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TABLES FOR THE IDENTIFICATION OF ORE MINERALS BY *X*-RAY POWDER PATTERNS*

G. ALAN HARCOURT,
Copper Cliff, Ontario.

TABLE OF CONTENTS

	Page
Introduction	63
Source of Material	64
Sampling and Preparation of *x*-ray Mounts	65
Equipment and Measurements	66
Description of Tables	66
Bibliography	69
Table 1, Powder Diffraction Data of Ore Minerals	69
Pattern Types	106
Some Observations and Conclusions Based on the Study of Minerals and Their Powder Patterns	109
Table 2, Index to Powder Patterns	109

INTRODUCTION

This paper presents *x*-ray powder diffraction data for most of the ore minerals. The patterns have been classified in such a way that an unknown mineral may be identified by its pattern, provided it is contained in this collection. Much of the work on the project was carried out at Harvard University during the years 1935–1937. Since then, data have been accumulating, and as there is an almost unlimited amount of work that could be done it has been difficult to choose a suitable point at which to stop for purposes of publication. The collection and classification as they now stand have been found to be most useful in the mineralogical study of ores. They have been in laboratory use for three years during which time they have been checked, revised and enlarged.

Dr. Harry Berman and Dr. L. C. Graton of Harvard University are largely responsible for the progress that has been made on this project. Dr. Berman made available *x*-ray equipment, supplied many mineral specimens from museum collections, provided a classification of the

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* Contribution from the Department of Mineralogy and Petrography, Harvard University, No. 250 in collaboration with the Laboratory of Mining Geology.

sulphide minerals that has been used as a basis for the comparison of powder pattern types, and has been most generous with his assistance throughout. Dr. Graton made available in the Department of Mining Geology all the facilities of that progressive laboratory, including spectrographic, microscopic and other special equipment, and a very complete collection of polished sections of ore minerals. This department supplied funds for making two precision powder cameras, for engraving and mounting a scale with which to measure spacings directly in angstroms, for assembling a micro-drill, and for spectrographic and *x*-ray materials. For the above and much more the writer is indebted to Dr. Berman and to Dr. Graton.

The basis for the present work was established by Hull,[1] in 1919, who showed that every crystalline substance gives a unique powder pattern. He also established conclusively that the same substance invariably gives the same powder pattern and that in a mixture of substances each substance produces its characteristic pattern independently of the other. The research staff of the Dow Chemical Company have demonstrated that it is possible to classify a large number of powder patterns in such a way that one may speedily recognize an unknown crystalline substance by its powder pattern. Kerr[2] has pointed out the possibilities of the powder pattern method as applied to the identification of opaque minerals. This method has been applied to the copper-bearing minerals by Waldo,[3] but to date no systematic collection of ore-mineral patterns has appeared, although some of them have been listed among those classified by the workers in the Dow Chemical Company laboratory.

SOURCE OF MATERIAL

In preparing any collection of powder patterns for use as standards it is absolutely essential to secure authentic material. One of the greatest dangers is to accept a powder pattern as representing a certain mineral that in reality represents a mixture. This danger is particularly grave in dealing with ores whose minerals are frequently intimately intergrown. For this reason the specimens here chosen for *x*-ray analysis have been taken from polished sections by a method of micro-sampling that greatly reduces the danger of contamination. The material for this work has come chiefly from a collection of polished sections at Harvard known as the Murdoch suite. Murdoch's original assemblage, enlarged and rechecked by several later experts, has been the basis for an important part of the work done to date on the identification of ore minerals in polished section; it underlies the work of Murdoch,[4] Talmage,[5] and Harvey[6] and much of the work of Farnham[7] and Short.[8]

SAMPLING AND PREPARATION OF *x*-RAY MOUNTS

The use of polished sections and very small samples has required the development of slightly modified methods of securing and mounting specimens for *x*-ray work. It has been found possible to obtain satisfactory powder patterns with samples weighing 0.5 milligram. In sampling extremely small grains from polished sections that yield only a minimum amount of powder, it is imperative not to waste any of the sample. Sampling is accomplished by means of a micro-drill[9] that consists of a sharp needle held in bearings at an angle of forty-five degrees to the axis of a reflecting microscope in such a position that its sharp point comes in the center of the field of view of the microscope. A small electric motor acting through a flexible cable rotates the needle. Preferably the stage of the microscope should permit raising and lowering—a type of design now becoming common. Drilling is then most easily achieved by raising the stage of the microscope and the polished specimen until the needle comes in contact with the chosen and previously centered mineral grain. The product of such drilling is a fine powder that piles up neatly at the side of the hole. The polished section and the powdered sample are carefully transferred from the reflecting microscope to a binocular microscope which affords greater working distance. Here, a drop of collodion is placed directly on the accumulated powder and when this drop is partially dry it is shaped in the form of a tiny rod in such a manner as to contain the sample concentrated in one end of the rod. This micro-drill does not work so satisfactorily on very hard or very soft minerals; and it has recently been found that a diamond chip mounted in copper in a pencil-like holder is highly satisfactory for nearly all sampling, as it yields a fine powder from either hard or soft minerals.

For preparing *x*-ray samples, polished sections, if they are suitably mounted in rectangular molds of bakelite or some similar medium, have a distinct advantage over ordinary mineral specimens in that any grain may be located for future reference by means of the coördinates of the mechanical stage. For the present investigation the Murdoch suite of polished sections was examined critically. Each mineral was sampled on a micro-scale and analyzed by a semi-quantitative spectrographic method. By this means it has been possible to check the authenticity of each mineral and to discard any about which there was doubt. For each specimen the coördinates were recorded for the grain from which the preliminary sample had been taken, and the final sample, for the purpose of *x*-ray powder patterns, was drilled from identical material on the polished surface, frequently from the very same grain.

Equipment and Measurements

The majority of the powder patterns were secured with x-ray equipment assembled by Dr. Berman. This consists of a gas tube provided with a series of interchangeable targets. Most of the patterns were prepared with the use of Cu-K-α radiation. When the sample demanded it, iron radiation was resorted to. With the gas tube, Debye powder cameras of 57.4 millimeter radius were used; these cameras yield almost a full 360° powder pattern. The sample was held on a central spindle rotated by a Telechron motor. Some of the powder patterns were taken with sealed tube equipment using Cu-K-α and Co-K-α radiation (courtesy of the International Nickel Company of Canada) and similar Debye cameras of 28.7 millimeter radius.

With both installations x-ray powder pattern spacings were measured with scales reading directly in angstroms. In each case the scales were checked by means of patterns of precipitated silver, the parameters of which are known with high accuracy. The intensity estimates recorded for each line are visual estimates of relative intensity on a scale ranging from zero to ten. The purpose of using numerical values rather than the customary designations (very strong, strong, etc.) is to establish and designate in definite order the strongest line in the pattern, the second strongest, the third strongest, etc., in order to classify, or index, the pattern on the basis of the three strongest lines. Where two lines are equally strong the one representing the larger spacing is given precedence.*

Description of Tables

In Table 1 the minerals are listed alphabetically. Each mineral is numbered and its locality stated. Since many of the specimens have been the subject of detailed work by various mineralogists, the precise number of each specimen is listed so that if desired further information concerning the actual specimen used may be secured. For this purpose the following symbols have been used:

M—Murdoch Suite
H—Harvard Museum

The radiation and filter used for each pattern is entered at the left of the page. The powder pattern data are in tabular form in three columns headed *O*, *d* and *I*. Under *O*, signifying order, the strongest, second strongest and third strongest lines of the pattern are designated by the respective figures 1, 2 and 3. Under *d* are listed the spacings in angstroms

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* Photographic reproductions of all the powder patterns have been made. Copies of these, as a complete set, may be obtained, at cost. from the author.

corresponding to each line of the powder pattern. Under *I* the estimated intensity of each line is given. At the end of this table there are included a few minerals whose powder pattern is distinct but whose identity for one reason or another is in doubt.

In Table 2, column 1, the measurements in angstroms of the strongest line of each pattern have been listed in ascending order with the estimated intensity placed in brackets. The corresponding second and third strongest lines and their intensities are in columns 2 and 3, respectively. In the last column is entered the number assigned to the pattern in Table 1.

Identification of an unknown mineral is made by reference to Table 2. In column 1 a line is sought that corresponds to the strongest line of the unknown pattern. Several lines (representing as many minerals) may fall within the limits of experimental error or within the limits of the variations to be found in natural minerals. To determine which one is correct, columns 2 and 3 should next be compared, in turn, with the values for the second and the third strongest lines of the unknown pattern. In most cases a match can be found almost immediately and the complete pattern can then be compared in detail by referring to Table 1. Patterns that have one line very much stronger than all others are particularly easy to identify, because there is no doubt at all of the strongest line. However, very few patterns give trouble in selecting the three strongest lines in their proper sequence. If any two lines appear to have the same intensity, the one representing the larger spacing should be rated as the stronger. If the pattern remains unidentified, the other line is then tried as the stronger and a match may thus be found.

In comparing patterns of the same material made with Cu, Co, Fe and Mo radiation some variation in the relative intensity of lines can be seen, but in all cases thus far encountered the three strongest or index lines have remained the same, regardless of the radiation used.

Variations of the resolution of the *x*-ray equipment on rare occasion may cause confusion by the failure to resolve two closely spaced and moderately strong lines (for example the third and fourth in intensity), which if considered as a single line, would be ranked as the strongest line of the pattern. Schapbachite, number 129, affords an example of this kind.

The three strongest lines have been selected from the region $2\phi=0$ to 90 degrees, where ϕ has its usual significance as in the Bragg law $n\lambda=2d \sin \phi$. The reasons for this are:

1. Many *x*-ray installations are equipped with half circle or quadrant powder cameras.

2. The absorption characteristics of the sample after its preparation as a spindle for the *x*-ray influence the intensities of high angle diffraction lines relative to the low angle lines. It is possible, although of course not at all desirable, to prepare a spindle, of altaite for example, containing so much material that the *x*-ray beam can only penetrate its surface. This results in strong back reflection lines and relatively weak low angle lines and the high angle lines may easily be the strongest lines of the pattern. The effect of absorption can be adequately reduced even when dealing with unknowns by using a sample containing a minimum amount of material.

In case an unknown cannot be identified by means of the three strongest lines, two possibilities exist. First, the unknown pattern may represent not a single mineral but a mixture. Second, the pattern may not be included in the present compilation. One should proceed to test the first possibility. To do this one finds a match for the strongest line of the unknown, then looks for a match for the second or third strongest line in the region of the table including about six patterns each way from the matched strongest line. When a match for the second or third line is found, the standard pattern in Table 1 may be compared directly with the unknown and all lines corresponding with respect to spacing checked off on the unknown pattern and relative intensity noted. The remaining unchecked lines should be regarded as a separate unknown pattern to be identified in the regular manner. Superimposed lines may be recognized by greater intensities than are indicated by the standard patterns. However, if the strongest line in an unknown is the result of the superimposition of two relatively weak lines of the different components of a sample, that is really a mixture, a match may not be found and the second strongest line must then be used. Members of the staff of the Dow Chemical Company[10] have found it to be practical to analyze mixtures with as many as four or five components by a method such as this.

