.585	1.660	1.649	Herrengrundite $3CuO.2SO_3.6H_2O$	2V=38° 2E=65°. *r*>*v* mkd.	X near *c* Z=*b*.	Mon. Thin tablets.	{001} perf. {110} dist.	Emeraid-green to bluish green.	H=2.5 G=3.13 F=3.5	Sol. in HCl. Pleoc.: X=very pale green, Y=Venice - green, Z=turquoise - green Abs.: X>Y>Z. Tw. pl. {001}.
^ v	1.623	1.651	1.650	Friedelite $9MnO.8SiO_2.MnCl_2.7H_2O$	Small		Trig.	{0001} perf.	Rose-red	H=4-5 G=3.07 F=4	Decpd. by HCl. Anom. biax. Pleoc.: X=colorless, Y and Z=greenish yellow.
^	1.625	1.655	1.65	Nontronite $Fe_2O_3.3SiO_2.5±H_2O$	2V=33° 2E=56°.	X nearly ⊥ {001}.	Mon. Fib., etc.	{001} dist.	Greenish yellow, earthy.	H=2.5-4.5 G=1.7-2.4 Infus.	Decpd. by HCl. Pleoc.: X=nearly colorless, Y and Z=yellow to greenish yellow.
□	B=.02		1.65	Strigovite $4FeO.2Al_2O_3.4SiO_2.4H_2O$	Small	X near *c*	Mon. Ps. hex.	{001} mic.	Green	G=3.14	X=pale green, Y and Z=nearly opaque. Fe:Mg=30:1; Fe:Al=2:5.
□	1.610	1.682	1.650	Epistolite $5Na_2O.2Cb_2O_5.9(Si,Ti)O_2.10H_2O$	2V=80°± *r*<*v*.	Y=*b* Z∧c=7°±. Disp. perc.	Mon. Rect. plates {001}.	{001} very perf. {110} dist. Very brittle.	White, yellow, gray.	H=1-1.5 G=2.89	

^ v	1.608	1.655	1.650	Iddingsite $MgO.Fe_2O_3.3SiO_2.4H_2O$	$2V=40°\pm$ $2E=69°$. $r<v$ strong.	$X=a$	Orth. After olivine.	{100}{001}{010} perf. {101} less so.	Dark brown	H=3.2 G=2.54 Infus.	Decpd. HCl. Pleoc slight in golden yellow.
v	*1.577	1.653	1.651	Camsellite $2MgO.B_2O_3.H_2O$	Very small Disp. slight.	X=elong	Orth. Fib		White	H=3 G=2.60 F=easy	Sol. in acid. British Columbia.
^ v	1.648	1.651	1.651	Aphrosiderite $15MgO.5Al_2O_3.9SiO_2.13H_2O$	Small	X near c	Mon. Ps. hex.	{001} mic.	Green	G=3.100	Chlorite group. Pleoc.: X and Y=pale yellow-green; Z=light olive-green.
[ ]	*1.643	1.654	1.652	Bityite $7(H_2,Li_2,Ca,Be)O.4Al_2O_3.5SiO_2$	Medium	$X=c$ $Z\wedge\{10\bar{1}0\}=30°$.	Ps. hex	{0001} easy	Yellowish	H=5.5 G=3.05 Fus.	Insol. in HCl. Basal section divided into six sectors, and these show poly. tw. with tw. pl. $\{10\bar{1}0\}$. Mount Bity, Madagascar.
	1.612	1.675	1.652	Liroconite $18CuO.4Al_2O_3.5As_2O_5.55H_2O$	$2V=67°$ $2E=132°$. $r<v$ mod.	$X=b$ $Z\wedge c=-25°$.	Mon. Oct	{110} {011} indist.	Sky-blue to verdigris-green.	H=2-2.5 G=2.88-2.98 F=3-3.5	In section turquoise-green and nonpleoc.
	1.626	1.670	1.654	Datolite $2CaO.2SiO_2.B_2O_3.H_2O$	$2V=74°$ $2E=166°$. $r>v$ weak.	$Y=b$ $Z\wedge c=-1°$ to $4°$. Disp. perc.	Mon. Elong. c.	None	Colorless	H=5 G=3.0 F=2-2.5	Gelat.
[ ]	1.62	1.689	1.654	Cabrerite $3(Ni,Mg)O.As_2O_5.8H_2O$	$2V=90°\pm$ $r>v$ strong.	$X=b$ $Z\wedge c=33°\pm$. Disp. mkd.	Mon. Fib. c	{010} perf.	Apple-green	H=2 G=2.96-3.11 F=4-5	Near annabergite. Sol. in HCl.
	1.647	1.660	1.654	Hureaulite $5MnO.2P_2O_5.5H_2O$	$2V=74°$ $2E=166°$. $r<v$ very strong.	$X=b$ $Z\wedge c=75°$. Disp. strong.	Mon. Tab. {100}.	{100} rather perf.	Orange, red, violet, etc.	H=5 G=3.18 F=3	Sol. in acid. Pleoc. faint: X=colorless, Y=clear yellow to pale rose, Z=reddish yellow to reddish brown.
v	1.633	1.662	1.655	Eosphorite $2MnO.Al_2O_3.P_2O_5.4H_2O$	$2V=51°\pm$ $2E=90°$. $r<v$ strong.	$X=b$ $Z=c$.	Orth	{100} nearly perf.	Rose, pink, yellow, etc.	H=5 G=3.11-3.14 F=4	Sol. in HCl. Pleoc. feeble: X=yellowish, Y=deep pink, Z=nearly colorless.
[ ]	*1.646	1.657	1.655	Wentzelite $3(Mn,Fe,Mg)O.P_2O_5.5H_2O$	Medium large $r<v$ easily perc.	$X=b$	Mon		Flesh-pink		Hagendorf. Cf. hureaulite, above.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.652	1.660	1.656	Palaite $5MnO.2P_2O_5.4H_2O$	Large. Disp. weak.		Mon.	None(?)	Flesh-colored.	G=3.2 F=easy	Readily sol. in acid. Alteration of lithiophilite.
□	*1.652	1.662	1.657	Baldaufite $3(Fe,Mn,Mg,Ca)O.P_2O_5.3H_2O$	Large.	X=*b*	do.		Flesh-red.		Hagendorf.
^ v	1.644	1.663	1.657	Pargasite $6CaO.3Na_2O.16(Mg,Fe)O.5Al_2O_3.26SiO_2.2H_2O.2F_2$	Medium large.	Y=*b*. Z∧*c*=18°.	Mon. Pris. *c*.	{110} perf. at 124°.	Black.	H=6 G=3.256	Amphibole group. Mg/Fe=3.
^ v	1.646	1.658	1.657	Seybertite $10(Mg,Ca)O.5Al_2O_3.4SiO_2.3H_2O$	2V=5°. 2E=8°. *r*<*v* weak.	Z=*b*. X∧⊥{001} small.	Mon. Hex. tablets {001}.	{001} perf.	Reddish brown, copper-red.	H=5 G=3.0 Infus.	Brittle mica. Insol. in acid. Pleoc. feeble: X=colorless, Y and Z=pale brownish-yellow.
^ v	*1.652	1.665	1.658	Hiortdahlite $(Na_2,Ca)O.FeO.2(Si,Zr)O_2$	Near 90°. *r*<*v* perc.	X nearly//tw. lamellae. Ext. on {100} 65°.	Tric. Tab. {100}.	Pris. at nearly 90° dist.	Bright yellow, yellow-brown.	H=5.5 G=3.27 F=3(?)	Gelat. Pleoc.: X=colorless, Y=yellowish-white, Z=wine-yellow. Poly. tw. Composition pl. {100}. Langesund.
□	1.622	1.687	1.658	Annabergite $3NiO.As_2O_5.8H_2O$	2V=84°. *r*>*v* rather strong.	X=*b*. Z∧edge 36° ±. Disp. mkd.	Mon. Plates {010}, elong. *c*.	{010} perf.	Apple-green.	H=2.5-3 G=3.0-3.1 F=4	Sol. in HCl.
□	1.648	1.660	1.660	Brandisite $12(Mg,Ca)O.6(Al,Fe)_2O_3.5SiO_2.4H_2O$	2V=18°-35°. 2E=30°-60°. *r*<*v*.	Y=*b*. X∧⊥{001}. small.	Mon. Hex. tablets.	{001} perf.	Leek-green, dark green.	H=5 G=3.0 Infus.	A brittle mica. Near seybertite. Insol. in acid. Pleoc.: X=pale orange-yellow, Y and Z=pale green.

	1.640	1.675	1.660	Tilasite $2CaO.MgO.As_2O_5.MgF_2$	2V=83°	Z=*b* Ext. 30°.	Mon.	{$\bar{1}$01}perf.	Pale green	H=5 G=3.77 F=4–5(?)	Sol. in acids. Tw. pl. {100}common.
◇ □	1.649	1.661	1.660	Xanthophyllite $14(Mg,Ca)O.8Al_2O_3.5SiO_2.4H_2O$	2V=20°–40° 2E=33°–70°. *r*<*v* weak.	Y=*b* Z∧*a*=0.5°.	Mon. Tab. {001}.	{001}perf.	Leek-green	H=4.5–6 G=3.09 Infus.	A brittle mica. Insol. in acid. Pleoc.: X=reddish-brown, Y and Z=green. Tw. after mica law, poly.
	1.63	1.69	1.66	Stewartite $3MnO.P_2O_5.4H_2O(?)$	Very large Disp. strong.	X nearly ⊥ {100}. On cleav. X∧*c*=56°. Cleav. shows an opt. axis in field.	Tric. Tab. {100}. Fib.	{010}good	Yellow	G=2.94	Pleoc.: X=colorless, Y=very pale yellow, Z=yellow.
◇ ◇	1.638	1.667	1.660	Eosphorite $2(Mn,Fe)O.Al_2O_3.P_2O_5.4H_2O$	2V=50°± 2E=89°. *r*<*v* perc.	X=*b* Z=*c*.	Orth. Pris.	{100} nearly perf.	Brown	H=5 G=3.067	FeO 3.74 per cent. Pleoc.: X=colorless, Y=light yellow, Z=brown.
◇ ◇	1.650	1.660	1.660	Chlorite $6(Fe,Mg)O.2Al_2O_3.3SiO_2.5H_2O$	2V=0°±		Mon. Tab. {001}.	{001}mic.	Green		Pleoc.: X=pale brown, Y and Z=green. Contains SiO_2 21.9, Al_2O_3 23.5, FeO 37.4, MgO 6.3, H_2O 10.9 per cent.
□	1.626	1.699	1.661	Erythrite $3CoO.As_2O_5.8H_2O$	2V=90°± *r*>*v* weak.	X=*b* Z∧*c*=−31°.	Mon. Pris. *c*. Vertically striated.	{010} highly perf.	Crimson to gray.	H=2 G=2.95 F=2	Sol. in HCl. Pleoc. strong: X=pale pink, Y=very pale violet, Z=red. Abs.: X and Y<Z.
◇ ◇	1.653	1.669	1.661	Hastingsite $4CaO.Na_2O.8(Mg,Fe)O.3(Al,Fe)_2O_3.12SiO_2.2H_2O$	2V=90°± *r*>*v*.	Z∧*c*=26°	Mon. Pris. *c*.	{110} at 124°		H=6± G=3.14	Amphibole group. Mg/Fe=13, Al/Fe=2.8. Pleoc.: X=light brown, Y=light green, Z=bluish green.
◇	1.595	1.660		Magnesiosussexite $2(Mg,Mn)O.B_2O_3.H_2O$		X=*c* // ext.	Orth.? Fib.		Straw-yellow to buff.	H=3 G=2.83 F=3	Sol. in HCl. Related to sussexite.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.651	1.668	1.662	Monticellite CaO. (Mg,Fe,Mn)O. SiO_2	2V=76° $r>v$.	X=*b*. Z=*a*.	Orth. Equant.	{010} poor	Colorless and different colors.	H=5-5.5 G=3.2 F=6	Olivine group. Gelat. Data for mineral with FeO 4.75, MnO 1.62 per cent. Mg:Fe:Mn=54:7:2.
	1.640	1.665	1.663	Seamanite $3MnO.(B,P)_2O_5.3H_2O$	2V=40°±. 2E=68°. $r<v$.	X=*a*. Y=*b*.	Orth. Acic.		Pale yellow	H=4 G=3.128 F=easy	Related to reddingite. Sol. in cold dilute acid.
^ v	1.655	1.668	1.664	Ternovskite $Na_2(Mg,Fe)_3(Al,Fe)_2Si_8O_{22}(OH)_2$	2V=42°. 2E=72°. $r<v$.	Z∧(001)=27°-35°. Y=*b*.	Mon.	{110} perf. at 124°.			Amphibole group. Pleoc. strong: X=pale blue-green, Y=pale violet, Z=pale yellow. SiO_2 52.72, TiO_2 0.31, Al_2O_3 3.65, Fe_2O_3 15.46. FeO 8.16, MgO 9.16, CaO 2.10, Na_2O 5.91, K_2O 0.68, Ignition 1.85 per cent.
^ v	1.650	1.679	1.665	Cummingtonite 7(Fe, Mg)O.8SiO_2.H_2O	2V=87°. $r<v$.	Y=*b*. Z∧*c*=16°.	Mon. Pris. *c*.	do	Gray, brown.	H=6 G=3.31 Fus.	Amphibole group. Insol. in HCl. Pleoc.: X and Y=yellow, Z=brown-yellow. Data for mineral with Fe:Mn:Mg=41:15:44.
^ v	1.653	1.665	1.665	Thuringite 7 (Fe,Mg)O. $3Al_2O_3.5SiO_2.6H_2O$	Small	X near *c*.	Mon. Platy.	{001}mic.		G=2.96	Chlorite? Mg:Fe=1:3, Al:Fe=3:1.
^ v	1.654	1.670	1.666	Hornblende $Ca_3Na_2(Mg,Fe)_8(Al,Fe)_4Si_{14}O_{44}(OH)_4$	2V=63°. 2E=121°.	Z∧*c*=32°	Mon. Pris. *c*.	{110} perf. at 124°.	Black	H=6±	Amphibole group. Mg/Fe=2, Al/Fe=1.7, Na/K=3.3. Pleoc.: X=light green, Y=deep green, Z=deep blue-green.

	*1.662	1.669	1.667	Clinohedrite $CaO.ZnO.SiO_2.H_2O$	Medium large. $r>v$ easily perc.	$Z=b$ $Y\wedge c=-28°$.	Mon.	{010}perf.	Colorless	H=5.5 G=3.33 F=4	Gelat. Type specimen. Franklin.
⊐	1.520	1.667	1.667	Strontianite $SrO.CO_2$	2V=7° 2E=12°. $r<v$ weak.	$X=c$ $Z=a$.	Orth. Elong. c.	{110} nearly perf. {010}tr.	do	H=4 G=3.7 F=dif.	Sol. in HCl.
	1.642	1.669	1.667	Uranophane $CaO.2UO_3.2SiO_2.6H_2O$	2V=32° 2E=55°. $r<v$ mkd.	X nearly ⊥ flat face. $Z\wedge c=2°$. X near a.	Tric.(?) Fib. c.	{100}	Yellow	H=2–3 G=3.8–3.96 Infus.	Gelat. Pleoc.: X=nearly colorless, Y=pale canary-yellow, Z=canary-yellow. Abnormal blue interference color.
◇	1.658	1.667	1.667	Prochlorite $16MgO.5Al_2O_3.9SiO_2.14H_2O$	Small	X near c	Mon. Platy	{001}mic.	Green	G=3.20	Chlorite group. At_2 Ant_5. Fe : Mg=10 : 1. Pleoc.: X=pale green, Y and Z=olive-green.
	1.635	1.702	1.668	Symplesite $3FeO.As_2O_5.8H_2O$	2V=87° $r>v$ rather strong.	$X=b$ $Z\wedge c=32°$.	Mon. Pris. c.	{010}perf.	Pale indigo, green.	H=2.5 G=2.96 Infus.	Depcd. by HCl. Pleoc.: X=deep blue, Y=colorless, Z=yellowish to oil-green.
	1.658	1.670	1.669	Zinkosite $ZnO.SO_3$	Small $r<v$ strong.	$Z=c$ X=a(bisects acute angle of rhombs).	Orth. Rect. or rhomb plates.		White	G=3.7	Alters on exposure to air.
⊐	B=weak		1.670	Crossite $Na_2O.4(Mg,Fe)O.(Fe,Al)_2O_3.8SiO_2$	Variable $r<v$ very strong.	$Z=b$ $Y\wedge c$=small to mod. Disp. strong.	Mon. Pris. c.	{110} perf. at 124°.	Bluish black	H=6 G=3.16 Fus.	Amphibole group. Insol. Strongly pleoc.: X=bright yellow to nearly colorless, Y=deep blue, Z=deep violet.
◇	1.618	1.670	1.670	Siderophyllite $K_2O.5FeO.2Al_2O_3.5SiO_2.2H_2O$	Small	$X\wedge c$=small $Y=b$.	Mon. Ps. hex.	{001}eminent.	Brown, black.	H=3	Mica group. Pleoc.: X<Y and Z. Data for mineral with theoretical composition.
◇	1.65	1.67	1.67	Strigovite $2(Fe,Mn)O.(Fe,Al)_2O_3.2SiO_2.2H_2O$	2V=0°±	$X=c$	Mon. Hex. plates{001}, fib.	{001}mic.	Dark green	H=1 G=3.14	Chlorite group. Pleoc. intense: X=pale greenish, Y and Z=nearly opaque.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
□	1.526	1.672	1.671	Bromlite $(Ca,Ba,Sr)O.CO_2$	2V=7° 2E=12°. $r>v$ weak.	X=c Z=b.	Ortho. Elong. c.	{110}poor	Colorless	H=4–4.5 G=3.71	Effervesces in HCl. Mineral with CaO 17.6, BaO 48.54, SrO 4.25, CO_2 29.41 per cent.
◇	1.664	1.680	1.672	Hastingsite $4CaO.Na_2O.$ $8(Mg,Fe)O.$ $3(Al,Fe)_2O_3.$ $11SiO_2.TiO_2.$ $2H_2O$	2V=90° $r>v$.	Z∧c=29° Y=b.	Mon. Pris. c.	{110}perf. at 124°.		G=3.189	Amphibole group. Mg/Fe = 4.5; Al/Fe =4.1.
	1.634	1.685	1.673	Durangite $Na_2O.2AlFO.$ As_2O_5	2V=45° 2E=79°. $r<v$ weak.	Y=b X∧c=25°. Disp. dist.	Mon	{110}dist	Orange-red	H=5 G=3.94–4.07 F=2	Decpd. by H_2SO_4. Pleoc.: X=orange-yellow, Y=very pale orange, Z=colorless.
◇	1.659	1.681	1.673	Green hornblende $4CaO.Na_2O.$ $9(Mg,Fe)O.$ $2(Al,Fe)_2O_3.$ $13SiO_2.2H_2O$	2V=66° 2E=130°.	Y=b Z∧c=17°.	Mon. Pris. c.	{110} perf. at 124°.	Green	H=6± G=3.234	Amphibole group. Mg/Fe=1.4; Al/Fe =4.8.
	1.640	1.679	1.674	Spurrite $5CaO.CO_2.2SiO_2$	2V=39½° 2E=69°. $r>v$ weak.	X=b Z∧a=nearly 0°. Disp. dist.	Mon.(?)	{001}good{100} at 79°.	Colorless	H=5 G=3.01 Infus.	Sol. in HCl with effervescence and gelat. Tw. {001} and orthodome at 57°, poly.
□	1.604	1.731	1.674	Butlerite $(Fe,Al)_2O_3.2SO_3.$ $5H_2O$	Large		Orth. Minute crystals.	{010}perf	Deep orange	H=2.5 G=2.548	X=pale brownish yellow, Z=canary yellow.
◇	1.657	1.685	1.674	Cummingtonite $7(Mg,Fe,Mn,Zn)O.$ $8SiO_2.H_2O$	2V=75°	Y=b Z∧c=15°.	Mon. Pris. c.	{110}perf. at 124°	Green	H=6± G=3.44	Amphibole group. Mg:Fe:Mn:Zn = 20:18:19:13.

V	1.664	1.679	1.675	Bustamite $(Mn,Ca)_2O.CaO.2SiO_2$	2V=50°-55°. 2E=90°-102°.	Ext. on {110} $\wedge c=10°-15°$; on $\{1\bar{1}0\} \wedge c=0°$; on {010} $\wedge c=3°$.	Tric.	{010}, {110}, $\{1\bar{1}0\}$, {100} perf.	Pale pink	H=6 G=3.802	Related to rhodonite. Ca:Mn=53:47.
	1.529	1.677	1.676	Witherite $BaO.CO_2$	2V=16°. 2E=27°. $r>v$ weak.	X=c. Z=a.	Orth. Elong. c.	{010} dist. {110} imperf.	Colorless	H=3 G=4.3 F=2.5-3	Sol. in dilute HCl.
□	1.665	1.677	1.676	Kornerupine $18MgO.6(Al,Fe,B)_2O_3.7SiO_2$	2V=20°±. 2E=33°. $r>v$ weak.	X=c. Z=b.	Orth. Pris. c.	{110} rather perf.	Black	H=6.5 G=3.27 F=dif.	Near prismatine. Insol. in acid. Pleoc.: X=wine - yellow, Y=brownish yellow, Z=greenish. Kornerupine is colorless.
^ v	1.623	1.677	1.676	Biotite $K_2O.4FeO.2(Al.Fe)_2O_3.6SiO_2.H_2O$	Small	X∧c=small. Y=b.	Mon. Hex. prisms.	{001} eminent.	Black, brown, green.	H=3 G=3.1 F=dif.	Mica group. Decpd. by H_2SO_4. Strongly pleoc.: X<Y and Z. Data for mineral with $FeO+Fe_2O_3$ 3.84, MgO 0.05 per cent.
^ v	1.663	1.685	1.677	Soretite $4CaO.Na_2O.8(Mg,Fe)O.3(Al,Fe)_2O_3.12SiO_2.2H_2O$	2V=83°	Y=b. Z∧c=19°.	Mon. Pris. c.	{110} perf. at 124°.		H=6± G=3.225	Amphibole group. Mg/Fe=1.7, Al/Fe=2.1.
^	1.643	1.684	1.678	Childrenite $2FeO.Al_2O_3.P_2O_5.4H_2O$	2V±45° 2E=80°. $r>v$ strong.	X=b. Z=c.	Orth. Pyram.	{100} perf.	White to brownish.	H=5 G=3.20 F=4	Sol. in HCl.
^	B=0.05		1.68	Annabergite $4NiO.As_2O_5.8H_2O$	2V=90°±	X=b. Z∧length=0°±.	Mon. Capillary crystals.	{010}	Apple-green	H=2.5 G=3.10 F=4	Do.
^ v	1.62	1.68	1.68	Annite $K_2O.Al_2O_3.6FeO.6SiO_2.2H_2O$	Small	X∧c=small. Y=b.	Mon. Hex. prisms.	{001} eminent.	Brown, black	H=3	Mica group. Pleoc.: X<Y and Z. Mineral with theoretical composition.
	*1.650	1.710	1.68	Soddyite $5UO_3.2SiO_2.6H_2O$	Near 90° $r>v$ strong.	Y=b. Z=c.	Orth. Pris. c. Flattened {010}.		Dirty greenish yellow.	H=3-4 G=4.63 Infus.	Gelat. Katanga.
	1.530	1.685	1.680	Aragonite $CaO.CO_2$	2V=18° 2E=30°. $r>v$ weak.	X=c. Z=b.	Orth. Acic. c.	{010} dist.	Colorless	H=4 G=2.94 Infus.	Sol. in dilute acid. Stains red when boiled with solution of $CoNO_3$. (Calcite does not.) $CaCO_3$=99.91 per cent.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.670	1.682	1.680	Arfvedsonite $5Na_2O.2CaO.14MgO.3Al_2O_3.30SiO_2.2TiO_2.2H_2O$	Small	$Y=b$ $Z\wedge c=20$–$25°$.	Mon. Pris. *c*.	{110} perf. at 124°.	Black	H=6 G=3.3±	Amphibole group. Pleoc.: X=dark green, Y=pale brown, Z=black. Fe/Mg=1.7, Al/Fe=1.
^ v	1.670	1.693	1.683	Basaltic hornblende $3CaO.Na_2O.7(Mg,Fe)O.3(Al,Fe)_2O_3.TiO_2.12SiO_2.2H_2O$	2V=83° $r>v$ small.	$Y=b$ $Z\wedge c=9°$.	Mon. Pris. *c*.	{110} perf. at 124°.	do	H=6± G=3.178	Amphibole group. Mg/Fe=3.7; Al/Fe=4.4. Pleoc.: X=pale yellow, Y=dark brown, Z=dark olive-green.
	1.525	1.686	1.684	Barytocalcite $BaO.CaO.2CO_2$	2V=15° 2E=25°. $r>v$ small.	$Z=b$ $X\wedge c=64.4°$.	Mon. Elong. *c*.	{1 1 0} perf. {001} less so.	Colorless	H=4 G=3.65 F=dif.	Sol. in HCl.
^ v	1.663	1.699	1.684	Gruenerite $7(Fe,Mg,Mn)O.8SiO_2.H_2O$	2V=79°	$Y=b$ $Z\wedge c=14½°$.	Mon. Pris. *c*.	{110} perf. at 124°.	Black	H=6 G=3.40 Fus.	Amphibole group. Pleoc.: X and Y=nearly colorless, Z=yellow to brownish. Data for mineral with Fe:Mn:Mg=61:12:27.
v	1.678	1.688	1.685	Axinite $6(Ca,Fe,Mn)O.2Al_2O_3.B_2O_3.8SiO_2.H_2O$	2V=71°± 2E=156°. $r<v$.	X=nearly $\perp\{111\}$. On {111} ext. to {110}40° and to {1$\bar{1}$1} 24.7°. Disp. perc.	Tric.	{001} {1$\bar{3}$0} {010} dist.	Colorless, pinkish, brown, plum-blue.	H=7 G=3.3 F=2	Insol. in acid.
^ v	1.672	1.687	1.685	Bustamite $CaO.MnO.2SiO_2$	2V=41° 2E=71°.	On {1$\bar{1}$0} ext. to $c=5°$; on {110} $Z'\wedge c=13°$; on {010} $Z'\wedge c=7°$.	do	{1$\bar{1}$0} {110} {010} perf. {001} poor.	Pale pink	H=6 G=3.317	Opt. orientation close to that of wollastonite and rhodonite. Tw. // {1$\bar{1}$0} or {110}.

