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Index to the Reflectance and Microindentation

Hardness of Ore Minerals in the IMA/COM

Quantitative Data File (First Issue, 1977)

expensive
By
unstable
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This report is preliminary and has not been
edited or reviewed for conformity with U.S.
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The COM Quantitative Data File (Henry, 1977) gives, on cards, the reflectance and microindentation hardness of a good selection of ore minerals. The 200 data cards are arranged alphabetically by mineral name and corresponding accession number. The numbering system accommodates multiple data cards for a given mineral and allows for expansion as new data are added to subsequent editions of the file. The first issue of the file contains an abundance of reflectance and microindentation hardness values of superior quality, but the lack of a direct index to the numerical data has inhibited the full and effective use of the file by the working ore microscopist.

This separately published index to numerical data in the COM Data File serves both as an index in the strict sense and as a set of determinative tables. As an index, it permits the user to find the reflectance and microhardness values that are recorded on the data cards. As a set of determinative tables, the index helps the user identify an unknown mineral, either directly from the index or after study of the data on the card found by use of the numerical index. The outline of the index is given, the arrangement of the contents of the index is explained, and the use of the index as a determinative table is illustrated.

The outline of the index is:

Table

1	Reflectance in air at 546 nm
1A	Monoreflecting or weakly bireflecting; $\Delta R(546) < 1\%$
1A.1	Dispersion (470, 546) positive
1A.2	Dispersion (470, 546) negative
1B	Bireflecting; $\Delta R(546) \geq 1\%$
1B.1	Dispersion (470, 546) positive
1B.2	Dispersion (470, 546) negative
2	Microindentation hardness

Reflectance data, Table 1.--The primary entry (left column) in all sections of Table 1 of the index is the reflectance in air at 546 nm.---

---/Preparation of an index to the reflectance in oil has been deferred.

Beginning at the primary entry, the user can retrieve specific reflectance data as carded in the Data File. The reflectance may be that of R , R_0 , R_E or R_E' , R_1 , R_2 , $R_{\underline{a}}$, $R_{\underline{b}}$, or $R_{\underline{c}}$, depending on the symmetry of the mineral and the character of the observations reported on the card. In the index, R_1 and R_2 refer to the least and greatest reflectances observed at 546 nm in a principal or near-principal section of the mineral. Some contributors to the Data File have followed other conventions in labeling R_1 and R_2 , but it is not practical to follow their various conventions in compiling a unified index.

The secondary entry (column 2) in Table 1 is bireflectance. Bireflectance, a measure of optical anisotropy observed with a single polar at a specified wavelength, is here referred to the standard wavelength of 546 nm. Table 1A lists isotropic (monoreflecting) minerals together with weakly anisotropic minerals whose bireflectance is sufficiently low (nominally <1% in this index) to cause uncertainty in measurement if only a few sections of the mineral are available for inspection. Table 1B lists minerals whose bireflectance ($\geq 1\%$) should be measurable with confidence. The positive or negative sign of bireflectance at 546 nm is given for uniaxial minerals: $R_O < R_E$ or R_E , (+), $R_O > R_E$ or R_E , (-). The sign of the bireflectance of minerals of lower symmetry is omitted from the index; the sign is not known for many of them.

The tertiary entry in Table 1 is the dispersion of the reflectance, defined by the difference in reflectance at pairs of standard wavelengths: (1) 470, 546; (2) 546, 589; and (3) 589, 650 nm. According to the mathematical convention for sign of slope, dispersion is termed positive if reflectance increases with increasing wavelength, and negative if reflectance decreases with increasing wavelength. To save space, only the negative sign of dispersion is shown in the index; an unlabeled dispersion is understood to be positive. Tables 1A and 1B are divided into two subsections, one listing minerals whose "initial" dispersion (470, 546) is positive, the other listing minerals whose initial dispersion is negative. The initial dispersion, given in column 3 of all subsections of Table 1, is followed in column 4 by the dispersion (546, 589) and in column 5 by the dispersion (589, 650). The indexed data for dispersion of reflectance indicate three "standard segments" that approximate the shape of the reflectance curve between 470 and 650 nm.— The reflectance curves of a few minerals have

— Many workers regard the shape of a reflectance curve, rather than the somewhat variable reflectance values, as characteristic for an ore mineral.

one or more inflections within the standard segments. This information is omitted from the index, which must provide alike for reflectances measured only at standard wavelengths and for reflectances measured at 20-nm intervals.

The foregoing account gives the elements of Table 1 that are essential if the index is used merely to retrieve reflectance data from the Data File. The use of the index for that purpose is shown by the following example.

A strongly bireflecting mineral has a reflectance of 55.8% at 546 nm. A search of Tables 1B.1 and 1B.2 shows only one entry at this R-value. It is in Table 1B.1, and the reflectance is labeled R_2 . At 546 nm, the bireflectance is 7.6%, which is strong. The dispersion of the reflectance for R_2 is (positive) 6.2%, -1.2%, and -1.0% for wavelength pairs 470, 546; 546, 589; and 589, 650 nm. The next column gives information on microhardness; it is not pertinent to the retrieval of reflectance data. The following column is blank. A little scanning of adjacent entries in this column of the table will show that evidently our mineral does not show crossed dispersion of the reflectance. The next column gives the crystal symmetry as orthorhombic; this information is merely auxiliary for indexing but potentially useful for mineral determination. The far-right column identifies the foregoing reflectance data as belonging to marcasite, for which data card 1.5400 lists further information. Since the cards are arranged alphabetically by mineral name, the card number itself is not needed in this index to numerical data. Had there been two data cards for marcasite, numbered 1.5400.1 and 1.5400.2, the far-right column of the index would read "Marcasite.1," calling attention to the first of the two cards. "Marcasite.2" would identify data from the second card, had there been one.

The single card for marcasite shows that the reflectance was measured at standard wavelengths, not at 20-nm intervals.

Data for R_1 of the example are also available in the index. If needed, they could have been found in the same part of the index (because crossed dispersion, if not demonstrably absent, is at least not indicated in the index) by looking for a primary entry whose $R_1 = 48.2\%$; R_2 minus the recorded bireflectance equals R_1 .

Microindentation hardness, Table 2.--The primary entry is the Vickers hardness number (VHN), reported from the Data File as range or mean. A number in parentheses represents the midrange, supplied by the indexer. The data are ranked according to increasing mean or midrange. The indentation load in grams is given at the lower left of the mean or midrange. If no number appears there, the load is 100 grams. VHN, if available, is also listed in column 6 of all sections of Table 1, where the conjunction of reflectance and microhardness data is useful for mineral identification.

Use of the index as a determinative table.--This use is best shown by an example.

An economic geologist with a mineralogical bent is obliged to identify two ore minerals, X and Y, each from a prospect under option to his company. A correct and prompt identification of the minerals is essential because the small company, pinched for cash, wants to drop its option on one of the prospects. Polished sections show that minerals X and Y are bright, yellow, and anisotropic. Except for the following data, all information on the samples is deemed confidential. Confidentiality, conveniently attributed to the company, is merely the indexer's device for focusing attention on the use of quantitative data in the index and in the Data File, without recourse here to other kinds of information.

At 470, 546, 589, and 650 nm, mineral X is found to have $R_1(\text{air}) = 45.9, 49.6, 50.0,$ and 49.1% ; $R_2(\text{air}) = 51.6, 57.2, 55.8,$ and 54.7% . $VHN_{100} = 762\text{--}1561$, midrange 1162. The economic geologist rearranges the optical data in the format

	R(546)	$\Delta R(546)$	(470, 546)	(546, 589)	(589, 650)
R_2	57.2	7.6	5.6	-1.4	-1.1
R_1	49.6	7.6	3.7	0.4	-0.9

He knows by experience that he should allow about 10%, relatively, for gross variation in reflectance. Therefore, for his R_2 set, he scans Table 1B.1, column 1, for values between ~ 50 and 63, column 2 for values between ~ 5 and 10, column 3 for values between ~ 4 and 8, and columns 4 and 5 for rough agreement in sign and size of dispersion. He concludes that his R_2 is a good match for R_2 of the Data File's marcasite.