The remarkable individuality of powder patterns which makes them so suitable for the purpose of identification has been demonstrated by the work in the Dow Chemical Company's laboratory. For instance, out of 1000 chemical substances which they investigated, it was found that among those patterns having practically identical first lines and practically identical second lines (that is to say, identical within 5 to 10 times the error of measurement), there were only eleven instances in which *two* different substances and only four instances in which *three* different substances have also the third line practically identical. And in seven of these eleven instances of confusion, the fourth line served to distinguish the patterns.

Unfortunately, natural minerals cannot be identified in quite such a clear-cut manner as pure chemical substances, even by powder patterns. Some minerals have a tendency to vary considerably in chemical composition from one occurrence to another. In minerals of the cobaltite group, for example, it is possible for any one of several elements to replace one of the elements of the mineral. When such a replacement occurs the resulting mineral is often given an independent name, but the powder pattern remains the same except for a very slight change in cell size. If some other element had been substituted, the mineral would be given still another name, and again the only difference in pattern would be a slight change in cell size. In short, members of an isomorphous mineral series give powder patterns that differ only by a small change in the spacings and little change in the relative intensities. For such cases, the powder pattern alone will not distinguish between these varieties and chemical tests must be invoked. On the other hand, certain minerals seem to show appreciable variation in unit cell size although no difference in chemical composition has been recognized.

BIBLIOGRAPHY

1. HULL, A. W., *Jour. Am. Chem. Soc.*, **41,** 1168 (1919).
2. KERR, PAUL F., *Ec. Geol.*, **19,** 1–34 (1924).
3. WALDO, ALLEN W., *Am. Mineral.*, **20,** 575–597 (1935).
4. MURDOCH, J., Microscopic Determination of the Opaque Minerals, *New York* **(1916)**.
5. TALMAGE, S. B., *Ec. Geol.*, **20,** 535–543 (1925).
6. HARVEY, R. D., *Ec. Geol.*, **23,** 778–803 (1928).
7. FARNHAM, C. M., Determination of the Ore Minerals, *New York* **(1931)**.
8. SHORT, M. N. *U.S.G.S. Bull.* **825** (1931); *U.S.G.S. Bull.* **914** (1940).
9. HAYCOCK, M. H., *Ec. Geol.*, **26,** 415–420 (1931). HARCOURT, G. ALAN, *Am. Mineral.*, **22,** 517–525 (1937).
10. HANAWALT, J. D., RINN, H. W., FREVEL, L. K., *Ind. Eng. Chem.*, *An. Ed.*, **10,** 457–512 (1938).

TABLE 1. POWDER DIFFRACTION DATA OF ORE MINERALS

The starred patterns check published data.

M—Murdoch Suite. H—Harvard Museum. B—broad line.

Cu-Ni 1. Aguilarite, $Ag_2(Se, S)$. Guanajuato, Mexico. M-1A

O	*d*	*I*	*O*	*d*	*I*
	3.11	.3		2.09	1.0
1	2.82	4.0	3	1.99	2.0
	2.65B	.3		1.625	.3
2	2.44	3.0		1.261	.3
	2.22	1.0		1.154	.3

Cu-Ni 2. Aikinite, $Cu_2S \cdot 2PbS \cdot Bi_2S_3$. Berezov, Urals. M-2

O	d	I	O	d	I	O	d	I
	4.1	3.0		2.03	1.0		1.480	.5
1	3.62	8.0		1.99	2.0		1.405	2.0
2	3.17	8.0		1.96	2.0		1.380	1.0
3	2.86	7.0		1.90	.5		1.350	.5
	2.69	4.0		1.805	.3		1.330	.5
	2.59	3.0		1.770	4.0		1.275	.5
	2.50	1.0		1.625	.3		1.265	.3
	2.36	1.0		1.590	2.0		1.155	.2
	2.27	1.0		1.522	1.0		1.120	.1
	2.17	2.0						

*Cu-Ni 3. Alabandite, MnS. Summit Co., Colorado. M-3

O	d	I	O	d	I	O	d	I
	3.0	.3		1.995	.2		1.302	.2
	2.83	.3	2	1.845	4.0		1.165	.5
1	2.61	7.0	3	1.502	1.0		1.065	.3

4. Algodonite, Cu_6As. (See No. 163)

*Cu-Ni 5. Altaite, PbTe. Burney Mine, Sonora, California. M-6

O	d	I	O	d	I	O	d	I
2	3.2	4.0	3	1.435	3.0		1.017	.5
1	2.27	5.0		1.312	2.0		.970	.5
	1.93	.5		1.136	.3		.892	.3
	1.85	1.0		1.072	1.0		.852	.2
	1.61	1.0						

Cu-Ni 6. Andorite, $Ag_2S \cdot 2PbS \cdot 3Sb_2S_3$. Oruro, Bolivia. M-7

O	d	I	O	d	I	O	d	I
	3.7	.5		2.38	.2		1.98	.3
	3.41	.5		2.27	.5		1.88	2.0
1	3.28	4.0		2.14	.3		1.795	2.0
2	2.90	3.0		2.06	1.0		1.681	.2
3	2.75	2.0		2.01	.5		1.418	.3
							1.385	.3

*Cu-Ni 7. Antimony, Sb. Near White River, California. H-87942

O	d	I	O	d	I	O	d	I
1	3.07	6.0		1.540	1.0		1.075	.5
3	2.23	2.0		1.470	.5		1.030	.3
2	2.13	2.0		1.405	1.0		1.008	.2
	1.92	.5		1.355	1.0		.985	.2
	1.87	.5		1.251	1.0		.962	.3
	1.755	1.0		1.231	1.0		.876	.3
	1.675	.2		1.215	.3		.841	.3

Cu-Ni 8. Aramayoite, $Ag_2S\cdot(Sb, Bi)_2S_3$. Chacaya, Potosi, Bolivia. M-207

O	d	I	O	d	I	O	d	I
3	3.43	4.0		1.765	1.0		1.415	1.0
2	3.24	5.0		1.71	2.0		1.355	.3
1	2.84	10.0		1.675	1.0		1.285	.3
	2.06	2.0		1.625	1.0		1.240	.2
	1.955	2.0		1.585	.5			

*Cu-Ni 9. Argentite, Ag_2S. M-9G

O	d	I	O	d	I	O	d	I
	3.4	.5		2.08	1.0		1.51	.2
	3.08	.5		1.99	.3		1.455	.3
2	2.83	3.0		1.96	.3		1.41	.2
1	2.59	4.0		1.905	.3		1.33	.2
3	2.43	3.0		1.86	.3		1.265	.2
	2.37	1.0		1.715	.5			
	2.21	1.0		1.575	.3			

Cu-Ni 10. Argyrodite, $4Ag_2S\cdot GeS_2$. Liza, Pio de Gallo Mine, Porco, Bolivia. M-10B

O	d	I	O	d	I	O	d	I
	3.2	1.0		2.04	1.0		1.515	.2
1	3.05	3.0		1.95	.3		1.480	.2
	2.82	1.0		1.87	1.0		1.410	.2
2	2.68	2.0		1.79	.5		1.380	.2
3	2.45	1.0		1.70	.2		1.215	.2
	2.18	.2		1.59	.2		1.163	.2

*Cu-Ni 11. Arsenic, As. Broken Hill Mines, N.S.W., Australia. H-82739

O	d	I	O	d	I	O	d	I
	6.50	.2		1.76	3.0		1.083	2.0
	6.17	2.0		1.65	3.0		1.068	1.0
	3.45	2.0		1.59	.5		1.061	1.0
	3.14	4.0		1.53	5.0		.993	2.0
	2.81	.5		1.433	1.0		.964	.5
1	2.74	8.0		1.380	2.0		.952	1.0
	2.52	2.0		1.363	1.0		.938	1.0
	2.25	.5		1.345	1.0		.921	1.0
	2.12	.5		1.299	.5		.897	.5
3	2.04	5.0		1.283	3.0		.889	.5
	1.95	1.0		1.195	4.0		.862	.2
2	1.867	6.0		1.112	2.0		.853	1.0
	1.837	.5		1.102	1.0		.827	1.0

Cu-Ni 12. Arsenopyrite, FeAsS. Auburn, Maine. M-13

O	d	I
3	2.82	1.0
	2.66	1.0
1	2.43	3.0
	2.02	.5
	1.95	.3
2	1.82	2.0
	1.63	.5
	1.54	.2
	1.342	.3

13. Beegerite $6PbS \cdot Bi_2S_3$ (See page 109)

Cu-Ni 14. Baumhauerite, $4PbS \cdot 3As_2S_3$. Binnenthal, Switzerland. M-15A

O	d	I
	3.78	.5
	3.65	.5
	3.40	.5
	2.97	.5
	2.89	.5
1	2.73	2.0
	2.63	.5
2	2.30	2.0
	2.22	.2
3	2.11	1.0
	2.03	.2
	1.95	.2
	1.90	1.0
	1.78	.3

Cu-Ni 15. Benjaminite, $(Cu,Ag)_2S \cdot 2PbS \cdot 2Bi_2S_3$. Outlaw Mine, Nye Co., Nevada.M-222

O	d	I
	3.60	1.0
2	3.48	2.0
	2.96	1.0
1	2.85	3.0
	2.25	.5
	2.10	.5
3	2.01	2.0
	1.89	.5
	1.72	.3
	1.64	.2

Cu-Ni 16. Berthierite, $FeS \cdot Sb_2S_3$. M-17

O	d	I
	4.30	1.0
2	3.62	4.0
	3.35	1.0
3	3.15	4.0
	3.01	1.0
	2.83	4.0
1	2.60	5.0
	2.51	1.0
	2.23	.5
	2.155	1.0
	2.035	1.0
	1.99	2.0
	1.90	1.0
	1.870	2.0
	1.785	1.0
	1.760	1.0
	1.690	.5
	1.660	.5
	1.630	
	1.585	1.0
	1.495	.2
	1.415	.5
	1.365	.5
	1.335	.3
	1.318	.2
	1.255	.3
	1.079	1.0
	1.059	1.0
	1.045	.5

*Cu-Ni 17. Berzelianite, Cu_2Se. Skikerum, Sweden. M-320

O	d	I
	3.51	1.0
2	3.20	4.0
	2.85	2.0
	2.50	.5
	2.27	1.0
1	1.98	7.0
3	1.84	3.0
	1.79	2.0
	1.64	2.0
	1.41	.5
	1.34	.5
	1.28	.5
	1.20	.5
	1.155	.5
	1.100	.3
	1.060	.5
	1.030	.5
	1.000	.5
	.940	2.0
	.885	.5
	.870	.5
	.835	.5
	.818	1.0
	.805	.3
	.794	1.0