	1.658	1.690	1.685	Schroeckingerite. Hydrous uranium carbonate	2V=40°–60°. 2E=70°–114°. $r>v$ very strong. Crossed very strong.	$X=b$. $Z\wedge c$ long. varies greatly with color of light.	Mon. Laths {010}.		Green-yellow.	Soft	Pleoc.: X=colorless, Y and Z=canary-yellow. Very abnormal interference colors and no extinction in white light on face {010}. Poly. tw. {100}(?).
^ v	1.610	1.704	1.685	Roscoelite. $2K_2O.2Al_2O_3.(Mg,Fe)O.3V_2O_3.10SiO_2.4\pm H_2O$	2V=10°–15°. $r<v$ strong.	$Z=b$. $X\wedge c=0°–4°$.	Mon. Plates {001}.	{001}mic.	Green.	H=3 G=2.97 F=3(?)	Mica group. Insol. in acid. Pleoc.: X=olive-green, Z=green-brown. Apple-green interference color is characteristic.
^ v	1.670	1.685	1.685	Thuringite. $10(Mg,Fe)O.6Al_2O_3.8SiO_2.9H_2O$	2V=0°±.	X near c.	Mon. Plates.	{001}perf.	Brown.	H=6± G=2.960	Brittle mica(?). Fe″ : Mg = 3:10, Fe‴:Al=1:2.
	1.67	1.698	1.686	Trichalcite. $3CuO.As_2O_5.5H_2O$	Large.	$X\perp$ plates. Y // length.	Orth. Plates.		Verdigris green.	H=2.5 F=2–2.5	Easily sol. in HCl. In section pale bluish green and nonpleoc.
	1.678	1.689	1.686	Dumortierite. $8Al_2O_3.B_2O_3.6SiO_2.H_2O$	2V=30°–40°. 2E=52°–70°. $r<v$.	$X\wedge c=0°\pm$. $Z=a$.	Orth. Acic. c.	{100}dist.	Blue, greenish, reddish violet.	H=7 G=3.3 Infus.	Insol. in acid. Pleoc.: X=deep blue or violet, Y=yellow to red violet or nearly colorless, Z=colorless or very pale blue.
^ v	1.682	1.694	1.689	Hypersthene. $(Mg,Fe)O.SiO_2$	2V=81°. $r>v$ weak.	$X=a$. $Z=c$.	Orth. Pris. c.	{110}perf. at 87°.	Greenish.	H=5.5 G=3.37 F=5	Pyroxene group. Isom. with enstatite. Nearly insol. in acid. Faintly pleoc.: X=clear, pink, Y=yellow, Z=green. Data for mineral with 14 per cent FeO=20 per cent (molecular) $FeO.SiO_2$.
	1.664	1.692	1.689	Cenosite. $2CaO.(Ce,Y)_2O_3.CO_2.4SiO_2.H_2O$	2V=40°. 2E=69°. $r<v$ strong.	$X=a$. $Y=b$.	Orth.		Light rose.	H=5–6 G=3.612	Sol. in HCl.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.675	1.693	1.690	Sincosite $CaO.V_2O_4.P_2O_5.5H_2O$	Small to mod		Ps. tetrag	{001} good			
	1.682	1.697	1.690	Chlorophoenicite $10(Mn,Zn)O.As_2O_5.7H_2O$	$2V=83°$ $r>v$ strong.	$Y=b$ Optic axis nearly $\perp$ {100}.	Mon. Elong. b.	{100} good		H=3–3.5	Sometimes Bx+ with $r<v$ (private communication).
^ v	1.60	1.69±	1.69±	Stilpnomelane $2(Fe,Mg)O.(Fe,Al)_2O_3.5SiO_2.3H_2O$	$2V=0°\pm$	$X\wedge c$ small	Mon. Plates	{001} mic	Black	H=3–4 G=2.71–3.4 F=4.5	Mica group. Chalcodite. Decpd. by HCl. Strongly pleoc.: X=yellowish, Y and Z=dark brown and nearly opaque.
^ v	1.675	1.701	1.691	Hornblende $Ca_4Na_2(Mg,Fe)_8(Al,Fe)_5TiSi_{12}O_{45}(OH)_3$	Large	$Z_r\wedge c=12\frac{1}{2}°$ $Z_o\wedge c=11°$.	Mon. Pris. c	{110} perf. at 124°.	do	H=6 G=3.21	Mg/Fe=4.3, Al/Fe=4.2.
^ u	1.684	1.696	1.692	Axinite $6(Ca,Fe,Mn)O.2Al_2O_3.B_2O_3.8SiO_2.H_2O$	$2V=74°$ $r<v$ strong.	X nearly $\perp$ {111}; on {111} ext. to {1$\bar{1}$0}=40°; on {111} ext. to {1$\bar{1}$1}=25°.	Tric		Brown	H=7	Manganese rich. Disp. of indices=0.015.
^ v	1.676	1.707	1.693	Gruenerite $(Fe,Mg,Mn)_7Si_8O_{22}(OH)_2$	$2V=84°$ Disp. weak.	$Y=b$ $Z\wedge c=13°$.	Mon. Pris	{110} perf. at 54°20′.	Whitish gray		Amphibole group. Fe: Mg: Mn: Ca=81:11:4:4.
	B=0.005		1.693	Pharmacosiderite $3Fe_2O_3.2As_2O_5.13H_2O$	Large $r>v$ very strong.	Ext. large $Y=b$(?). Disp. strong.	Mon.(?) Ps. isomet. Cubic.	{100} imperf	Olive-green, brown, yellow.	H=2.5 G=2.9–3.0 F=1.5–2	Sol. in HCl. Divided into cubic segments and these show poly. tw. Abnormal interference colors.

^ v	1.676	1.708	1.694	Kaersutite. Titaniferous hornblende.	2V=82°. Disp. weak.	On{110}Z∧c =8°.	Mon. Pris. c.	{110}perf. at 124°.	Black	H=6 G=3.14 Fus.	Amphibole group. Pleoc.: X=light brown, Y=dark reddish brown, Z=darker reddish brown.
^ v	1.679	1.698	1.694	Hastingsite. $4CaO.Na_2O.8(Mg,Fe)O.3Al_2O_3.12SiO_2.2H_2O$	2V=60°. 2E=116°. r<v mod.	Y=b. Z∧c=11°.	do	do	Brown	H=6 G=3.518	Amphibole group. Fe/Mg=1.2, Al/Fe=3.4. Pleoc.: X=light brown, Y=brown, Z=greenish brown.
^ ⌐	1.540	1.703	1.695	Tarnowitzite. $(Ca, Pb)O.CO_2$	2V=23°. 2E=40°.	X=c. Z=b.	Orth	{010}dist.	White	H=4 G=3.015	Sol. in dilute acid. A plumbiferous aragonite. Ca:Pb=15:2. Tw.
^ v	1.675	1.714	1.695	Forsterite. $2(Mg, Fe)O.SiO_2$	2V=84°–88°	X=b. Z=a.	Orth. Equant.	{010}dist.{100} less so.	Colorless, etc.	H=7	Olivine group. Forsterite, 78; fayalite, 17 per cent.
^	1.691	1.696	1.695	Triphylite. $Li_2O.2FeO.P_2O_5$	Medium large. r<v strong.	X=c. Z=b.	Orth	{001}perf.{010} dist.	Greenish gray, bluish.	H=5 G=3.55 F=1.5	Isomor. with lithiophilite, which is opt. + and has lower n. Sol. in acid.
	B=.007	1.70		Arrojadite. $6R_2O_3.27RO.11P_2O_5$. R=Fe, Mn, etc.	2V=71° 2E=162°.		Mon	One perf.	Dark green	H=5	Pleoc.: X and Y=colorless, Z=pale green.
^ v	B=low		1.695	Riebeckite. $Na_2O.FeO.Fe_2O_3.5SiO_2$?	Large	X=b. Z∧c=4°.	Mon. Fib. c.	{110}perf. at 124°.	Black, blue	H=4 G=3.2–3.3 F=3(?)	Amphibole group. Insol. in acid. Pleoc.: X=deep blue to smoky green, Y=yellowish to brownish yellow, Z=very dark smoky green to black.
	1.684	1.698	1.695	Kempite. $MnCl_2.3MnO_2.3H_2O$	Small	X=c. Y=b.	Orth. Elong. c.		Emerald-green	H=3.5 G=2.94	Sol. in HCl with evolution of Cl.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
◇ ◇	1.672	1.717	1.697	Gruenerite $7FeO.8SiO_2.H_2O$	$2V=82°$ $r<v$. Disp. weak.	$Y=b$ Ext. $\{010\}=10°$ to 11°.	Mon. Pris. c	$\{110\}$ perf. at 124°.	Black	H=6 G=3.47 Fus.	Amphibole group. Pleoc.: X and Y= colorless, Z=pale yellow to brownish. Poly. tw. $\{100\}$. Data for mineral with $FeSiO_3$ .91, $MgSiO_3$ 5, Na_2SiO_3 3, K_2SiO_3 1 per cent. MnO replaces Fe, changing properties but little.
◇ ◇	1.695		1.698	Arfvedsonite $5Na_2O.14(Fe,Mg)O.3(Al,Fe)_2O_3.32SiO_2.4H_2O$	Large	$Z=b$ $X\wedge c=8°$.	do	do		H=6± G=3.421	Amphibole group. Mg/Fe=48, Al/Fe =0.2.
◇ ◇	1.625	1.735	1.700	Ancylite $2Ce_2O_3.3SrO.7CO_2.5H_2O$	$2V=66°$ $2E=136°$.	$X=a$ $Y=b$.	Orth. Rhombic pyramids		Hair-brown, yellow-green, orange.	H=4.5 G=3.95 Infus.	Related to bastnaesite. Sol. in acid.
◇	1.687	1.703	1.701	Bustamite $(Ca,Mn,Mg,Fe)O.MnO.2SiO_2$	$2V=36°$ $2E=65°$.	Ext. on $\{1\bar{1}0\}$ $Z'\wedge c=1°$; on $\{110\}$ $Z'\wedge c=5°$.	Tric	$\{010\}\{110\}\{1\bar{1}0\}$ perf. $\{001\}$ poor.	Pale pink	H=6 G=3.410	Opt. orientation close to wollastonite and rhodonite. Tw. pl. // $\{110\}$ or $\{1\bar{1}0\}$. Mn: Fe: Mg: Ca= 58:3:6:33.
◇ ◇	1.680	1.720	1.701	Olivine $2(Mg,Fe)O.SiO_2$	$2V=86.4°$ $r>v$.	$X=b$ $Z=a$.	Orth. Equant	$\{010\}$ dist. $\{100\}$ less so.	Green	H=7 G=3.471 F=dif.	Olivine group. Gelat. Habit characteristic. Alters to serpentine and iddingsite. Mineral with 21.7 per cent FeO= 22 per cent (molecular) $2FeO.SiO_2$.

	1.693	1.704	1.701	Tinzenite $Al_2O_3.Mn_2O_3.2CaO.4SiO_2$	$2V=63°$ $2E=126°$. Medium large. $r>v$.	$Y=b$ $Z=$near c.	Mon. Radial plates.	{100}perf	Yellow	G=3.29	Pleoc.: X=pale yellowish-green, Y=pale greenish, Z=colorless.
^ v	1.692	1.705	1.702	Hypersthene $(Mg,Fe)O.SiO_2$	$2V=75°$ $r>v$ weak.	$X=a$ $Z=c$.	Orth. Pris. c.	{110}perf. at 90°.	Greenish	H=5.5 G=3.42 F=5	Pyroxene group. Isomor. with enstatite. Nearly insol. in acid. Data for mineral with FeO 18 per cent=26 per cent (molecular) FeO.SiO_2. As iron increases B increases, 2V decreases, pleoc. increases. Pleoc.: X=clear red, Y=yellow, Z=green.
	1.695	1.708	1.702	Barylite $2BeO.BaO.2SiO_2$	$2V=70°$ $2E=156°$.	Y and Z ⊥ cleavages.	Orth	{001}{100}good.	White	H=7 G=4.07	Franklin, N.J. Sometimes opt. positive.
	1.660	1.713	1.705	Tarbuttite $4ZnO.P_2O_5.H_2O$	$2V=50°$ $2E=92°$. One bar indicates $r>v$ weak. The other $r<v$.	Ext. on {001} to {100}=35°; on {100} to {001}=15°; on {010} to {001}=21°. Disp. strong.	Tric	{001} perf	Colorless, yellowish, brownish.	H=4 G=4.15 F=easy	Sol. in dil. HCl.
^ v	B=0.005		1.705	Arfvedsonite $5Na_2O.2CaO.14(Mg,Fe)O.5(Al,Fe)_2O_3.TiO_2.27SiO_2.4(H_2O,F_2)$		$Z=b$ $X\wedge c=10°$.	Mon. Elong. c.	{110}perf. at 124°.	Black	H=6± G=3.463	Amphibole group. Mg/Fe=0.09, Al/Fe=7, $H_2O/F=1$. Pleoc. X=deep bluish green, Y=brownish yellow, Z=dark bluish gray.
^ v	1.681	1.718	1.706	Olivine $2(Mg,Fe)O.SiO_2$	Large	$X=b$ $Z=a$.	Orth, Equant.	{010} dist. {100} less so.	Green, etc.	H=7 G=3.46	Olivine group. Indices for sodium light. SiO_2 38.40, FeO 22.98, MgO 38.62 per cent.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
∧ ∨	1.687	1.708	1.707	Barkevikite. Between hornblende and arfvedsonite	2V=54°. 2E=102°.	X=*b*. Z∧*c*=12°–14°.	Mon. Fib. *c*.	{110}perf. at 124°.		H=6 G=3.43	Amphibole group. Pleoc.: X=bright brownish yellow, Y=reddish brown, Z=deep brown.
	1.704	1.710	1.707	Sapphirine. $9MgO.10(Al,Fe,B)_2O_3.4SiO_2$	2V=69°. 2E=151°. *r*<*v*.	Y=*b*. Z∧*c*=−8.5°. Disp. perc.	Mon. Tab. {010}.	None.	Pale blue, green.	H=7.5 G=3.45 Infus.	Insol. in acids. Pleoc.: X=light greenish blue, Y=blue, Z=blue or X=light greenish blue, Y=dark pure green, Z=yellow, faded green.
∧	*1.630	1.712	1.709	Sussexite. $2(Mn,Zn,Mg)O.B_2O_3.H_2O$	Small. *r*>*v*=perc.	X=*c*. Z bisects acute angle of {110}.	Orth. Fib. *c*.		White.	H=3 G=3.12 F=2	Sol. in HCl. Franklin.
∧ ∨	1.695	1.710	1.710	Hastingsite. $6CaO.3Na_2O.14(Mg,Fe)O.7Al_2O_3.24SiO_2.4H_2O$	2V=near 0°. *r*<*v* rather strong.	Y∧*c*=12°–17°.	Mon. Pris. *c*.	{110}perf. at 124°.	Black.	H=6 G=3.42	Amphibole group. Mg/Fe=6, Al/Fe=3. Pleoc.: X=deep yellow. Y and Z=deep greenish blue.
	1.703	1.722	1.713	Gerhardtite. $4CuO.N_2O_5.3H_2O$	Large. *r*>*v* strong.	X=*a*. Z=*c*.	Orth. Striated horizontally.	{001} perf. {100} less perf.	Emerald-green	H=2 G=3.40 F=2	Sol. in dilute acids. Pleoc.: X and Y=green, Z=blue.
∧	1.697	1.722	1.714	Strengite (manganiferous) $(Fe,Mn)_2O_3.P_2O_5.4H_2O$	Medium. Disp. strong.		Orth.		Blue.	H=3–4 G=2.8 F=2.5–3	Sol. in HCl. Pleoc.: X=very pale violet, Y=violet, Z=deep blue.

	*1.690	1.735	1.714	Schoepite $UO_3.2H_2O$	Large $r>v$.	X=c	Orth. Pris. c	{001}perf	Sulphur - yellow.	G=4.96	Pleoc.: X=colorless, Y and Z=lemon-yellow. Katanga.
^ v	1.674	1.718	1.715	Iddingsite $MgO.Fe_2O_3.3SiO_2.4H_2O$	2V=35°±. 2E=62°. $r<v$ strong.	X=a. Y=b.	Orth. Pseudomorph after olivine.	{100} {010} {001} perf. {101}less so.	Brown	H=3 G=2.6 Infus.	Decpd. by acid. Pleoc. in red-brown.
^ v	1.679	1.729	1.716	Glaucochroite $CaO.MnO.SiO_2$	Medium large. $r>v$ rather strong.	X=b. Z=a.	Orth. Pris		Pale pink to violet.	H=6 G=3.41 F=3	Easily decpd. (Type material.)
^ v	1.700	1.726	1.716	Woehlerite $10CaO.Na_2O.10SiO_2.3ZrO_2.Cb_2O_5.3NaF$	2V=71°-79°. 2E=Near 180°. $r<v$ dist.	Z=b. X∧c=−45°±.	Mon. Tab. {100}.	{010}dist	Light yellow, brown.	H=6 G=3.42 F=3-3.5	Sol. in HCl. Pleoc. weak: X and Y=light wine-yellow, Z=deep wine-yellow.
^ v	1.716	1.723	1.719	Epidote $4CaO.3Al_2O_3.6SiO_2.H_2O$	2V=89°. $r>v$ strong.	Y=b. Z∧c=1°.	Mon. Elong. b.	{001}perf	Colorless	H=7 G=3.36 F=3-4	Epidote group. Insol. in HCl. Data for mineral with 12 per cent iron.
^ v	1.698	1.722	1.719	Ferrohastingsite $Ca_2Na(Fe,Mg)_4(Al,Fe)_3Si_8O_{22}(OH)_2$	2V=47°. 2E=86°. $r>v$ medium.	Y=b. Z∧c=20°.	Mon	{110}perf		G=3.375	Amphibole group. X=yellow, Y=olive-green, Z=deep green. Analysis: SiO_2 37.40, Al_2O_3 12.34, Fe_2O_3 4.16, FeO 25.84, MgO 2.20, CaO 9.72, Na_2O 1.80, K_2O 1.36, H_2O 0.60 per cent. Fe/Mg=6.5, Al/Fe=4.7.
^ ⊐	1.699	1.721	1.719	Hastingsite $Ca_2Na_4Fe_7(Al,Fe)_6Si_{13}O_{44}(OH)_4$	2V=36°±. 2E=64°.	Y=b. Z∧c=20°.	do	do			Amphibole group. X=greenish yellow, Y=olive-green, Z=bluish green. SiO_2 35.42, Al_2O_3 8.89, Fe_2O_3 9.73, FeO 24.48, MgO 0.17, CaO 6.93, Na_2O 5.13, K_2O 3.23, H_2O 3.15, MnO 1.17, TiO_2 1.34 per cent. Al/Fe=1.4.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.715	1.720	1.719	Vesuvianite $12CaO.3Al_2O_3.10SiO_2.H_2O$	$2V=30°-60°$ $2E=53°-118°$.		Tetrag.	{110}poor		H=6.5 G=3.4 F=3	Partly decpd. by HCl. Anom. biax. Pleoc. slight.
	1.715	1.725	1.720	Trimerite $(Mn,Ca)O.BeO.SiO_2$	$2V=83°$	Axial pl. and X nearly $\perp$ {0001}.	Tric. Ps. hex. Thick tablets {0001}.	{0001}dist.	Colorless	H=6 G=3.47 F=dif.	Sol. in HCl. Basal section shows three radial segments.
	1.712	1.728	1.720	Cyanite $Al_2O_3.SiO_2$	$2V=82°$ $r>v$ slight.	X=almost. $\perp$ {100}. Ext. on {100} $Z\wedge c=-30°\pm$. Disp. dist.	Tric. Blades {100}. Elong. *c*.	{100}very perf. {010}less so. {001}parting.	Colorless, blue.	H=4-7 G=3.6 Infus.	Insol. in acid. Pleoc. faint: X=colorless, Y=violet-blue, Z=cobalt-blue. (1) Tw. pl. composition face {100}; (2) tw. axes {100}{001}; composition face {100}; (3) tw. and composition pl. {001} poly., etc.
	1.691	1.720	1.720	Phosphuranylite $3UO_3.P_2O_5.6H_2O$	$2V=0°\pm$ $r\lessgtr v$ very strong.	X=*b*. Disp. strong.	Mon. (?). Plates {010}.		Deep lemon-yellow.	F=3(?)	Sol. in HCl. Pleoc. strong: X=nearly colorless, Y and Z=canary-yellow.
	1.687	1.731	1.722	Tarapacaite $K_2O.CrO_3$	$2V=52°$ $2E=98°$. $r>v$ weak.	X=*b*. Z=*c*.	Orth. Ps. hex. due to tw.	{010}{001} fair.	Yellow	G=2.74	Data for artificial mineral.
□	*1.698	1.745	1.723	Lavenite $(Mn_2,Zr,Ca_2,Na_4)O_2.(Si,Zr)O_2$	$2V=80°$ $r<v$ perc.	Y=*b*. $X\wedge c=-20°$.	Mon. Tab. {100}.	{100}good	Yellow to brown, colorless.	H=6 G=3.5 Fus.	Dif. sol. in HCl. Tw. pl. {100} lamellar. Pleoc.: X=colorless to clear wine-yellow, Y=colorless to greenish yellow, Z=golden or brownish yellow to orange-red. Lange-sundford.

	1.692	1.738	1.725	Phosphosiderite $2Fe_2O_3.2P_2O_5.7H_2O$	2V=62° 2E=125°. $r>v$ strong.	$Y=b$ $X\wedge c=3°-5°$.	Mon. Pris.	{010}perf. {001}dist.	Pinkish red	H=3.5 G=2.724 F=easy	Tw. on {101}. Pleoc.: X=pale rose, Y=carmine, Z=nearly colorless. See strengite, p. 190.
<>	1.680	1.752	1.725	Basaltic hornblende. Silicate of Fe, Al, Mg, Ca, Na.	2V=79°±. $r<v$.	$Y=b$ $Z\wedge c=0°-10°$.	Mon. Pris. c.	{110} perf. at 124°.	Brownish black.	H=6 G=3.4 Fus.	Amphibole group. Insol. in acid. Pleoc.: X=yellow, Y and Z=dark brown or green.
	1.694	1.730	1.726	Tyrolite $5CuO.As_2O_5.9H_2O$	2V=36° 2E=64°. $r>v$ strong.	$X=c$ $Z=a$.	Orth. Laths {001}, elong. b. Fan-shaped aggregates.	{001}perf.	Pale green, sky-blue.	H=1–1.5 G=3.02–3.10 F=2–2.5	Sol. in HNO_3 or NH_4OH. Pleoc.: X=grass-green, Y=yellowish green, Z=grass-green.
<	1.615	1.733	1.726	Lepidomelane. An iron mica	2V=31° 2E=52°. $r<v$ strong.	$X\wedge c$=small $Y=b$.	Mon.	{001}mic.	Red-brown	G=3.3	Mica group. Fe_2O_3 14, TiO_2 8 per cent.
□	1.711	1.740	1.727	Picrotephroite $2(Mn,Mg)O.SiO_2$	2V=85° $r>v$.	$X=b$ $Z=a$.	Orth. Equant.	{010}dist.	Red, brown	H=6 G=4.0 F=3–4	Olivine group. Gelat. Data for mineral with Mg_2SiO_4 40.4, Mn_2SiO_4 59.6 per cent.
<>	1.715	1.731	1.728	Hypersthene $(Mg,Fe)O.SiO_2$	2V=63° 2E=129°. $r>v$ weak.	$X=a$ $Z=c$.	Orth. Pris. c.	{110}perf. at 87°.	Greenish	H=5.5 G=3.49 F=5	Pyroxene group. Isomor. with enstatite. Dif. sol. in acid. Pleoc. faint: X=clear pink, Y=yellowish, Z=green. Data for mineral with 25 per cent FeO =40 per cent (molecular) $FeO.SiO_2$.
□	*1.675	1.730	1.728	Sarcopside $6RO.2P_2O_5.RF_2$. R=Fe>Mn>Ca	Small $r>v$ perc.	$Z=b$ $X\wedge c=45°$.	Mon.(?). Fib.	{010}perf. {100}perf.	Flesh-red, lavender.	H=4 G=3.64	Sol. in acid. Deering, N.H.
	1.720	1.735	1.728	Landesite $20MnO.3Fe_2O_3.8P_2O_5.27H_2O$	Large	$Z\perp$ best cleav. $X\perp$ inferior cleav.	Orth. (?)	Two cleavages at right angles.	Brown	H=2 G=3.026	Pleoc.: X=dark brown, Y=brown, Z=yellow.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
^ v	1.692	1.760	1.730	Kaersutite. Titaniferous hornblende	2V=80°. Weak.	On {110}. Z∧c=1°.	Mon. Pris. c.	{110} perf. at 124°.	Black	H=6 G=3.34 F=readily	Amphibole group. Pleoc.: X=pale olive-brown or olive-green, Y=brown, Z=dark brown, almost opaque.
	1.710	1.732	1.731	Chalcomenite. $CuO.SeO_3.2H_2O$	$2V_{Li}=34°$. 2E=61. r>v extr.	Y=b	Mon		Blue	H=2.5–3 G=3.76 F=1.5	In section pale greenish blue and nonpleoc.
	1.724	1.739	1.733	Hydrocyanite. $CuO.SO_3$	Large. r>v extr.		Orth		Colorless. Becomes pale blue on hydration.		Effloresces in contact with air. Artificial mineral.
□	1.723	1.736	1.734	Gageite. $8(Mn,Mg,Zn)O.3SiO_2.2H_2O$	Medium. r<v extr.	Z=c	Orth.(?) Acic. c.		Colorless	H=3± G=3.584 Infus.	Decpd. by HCl.
^	1.696	1.743	1.734	Monticellite. $(Mg,Zn,Fe)O.CaO.SiO_2$	2V=49°. 2E=91°.	X=b. Z=c.	Orth	{010} poor	White, etc	H=5–5.5 F=6	Olivine group. Gelat. Mg:Zn:Fe=5:3:54.
	1.715	1.745	1.735	Sicklerite. $6MnO.Fe_2O_3.4P_2O_5.3(Li,H)_2O$	Medium large. r>v very strong.	Z⊥best cleav.	Orth.(?)	Two unequal at 90°.	Dark brown, etc.	H=4 G=3.45 Fus. easily	Sol. in acid. Pleoc.: Yellow to orange-red. Abs.:X>Y>Z.
	1.640	1.750	1.736	Hydrozincite. $7ZnO.3CO_2.4H_2O$	2V=40°. 2E=73°. r<v strong.	X=b. On {010} ext.=13°.	Mon.(?) Fib. c. Laths {100}.	{100}perf.	White, gray, yellow.	H=2–2.5 G=3.6–3.8 Infus.	Decpd. by HCl.
	1.715	1.739	1.736	Renardite. $PbO.4UO_3.P_2O_5.9H_2O$	r>v.	X=a. Z=b.	Orth. Pris. tab.{100}.	{100}very perf.	Yellow	G=>4	Pleoc.: X=colorless, Y and Z=yellow.
	1.731	1.744	1.738	Thalenite. $2Y_2O_3.4SiO_2.H_2O$	2V=68°. 2E=152°. r<v weak.	Z=b or X=b. Y∧c=small.	Mon. Tab. {100}.	None	Pink	H=6.5 G=4.23–4.45	