Allowing again for variation, he repeats the procedure for his R_1 set and decides that both marcasite and emplectite match reasonably well. He then looks with care at the data for emplectite, realizes that he has allowed too generously for variation, finally sees that he is trying to compare his R_1 set with the R_2 set of emplectite, and eliminates emplectite from further consideration. Indeed, he is ready to believe that mineral X is marcasite until he compares his microhardness data with those in the index. The discrepancy is considerable at the midrange, though the ranges overlap. The economic geologist then scans Table 2 for VHN's whose mean or midrange is ~ 950 –1300, but in that range he finds no VHN for a mineral optically similar to mineral X. However, just beyond the 950–1300 range lies the VHN of marcasite, and it is the first mineral beyond the range to have properties corresponding to those of mineral X.

Hoping that some feature of the dispersion curves may be fully diagnostic, the economic geologist now turns to the COM data card for marcasite, but the card lists R at standard wavelengths only. This discovery is a little disappointing. However, the economic geologist takes a last look at his data and the COM's, concludes with considerable confidence that mineral X is indeed marcasite, and proceeds to identify mineral Y.

Mineral Y has, at the four standard wavelengths, $R_1(\text{air}) = 42.4$, 50.1, 52.2, 54.7%; $R_2(\text{air}) = 41.5$, 55.3, 58.6, 61.3%. $VHN_{100} = 219-330$, midrange 274. Rearranged in the format of the index, the optical data are:

	R(546)	$\Delta R(546)$	(470, 546)	(546, 589)	(589, 650)
R_2	55.3	5.2	13.8	3.3	2.7
R_1	50.1	5.2	7.7	2.1	2.5

The economic geologist turns quickly to Table 1B.1. Step by step, with appropriate allowance for variation in mineral properties, he finds that his data for R_2 of mineral Y correspond closely to the COM's for R_E , of two different millerites. His data for R_1 of mineral Y correspond rather well to the COM's for R_0 of the millerites, but some of the COM data for chalcopyrite, marcasite, and nickeline also seem to fit. The economic geologist at once thinks of many properties that would confirm or deny the initial correspondences. He settles first on VHN but is disappointed. The index shows no VHN for either millerite, and the data cards confirm that the desired information is lacking. But a glance at the data cards for chalcopyrite and marcasite shows that the first mineral is somewhat softer, and the second much harder, than mineral Y; the weight of the evidence, then, favors millerite.

Our economic geologist looks next at two optical properties that the index and the data cards give for millerite: uniaxial positive character, and crossed dispersion near 470 nm. He selects several additional grains of mineral Y, measures $R_1(546)$ in air, and finds R_1 to be nearly constant, as well as representative of R for one nearly isotropic grain. The behavior of $R_1(546)$ is thus clearly appropriate for R_0 of a uniaxial mineral. Somewhat to his surprise (he overlooked it, earlier), the economic geologist discovers that his initial set of measurements pointed to crossed dispersion of R_1 and R_2 in the blue. That the phenomenon truly exists in mineral Y, he proves by making some additional measurements between 440 and 500 nm; crossed dispersion occurs at ~ 475 nm. Mineral Y is pretty surely millerite.

This very model of a modern ore microscopist now reports to his chief that mineral X is marcasite, that mineral Y is millerite, and that his confidence in identifying the minerals is about 90%. The chief, a bit old-fashioned, says, "Make a microchemical test for Ni on both minerals." The test is made, Ni is found in mineral Y but not in mineral X, and the company drops its option on the mining claim from which mineral X was collected.

The fictitious example illustrates the use of the index and shows that reliable determinations can be made by application of the COM data. The example also serves as a reminder that the First Issue of the COM Data File is less comprehensive than the working microscopist might wish, as noted elsewhere (Leonard, 1978). Nevertheless, by providing direct access to the reflectance data for the 159 ore minerals in the COM Data File, the index permits the user to turn to comparable data (indexed by mineral name) in the works of Bezsmertnaya and Chvilëva (1976), Picot and Johan (1977), Uyténbogaardt and Burke (1971), and Vyal'sov (1973). The Russian data, slightly abbreviated, are conveniently available in the Tabellen neuer Reflexionswerte published as a supplement to the compendium of Ramdohr (1975). For microindentation hardness data supplementary to those of COM, see Uyténbogaardt and Burke (1971) and references given therein.

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Abbreviations

cub. -- cubic
hex. -- hexagonal
monocl. -- monoclinic
orth. -- orthorhombic
pscub., etc. -- pseudocubic
tetrag. -- tetragonal
tricl. -- triclinic
trig. -- trigonal

R -- reflectance in air, in percent

ΔR -- bireflectance, in percent. Unless otherwise indicated, refers to
bireflectance at 546 nm

R_{subscript} -- see text

VHN -- Vickers hardness number

X disp. 480 -- Crossed dispersion at 480 nm; reflectance curves cross at
480 nm

do. -- ditto

var. -- variety

% -- percent

>, >> -- greater than, much greater than

<, << -- less than, much less than

\approx -- approximately equal to

λ -- wavelength

Notes -- Notes and queries are mainly those of the indexer. A few notes
are taken directly from the COM data cards. A distinction between
the sources can be made by consulting the data cards.

Table 1. Reflectance in air at 546 nm

1A. Monoreflecting or weakly bireflecting; $\Delta R(546) < 1\%$

1A.1. Dispersion (470, 546) positive

Table 1A.1.--Dispersion (470, 546) positive

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
15.5	0	0.45	0.35	1.3			cub.	Ulvöspinel
18.4	0	0.3	0.25	0.45	490 100-300	Wuestite	cub.	FeO synth.
18.5	0	1.9	3.0	4.3	95-105 100		cub.	Bornite.1
19.4	0	0.1	0.0	-0.1	665-707 100		cub.	Jacobsite
20.4	0	0.1	1.9	2.8			cub.	Germanite
21.3	?	4.3	3.2	4.75			tetrag.	Bornite.2
22.6	0	3.6	1.2	1.5	172 20		cub.	Djerfisherite
24.4 R_O	+0.5	5.9	3.3	3.9		X disp. 480	tetrag.	Renierite
24.9 R_E	+0.5	6.7	3.5	3.7		do.	do.	do.
25.0	?	4.8	2.2	2.6	210 20		cub.?	Shadlunite
29.8	0	3.2	1.6	0.4			cub.	Colusite
30.5	0	0.0	-0.5	-1.8			cub.	Tetrahedrite.1
30.8	0	0.1	-0.4	-0.9	351-380 100		cub.	Tetrahedrite.4
30.8	0	0.4	-0.4	-1.2	309-360 100		cub.	Tetrahedrite, argentian.3
32.2	0	0.6	-0.4	-1.6	285-322 100		cub.	Tetrahedrite.2
39.2	0	4.1	2.3	2.7	1033-1150 100		cub.	Pyrite, nickelian.3