*Cu-Ni 18. Bismuth, Bi. Altenberg, near Zinnwald, Saxony, Germany. H-87945

O	d	I	O	d	I	O	d	I
1	3.21	3.0		1.304	1.0		.982	.5
	2.34	1.0		1.278	.5		.968	.5
3	2.245	2.0		1.254	.5		.943	.5
	2.015	.5		1.240	.3		.927	.5
	1.955	.5		1.180	.5		.915	.5
	1.850	1.0		1.132	2.0		.891	1.0
	1.625	1.0		1.112	1.0		.878	.3
	1.545	.5		1.088	2.0		.872	1.0
	1.480	2.0		1.069	2.0		.862	1.0
2	1.435	3.0		1.047	.5		.858	1.0
	1.378	.5		1.036	.5		.827	1.0
	1.325	2.0		1.021	1.0		.819	.5

Cu-Ni 19. Bismuthinite, Bi_2S_3. Persberg, Sweden. M-20

O	d	I	O	d	I	O	d	I
	5.55	1.0		1.870	1.0		1.242	.5
	4.95	1.0		1.840	1.0		1.184	2.0
	3.92	2.0		1.725	5.0		1.160	.5
1	3.50	9.0		1.690	1.0		1.138	2.0
	3.22	1.0		1.670	1.0		1.116	.5
2	3.08	6.0		1.595	.2		1.096	.3
	2.79	4.0		1.550	3.0		1.082	.3
	2.69	1.0		1.521	.5		1.053	2.0
	2.61	1.0		1.475	2.0		1.028	1.0
	2.495	3.0		1.430	2.0		1.017	1.0
	2.425	1.0		1.390	1.0		.990	.5
	2.28	1.0		1.375	1.0		.974	.2
	2.23	3.0		1.347	2.0		.965	2.0
	2.11	1.0		1.315	1.0		.897	2.0
	2.06	.5		1.302	2.0		.881	.3
	1.98	1.0		1.289	.5		.865	.2
3	1.935	5.0		1.275	.5		.846	.3

*Cu-Ni 20. Bornite, Cu_5FeS_4. Magma, Arizona.

O	d	I	O	d	I	O	d	I
2	3.31	2.0		1.65	1.0		1.265	.3
3	3.15	2.0		1.58	.1		1.117	2.0
	2.82	.5		1.535	.2		.967	.5
	2.74	2.0		1.47	.1		.925	.3
	2.51	2.0		1.425	.5			
	2.12	.3		1.372	.5			
1	1.94	8.0						

*Cu-Ni 21. Boulangerite, $5PbS \cdot 2Sb_2S_3$. M-22

O	d	I	O	d	I	O	d	I
2	3.68	2.0	1	2.80	3.0		1.77	.5
	3.21	.2	3	2.00	1.0			
	3.00	.5		1.93	.2			
				1.86	1.0			

*Cu-Ni 22. Bournonite, $Cu_2S \cdot 2PbS \cdot Sb_2S_3$. Cornwall, England. H-82462

O	d	I	O	d	I	O	d	I
2	3.90	1.0		2.59	1.0	3	1.765	1.0
	3.69	.5		2.37	.3		1.665	.3
	3.26	.5		2.24	.2		1.63	.3
	2.97	.5		2.17	.2		1.59	.2
	2.90	.2		2.10	.2		1.56	.2
	2.82	.2		1.99	.3		1.425	.3
1	2.74	5.0		1.95	1.0		1.39	.3
	2.68	.5		1.85	1.0		1.26	.3

Cu-— 23. Bravoite, $(Fe, Ni)S_2$. Minas Ragra, Peru. M-209
Note similarity to pyrite No 117

O	d	I	O	d	I	O	d	I
	3.21	.5		1.682	.2		1.178	.2
	3.08	.5	2	1.675	3.0		1.135	.2
1	2.77	4.0		1.61	.3		1.072	.5
3	2.49	2.0		1.545	.3		1.035	.3
	2.27	1.0		1.488	.5		.984	.2
	2.18	.2		1.275	.3		.929	.2
	2.04	.2		1.246	.3		.904	.2
	1.97	1.0		1.215	.2		.880	.2
	1.86	.3						

Fe-— 24. Braunite, $3Mn_2O_3 \cdot MnSiO_3$. Vizagapatan Dist., Madras, India. H-83692

O	d	I	O	d	I	O	d	I
	4.65	.3		1.822	.3		1.365	.5
	3.455	1.0		1.80	.3		1.35	1.0
	3.33	.3		1.76	.5		1.265	.5
	2.955	.5	2	1.65	6.0		1.174	.3
1	2.69	9.0		1.533	1.0		1.165	.3
	2.34	2.0		1.495	1.0		1.145	.2
	2.138	2.0		1.46	1.0		1.076	2.0
	1.865	.5	3	1.415	3.0		1.05	1.0

Cu-— 25. Breithauptite, NiSb. Andreasberg, Harz, Germany. M-24

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.12	.5		1.62	1.0		1.150	.3
1	2.85	5.0		1.56	.3		1.135	.2
	2.56	.2		1.525	1.0		1.075	.3
	2.26	.3		1.415	1.0		1.028	.3
	2.17	.3		1.280	.2		.981	.2
2	2.05	2.0		1.248	.5		.932	.2
3	1.97	2.0		1.210	.2			

Cu-Ni 26. Calaverite, (Au, Ag)Te_2. Cripple Creek, Colorado. M-26A

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	2.99	5.0		1.22	.5		.882	.3
	2.20	.5		1.20	1.0		.862	.3
2	2.09	4.0		1.09	.3		.847	.5
	1.93	.5		1.055	.3		.830	.5
3	1.77	1.0		1.030	.5		.820	.5
	1.68	1.0		1.005	.5		.812	.5
	1.51	1.0		.975	1.0		.791	.5
	1.37	.5		.952	.5		.789	.5
	1.34	1.0		.936	.3		.785	1.0
	1.31	1.0		.928	.2		.779	1.0
	1.26	1.0		.890	1.0			

Cu-Ni 27. Cannizarite (=galenobismutite), $PbS \cdot 2Bi_2S_3$. From fumeroles, Lipari Islds. Italy. H-89262

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	3.80	3.0		1.79	1.0		1.265	.2
	3.51	1.0		1.735	.5		1.228	.3
	3.35	1.0		1.68	.5		1.205	.3
2	3.00	3.0		1.62	.3		1.168	.3
	2.87	2.0		1.58	.2		1.145	.3
	2.78	.3		1.482	.2		1.130	.2
	2.68	2.0		1.435	.2		1.075	.2
	2.54	.2		1.385	.2		1.050	.2
	2.37	.2		1.355	.2		1.012	.2
	2.22	1.0		1.320	.2		.995	.2
3	2.03	3.0		1.295	.3		.961	.2
	1.90	.5						

Cu-—28. Carrollite, (Co, Cu)$_3$S$_4$. Finksburg, Maryland. M-27

Note pattern identity with violarite, linnaeite, polydymite.

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.35	1.0		1.82	4.0		1.18	.3
	3.15	.5	2	1.67	5.0		1.06	.3
1	2.85	6.0		1.43	.3		.988	.5
3	2.47	4.0		1.36	.3		.965	1.0
	2.03	.3		1.23	.3		.915	1.0
	1.92	.5						

*Cu-Ni 29. Cassiterite, SnO_2. Llallagua, Bolivia.

O	d	I	O	d	I	O	d	I
1	3.32	6.0		1.405	2.0		.945	3.0
2	2.62	6.0		1.315	1.0		.926	1.0
	2.35	2.0		1.209	2.0		.912	1.0
	2.28	.5		1.179	.5		.905	2.0
	2.11	.3		1.149	1.0		.879	3.0
3	1.75	6.0		1.111	1.0		.846	3.0
	1.665	2.0		1.086	2.0		.836	1.0
	1.58	1.0		1.075	2.0		.824	2.0
	1.49	2.0		1.055	1.0		.811	.5
	1.43	2.0		1.031	1.0		.805	2.0

*Cu-Ni 30. Cerargyrite, AgCl. Southeast California. H-82732

O	d	I	O	d	I	O	d	I
3	3.20	.5		1.61	.5		.987	.2
1	2.80	2.0		1.395	.2		.930	.2
	2.75	2.0		1.274	.2		.883	.2
2	1.97	1.0		1.245	.5		.843	.2
	1.67	.3						

*Cu-Ni 31. Chalcocite, Cu_2S. Magma, Arizona.

O	d	I	O	d	I	O	d	I
	3.37	1.0		2.06	.5		1.345	.3
	3.18	.5	1	1.95	8.0		1.275	1.0
	3.02	.5	2	1.865	8.0		1.125	.3
	2.85B	1.0		1.685	2.0		1.068	.5
	2.67B	.5		1.638	1.0		.971	.2
3	2.38	6.0		1.505	.5		.936	.2

*Cu-Ni 32. Chalcopyrite, $CuFeS_2$. Franklin, New Jersey. M-191A

O	d	I	O	d	I	O	d	I
1	3.03	7.0	3	1.59	1.0		1.205	.5
	2.62	.2		1.52	.2		1.075	.5
2	1.86	4.0		1.32	.5			

Cu-Ni 33. Chalcostibite, $Cu_2S \cdot Sb_2S_3$. Rar-el-Anz, Morocco. H-88659

O	d	I	O	d	I	O	d	I
	3.67	.5		1.83	3.0		1.262	.5
1	3.13	8.0	3	1.76	4.0		1.202	.3
2	2.99	8.0		1.69	.5		1.145	.3
	2.80	.2		1.61B	2.0		1.084	.2
	2.55	.2		1.550	1.0		1.068	.2
	2.31	3.0		1.440	1.0		1.006	.2
	2.24	.5		1.345	.5		.981	.2
	2.12	1.0		1.310	.5		.950	.2
	1.90	1.0		1.289	1.0			

Cu-— 34. Chloanthite-smaltite, (Ni, Co)As$_2$. Schneeberg, Saxony, Germany. M-36

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	6.0	1.0		1.77	1.0		1.20	1.0
	4.2	2.0		1.69	2.0		1.17	1.0
	3.4	1.0		1.63	3.0		1.15	1.0
	2.9	2.0		1.43	2.0		1.13	1.0
1	2.64	9.0		1.38	1.0		1.09	2.0
3	2.22	3.0		1.31	.5		1.05	1.0
	2.07	.5		1.25	.3		1.005	1.0
	1.95	1.0		1.23	2.0		.990	.5
2	1.87	4.0						

*Cu-Ni 35. Chromite, FeO · Cr$_2$O$_3$. M-37B

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
3	3.10	.5	1	2.02	3.0		1.26	.2
2	2.82	1.0		1.62	.2		1.17	.2
	2.21	.3						