□	1.727	1.751	1.739	Allanite (altered) 4(Ca,Fe)O. 3(Al,Ce,Fe,Di)$_2$O$_3$. 6SiO$_2$.H$_2$O	Medium large. $r>v$ rather strong.	$Y=b$	Mon	{001}{100}{110} poor.	Brown, black	H=6 G=3.5–4.2 F=3	Epidote group. May gelat. Pleoc.: X=pale yellowish or pale greenish, Y and Z=brownish red or green.
◇	1.733	1.744	1.740	Rhodonite MnO.SiO$_2$	Large to small. $r<v$ weak.	On {100}Z′∧c =32°±. On {010}Z′∧c =10°±.	Tric. Tab. {001}.	{110}{1$\bar{1}$0}perf. {001}less so.	Red, etc	H=6 G=3.67 F=2.5	Nearly insol. in acid.
	B=rather strong		1.74	Vilateite $Mn_3O_3.P_2O_5.4H_2O$?	$r>v$ strong	Ext. small	Mon		Violet, etc	H=3 G=2.75	Manganese strengite. Compare with blue strengite. Pleoc. slight; rose tint//c.
□	1.655	1.744	1.740	Aurichalcite 7(Zn,Cu)O.3CO$_2$. 4H$_2$O	Very small. $r<v$ strong.	Y near a. Z near elong.	Tric.(?) Plates {100}. Fib. c.	{100}mic	Pale green or blue.	H=2 G=3.54–3.64. Infus.	Sol. in acid. Pleoc.: X=nearly colorless, Y and Z=pale greenish.
◇	1.722	1.750	1.742	Epidote 4CaO.3(Al,Fe)$_2$O$_3$. 6SiO$_2$.H$_2$O	2V=80°. $r>v$ easily perc.	$Y=b$. X∧$c=-2°$.	Mon. Elong. b.	{001}perf.{100} imperf.	Pistachio-green	H=6 G=3.4 F=3–4	Epidote group. Partly decpd. by HCl. Pleoc.: X=colorless, Y=pale greenish yellow, Z=colorless, etc. Data for mineral with 22 per cent iron.
□	1.724	1.746	1.742	Hodgkinsonite 2ZnO.MnO.SiO$_2$. H$_2$O	Medium large. $r>v$ rather strong.	$Y=b$; Z∧c= 38°.	Mon. Pyram.	{001}perf.	Pink to pale reddish brown.	H=5 G=3.91 Fus. readily.	Gelat. Pleochroic in lavender.
	1.708	1.773	1.744	Adamite 4ZnO.As$_2$O$_5$.H$_2$O	2V=90°±. $r>v$ strong.	$Z=b$ $X=a$.	Orth. Elong. b.	{010} discontinuous.	Yellow, green, etc.	H=3.5 G=4.35 F=3	Sol. in HCl.
◇	1.723	1.765	1.745	Iddingsite MgO.Fe$_2$O$_3$.3SiO$_2$. 4H$_2$O	Large. $r<v$ strong.	$X=a$ $Y=b$.	Orth	{100}{010}{001} perf. {101} less so.	Reddish brown	H=3 G=2.8 Infus.	Decpd. by HCl. Pleoc. in brown and yellow. Abs.: X<Y<Z.
	1.702	1.789	1.745	Libethenite 4CuO.P$_2$O$_5$.H$_2$O	2V=85°. $r>v$ strong.	$X=b$ $Y=c$.	Orth. Elong. c.	{100}{010}poor.	Olive-green	H=4 G=3.7 F=2–2.5	Sol. in acid. Pleoc.: X=pale green to yellow, Y=bright green to greenish yellow, Z=yellow to yellowish green.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.724	1.749	1.749	Allodelphite 5MnO. $2(Mn,Al)_2O_3$. $As_2O_3.SiO_2.5H_2O$?	Very small		Orth.? Tab. // to elong.		Brown	G=3.57	Crystals zoned. Outer zone has high refractive index. A mixture?
	1.57		1.75	Hoelite $C_{14}H_8O_2$	Small	X=*c*. Y=*a*.	Orth	Pris.; also {001} {100}.	Colorless	G=1.43	
	1.738	1.755	1.752	Sobralite (Mn,Fe,Mg,Ca)O. SiO_2	2V=42°. 2E=73°.		Tric	{010}{100}perf. {001} poor.	Brown to black.	H=6 G=3.72	Related to rhodonite. Mn: Fe: Mg: Ca= 37.5:45:4.5:13.
	1.743	1.764	1.754	Caracolite $Na_2O.SO_3$. Pb(OH)Cl	Nearly 90° *r*>*v* rather strong.		Orth	None	do	H=4.5 F=1.5–2	Somewhat sol. in hot dilute HCl. Complex tw. or similar structure.
	1.736	1.766	1.755	Sursassite 5MnO.$2Al_2O_3$. $5SiO_2.3H_2O$	Medium large. *r*>*v* easily perc.	Y=*b*. X∧cleav.= 55°.	Mon. (?) Elong. *b*.	One good	Deep brown	G=3.25	Pleoc.: Y=deep brown, X and Z= nearly colorless.
^ v	1.738	1.778	1.757	Piedmontite 4CaO. $3(Al,Mn,Fe)_2O_3$. $6SiO_2.H_2O$	Near 90° *r*>*v* strong.	Y=*b*.	Mon. Elong. *b*.	{001} perf. {100} imp.	Red-brown	H=6.5 G=3.4 F=about 3	Epidote group. Partly decpd. by acid. Pleoc.: X=pale yellow, Y=pale purple, Z=old rose.
□	1.750	1.765	1.760	Nagatelite $4RO.3R_2O_3.6SiO_2$. $P_2O_5.2H_2O$	Medium large.	Y=*b*. X∧*c*=32°.	Mon		Black	H=5.5 G=3.91	Related to allanite. R″=Ca, Fe, etc. R‴=Al, Fe‴, Ce, etc. Sol. in HCl. Pleoc.: X=brownish yellow, Y=reddish brown, Z=pale yellow.
^	1.738	1.782	1.761	Manganepidote 4(Ca,Na,Mn)O. $3(Al,Fe)_2O_3$. $6SiO_2.H_2O$	2V=87° *r*>*v*.	Y=*b*. X∧*c*=−4°.	Mon. Elong. *b*.	{001} perf. {100}.	Brown	H=6 G=3.425	Epidote group. MnO 2.26 per cent. Al:Fe=3:1. Abs.: Y>Z>X for red, Z>Y>X for yellow.

	1.719	1.805	1.762	Dihydrite $5CuO.P_2O_5.2H_2O$	$2V=90°\pm$ $r>v$ strong.	$X\wedge c=22°$ Z near *b*.	Mon. or tric. Crystals. crusts, fibers.	{010}imperf	Dark emerald-green.	H=4.5-5 G=4.0-4.4 F=2-2.5	Sol. in HCl. Pleoc. faint. X=bluish green, Y=yellowish green, Z=deep bluish green.
∧ ∪	1.729	1.780	1.763	Epidote $4CaO.3(Al,Fe)_2O_3.6SiO_2.H_2O$	$2V=69°$ $r>v$ easily perc.	$X=b$ $Z\wedge c=5°$.	Mon. Elong. *b*.	{001} perf. {100} imp.	Pistachio-green.	H=6 G=3.4 F=3-4	Epidote group. Partly decpd. by HCl. Pleoc.: X=colorless, Y=pale greenish yellow, Z=colorless, etc. Data for mineral with 37 per cent iron epidote.
∧ ∨	1.744	1.788	1.768	Diopside-acmite $nNa_2O.Fe_2O_3.4SiO_2.mCaO.(Mg.Fe)O.2SiO_2$	$2V=70°-80°$ $r>v$ dist.	$Y=b$ $X_{red}\wedge c=9.5°$. $X_{blue}\wedge c=10°$.	Mon. Pris. *c*.	{110}perf. at 90°.	Green, brown.	H=6 G=3.5	Pyroxene group. Nearly insol. in acid. Pleoc. in green and brown. Contains SiO_2 52.0, Al_2O_3 1.0, Fe_2O_3 27.2, FeO 2.7, MgO 2.2, CaO 4.4, Na_2O 9.7, K_2O 0.3, H_2O 0.3, TiO_2 0.6, MnO 0.1 per cent, or 8.6 per cent. $CaFe(SiO_3)_2$ and 10.4 per cent $CaMg(SiO_3)_2$.
	1.760	1.768	1.768	Corundum Al_2O_3	$2V=0°-32°$ $2E=0°-58°$.		Trig. Anom. biax.	{0001} perf. parting.	Red, blue, etc.	H=9 G=4.0 Infus.	Insol. in acid. Pleoc. faint.
∧ ∨	1.742	1.787	1.768	Aegirite SiO_2, Fe_2O_3, Al_2O_3, CaO, Na_2O, etc.	$2V=81°$ calc.	$X\wedge c=2°\pm$ $Y=b$.	Mon. Elong. *c*.	{110} perf	Leaf-green	G=3.52 F=2	Pyroxene group. Pleoc.: X=olive-green, Y=lighter olive-green, Z=yellowish green. Analysis: SiO_2 53.11, TiO_2 2.59, Al_2O_3 1.25, Fe_2O_3 21.73, FeO 1.57, MnO 0.44, MgO 3.97, CaO 5.15, Na_2O 10.22, K_2O 0.18, H_2O 0.27 per cent.
∪	1.760	1.769	1.769	Calcium larsenite $(Pb,Ca)O.ZnO.SiO_2$	Very small		Orth	Indistinct	White. Greasy luster.	G=4.421	Chrysolite group.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.730	1.771	1.77	Conichalcite $2CuO.2CaO.As_2O_5.1\frac{1}{2}H_2O$	$2V=25°\pm$ $2E=45°$. $r>v$ very strong.	Z=elong	Orth. Fib		Pistachio to emerald green.	H=4.5 G=3.9± F=2.5-3.	Sol. in acid. Pleoc. faint: X=yellowish to colorless, Y=pale greenish, Z=pale bluish green
^ v	1.745	1.782	1.770	Aegirite (vanadiferous). $Na_2O.(Fe,V)_2O_3.4SiO_2$. Some $CaO.MgO.2SiO_2$	$2V=69°$ $r>v$ easily perc.	$X \wedge c=1.4°$	Mon. Pris. c	{110} perf. at 89°.	Brownish black.	H=6 G=3.55 F=3.5	Pyroxene group. Compare with acmite. Insol. in acid. Pleoc.: X=dark brown, Y=light brown, Z=yellowish brown.
	1.751	1.782	1.771	Leucophoenicite $7(Mn,Zn,Ca)O.3SiO_2.H_2O$	$2V=74°$ $r>v$ slight.	$X \perp$ cleav	Mon. Massive.	One imperf	Light purplish red.	H=6 G=3.85 F=3	Gelat. Pleoc. slight in pale rose to colorless.
□	1.728	1.800	1.771	Brochantite $4CuO.SO_3.3H_2O$	$2V=77°$ $r<v$ medium.	$X=b$ $Z=c$.	Orth. Pris. c	{010} perf	Emerald-green	H=4 G=3.8-3.9 F=3.5	Sol. in acid. In section slightly pleochroic in bluish-greens.
	1.729	1.807	1.773	Margarosanite $PbO.2(Ca,Mn)O.3SiO_2$	$2V=83°$ $r<v$ perc.	Tablets give ext. $X' \wedge$ cleav.=44°.	Tric. Lamellar.	One very perf. // tablets. Two others at nearly right angle to tablets, giving rhombic tablets, angle of 78°.		H=2.5-3 G=3.99 F=dif.(oxidizing flame) F=2 (reducing flame).	
	*1.772	1.777	1.775	Britholite Silicate and phosphate of cerium metals and calcium	Medium small.	$X=c$ $Y=a$.	Orth. Ps. hex. Pris.		Brown. Vitreous luster.	H=5.5 G=4.446	
	1.742	1.762	1.776	Gummite $(Pb,Ca,Ba)O.3UO_3.SiO_2.6H_2O$	$2V=60°$ $r<v$.		Fine-grained aggregate.	None	Yellow	H=2.5-3 G=4	X-ray pattern distinct from clarkeite.

	1.760	1.779	1.779	Allactite $7MnO.As_2O_5.4H_2O$	$2V_{Na}=4°$ $2E=7°$. $0°$ for green, $r > v$ very strong.	For red and yellow $Y=b$ and $X \wedge c=51.3°$. For blue $Z=b$.	Mon. Pris. c.	$\{\bar{1}01\}$ dist. $\{010\}$ less so.	Brownish red.	H=4.5 G=3.84 F=2(?)	Easily sol. Pleoc. weak in hyacinth-red and olive-green. Nearly colorless in section.
∧ ∨	1.763	1.812	1.780	Diopside-acmite $Na_2O.Fe_2O_3.4SiO_2$. Some CaO, MgO, $2SiO_2$	Medium large $r > v$ dist.	$Y=b$ $X \wedge c=3°$.	do	$\{110\}$ perf. at $90°$.	Green, brown.	H=6 G=3.545 F=2	Pyroxene group. Nearly insol. Tw. pl. $\{100\}$ common. Pleoc. in green and brown. Contains SiO_2 50.5, Al_2O_3 1.8, Fe_2O_3 23.4, FeO 5.3, MgO 1.5, CaO 5.9, Na_2O 9.8, K_2O 0.2, H_2O 0.6, TiO_2 0.9, ZrO_2 0.1, MnO 0.1 per cent or 17.4 per cent $CaFe(SiO_3)_2$ and 7.8 per cent $CaMg(SiO_3)_2$.
	1.756	1.792	1.780	Alleghanyite $5MnO.2SiO_2$	$2V=72°$ $r > v$.	Ext. to tw. pl. $=22°$.	Orth.	None	Pink, grayish pink.	H=5.5 G=4.02	Close to tephroite. Nonpleoc. in thin section. Lamellar tw.
∧	1.65	1.78	1.78	Stilpnomelane $2(Fe,Mg)O.(Fe,Al)_2O_3.5SiO_2.3H_2O$	$2V=0°\pm$	$X=c$	Mon. (?) Hex. plates.	$\{001\}$ mic.	Black	H=3-4 G=2.71-3.4 F=4.5	Chlorite group. Decpd. by HCl. Strongly pleoc.: X =yellowish, Y and Z=dark brown and nearly opaque.
			1.785	Lessingite $2CaO.2Ce_2O_3.3SiO_2.H_2O$	$2V=44°$ $2E=84°$.				Cherry-red, vitreous luster.	H=4.5 G=4.693	Same as britholite?
∧ ∨	1.758	1.804	1.786	Roepperite $2(Mn,Fe,Zn)O.SiO_2$	$2V=77°\pm$ $r>v$ rather strong.	$X=b$ $Z=c$.	Orth. Equant.	$\{010\}$ dist. $\{001\}$ dist.		H=5.5-6 G=3.95-4.10 Fus. easy	Olivine group. Gelat.
∨	1.759	1.797	1.786	Tephroite $2MnO.SiO_2$	$2V=65°$ $2E=148°$. $r>v$ perc.	$X=b$ $Z=a$.	do	$\{010\}$ dist.	Red, brown, gray, etc.	H=6 G=4.1 F=3.5	Olivine group. Gelat. Pleoc. faint: X= brownish-red, Y= reddish, Z=greenish-blue. Data for mineral with 7.8 per cent of Mg_2SiO_4.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.747	1.829	1.788	Olivenite $4CuO.As_2O_5.H_2O$	$2V=90°\pm$ $r<v$ strong.	$X=b$ $Z=a$.	Orth. Pris. *c*, acic. *c*.	Traces	Olive-green to dark yellow-brown.	H=3 G=4.1–4.4 F=2–2.5	Sol. in HCl. In large part opt.+. In section pale green and nonpleoc.
^ v	1.768	1.803	1.792	Hortonolite 2(Fe, Mg, Mn)O. SiO_2	$2V=69°$ $r>v$.	$X=b$ $Z=a$.	Orth. Equant.	{010}	Yellow, yellow-green, black.	H=6.5 G=3.91 F=4.5	Olivine group. Gelat. Pleoc. faint: Y=orange-yellow, X and Z=green-yellow.
□	1.756	1.809	1.793	Thortveitite $(Sc,Y)_2O_3.2SiO_2$	$2V=50°–65°$ $2E=98°–149°$. $r<v$.	$X\wedge c=5°$ $Y=b$.	Mon. Pris., radial rosettes.	{110} good	Grayish green	H=6–7 G=3.57 F=dif.	Near thalenite. Insol. in acid. Tw. pl. {110}. Pleoc. weak. X=deep to pure green, Y and Z=yellow with a touch of brown.
^	B=strong		1.80	Cronstedtite $3(Fe,Mg)O.Fe_2O_3.2SiO_2.3H_2O$	$2V=0°\pm$	$X=c$	Tapering hex. prisms.	{001} mic	Black	H=3.5 G=3.34 F=4	Chlorite group. Gelat. Pleoc. marked in dark brown to nearly opaque.
^ v	1.778	1.815	1.804	Tephroite $2MnO.SiO_2$	$2V=66°$ $2E=136°$. $r>v$ perc.	$X=b$ $Z=c$.	Orth. Equant.	{010} dist	Brownish red	H=6 G=4.113	Data for mineral with Mn_2SiO_4 96 per cent.
^ v	1.769	1.822	1.807	Acmite $Na_2O.Fe_2O_3.4SiO_2$	$2V=60°$ $2E=128°$. $r>v$ dist.	$Y=b$ $X_{red}\wedge c=5.5°$. $X_{blue}\wedge c=7°$.	Mon. Pris. *c*.	{110} perf. at 90°.	Green, brown, black.	H=6 G=3.5 F=2	Pyroxene group. Nearly insol. Tw. pl. {100} common. Pleoc. in green and brown. Contains SiO_2 52.1, Al_2O_3 1.0, Fe_2O_3 31.8, FeO 0.9, MgO 0.1, CaO 0.6, Na_2O 11.7, K_2O 0.4, H_2O 0.2, TiO_2 0.6, ZrO_2 0.4, Ce_2O_3 0.5, MnO 0.4 per cent.

	1.793	1.809	1.807	Sarkinite $4MnO.As_2O_5.H_2O$	$2V=83°$	$Y=b$ $X\wedge c=-54°$.	Mon. Pris. b.	Pris. dist	Rose-red, etc.	H=4–4.5 G=4.18 F=4	Easily sol. in HCl.
	1.787	1.816	1.810	Arsenoklasite $5MnO.As_2O_5.2H_2O$	$2V=54°$ $2E=111°$.	$X=b$ $Y=a$.	Orth. Massive.	{010} good	Brownish red	H=5–6 G=4.16	Related to allactite.
	*1.765	1.82	1.81	Cornetite $6CuO.P_2O_5.3H_2O$	$2V_{Tl}=33°$ $2E=62°$. $r<v$ strong.	$X=a$ $Z=b$.	Orth		Peacock to greenish blue.	H=5 G=4.1	Sol. in HCl. Nonpleoc.
	1.775	1.825	1.815	Pascoite $3V_2O_5.2CaO.11H_2O$	$2V=50°$ $2E=100°$. $r>v$ very strong.	$X=b$ Disp. ext.	Mon	{010} poor(?)	Red-orange to yellow-orange.	H=2.5 G=2.46	Readily sol. in H_2O. Pleoc.: X=light cadmium - yellow, Y=cadmium - yellow, Z=orange.
^	1.776	1.836	1.816	Acmite $Na_2O.Fe_2O_3.4SiO_2$	$2V_{Na}=60°$ $2E=130°$. $r>v$ strong.	$Y=b$ $Z\wedge c=+8°_{Li}$	Mon. Thin platy //{100} elong. c.	{110} perf. at 90°.	Yellow to brown.	H=6–6.5 G=3.55±	Pyroxene group. Data for pure artificial mineral. Weakly pleoc.
	1.715	1.820	1.817	Jarosite $K_2O.3Fe_2O_3.4SO_3.6H_2O$	Very small	$X=c$ Opt.pl.//edge.	Orth. Hex. tablets and fib.	{0001} dist	Ocher-yellow, brown.	H=3 G=3.2 F=4.5	Alunite group. Sol. in HCl. Basal section divided into six segments. Faintly pleoc.: X=nearly colorless, Y and Z=pale yellowish.
	1.735	1.830	1.820	Becquerelite $UO_3.2H_2O$	$2V=30°$ $2E=56°$. $r>v$ perc.	$X=c$ $Y=b$.	Orth. Elong. b.	{001} perf	Orange-yellow to brownish.	H=2–3 G=5.68	Pleoc.: X=colorless, Y and Z=yellow. Tw. pl. {011}.
^	1.788	1.830	1.825	Hancockite $4(Pb,Ca,Sr)O.3(Al,Fe,Mn)_2O_3.6SiO_2.H_2O$	$2V=38°$ $2E=73°$. $r>v$ perc.	$Y=b$	Mon	{001}	Brownish red	H=6–7 G=4.03 F=3	Epidote group. Gelat. in acid after ignition. Pleoc. in reddish brown. Abs.: Z>X.
^	1.792	1.864	1.83±	Iddingsite(?) $(Mg,Ca)O.5Fe_2O_3.4SiO_2.10H_2O$	$2V=80°\pm$ $r<v$ strong.	$X=a$ $Y=b$.	Orth	{100}{010}{001} perf. {101} less so.	Red-brown	H=3.5 G=2.80 Infus.	Decpd. by acid. Pleoc. in red-brown.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
□	1.672	1.83	1.83	Rosasite $2(Cu,Zn)O.CO_2.H_2O$	Small $r<v$ strong.	Elong.−	Orth.(?) Laths		Blue-green	G=4.09	Pleoc.: X=colorless, Z=blue. CuO 41.58, ZnO 28.96 per cent. Related to malachite?
	1.800	1.846	1.831	Higginsite $2CuO.2CaO.As_2O_5.H_2O$	Near 90° $r>v$ rather strong.	X=a Y=b.	Orth. Stout prisms.		Malachite to yellow-green.	H=4.5 G=4.33 F=3	Sol. in acid. Pleoc.: X=green, Y=yellow-green, Z=blue-green.
	1.750	1.832	1.832	Natrojarosite $Na_2O.3Fe_2O_3.4SO_3.6H_2O$	Very small	X=c	Orth. Hex. tablets.	{0001} perf.	Yellow, brown.	H=3 G=3.2 F=3	Alunite group. Sol. in HCl. Faintly pleoc.: X=nearly colorless, Y and Z=pale yellowish.
^ v	1.805	1.846	1.836	Manganfayalite $2(Fe,Mn)O.SiO_2$.	Medium large. $r>v$.	X=b Z=a.	Orth. Equant.	{010} dist.		H=6.3 G=4.3 F=4	Olivine group. Gelat. Data for mineral with Mn_2SiO_4 25.5, Fe_2SiO_4 74.5 per cent.
^ v	1.805	1.847	1.838	Knebelite $2(Fe,Mn,Mg)O.SiO_2$	2V=54° 2E=113°. $r>v$ mod.(?).	X=b Z=a.	do	{110} dist.	Gray, etc.	H=6.5 G=3.9–4.17 F=3	Olivine group. Gelat. Data for mineral with Mg_2SiO_4 7.5 Mn_2SiO_4 26.7, Fe_2SiO_4 65.8 per cent. Faintly pleoc.
	1.809	1.859	1.838	Linarite $PbO.CuO.SO_3.H_2O$	2V=80° $r<v$ mkd.	Z=b X∧a = −24°.	Mon. Tab. {001} or elong. b.	{100} very perf. {001} less so.	Deep sky-blue.	H=2.5 G=5.4 F=1.5	Partly sol. in HNO_3.
	B=0.05±		1.84±	Dufrenite $2Fe_2O_3.P_2O_5.3H_2O$	Large $r<v$ extr.	Z=b X=Fib. Disp. extr.	Mon. Fib.	{010} perf.	Dull leek-green	H=3.5–4 G=3.2–3.4 F=2.5	Sol. in acid. Pleoc. strong: X=bright green, Y=pale yellowish, Z=dark reddish brown.

1.69	1.85	1.84	Tagilite $4CuO.P_2O_5.3H_2O$	Small	Elong.−	Mon. Concretionary.	{010} dist.	Green	H=3–4 G=4.08 F=2–2.5	Sol. in acid.
1.773	1.845	1.840	Chalcosiderite $CuO.3Fe_2O_3.2P_2O_5.8H_2O$	2V=24° 2E=45°. $r>v$ very strong.	X near b Disp. strong.	Tric. Sheaflike aggregates.	{010} easy	Siskin-green	H=4.5 G=3.11 F=4–4.5	Sol. in HCl. Pleoc. in thick sections: X=colorless, Z=pale green. Section {010} gives no extinction in white light but very abnormal red, blue, and green interference colors.
1.825	1.857	1.842	Dietzeite $2CaO.I_2O_5.CrO_3$	2V=86° $r<v$ very strong.	Y=b Ext.{010}=6°. Disp. mkd.	Mon. Tab. {100}. Elong. c.	{100} imperf.	Dark golden yellow.	H=3–4 G=3.70 F=1.5	Sol. in hot H_2O, with separation of $CaIO_3$ on cooling.
*1.847	1.850	1.850	Romeite $5CaO.3Sb_2O_5$	Medium		Ps. isomet. Oct.		Brown	H=6 G=5.0 Fus.	Insol. in HCl. Opt. anom. Divides into sections which show poly. tw. lamellae parallel to the edges. β decreases as Na_2O increases. Abnormal interference colors. Långban.
1.820	1.88	1.86	Erinite $5CuO.As_2O_5.2H_2O$	Small $r<v$ mod.	Z⊥cleav Y // elong.	Fib	One perf.	Emerald-green	H=5 G=4.04 F=2–2.5	
1.85		1.86	Parsonsite $2PbO.UO_3.P_2O_5$ H_2O.		Z∧c=12°	Mon. Elong. c.		Chocolate-brown.	G=6.25	Readily sol. in acid.
1.831	1.880	1.861	Atacamite $3CuO.CuCl_2.3H_2O$	2V=75° $r<v$ strong.	X=b Z=c.	Orth. Slender prisms c.	{010} highly perf. {101} imperf.	Green, streak green.	H=3 G=3.78 F=3–4	Sol. in acid. Tw. pl. {110}. Pleoc.: X=pale green, Y=yellow-green, Z=grass-green.
1.818	1.909	1.866	Caledonite $2(Pb,Cu)O.SO_3$ H_2O.	2V=85°± $r<v$ slight.	X=b Z=c.	Orth. Pris. a.	{001} perf. {100} less so.	Bluish green	H=3 G=6.4 F=1.5	Sol. in part in HNO_3. Pleoc.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	1.750	1.88	1.87	Becquerelite $UO_3.2H_2O$	$2V=30°$. $2E=54°$. $r>v$.	$X=c$. $Y=b$.	Orth. Elong. b.	{001} perf.	Brownish yellow.	H=2–3 G=4.967	Tw. pl. {011}. Pleoc.: X=colorless. Y and Z=yellow.
	1.73	1.91	1.870	Clinoclasite $6CuO.As_2O_5.3H_2O$	$2V=53°$. $2E=113°$. $r<v$ very strong.	$Y=b$. Z near a. Disp. small.	Mon.	{001} highly perf.	Blackish blue-green.	H=3 G=4.19–4.38 F=2–2.5	Pleoc.: X=pale blue-green, Y=light blue green, Z=benzol-green.
V	1.670	1.895	1.870±	Tyuyamunite $CaO.2UO_3.V_2O_5.8±H_2O$	$2V=36°$. $2E=71°$. $r<v$ rather strong.	$X=c$. Y bisects acute angle of rhombs or // length.	Orth. Plates {001}. Elongated or rhombic.	{001} mic.	Yellow	Soft	Pleoc.: X=nearly colorless, Y=canary-yellow, Z=darker canary-yellow.
	1.786	1.875	1.875	Plumbojarosite $PbO.3Fe_2O_3.4SO_3.6H_2O$	Small	$X\perp$ plates.	Ps. trig. Hex. plates.	{10$\bar{1}$1}.	Brown	G=3.63	Alunite group. Sol. in HCl. Pleoc.: X=pale golden yellow, Y and Z=dark brownish red. Basal plates divided in hexagonal segments.
	1.655	1.909	1.875	Malachite $2CuO.CO_2.H_2O$	$2V=43°$. $2E=86°$. $r<v$ in air.	$Y=b$. $X\wedge c=23°$. X nearly $\perp$ {001}.	Mon. Pris. c.	{001} perf. {010} less so.	Green	H=4 G=4.0 F=2	Sol. with effervescence. Disp. within crystal, $r>v$ large. Pleoc.: X=nearly colorless, Y=yellowish green, Z=deep green.
∧	1.835	1.886	1.877	Fayalite $-2FeO.SiO_2$	$2V=47°$. $2E=96°$. $r>v$ rather strong.	$X=b$. $Z=a$.	Orth. Equant.	{010} dist. {100} less so.	Yellow, brown, black.	H=6.5 G=4.34 F=4	Olivine group. Gelat. Pleoc. Nearly colorless in section. Abnormal blue and yellow interference colors. Data for nearly pure Fe_2SiO_4.