Table 1A.1.--Dispersion (470, 546) positive--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
39.3	0	12.7	2.6	1.6	144-178 150		cub.	Talnakhite
44.4 R_O	+0.9	11.9	1.6	1.6	181-203 100		tetrag.	Chalcopyrite.1
45.3 R_E	+0.9	11.7	1.7	1.7	do.		do.	do.
45.4	0	2.4	1.8	2.9	503-525 100		cub.	Siegenite
45.8	?	11.7	1.8	0.9			tetrag.	Chalcopyrite.2
46.5	0	6.9	2.5	3.2	268-285 100		cub.	Pentlandite.2
47.2 R_O	?	10.7	1.9	0.5	186-191 150		tetrag.	Chalcopyrite.3
47.8 R_1	0.7	2.0	2.2	3.7	715-743 100	ΔR too low?	tetrag.	Maucherite
48.5 R_2	0.7	2.4	2.2	3.6	do.	do.	do.	do.
50.0 R_1	0.6	1.6	0.4	0.7	1097-1115 100	ΔR too low?	orth.	Glaucodot
50.0	0	6.3	1.95	2.25			cub.	Pentlandite.1
50.5	?	3.2	1.4	1.0	935-1131 100		orth.	Cobaltite
50.6 R_2	0.6	1.4	0.1	0.6	1097-1115 100	ΔR too low?	orth.	Glaucodot
51.7	0	6.1	1.8	0.9	1505-1620 100		cub.	Pyrite.2

Table 1A.1.--Dispersion (470, 546) positive--Continued

R	ΔR	Dispersion			VHN	Notes	Symmetry	Mineral
546		470, 546	546, 589	589, 650				
51.85 R_b	0.35	3.15	-0.15	-0.4	1081 100	X disp. 525, 555	monocl.	Arsenopyrite.1
52.2 R_a	0.35	0.35	1.0	0.4	do.	do.	do.	do.
52.8	0	6.8	2.2	0.5	1505-1561 100		cub.	Pyrite.1
54.0	0	1.8	-0.5	-0.8	894-1048 100	Skutterudite.1 has (-) slope	cub.	Skutterudite.2
54.2	0	0.4	0.1	0.4	782-835 100		"cub."	Gersdorffite
59.0 $R_2?$?	2.5	0.9	1.0	168-232 50	Single curve only, labeled R_0 by COM. Anisotropic effects are tinted, though bire- flectance was not observed by the original investiga- tors.	orth.	Polarite
70.3	0	3.5	1.6	2.3	122-129 50		cub.	Platinum
71.2	0	2.6	0.8	0.8	698-782 100		cub.	Osmiridium
71.5	0	32.0	11.9	6.2	53-58 100		cub.	Gold
94.2	0	2.5	0.8	0.7	55-63 100		cub.	Silver

Table 1. Reflectance in air at 546 nm

1A. Monoreflecting or weakly bireflecting; $\Delta R(546) < 1\%$

1A.2. Dispersion (470, 546) negative

Table 1A.2.--Dispersion (470, 546) negative

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
7.9 R ₁	0.1	-0.2	-0.1	0.0	230-302 100		tetrag.	Coffinite
8.0 R ₂	0.1	-0.2	-0.1	0.0	do.	do.	do.	do.
9.9 R ₁	0.1	-0.3	-0.15	-0.1	387-409 100	ΔR too low	tetrag.	Scheelite
10.0 R ₂	0.1	-0.35	-0.1	0.0	do.	do.	do.	do.
11.8 R ₁	0?	-0.7	-0.4	-0.4	190-219 100	Isotropic at 546 nm; other zincites are anisotropic in white light	hex.	Zincite
11.8 R ₂	0?	-0.9	-0.3	-0.3	do.	do.	do.	do.
12.1	0	-0.6	-0.3	-0.2	249-287 100		cub.	Betafite (metamict)
12.3	0	-0.5	-0.2	-0.2	1332 100	Varies!	cub.	Chromite
12.8	0	-0.8	-0.2	-0.2	542-665 100		cub.	Pyrochlore.2
13.4	0	-0.3	0.0	-0.1	1150-1332 100		cub.	Thorianite.1
13.6	0	-0.5	0.0	-0.1	499-548 50		cub.	Uraninite.2 var. Pitchblende
14.2	0	-0.6	-0.3	-0.2	782-813 100		orth.	Euxenite (metamict)

Table 1A.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
15.0	0	-0.5	-0.2	-0.2	606-627 100	var. Hatchet- tolite	cub.	Pyrochlore.1 (metamict)
15.0	0	-0.6	-0.3	-0.3	690 100		monocl.	Brannerite (metamict)
15.1	0	-0.6	-0.3	-0.2	do.		do.	do.
15.7	0	-0.5	-0.3	-0.1			cub.	Thorianite.2 var. Uranothorianite
16.1	0	-0.4	-0.1	0.1	792-813 100		cub.	Uraninite.1
16.7	0	-0.8	-0.3	-0.2	218-227 100		cub.	Sphalerite
17.2	0	-0.7	-0.3	-0.2	803-907 100		trig.	Davidite (metamict)
17.6	?	-1.1	-0.3	-0.35			tetrag.	Gallite
18.6 R_Q	+0.9	-1.4	-0.5	-0.3	1027-1225 50		tetrag.	Braunite
19.5 R_E	+0.9	-1.2	-0.6	-0.4	do.		do.	do.
20.0	0	-0.1	0.3	0.2	592 100		cub.	Magnetite.2
20.1	0	-0.1	0.2	0.2			cub.	Magnetite.1
22.2	0	-0.1	-0.2	-0.4	946-1402 100		cub.	Bixbyite
22.7	0	-1.5	0.0	-1.4	169-239 50		cub.	Alabandite.2
22.8	0	-1.6	-0.5	-0.4	240-251 100		cub.	Alabandite.1

Table 1A.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
23.1	0	-4.0	-2.1	-2.6	67-76 100		cub.	Digenite
24.4	0	-2.7	-1.6	-1.4	412 50		cub.	Maghemite
24.6	0?	-1.3	-0.1	0.1			pscub.	Canfieldite
24.7 R_1	0.4	-1.35	-0.25	0.1			pscub.	Argyrodite
24.8 R_E	-0.4	-5.0	0.3	2.9		X disp. 520, 570	tetrag.	Permingeatite
25.1 R_2	0.4	-1.5	-0.2	0.0			pscub.	Argyrodite
25.2 R_O	-0.4	-1.5	-1.0	0.8		X disp. 520, 570	tetrag.	Permingeatite
26.6	~0	-4.5	-2.0	-1.6	193-207 100		cub.	Cuprite.1
26.7	~0	-4.7	-1.7	-1.5			cub.	Cuprite.2
27.4 R_E	-0.7	-4.9	-1.55	-1.45		Proustite.2 has higher ΔR	trig.	Proustite.1
28.1 R_O	-0.7	-5.05	-1.65	-1.45		do.	do.	do.
29.6	0	-0.3	-1.7	-2.2			cub.	Tennantite.3
29.7	0	-0.4	-1.1	-1.5			cub.	Tennantite.1
30.0	0	-1.5	-0.2	-1.0	297-354 100		cub.	Tennantite.2
30.1	0	-0.2	0.1	0.7			cub.	Goldfieldite
30.5	0	0.0	-0.5	-1.8			cub.	Tetrahedrite.1

Table 1A.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
31.9	0?	-0.5	-0.85	-1.35	180-192 100	$\Delta R > 0$	monocl.	Pearceite
33.20 R_c	0.24	-3.48	-1.71	-1.58	84-87 100	X disp. complex	psorth.	Chalcocite
33.44 R_a	0.24	-3.16	-1.24	-2.47	do.	do.	do.	do.
35.7 R_o	<0.1?	-1.0	0.6	-0.7		ΔR not measurable	trig.	Gratonite
36.2 R_1	0.35	-2.7	-1.2	-1.7		X disp. 510	orth.	Bournonite.2
36.55 R_2	0.35	-0.85	-1.15	-1.9		do.	do.	do.
37.5	?	-0.1	0.4	1.1	28-34 100		monocl.	Hessite
43.1	0	-3.5	-1.2	-0.1	71-72 100	Galena.2	cub.	Galena
43.6	0	-2.6	-0.6	0.5	59-65 100	"Galena.1"	cub.	PbS synth.
44.1	0	-1.7	-1.9	-1.4	1220-1288 100		cub.	Irarsite.1
46.4	0	-1.2	-0.7	0.8	536-592 100		cub.	Ullmannite
47.3	0	-1.4	-1.7	-2.0	1100-1145 50		cub.	Irarsite.2
48.5	0	-1.4	0.8	0.4	644-689 50		cub.	Hollingworthite
50.9	0	-4.7	-1.8	-1.8	44 50	"Clausthalite"	cub.	PbSe synth.