*Cu-Ni 36. Cinnabar, HgS. Almaden, Spain. H-88522

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	3.34	9.0		1.360	.5		1.014	.3
	3.16	1.0		1.345	.5		.992	.5
2	2.85	9.0		1.305			.975	.5
	2.36	.5		1.268	1.0		.960B	.5
	2.07	3.0		1.258	1.0		.950B	.5
	2.02	1.0		1.248	.5		.941	.5
	1.980	3.0		1.179	.5		.918	1.0
	1.900	.3		1.161	.3		.910	.5
	1.765	2.0		1.125	.3		.898B	.3
	1.735	3.0		1.120	.2		.882	.5
3	1.680	4.0		1.105	1.0		.865	.5
	1.581	1.0		1.083	.5		.840	.5
	1.560	1.0		1.069	.5		.833	.2
	1.435	2.0		1.031	1.0		.820	.2
	1.401	.5						

*Cu-Ni 37. Clausthalite, PbSe. Prov. of Mendoza, Argentina. M-39B

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.53	3.0		1.530	2.0		1.035	.2
1	3.06	9.0		1.405	.5		1.020	1.0
	2.86	.3	3	1.370	4.0		.968	1.0
2	2.165	7.0		1.250	3.0		.923	.5
	1.850	2.0		1.180	.5		.849	.3
	1.770	3.0		1.083	.5		.818	.3

*Cu-Ni 38. Cobaltite, CoAsS. Cobalt, Ontario. M-40

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.12	.5		2.21	.5		1.622	.3
1	2.81	4.0	2	2.03	2.0		1.545	.2
3	2.49	2.0		2.00	2.0		1.490	1.0
	2.27	1.0		1.688	1.0		1.405	.3

*Cu-Ni 39. Coloradoite, HgTe. Vulcan Mine, Gunnison Co., Colorado. M-136

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.23	.2		1.485	3.0		1.023	1.0
	2.82	.2	3	1.320	4.0		.985	.3
	2.52	.3		1.245	3.0		.905	.3
1	2.28	10.0		1.142	1.0		.865	.3
2	1.955	7.0		1.093			.842	.2
	1.620	2.0						

Co-— 40. Columbite-tantalite, (Fe, Mn)(Cb, Ta)$_2$O$_6$. M-230

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.65	2.0		2.08	1.0		1.38	1.0
1	3.00	10.0		1.78	1.0		1.19	.3
	2.53	2.0	2	1.72	4.0		1.100	1.0
	2.39	1.0		1.54	2.0		1.075	1.0
	2.25	1.0	3	1.45	3.0		1.032	.2

*Cu-Ni 41. Colusite, (Cu, Fe, Mo, Sn)$_4$(S, As, Te)$_{3-4}$. Butte, Montana.

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	3.07	7.0		1.327	1.0		.982	.2
	2.82	.5		1.240	2.0		.939	.3
	2.66	.5		1.085	3.0		.898	.5
2	1.88	5.0		1.022	1.0		.841	.5
3	1.601	3.0						

*Cu-Ni 42. Copper, Cu.

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	2.08	8.0		1.088	3.0		.8285	.5
2	1.81	4.0		1.043	1.0		.808	.5
3	1.275	3.0		.903	.3			

Cu-— 43. Corynite, Ni(As, Sb)S. Olsa, Carinthia, Austria. M-210

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	2.85	4.0		1.40	.5		.921	1.0
1	2.55	6.0		1.24	1.0		.868	.5
3	2.33	4.0		1.21	.5		.858	.3
	2.02	.5		1.16	.3		.848	.5
	1.91	.2		1.11	.3		.839	.5
2	1.71	5.0		1.09	2.0		.820	.3
	1.65	.5		1.06	1.0		.790	.3
	1.57	2.0		1.035	.5		.782	.3
	1.51	3.0		1.002	2.0			

*Cu-Ni 44. Cosalite, $2PbS \cdot Bi_2S_3$, M-43A

O	*d*	*I*
	3.75	.5
	3.52	.5
2	3.40	2.0
	3.30	.5
	3.06	
1	2.95	4.0
	2.80	1.0
	2.27	.5
	2.14	1.0
3	2.02	2.0
	1.91	.5
	1.80	.5
	1.75	.5

*Cu-Ni 45. Covellite, CuS. Butte, Montana.

O	*d*	*I*
	3.22	2.0
3	3.02	7.0
2	2.82	8.0
	2.72	6.0
	2.31	.5
1	1.90	9.0
	1.735	4.0
	1.560	6.0
	1.352	.5
	1.280	.5
	1.098	.5
	1.061	.5

*Fe-— 46. Cubanite, $CuS \cdot 2FeS$. Sudbury, Ontario.

O	*d*	*I*
	3.50	2.0
1	3.23	5.0
	3.115	.5
	3.00	1.0
	2.79	1.0
	2.50	.5
	2.375	.5
	2.255	.5
	2.21	.2
	2.06	.5
	1.99	.3
	1.935	.3
2	1.875	4.0
3	1.75	3.0
	1.70	.3
	1.61	.5
	1.50	.3
	1.295	.5
	1.165	.5
	1.075	.2
	1.050	.2

*Cu-Ni 47. Cuprite, Cu_2O. Cuba. M-47A

O	*d*	*I*
	3.00	.5
1	2.46	5.0
2	2.13	1.0
3	1.51	.5
	1.285	.3

Cu-Ni 48. Cuprodescloizite, $Pb_2(Zn, Cu)_2V_2O_9 \cdot H_2O$. Skattuck Mine, Bisbee, Arizona. M-48

O	*d*	*I*
	5.0	.5
	4.55	.3
	4.20	.3
	3.54	.5
1	3.22	4.0
	2.97	.3
	2.86	1.0
2	2.67	2.0
	2.60	.5
	2.46	.2
	2.36	.2
	2.28	.5
	2.08	.5
	1.87	.3
	1.77	1.0
	1.72	.2
3	1.64	2.0
	1.538	.3
	1.492	.3
	1.450	.2
	1.395	.3
	1.335	.2
	1.250	3
	1.112	.2
	1.075	.2

Cu-Ni 49. Cylindrite, $6PbS \cdot Sb_2S_3 \cdot 6SnS_2$. Mina Santa Cruz, Poopo, Bolivia. M-49

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.45	.2	2	2.03	1.0		1.455	.3
	3.15	.2	3	1.81	1.0		1.290	.2
1	2.89	4.0						

Cu-Ni 50. Daubreelite, $FeS \cdot Cr_2S_3$. Alliers, France. H-82055

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.52	1.0	2	1.77	6.0		1.152	.3
1	3.02	6.0		1.52	.3		1.116	.3
3	2.50	3.0		1.44	.3		1.046	.2
	2.04	.5		1.30	.5		1.020	1.0
	1.925	3.0		1.25	.5		.965	.3

*Cu-Ni 51. Delafossite, $Cu_2O \cdot Fe_2O_3$. Bisbee, Arizona. M-50

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
2	2.84	1.0		1.66	1.0		1.340	1.0
1	2.51	5.0		1.515	1.0		1.295	.5
3	2.23	1.0		1.435	.5		1.080	.2

Cu-Ni 52. Diaphorite, $3Ag_2S \cdot 4PbS \cdot 3Sb_2S_3$. Příbram, Bohemia. H-80251

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	3.28	5.0		1.84	.3		1.320	.3
	2.92	1.0		1.76	1.0		1.305	.3
2	2.80	4.0		1.705	1.0		1.286	.3
	2.23	.2		1.65	.5		1.271	.3
	2.08	.2		1.585	.3		1.254	.3
3	2.04	2.0		1.520	.2		1.154	.3
	2.01	.3		1.470	.2		1.130	.2
	1.99	.3		1.410	.5		1.090	.2

Co-Fe 53. Dufrenoysite, $2PbS \cdot As_2S_3$. Binnenthal, Switzerland. M-53

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.36	.5		2.20	.5		1.53	.5
	3.20	.5	3	2.09	2.0		1.45	.2
1	3.01	4.0		1.91	.5		1.42	.2
2	2.84	3.0		1.86	.5		1.22	.2
	2 32	1.0						

Cu-Ni 54. Dyscrasite, As_3Sb. Andreasberg, Germany. M-24D

O	d	I	O	d	I	O	d	I
3	2.55	1.0		1.76	.2		1.35	.2
2	2.39	2.0		1.475	.2		1.265	.2
1	2.26	4.0						

*Cu-Ni 55. Emplectite, $Cu_2S \cdot Bi_2S_3$. Johanngeorgenstadt, Saxony, Germany. H-82378

O	d	I	O	d	I	O	d	I
	4.7	1.0		1.755	.5		1.100	.3
2	3.20	7.0		1.655	2.0		1.090	.3
1	3.10	8.0		1.560	1.0		1.055	.3
	3.02			1.475	.3		1.040	.3
	2.81	.3		1.450	1.0		1.015	.3
	2.72	.2		1.365	.5		1.000	.5
3	2.34	3.0		1.320	1.0		.971	.3
	2.24	.5		1.260	.3		.948	.3
	2.16	3.0		1.225	1.0		.928	.3
	1.96	1.0		1.208	1.0		.918	.3
	1.86	2.0		1.190	1.0		.908	.3
	1.80	2.0		1.168	2.0		.899	.3
	1.78	.5		1.112	.5		.871	.3

*Cu-Ni 56. Enargite, $Cu_2S \cdot 4CuS \cdot As_2S_3$. Tintic, Utah. H-82656

O	d	I	O	d	I	O	d	I
1	3.21	8.0		1.425	.5		1.046	3.0
	3.08	6.0		1.266	2.0		1.014	.5
2	2.85	8.0		1.215	1.0		.978	.5
	2.22	3.0		1.195	1.0		.928	.5
3	1.86	7.0		1.150	1.0		.899	.5
	1.73	5.0		1.130	.5		.8605	.5
	1.59	4.0		1.072	.5		.818	.5
	1.555	1.0						

Cu-Ni 57. Famatinite (luzonite), $Cu_2S \cdot 4CuS \cdot Sb_2S_3$. Sierro de Famatina, Argentina. H-80792

O	d	I	O	d	I	O	d	I
	3.23	.5		1.73	.2		1.079	1.0
1	3.06	10.0	3	1.59	4.0		1.018	.5
	2.85	.3		1.53	.2		.931	.3
	2.66	.5		1.327	.3		.895	.3
2	1.87	8.0		1.212	1.0		.836	.2

Fe-— 58. Ferberite, $FeWO_4$. Nederland, California. M-211

O	d	I	O	d	I	O	d	I
	5.69	.5		1.935	.3		1.316	.5
	5.22	.5		1.872	1.0		1.295	.3
2	4.71	4.0		1.815	.5		1.272	.3
	3.76	2.0		1.760	1.0		1.231	.3
	3.64	2.0	3	1.71	4.0		1.225	.3
	3.24	3.0		1.658	.3		1.212	.2
1	2.94	8.0		1.625	.2		1.201	.2
	2.84	.5		1.584	1.0		1.185	.5
	2.735	1.0		1.510	3.0		1.175	.3
	2.620	.5		1.462	.5		1.132	.3
	2.490	3.0		1.450	1.0		1.116	.3
	2.370	1.0		1.433	2.0		1.098	.2
	2.195	3.0		1.370	1.0		1.089	.3
	2.060	1.0		1.325	.5		1.080	.3
	2.00	1.0					1.066	.3
							1.041	.3
							1.025	.2