⊏	B=0.01		1.88±	Tscheffkinite (altered) Titanosilicate of Ce, Fe, etc.	Medium		Mon.(?)	Conc	Velvet-black	H=5 G=4.3-4.55 F=4	Gelat. Pleoc.: X=nearly colorless, Y=pale red-brown, Z=rather dark red-brown. In part isotropic.
	1.80	1.88	1.88±	Arseniosiderite $3CaO.2Fe_2O_3.2As_2O_5.6H_2O$	2V=0°±	X=c	Orth. Pris. or blades {001}	{001} perf	Yellow to black. Blood-red in splinters.	H=4.5 G=3.57 F=3	Sol. in HCl. Pleoc.: X=nearly colorless, Y and Z=dark reddish brown.
⊏	1.86	1.91	1.89±	Heterosite $(Fe,Mn)_2O_3.P_2O_5.H_2O$	Large	X⊥ cleav	Massive. Lamellar.	Three unequal	Black. Powder red.	H=5.5-6 G=3.52 Fus.	Sol. in acid. Pleoc.: X=gray, brown, reddish brown, Y=brilliant carmine, Z=very dark violet or red.
	1.674	1.920	1.900	Ianthinite $2UO_2.7H_2O$	do	X=c Y=b.	Orth	{001} mic	Violet-black		Pleoc. very strong in violet.
	B=strong	1.91	1.91	Ilvaite $2CaO.4FeO.Fe_2O_3.4SiO_2.H_2O$	Small $r<v$ very strong.	Z=c X=b.	do	{010}{001} dist	Brownish black.	H=5.5-6 G=3.8-4.1 F=2.5	Gelat. Strongly pleoc. in transmitted light: X and Y=green nearly opaque, Z=pale yellow-brown.
<>		1.92	1.895	Carnotite	2V=39°-44°	X=c	Orth. Rhombic plates {001}, shreds.	{001} mic	Yellow	Soft F=dif.	Colorless to pale yellow in section.
<>	1.750	1.95	1.925	$K_2O.2UO_3.V_2O_5.8±H_2O$	2E=79°-91°. $r<v$ weak.	Y bisects acute angle of plates.					
	1.85	1.94	1.92	Fourmarierite $PbO.5UO_3.10H_2O$	Large $r>v$ strong.	X=a Y=c.	Orth. Tab.// {100}.	{100} dist	Red, yellow	H=3-4 G=6.05	Pleoc.: X=colorless, Y=pale yellow, Z=deeper yellow.
<>	1.77	1.97	1.93±	Tyuyamunite $CaO.2UO_3.V_2O_5.8±H_2O$	2V=40°-55° 2E=82°-126°. $r<v$ rather strong.	X=c Y=b. Y bisects acute angle of rhombs or // length.	Orth. Plates {001} elongated or rhombic.	{001} mic	Yellow	Soft F=easy	Pleoc.: X=nearly colorless, Y=canary-yellow, Z=darker canary-yellow.
	B=weak		1.93	Corkite $2PbO.3Fe_2O_3.P_2O_5.2SO_3.6H_2O$	Medium $r<v$ very strong.	X=c	Ps. trig. Hex. plates. Cubic.	{0001} easy	Olive-green, etc.	H=4 G=4.1	Alunite group. Basal section divided into biaxial segments Abnormal green interference colors.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
□	1.886	1.939	1.930	Fersmanite $8(Ca,Na)(O,F_2).4TiO_2.3SiO_2$	$2V=0°$-$7°$ $2E=0°$-$14°$.	$Y=b$ X near c.	Mon.		Brown	H=5.5 G=3.44	
	1.92	1.96	1.95	Manganostibiite $10MnO.Sb_2O_5$	Small	X⊥ cleav. Ext. large.	Mon. Fib.	One	Black	Infus.	Sol. in HCl. Pleoc.: X=reddish brown. Z=nearly opaque.
□	*1.92	1.95	1.95	Catoptrite $2(Al,Fe)_2O_3.14(Mn,Fe,Ca)O.2SiO_2.Sb_2O_3$	Small $r>v$.	X nearly ⊥ cleav. Z tr. of {100}=14°. Incl. disp. strong.	Mon. Tab. {010}.	{100} very perf.	Black. In splinters blood-red. Luster metallic.	H=5.5 G=4.5	Not attacked by acid. Pleoc. strong in red-brown to red-yellow. Near manganostibiite and hematostibiite. Nordmark, Sweden.
	1.85	1.96	1.95±	Chapmanite $5FeO.5SiO_2.Sb_2O_5.2H_2O$	Small(?)	Z=elong. X⊥flat face.	Orth.(?). Minute laths.		Green	G=3.58	Insol. in acid.
∧	1.92	1.96	1.95	Larsenite $PbO.ZnO.SiO_2$	$2V=80°$	X=a	Orth. Pris.	{120} good	White. Greasy luster.	H=3 G=5.90	Olivine group.
	1.702	1.965	1.955	Durdenite $Fe_2O_3.3TeO_2.4H_2O$	$2V=22°$ $2E=44°$. $r>v$ very strong.	X⊥cleav.	Orth.	One perf.	Greenish yellow.	H=2-2.5 Fus.	Sol. in acid. Pleoc.: X=nearly colorless, Y=pale yellowish with a greenish tinge, Z=rather pale sulphur-yellow.
	*1.73	1.98	1.96	Melanovanadite $2CaO.3V_2O_5.2V_2O_4.nH_2O$	Medium	$Z=b$ $Y\wedge c=15°$.	Mon. Pris.	{010} perf.	Black	H=2.5 G=3.48 F=easy	Sol. in acid. Pleoc.: X=yellowish brown, Y=deep reddish brown, Z=dark reddish brown (almost opaque).

	B=weak.		1.96	Beudantite $2PbO.3Fe_2O_3.As_2O_5.2SO_3.6H_2O$	Medium Disp. abnormal.	X=c	Ps.trig. Acute rhombs, etc.	{0001}easy	Green, brown, black.	H=4 G=4.1 F=3.5	Alunite group. Rather sol. in hot dilute HCl. Base divided into six biax. segments. Abnormal interference colors. Complex tw.
	1.947	1.968	1.961	Alamosite $PbO.SiO_2$	2V=65° r<v extr.	Y=b Disp. slight.	Mon. Fib. b.	{010}perf.	Colorless	H=4.5 G=6.49	
⊂⊃	B=0.02		1.97	Tscheffkinite(altered) Titanosilicate of Ce, Fe, etc.	Small		Mon	Conch	Velvet-black	H=5 G=4.3-4.55 F=4	Gelat. Pleoc.: X=pale brown, Z=dark red-brown. In part isotropic.
V	1.871	2.005	1.975	Walpurgite $5Bi_2O_3.3UO_3.2As_2O_5.12H_2O$	2V=52° 2E=120°. Disp. slight.	Ext. {100} Y∧c=8°.	Tric. Tab. {010}, elong. c		Yellow-green, wax-yellow.	H=5 G=5.76 F=1.5	Tw.// tablets.
	1.93	2.02	1.99	Lanarkite $2PbO.SO_3$	2V=47° 2E=105°. r>v perc.	Y=b	Mon. Tab. {100}, elong. b.	{001}perf.	White, etc.	H=2-2.5 G=6.4-6.8 F=2	Somewhat sol. in hot dilute HCl.
∧	1.90	2.05±	2.00±	Walpurgite $5Bi_2O_3.3UO_3.2As_2O_5.12H_2O$	Large	X nearly ⊥ {010}.	Tric. Tab. {010}, elong. c.	{010}dist.	Wax-yellow	H=3.5 G=5.8 F=1.5	Tw. pl.{010}.
	1.87	2.01	2.00	Leadhillite $4PbO.SO_3.2CO_3.H_2O$	2V=10° 2E=20°. r<v strong.	X∧c=5½° Z=b.	Mon. Plates {001}.	{001}very perf.	Colorless	H=2.5 G=6.26-6.44 F=1.5	Effervesces in HNO_3.
⊂⊃	*1.91	2.03	2.01	Lorenzenite $Na_2O.2SiO_2.2(Ti,Zr)O_2$	2V=33° 2E=69°. r>v easily perc.	X=a Y=b.	Orth. Pris. c.	{100}perf.{110}less so.	Brown to black.	H=6 G=3.43 F=easy	Insol. in acid. Pleoc.: X and Y=pale orange, Z=pale yellow. Narsarsuk. Ramsayite from Kola has identical opt. properties.
⊂⊃	2.00	2.02	2.01	Volborthite $6(Cu,Ca,Ba)O.V_2O_5.15H_2O$	2V=0-90° r≷v very strong.	X nearly ⊥ plates.	Six-sided tablets.	One perf.	Olive-green, citron-yellow.	H=3-3.5 G=3.55 F=1.5(?)	Pleoc.: X=nearly colorless, Y and Z=pale green.
	2.00	2.02	2.01	Turanite $5CuO.V_2O_5.2H_2O$	Medium r>v strong.	Elong. +. Ext. parallel.	Orth.(?) Radial aggregates.		Dark olive-green.	H=5	Pleoc.: X=brown, Y=brown, Z=green. Cf. volborthite.
	2.01	2.07	2.04	Uzbekite $3CuO.V_2O_5.3H_2O$	Large r<v strong.				Dark green		Slightly pleoc.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	*1.99	2.08	2.04	Kolovratite Nickel vanadate	Near 90° $r<v$ very strong.		Crusts		Dark green		Gergano, Siberia.
	1.908	2.065	2.05	Pinakiolite $3MgO.B_2O_3.MnO.Mn_2O_3$	$2V=32°$ $2E=69°$. Disp. mod.	$X=b$ $Z=a$.	Orth. Rect. tablets{010}.	{010}perf.	Black	H=6 G=3.88 F=5	Sol. in HCl. Pleoc. not strong in reddish brown.
V	2.042	2.050	2.050	Pyromorphite $9PbO.3P_2O_5.PbCl_2$	Very small		Ps. hex. Pris.	{10$\bar{1}$0} {10$\bar{1}$1} traces.	Green, yellow, brown, white.	H=4 G=6.5–7.1 F=1.5	Sol. in HNO_3. Pleoc.: X=greenish-yellow, Z=green. 2V increases with As.
	*2.03	2.08	2.06	Duftite $2PbO.2CuO.As_2O_5.H_2O$	Large $r<v$ perc.		Curved aggregates.		Pale apple-green.	H=3 G=6.19 Fus.	Tsumeb.
>	2.06	2.08		Carnotite $K_2O.2UO_3.V_2O_5.8\pm H_2O$	Small	$X=c$	Orth. Rhombic plates {001}.	{001} perf.	Yellow	Soft F=dif.	Pleoc.: X=grayish yellow, Y and Z=lemon-yellow. Contains 1.32 per cent H_2O.
	1.804	2.078	2.076	Cerusite $PbO.CO_2$	$2V=8°$ $2E=17°$. $r>v$ large.	$X=c$ $Z=a$.	Orth. Pris. c.	{110}{021} dist.	Colorless	H=3 G=6.5	Sol. in dil. HNO_3. Uniax. at 415 A.
	1.95	2.10	2.09±	Emmonsite Hydrated ferric tellurite	$2V=20°\pm$ $2E=42°$. $r>v$ strong.	$Y=b$ X nearly ⊥ to a cleav.	Mon. Fib., plates.	{010} perf. Other less so.	Clear yellow-green.	H=5	In section colorless.
	B=0.01		2.09±	Montanite $Bi_2O_3.TeO_3.2H_2O$	Small $r<v$ extr.	Tend to lie nearly ⊥X.	Fib		Yellowish-white earthy incrustations.	Soft G=±3.79 F=1.5	Sol. in dilute HCl. Very abnormal green interference colors.
<	1.997	2.108	2.098	Clarkeite $(Ca,Pb,K_2,Na_2)O.3UO_3.3H_2O$	$2V=30°–50°$ $2E=65°–126°$. $r<v$ weak.			None	Dark brown to orange-brown.	H=4–4.5 G=6.39	Pleoc. in deep orange.

	1.70	2.23±	2.10	Metahewettite $CaO.3V_2O_5.9H_2O$	$2V=52°$ $2E=134°$.	$X\perp$ blades Z//elong.	Orth.(?). Broad blades.		Red	G=2.51 F=easy	Slightly sol. in H_2O. Pleoc.: X=light orange-yellow, Y and Z=deep red.
	*2.07	2.12	2.10	Trigonite $6PbO.2MnO.3As_2O_5.H_2O$	Very large $r<v$ easily perc.	$Y=b$ Ext. 45°.	Mon. Domatic	{010}very perf. {101}less so.	Sulphur-yellow to brownish.	H=2-3 G=8.28	Sol. in acid. Långban.
	1.816	2.126(?)	2.102	Fiedlerite $PbO.2PbCl_2.H_2O$		$Z=b$ $X\wedge\perp\{100\}=6°$.	Mon. Tab. {100}.	{001}dist.	Colorless	H=3 G=5.88	Sol. in HNO_3.
	*2.06	2.15	2.11	Curite $2PbO.5UO_3.4H_2O$	Large $r>v$ strong.	$Z=c$=elong.	Orth. Pris.	{100} perf.	Reddish brown.	H=4-5 G=7.19	Sol. in cold acid. Katanga.
	2.077	2.158	2.116	Laurionite $PbCl_2.PbO.H_2O$	$2V=82°$	$X=a$ $Z=c$.	Mon. Ps. orth. Pris. b or tab.{100}.	{100}dist.	Colorless	H=3 G=6.05 F=1	Sol. in HNO_3. Tw pl. {001}.
<	2.118	2.135	2.13	Mimetite $9PbO.3As_2O_5.PbCl_2$	$2V=29°$ or less. $2E=64°$.	$X=c$	Ps. hex. Pyram. c.	{10$\bar{1}$1}imperf.	Yellow to brown.	H=3.5 G=7.1 F=1	Isomor. with pyromorphite, vanadinite, etc. Sol. in HNO_3. Basal section in six segments with axial pl. // edges of hexagon.
	2.04	2.15	2.15	Matlockite $PbO.PbCl_2$	$2V=0°\pm$	$X=c$	Ps. tetrag.	{001}perf.	Yellow, etc.	H=3 G=7.21 F=easy	Decpd. by HNO_3.
□	B=0.05±		2.16±	Bismutite $Bi_2O_3.CO_2.nH_2O$(?)	Medium	Z=elong.	Massive. Fib.		Colorless	H=4 G=7.0± F=1.5	Sol. in HNO_3. May be in part amorphous.
	2.16	2.18	2.18	Kleinite Hg, NH_4, and Cl	Small $r<v$ very strong.		Ps. hex. Short prisms.	{0001}good.	Yellow to orange.	H=3.5 G=7.98	Sol. in HCl. Volatile. Darkens on exposure but regains its original color in dark. Uniax. above 130°. Poly. tw.
	1.77	2.35	2.18	Hewettite $CaO.3V_2O_5.9H_2O$	Medium	Z=elong.	Orth. Slender blades.			G=2.55 F=readily	Slightly sol. in H_2O. Pleoc.: X and Y=very light orange-yellow, Z=dark red.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	2.00$_{Li}$	2.35$_{Li}$	2.18$_{Li}$	Tellurite TeO_2	2V=90°. $r>v$ mod.	X=*b*. Z=*c*.	Orth. Tab. {010}, acic. *c*.	{010} very perf.	White	H=2 G=5.90 Fus.	Flexible.
	2.13	2.20	2.19	Baddeleyite ZrO_2	2V=30°. 2E=69°. $r>v$ rather strong.	X∧*c*=12°. Y=*b*.	Mon. Tab. {100}.	{001} perf.	Colorless to black.	H=6.5 G=5.7± Nearly infus.	Decpd. by conc. H_2SO_4. Poly. tw. {100}and{110}.
	1.94	2.51	2.20	Lepidocrocite $Fe_2O_3.H_2O$	2V=83°. Disp. slight.	X=*b*. Y=*a*.	Orth. Blades {010}, elong. *c*.	{010} very perf. {001} perf. {100} good.	Red. Streak dull orange.	H=4 G=4.1	Pleoc. strong: X=clear yellow, Y=red-orange, Z=orange-red. Abs.: X<Y<Z.
□	2.11	2.22	2.22	Vauquelinite $5(Pb,Cu)O.2CrO_3.P_2O_5$	Near 0°	X ∧ fib. small.	Mon. Fib.		Green to brown black.	H=3 G=6.0± F=2(?)	Sol. in H_2SO_4. Pleoc.: X=pale green, Z=pale brown. Abs.: Z>X. Tw. pl. {102}.
□	2.15	2.23	2.22	Goethite (impure) $Fe_2O_3.H_2O+nH_2O$	Small. Disp. strong.		Orth. Tetrag.	{010} perf.	Yellow. Streak same.	H=5 G=3.8± Infus.	Sol. in HCl. Pleoc.: X=clear yellow, Y=brownish yellow, Z=orange-yellow.
□	2.186	2.224	2.222	Fervanite $2Fe_2O_3.2V_2O_5.5H_2O$	Very small.	Ext. small.	Mon.(?) Fib.	None	Golden brown		Insol. in H_2O.
	*2.16	2.25	2.24	Chloroxiphite $2PbO.Pb(OH)_2.CuCl_2$	Medium. $r>v$ strong.	Z=*b*. X near *c*.	Mon. Blades {001}, elong. *b*.	{001} perf. {100} poor.	Dull olive-green.	H=2.5 G=6.76 F=easy	Sol. in HNO_3. Pleoc.: Z=emerald-green, Y=paler green, X=pale yellowish brown. Mendip Hills.
	B-strong			Thorotungstite $2WO_3.ThO_2.2H_2O$			Orth.(?) Acic.		Honey-yellow.	G=5.55	Attacked by acids.

	2.09	2.26	2.24	Tungstite $WO_3.H_2O$	Medium small $r<v$ rather strong.		Orth.	One perf.	Yellow to green. Earthy.	H=2.5 G=5.52(?) Infus.	Sol. in KOH but not in acids. Abs. rather strong: X>Y>Z.
^ v	2.17	2.32	2.26	Cuprodescloizite $2PbO.2CuO.V_2O_5.H_2O$	2V=73°± $r>v$ very strong.	X=fib	Orth. Stalactites, fib.	None	Siskin to olive-green, brown.	H=3–4 G=6.1 F=1.5	Sol. in dilute HNO_3. Pleoc. marked: X=very pale yellow, Y and Z=deep reddish brown.
	B=0.05±		2.26	Bismutite $Bi_2O_3.CO_2.nH_2O$(?)			Fib		Colorless	H=4–4.5 G=6.9± F=1.5	Sol. in acid. May be in part amorphous.
^ v	2.18	2.35	2.27	Descloizite $4(Pb,Zn)O.V_2O_5.H_2O$	Large $r<v$ rather strong.	X=c Z=a.	Orth. Short prisms.	None	Red, brown, black.	H=3.5 G=6.0± F=1.5	Sol. in dilute HNO_3.
^ v	2.17	2.31	2.29	Goethite (impure) $Fe_2O_3.H_2O+nH_2O$	2V=42° 2E=110° $r>v$ very strong.	X=b Z=c.	Orth. Fib. c.	{010}perf.	Yellow. Streak same.	H=5 G=3.8± Infus.	Sol. in HCl. Pleoc. X=clear yellow, Y=brownish yellow, Z=orange-yellow.
^ v	2.21$_{Li}$	2.33$_{Li}$	2.31$_{Li}$	Cuprodescloizite $2PbO.2CuO.V_2O_5.H_2O$	2V=47°± 2E=134°. $r>v$ strong.	X=fib	Orth. Stalactites, fib., grains.	None	Siskin to olive green, brown	H=3–4 G=6.1 F=1.5.	Sol. in dilute HNO_3. Pleoc. faint to strong in canary-yellow, etc.
	*2.30$_{Li}$	2.36$_{Li}$	2.34$_{Li}$	Ochrolite $4PbO.Sb_2O_3.2PbCl_2$	Near 90° $r>v$ strong.		Orth. Thick tablets {001}.		Sulphur - yellow.	H=3	Pajsberg.
^	2.21$_{Li}$ 2.26$_{Na}$	2.35$_{Li}$ 2.40$_{Na}$	2.35$_{Li}$ 2.39$_{Na}$	Goethite (pure) $Fe_2O_3.H_2O$	Small $r>v$ extr.	X=b Z=c.	Orth. Fib. c.	{010}very perf.	Brown to black	H=5–5.5 G=4.0–4.4 Infus.	Sol. in HCl. Pleoc. perceptible in red-brown. Abs.: X<Y and Z.
	2.25$_{Li}$	2.36$_{Li}$	2.35$_{Li}$	Schwartzembergite $2PbO.Pb(I,Cl)_2$	Small Disp. slight.		Ps. tetrag.	None	Honey-yellow.	H=2–2.5 G=6.2 F=1	Sol. in hot HNO_3.
	2.18	2.35	2.35	Valentinite Sb_2O_3	Very small $r<v$ mkd.	X=a $Z_{Li}=b$.	Orth. Fib. c.	{010}perf.	White, gray, rose, etc.	H=3 G=5.57 F=1.5	Sol. in HCl. Volatile.
□	*2.32	2.37	2.36	Pyrobelonite $4(Mn,Pb)O.V_2O_5.H_2O$	2V=29° 2E=73°. $r>v$ easily perc.	X=a Y=c.	Orth. Pris. c.	None	Deep red	H=3.5 G=5.38	Near descloizite. Mn:Pb=7:4. Pleoc. in red-brown. Abs. Y>X and Z. Långban.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Biaxial negative group—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	B=very low	----------	2.38	Perofskite $CaO.TiO_2$	$2V=90°\pm$ $r>v$.	----------	Ps. isomet.	Cubic dist.	Brown-black	H=5.5 G=4.04 Infus.	Decpd. by H_2SO_4. Complex poly. tw. Isot. in part.
□	B=extr.	----------	2.40_{Li}	Ferrocolumbite $FeO.Cb_2O_5$	----------	----------	Orth.	Poor	Black	H=6 G=6.26± Infus.	Insol. Nearly opaque Abs. rather strong: Z>X.
	2.41_{Li}	2.51_{Li}	2.50_{Li}	Pucherite $Bi_2O_3.V_2O_5$	$2V=20°\pm$ $2E=52°$. $r<v$ extr.	X=c. Y=a.	Orth. Tab. {001}, acic.	{001}perf.	Reddish brown	H=4 G=6.25 F=2	Sol. in HCl with evolution of Cl.
□	$2.45_{Li}\pm$	$2.55_{Li}\pm$	$2.55_{Li}\pm$	Hematite (hydrous) $Fe_2O_3+nH_2O$	Near 0°	Elong.−	Compact, fib.	----------	Brownish-black. Powder red.	H=5–6 G=4.3± Infus.	Hematite with admixed H_2O. Dif. sol. in acid. Pleoc. faint.
	2.48_{Li}	2.60_{Li}	2.58_{Li}	Smithite (?) $Ag_2S.As_2S_3$	$2V=26°\pm$ $2E=71°$. $r>v$ strong.	Y=b. Z∧c=6°.	Mon. Hex. tablets.	{100}perf.	Scarlet to vermilion, streak same.	H=2 G=4.88	Pleoc. very weak. See Trechmannite (p. 94).
	2.46_{Li} 2.538_{Na}	2.61_{Li} 2.704_{Na}	2.59_{Li} 2.684_{Na}	Realgar AsS	$2V_{Li}=40°\pm$ $2E=125°$. $r>v$ very strong.	Y=b. X∧c=11°. Disp. strong.	Mon. Short prisms c.	{010} rather perf. Sectile.	Aurora-red to orange-yellow.	H=1.5–2 G=3.56 F=1	Sol. in alkalies. Volatile. Pleoc.: X= nearly colorless, Y and Z=pale golden yellow.
	*2.52$_{Li}$	2.67_{Li}	2.61_{Li}	Koechlinite $Bi_2O_3.MoO_3$	Large $r<v$ rather strong.	Y=c. Z=a.	Orth. Sq. tablets{100}. Diagonal striations//c.	{100}perf.	Greenish yellow.	Fus.	Sol. in HCl. Pleoc. in thick sections. Schneeberg.
	2.35_{Li}	2.66_{Li}	2.64_{Li}	Terlinguaite Hg_2OCl	$2V_{Li}=20°$ $2E=54°$. $r<v$ extr.	----------	Mon. Pris. c.	{101}perf.	Sulphur-yellow, etc.	H=2–3 G=8.73	Volatile.

2.4±$_{Li}$	3.02$_{Li}$	2.81$_{Li}$	Orpiment As_2S_3	2V=76°. $r>v$ strong.	X=b. Y∧c=1.5°–3°.	Mon. Foliated	{010} highly perfect.	Lemon-yellow.	H=2 G=3.4 F=1	Sol. in H_2SO_4. Volatile. Luster on {010} pearly.
B=extreme		3	Xanthoconite $3Ag_2S.As_2S_3$	2V=34°. 2E=125°±. $r<v$.	Y near a. Z=b.	Mon. Ps. trig. Tab. {001}.	{001} dist.	Orange-yellow, etc.	H=2–3 G=4.1–5.6 F=1	Sol. in HNO_3. In section lemon-yellow. Tw. pl. {001} common.
B=extreme		3	Livingstonite $HgS.2Sb_2S_3$			Pris.	Pris. at 90°.	Lead-gray, streak red.	H=2 G=4.81 F=1	Volatile. Faintly pleoc. in red.
B=very strong		3	Polybasite $9(Ag,Cu)_2S.Sb_2S_3$	2V=22°. 2E=70°±.	X=c. Y=a.	Mon. or orth. Tab. {001}.	{001} imperf.	Iron-black, in splinters cherry-red.	H=2–3 G=6.1 F=1	Decpd. by HNO_3. In section cherry-red.
3.078$_{Na}$ 2.779$_{Li}$	3.188$_{Na}$ 3.073$_{Li}$	3.176$_{Na}$ 3.063$_{Li}$	Hutchinsonite $(Tl,Ag,Cu)_2S.PbS.2As_2S_3$(?)	2V=38°. $r<v$ extr.	X=b. Z=c.	Orth. Flattened rhombs.	{100} good.	Scarlet to vermilion, streak same.	H=1.5–2 G=4.6	Pleoc. very weak. Abs. strong.
B=very strong		3.27(?)	Smithite $Ag_2S.As_2S_3$	2V=65°±.	Y=b. Z∧c=6°.	Mon. Hex. tablets.	{101} perf.	do.	H=1.5–2 G=4.88	Pleoc. very weak.
3.194	4.303	4.046	Stibnite Sb_2S_3	2V=26°. 2E=129°. Disp. extr.	X=c. Z=b.	Orth. Acic. Striated c.	{010} highly perf. {100} {110} imperf.	Lead-gray, streak same.	H=2 G=4.6 F=1	Sol. in HCl. Translucent to red. Luster metallic.