Table 1A.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
52.8	0	-1.3	-0.7	0.4	1080-1145 100		cub.	Sperryllite
54.4	0	-1.6	-0.6	-1.1	792-907 100	Skutterudite.2 has (+) slope	cub.	Skutterudite.1
57.7	0	-0.35	0.3	1.0	158 100-300	Presumably nickel-iron	cub.	Iron
58.2	0	-0.5	-1.2	-1.8	726-766 50		cub.	Geversite
58.8	0	-0.7	-1.5	-0.5	do.		do.	do.
68.8	0	-1.3	-1.5	-3.7	47-51 100		cub.	Altaite

Table 1.	Reflectance in air at 546 nm
1B.	Bireflecting; $\Delta R(546) \geq 1\%$
1B.1.	Dispersion (470, 546) positive

Table 1B.1.--Dispersion (470, 546) positive

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
6.8 R_1	10.6	0.2	0.2	0.3	12-16 50	Presumably $R_1 = R_{E'}$, $R_2 = R_0$. If so, $\Delta R (-)$.	hex.	Graphite
17.4 R_2	10.6	1.3	0.7	1.2	do.	do.	do.	do.
18.0 R_2	9.2	2.0	0.9	1.5	15-49 5	R_1 has (-) slope	tricl.	Tochilinite
19.5 R_2	3.2	0.4	-0.4	-0.7		R_1 has (-) slope	orth.	Marokite
21.6 R_1	3.9	2.4	1.8	4.0	232-271 50		orth.	Stannoidite.2
24.3 R_1	3.65	2.4	1.5	2.75			orth.	Stannoidite.3
24.6 R_0	+2.8	1.1	1.5	2.3			tetrag.	Luzonite.1
25.2	?	3.2	1.8	4.1	258-277 ?	Single curve only	orth.	Stannoidite.1
25.5 R_2	3.9	2.4	1.0	1.7	232-271 50		orth.	Stannoidite.2
25.9 R_2	2.1	0.7	1.3	1.2	345-387 100	R_1 has (-) slope	tetrag.	Luzonite.2
26.0 R_0	+1.3	2.5	0.1	0.15			tetrag.	Stannite
26.9 R_0	+2.1	4.4	2.2	3.4		X disp. 530	tetrag.	Mawsonite
27.3 $R_{E'}$	+1.3	1.4	0.0	-0.1			tetrag.	Stannite

Table 1B.1.—Dispersion (470, 546) positive--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
27.3 R_1	5.1	1.3	0.5	0.4			orth.	Raguinite
27.4 R_E	+2.8	2.8	1.4	1.2			tetrag.	Luzonite.1
27.95 R_2	3.65	3.35	1.15	1.7			orth.	Stannoidite.3
29.0 R_E	+2.1	9.5	6.1	5.3		X disp. 530	tetrag.	Mawsonite
29.2 R_E	-3.6	3.3	1.3	1.75			tetrag.	Eskebornite
30.1 R_1	6.7	2.45	1.2	1.9			orth.	Argentopyrite
31.1 R_D	$R_c - R_D$ 17.0	0.3	-0.45	-1.3	71-86 100 on {010}	$R_c > R_a > R_D$ R_c has (-) slope	orth.	Stibnite
32.35 R_1	1.3	0.45	0.05	-0.05		R_2 has (-) slope	orth.	Naumannite.1
32.4 R_2	5.1	2.4	2.3	1.8			orth.	Raguinite
32.8 R_0	-3.6	4.0	1.4	2.0			tetrag.	Eskebornite
33.3 R_1	1.6	0.8	0.1	-0.1			orth.	Wittichenite
34.0 R_0	+5.2	3.1	1.8	2.8	230-318 100		hex.	Pyrrhotite.2
34.5 R_0	+6.2	3.4	2.9	-0.2			hex.	Pyrrhotite.3

Table 1B.1.—Dispersion (470, 546) positive--Continued

R	ΔR 546	Dispersion 470, 546, 589, 546 589 650			VHN	Notes	Symmetry	Mineral
34.8 R ₀	+5.1	4.0	2.1	2.6	373-409 100		monocl. (ps hex.)	Pyrrhotite.1
34.9 R ₂	1.6	0.4	-0.2	-0.45			orth.	Wittichenite
35.4 R ₁	4.0	6.6	2.25	2.85			orth.	Cubanite.1
36.3 R ₁	1.5	1.9	0.5	-1.9		X disp. 434, 572	orth.	Eucairite
36.8 R ₂	6.7	2.4	1.0	1.0			orth.	Argentopyrite
37.1 R ₁	5.2	0.4	-0.3	0.1		X disp. 425	orth.	Emplectite
37.6 R ₁	2.7	7.5	2.4	2.4	247-287 100		orth.	Cubanite.2
37.8 R ₂	1.5	2.3	-1.9	-1.9		X disp. 434, 572	orth.	Eucairite
39.2 R _E	+5.2	3.0	1.5	1.8	230-318 100		hex.	Pyrrhotite.2
39.4 R ₂	4.0	5.3	1.3	1.8			orth.	Cubanite.1
39.9 R _E	+5.1	4.4	1.7	1.7	373-409 100		monocl. (ps hex.)	Pyrrhotite.1
40.0 R ₂	11.0	0.1	-0.7	-1.2	146-243 100 Too low!	Optic sign? R ₁ has (-) slope	tetrag.	Pyrolusite
40.3 R ₂	2.7	8.1	2.1	1.8	247-287 100		orth.	Cubanite.2
40.7 R _E	+6.2	3.5	2.4	-1.9			hex.	Pyrrhotite.3

Table 1B.1.—Dispersion (470, 546) positive--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
42.3 R_2	5.2	3.1	-0.2	-1.6		X disp. 425	orth.	Emplectite
42.45 R_1	1.5	0.65	-0.45	-1.2		R_2 has (-) slope	orth.	Teallite
46.3 R_2	7.05	1.12	-0.1	-1.0		R_1 has (-) slope	orth.	Aikinite
47.2 R_0	?	10.7	1.9	0.5	186-191 150	R_E not deter- mined	tetrag.	Chalcopyrite.3
47.2 R_E	-4.4	9.8	6.1	5.8	363-372 100		hex.	Nickeline
47.8 R_1	0.7	2.0	2.2	3.7	715-743 100	Optic sign? ΔR perhaps too low	tetrag.	Maucherite
48.2 R_1	7.6	5.1	0.2	-0.6	1288-1681 100		orth.	Marcasite
48.5 R_2	0.7	2.4	2.2	3.6	715-743 100	Optic sign? ΔR perhaps too low	tetrag.	Maucherite
49.4 R_0	+4.9	5.95	2.0	1.0		X disp. 470	trig.	Millerite.2
49.4 R_E	-8.1	1.0	-0.6	-1.3			trig.	Paraguajuatite
50.1 R_b	$R_c - R_b$ 1.5 $R_a - R_b$ 0.2	1.05	0.5	0.65	760-1150 100	$R_c > R_b \approx R_a$ R_c has (-) slope X disp. R_a , R_c 600; R_b , R_c 640	monocl. (psorth.)	Arsenopyrite.2 (cobaltian)
50.2 R_0	+6.4	5.55	1.7	2.2		X disp. 470	trig.	Millerite.1