Cu-Ni 59. Franckeite, 5 $PbS \cdot Sb_2S_3 \cdot 2SnS_2$. Poopo, Bolivia. M-61A

O	d	I	O	d	I	O	d	I
2	3.43	3.0		2.22	.5		1.441	.3
	3.15	.3	3	2.06	2.0		1.300	.1
1	2.88	5.0		1.82	1.0			

Cu-Ni 60. Franklinite, (Fe, Zn, Mn)O · (Fe, Mn)$_2$O$_3$. Franklin, New Jersey. M-12

O	d	I	O	d	I	O	d	I
	3.00	1.0		1.28	.5		.972	1.0
1	2.55	7.0		1.13	.5		.881	
	2.12	1.0		1.10	1.0		.860	
	1.70	.5		1.05	1.0		.826	
3	1.62	2.0		.995			.815	
2	1.49	4.0						

Cu-Ni 61. Freieslebenite, $2Ag_2S \cdot 3PbS \cdot 3Sb_2S_3$. Verdad de los Aristas Mine, Guadalajara near Hiedelaencina, Spain. H-93145

O	d	I	O	d	I	O	d	I
1	3.45	5.0		2.01	2.0		1.481	.3
	3.23	1.0		1.88	1.0		1.410	.3
	3.11	1.0		1.78	1.0		1.385	.3
3	2.96	2.0		1.725	1.0		1.365	.3
2	2.82	5.0		1.68	1.0		1.330	.3
	2.23	.3		1.625	.3		1.255	.2
	2.13	1.0		1.560	.3		1.215	.2
	2.07	2.0		1.515	.2			

Cu-Ni 62. Fuloppite, $2PbS \cdot 3Sb_2S_3$. Nagybánya, Rumania. M-212A

O	d	I	O	d	I	O	d	I
2	3.82	.5		2.74	.3		2.00	.3
	3.61	.3		2.47	.3		1.89	.3
3	3.38	.5		2.23	.5		1.75	.2
1	3.23	1.0		2.14	.3		1.69	.2
	2.93	.5						

*Cu-Ni 63. Galena, PbS. Joplin, Missouri.

O	d	I	O	d	I	O	d	I
	3.42	3.0		1.325	5.0		.938	3.0
1	2.96	6.0		1.220	4.0		.905	.5
2	2.08	5.0		1.140	3.0		.895	3.0
3	1.785	5.0		1.049	1.0		.856	.5
	1.710	3.0		1.004	2.0		.831	3.0
	1.480	3.0		.989	3.0		.823	3.0
	1.360	2.0						

Cu-Ni 64. Geocronite, $5PbS \cdot Sb_2S_3$. Sala, Sweden. M-66

O	d	I	O	d	I	O	d	I
	3.69	.5	1	2.23	5.0		1.480	.2
	3.50	1.0		2.115	2.0		1.450	.2
	3.37	1.0		2.09	.5		1.410	.2
3	3.19	1.0		2.04	.5		1.325	.2
	3.04	1.0		1.945	1.0		1.299	.3
	2.97	.5	2	1.830	3.0		1.255	.2
	2.88	1.0		1.765	2.0		1.162	.3
	2.79	.5		1.730	.3		1.117	.2
	2.71	.5						

*Cu-Ni 65. Germanite, Cu_xGeS_y. Tsumeb, S.W. Africa. H-91131

O	d	I	O	d	I	O	d	I
1	3.07	8.0	3	1.60	2.0		1.080	.5
	2.66	.5		1.325	.3		1.017	.2
2	1.875	4.0		1.215	.3		.934	.2

*Cu-- 66. Gersdorffite, NiAsS. Sudbury, Ontario.

O	d	I	O	d	I	O	d	I
	2.83	4.0		1.518	2.0		1.038	.5
1	2.53	6.0		1.270	.3		1.000	2.0
3	2.31	5.0		1.240	1.0		.923	2.0
	2.01	1.0		1.208	.5		.866	1.0
	1.90	.5		1.148	.2		.847	.3
2	1.715	6.0		1.093	2.0		.834	.3
	1.55	1.0		1.055	1.0			

Co- — 67. Glaucodot, (Co, Fe)AsS. Hakansba, Sweden. U. S. National Museum No. 93558

O	d	I
	3.72	1.0
	2.96	.3
	2.84	1.0
2	2.72	5.0
1	2.45	8.0
	2.18	.5
	2.02	.3
	1.94	.5
3	1.82	4.0
	1.75	1.0
	1.635	3.0
	1.59	1.0
	1.555	.5
	1.53	.5
	1.415	.3
	1.380	.5
	1.345	1.0
	1.270	.3
	1.210	2.0

Co-— 68. Goethite, FeO(OH). Marquette, Michigan. M-213

O	d	I
1	4.17	9.0
	3.36	.5
	2.69	2.0
2	2.46	4.0
	2.21	2.0
	1.915	.5
	1.80	1.0
3	1.73	3.0
	1.58	.5
	1.565	1.0
	1.51	1.0
	1.46	1.0
	1.31	.5
	1.195	.3
	1.140	.5
	1.115	.3
	1.050	.3
	1.020	.3
	1.008	.3

*Cu-Ni 69. Gold, Au. North Carolina. H-90583

O	d	I
1	2.36	9.0
2	2.04	6.0
	1.44	4.0
3	1.23	5.0
	1.175	1.0
	1.017	.3
	.933	2.0
	.910	2.0
	.830	3.0
	.784	3.0

Cu-Ni. 70. Gratonite, $Pb_{27}As_{12}S_{45}$. Cerro de Pasco, Peru. Type material

O	d	I
1	3.80	5.0
2	3.47	5.0
3	2.94	3.0
	2.74	3.0
	2.22	2.0
	2.07	2.0
	1.93	1.0
	1.75	1.0
	1.60	.3
	1.50	.5
	1.43	1.0
	1.36	1.0
	1.20	.7
	1.16	.5
	1.095	1.0
	1.065	.5
	.890	1.0
	.875	2.0
	.844	.5
	.832	1.0
	.817	.5
	.805	

*Cu-Ni 71. Graphite, C.

O	d	I
1	3.40	10.0
2	2.06	3.0
3	1.68	2.0
	1.54	.5
	1.23	2.0
	1.155	2.0
	1.120	.3
	1.050	.3
	.990	1.0
	.838	.3
	.827	1.0
	.799	2.0

Cu-Ni 72. Greenockite, CdS. Bishoptown, Scotland. M-235

O	d	I	O	d	I	O	d	I
	3.55	2.0		1.57	.3		1.122	.5
	3.32	1.0		1.395	1.0		1.072	.5
1	3.12	4.0		1.322	1.0		1.032	.3
	2.42	1.0		1.30	.3		.982	.3
2	2.06	3.0		1.255	1.0		.952	.3
3	1.89	3.0		1.190	.5		.906	.3
	1.75	2.0		1.155	1.0		.815	.2

Cu-Ni 73. Grunlingite, Bi_4S_3Te, Bandy Grill, Cumberland, England. M-231

Oruetite yields an identical pattern.

O	d	I	O	d	I	O	d	I
	4.40	1.0	3	2.25	2.0		1.542	.5
	3.65	1.0	2	2.13	3.0		1.410	.5
	3.35	.5		1.98	.3		1.355	1.0
1	3.10	9.0		1.92	.3		1.305	.3
	2.80	.3		1.75	1.0		1.250	.3
	2.58	.5						

Cu-Ni 74. Guanajuatite, $Bi_2(Se, S)_3$. Guanajuato, Mexico. M-70

O	d	I	O	d	I	O	d	I
	5.85	.5		2.57	3.0		1.585	2.0
	5.15	1.0		2.50	.5		1.518	1.0
	4.05	1.0		2.29	3.0		1.460	.5
1	3.61	9.0		2.15	1.0		1.382	.5
2	3.16	8.0		1.98	4.0		1.330	.5
	3.01	.3		1.89	1.0		1.278	.3
3	2.86	4.0		1.765	2.0		1.215	.3
	2.76	1.0		1.702	.3		1.160	.3
	2.67	1.0						

Cu-Ni 75. Guitermanite, $3PbS \cdot As_2S_3$. Zuni mine, Silverton, Colorado. M-72

O	d	I	O	d	I	O	d	I
	4.80	.5	2	2.22	2.0		1.435	.3
	4.4	.5		2.11	1.0		1.395	.3
	4.2	.5		2.02B	.5		1.355	.3
	3.68	.5		1.93	1.0		1.335	.3
	3.52	1.5		1.87	.2		1.318	.3
	3.36	1.5	3	1.82	2.0		1.292	.3
1	3.18	3.0		1.75	1.0		1.266	.3
	3.04	1.0		1.72	.3		1.248	.3
	2.88	1.0		1.68	.3		1.232	.3
	2.78	.5		1.60	.2		1.207	.3
	2.70	.5		1.585	.2		1.182	.3
	2.57	.2		1.482	.2		1.160	.3
	2.37	.2		1.460	.3		1.115	.2

*Fe-— 76. Hauerite, MnS$_2$. Raddusa, Sicily. M-75

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	3.035	3.0		2.15	1.0		1.625	1.0
2	2.715	1.0		1.832	1.0		1.172	1.0
3	2.49	1.0						

Fe-— 77. Hausmannite, Mn$_3$O$_4$. Harz Mts., Germany. M-190

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.08	2.0		1.700	.5		1.275	.3
	2.865	1.0		1.640	.3		1.225	.3
3	2.76	3.0		1.575	.5		1.193	.3
2	2.490	4.0		1.545	2.0		1.169	.2
	2.36	1.0		1.440	1.0		1.120	.2
1	2.030	5.0		1.348	.5		1.080	.2
	1.795	1.0						

*Co-— 78. Hematite. Fe$_2$O$_3$.