Minerals of unknown optical character

[The few minerals in this group were so finely crystalline, so intricately twinned, so weakly birefracting, or so deeply colored that their optical character has not been determined. A number of these very finely crystalline minerals may not be homogeneous or may be submicroscopic impure varieties of some mineral that apparently has rather different composition and other properties. A difference in content of water, in particular, is a very unsafe criterion for distinguishing between the very finely crystalline minerals, for the content of water in many of them varies according to the treatment of the material before analysis, and a specimen analyzed shortly after being taken from the ground may contain much more water than it would contain after it had been kept in a dry place for some time. This water may be in part hygroscopic water and in part may come from admixed amorphous material]

B=weak		1.427	Ralstonite $(Na_2,Mg)F_2.3Al(F,OH)_3.2H_2O$			Isomet. Oct.		Colorless.	H=4.5 G=2.61 Infus.	Insol. in HCl. Opt. anom. Divides into sections corresponding to oct. Alteration of cryolite.
			Mallardite $MnO.SO_3.7H_2O$			Mon. Fib.		do.		Rapidly loses water on exposure.
B=0.02		1.48	Vashegyite $4Al_2O_3.3P_2O_5.30H_2O$		Elong.+	Minute fib.		White, yellowish, greenish.	H=2–3 G=1.96 Infus.	Easily sol. in acid.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Minerals of unknown optical character—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	B=feeble		1.500	Bilinite $FeO.Fe_2O_3.4SO_3.24H_2O$	Ext. 35° to 39°		Fib		White to yellow.	H=2 G=1.875	A ferric iron halotrichite.
◇			1.51	Hisingerite Hydrous silicate of FeO, Fe_2O_3, MgO			Cryptocrystalline.		Black, brownish-black.	H=3 G=2.5-3.0 Infus.	Decpd. by HCl. In part amorphous.
	B=0.01		1.537	Chalcedony SiO_2			Fib			H=6 G=2.6 Infus.	Insol.
		1.542		Glaucokerinite $10(Zn,Cu)O.2Al_2O_3.SO_3.7H_2O$		Z=elong	Radially fib		Sky-blue	Very soft G=2.75	
	B=0.02±		1.55	Zepharovichite $Al_2O_3.P_2O_5.6H_2O$		Elong.+	Cryptocrystalline fib., plates.		Grayish, greenish, yellowish.	H=5.3 G=2.37 Infus.	Sol. in HCl.
				Wapplerite $2CaO.As_2O_5.8H_2O$	2E=55° $r<v$.	Z near *b*. Axial pl. $\wedge c=69\frac{1}{2}°$	Mon.(?) Equant.	{010} perf	White	H=2.5 G=3.48	
□	B=weak		1.552	Zirklerite $2Al_2O_3.9(Fe,Mg,Ca)Cl_2.3H_2O$			Rhomb	Rhomb. cleav.		H=3.5 G=2.6	Sol. in acids. Decpd. by H_2O with separation of Al_2O_3 and $Fe(OH)_3$.
	1.595	1.603	1.60	Riversideite $2CaO.2SiO_2.3H_2O$		Z=elong	Fib		White	H=3 G=2.64 F=2	Decpd. by acid.
	1.593	1.607	1.603	Crestmoreite $4CaO.4SiO_2.7H_2O$		do	do		do	H=3 G=2.22 F=easy	Do.
	*B=0.02±		1.64	Bakerite $8CaO.5B_2O_3.6SiO_2.6H_2O$			Cryptocrystalline.		do	H=4.5 G=2.7-2.9 Fus.	Gelat. with HCl. Calico Hills.

			Kremersite $KCl.NH_4Cl.FeCl_3.H_2O$			Orth. Oct.		Ruby red		Sol. in H_2O. Unstable.
B=0.01		1.73±	Stibiconite(?) $Sb_2O_4.nH_2O$		Z=elong	Fib		White, earthy	H=4–5.5 G=5.1–5.3 Infus.	Insol. in HCl.
1.72	1.80	1.75±	Rutherfordine $UO_3.CO_2$.			Minute fib		Yellow, earthy	Soft G=4.82	Sol. in acid.
1.76	1.81	1.8±	Glockerite $2Fe_2O_3.SO_3.6H_2O$(?)			Fib., crusts		Brown, yellow, black, dull green.	Soft	
B=rather strong		1.88	Chenevixite $2CuO.Fe_2O_3.As_2O_5.2H_2O$			Cryptocrystalline.		Dark green to greenish yellow.	H=4 G=3.9 F=2.5	
B=0.01±		1.91	Daubréeite $2Bi_2O_3.BiCl_3.3H_2O$(?)			do		Gray powder	H=2 G=6.4 F=1.5(?)	Sol. in HCl.
			Molysite $FeCl_3$			Hex		Red, yellow, brown.	G=2.80	Unstable.
			Dolerophanite $2CuO.SO_3$			Mon		Brown		Do.
B=strong		2.0±	Bindheimite(?) Antimonate of Pb $+H_2O$					Gray	H=4 G=4.5–5 F=3–4	
B=strong		2.05	Fernandinite $CaO.V_2O_4.5V_2O_5.14H_2O$			Fib		Dull green		Partly sol. in H_2O. Sol. in acid to a green solution.
B=weak		2.09	Schneebergite $2CaO.Sb_2O_4$			Ps. isomet. Oct.		Brown, yellow	H=6.5 G=4.1 Infus.	Insol.
*2.10	B=strong	2.1	Rhagite $5Bi_2O_3.2As_2O_5.9H_2O$(?)		X=elong	Cryptocrystalline aggregates.		Yellow, green	H=5 G=6.82	Schneeberg.
B=strong		2.15	Cuprotungstite $2CuO.WO_3.H_2O$			Cryptocrystalline. Fib.		Green	H=4.5	
B=mod.		2.25±	Bismutite $Bi_2O_3.CO_2.H_2O$(?)			Cryptocrystalline.		Gray, etc.	H=4–4.5 G=6.8–7.7 F=1.5	Sol. in acid.

TABLE 4.—*Data for the determination of the nonopaque minerals*—Continued

Minerals of unknown optical character—Continued

Variability	α	γ	β	Mineral name and composition	Axial angle and dispersion	Optical orientation	System and habit	Cleavage	Color	Hardness, specific gravity, and fusibility	Remarks
	B=strong		2.40_{Li}	Ferberite $FeO.WO_3$			Tetrag.		Black	H=4 G=6.64	Translucent only in thinnest edges with reddish colors. Pleoc.
	B=weak		2.42_{Li}	Minium Pb_3O_4		X// fib.	Cryptocrystalline. Fib., powder.		Vivid red, streak orange-yellow.	H=2–3 G=4.6 F=1.5	Abnormal green interference color. Pleoc.: Nearly colorless to deep reddish brown.
□	B=strong		$2.45\pm_{Li}$	Columbite $(Fe,Mn)O.(Cb,Ta)_2O_5$			Orth.	{100}good	Black	H=6 G=5.48± Infus.	Insol. in acid. G indicates about 10 per cent Ta_2O_5. Nearly opaque and dark red on thin edges.
□				Magnetoplumbite $2(Pb,Mn)O.3Fe_2O_3$			Hex. Acute pyramids.	{0001} perf.	do	H=6 G=5.52	Streak brown. Luster metallic.
				Quenselite $2PbO.Mn_2O_3.H_2O$			Mon.	{001} very perf.	Pitch-black	H=2.5 G=6.7–6.8	Sol. in acid.
	B=weak			Kalkowskyn $(Fe,Ce)_2O_3.4(Ti,Si)O_2$			Fib.	Conch.	Black or brown.	H=3–4 G=4.01 Infus.	Decpd. by acid.
	B=weak		2.49_{Li}	Eglestonite Hg_4Cl_2O			Ps. isomet.	None	Brownish-yellow. Darkens on exposure.	H=2–3 G=8.33.	Decpd. by acid. Volatile.
	B=mod.		$2.62\pm_{Li}$	Arizonite $Fe_2O_3.3TiO_2$			Mon.(?)	Conch.	Steel gray	H=5–6 G=4.25	Decpd. by hot H_2SO_4. Translucent only in very thin edges in blood red. Pleoc. weak. Abs.: X<Z.

B=strong		2.63red 3.17blue	Tenorite CuO		X oblique to plates; on laths Z′∧ elong. and tw.pl.=35°±.	Mon. Laths	{111}perf. {001} less so.	Black scales	H=3–4 G=6.45 F=3	Abs. in brown, very strong, X<Z.
B=very strong		Extr.	Dufrenoysite $2PbO.As_2O_3$			Mon	{010}perf	Blackish lead-gray, streak reddish brown.	H=3 G=5.55–5.57 F=1	Sol. in HNO_3. Nearly opaque in section and slightly pleoc.
B=very strong		do	Ilmenite $FeO.TiO_2$			Trig	None	Iron-black	H=5–6 G=4.7± Infus.	Nearly opaque.
		do	Sartorite $PbS.As_2S_3$			Orth. Needles	{001}	Dull brown	H=3 G=5.4 F=1	Sol. in HNO_3.
(?)		do	Frieseite $Ag_2Fe_3S_8$			Orth. Tab. {001}.	{001}perf	Pinchbeck-brown to black.	H=2.5 G=4.21	Opaque to translucent in greenish gray.

DATA ON MINERAL GROUPS

TABLE 5.—*Alunite group*

The minerals in this group are uniaxial, the aluminum members positive in optical character, the ferric members negative. The birefringence of the jarosites, the negative members, is greater than that of the aluminum minerals in the group. In general mixed crystals are not formed. Basal cleavage is distinct.

Uniaxial positive

Mineral and composition	ω	ε	Specific gravity
Alunite $K_2O.3Al_2O_3.4SO_3.6H_2O$	1.572	1.592	2.60
Natroalunite $Na_2O.3Al_2O_3.4SO_3.6H_2O$	1.585	B=.01	2.6
Goyazite $2SrO.3Al_2O_3.2P_2O_5.7H_2O$	1.620	1.630	3.2
Georgeixite $(Ba,Ca,Ce)O.2Al_2O_3.P_2O_5.5H_2O$	1.625	B=weak	3.10
Svanbergite $2SrO.3Al_2O_3.P_2O_5.2SO_3.6H_2O$	1.626	1.640	3.52
Plumbogummite $2PbO.3Al_2O_3.2P_2O_5.7H_2O$	1.654	1.676	4
Hinsdalite $2PbO.3Al_2O_3.2SO_3.P_2O_5.6H_2O$	1.671	1.689	3.65
Florencite $Ce_2O_3.3Al_2O_3.2P_2O_5.6H_2O$	1.680	1.685	3.59

Uniaxial negative

Ammoniojarosite $(NH_4)_2O.3Fe_2O_3.4SO_3.6H_2O$	1.80	1.75	----------
Jarosite $K_2O.3Fe_2O_3.4SO_3.6H_2O$	1.820	1.715	3.2
Natrojarosite $Na_2O.3Fe_2O_3.4SO_3.6H_2O$	1.830	1.750	3.2
Argentojarosite $Ag_2O.3Fe_2O_3.4SO_3.6H_2O$	1.882	1.785	3.65
Plumbojarosite $PbO.3Fe_2O_3.4SO_3.6H_2O$	1.875	1.784	3.63
Corkite $2PbO.3Fe_2O_3.P_2O_5.2SO_3.6H_2O$	1.93	B=low	4.2±
Beudantite $2PbO.3Fe_2O_3.As_2O_5.2SO_3.6H_2O$	1.96	B=low or moderate	4.1±

TABLE 6.—*Amphibole group*

The general formula [27] of the alkali and lime amphiboles is $(Ca,Na)_2Na_{0-1}Mg_1(Mg,Al)_4(Al,Si)_2Si_6O_{22}(O,OH,F)_2$, with K replacing Na in part and Fe'',Fe''',Mn, and Ti replacing more or less Mg and Al.

For those amphiboles free of calcium and sodium the formula $(Mg,Fe)_7Si_8O_{22}(OH)_2$ adequately expresses the composition.

In the following table the formulae are doubled in order to show better the real variations in composition of the material for which optical data are given. The table is divided into (A) the orthorhombic amphiboles and (B) the mono-

[27] Berman, Harry, and Larsen, E. S., Composition of the alkali amphiboles: Am. Mineralogist, vol. 16, p. 140, 1931.

TABLE 6.—*Amphibole group*—Continued

clinic amphiboles. (B) is further divided into (1) the cummingtonite series, (2) the tremolite-actinolite series, (3) the hornblende series, and (4) the soda amphibole series. The third and fourth divisions might easily be further subdivided, but for the present purposes a further subdivision seems inadvisable.

A. ORTHORHOMBIC AMPHIBOLES

The composition of the orthorhombic amphiboles is expressed by the formula $(Mg,Fe)_7Si_8O_{22}(OH)_2$. Probably only a portion of the Mg is replaceable by Fe, for no member of this series high in iron is known.

The index of refraction and specific gravity increase with the iron content. The birefringence is about 0.02 ± 0.005. The Mg members are optically negative and have large axial angles, but as the iron increases in amount the axial angle increases and passes through 90°. (See No. 4 of table below.) Thus the iron-rich members are optically positive. The orientation for all the members is $Y=b$, $Z=c$.

B. MONOCLINIC AMPHIBOLES

Cummingtonite series.—The cummingtonite series has the composition $(Fe,Mg)_7Si_8O_{22}(OH)_2$, which is similar to that of the orthorhombic members. The Fe predominates, however, in the monoclinic series, whereas Mg predominates in the orthorhombic series. Rarely Mn (and in one entry, No. 6, Zn) enters into the composition.

The axial angle about X is large, the dispersion is noticeable, and the birefringence (0.035 ± 0.005) is greater than that in the orthorhombic series. The extinction $Z \wedge c$ ranges from 11° to about 16°, increasing with the Mg content. In all members $Y=b$. Pleochroism is not strong in yellow and brown, and the absorption formula is $X<Y<Z$.

Tremolite-actinolite series.—The tremolite-actinolite series has the composition $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$. A slight amount of Al may replace the Si, with the attendant addition of Na to the composition. The small amounts of Al and Na thus introduced apparently have little effect on the optical properties.

The birefringence of this series (0.025 ± 0.005) is less than that of the cummingtonite series and somewhat greater than the birefringence of the hornblende series. The axial angle is large about X; and the extinction angle $Z \wedge c$ ranges from 14° to about 20°, increasing with the Mg content. Pleochroism is only apparent in the members high in Fe. In all members $Y=b$.

Hornblende series.—The amphiboles grouped together in the hornblende series show a considerable variation in composition. The principal feature of the composition which characterizes the series, as here grouped, is the presence of both Ca and Na, the former predominating. Further, most of the members deficient in silica belong here. The composition of the series may be expressed by the formulae $Ca_4Na_2Mg_{10}Al_2Si_{14}O_{44}(OH,F)_4$ and $Ca_4Na_2Mg_8Al_6Si_{12}O_{44}(OH,F)_4$ with Fe'' replacing Mg, and Fe''' replacing Al in part. Fluorine commonly enters into the composition, as do Ti and Mn. Many of the members of this series depart from the compositions expressed by the formulae above, but they are entered here because of their intermediate composition between the second and fourth groups.

The nomenclature of this series is complicated and unsystematic, as most of the names are based on optical peculiarities rather than on the more fundamental property of chemical composition. In this table composition is used as a basis for nomenclature, according to the following system:

(1) $Ca_4Na_2(Mg,Fe)_{10}Al_2Si_{14}O_{44}(OH,F)_4$ = edenite.

(2) $Ca_4Na_2(Mg,Fe)_8Al_6Si_{12}O_{44}(OH,F)_4$ = hastingsite.

TABLE 6.—*Amphibole group*—Continued

Intermediate members between (1) and (2) are designated pargasite. The high iron members of the series are here called hornblende. Kearsutite is used for the titanium-rich members and basaltic hornblende for those members containing appreciable Ti with less Mg+Fe than hastingsite and less (OH) than the normal amphiboles.

The optical properties of this series are more varied than are those of the other groups. The birefringence is in general less than that in the tremolite-actinolite series and greater than that in the more alkalic amphiboles. There are, however, striking exceptions to this rule. The extinction, $Z/\wedge c$, is very variable, and $Y=b$ in most measurements. The axial angle (2V) is likewise variable. Most of the members are optically negative, but high Mg and Al members are optically positive.

Soda amphibole series.—In the soda amphibole series are included all amphiboles in which the Na (+K) exceeds the Ca. Here, as in the hornblende series, the composition shows considerable variability. The most alkaline members may be expressed by the formulae $Na_3Fe''_3Fe'''_2Si_8O_{23}(OH)$ (riebeckite), and $Na_3(Fe,Mg)_4(Fe,Al)Si_8O_{22}(OH)_2$ (arfvedsonite). Ca enters into the composition of many of the members here included.

The members of this series have a considerably lower birefringence than the other amphiboles. Pleochroism is marked, commonly in blue and violet.

With increase of Na there is a change from the normal amphibole orientation, so that $Z=b$ and $X\wedge c$ is small. The optical sign is generally negative.

TABLE 6.—*Amphibole group*—Continued

No.	α	β	γ	Name	Composition											Miscellaneous
					Ca	Na	Mg+Fe	Al+Fe'''	Ti	Si	O	OH	F	Mg/Fe	Al/Fe	
Anthophyllite series																
1	1.598	-------	1.623	Anthophyllite	-------	-------	-------	-------	-------	-------	-------	-------	-------	21	-------	
2	1.608	-------	1.631	----do	-------	-------	-------	-------	-------	-------	-------	-------	-------	9	-------	
3	1.629	1.635	1.640	----do	-------	-------	-------	-------	-------	-------	-------	-------	-------	5	-------	
4	1.633	1.638	1.652	----do	-------	-------	-------	-------	-------	-------	-------	-------	-------	2.6	-------	
Cummingtonite series																
5	1.639	1.647	1.664	Cummingtonite	-------	-------	-------	-------	-------	-------	-------	-------	-------	1.5	-------	
5a	1.650	1.665	1.679	----do	-------	-------	-------	-------	-------	-------	-------	-------	-------	.8	-------	
6	1.657	1.674	1.685	Zinc cummingtonite	-------	-------	-------	-------	-------	-------	-------	-------	-------	(a)	-------	
7	1.663	1.684	1.699	Gruenerite	-------	-------	-------	-------	-------	-------	-------	-------	-------	.4	-------	
8	1.666	1.684	1.700	----do	-------	-------	-------	-------	-------	-------	-------	-------	-------	.2	-------	
9	1.677	1.697	1.717	----do	-------	-------	-------	-------	-------	-------	-------	-------	-------	.1	-------	
Tremolite-actinolite series																
10	1.599	1.613	1.625	Tremolite	4	-------	10	-------	-------	16	44	4	-------	-------	-------	Al_2O_3=1.30 per cent.
11	1.600	1.616	1.627	----do	4	-------	10	-------	-------	16	44	4	-------	-------	-------	
12	1.602	1.618	1.631	----do	4	-------	10	-------	-------	16	44	4	-------	-------	-------	Al_2O_3=1.21 per cent.
13	1.602	1.614	1.635	----do	4	-------	10	-------	-------	16	44	4	-------	75	-------	Al_2O_3=1.80 per cent.
14	1.604	1.617	1.630	----do	4	-------	10	-------	-------	16	44	4	-------	20	-------	Al_2O_3=1.30 per cent.
15	1.609	1.623	1.636	----do	4	0.5	10	0.5	-------	15.5	44	4	-------	13	6.3	
16	1.609	1.622	1.636	----do	4	1	10	-------	-------	16	45	2	1	40	-------	
17	1.613	1.621	1.634	----do	4	1	10	1	-------	15	44	2	2	11	3	
18	1.614	1.630	1.641	Actinolite	4	-------	10	-------	-------	16	44	4	-------	7.4	-------	
19	1.615	1.629	1.637	Richterite	3	2	10	-------	-------	16	44	4	-------	-------	-------	Mg/Mn=6.9.
20	1.616	1.630	1.641	Actinolite	4	1	10	1	-------	15	44	3	1	8	1.7	
21	1.617	1.633	1.641	----do	4	.5	10	.5	-------	15.5	44	4	-------	6.8	2.4	
22	1.624	1.638	1.650	----do	4	1	10	1	-------	15	44	3	1	4.6	1.4	
23	1.628	1.644	1.655	----do	3.5	1.5	9.5	.5	-------	15	44	4	-------	6	2.7	Some F.

TABLE 6.—*Amphibole group*—Continued

No.	α	β	γ	Name	Axial angle and dispersion	Optical sign	Birefringence	Orientation	Specific gravity	Color	Remarks
Anthophyllite series											
1	1.598		1.623	Anthophyllite			0.025		3.06	Light yellow	
2	1.608		1.631	do			.023		3.03	Brown and green.	
3	1.629	1.635	1.640	do			.011(?)		3.09	Clove-brown	Opt.(+) for red light.
4	1.633	1.638	1.652	do			.019		3.16	Colorless	
Cummingtonite series											
5	1.639	1.647	1.664	Cummingtonite	112°		0.251	Z∧c=16°	3.24		
5a	1.650	1.665	1.679	do	87°		.029	Z∧c=16°	3.31	Gray-brown	X and Y=yellow, Z=brown.
6	1.657	1.674	1.685	Zinc cummingtonite	75°		.028	Z∧c=15°	3.44	Green	Mg:Fe:Mn:Zn=20:18:19:13.
7	1.663	1.684	1.699	Gruenerite	79°		.036	Z∧c=14½°	3.40	Black	X and Y nearly colorless, Z=yellow.
8	1.666	1.684	1.700	do	85°-86°		.034				X=colorless, Y=pale yellow, Z=pale green.
9	1.677	1.697	1.717	do	82°		.040	Z∧c=11°	3.52	Black	X and Y=colorless, Z=pale yellow-brown.
Tremolite-actinolite series											
10	1.599	1.613	1.625	Tremolite	Large		0.026	Z∧c=20°			Almost pure.
11	1.600	1.616	1.627	do	80°		.027	Z∧c=15°	2.980	Colorless	
12	1.602	1.618	1.631	do	82°		.029	Z∧c=15½°			
13	1.602	1.614	1.635	do	Large		.033	Z∧c=17°			
14	1.604	1.617	1.630	do	88°		.026	Z∧c=18°	3.02	Light green	
15	1.609	1.623	1.636	do			.027	Z∧c=16°		Green	
16	1.609	1.622	1.636	do			.027	Z∧c=17°-18°			
17	1.613	1.621	1.634	do			.021	Z∧c=17°	3.06		
18	1.614	1.630	1.641	Actinolite	80°		.027	Z∧c=16°	3.04	Green	
19	1.615	1.629	1.637	Richterite	69°		.022	Z∧c=17°	3.15		
20	1.616	1.630	1.641	Actinolite	Large		.025	Z∧c=15°			
21	1.617	1.633	1.641	do	do		.024	Z∧c=15°			
22	1.624	1.638	1.650	do	do		.026				X=colorless, Y=yellow-green. Z=blue-green.
23	1.628	1.644	1.655	do	do		.027	Z∧c=14°			X and Y=pale brown, Z=light green.