Table 1B.1.--Dispersion (470, 546) positive--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
50.3 R_a	$\frac{R_c - R_a}{1.3}$ $\frac{R_a - R_b}{0.2}$	0.65	0.65	0.65	760-1150 100	See Arsenopyrite.2, above	monocl. (psorth.)	Arsenopyrite.2 (cobaltian)
50.3 R_1	8.7	2.5	0.5	0.9	91-104 100		monocl.	Sylvanite
50.9 R_1	6.2	1.25	0.2	0.1			trig.	Tetradymite
51.2 R_1	1.1	4.2	2.3	2.4	379-449 100		tricl.	Arsenopalladinite
51.2 R_E'	-3.6	6.0	3.3	4.7	407-441 50		hex.	Plumbopalladinite
51.6 R_0	-4.4	6.7	4.4	4.1	363-372 100		hex.	Nickeline
52.1 R_1	1.2	0.0	-0.9	-0.2	824-870 100	R_2 has (-) slope	orth.	Loellingite.1 (nickelian)
52.3 R_2	1.1	3.9	2.1	2.2	379-449 100		tricl.	Arsenopalladinite
52.3 R_1	2.2	3.5	3.2	1.0	485-602 15, 25		orth.(?)	Stibiopalladinite.2
52.4 R_1	1.7	0.0	-1.2	-1.5	446-560 100	R_2 has (-) slope	orth.	Loellingite.2
52.9 R_1	1.0	5.4	2.5	3.0	603-617 100	X disp. 640	orth.(?)	Stibiopalladinite.1
53.9 R_2	1.0	4.7	2.2	2.2	do.	do.	do.	do.
54.3 R_E'	+4.9	10.7	3.1	1.0		X disp. 470	trig.	Millerite.2

Table 1B.1,--Dispersion (470, 546) positive--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
54.5 R ₂	2.2	3.9	2.5	1.9	485-602 15, 25		orth.(?)	Stibiopalladinite.2
54.8 R ₀	-3.6	6.0	2.7	4.1	407-441 50		hex.	Plumbopalladinite
55.8 R ₂	7.6	6.2	-1.2	-1.0	1288-1681 100		orth.	Marcasite
56.3 R ₁	1.5	0.4	0.5	0.6	762-792 100		orth.	Pararammelsbergite
56.6 R _{E'}	+6.4	11.45	2.45	1.65		X disp. 470	trig.	Millerite.1
57.1 R ₂	6.2	0.75	-0.15	0.0			trig.	Tetradymite
57.5 R ₀	-8.1	0.5	-0.45	-1.2			trig.	Paraguanajuatite
57.8 R ₂	1.5	0.6	0.0	-0.2	762-792 100		orth.	Pararammelsbergite
58.7 R ₁	2.7	0.2	0.75	1.55		Optic sign? Isotropic at 400 X disp. 430	trig.	Tellurobismuthite
59.0 R ₂	8.7	1.4	0.0	0.4	91-104 100		monocl.	Sylvanite
59.0 R ₂ (?)	?	2.5	0.9	1.0	166-232 50	Single curve only, labeled R ₀ by COM	orth.	Polarite
60.2 R ₀	+9.7	0.7	-0.1	-1.6	68-117 25 on {00.1}		trig.	Tellurium synth.
61.4 R ₂	2.7	1.6	1.0	1.7		Optic sign? Isotropic at 400 X disp. 430	trig.	Tellurobismuthite

Table 1B.1.--Dispersion (470, 546) positive--Continued

R	ΔR 546	Dispersion 470, 546, 589, 546 589 650			VHN	Notes	Symmetry	Mineral
62.1 R_1	1.1	1.9	0.7	1.1	146-160 100		orth.	Dyscrasite
63.2 R_2	1.1	2.2	0.8	1.2	do.		do.	do.
63.7 R_0	?	7.5	2.8	3.0	214-405 20	R_E not deter- mined. ΔR should be appreciable	hex.	Kotulskite
66.7 $R_2 \neq R_0$?	4.3	2.1	2.4	15-18 100	Single curve only. ΔR should be strong	trig.	Bismuth
69.9 R_E	+9.7	0.4	-0.9	-2.0	68-117 25 on {00.1}		trig.	Tellurium synth.

- Table 1. Reflectance in air at 546 nm
- 1B. Bireflecting; $\Delta R(546) \geq 1\%$
 - 1B.2. Dispersion (470, 546) negative

Table 1B.2.--Dispersion (470, 546) negative

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
6.4 R_0	+16.6	-6.0	-2.7	3.1		X disp. 696	hex.	Covellite.2
7.2 R_0	+16.5	-6.2	-3.0	1.7	128-138 100	X disp. absent	hex.	Covellite.1
8.2 R_0	+8.2	-4.7	-2.5	-3.5		X disp. absent	hex.	Covellite, blaubleibender
8.8 R_1	9.2	-0.4	-0.3	-0.3	15-49 5	R_2 has (+) slope	tricl.	Tochilinite
9.9 R_1	15.0	-0.5	-0.2	-0.2	188-253 100		tricl.	Chalcophanite
11.5 $R_1 \neq R_0$	+0.9	-0.45	-0.2	-0.1	1168-1332 100	ΔR too low	tetrag.	Cassiterite
11.6 R_1	6.8	-1.45	-0.5	-0.45	402 100-300		orth.	Lepidocrocite
12.15 R_0	+4.45	-4.55	1.25	8.7		Isotropic at 400 X disp. 610	tetrag.	Umangite
12.4 $R_2 \neq R_1$	+0.9	-0.4	-0.2	0.0	1168-1332 100	ΔR too low	tetrag.	Cassiterite
14.8 R_1	5.9	-0.3	-0.5	-0.3	698-772 100		monocl.	Manganite
15.0 R_1	1.2	-0.6	-0.3	-0.1	312-342 100		monocl.	Wolframite
15.5 R_1	2.0	-1.75	-0.5	-0.55	667 100-300		orth.	Goethite
16.2 R_2	1.2	-0.4	-0.3	-0.1	312-342 100		monocl.	Wolframite

Table 1B.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
16.3 R_1	3.2	-1.15	-0.25	-0.55		R_2 has (+) slope	orth.	Marokite
16.4 R_E	+8.2	-4.0	-2.2	-3.1		X disp. absent	hex.	Covellite, blaubleibender
16.6 R_E	+4.45	-2.8	-0.5	0.4		Isotropic at 400 X disp. 610	tetrag.	Umangite
17.0 R_E	-3.1	-0.3	0.4	0.6	519-703 100		trig.	Ilmenite
17.5 R_2	2.0	-2.4	-0.9	-0.5	667 100-300		orth.	Goethite
17.6 R_1	2.0	-0.2	-0.1	0.0	536-566 100	Optic sign?	tetrag.	Hausmannite
18.4 R_2	6.8	-2.45	-1.0	-0.9	402 100-300		orth.	Lepidocrocite
19.5 R_E	-19.05	-1.9	-0.45	-0.35			trig.	Molybdenite-3R
19.6 R_2	2.0	-1.2	-0.7	-0.7	536-566 100	Optic sign?	tetrag.	Hausmannite
19.8 $R_1 \neq R_E$	20.6	-2.2	-0.6	-0.3	32-33 100		hex.	Molybdenite-2H
20.1 R_O	-3.1	-0.5	0.1	0.2	519-703 100		trig.	Ilmenite
20.3 R_O	?	-1.3	-0.5	-0.4	1132-1187 100	R_E not given; should be > R_O	tetrag.	Rutile
20.7 R_2	5.9	-0.6	-0.8	-0.6	698-772 100		monocl.	Manganite