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	4.06	.3		1.58	.5		1.135	.3
	3.66	1.0		1.485	1.0		1.100	.5
1	2.69	7.0		1.44	2.0		1.055	.5
3	2.51	4.0		1.30	.5		1.030	.3
	2.18	2.0		1.255	.3		.987	.3
	1.835	3.0		1.182	.3		.959	.5
2	1.68	5.0		1.160	.3		.952	.3

Cu-Ni 79. Hessite, Ag$_2$Te. Calaveras Co., California. M-77B

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.35	.5		2.180	1.0		1.585	.5
	3.15	1.0		2.130	4.0		1.440	1.0
	2.975	4.0		2.020	1.0		1.392	3.0
1	2.870	6.0		1.930	.5		1.342	.3
	2.690	.5		1.850	.3		1.302	.5
	2.450	.3		1.810	.3		1.260	.3
2	2.300	6.0		1.775	.5		1.250	.3
3	2.240	5.0		1.690	.5			

Fe-— 80. Hübnerite, MnWO$_4$. Silverton, Colorado. M-214

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	5.72	1.0		2.49	3.0		1.715	1.0
	5.28	.5		2.41	1.0		1.600	.2
2	4.83	6.0		2.22	1.0		1.525	1.0
	4.11	.5		2.05	.3		1.470	.5
3	3.77	5.0		2.02	.3		1.380	1.0
	3.28	1.0		1.885	.5		1.325	.3
1	2.965	8.0		1.845	.5		1.225	.2
	2.87	.5		1.785	1.0		1.198	.3
	2.74	.5		1.745	1.0			

Fe-Mn 81. Ilmenite, $FeO \cdot TiO_2$, Egersund, Norway. M-81C

O	d	I	O	d	I	O	d	I
1	2.72	2.0		1.86	.5		1.498	.3
2	2.53	2.0		1.717	1.0		1.458	.3
	2.225	1.0		1.622	.2		1.326	.2
3	2.025	2.0						

Cu-Ni 82. Jamesonite, $4PbS \cdot FeS \cdot 3Sb_2S_3$. Cornwall, England. M-83

O	d	I	O	d	I	O	d	I
1	3.40	3.0		2.23	1.0		1.75	.2
	3.10B	1.0		2.04	1.0		1.71	.2
2	2.81	2.0		2.01	1.0		1.45	.3
3	2.72	2.0		1.90	.5		1.41	.2
	2.28	1.0		1.825	1.0			

Cu-Ni 83. Jordanite, $4PbS \cdot As_2S_3$. Silesia. M-84

O	d	I	O	d	I	O	d	I
	3.49	1.0		2.75	.5		2.01	.5
	3.31	1.0		2.48	.3		1.93	.5
	3.15	1.0		2.36	.3	3	1.815	2.0
	3.01	1.0	1	2.22	3.0		1.745	1.0
	2.87	1.0	2	2.10	2.0			

Cu-— 84. Kallilite, Ni(Sb, Bi)S. Westphalia. M-86

O	d	I	O	d	I	O	d	I
	4.15	.3		1.87	.2		1.255	.3
	3.41	.2	3	1.78	1.0		1.155	.2
	2.93	.5		1.70	.3		1.130	.2
1	2.62	5.0		1.63	1.0		1.090	.3
2	2.40	2.0		1.575	1.0		1.075	.3
	2.32	.3		1.470	.2		1.040	.3
	2.08	.3		1.390	.2		.955	.2
	1.98	.2		1.285	.5		.876	.2

Cu-Ni 85. Kermesite. Sb_2S_2O. M-87

O	d	I	O	d	I	O	d	I
	5.15	1.0		2.21	.2		1.575	.5
	4.35	1.0		2.18	.2		1.525	.3
	4.09	1.0		2.09	.2		1.490	.3
	3.82	.5		2.03	2.0		1.445	.3
	3.67	.3		1.99	.3		1.390	.2
	3.30	.5		1.91	.5		1.350	.5
1	3.14	5.0		1.820	.3		1.310	.3
2	2.92	4.0		1.785	1.0		1.295	.2
3	2.70	3.0		1.74	.2		1.205	.2
	2.50	2.0		1.69	.3		1.120	.2
	2.27	1.0		1.63	1.0		1.100	.2

Cu Ni 86. Klaprotholite, $3Cu_2S \cdot 2Bi_2S_3$. Schapbachthal, Baden, Germany. M-89A

O	d	I	O	d	I	O	d	I
	5.7	.5		2.39	1.0		1.500	.3
	5.1	.5		2.31	.3		1.455	.3
1	4.57	4.0		2.18	.5		1.410	.3
	4.10	.2		2.10	.3		1.385	.3
	3.81	2.0		2.04	.5		1.315	.2
	3.60	.5		1.99	2.0		1.300	.3
	3.35	.5		1.895	1.0		1.260	.3
	3.18	1.0		1.82	2.0		1.232	.3
3	3.07	3.0		1.76	1.0		1.205	.3
	2.95	1.0		1.73	.5		1.160	.3
2	2.85	3.5		1.68	2.0		1.125	.2
	2.65	2.0		1.60	.5		1.078	.2
	2.57	1.0		1.550	.3		1.065	.2

Cu-Ni 87. Klockmannite, CuSe. Harz, Germany.

O	d	I	O	d	I	O	d	I
	3.35	1.0		1.84	4.0		1.158	.5
1	3.25	8.0		1.64	2.0		1.102	.3
3	2.90	7.0		1.42	.3		.995	.5
	2.20	.3		1.34	.5		.945	.2
2	2.00	8.0		1.28	.3		.887	.2

Cu-Ni 88. Kobellite, $2PbS \cdot (Bi, Sb)_2S_3$. Hvena, Sweden. M-90A

O	d	I	O	d	I	O	d	I
	4.25	.3	1	2.86	3.0		1.94	.2
	4.00	.5		2.72	2.0		1.81	.3
	3.78	.5		2.60	.3		1.74	.5
2	3.55	2.0		2.31	.3		1.71	.2
3	3.38	2.0		2.25	.3		1.46	.2
	3.27	1.0		2.13	1.0		1.43	.2
	3.14	.5		2.02	1.0		1.39	.2
	2.98	.5						

Cu-Ni 89. Krennerite, $(Ag, Au)Te_2$. Cripple Creek, Colorado. M-91

O	d	I	O	d	I	O	d	I
1	3.05	8.0		1.98	.3		1.350	.5
3	2.95	3.0		1.785	1.0		1.322	.5
	2.24	1.0		1.699	1.0		1.271	.3
2	2.12	5.0		1.522	1.0		1.205	.5
	2.07	.5		1.475	.5			

*Cu-Ni 90. Lead, Pb. Långban, Sweden.

O	d	I	O	d	I	O	d	I
2	2.84	8.0		1.233	1.0		.9515	6.0
	2.445	6.0		1.133	6.0		.875	1.0
3	1.740	7.0		1.105	6.0		.8365	6.0
1	1.485	9.0		1.009	6.0		.8250	5.0
	1.423	4.0						

Cu-Ni 91. Linnaeite, Co_3S_4. Siegen, Westphalia. M-96A

O	d	I	O	d	I	O	d	I
	3.35	1.0		1.44	.5		.985	.5
1	2.82	6.0		1.37	.5		.960	2.0
3	2.38	2.0		1.23	1.0		.908	1.0
	1.91	.3		1.17	1.0		.831	1.0
	1.82	2.0		1.085	.5		.797	.5
2	1.68	5.0		1.055	.5		.784	1.0

Cu-Ni 92. Livingstonite, $HgS \cdot 2Sb_2S_3$. Beresow, near Ekaterinberg, Russia. M-97A

O	d	I	O	d	I	O	d	I
	5.10	1.0		2.03	.3		1.50	1.0
2	3.75	3.0		1.93	.5		1.43	.5
3	3.45	2.0		1.88	.5		1.37	.2
	3.28	.5		1.83	1.0		1.33	.2
1	2.99	5.0		1.80	.3		1.305	.2
	2.86	1.0		1.725	2.0		1.275	.2
	2.67	1.0		1.64	.5		1.202	.2
	2.41	1.0		1.595	.3		1.095	.2
	2.27	2.0						

Fe-Mn 93. Löllingite, $FeAs_2$. Silver Center, Ontario.

O	d	I	O	d	I	O	d	I
	3.45	.5	1	2.425	4.0	3	1.81	1.0
	2.83	.5		2.192	.2		1.628	.5
2	2.665	1.0		2.092	.2		1.340	.3
	2.54	.2		2.025	.5		1.215	.2

Cu-Ni 94. Lorandite, $Tl_2S \cdot As_2S_3$. Allchar, Macedonia. M-99

O	d	I	O	d	I	O	d	I
	5.10	.5		2.28	.5		1.43	.2
	4.40	.2		2.05	.5		1.41	.2
	4.05	.5		1.94	.3		1.380	.2
1	3.65	5.0		1.84	.5		1.320	.2
	3.50			1.78	.3		1.271	.2
	3.15	.5		1.74	.3		1.217	.2
3	2.95	2.0		1.65	.5		1.148	.2
2	2.85	3.0		1.585	.3		1.100	.3
	2.74	1.0		1.541	.3		1.063	.2
	2.61	1.0		1.510	.3		1.021	.2
	2.40	.5		1.470	.5		.995	.2
	2.34	.3						

*Fe-— 95. Magnetite, Fe_3O_4. Mineville, New York. M-101

O	d	I	O	d	I	O	d	I
3	2.96	1.0		2.085	1.0	2	1.475	2.0
	2.79	.5		1.71	.5		1.275	.3
1	2.53	5.0		1.62	1.0		1.09	.3

Co-— 96. Marcasite, FeS_2. Creighton, Ontario.

O	d	I	O	d	I	O	d	I
3	3.47	3.0	2	1.762	4.0		1.158	1.0
1	2.715	6.0		1.692	1.0		1.092	1.0
	2.42	2.0		1.600	2.0		1.033	1.0
	2.32	2.0		1.520	2.0		.991	1.0
	1.925	1.0		1.370	1.0		.957	3.0

*Cu-— 97. Maucherite. Ni_3As_2. Sudbury, Ontario.

O	d	I	O	d	I	O	d	I
	3.18	1.0	3	1.73	7.0		1.14	1.0
1	2.72	10.0		1.638	1.0		1.118	1.0
	2.395	1.0		1.515	.5		1.19	1.0
2	2.035	9.0		1.46	2.0		1.075	.5
	1.902	2.0		1.22	2.0		1.048	.5

Cu-Ni 98. Melonite, Ni_2Te_3. Boulder Co., Colorado. M-105A

O	d	I	O	d	I	O	d	I
	3.33	1.0	2	1.930	4.0		1.318	.2
1	2.82	8.0		1.592	2.0		1.228	2.0
	2.63	1.0		1.555	3.0		1.135	.2
	2.35	2.0		1.442	.3		1.086	.2
3	2.075	3.0		1.410	.3		1.024	.2
	2.030	.5						

Cu-Ni 99. Meneghinite, $4PbS \cdot Sb_2S_3$. Marble Lake, Frontenac Co., Quebec. M-106

O	d	I	O	d	I	O	d	I
	3.45	1.0		2.07	2.0		1.682	.5
2	3.24	3.0		1.97	1.0		1.630	.3
	3.05	1.0		1.93	.5		1.480	.3
1	2.90	4.0		1.882	1.0		1.441	.2
3	2.74	2.0		1.840	.3		1.422	.5
	2.64	1.0		1.800	1.0		1.395	2.0
	2.36	.5		1.785	.3		1.322	.3
	2.24	1.0		1.745	.5		1.240	.5
	2.17	.5		1.715	1.0		1.199	1.0

*Cu-Ni 100. Metacinnabar, HgS. Reddington Mine, Lake Co., California. M-107

O	d	I	O	d	I	O	d	I
1	3.36	10.0		1.69	1.0		1.192	1.0
	2.92	2.0		1.461	.5		1.125	1.0
2	2.07	5.0		1.34	2.0		.988	.5
3	1.77	5.0		1.31	.5		.925	.3

Cu-Ni 101. Miargyrite, $AgS \cdot Sb_2S_3$. Zacatecas, Mexico. M-108

O	d	I	O	d	I	O	d	I
2	3.42	4.0		1.910	1.0		1.330	.3
	3.16	1.0		1.800	2.0		1.301	.2
	3.08	1.0		1.715	.5		1.285	.2
1	2.88	5.0		1.682	1.0		1.250	.5
3	2.74	3.0		1.625	.5		1.228	.5
	2.64	.5		1.588	.5		1.145	.3
	2.20	.5		1.550	.5		1.130	.3
	2.01	2.0		1.425	.3		1.105	.2
	1.965	2.0		1.415	.5		1.065	.2
				1.372	.3			

*Fe-— 102. Moschellandsbergite, Ag_2Hg_3. Moschellandsberg, Germany. Type material

O	d	I	O	d	I	O	d	I
	2.91	.3		1.555	.2		1.192	.5
	2.85	.5		1.538	.2		1.175	1.0
	2.65	1.0		1.497	.5		1.158	2.0
	2.57	2.0		1.470	1.0		1.142	1.0
1	2.34	6.0		1.437	2.0		1.110	.3
	2.22	1.0		1.410	2.0		1.100	.5
	2.115	1.0	2	1.360	4.0		1.088	.5
	1.95	2.0		1.332	1.0		1.076	1.0
	1.710	1.0		1.268	2.0		1.054	1.0
	1.660	2.0	3	1.229	3.0		1.030	2.0
	1.620	.3						

Cu-— 103. Millerite, NiS. Sudbury, Ontario.