TABLE 6.—*Amphibole group*—Continued

Hornblende series

No.	α	β	γ	Name	Composition											
					Ca	Na	Mg+Fe	Al+ Fe'''	Ti	Si	O	OH	F	$\frac{Mg}{Fe}$	$\frac{Al}{Fe}$	Miscellaneous
24	1.618	1.631	1.642	Pargasite	4	1	8	3		15	46	2		5.1	5.5	
25	1.659	1.673	1.681	do	4	1	8	5		13	44	4		1.5	.2	
26	1.692	1.730	1.760	Kearsutite	4	1	7	5	2	12	46	2		5.7	1.7	
27	1.621	1.627	1.642	Edenite	4	2	10	1		15	45	3				
28	1.622	1.630	1.645	do	4	2	10	2		14	44	2	2	13	16	
29	1.613	1.618	1.633	Pargasite	4	2	9	4		13	44	1	3			
30	1.614	1.619	1.633	do	4	2	9	4		13	44	1	3			
31	1.616	1.62	1.635	do	4	2	9	4		13	44	2	2	23	21	
32	1.619	1.626	1.641	do	4	2	9	4		13	44	4		36	67	
33	1.622	1.628	1.643	do	4	2	9	4		13	44	4		16	17	Na/K=5.
34	1.622	1.632	1.641	Hastingsite	4	2	8	6		12	44	1	3	10	12	
35	1.633	1.638	1.652	Pargasite	4	2	9	4		13	44	2	2	6.2		
36	1.640	1.646	1.659	do	4	2	9	4		13	44	2	2	2		
37	1.653	1.663	1.670	do	4	2	9	4		13	44	4		4	4	TiO_2=1.55 per cent.
38	1.653	1.661	1.669	Hastingsite	4	2	8	6		12	44	4		13	2.8	
39	1.658	1.670	1.680	Pargasite	4	2	9	3	.5	13.5	44	3	1	1.4	4.3	
40	1.659	1.673	1.681	do	4	2	9	4		13	44	4		1.4	4.8	
41	1.663	1.677	1.685	Hastingsite (soretite)	4	2	8	6		12	44	4		1.7	2.1	
42	1.664	1.672	1.680	Hastingsite	4	2	8	6	1	11	44	4		4.5	4.1	
43	1.667		1.688	Basaltic hornblende	4	2	7	7		12	45	3		7	3	
44	1.670		1.693	do	4	2	7	6	1	12	46	2		3.5	4.5	
45	1.675	1.691	1.701	do	4	2	8	5	1	12	45	3		4.3	4.2	
46	1.676	1.700	1.718	do	4	2	7	6	1	12	46	2		12	3	
47	1.677		1.700	do	4	2	7	6	1	12	46	2		4	3	
48	1.679	1.694	1.698	Hornblende	4	2	8	6		12	44	4		.9	3.4	
49	1.681		1.700	Basaltic hornblende	4	2	6	7	1	12	47	1		2.2	1.6	
50	1.687		1.708	do	4	2	7	7	1	11	45	3		1.5	2	
51	1.693	1.711	1.713	do	4	2	8	5	1	12	44	4		.03	4	
52	1.693	1.710	1.713	Hornblende	4	2	8	6		12	44	4		.1	2.5	
53	1.693		1.714	do	4	2	8	6	1	11	44	4		.14	3	
54	1.695		1.711	do	4	2	8	6		12	44	4		0	2	
55	1.698	1.719	1.722	do	4	2	8	6		12	44	4		.15	4.7	

TABLE 6.—*Amphibole group*—Continued

Hornblende series

No.	α	β	γ	Name	Axial angle and dispersion	Optical sign	Birefringence	Orientation	Specific gravity	Color	Remarks
24	1.618	1.631	1.642	Pargasite	90°	−	0.024	Z∧c=15°	3.15	Green	
25	1.659	1.673	1.681	do	66°	−	.022	Y=b; Z∧c=16½°	3.23		
26	1.692	1.730	1.760	Kearsutite	80°	−	.068	Z∧c=1°	3.34	Black	X=pale olive, Y=brown, Z=dark brown.
27	1.621	1.627	1.642	Edenite	64°	+	.021	Z∧c=22°			
28	1.622	1.630	1.645	do	60° r<v	+	.023	Z∧c=27°		Brownish green.	X=colorless, Y=light violet, Z=violet-blue.
29	1.613	1.618	1.633	Pargasite	53°	+	.020	Z∧c=28°			
30	1.614	1.619	1.633	do	58°	+	.019	Y=b; Z∧c=27°	3.095		
31	1.616	1.62	1.635	do	59°	+	.017	Z∧c=27°	3.095	Green	
32	1.619	1.626	1.641	do	70°	+	.022	Z∧c=21°			
33	1.622	1.628	1.643	do	66°	+	.021	Z∧c=24°			X=colorless. Y=very light green, Z=brown-green.
34	1.622	1.632	1.641	Hastingsite		−	.019	Z∧c=18°	3.16		
35	1.633	1.638	1.652	Pargasite	63°	+	.019	Z∧c=26°	3.19		
36	1.640	1.646	1.659	do	65°	+	.019	Z∧c=26°	3.20		
37	1.653	1.663	1.670	do	64°	−	.017	Z∧c=40°	3.16		X=pale yellow, Y and Z=green.
38	1.653	1.661	1.669	Hastingsite	90° r>v	−	.016	Z∧c=26°	3.14		
39	1.658	1.670	1.680	Pargasite	Large	−	.022	Z∧c=24°			X and Y=light-green, Z=dark green.
40	1.659	1.673	1.681	do	66°	−	.022	Z∧c=17°	3.23	Green	
41	1.663	1.677	1.685	Hastingsite (soretite)	83°	−	.022	Z∧c=19°	3.23		
42	1.664	1.672	1.680	Hastingsite	90° r>v	−	.016	Z∧c=29°	3.19		
43	1.667		1.688	Basaltic hornblende		−	.021	Z∧c=3°	3.19		
44	1.670		1.693	do	83°	−	.023	Z∧c=8°	3.18		
45	1.675	1.691	1.701	do		−	.026	Z∧c=12°	>3.21	Black	
46	1.676	1.700	1.718	do		−	.042	Z∧c=13°	3.22		
47	1.677		1.700	do		−	.023	Z∧c=6°	3.22		
48	1.679	1.694	1.698	Hornblende	60° r<v	−	.019	Z∧c=11°	3.52		X=light brown, Y=brown, Z=green-brown.
49	1.681		1.700	Basaltic hornblende		−	.019	Z∧c=0°	3.25		
50	1.687		1.708	do		−	.021	Z∧c=10°	3.30		
51	1.693	1.711	1.713	do	43°	−	.020	Z∧c=21°	3.42		X=light yellow, Y=deep olive-green, Z=deep grass-green.
52	1.693	1.710	1.713	Hornblende	Small	−	.020	Z∧c=17°		Black	X=green-brown, Y=brown-green, Z=smoky blue-green.
53	1.693		1.714	do	36° r>v	−	.021	Z∧c=12°–13°			X=greenish yellow, Y=olive-green, Z=green to dark green
54	1.695		1.711	do	r>v	−	.016	Z=b; X∧c=15°–17°			X=light brown, Y=green, Z=greenish brown.
55	1.698	1.719	1.722	do	47° r>v	−	.024	Y=b; Z∧c=20°	3.38	Deep green	X=yellow, Y=green, Z=olive-green.

TABLE 6.—*Amphibole group*—Continued

Hornblende series—Continued

No.	α	β	γ	Name	Composition											Miscellaneous
					Ca	Na	Mg+Fe	Al+Fe'''	Ti	Si	O	OH	F	Mg/Fe	Al/Fe	
56	1.634	1.647	1.652	Edenite	3	2	9	2		15	44	4		3.6	.4	Na/K=7.
57	1.644	1.657	1.663	Hastingsite	3	3	8	5		13	44	2	2	3	2.2	
58	1.654	1.666	1.670	do	3	2	8	4		14	44	4		2	1.7	
59	1.670	1.683	1.693	Basaltic hornblende	3	2	7	6	1	12	44	4		3.7	4.4	
60	1.695	1.710	1.710	Hastingsite	3	3	7	7		12	44	4		6	3	Na/K=2.
				Soda amphibole series												
61	1.606	1.613		Soda tremolite	2	4	10			16	44	4				
62	1.605	1.615	1.622	do	2	4	9	1		16	45	3		15	0.17	
63	1.66	1.673	1.673	Arfvedsonite(?)	2	4	8	3		15	45	3		2.9	1.2	
64	1.699	1.719	1.721	do	2	4	7	6		13	44	4		0	1.4	Li/Na.
65	1.625	1.645	1.654	Holmquistite	1	3	6	5		15	44	4		2		Li/Na=4.
66	1.652	1.655	1.661	Arfvedsonite(?)	1	4	8	2		16	44	4		6	.5	
67	1.655		1.664	do	1	4	7	3		16	45	1	2	2	.2	
68	1.655	1.664	1.668	Glaucophane		4	6	4		16	44	4		2	.3	
69	1.670	1.680	1.682	Arfvedsonite(?)	1	5	7	3	1	15	46	2		.6	1	
70	1.688		1.691	Glaucophane	1	3	6	4	1	15	45	3		.4	.08	
71	1.694		1.699	Arfvedsonite	1	5	9	1		16	44	4				
72	1.695	1.698		do		5	7	3		16	44	4		48	.2	
73	1.695		1.703	Riebeckite		5	5	5		16	46	2		.07	.15	
74		1.696		Arfvedsonite		6	8	2		16	44	4			.2	Na/K=4.
75	1.695	1.699		Riebeckite		6	6	4		16	46	2		.05	.09	
76		1.705		Arfvedsonite	1	5	7	5	.5	13.5	44	2	2	.1	7	

TABLE 6.—*Amphibole group*—Continued

Hornblende series—Continued

No.	α	β	γ	Name	Axial angle and dispersion	Optical sign	Birefringence	Orientation	Specific gravity	Color	Remarks
56	1.634	1.647	1.652	Edenite	62°	−	0.018	Z∧c=21°			X=light bluish green, Y=deep green, Z=deep bluish green.
57	1.644	1.657	1.663	Hastingsite		−	.019	Z∧c=18°	3.26		
58	1.654	1.666	1.670	do	63°	−	.016	Z∧c=32°			X=light green, Y=deep green, Z=deep blue-green.
59	1.670	1.683	1.693	Basaltic hornblende	83° r>v	−	.023	Z∧c=9°	3.18		X=pale yellow, Y=dark brown, Z=dark olive-green.
60	1.695	1.710	1.710	Hastingsite	r>v	−	.015	Y∧c=12°–17°	3.42	Black	X=yellow, Y and Z=deep greenish blue.

Soda amphibole series

No.	α	β	γ	Name	Axial angle and dispersion	Optical sign	Birefringence	Orientation	Specific gravity	Color	Remarks
61	1.606	1.613	1.623	Soda tremolite		+		Z near c(?)		White to gray	X and Y=colorless, Z=yellow-green.
62	1.605	1.615	1.622	do	Medium large.	−	0.017	Z∧c=25°	3.07		
63	1.66	1.673	1.673	Arfvedsonite(?)	Small	−	.013	Z∧c=45°(?)	3.14		
64	1.699	1.719	1.721	do	36°	−	.022	Z∧c=20°			X=green-yellow, Y=olive-green, Z=blue-green.
65	1.625	1.645	1.654	Holmquistite	51° r>v	−	.029	Y=b; Z∧c=0°	3.11	Blue	X=light yellow, Y=violet, Z=purplish.
66	1.652	1.655	1.661	Arfvedsonite(?)	Medium strong.	−	.009	Z∧c=44°			X=yellow, Y=green, Z=blue-gray.
67	1.655		1.644	do	41° r>v	−	.009	Z=b; X∧c=18°–30°			
68	1.655	1.664	1.668	Glaucophane	42° r<v	−	.013	Y=b; X∧c=27°–35°			X=pale blue, Y=pale violet, Z=pale yellow.
69	1.670	1.680	1.682	Arfvedsonite(?)	Small	−	.012	Y=b; X∧c=20°–25°	3.3±	Black	X=dark green, Y=pale brown, Z=black.
70	1.688		1.691	Glaucophane	68° r>v	+	.003	Z=b; Y∧c=1°±			X=light green, Y=light yellow, Z=dark blue-back.
71	1.694		1.699	Arfvedsonite		−	.005	Z=b; X∧c=12°	3.41		
72	1.695	1.698		do	Large	−	.005	Z=b; X∧c=8°	3.42		
73	1.695		1.703	Riebeckite		−	.008	Z=b; X∧c=8°			
74		1.696		Arfvedsonite		−	.005	Z=b; X∧c=10°	3.41	Black	
75	1.695	1.699		Riebeckite		−	.004	X∧c=3°	3.39		
76		1.705		Arfvedsonite		−	.005	Z=b; X∧c=10°	3.46	Black	

TABLE 7.—*Apatite group*

ε	ω	Mineral name and composition	Color	Specific gravity
1.609	1.620	Dahllite $7CaO.2P_2O_5.CO_2.\frac{1}{2}H_2O$		3
1.620	1.623	Merrillite $3CaO.Na_2O.P_2O_5$		3.10
B=low	1.625	Francolite $10CaO.3P_2O_5.CaF_2.CO_2.H_2O$	White, etc.	3.1
1.629	1.633	Voelckerite $10CaO.3P_2O_5$		
1.630	1.633	Fluorapatite (pure) $9CaO.3P_2O_5.CaF_2$		3.2
1.631	1.635	Dahlite $7CaO.2P_2O_5.CO_2$		3.08
1.650	1.655	Wilkeite $20CaO.3P_2O_5.CO_2.3SiO_2.3SO_3$		3.23
1.651	1.655	Manganapatite $9(Ca,Mn)O.3P_2O_5.Ca(F,OH)_2$	Green	3.26
B=weak	1.660	Fermorite $9(Ca,Sr)O.(P,As)_2O_5.Ca(OH,F)_2$		3.52
1.664	1.667	Chlorapatite $9CaO.3P_2O_5.CaCl_2$		3.20
1.672	1.684	Svabite $9CaO.3(As,P)_2O_5.Ca(F,OH)_2$	Gray-green	
1.698	1.706	Svabite $9CaO.3As_2O_5.CaF_2$	White	3.7
2.042	2.050	Pyromorphite $9PbO.3P_2O_5.PbCl_2$	Green, etc.	7.0
2.010	2.026	Hedyphane $4\frac{1}{2}PbO.4\frac{1}{2}(Ca,Ba)O.3P_2O_5.PbCl_2$	White	5.7
2.118	2.135	Mimetite $9PbO.3As_2O_5.PbCl_2$		7.1
2.20	2.25	Endlichite $9PbO.3(As,V)_2O_5.PbCl_2$	Yellow	7.0
2.285	2.295	Finnemanite $9PbO.3AsO_3.PbCl_2$		7.27
2.299	2.354	Vanadinite $9PbO.3V_2O_5.PbCl_2$	Red, etc.	7±

TABLE 8.—*Aragonite group*

Orthorhombic, biaxial negative

α	β	γ	Name and composition	Axial angle and dispersion	Orientation	Cleavage	Specific gravity	Remarks
1.520	1.667	1.667	Strontianite $SrO.CO_2$	7° $r<v$ weak	X=c Z=a.	{110} nearly perf. {010} trace.	3.7	
1.526	1.671	1.672	Bromlite $(Ba,Ca,Sr)O.CO_2$	7° $r>v$ weak	X=c Z=b.	{110} poor	3.71	CaO 17.6, BaO 48.54, SrO 4.25, CO_2 29.41 per cent.
1.529	1.676	1.677	Witherite $BaO.CO_2$	16° $r>v$ weak	X=c Z=a.	{010}{110}	4.3	
1.530	1.680	1.685	Aragonite $CaO.CO_2$	18° $r<v$ weak	X=c Z=b.	{010}dist	2.94	99.91 per cent pure.
1.540	1.695	1.703	Tarnowitzite $(Ca,Pb)O.CO_2$	23° $r>v$	X=c Z=b.	{010}	3.02	Ca:Pb=15:2.
1.804	2.076	2.078	Cerusite $PbO.CO_2$	8° $r>v$ strong	X=c Z=a.	{110}{021}	6.5	

TABLE 9.—*Barite group*

The members of this group have the following characteristics:

Orthorhombic.

Optically biaxial positive and a rather small axial angle, with the exception of anglesite, which has an angle of 60° to 75°. The orientation in all the members is $X=c$ and $Z=a$. The dispersion is $r<v$, varying in intensity.

The specific gravity is markedly different for the different members of the group and is probably the most satisfactory means of identification if the material available is suitable for the test.

α	β	γ	Mineral and composition	Axial angle and dispersion	Cleavage	Specific gravity
1.571	1.576	1.614	Anhydrite $CaO.SO_3$	42°	{001} very perf., {010} perf., {100} less so	2.93
1.622	1.624	1.631	Celestite $SrO.SO_3$	51°	{001} perf., {110} nearly so, {010} less so	3.96
1.636	1.637	1.648	Barite $BaO.SO_3$	37½°	{001} {110} perf., {010} less so	4.5
1.877	1.882	1.894	Anglesite $PbO.SO_3$	60°–75° Disp. strong	{001} {110} dist	6.3

TABLE 10.—*Calcite group*

Uniaxial negative

ϵ	ω	Mineral name and composition	Color	Specific gravity	Remarks
1.486	1.658	Calcite (pure) $CaO.CO_2$	Colorless	2.715	
1.500	1.681	Dolomite (pure) $CaO.MgO.2CO_2$	do	2.87	
1.518	1.698	Ankerite $CaO.(Mg,Fe)O.2CO_2$	do	2.95	$CaCO_3$ 52.6, $MgCO_3$ 36.7, $FeCO_3$ 10.7 per cent.
1.509	1.700	Magnesite $MgO.CO_2$	do	2.96	Pure.
1.526	1.716	Ankerite $CaO.(Mg,Fe)O.2CO_2$	do	2.97	$CaCO_3$ 52, $MgCO_3$ 26, $FeCO_3$ 22 per cent.
1.527	1.726	Magnesite $(Mg,Fe)O.CO_2$	do	3.09	$MgCO_3$ 85, $FeCO_3$ 15 per cent.
1.547	1.749	Ankerite $CaO(Fe,Mg)O.2CO_2$		3.12	$CaCO_3$ 48.3, $MgCO_3$ 11.3, $FeCO_3$ 37.9, $MnCO_3$ 2.5 per cent.
1.570	1.788	Mesitite $(Fe,Mg)O.CO_2$		3.43	$FeCO_3$ 50, $MgCO_3$ 50 per cent.
1.597	1.817	Rhodochrosite $MnO.CO_2$	Pink	3.70	Pure.
1.605	1.826	Rhodochrosite $(Mn,Fe)O.CO_2$	do	3.74	$MnCO_3$ 79.3, $FeCO_3$ 19.9, $CaCO_3$ 0.8 per cent.
1.596	1.830	Siderite $(Fe,Mn,Mg)O.CO_2$			$FeCO_3$ 73.2, $MnCO_3$ 2.2, $MgCO_3$ 23.3, $CaCO_3$ 1.3 per cent.
1.621	1.849	Smithsonite $ZnO.CO_2$	Colorless	4.398	$ZnCO_3$ 97, $FeCO_3$, $CaCO_3$ 3 per cent.
1.613	1.855	Siderite $FeO.CO_2$		3.78	$FeCO_3$ 90, $MgCO_3$ 5, $CaCO_3$ 5 per cent.
1.60	1.855	Sphaerocobaltite $CoO.CO_2$	Red	4.1	
1.633	1.875	Siderite $FeO.CO_2$	Gray-brown	3.89	Pure.

TABLE 11.—*Chlorite group*

Chemical characteristics.—The chlorites are essentially hydrous magnesium-aluminum silicates, in which ferrous iron replaces more or less of the magnesium and slight amounts of ferric iron, and in some varieties chromium replaces the aluminum. Winchell has shown that the composition can be adequately expressed for most of the chlorites by assuming for the end members antigorite (Ant), $H_4Mg_3Si_2O_9$, and amesite (At), $H_4Mg_2Al_2SiO_9$, together with their ferrous equivalents, ferroantigorite and daphnite. Many of the so-called chlorites, however, show serious discrepancies in composition when an attempt is made to fit them into this series. It is here suggested that this apparent discrepancy is due to the fact that some chlorites are intermediate in composition between the true chlorites and the clintonite group. On this assumption most of the discrepancies cease to exist. As this intermediate series has not been the subject of an optical study, the few data available have not been included in this table.

Optical characteristics.—Many of the data in the table have been drawn from the recent excellent chemical study of the chlorites by Orcel.[28] Most of the new analyses, for which optical data were given, are here used, but those chlorites that seemed to be intermediate members, as above defined, were excluded.

The chlorites approaching antigorite are generally low in birefringence (0.003–0.009), whereas those nearer the amesite end of the series are higher (0.009–0.015). Likewise, there is a slight increase in refringence from antigorite to amesite. An increase in iron content at either end of the series, however, causes an increase in the index of refraction. Absorption also increases with the higher iron content. There seems to be little relation between composition and optical sign or axial angle, which ranges from 0 to 30°. Most chlorites are optically positive, with dispersion $r < v$ and absorption X and Y > Z, in green and yellow. When they are negative the dispersion and absorption formulae are reversed. The acute bisectrix is in either case nearly normal to the plates.

Thus, a chlorite with low birefringence and comparatively low refractive index may generally be called penninite or clinochlore, whereas one with a higher index together with a low birefringence would probably be a ferrous member, such as delessite. Likewise a chlorite with a low index of refraction and a comparatively high birefringence would be near amesite, and the corresponding high index member would be daphnite.

The optical differences between the chlorites and micas are that (1) the birefringence of the chlorites is considerably less, (2) all the micas are optically negative, and (3) the chlorites are usually green, whereas the micas are generally not so colored, under transmitted light.

The chlorites differ optically from the clintonites mainly in having a lower birefringence and generally a lower index of refraction, but, as has been suggested above, the two groups probably merge into each other.

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[28] Orcel, J., Recherches sur la composition chimique des chlorites: Soc. franç. minéralogie Bull., vol. 50, pp. 75–456, 1927.

TABLE 11.—*Chlorite group*—Continued

Optically positive

β	Birefringence	Name	Composition				Axial angle	Specific gravity	Remarks
			Ant	At	Fe″/Mg	Fe‴/Al			
1.562	0.014	Chlorite	33	67			2V=0°±		Colorless. Fe_2O_3 1.74 per cent.
1.571	.005	Clinochlore	50	50			Small	2.657	Green. FeO 1.05 $Fe_2O_3+Cr_2O_3$ 1.57 per cent.
1.572	.003	Leuchtenbergite	50	50			2V=10°		Nearly colorless.
1.572	.003	Chlorite	50	50					MnO 1.06 per cent.
1.575	.015	Leuchtenbergite	40	60			2V18°-19°	2.656	Amber colored.
1.575	.015	do	40	60			2E=28°-30°	2.735	
1.576	.003	Penninite	50	50				2.7	
1.579	.005	Clinochlore	50	50			2V=0°±	2.675	$\frac{Cr}{Al}$=0.2. Violet.
1.580	.008	Sheridanite	25	75			2V=20°±	2.680	FeO 1.24 per cent.
1.580	.009	Ripidolite	50	50			Small	2.70	Some FeO.
1.582	.011	Chrome clinochlore	45	55			Varies	2.7	
1.587	.008	Chlorite	29	71	0.10		2E=35°	2.718	
1.588	.012	Prochlorite	33	67	.08		2V=19°	2.696	Light green.
1.589	.011	do	40	60	.07	0.05	2V=29°	2.713	Green.
1.593	.009	Chlorite	33	67	.16			2.788	
1.594	.012	do	29	71	.17	.03	2E=40°	2.754	
1.597	.015	Amesite		100	.16		Small	2.77	Pale green.
1.607	.008	Corundophilite	20	80			Medium	2.9	
1.616	.004	Ripidolite	33	67	.61	.06		2.901	
1.618	.003	do	33	67	.33	.05	2V=0°	2.883	
1.633	.001	do	29	71	.79	.12		2.94	

Optically negative

1.578	.003	Penninite	50	50			2V=0°	2.7	Abnormal interference; colorless.
1.590	.003	Kammererite	57	43	0.03				$\frac{Cr_2O_3}{Al_2O_3}$=0.55.
1.594	.010	Clinochlore	40	60	.08	0.07	2V=0°		
1.60	.002	Thuringite	25	75	4.9	.38			
1.637	.023	Chlorite	50	50	.5	1.0	2V=15°		
1.639	.006	Brunsvigite	45	55	2.13	.07			
1.649	.006	Daphnite	33	67	17.2		Small		Dark green. Pure Fe″ member? X=pale yellowish, Y and Z=olive-green.
1.651	.003	Aphrosiderite	29	71	2.90	.05		3.100	
1.665	.012	Thuringite	25	75	3.0	.36		2.96	
1.667	.009	Prochlorite (bavalite) (?).	29	71	9.75	.01		3.20	
1.80	Strong	Cronstedtite	25	75	4.6		2V=0°±	3.34	No Al_2O_3. Abs. strong. X=brown, Y and Z=black.

TABLE 12.—*Epidote group*

The general formula for the epidote group may be written $Ca_2(Al,Mn,Fe)_3Si_3O_{12}(OH)$.

Clinozoisite is the almost pure aluminum member, whereas epidote contains more or less iron, and piedmontite has, in addition to iron, some manganese. The calcium is in general not variable, although minor amounts of sodium are present, and in hancockite some of the calcium is replaced by lead and strontium. The members of this group are monoclinic and elongated along the *b* axis, with the exception of zoisite, which has a composition similar to that of clinozoisite but is orthorhombic. Only small amounts of iron are found in zoisite. Allanite is a related species containing rare earths.

The optical characters that are common to the group are as follows:

The plane of the optic axes is *b* {010}.

TABLE 12.—*Epidote group*—Continued

The optic angle (2V) is generally large. In the Al-Fe series an increasing content of Fe tends to decrease the axial angle somewhat.

The inclined dispersion is strong, with $r < v$ for the optical positive and $r > v$ for the optically negative members.

The birefringence is moderate to fairly strong, increasing with the iron content.

The extinction is variable, from $X \wedge c = 0°$ in zoisite to $X \wedge c = -7°$ in piedmontite. $Y = b$ for all members. An optic axis emerges nearly normal to the basal cleavage.

The absorption and pleochroism are marked. The pleochroic colors are in red, yellow, and green.

Optically positive

α	β	γ	Mineral name and composition	Axial angle (2V)	Extinction	Specific gravity	Remarks
1.700	1.702	1.706	Zoisite. Pure Al member.	0°–60°	$X = c$	3.2	When iron is present zoisite may be optically negative with $Y = c$ and $X = b$.
1.700	1.703	1.718	Zoisite. Al:Fe=30:1.	Medium small.	$X = c$		
1.715	1.717	1.719	Clinozoisite. Pure Al member.	66°	$X \wedge c = -7°$	3.21	
1.715	1.720	1.725	Clinozoisite. Al:Fe=14:1.	90°	$X \wedge c = (?)$	3.36	
1.738	1.757	1.778	Piedmontite. Little Mn‴.	90°±	$X \wedge c = -7°$	3.40	Pleoc.: X=light orange-yellow, Y=light phlox-purple, Z=old rose.
1.745	1.764	1.806	Piedmontite. Al:Mn:Fe=6:2:1.	68°	$X \wedge c = -6°$	3.447	Tunaberg.
1.756	1.789	1.829	Piedmontite. Al:Mn:Fe=6:7:1.	86°	$X \wedge c = -4°$	3.470	Na_2O=2.96 per cent.
1.750	1.782	1.832	Piedmontite. Al:Mn:Fe=7:3:2.	81°	$X \wedge c = -7°$	3.453	Ca:Mn=10:1.

Optically negative

1.716	1.719	1.723	Epidote. Al:Fe=9:1.	89°	$X \wedge c = -1°$	3.36	Green.
1.727	1.739	1.751	Allanite. $(Ca,Fe)_2(Al,Cr,Fe''' Di)_3Si_3O_{12}(OH)$	Medium large.		3.5–4.2	Brown and black. Altered. X=pale yellow, Y and Z=brownish red.
1.722	1.742	1.750	Epidote. Al:Fe=9:2.	80°	$X \wedge c = -2°$	3.4	Pleoc.: X=colorless, Y=pale greenish yellow, Z=colorless.
1.733	1.755	1.768	Epidote. Al:Fe=5:2.	74°	$X \wedge c = -3°$	3.433	Abs.: Y>Z>X. Nordmark.
1.729	1.763	1.780	Epidote. Al:Fe=5:3.	69°	$X \wedge c = -5°$	3.4	Green. Pleoc.: X=colorless, Y=pale greenish yellow, Z=colorless.
1.737	1.761	1.782	Manganepidote. MnO=2.26 per cent. Al:Fe=3:1.	87°	$X \wedge c = -4$	3.425	
1.788	1.81	1.830	Hancockite. $(Pb,Ca,Sr)_2(Al,Fe,Mn)_3Si_3O_{12}(OH)$	50°		4.03	Brownish red. Pleoc. faint in reddish brown. Abs.: Z>X.

TABLE 13.—*Feldspar group*

Orthoclase, celsian

Monoclinic. Carlsbad twins common.

α	β	γ	Mineral name and composition	Optical sign	Axial angle (2V)	Optical orientation	Specific gravity
1.518	1.524	1.526	Orthoclase $K_2O.Al_2O_3.6SiO_2$	−	0–70°	Y or Z=*b* X∧*a*=5°	2.56
1.518	1.525	1.527	Natrosanidine $(Na,K)_2O.Al_2O_3.6SiO_2$	−	Small		
1.537	1.540	1.542	Hyalophane Ce_1Or_4	−	75°	Z=*b* X∧*a*=−2°	2.72
1.542	1.545	1.547	Hyalophane Ce_3Or_7	−	79°	Z=*b* X∧*a*=−18°	2.82
1.584	1.589	1.594	Celsian $BaO.Al_2O_3.2SiO_2$	+	87°	Y=*b* Z∧*a*=28°	3.38

Microcline

Monoclinic, characterized by a fine grating of albite and pericline twins. Carlsbad twins are also common.