Table 1B.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion 470, 546, 589, 546 589 650			VHN	Notes	Symmetry	Mineral
21.1 R_1	4.6	-0.8	-0.2	-0.2	304-339 100		monocl.	Tenorite
21.7 R_0	+6.7	-1.0	-0.7	-0.4	566-681 100		monocl. (pstetrag.)	Hollandite
22.1	?	-3.7	-1.2	-1.0		Single curve (max.?) ΔR negligible on section measured	monocl.	Realgar
22.2 R_1	7.35	-1.4	-0.65	-0.55	681-724 100		orth.	Romanechite
23.0 R_E	-1.2	-0.7	0.2	0.7		X disp. 640	tetrag.	Hocartite
23.0 R_E	+16.6	-5.3	-2.1	1.6		X disp. 696	hex.	Covellite.2
23.05 R_1	4.45	-3.7	-0.9	-0.75			monocl.	Orpiment
23.7 R_E	+16.5	-5.4	-2.5	1.8	128-138 100	X disp. absent	hex.	Covellite.1
23.8 R_1	2.1	-0.5	0.7	1.7	345-387 100	R_2 has (+) slope	tetrag.	Luzonite.2
24.1 R_0	+4.7	-2.1	-0.7	-0.8			trig.	Cinnabar.2
24.2 R_0	-1.2	-0.85	0.1	-0.55		X disp. 640	tetrag.	Hocartite
24.3 R_a	$R_b - R_a$ 0.9	-2.05	-0.5	1.1		$R_b > R_a$. No data for R_c X disp. 425, 500	orth.	Enargite.2

Table 1B.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
24.6 R_O	+5.0	-2.1	-0.8	-0.8	82.4-156 10		trig.	Cinnabar.1
24.9 R_2	15.0	-3.8	-1.3	-1.1	188-253 100		tricl.	Chalcophanite
25.1 R_a	$\frac{R_b - R_a}{0.8}$	-2.3	-0.7	1.2	285-327 100	$R_c > R_b > R_a$ X disp.: R_a, R_b 500 R_b, R_c 660	orth.	Enargite.1
25.1 R_a	$\frac{R_b - R_a}{5.35}$	-2.5	-0.85	-0.85	39-90 5	At all λ 's, $R_b > R_c > R_a$	monocl.	Kermesite
25.2 R_b	$\frac{R_b - R_a}{0.9}$	-0.7	0.4	1.3		$R_c > R_a$ No data for R_c X disp. 425, 500	orth.	Enargite.2
25.3 $R_{E'}$	-2.4	-4.5	-1.6	-1.2	103-137 50		trig.	Proustite.2
25.7 R_2	4.6	-0.6	-0.5	-0.3	304-339 100		monocl.	Tenorite
25.9 R_b	$\frac{R_b - R_a}{0.8}$ $\frac{R_c - R_b}{2.8}$	-0.9	0.2	1.9	285-327 100	$R_c > R_b > R_a$ X disp: R_a, R_b 500 R_b, R_c 660	orth.	Enargite.1
26.1 $R_{E'}$	-4.1	-1.35	-1.0	-2.1	1038 100-300		trig.	Hematite
26.35 R_1	3.35	-3.85	-0.9	-0.65			orth.	Stromeyerite.1

Table 1B.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
26.8 R_1	3.95	-1.9	-0.95	-0.65	30-32 100		orth.	Stromeyerite.2
27.2 R_1	1.5	-2.7	-1.55	0.05		X disp. 465	tetrag.	Bukovite
27.4 $R_{E'}$	-0.7	-4.9	-1.55	-1.45		ΔR perhaps too low	trig.	Proustite.1
27.5 R_1	>>0.2	-2.0	-1.2	-1.2	592-690 100	ΔR much too low	tetrag.	Coronadite
27.5 R_2	4.45	-3.4	-0.75	-0.9			monocl.	Orpiment
27.65 R_1	1.9	-2.6	-1.7	-1.95		Optic sign?	tetrag.	Routhierite
27.7 R_2	>>0.2	-2.35	-1.1	-1.3	592-690 100	ΔR much too low	tetrag.	Coronadite
27.7 R_0	-2.4	-5.0	-0.9	-1.3	103-137 50		trig.	Proustite.2
28.0 $R_{E'}$	-3.0	-4.0	-1.5	-2.2	107-144 50		trig.	Pyrargyrite.2
28.1 R_0	-0.7	-5.05	-1.65	-1.45		ΔR perhaps too low	trig.	Proustite.1
28.15 R_1	2.25	-3.05	-0.6	0.35			orth.	Stephanite
28.3 R_1	2.0	-3.2	-0.8	0.1	66-87 100		trig.	Pyrargyrite.3
28.4 $R_{E'}$	+6.7	-1.7	-0.9	-1.0	566-681 100		monocl. (pstetrag.)	Hollandite
28.5 $R_{E'}$	-1.85	-5.3	-2.0	-1.7			trig.	Pyrargyrite.1

Table 1B.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
28.7 R_2	1.5	-1.3	-0.7	1.2		X disp. 465	tetrag.	Bukovite
28.7 R_c	$\frac{R_c - R_d}{2.8}$ $\frac{R_c - R_a}{3.6}$	-0.5	0.0	-0.3	285-327 100	$R_c > R_b > R_a$ X disp: R_a, R_b 500 R_b, R_c 660	orth.	Enargite.1
28.8 R_E	+4.7	-2.05	-1.0	-1.2			trig.	Cinnabar.2
29.0 R_1	11.0	-1.5	-0.9	-0.6	146-243 100 Probably too low	Optic sign? R_2 has (+) slope	tetrag.	Pyrolusite
29.55 R_2	1.9	-1.9	-2.15	-1.5		Optic sign?	tetrag.	Routhierite
29.55 R_2	7.35	-3.05	-1.4	-1.65	681-724 100		orth.	Romanechite
29.6 R_E	+5.0	-2.3	-1.4	-1.3	82.4-156 10		trig.	Cinnabar.1
29.7 R_2	3.35	-6.8	-1.05	-0.35			orth.	Stromeyerite.1
29.8 R_1	1.6	-2.1	-1.1	-1.3			monocl.	Parapierrotite
30.2 R_0	-4.1	-1.6	-1.05	-2.8	1038 100-300		trig.	Hematite
30.3 R_1	1.0	-2.2	-1.3	-0.7	23-26 100		monocl.	Acanthite
30.3 R_2	2.0	-2.0	-1.0	-0.2	66-87 100		trig.	Pyrargyrite.3

Table 1B.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
30.35 R_0	-1.85	-4.95	-1.95	-1.9			trig.	Pyrargyrite.1
30.4 R_2	2.25	-2.45	-0.65	-0.4			orth.	Stephanite
30.45 R_b	$R_b - R_a$ 5.35	-3.05	-1.25	-1.05	30-90 5	At all λ 's, $R_b > R_c > R_a$	monocl.	Kermesite
30.7 R_1	1.85	-2.0	-0.7	-1.5		X disp. 448	monocl.	Polybasite
30.75 R_2	3.95	-7.05	-1.4	-0.6	30-32 100		orth.	Stromeyerite.2
31.0 R_0	-3.0	-3.5	-2.3	-1.9	107-144 50		trig.	Pyrargyrite.2
31.3 R_2	1.0	-2.7	-1.5	-0.8	23-26 100		monocl.	Acanthite
31.4 R_2	1.6	-1.5	-1.0	-1.1			monocl.	Parapierrrotite
31.6 R_1	2.9	-3.4	-1.55	-2.05			monocl.	Miargyrite
31.9 R_1	0.0?	-0.5	-0.85	-1.35	180-192 100	ΔR perhaps >>0	monocl.	Pearceite
31.9 R_2	0.0?	-0.7	-0.7	-1.3		See above	monocl.	Pearceite
32.55 R_2	1.85	-1.4	-1.15	-2.15		X disp. 448	monocl.	Polybasite
33.6 R_1	3.3	-2.3	-1.3	-2.2			monocl.	Sartorite
33.65 R_2	1.3	-1.2	-0.05	0.9		R_1 has (+) slope	orth.	Naumannite.1