O	d	I	O	d	I	O	d	I
	4.80	2.0		1.805	1.0		1.197	.2
	3.05	.2		1.730	2.0		1.170	.2
	2.94	1.0		1.625	.5		1.140	.2
1	2.77	5.0		1.595	1.0		1.108	.2
3	2.50	3.0		1.540	1.0		1.102	.2
	2.39	.2		1.400	.2		1.080	.2
	2.22	3.0		1.380	.3		1.028	.3
	2.05	.3		1.322	.2		.978	.2
	2.00	.2		1.295	.3		.925	.2
	1.91	.2		1.251	.3		.908	.2
2	1.85	4.0		1.205	.2			

Cu-Ni 104. Molybdenite, MoS_2. Ogden Mine, New Jersey. H-88915

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	6.61	3.0	3	1.530	6.0		1.021	1.0
	5.63	5.0		1.475	.3		1.002	2.0
	2.74	2.0		1.365	.3		.968	.5
	2.66	.5		1.335	2.0		.953	2.0
	2.49	1.0		1.295	2.0		.912	.5
1	2.27	8.0		1.251	2.0		.901	.3
	2.040	2.0		1.222	.3		.894	2.0
2	1.820	7.0		1.195	1.0		.865	1.0
	1.635	.5		1.100	2.0		.858	.5
	1.578	2.0		1.034	3.0		.834	.2

Cu-Ni 105. Nagyagite, Pb, Au, Te, S. Nagyág, Transylvania. M-112

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.62	1.0	3	2.09	4.0		1.360	.3
	3.40	3.0		1.835	2.0		1.315	.3
2	3.02	7.0		1.790	1.0		1.215	.3
1	2.83	8.0		1.715	4.0		1.142	.2
	2.65	.3		1.518	1.0		1.078	.2
	2.43	2.0		1.475	1.0			

Cu-— 106. Niccolite, NiAs. Bebra, Hesse, Germany. M-114A

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	4.10	.2		2.16	.2		1.245	.5
	3.10	.3	2	1.95	5.0		1.065	.5
	2.94	.3	3	1.795	3.0		1.028	.3
1	2.64	6.0		1.475	1.0		.964	.2
	2.49	.2		1.320				

*Cu-Ni 107. Orpiment, As_2S_3. Kurdistan. M-116

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	4.80	6.0		2.29	1.0		1.50	.2
	4.40	.3		2.22	.2		1.442	.2
	3.95	1.0		2.10B	.5		1.381	.2
	3.65	1.0		2.02	.3		1.320	.2
	3.17	1.0		1.90	.5		1.292	.2
2	2.82	3.0		1.87	.5		1.170	.2
3	2.70	3.0		1.74	1.0		1.100	.2
	2.55	.5		1.68	1.0		1.060	.2
	2.43	2.0		1.63	.2		1.002	.2

Cu-Ni 108. Pearceite, $8Ag_2S \cdot As_2S_3$. M-117A

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
3	3.09	.3		2.72	.2		2.18	.2
2	3.00	.5		2.52	.2		2.01	.2
1	2.84	1.0		2.34	.2		1.86	.2

*Cu-Ni 109. Penroseite, $5(Ni, Co)Se_2 \cdot 2PbSe_2 \cdot 3CuSe$. Colquechaca, Bolivia.

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.50	2.0	3	1.81	4.0		1.115	1.0
	3.01	2.0		1.665	2.0		1.095	.3
1	2.68	6.0		1.602	2.0		1.062	1.0
2	2.45	5.0		1.555	.2		.974	.5
	2.14	2.0		1.510	.2		.914	.2
	2.00	.2		1.310	1.0		.896	.1
	1.93	.2		1.155	1.0			

*Fe-Mn 110. Pentlandite, $(Fe, Ni)_9S_8$. Sudbury, Ontario.

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.54	.3		2.13	.1		1.25	1.0
	3.34	.3	3	1.95	3.0		1.225	.3
2	3.03	4.0	1	1.77	6.0		1.155	.2
	2.89	2.0		1.695	.2		1.069	.1
	2.51	.2		1.525	.3		1.049	.1
	2.30	1.0		1.515	.3		1.022	1.0
	2.095	.1		1.305	1.0			

Cu-Ni 111. Petzite, $(Ag, Au)_2Te$. Upper Canada Mine, Ontario.

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.64	1.0		1.89	2.0		1.407	.3
	2.99	1.0		1.83	1.0		1.385	1.0
1	2.77	6.0		1.56	.5		1.315	2.0
	2.68	.2		1.525	.5		1.295	.3
	2.43	2.0		1.49	.3		1.275	.5
	2.31	2.0		1.465	.3		1.205	.3
2	2.11	3.0		1.435	.3		1.172	.3
3	2.03	3.0						

Cu-Ni 112. Plagionite. $5PbS \cdot 4Sb_2S_3$. Wolfsberg, Harz, Germany. M-120A

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.92	1.0		2.05	.5		1.78	.3
1	3.42	4.0	3	1.99	1.0		1.715	.5
2	2.78	3.0		1.89	.5		1.460	.5
	2.14	1.0		1.825	.5		1.345	.5

Cu-Ni 113. Polybasite, $8Ag_2S \cdot Sb_2S_3$. Pillow's Lake, Nevada. M-123

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.11	.5		2.22	.2		1.675	.5
3	2.94	2.0		2.06	.2		1.63	.3
1	2.81	4.0		1.99	1.0		1.49	.2
2	2.47	3.0		1.85	1.0		1.45	.1
	2.37	.5		1.75	.5		1.41	.1
	2.30	.5						

Co-— 114. Polydymite, Ni_3S_4. Grunau Mine, Siegen, Westphalia. U. S. National Museum No. 48491
(Pattern identical to that of violarite)

Cu-Ni 115. Proustite, $3Ag_2S \cdot As_2S_3$. Cobalt, Ontario. M-126E

O	d	I	O	d	I	O	d	I
1	3.20	6.0		2.08	.5		1.57	.3
3	2.75	2.0		1.94	1.0		1.52	.3
2	2.53	4.0		1.73	.3		1.43	.3
	2.27	.5		1.64	.3			

Cu-Ni 116. Pyrargyrite, $3Ag_2S \cdot Sb_2S_3$. Himmelfurst mine, Freiburg, Germany. M-128

O	d	I	O	d	I	O	d	I
	3.35	2.0		2.00	1.0		1.530	.5
3	3.20	5.0		1.960	1.0		1.458	.3
1	2.79	7.0		1.865	1.0		1.402	.5
2	2.55	6.0		1.750	1.0		1.350	.3
	2.26	1.0		1.680	1.0		1.262	1.0
	2.12	1.0		1.600	1.0		1.210	.3

*Cu-Ni 117. Pyrite, FeS_2, Sudbury, Ontario.

O	d	I	O	d	I	O	d	I
	3.10	.5		1.522	.5		1.013	.3
2	2.76	3.0		1.460	.5		.990	.3
3	2.46	3.0		1.224	.3		.961	.5
	2.24	1.0		1.195	.3		.907	.5
	1.93	2.0		1.160	.3		.880	.5
	1.82	.5		1.120	.3		.825	.5
1	1.645	4.0		1.050	1.0		.817	.3
	1.585	.3		1.028	.3		.807	.3

*Fe-— 118. Pyrolusite, MnO_2. M-193A

O	d	I	O	d	I	O	d	I
	3.44	1.0		2.11	3.0		1.435	2.0
1	3.11	10.0		1.97	1.0		1.395	.2
	2.65	.5		1.795	1.0		1.305	2.0
3	2.41	5.0	2	1.625	6.0		1.047	1.0
	2.20	.5		1.560	2.0			

*Co-— 119. Pyrrhotite, $Fe_{1-x}S$. Noranda, Quebec.

O	d	I	O	d	I	O	d	I
	2.97	1.0	3	1.718	3.0		1.067	.5
2	2.63	4.0		1.612	.5		1.045	2.0
	2.45	.2		1.428	.7		.990	1.0
	2.26	.2		1.315	1.0		.968	1.0
1	2.062	8.0		1.170	.5		.908	2.0
	1.88	.2		1.10	3.0			

*Cu-— 120. Rammelsbergite, $NiAs_2$. Eisleben, Germany.