1.519	1.525	1.527	Anorthoclase $Ab_{65}Or_{35}$	−	45°	Ext.{001}2°; ext.{010}10.6°	2.58
1.522	1.526	1.530	Microcline $K_2O.Al_2O_3.6SiO_2$	−	83°	On{001}=15°; on{010}=6°	2.56

Plagioclase

In powder the albite twins are common on the basal cleavage. Pericline twins may be seen on {010} cleavage. Other twins are less noticeable. The indices of refraction and the extinction angles on the {001} cleavage and to a less extent on the {010} cleavage serve to determine the members in powdered fragments.

α	β	γ	Mineral name and composition	Optical sign	Axial angle (2V)	Ext. on {010}	Ext. on {001}	Specific gravity
					°	°	°	
1.525	1.529	1.536	Albite (Ab) $Na_2O.Al_2O_3.6SiO_2$	+	74	24	3½	2.605
1.539	1.543	1.547	Oligoclase $Ab_{80}An_{20}$	−	86	6	1	2.64
1.550	1.553	1.557	Andesine $Ab_{60}An_{40}$	+	88	8	2	2.678
1.559	1.563	1.568	Labradorite $Ab_{40}An_{60}$	+	79	21	9	2.70
1.566	1.572	1.576	Bytownite $Ab_{20}An_{80}$	−	82	33	22	2.73
1.576	1.584	1.588	Anorthite (An) $CaO.Al_2O_3.2SiO_2$	−	77	37	40	2.765

TABLE 14.—*Garnet group*

Isometric.—Commonly isotropic but may be weakly birefracting with complex twin grating. The garnets show a wide range in index of refraction, but they have an equally wide range in chemical composition, and the index of refraction is not

TABLE 14.—*Garnet group*—Continued

invariably sufficient to place accurately a member of the group. The specific gravity is an additional help for identification, as are also the color and the occurrence and associations, but some knowledge of the chemical composition may be necessary. The indices of refraction of the pyropes that contain some iron overlap those of the grossularites, but the specific gravity of a pyrope is considerably greater than that of a grossularite that has the same index of refraction. The manganese garnets have about the same range as the iron garnets. The indices of refraction of the ferric garnets and the ferrous garnets overlap, but the specific gravities of the ferric garnets are much lower. The titanium garnets, in common with all titanium minerals, have high indices of refraction and relatively low specific gravities. The general range of the different garnets is given by the following list:

Mineral name and composition	n	Specific gravity	Composition
Pyrope $3MgO.Al_2O_3.3SiO_2$	1.705	3.510	Pure.
Grossularite $3CaO.Al_2O_3.3SiO_2$	1.735	3.530	Do.
Pyrope $3(Mg,Fe)O.Al_2O_3.3SiO_2$	1.742	3.713	Cr_2O_3 2.4, FeO 10.2, MgO 18.4, CaO 4.5, MnO 0.5 per cent.
Pyrope $3(Mg,Fe,Ca)O.(Al,Fe)_2O_3.3SiO_2$	1.749	-------	Pyrope 60, almandite 24, grossularite 12, andradite 4 per cent.
Rhodolite $3(Mg,Fe)O.Al_2O_3.3SiO_2$	1.760	3.837	Fe_2O_3 1.9, FeO 15.6, MgO 17.2, CaO 0.9 per cent.
Hessonite $3CaO.(Al,Fe)_2O_3.3SiO_2$	1.763	3.633	Fe_2O_3 7.2, MnO 0.1 per cent.
Almandite $3(Mn,Fe,Ca)O.(Al,Fe)_2O_3.3SiO_2$	1.766	-------	Almandite 41.5, grossularite 24.5, pyrope 31, andradite 3 per cent.
Almandite $3(Fe,Ca,Mg)O.Al_2O_3.3SiO_2$	1.789	3.917	Fe_2O_3 2.4, MnO 0.6, CaO 4.8, MgO 7.9 per cent.
Spessartite $3(Mn,Fe)O.Al_2O_3.3SiO_2$	1.794	4.153	MnO 37.98, FeO 4.99, CaO 1.66 per cent.
Spessartite $3MnO.Al_2O_3.3SiO_2$	1.800	4.180	Pure.
Almandite $3(Fe,Mg,Ca)O.Al_2O_3.3SiO_2$	1.801	4.093	MnO 1.5, CaO 2.0, MgO 5.3 per cent.
Spessartite $3(Mn,Fe)O.Al_2O_3.3SiO_2$	1.811	4.273	FeO 11.1, MnO 32.2, CaO 0.6, MgO 0.2 per cent.
Spessartite $3(Mn,Fe)O.Al_2O_3.3SiO_2$	1.814	4.158	Fe_2O_3 1.26, FeO 15.02, MnO 25.24 per cent.
Almandite $3(Fe,Mn)O.Al_2O_3.3SiO_2$	1.818	-------	FeO 27.8, MgO 1.0, MnO 14.3 per cent.
Almandite $3FeO.Al_2O_3.3SiO_2$	1.830	4.250	Pure.
Uvarovite $3CaO.Cr_2O_3.3SiO_2$	1.838	3.418	Al_2O_3 5.9, Cr_2O_3 22.5 per cent.
Andradite $3CaO.Fe_2O_3.3SiO_2$	1.865	3.781	Al_2O_3 6.1, Fe_2O_3 25.1, FeO 0.8, CaO 33.7 per cent.
Andradite $3CaO.Fe_2O_3.3SiO_2$	1.895	3.750	Pure.
Melanite $3CaO.(Fe,Ti)_2O_3.3(Si,Ti)O_2$	1.94	3.7	TiO_2 8.7 per cent.
Schorlomite $3CaO.(Fe,Ti)_2O_3.3(Si,Ti)O_2$	1.98	3.85	TiO_2 16.9 per cent.
Ivaarite $3CaO.(Fe,Ti)_2O_3.3(Si,Ti)O_2$	2.01	3.7	TiO_2 25 per cent.

TABLE 15.—*Melilite group*

The melilites are composed of the following end members (Berman): Gehlenite, $Ca_2Al_2SiO_7$; åkermanite, $Ca_2MgSi_2O_7$; soda melilite, $Na_2Si_3O_7$; submelilite molecule, $CaSi_3O_7$.

In addition to this isomorphous series the following members are closely related: Hardystonite, $Ca_2ZnSi_2O_7$; meliphanite, $(Ca,Na)_2Be(Al,Si)_2(O,F)_7$; leucophanite, $CaNaBeSi_2(O,F)_7$.

The following are the important optical characteristics in the melilite group:

The åkermanite end of the series is optically positive, and the gehlenite members are negative. Some of the intermediate members are sensibly isotropic and show abnormal interference colors.

The birefringence is generally weak, the iron members having a somewhat greater birefringence than the magnesium-aluminum members.

In the table below the compositions of the members of the group are given in terms of the percentages of the end members as indicated above. (A, Gehlenite; B, åkermanite; C, soda melilite; D, submelilite molecule.)

ϵ	ω	Mineral name and composition	Specific gravity	Remarks
1.571	1.595	Leucophanite $CaNaBeSi_2(O,F)_7$	2.96	Orthorhombic. X=*c*. 2V=39°.
1.593	1.612	Meliphanite $(Ca,Na)_2Be(Al,Si)_2(O,F)_7$	3.01	
1.626	1.632	Melilite A=31, B=46, C=13, D=10	2.98	FeO 2.18 per cent.
1.629	1.633	Melilite A=36, B=46, C=16, D=4	2.93	Fe_2O_3 3.80 per cent.
1.639	1.633	Åkermanite $Ca_2MgSi_2O_7$. B=100	3.12	Pure artificial compound.
1.636	1.647	Gehlenite A=51, B=37, C=12		
1.653	1.657	Gehlenite A=71, B=29		Fe_2O_3 1.59 per cent (velardeñite).
1.658	1.666	Gehlenite A=79, B=20, C=1	3.04	Fe_2O_3 1.43 per cent (velardeñite).
1.658	1.669	Gehlenite $Ca_2Al_2SiO_7$. A=100	3.04	Pure artificial compound.
1.657	1.669	Hardystonite $Ca_2ZnSi_2O_7$	3.4	
1.658	1.670	Iron åkermanite $Ca_2FeSi_2O_7$	3.23	Do.
1.691	1.691	Gehlenite A=56, B=35, C=9	3.0	Fe_2O_3 3.49 per cent (fuggarite).

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TABLE 16.—*Mica group*

The micas are characterized by the following physical and chemical properties:

1. An exceedingly perfect cleavage giving rise to thin elastic plates of hexagonal outline.

2. They are basic silicates of magnesium, aluminum, and potassium, with or without magnesium, with little sodium and no calcium. Iron replaces both the magnesium and aluminum. In the lithia micas, however, the lithium does not replace the potassium but rather magnesium or aluminum.

3. The optical characteristics may be summarized as follows: The true micas are all optically negative. 2V is generally small, but becomes 45° in muscovite. The acute bisectrix (X) is nearly normal to the basal cleavage. The iron and manganese micas are rather strongly pleochroic. The birefringence is generally between 0.03 and 0.04.

TABLE 16.—*Mica group*—Continued

α	β	γ	Mineral name and composition	Axial angle (2V) and dispersion	Color	Specific gravity	Remarks
1.503	1.545	1.545	Pholidolite $KMg_6AlSi_7O_{20}(OH)_4$	0–20°	Colorless	2.41	
1.530	1.553	1.556	Lepidolite $K_2Li_3Al_4Si_7O_{21}(OH)F_2$	46°		2.820	
1.54	1.57	1.57	Phlogopite $K_2Mg_6Al_2Si_6O_{20}(OH)_4$	Small	Pale brown	2.8	Mineral with theoretical composition.
1.551	1.578	1.581	Zinnwaldite $K_2Li_2Fe''_2Al_4Si_6O_{20}(OH)_2F_2$	29°		2.987	Zinnwald.
1.545	1.582	1.582	Hydrobiotite $K_2Mg_5Al_3Si_6O_{18}(OH)_6$	0°		2.783	Haddam Neck.
1.560	1.593	1.598	Muscovite $(Na,K)_2Al_6Si_6O_{20}(OH)_4$	42°			Green, from pegmatite. Al:Fe'''=20:1, Na:K=1:1.
1.55	1.594	1.594	Alurgite $K_2MgAl_4Si_7O_{22}(OH)_2$	0° $r>v$ weak.	Copper-red	2.84	Pleoc. faint.
B=.04		1.594	Fuchsite Chromium mica	40° $r>v$ strong.	Greenish yellow	2.86	Pleoc.: X=robin's egg blue, Y=yellowish green, Z=bluish chrome-green.
1.558	1.595	1.601	Muscovite $(K,Na)_2Al_6Si_6O_{20}(OH)_4$	41°			K:Na=5:1.
1.551	1.598	1.598	Phlogopite $(K,Na)_2Mg_5Al_3Si_6O_{21}(OH)_3$	3°			K:Na=5:1. TiO_2=0.66 per cent.
1.568	1.598	1.598	Manganophyllite $K_2(Mg,Mn)_6Al_2Si_6O_{20}(OH)_4$	4°			Mg:Mn=4:1. Al:Fe''':Mn'''=3:1:1.
1.556	1.599	1.602	Muscovite $K_2Mg_{0.5}Al_5Si_{6.5}O_{20}(OH)_4$	29°			Green. TiO_2 1.10, Fe_2O_3 2.94, Na_2O 1.05 per cent.
B=.03		1.60	Paragonite $Na_2Al_6Si_6O_{20}(OH)_4$	40°	Colorless	2.8	
1.563	1.599	1.604	Muscovite $K(Mg,Fe)Al_6Si_6O_{21}(OH)_3$	39° $r>v$ weak.		2.891	FeO 5.30 per cent.

TABLE 16.—*Mica group*—Continued

α	β	γ	Mineral name and composition	Axial angle (2V) and dispersion	Color	Specific gravity	Remarks
1.572	1.611	1.615	Muscovite $K_2Al_6Si_6O_{20}(OH)_4$	30° $r>v$ perc.	Colorless, pale green, or brown.	2.885	Al: Fe‴=10:1.
1.592	1.625	1.625	Protolithionite $K_2Li_2Fe''_2Al_4Si_6O_{20}(OH)_4$	0°		3.305	
1.60	1.63	1.63	Mariposite Chromium mica	0°	Light apple-green.	2.79	Abs. Z>Y and X.
1.58	1.63	1.630	Biotite $K_2(Mg,Fe)_4(Al,Fe)_4Si_6O_{22}(OH)_2$	Small	Brown or black	3.02	X=yellow, Y and Z=brown or green. FeO+Fe_2O_3 15.2, MgO 16.6 per cent.
1.622	1.636	------	Manganophyllite $K_2(Mg,Mn'')_6Fe'''_2Si_6O_{20}(OH)_4$	14° $r>v$.	Red	2.953	X=dark red, Y=light red. MnO 4.52 per cent.
1.584	1.648	1.648	Biotite $K_2(Mg,Fe)_4(Al,Fe)_4Si_6O_{22}(OH)_2$	Small	Brown to black	3.12	Pleoc. strong. X<Y and Z. FeO+Fe_2O_3 21.6, TiO_2 4.3 per cent.
1.618	1.670	1.670	Siderophyllite $K_2Fe''_5Al_4Si_5O_{20}(OH)_4$	do	do		Pleoc. strong. Abs.: X<Y and Z. Data for mineral with theoretical composition.
1.623	1.676	1.677	Biotite $K_2(Fe,Mg)_4(Al,Fe)_4Si_6O_{22}(OH)_2$	do	do	3.1	Pleoc. intense in green and brown. Abs.: X<Y and Z. FeO+Fe_2O_3=38.4 per cent.
1.62	1.68	1.68	Annite $K_2Fe''_6Al_2Si_6O_{20}(OH)_4$	do	do		Abs.: X<Y and Z.
1.610	1.685	1.704	Roscoelite (vanadium mica) $K_2V_4Al_2Si_6O_{20}(OH)_4$	do $r<v$ strong.	Green	2.97	Pleoc.: X=olive-green, Z=green-brown. Apple-green interference color. Some MgO.

TABLE 17.—*Olivine group*

The composition of the olivines is represented by the formula (Mg,Fe,Mn,Ca)$_2$(Mg,Fe,Mn,Zn,Pb)SiO$_4$, with the following as the end compounds: Forsterite, Mg_2SiO_4; fayalite, Fe_2SiO_4; tephroite, Mn_2SiO_4; monticellite, $CaMgSiO_4$; glaucochroite, $CaMnSiO_4$; and the rare compound larsenite, $PbZnSiO_4$.

Others to be found in the table below are more or less intermediate members.

The optical characteristics of the group are as follows:

1. The orientation is $X=b$, $Y=c$.
2. The less ferrous members are optically positive, and the dispersion is $r<v$, whereas the iron-rich members are negative and have $r>v$.
3. The axial angle (2V) decreases and the birefringence increases with increasing iron content.
4. The birefringence is fairly strong (0.03–0.05).
5. Manganese acts much like iron in its effect on the optical properties.
6. Calcium tends to lower the index of refraction somewhat.
7. The iron-rich members have abnormal interference colors in blue and yellow.

Optically positive

α	β	γ	Name and composition	Axial angle (2V)	Specific gravity	Remarks
1.635	1.651	1.670	Forsterite Mg_2SiO_4	85°		Pure artificial compound.
1.640	1.661	1.680	Forsterite $(Mg,Fe)_2SiO_4$	90°±	3.2	Mg:Fe=94.9:5.1.
1.653	1.670	1.689	Olivine $(Mg,Fe)_2SiO_4$	88°	3.341	Mg:Fe=88:12.
1.663	1.681	1.700	Olivine $(Mg,Fe)_2SiO_4$	90°	3.404	Mg:Fe=83.8:16.2.

Optically negative

1.651	1.662	1.668	Monticellite $CaMgSiO_4$	75°	3.2	Colorless. FeO 4.8, MnO 1.6 per cent.
1.679	1.716	1.729	Glaucochroite $(CaMnSiO_4$	Medium large	3.41	
1.680	1.701	1.720	Olivine $(Mg,Fe)_2SiO_4$	86°	3.52	Pale green. Mg:Fe=78:22.
1.681	1.706	1.718	Olivine $(Mg,Fe)_2SiO_4$		3.46	Mg:Fe=75:25.
1.711	1.727	1.740	Picrotephroite $(Mg,Mn)_2SiO_4$	85°	4.0	Red, brown. Mg:Mn=40:60.
1.758	1.786	1.804	Roepperite $(Mn,Fe,Zn,Mg)_2SiO_4$	77°	4.0	Mn:Fe:Zn:Mg=24:48:13:15.
1.759	1.786	1.797	Tephroite $(Mn,Mg)_2SiO_4$	65°	4.1	Brown. Faint pleoc.: X=reddish brown, Y=red, Z=greenish blue. Mn:Mg=92:8.
1.760	1.769	1.770	Calcium larsenite $(Ca,Pb)ZnSiO_4$	40°	4.42	White. Ca:Pb=71:29.
1.768	1.792	1.803	Hortonolite $(Fe,Mg,Mn)_2SiO_4$	69°	3.91	Yellow to black. Pleoc. faint: X and Z=greenish yellow, Y=orange-yellow. Fe:Mg:Mn=57:38:5.
1.777	1.807	1.825	Tephroite Mn_2SiO_4	60°±	4.113	Reddish brown. Practically pure.

TABLE 17.—*Olivine group*—Continued

Optically negative—Continued

α	β	γ	Name and composition	Axial angle (2V)	Specific gravity	Remarks
1.805	1.838	1.847	Knebelite $(Fe,Mn,Mg)_2SiO_4$	54°	4.1	Gray, etc. Fe:Mn:Mg=66:27:7.
1.808	1.836	1.846	Manganfayalite $(Fe,Mn)_2SiO_4$	Large	4.3	Fe:Mn=76:24.
1.823	1.864	1.873	Fayalite $(Fe,Mn,Mg)_2SiO_4$	51°	4.3	Yellow to black. Nearly colorless in section. Abnormal blue and yellow interference colors. Fe:Mn:Mg=87:7:6.
1.835	1.877	1.886	Fayalite Fe_2SiO_4	47°	4.34	Yellow to black. Nearly colorless in section. Abnormal blue and yellow interference colors. Nearly pure Fe_2SiO_4.
1.92	1.95	1.96	Larsenite $PbZnSiO_4$	Large	5.90	White.

TABLE 18.—*Pyroxene group*

The pyroxenes have a composition which may be expressed by the general formula (Ca,Na,Mg) (Mg,Fe″,Mn,Al,Fe‴) (Al,Si) SiO_6.

The various end compounds corresponding to this formula are enstatite, $Mg_2Si_2O_6$; hypersthene, $(Mg,Fe)_2Si_2O_6$; clinoenstatite, $Mg_2Si_2O_6$; diopside, $CaMgSi_2O_6$; hedenbergite, $CaFe''Si_2O_6$; johannsenite, $CaMnSi_2O_6$; jadeite, $NaAlSi_2O_6$; acmite, $NaFe'''Si_2O_6$; Tschermak's molecule, $(Ca,Mg)Al_2SiO_6$; and spodumene, $LiAlSi_2O_6$.

Many names have been given to pyroxenes intermediate in composition. Aegirite, pigeonite, augite, etc., are such intermediate members. Schefferite is a manganese-bearing diopside. Jeffersonite contains manganese and zinc. Commonly chromium, vanadium, or titanium enter into the composition. These elements are comparatively rare and are not included in the general formula.

Wollastonite and the so-called triclinic pyroxenes are not included in the tables because they do not seem sufficiently related, either chemically or optically, to the monoclinic pyroxenes to warrant such a grouping. Further, there is no evidence that isomorphism exists between the monoclinic pyroxenes and the triclinic species, whereas the monoclinic members seem completely miscible in each other (with the exception of spodumene).

In the table the composition is given in terms of 24 oxygen atoms in order to reduce fractional quantities and yet record the significant features of the analysis. The axial angle (2V) and the dispersion are given about the bisectrix Z in all cases, in order to show the systematic variation. Likewise the extinction angle, in the monoclinic members, is given for $Z \wedge c$ in all cases, for the same reason.

The table is divided into two main groups—the orthorhombic pyroxenes and the monoclinic pyroxenes. The first group is arranged according to the increasing amount of iron, which causes an increase in the index of refraction. The monoclinic pyroxenes are arranged according to the decrease in the amount of the Mg+Fe atoms. This arrangement shows the chemical gradation from clinoenstatite to the diopside-hedenbergite series, which in turn grades into the soda pyroxenes, of which the end compounds are acmite and jadeite. The monoclinic pyroxenes are therefore divided into three groups, each of which has its special optical characteristics.

TABLE 18.—*Pyroxene group*—Continued

ORTHORHOMBIC PYROXENES

The orthorhombic pyroxenes have the composition $(Mg,Fe)SiO_3$. They have parallel extinction, generally with $Y=b$ and $Z=c$. The birefringence is comparatively low. With an increase in iron—that is, from enstatite to hypersthene—the following changes take place in the optical properties:

Index of refraction increases.

2V increases to 90° (about Z) for about 15 molecular per cent of iron and then increases rapidly with additional iron, so that X becomes the acute bisectrix.

Birefringence increases.

The magnesium end of the series has no pleochroism, but an increasing iron content tends to make pleochroism more noticeable. The usual pleochroic colors are X=pink to red, Y=yellow, Z=green.

In this series the most reliable means of determining the composition seems to be by refractive index. The orthorhombic symmetry serves to distinguish this series from the other pyroxenes.

MONOCLINIC PYROXENES

Clinoenstatite-pigeonite series.—The clinoenstatite-pigeonite series may be expressed by the formula $(Ca,Mg)(Mg,Fe)Si_2O_6$.

The principal chemical characteristic is a ratio of $\frac{Mg}{Ca}>1$, without any appreciable amount of soda or alumina.

The optical characteristics may be summarized as follows:

Opt. + with a small axial angle (2V).

No marked variation in the extinction angle, which is $Z\wedge c=40°\pm$ (clinoenstatite has $Z\wedge c=22°$).

Pleochroism is weak, but increases with iron content.

The small optic angle is perhaps the best means of identifying the members of this series.

Diopside-hedenbergite series.—The formula for the diopside-hedenbergite series is $Ca(Mg,Fe,Mn,Zn,Al,Fe''')(Al,Si)_2O_6$.

The calcium-magnesium-iron members are the most common; schefferite has some manganese, and jeffersonite has manganese and zinc. The chief chemical characteristics of the series are a ratio of $\frac{Ca}{Mg,\ etc.}=1$, with no sodium. However, certain pyroxenes containing aluminum and ferric iron, with no sodium, are to be referred to this group. These are the augites, which are optically similar to the nonaluminous members of the series. The so-called Tschermak molecule enters into the composition of augite—that is, the molecular percentage of silica is lower than that ordinarily found in the pyroxenes. Optically the chief characteristics of the series are—

The extinction $Z\wedge c$ ranges from 38½° in diopside to 48° in hedenbergite, the iron end of the series.

The birefringence ranges from 0.030 in diopside to 0.018 in hedenbergite.

The axial angle (2V) shows little variation from 60°; the dispersion is $r>v$ distinct for most of the members but is strong for the titanium-rich member.

The index of refraction increases with the increase in iron.

Pleochroism is noticeable only in the higher iron members of the series, and then only weakly.

A combination of axial angle, extinction angle, birefringence, and index of refraction serve to differentiate this series from the other monoclinic pyroxenes.

TABLE 18.—*Pyroxene group*—Continued

The probable composition, within the series, can most easily be determined by the index of refraction.

Soda-pyroxene series.—The formula for the soda pyroxene series is (Ca,Na)(Mg,Fe,Al,Fe$'''$)Si_2O_6.

The presence of sodium, with an equal molecular amount of aluminum (or ferric iron) is the chief chemical characteristic of this series. Titanium, vanadium, and chromium are present in some members. The series grades from diopside-hedenbergite, with no sodium, to acmite-jadeite, with the maximum amount of sodium. For simplification of nomenclature the intermediate members of this series are called aegirite.

The optical characteristics of the series are as follows:

A large extinction angle, $Z \wedge c$, which generally increases with an increase in sodium.

A large axial angle, which increases beyond 90° (about Z) as the sodium increases.

A rather strong birefringence for the members rich in sodium and ferric iron and a rather low birefringence for the aluminous members.

Pleochroism in green and yellow is common and in brown is less common, but it appears to bear no simple relation to composition.

The large axial angle (about Z), high index of refraction, and large extinction angle serve to distinguish this series from the other monoclinic pyroxenes and to differentiate between the members of the group.

TABLE 18.—*Pyroxene group*—Continued

Orthorhombic pyroxenes

No.	α	β	γ	Mineral name	Composition									Birefringence	Axial angle (2V) and dispersion	Extinction (Z∧c)	Color	Specific gravity	Remarks
					Na	Ca	Mg/(Mg+Fe)	Al/(Al+Fe)	Si	O	Mg/Fe	Al/Fe	Miscellaneous						
																°			
1	1.650	1.653	1.658	Enstatite										0.008	31°; r<v		White	3.18	Artificial mineral.
2	1.656	1.659	1.665	do							24			.009					
3	1.661	1.666	1.672	do							12.4			.011					
4	1.660	1.670	1.675	do							9.8			.015(?)					
5	1.665	1.669	1.674	do							10			.009	80°; r<v		Green	3.28	
6	1.673	1.678	1.683	Hypersthene							6.1			.010	90°		do	3.3	
7	1.682	1.689	1.694	do							4			.012	99°; r>v		Greenish	3.37	Pleoc.: X=clear pink, Y=yellow, Z=green.
8	1.692	1.702	1.705	do							2.8			.013	105°; r>v		do	3.42	Do.
9	1.715	1.728	1.731	do							1.5			.016	117°		do	3.49	Do.
				Monoclinic pyroxenes															
				CLINOENSTATITE-PIGEONITE SERIES															
10	1.651	1.654	1.660	Clinoenstatite			8		8	24				0.009	54°; slight	22	White	3.28	Artificial compound. Poly. tw. {100}.
11	1.714	1.714	1.744	Pigeonite		1	7		8	24	0.8		Fe_2O_3=1.72	.030	0	40		3.44	Pleoc.: X and Y=smoky brown, Z=pale yellow.
12	1.690	1.691	1.711	do	0.5	1	6	0.5	8	24	1.6	1.6		.021	15°–20°	44		3.42	Pleoc.: X=yellowish green, Y=brownish pink, Z=greenish white.
13	1.717	1.719	1.741	do		2.5	5	1	7.5	24	1.1	1.6		.024	23°–40°; r>v weak.	45		3.46	
				DIOPSIDE-HEDENBERGITE SERIES															
14	1.664	1.671	1.694	Diopside		4	4		8	24				.030	59°; r>v weak	38½	White	3.28	Pure artificial.
15	1.675	1.685	1.701	do		4	4		8	24	30			.026	60°	40	Light green	3.29	
16	1.678	1.685	1.703	do		4	3.5	1	7.5	24	36			.025	59°	40		3.18	
17	1.681	1.684	1.704	Augite		3.5	4	1	7.5	24	26			.023	60°	42	Greenish white	3.20	

TABLE 18.—*Pyroxene group*—Continued

Monoclinic pyroxenes—Continued

No.	α	β	γ	Mineral name	Composition									Birefringence	Axial angle (2V) and dispersion	Extinction (Z∧c)	Color	Specific gravity	Remarks
					Na	Ca	Mg + Fe	Al + Fe	Si	O	Mg / Fe	Al / Fe	Miscellaneous						
				DIOPSIDE-HEDENBERGITE SERIES—continued															
18	1.686	1.692	1.711	Augite		3.5	4	1	7.5	24	10	3.9		0.025	58°	42	Olive-green to black.	3.34	Tw. on {100}.
19	1.693	1.699	1.719	do		3.5	4	1	7.5	24	3.6	2.5		.026	58°	43	Black	3.24	Do.
20	1.698	1.704	1.723	do		4	3.5	1	7.5	24	4.4			.025	61°	45			
21	1.702	1.708	1.726	Diopside hedenbergite.		4	4		8	24	1.0			.024	61°	45	Green	3.6	
22	1.704	1.714	1.744	Hedenbergite		4	4		8	24	.8			.041(?)	Medium large				
23	1.732	1.737	1.751	do		4	4		8	24	.2			.019	60°	47			
24	1.699	1.718	1.742	Augite		4	3	2	7	24	5.1	1.3		.043	65°–67°	46–51		3.41	
				SODA PYROXENE SERIES															
25	1.680	1.687	1.709	Aegirite(federovite)	.5	3.5	3.5	.5	8	24	1.3	1.7		.029	60°	65–75			Pleoc.: X and Y=olive-green, Z=yellow.
26	1.720		1.747	Aegirite	2	2	2	2	8	24	3			.027	Large	66		3.42	Al:Fe:V=14:19:77. Fibrous. Pleoc.:X=light green, Y=greenish yellow, Z=pale yellow.
27	1.742	1.768	1.787	do	3	1	1.5	2	8	24	5	.07	Ti=0.5	.035	99°; $r<v$	92	Leaf-green	3.52	Pleoc.: X=olive-green, Y=light blue green Z=yellowish green.
28	1.745	1.770	1.782	do	3	1	1	3	8	24	4		V:Fe'''=0.2	.037	111°; $r<v$	91	Brown	3.55	Pleoc.: X=dark brown, Y=lighter brown, Z=amber.
29	1.744	1.768	1.788	do	3	1	1	3	8	24	1.3	.06		.044	100°–110°; $r<v$	100	Green, brown	3.5	
30	1.776	1.819	1.836	Acmite	4			4	8	24		0		.060	120°	98	Yellow to brown.	3.55	Pure artificial. $NaFeSi_2O_6$. Weakly pleochroic.
31	1.654	1.659	1.667	Jadeite	4			4	8	24		24		.013	Large; $r<v$	34	Green	3.4	
32	1.660	1.666	1.676	Spodumene	[a]4			4	8	24				.016	54°–60°	26	White, etc	3.1–3.2	

[a] Lithium.