Table 1B.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
33.95 R_b	$\frac{R_a - R_b}{1.65}$ $\frac{R_c - R_b}{1.55}$	-1.55	-1.0	-1.3	176-205 100	$R_a \approx R_c > R_b$ X disp.: R_a, R_b 420 R_a, R_c 520, 660	orth.	Bournonite.1
34.0	?	-2.4	-1.6	-1.1	22-33 100	Single curve	orth.	Naumannite.2
34.1 R_1	5.7	-2.4	-1.0	-1.5			orth.	Pierrotite
34.5 R_2	2.9	-3.45	-1.7	-2.5			monocl.	Miargyrite
34.8 R_1	7.0	-0.6	-0.85	-2.05			monocl.	Plagionite
35.05 R_1	6.35	-2.45	-1.35	-2.1			monocl.	Rathite
35.5 R_c	$\frac{R_a - R_b}{1.55}$ $\frac{R_a - R_c}{0.1}$	-2.15	-1.25	-1.6	176-205 100	$R_a \approx R_c > R_b$ X disp.: R_a, R_b 420 R_a, R_c 520, 660	orth.	Bournonite.1
35.55 R_1	3.95	-1.65	-0.8	-1.1			monocl.	Freieslebenite
35.6 R_a	$\frac{R_a - R_b}{1.65}$ $\frac{R_a - R_c}{0.1}$	-0.7	-0.95	-1.9	176-205 100	$R_a \approx R_c > R_b$ X disp.: R_a, R_b 420 R_a, R_c 520, 660	orth.	Bournonite.1

Table 1B.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
35.65 R ₁	1.8	-1.5	-0.8	-1.25			tricl.	Franckeite
36.25 R ₁	4.75	-1.45	-0.55	-0.85			orth.	Andorite
36.6 R ₁	5.7	-0.95	-0.85	-1.8			monocl.	Semseyite
36.65 R ₁	5.35	-1.45	-0.15	-0.4			orth.	Berthierite
36.7 R ₁	1.2	-1.4	-1.4	-2.2			tricl.	Aramayoite
36.9 R ₂	3.3	-2.15	-1.4	-2.45			monocl.	Sartorite
36.9 R ₁	5.3	-1.4	-1.7	-1.5	283-309 100		orth.	Chalcostibite
36.9 R ₀	+5.5	-1.15	-0.9	-1.75		X disp. 430	hex.	Zinkenite.1
37.0 R ₁	6.3	-1.0	-0.5	-1.3			orth.	Meneghinite
37.4 R ₁	4.4	-1.45	-0.9	-1.25			monocl.	Boulangerite.1
37.4 R ₁	5.5	-1.1	-0.7	-1.0	113-117 100		monocl.	Jamesonite
37.45 R ₂	1.8	-1.15	-0.75	-1.2			tricl.	Franckeite
37.7 R ₁	1.6	-1.1	-1.1	-1.9	177-185 100		hex.	Zinkenite.2

Table 1B.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
37.9 R ₂	1.2	-2.0	-1.0	-1.4			tricl.	Aramayoite
38.3 R ₁	5.2	-1.3	-1.0	-1.6	92-125 100		monocl.	Boulangerite.2
38.5 R ₁	6.9	-1.1	-0.4	-0.5	110-136 100	ΔR too low	orth.	Bismuthinite
38.55 R ₀	-19.05	-6.15	0.25	0.6			trig.	Molybdenite-3R
39.25 R ₁	7.05	-0.15	-0.25	-0.5		R ₂ has (+) slope	orth.	Aikinite
39.3 R ₂	1.6	-1.2	-1.3	-1.7	177-185 100		hex.	Zinkenite.2
39.5 R ₂	3.95	-1.6	-0.75	-1.3			monocl.	Freieslebenite
39.8 R ₂	5.7	-2.9	-1.8	-1.9			orth.	Pierrotite
40.0 R ₁	6.1	-2.2	-0.9	-0.5	100-117 100		orth.	Kobellite.2
40.4 R ₂ ?R ₀	20.6	-6.5	-1.6	1.2	32-33 100		hex.	Molybdenite-2H
41.0 R ₂	4.75	-1.2	-0.8	-1.35			orth.	Andorite
41.4 R ₁	4.3	-3.0	-0.75	-0.5			orth.	Cosalite
41.4 R ₂	6.35	-2.3	-1.6	-2.6			monocl.	Rathite
41.8 R ₂	4.4	-1.3	-1.1	-2.3			monocl.	Boulangerite.1

Table 1B.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
41.8 R ₂	7.0	-1.6	-0.95	-1.85			monocl.	Plagionite
42.0 R ₂	5.35	-2.4	-1.0	-1.35			orth.	Berthierite
42.2 R ₂	5.3	-3.3	-2.6	-1.7	283-309 100		orth.	Chalcostibite
42.3 R ₂	5.7	-1.1	-0.9	-1.95			monocl.	Semseyite
42.4 R _{E'}	+5.5	-1.7	-1.1	-2.0		X disp. 430	hex.	Zinkenite.1
42.9 R ₂	5.5	-0.7	-1.4	-1.8	113-117 100		monocl.	Jamesonite
43.3 R ₂	6.3	-1.3	-0.8	-2.0			orth.	Meneghinite
43.5 R ₂	5.2	-1.6	-1.4	-2.5	92-125 100		monocl.	Boulangerite.2
43.95 R ₂	1.5	-0.55	-0.65	-1.3		R ₁ has (+) slope	orth.	Teallite
44.8 R ₁	2.4	-2.0	-0.8	-0.8			orth.	Kobellite.1
45.4 R ₂	6.9	-2.4	-0.4	-0.4	110-136 100	ΔR too low	orth.	Bismuthinite
45.7 R ₂	4.3	-2.6	-0.4	-0.1			orth.	Cosalite
46.1 R ₂	6.1	-2.4	-0.4	-0.3	100-117 100		orth.	Kobellite.2

Table 1B.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
47.2 R_2	2.4	-2.4	-1.0	-0.75			orth.	Kobellite.1
48.1 R_c	$R_c - R_b$ 17.0	-4.5	-2.85	-3.1	71-86 100	$R_c > R_a > R_b$ R_b has (+) slope	orth.	Stibnite
51.3 R_1	5.1	-2.25	-0.9	-0.4	83-149 100	Optic sign?	trig.	Arsenic
51.6 R_c	$R_c - R_b$ 1.5 $R_c - R_a$ 1.3	-1.3	-0.4	-0.1	760-1150 100	$R_c > R_b \approx R_a$ R_a, R_b have (+) slope X disp.: R_a, R_c 600 R_b, R_c 640	monocl. (psorth.)	Arsenopyrite.2, cobaltian
52.1 R_1	1.2	0.0	-0.9	-0.2	824-870 100		orth.	Loellingite.1, nickelian
52.4 R_1	1.7	0.0	-1.2	-1.5	446-560 100		orth.	Loellingite.2
52.6 R_1	1.8	-0.7	0.2	0.0	55-99 20		orth.	Volynskite
53.2 R_1	3.1	-0.5	0.3	0.0	585-803 100		orth.	Rammelsbergite
53.3 R_2	1.2	-0.8	0.7	1.1	824-870 100		orth.	Loellingite.1, nickelian
54.1 R_2	1.7	-2.3	1.1	-0.7	446-560 100	R_1 has 0 slope	orth.	Loellingite.2
54.4 R_2	1.8	-1.4	0.7	0.4	55-99 20		orth.	Volynskite

Table 1B.2.--Dispersion (470, 546) negative--Continued

R	ΔR 546	Dispersion			VHN	Notes	Symmetry	Mineral
		470, 546	546, 589	589, 650				
56.3 R ₂	3.1	-0.8	-0.2	-0.4	585-803 100		orth.	Rammelsbergite
56.4 R ₂	5.1	-1.0	-0.6	0.15	83-149 100	Optic sign?	trig.	Arsenic
60.3 R ₁	1.1	-2.4	-4.5	-0.9	1246 25		hex.	Osmium
61.4 R ₂	1.1	-2.6	-4.8	-0.5	do.		hex.	Osmium
71.1 R ₁	1.9	-0.5	-1.1	-1.5	84-98 100	Optic sign?	trig.	Antimony
73.0 R ₂	1.9	-0.2	-0.9	-0.8	do.	do.	trig.	Antimony

Table 2. Microindentation hardness

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Table 2.--Microindentation Hardness

[Load is 100 grams, unless otherwise indicated. Midrange of VHN is shown in parentheses]

<u>VHN</u>	<u>Mineral</u>	<u>VHN</u>	<u>Mineral</u>
12-16 (14) 50	Graphite	67-76 (72)	Digenite
15-18 (16)	Bismuth	71-72 (72)	Galena
23-26 (24)	Acanthite	66-87 (76)	Pyrargyrite.3
22-33 (28)	Naumannite.2	55-99 (77) 20	Volynskite
28-34 (31)	Hessite	71-86 (78)	Stibnite
30-32 (31)	Stromeyerite.2	84-87 (86)	Chalcocite
15-49 (32) 5	Tochilinite	84-98 (91)	Antimony
32-33 (32)	Molybdenite-2H	68-117 (92) 25	Tellurium synth.
44 50	PbSe synth. ("Clausthalite")	91-104 (98)	Sylvanite
47-51 (49)	Altaite	95-105 (100)	Bornite.1
53-58 (56)	Gold	96-104 (100)	Copper
55-63 (59)	Silver	92-125 (108)	Boulangerite.2
30-90 (60) 5	Kermesite	100-117 (108)	Kobellite.2
59-65 (62)	PbS synth. ("Galena")	113-117 (115)	Jamesonite
		83-149 (116)	Arsenic

Table 2.--Microindentation Hardness--Continued

<u>VHN</u>	<u>Mineral</u>	<u>VHN</u>	<u>Mineral</u>
82-156 (119) 10	Cinnabar.1	146-243 (194) Prob. too low	Pyrolusite
103-137 (120) 50	Proustite.2	---	
		168-232 (200) 50	Polarite
110-136 (123)	Bismuthinite	193-207 (200)	Cuprite.1
107-144 (126) 50	Pyrargyrite.2	169-239 (204) 50	Alabandite.2
122-129 (126) 50	Platinum	190-219 (204)	Zincite
128-138 (133)	Covellite.1	210 20	Shadlunite
146-160 (153)	Dyscrasite	188-253 (220)	Chalcophanite
158 100-300	Iron	218-227 (222)	Sphalerite
144-178 (161) 150	Talnakhite	240-251 (246)	Alabandite.1
172 20	Djerfisherite	232-271 (252) 50	Stannoidite.2
177-185 (181)	Zinkenite.2	230-302 (266)	Coffinite
180-192 (186)	Pearceite	247-287 (267)	Cubanite.2
186-191 (188) 150	Chalcopyrite.3	249-287 (268)	Betafite
176-205 (190)	Bournonite.1	258-277 (268) ?	Stannoidite.1
181-203 (192)	Chalcopyrite.1		

Table 2.--Microindentation Hardness--Continued

<u>VHN</u>	<u>Mineral</u>	<u>VHN</u>	<u>Mineral</u>
230-318 (274)	Pyrrhotite.2 (hex.)	402 100-300	Lepidocrocite
268-285 (276)	Pentlandite.2	412 50	Maghemite
283-309 (296)	Chalcostibite	379-449 (414)	Arsenopalladinite
--		407-441 (424)	Plumbopalladinite
285-322 (304)	Tetrahedrite.2	50	
285-327 (306)	Enargite.1	490 100-300	FeO synth. (Wuestite)
214-405 (310)	Kotulskite	446-560 (503)	Loellingite.2
20		503-525 (514)	Siegenite
304-339 (322)	Tenorite	499-548 (524)	Uraninite.2 var. Pitchblende
297-354 (326)	Tennantite.2	50	
312-342 (327)	Wolframite	485-602 (544)	Stibiopalladinite.2
309-360 (334)	Tetrahedrite.3, argentian	15,25 536-566 (551)	Hausmannite
345-387 (366)	Luzonite.2	536-592 (564)	Ullmannite
351-380 (366)	Tetrahedrite.4	592	Magnetite.2
363-372 (368)	Nickeline	--	
373-409 (391)	Pyrrhotite.1 (monocl.)	542-665 (604)	Pyrochlore.2
387-409 (398)	Scheelite	603-617 (610)	Stibiopalladinite.1
--		519-703 (611)	Ilmenite

Table 2.--Microindentation Hardness--Continued

<u>VHN</u>	<u>Mineral</u>	<u>VHN</u>	<u>Mineral</u>
606-627 (616)	Pyrochlore.1	792-813 (802)	Uraninite.1
566-681 (624)	Hollandite	782-835 (808)	Gersdorffite
592-690 (641)	Coronadite	824-870 (847)	Loellingite.1, nickelian
644-689 (666)	Hollingworthite	792-907 (850)	Skutterudite.1
50		803-907 (855)	Davidite
667	Goethite	--	
100-300			
665-707 (686)	Jacobsite	760-1150 (955)	Arsenopyrite.2, cobaltian
690	Brannerite	894-1048 (971)	Skutterudite.2
585-803 (694)	Rammelsbergite	--	
--		935-1131 (1033)	Cobaltite
681-724 (702)	Romanechite	1038	Hematite
		100-300	
715-743 (729)	Maucherite	1081	Arsenopyrite.1
698-772 (735)	Manganite	1033-1150 (1092)	Pyrite.3, nickelian
698-782 (740)	Osmiridium	--	
		1097-1115 (1106)	Glaucodot
726-766 (746)	Geversite	1080-1145 (1112)	Sperrylite
50			
762-792 (777)	Pararammelsbergite	1100-1145 (1122)	Irarsite.2
		50	
782-813 (798)	Euxenite	1027-1225 (1126)	Braunite
--		50	

Table 2.--Microindentation Hardness--Continued

<u>VHN</u>	<u>Mineral</u>	<u>VHN</u>	<u>Mineral</u>
1132-1187 (1160)	Rutile	1220-1288 (1254)	Irarsite.1
946-1402 (1174)	Bixbyite	--	
--		1332 Varies!	Chromite
1150-1332 (1241)	Thorianite.1	--	
		1288-1681 (1484)	Marcasite
1246 25	Osmium	--	
1168-1332 (1250)	Cassiterite	1505-1561 (1533)	Pyrite.1
		1505-1620 (1562)	Pyrite.2

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