TABLE 19.—*Scapolite group*

The composition in the scapolite group may be expressed by the two end components marialite (Ma), $Na_3Al_3Si_9O_{24}.NaCl$, and meionite (Me), $Ca_3Al_6Si_6O_{24}.CaCO_3$.

A small amount of SO_3 enters into the composition in some members. Likewise H_2O is commonly present. K_2O commonly replaces some Na_2O, and this replacement somewhat lowers the index of refraction.

The optical properties of the group are as follows:

1. Uniaxial negative (pure marialite may be optically positive).

2. An increasing birefringence, refringence, and specific gravity, with an increase in the Me component.

3. The index of refraction (ω) is approximately a straight line function of the molecular percentages of the two components.[29]

ω	ϵ	Name and composition	Specific gravity	Birefringence	Remarks
1.534	1.522	Marialite $Ma_{75}Me_{25}$		0.012	Orvald. K_2O 4.25, Cl 0.01, CO_2 2.00, H_2O 3.14 per cent.
1.550	1.542	Marialite $Ma_{74}Me_{26}$		.008	Enterprise. Cl 2.29, SO_3 0.23, CO_2 0.33 per cent.
1.550	1.540	Marialite $Ma_{76}Me_{24}$		.010	Kalpivaara.
1.552	1.543	Dipyre $Ma_{71}Me_{27}$		.009	Olsbo. Cl 2.89, SO_3 0.22, CO_2 1.14 per cent.
1.554	1.541	Dipyre $Ma_{71}Me_{29}$		.013	Pohtosvaara. $Ma_{71}SMe_6KMe_{23}$.
1.565	1.545	Mizzonite $Ma_{55}Me_{45}$	2.612	.020	Zdar. K_2O 2.52, Cl 1.30, CO_2 1.66, H_2O 0.67 per cent.
1.569	1.550	Mizzonite $Ma_{58}Me_{42}$		.019	Haliburton. Cl 2.32, SO_3 0.98, CO_2 1.59 per cent.
1.570	1.545	Mizzonite $Ma_{49}Me_{51}$	2.711	.025	Kanda River. K_2O 0.62, CO_2 2.65, SO_3 0.36, Cl 1.03 per cent.
1.575	1.552	Mizzonite $Ma_{39}Me_{61}$	2.698	.023	Nautauen. $SMa_{10}Ma_{29}KMe_{61}$.
1.575	1.550	Mizzonite $Ma_{42}Me_{58}$		.025	Vahaive.
1.580	1.553	Mizzonite $Ma_{38}Me_{62}$		.027	Larinkari. Cl 0.72, SO_3 1.41, CO_2 3.12, H_2O 1.16 per cent.
1.581	1.551	Mizzonite $Ma_{34}Me_{66}$	2.676	.030	Studnice. Cl 0.46, CO_2 3.49, H_2O 0.27 per cent.
1.582	1.545	Mizzonite $Ma_{29}Me_{71}$		.037	Kristiansand. K_2O 1.31, CO_2 3.54, H_2O 1.56 per cent.
1.583	1.549	Mizzonite $Ma_{40}Me_{60}$	2.710	.034	Waldviertel. Cl 0.17, CO_2 4.50 per cent.
1.584	1.554	Mizzonite $Mg_{37}Me_{63}$	2.716	.030	Mansjo Mountains. Cl 1.27, CO_2 3.43, H_2O 0.28 per cent.
1.585	1.551	Mizzonite $Ma_{37}Me_{63}$	2.715	.034	Gulla Tal. Cl 0.24, CO_2 4.55 per cent.
1.587	1.559	Mizzonite $Ma_{33}Me_{67}$	2.748	.028	Laacher See. SO_3 2.06, CO_2 3.52, H_2O 0.80 per cent.
1.588	1.553	Mizzonite $Ma_{30}Me_{70}$	2.730	.035	Hesselkulla. Cl 0.10, CO_2 4.61 per cent.

[29] Winchell, A. N., Am. Mineralogist, vol. 9, p. 108, 1924.

TABLE 19.—*Scapolite group*—Continued

ω	ε	Name and composition	Specific gravity	Birefringence	Remarks
1.590	1.560	Mizzonite $Ma_{23}Me_{77}$	2.755	0.030	Laacher See. Cl 0.49, SO_2 2.28, CO_2 3.23, H_2O 0.21 per cent.
1.594	1.556	Mizzonite $Ma_{24}Me_{76}$	2.702	.038	Mansjo Mountains. CO_2 4.47, Cl 0.31 per cent.
1.595	1.557	Mizzonite $Ma_{29}Me_{71}$	------	.038	Pargas. CO_2 4.74 per cent.
1.607	1.571	Meionite $Ma_{12}Me_{88}$	------	.036	Vesuvius. Cl 0.22, SO_3 0.27, CO_2 4.07 per cent.

TABLE 20.—*Spinel group*

The spinels are isometric and octahedral in habit. Quantitative data on the group are not yet as detailed as could be wished. The color and indices of refraction serve to distinguish the members fairly well.

Mineral name and composition	n	Specific gravity	Color
Spinel $MgO.Al_2O_3$(pure)	1.718	3.6	In transmitted light nearly colorless.
Spinel $(Mg,Fe,Na_2,K_2)O.(Al,Fe)_2O_3$	1.720	3.68	Dark green.
Spinel $MgO.Al_2O_3$(some FeO)	1.75	3.73	In transmitted light nearly colorless.
Pleonaste $(Mg,Fe)O.Al_2O_3$	1.77	3.8	Green.
Hercynite $FeO.Al_2O_3$	1.80	3.9	Do.
Gahnite $ZnO.Al_2O_3$	1.80	4.55	Do.
Galaxite $MnO.Al_2O_3$	1.923	4.23	Reddish brown.
Picotite $(Mg,Fe)O.(Al,Cr)_2O_3$	2.05	4.08	Dark brown.
Chromite $(Fe,Mg)O.Cr_2O_3$	2.07	4.5	Do.
Chromite $FeO.Cr_2O_3$	2.16	4.5	Dark brown, nearly opaque.
Trevorite $NiO.Fe_2O_3$	2.3(?)	------	Black.
Jacobsite $(MnO.Fe_2O_3)$	2.3±	4.75	Black, nearly opaque.
Magnesioferrite $MgO.Fe_2O_3$	2.34_{Li}	4.6	Dark red.
Franklinite $(Zn,Fe,Mn)O.(Fe,Mn)_2O_3$	2.36_{Li}	5.1	Reddish brown, nearly opaque.
Magnetite $FeO.Fe_2O_3$	2.42_{Na}	5.17	Black, opaque.

TABLE 21.—*Tourmaline group*

The composition of the members of the tourmaline group may be expressed by the general formula (modified from Machatschki [30]) $(Na,Ca)R_3(Al,Fe)_6B_3Si_6O_{27}(O,OH,F)_4$, with R = Mg, Fe″, Fe‴, Al, Li, Mn″, and in some members Cr.

In some tourmalines R = Mg entirely, or Fe entirely. Little Fe‴ replaces Al. Na and Ca are apparently completely replaceable in this series. The lighter colored varieties usually have lithium and manganese present, with little iron.

Optical characteristics: All tourmalines are optically negative and uniaxial. The birefringence is moderate to strong, the high iron members having both a stronger birefringence and a higher index of refraction. The colored and dark members show marked pleochroism and absorption, with $\omega > \epsilon$.

ϵ	ω	Mineral name and composition	Specific gravity	Color	Remarks
1.613	1.636	Dravite $NaMg_3Al_6B_3Si_6O_{27}(OH)_4$	3.038	Brown	Dabrova.
1.621	1.641	Calcium tourmaline (uvite) $CaMg_3Al_6B_3Si_6O_{28}(OH)_3$	3.054		Ceylon.
1.623	1.642	Rubellite $(Na,Ca)R_3Al_6B_3Si_6O_{29}(OH,F)_2$	3.020	Red	Penig. R = Li:Fe:Al = 1:2:3. (OH):F = 3:1.
1.625	1.646	Indicolite $NaR_3Al_6B_3Si_6O_{28}(OH,F)_3$	3.086	Bluish green	R = Li:Fe″:Mg:Al = 5:8:2:15. (OH):F = 5:1.
1.625	1.648	Rubellite $NaR_3Al_6B_3Si_6O_{28}(OH,F)_3$	3.135		Tsilaisina. R = Li:Mn:Al = 1:2:3.
1.633	1.655	Tourmaline $(Na,Ca)R_3Al_6B_3Si_6O_{29}(OH)_2$	3.089	Black	Na:Ca = 2:1. R = Mg:Fe″:Al = 3:1:2.
1.633	1.662	Tourmaline $(Na,Ca)R_3Al_6B_3Si_6O_{29}(OH)_2$	3.10	do	Na:Ca = 12:1. R = Mg:Fe″:Fe‴ = 2:3:5.
1.636	1.662	Tourmaline $(Na,Ca)R_3Al_6B_3Si_6O_{28}(OH)_3$	3.00	do	Na:Ca = 7:3. R = Mg:Fe″:Fe‴ = 7:3:2.
1.636	1.662	Tourmaline $(Na,Ca)R_3Al_6B_3Si_6O_{29}(OH)_2$	3.08	do	Na:Ca = 2:5. R = Mg:Fe″:Fe‴ = 5:3:4.
1.639	1.671	Schorlite $NaR_3Al_6B_3Si_6O_{27}(OH)_4$	3,212	do	R = Mg:Fe″ = 6:1.
1.644	1.672	Tourmaline $(Na,Ca)R_3Al_7B_2Si_6O_{28}(OH)_3$	3.104	do	Na:Ca = 5:2. R = Mg:Fe″:Fe‴ = 3:5:8.
1.647	1.681	Schorlite $NaFe_3Al_6B_3Si_6O_{27}(OH)_4$	3.24	do	Some TiO_2. Andreasberg.
1.662	1.682	Tourmaline $(Na,Ca)R_3(Al,Fe)_6B_3Si_6O_{27}(O,OH)_4$	3.09	do	Na:Ca = 4:3. R = Mg:Fe″ = 2:5. Al:Fe‴ = 6:1.
1.641	1.687	Chromium tourmaline $(Na,Ca)R_3Al_6B_3Si_6O_{27}(OH,F)_4$	3.3	do	R = Cr:Mg:Fe″ = 7:6:2. Na:Ca = 2:1.
1.658	1.698	Schorlite $NaFe_3Al_6B_3Si_6O_{27}(OH)_4$		do	

[30] Machatschki, Felix, Die Formeleinheit des Turmalins: Zeitschr. Kryst., Band 70, Heft 3, pp. 211–233, 1929.

TABLE 22.—*Uranite group*

The members of the uranite group are pseudotetragonal and have an axial angle ranging from 0 to a small angle. They are negative in optical character and the acute bisectrix is normal to the more or less perfect basal cleavage {001}. The minerals of the group have the characteristic yellow and green colors of uranium minerals with a rather marked pleochroism.

α	β	γ	Mineral and composition	Axial angle (2V) and dispersion	Specific gravity	Color	Remarks
1.553	1.575	1.577	Autunite $CaO.2UO_3.P_2O_5.8H_2O$	30° $r>v$.	3.1	Yellow	
1.560	1.582	1.587	Uranospinite $CaO.2UO_3.As_2O_5.8H_2O$	46° $r>v$ strong.	3.45	do	
1.582	1.592	1.592	Torbernite $CuO.2UO_3.P_2O_5.8H_2O$	0°	3.4–3.6	Green	
1.610	1.623	1.623	Uranocircite $BaO.2UO_3.P_2O_5.8H_2O$	10°	3.5	Yellow-green.	Z=a. Pleoc. Has also {100} {010} cleavages.
1.585	1.630	1.630	Troegerite $3UO_3.As_2O_5.12H_2O$	0°±	3.23	Yellow	Also {100} cleavage.
1.623	1.643	1.643	Zeunerite $CuO.2UO_3.As_2O_5.8H_2O$	0°	3.2	Green	

TABLE 23.—*Vivianite group*

The members of the vivianite group have the following optical characteristics:

A large axial angle, which may be positive or negative, the dispersion changing with the change in sign of the angle.

X is normal to a perfect cleavage; the members of the group are all monoclinic; Z inclined to *c* about 30°.

The members of the group are usually deeply colored and pleochroic.

TABLE 23.—*Vivianite group*—Continued

Biaxial positive

α	β	γ	Mineral and composition	Axial angle and dispersion	Orientation	Cleavage	Specific gravity	Remarks
1.510	1.520	1.543	Bobierite $3MgO.P_2O_5.8H_2O$	71° $r<v$ weak.	$X=b$ $Z\wedge c=29°$.	{010}	2.41	Colorless.
1.563	1.571	1.596	Hoernesite $3MgO.As_2O_5.8H_2O$	60°	$X=b$ $Z\wedge c=31°$.	{010}perf.	2.60	White.
1.579	1.603	1.633	Vivianite $3FeO.P_2O_5.8H_2O$	83° $r<v$ weak.	$X=b$ $Z\wedge c=28°$.	do	2.6	Colorless, blue, green; pleoc. when blue.
1.626	1.661	1.699	Erythrite $3CoO.As_2O_5.8H_2O$	90° $r<v$ weak.	$X=b$ $Z\wedge c=31°$.	{010}highly perf.	2.95	Crimson to gray; pleoc. in red and violet; may be opt. negative.
1.662	1.683	1.717	Koettigite $3ZnO.As_2O_5.8H_2O$	77° $r<v$ rather strong.	$X=b$ $Z\wedge c=37°$.	{010}perf.	3.1	Carmine; nonpleoc.

Biaxial negative

α	β	γ	Mineral and composition	Axial angle and dispersion	Orientation	Cleavage	Specific gravity	Remarks
1.62	1.654	1.689	Cabrerite $3(Ni,Mg)O.As_2O_5.8H_2O$	90°± $r>v$ strong.	$X=b$ $Z\wedge c=33°$.	{010}perf.	3.0	Apple-green.
1.622	1.658	1.687	Annabergite $3NiO.As_2O_5.8H_2O$	84° $r>v$ rather strong.	$X=b$ $Z\wedge c=36°$.	do	3.0–3.1	Do.
1.626	1.661	1.699	Erythrite $3CoO.As_2O_5.8H_2O$	90°± $r>v$ weak.	$X=b$ $Z\wedge c=31°$.	do	2.95	Crimson to gray. Pleoc.
1.635	1.668	1.702	Symplesite $3FeO.As_2O_5.8H_2O$	87° $r>v$ rather strong.	$X=b$ $Z\wedge c=31°$.	do	2.96	Pale indigo, green, etc.

TABLE 24.—*The zeolites*

The zeolites are here grouped together for convenience in identification. In general, they form isomorphous series only over very narrow ranges. Unlike those in tables 5–23, most of the species here entered are not isomorphously related to each other. There is, however, a close similarity of chemical composition in the zeolites, which may be expressed by the general formula $(Na,Ca)_x Al_x(Al,Si)_x Si_y O_{2(2x+y)} nH_2O$, which, it is believed, holds for most analyses of zeolites. As complete substitution between Na and Ca is rare in the zeolites, the substitution (Al,Si) generally does not reach its limit x. The formula is based on the assumption that Na replaces Ca, as shown by Winchell.[30]

The general optical characteristics of this class are a low index of refraction, weak birefringence, and white to colorless, rarely colored.

Further, the zeolites are commonly fibrous; many are well crystallized. They have a low specific gravity and give off water readily.

[30] Am. Mineralogist, vol. 10, pp. 97, 112, 145, 166, 1925.

TABLE 24.—*The zeolites*—Continued

Isotropic zeolites

n	Mineral and composition	System and habit	Specific gravity	Remarks
1.48	Faujasite $Na_2CaAl_4Si_{10}O_{28}+20H_2O$	Oct	1.92	Uniaxial (+) in eight segments upon loss of water.
1.487	Analcite $Na_2Al_2Si_4O_{12}+2H_2O$	Trapezohedral	2.25	

Uniaxial positive

ϵ	ω	Mineral and composition	System and habit	Cleavage	Specific gravity
1.474	1.470	Gmelinite $(Na,Ca)_2Al_2(Al,Si)Si_5O_{20}+10H_2O$	Trig	{10$\bar{1}$0} dist	2.1
1.486	1.475	Laubanite $Ca_2Al_2Si_5O_{14}+6H_2O$	Mon? Fib. *c*	Pris. good	2.2
1.482	1.480	Chabazite $(Na,Ca)_2Al_2(Al,Si)Si_5O_{24}+12H_2O$	Ps. trig. Cubic	{10$\bar{1}$0} dist	2.1
B=weak.	1.48	Faujasite $Na_2CaAl_4Si_{10}O_{28}+20H_2O$	Oct	{111} dist	1.92
1.502	1.490	Natrolite hydronephelite $(Na,Ca)_4Al_6Si_6O_{24}+14H_2O$	Hex. Fib		2.26

Uniaxial negative

1.464	1.465	Gmelinite $(Na,Ca)_2Al_2(Al,Si)Si_5O_{20}+10H_2O$	Trig	{10$\bar{1}$0} easy	2.1
1.478	1.480	Chabazite $(Na,Ca)_2Al_2(Al,Si)Si_5O_{24}+12H_2O$	Trig. Cubic	do	2.1

163287—34—17

TABLE 24.—*The zeolites*—Continued

Uniaxial negative—Continued

ε	ω	Mineral and composition	System and habit	Cleavage	Specific gravity
1.486	1.487	Analcite $Na_2Al_2Si_4O_{12}+2H_2O$	Ps. isomet	{211}	2.25
1.491	1.496	Levynite $CaAl_2Si_3O_{10}+5H_2O$	Trig	{02$\bar{2}$1} dist	2.1

Biaxial positive

α	β	γ	Mineral and composition	Axial angle (2V) and dispersion	Optical orientation	System and habit	Cleavage	Specific gravity	Remarks
1.438	1.44	1.452	Erionite $(Na,K,Ca)_3Al_3(Al,Si)Si_{12}O_{32}+12H_2O$						
B=weak	1.480	------	Faujasite $Na_2CaAl_4Si_{10}O_{28}20H_2O$			Oct	{111} dist	1.92	
B=.004	1.481	------	Gmelinite $(Na,Ca)_2Al_2(Al,Si)Si_5O_{20}+10H_2O$	Small		Ps. trig	{10$\bar{1}$0} easy	2.7	Tw. axis=*c*.
1.480	1.482	1.493	Natrolite $Na_2Al_2Si_3O_{10}+2H_2O$	63° $r<v$ weak.	X=*a*. Z=*c*.	Orth. Needles *c*.	{110} perf., {010} imperf.	2.25	Tw. plane {110} and {100}.
1.474	1.476	1.478	Arduinite $(Ca,Na)_2Al_2(Al,Si)Si_2O_{14}+5H_2O$	Near 90°	Opt. plane // cleav.	Orth.(?) Radially fib.	One perf	2.26	Same as gonnardite?
1.485	1.485	1.48	Chabazite $(Na,Ca)_2Al_2(Al,Si)Si_3O_{24}+12H_2O$	Small		Ps. trig	{10$\bar{1}$1} dist	2.1	
1.482	1.485	1.489	Heulandite $(Na,Ca)_2Al_2(Al,Si)Si_{14}O_{40}+10H_2O$	50°	Z=*b* Y∧c=35°.	Mon. Tab. {010}.	{010} perf	2.2	
1.498	1.499	1.505	Heulandite? $CaAl_2Si_6O_{16}+5H_2O$	34° $r>v$.	Z=*b* Y∧c=6°.	do	do	2.3	

1.498	1.500	1.503	Phillipsite $(K,Na,Ca)_2Al_3(Al,Si)Si_5O_{20}+8H_2O$	70° $r<v$.	$X=b$ $Z\wedge a=19°$.	Mon. Fib. a	{001}{010} rather dist.	2.2	
1.498	1.50	1.503	Wellsite $(Ba,Ca,K)_2Al_2(Al,Si)Si_5O_{20}+8H_2O$	39°	$Z=b$ $Y\wedge c=52°$.	Mon	None	2.3	Complex tw.
1.503	1.505	1.508	Harmotome $(Ba,K)Al(Al,Si)Si_5O_{16}+5H_2O$	43°	$Z=b$ $Y\wedge a=23½$.	Mon. Pris. a	{010} easy, {001} less so.	2.5	Tw. {001} cruciform.
1.505	1.505	1.506	Mesolite $Na_2Ca_2Al_6Si_9O_{30}+8H_2O$	80° $r>v$ strong.	Z near a $Y\wedge c=5°\pm$.	Tricl. Needles	{110} and {1$\bar{1}$0} perf.	2.27	Tw. pl. {100}.
B=.002	-------	1.5	Pseudomesolite $Na_2Ca_2Al_6Si_9O_{30}+8H_2O$	Very small	$Z\wedge c=20°$	Tricl. Fib. c	{110} and {110} perf.	2.22	
1.510	1.512	1.523	Brewsterite $(Sr,Ba,Ca)Al_2Si_6O_{16}+5H_2O$	50° $r>v$ weak.	$Z=b$ $X\wedge c=22°$.	Mon. Elong. c	{010} perf	2.45	
1.512	1.513	1.518	Thomsonite $Ca_2NaAl_5Si_5O_{20}+5H_2O$	Medium $r<v$.	$X=a$ $Z=b$.	Orth. Fib. c	{010}	2.3	"Faroelite."
1.523	1.525	1.535	Thomsonite $Ca_2NaAl_5Si_5O_{20}+6H_2O$	48° $r>v$.	$X=a$ $Z=b$.	do	do	2.35	
1.535	1.537	1.545	Thomsonite $Ca(Na,K)Al_4Si_6O_{20}+5H_2O$		$X=b(?)$ $Z=c$.	Orth	{010} perf	2.37	Na:K=1:1.

Biaxial negative

1.472	1.475	1.476	Mordenite $Na_2CaAl_4Si_{10}O_{40}+12H_2O$	Large	$Z=b$ $X\wedge c=4°$.	Mon. (or tric.). Tab. {010} elong. c.	{010} perf	2.15	
B=0.001-0.008	-------	1.474	Gmelinite $(Na,Ca)_2Al_2(Al,Si)Si_6O_{20}+10H_2O$	Small		Ps. trig	{10$\bar{1}$0} easy	2.1	Tw. axis c.
1.474	1.475	1.477	Ptilolite $(Na,Ca)Al(Al,Si)Si_{10}O_{24}+5H_2O$	57°	$X=c$ $Y=a$.	Orths. Laths {100}, elong. c.	{100} perf	-------	Cottonlike.
B=.001	-------	1.487	Analcite $Na_2Al_2Si_4O_{12}+2H_2O$	Very small	Ps. isomet			2.25	Tw. grating.
1.484	1.492	1.495	Stellerite $CaAl_2Si_7O_{18}+7H_2O$	44° $r<v$ weak.	$Y=b$ $X=c$.	Orth. Tab	{010} perf. {100} dist. {001} indist.	2.12	
1.493	1.501	1.507	Epidesmine $CaAl_2Si_6O_{16}+6H_2O$	40°	$Y=a$ $X=c$.	Orth	{100} perf. {010} less so.	2.16	

TABLE 24.—*The zeolites*—Continued

Biaxial negative—Continued

α	β	γ	Mineral and composition	Axial angle (2V) and dispersion	Optical orientation	System and habit	Cleavage	Specific gravity	Remarks
1.494	1.498	1.500	Stilbite $(Ca,Na)Al(Al,Si)Si_6O_{18}+5H_2O$	33° $r<v$.	$Y=b$ $X\wedge a=5°$.	Mon. Acic. a	{010} perf. {001} trace.	2.2	Tw. on {001} cruciform penet.
1.502	1.510	1.512	Epistilbite $CaAl_2Si_6O_{16}+5H_2O$	44° $r<v$ strong.	$Y=b$ $Z\wedge c=9°$.	Mon. Elong. c	{010} perf.	2.25	
1.512	1.519	1.519	Scolecite $CaAl_2Si_3O_{10}+3H_2O$	36° $r<v$ strong.	$Z=b$ $X\wedge c=17°$.	do	{110} perf.	2.3	
1.513	1.524	1.525	Laumontite $CaAl_2Si_4O_{12}+4H_2O$	25° $r<v$ strong.	$Y=b$ $Z\wedge c=20°-30°$.	do	{010} {110} very perf.	2.28	Tw. pl. {100}.
1.538	1.549	1.554	Edingtonite $BaAl_2Si_3O_{10}+3H_2O$	53° Weak.	$X=c$ $Z=a$.	Orth. Ps. tetrag. sphenoidal.	{110} perf.	2.7	

INDEX