O	d	I
	3.60	.3
	2.90	.5
3	2.76	4.0
2	2.485	5.0
	2.415	3.0
	2.32	.3
	2.17	1.0
	1.985	1.0
1	1.833	8.0
	1.730	1.0
	1.670	3.0
	1.610	1.0
	1.578	2.0
	1.515	2.0
	1.422	4.0
	1.347	1.0
	1.280	.5
	1.265	.5
	1.241	.5
	1.228	3.0
	1.157	4.0
	1.132	.2
	1.112	2.0
	1.092	2.0
	1.066	3.0
	1.046	3.0
	1.030	1.0
	1.020	3.0
	1.008	4.0
	.999	.5
	.987	1.0
	.972	4.0
	.947	4.0
	.934	.5
	.920	3.0

*Cu-— 121. Pararammelsbergite, $NiAs_2$. Elk Lake, Ontario. Type material

O	d	I
2	2.86	3.0
1	2.55	8.0
3	2.37	2.0
	2.005	2.0
	1.82	2.0
	1.735	2.0
	1.660	.3
	1.595	.5
	1.537	1.0
	1.481	.3
	1.440	.3
	1.382	.3
	1.320	.5
	1.258	.2
	1.227	.5
	1.135	.3
	1.103	.3
	1.060	.5
	1.047	.3
	1.017	1.0

Cu-Ni 122. Rathite, $3PbS \cdot 2As_2S_3$. Binnenthal, Switzerland. M-132

O	d	I
	4.1	.5
	3.6	.3
	3.4	.5
	3.17	.5
1	2.96	2.0
2	2.72	2.0
3	2.32	1.0
	2.22	.5
	2.08	.5
	2.02	.3
	1.92	.5
	1.82	.3
	1.78	.2
	1.515	.2
	1.455	.2
	1.415	.2
	1.365	.2

Cu-Ni 123. Realgar, AsS. Felsöbánya, Hungary. M-133

O	d	I
	5.95	.3
1	5.40	3.0
	4.05	.3
2	3.15	3.0
3	2.93	3.0
	2.71	3.0
	2.60	.3
	2.48	.5
	2.40	.2
	2.23	.3
	2.18	.3
	2.12	.5
	1.85	.5
	1.67	.5
	1.63	.3
	1.58	.2
	1.51	.2
	1.47	.2

Cu-Ni 124. Rezbanyite, $2PbS \cdot 3Sb_2S_3$. Rezbánya, Hungary. M-135

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
3	3.60	2.0		2.18	1.0		1.676	.5
1	3.22	3.0		2.05	.3		1.625	.5
2	3.01	3.0		1.965	2.0		1.460	.3
	2.85B	1.0		1.915	.5		1.382	.2
	2.74	.5		1.800	.5		1.275	.2
	2.63	.5		1.730	.5		1.251	.5

*Cu-Ni 125. Rickardite, Cu_4Te_3. Vulcan Mine, Gunnison Co., Colorado. M-136

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
2	3.32	4.0		1.810	.5		1.425	.2
	2.82	.5		1.705	.5		1.340	.2
3	2.55	1.0		1.665	.2		1.158	.3
1	2.06	3.0		1.580	.2		1.120	.3
	1.99	2.0		1.532	.2		1.084	.2

Cu-Ni 126. Samsonite, $2Ag_2S \cdot MnS \cdot Sb_2S_3$. Andreasberg, Harz, Germany. H-82439

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	6.2	.3		2.24	.3		1.402	.3
	5.22	.3		2.17	.3		1.370	.3
	4.08	.3		2.08	.5		1.345	.2
	3.73	.3		2.01	.3		1.295	.2
	3.28	.5		1.93	.5		1.255	.2
1	3.17	2.0		1.84	.5		1.235	.2
2	2.99	2.0		1.81	.5		1.205	.2
3	2.85	1.0		1.755	.5		1.165	.2
	2.70	.5		1.620	.5		1.133	.2
	2.57	1.0		1.545	.3		1.108	.2
	2.47	.5		1.48	.2		1.095	.2
	2.42	1.0		1.44	.3		1.082	.2
	2.32	.3						

Co-— 127. Safflorite, $CoAs_2$. Quartzburg, Grant Co., Oregon. U. S. National Museum.
No. 84753

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	2.84	.5	3	1.635	4.0		1.100	1.0
1	2.60	10.0		1.565	1.0		1.075	1.0
2	2.37	4.0		1.500	2.0		1.048	1.0
	2.04	.3		1.275	1.0		.975	.5
	1.94	.5		1.160	.5		.965	.5
	1.87	3.0						

Cu-Ni 128. Sartorite, $PbS \cdot As_2S_3$. Binnenthal, Switzerland. M-139A

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	4.1	.3		2.62	1.0		1.94	.5
	3.87	.3		2.54	.3		1.86	.3
1	3.48	3.0		2.45	.3		1.79	.2
	3.23	.5		2.32	1.0		1.73	.2
2	2.95	2.0		2.10	.5		1.55	.2
3	2.76	2.0						

Cu-Ni 129. Schapbachite, $Ag_2S \cdot PbS \cdot Bi_2S_3$. Schapbach, Baden, Germany. M-141A

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
3	3.42	3.0		1.705	2.0		1.255	.2
2	3.28	4.0		1.640	.3		1.205	.2
1	2.95	2.0		1.476	.3		1.045	.2
	2.82	5.0		1.410	.2		.984	.2
	2.08	2.0		1.355	.2		.934	.2
	2.00	2.0		1.320	.5		.891	.2
	1.78	2.0						

If the doublets indicated by the brackets are not resolved, the apparent order of strongest lines is: (1) 3.35, (2) 2.88, (3) 2.08.

Cu-Ni 130. Schirmerite, $3(As_2, Pb)S \cdot 2Bi_2S_3$, Lake City, Colorado. M-16A

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.67	2.0		2.03	1.0		1.318	.3
1	3.00	10.0		1.89	1.0		1.296	.3
	2.82	.2	2	1.83	7.0		1.275	.3
	2.76	.3		1.775	.5		1.239	.5
	2.58	2.0		1.680	1.0		1.205	.5
	2.44	1.0		1.630	.3		1.189	.5
	2.32	.5	3	1.560	5.0		1.116	.3
	2.22	.5		1.495	.2		1.092	.3
	2.12	.5		1.465	.3		1.057	.5

Cu-Ni 131. Seligmannite, $Cu_2S \cdot 2PbS \cdot As_2S_3$. Butte, Montana. H-85708

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	5.80	.5		2.23	.3		1.450	.2
	4.75	.2		2.16	.3		1.418	1.0
	4.35	1.0		2.09	.5		1.385	1.0
	4.10	.5		1.97	.5		1.361	.5
2	3.85	3.0		1.94	.5		1.337	.3
	3.66	1.0		1.84	1.0		1.325	.2
	3.25	1.0	3	1.77	2.0		1.282	.2
	2.97	1.0		1.725	.2		1.248	.2
	2.90	.3		1.66	1.0		1.225	.3
	2.82	.4		1.635	1.0		1.212	.2
1	2.72	4.0		1.590	.2		1.145	.3
	2.65	1.0		1.550	1.0		1.114	.3
	2.57	2.0		1.495	.2		1.102	.3
	2.36	1.0		1.482	.2		.985	.3
	2.28	.3						

Cu-Ni 132. Semseyite, $9PbS \cdot 4Sb_2S_3$. Rezbánya, Hungary. M-143

O	d	I	O	d	I	O	d	I
	3.85	1.0		2.47	.3		1.81	.2
	3.60	.2		2.25	1.0		1.72	.2
1	3.28	5.0		2.17	.5		1.635	.2
2	3.00	3.0		2.06	.5		1.490	.2
3	2.74	1.0		1.93	.2		1.362	.2

Cu-— 133. Siegenite, $(Co, Ni)_3S_4$. U. S. National Museum. C-529

Identical to patterns of violarite, polydymite, carrollite.

O	d	I	O	d	I	O	d	I
	3.36	.2	3	2.36	1.0		1.83	.3
1	2.85	2.0		2.04	.2	2	1.67	2.0

*Cu-Ni 134. Silver, Ag.

O	d	I	O	d	I	O	d	I
1	2.35	9.0	2	1.228	6.0		.936	5.0
3	2.04	5.0		1.176	2.0		.912	5.0
	1.44	4.0		1.018	1.0		.8335	5.0

Cu-— 135. Skutterudite, $(Co, Ni)As_3$. Skutterud, Norway. M-145

Identical to pattern of smaltite-chloanthite.

O	d	I	O	d	I	O	d	I
	3.40	.5	3	1.62	3.0		1.005	.2
	2.90	.5		1.42	1.0		.975	.3
1	2.64	10.0		1.38	.2		.965	.3
	2.45	.2		1.32	.2			1.0
	2.21	2.0		1.22	1.0		.916	.3
	2.08	.2		1.20	.2		.855	1.0
	1.96	.3		1.142	.2		.840	.5
2	1.86	3.0		1.125	.2		.805	.2
	1.76	.5		1.085	1.0		.790	1.0
	1.70	1.0		1.050	.3			

*Cu-Ni 136. Sperrylite, $PtAs_2$. Sudbury, Ontario.

O	d	I	O	d	I	O	d	I
	3.38	1.0		1.30	.5		.908	3.5
	2.94	2.0		1.272	.3		.898	3.0
	2.64	1.0		1.220	3.0		.888	.3
	2.41	1.0	2	1.144	4.0		.880	.3
	2.10	2.0		1.105	1.0		.835	4.0
1	1.788	4.0		1.088	1.0		.827	4.0
	1.720	.5	3	1.050	3.0		.819	1.0
	1.65	.5		1.005	2.5		.812	1.0
	1.59	1.0		.990	.3		.797	4.0
	1.37	1.0		.966	1.0		.777	9.0
	1.33	2.0		.941	3.0		.775	6.0

*Cu-Ni 137. Sphalerite, ZnS. Butte, Montana.

O	d	I
	3.95	.5
1	3.12	6.0
	2.70	2.0
2	1.91	5.0
3	1.63	4.0
	1.555	.5
	1.350	2.0
	1.241	3.0
	1.210	.5
	1.105	3.0
	1.041	2.0
	.966	1.0
	.914	2.0
	.855	1.0

*Cu-Ni 138. Stannite, $Cu_2S \cdot FeS \cdot SnS_2$. Cairn Brea, Redruth, Cornwall, England. M-149
Note similarity to sphalerite pattern.

O	d	I
1	3.11	8.0
	2.82	1.0
	2.70	.5
	2.20	.3
	1.99	1.0
2	1.91	5.0
	1.80	.2
3	1.630B	2.0
	1.560	.3
	1.238	.5
	1.105	.5
	1.042	.3
	.916	.2

Cu-Ni 139. Stephanite, $5Ag_2S \cdot Sb_2S_3$. Freiberg, Saxony, Germany. M-151

O	d	I
	3.31	.5
1	3.06	4.0
3	2.90	2.0
	2.75	1.0
2	2.56	3.0
	2.49	.5
	2.42	1.0
	2.33	.5
	2.18	1.0
	2.13	1.0
	2.01	.3
	1.96	.3
	1.86	.5
	1.84	.5
	1.78	.5
	1.63B	.5
	1.515	.5
	1.465	.3
	1.418	.2
	1.390	.3
	1.345	.3
	1.305	.2
	1.260	.2
	1.195	.5

Cu-Ni 140. Sternbergite, $AgFe_2S_{3-4}$. Joachimsthal, Bohemia. M-152

O	d	I
	4.75	.5
1	4.25	6.0
2	3.25	3.0
3	2.79	3.0
	2.64	1.0
	2.36	.5
	1.945	1.0
	1.895	1.0
	1.79	2.0
	1.66	1.0
	1.59	.5

*Cu-Ni 141. Stibnite, Sb_2S_3. Nmokain, Araigai, Iyo, Japan. H-81565

O	d	I
	5.60	2.0
	5.00	2.0
	3.95	1.0
1	3.55	6.0
	3.11	2.0
	3.05	3.0
	2.77	3.0
	2.67	.5
	2.52	3.0
	2.42	1.0
	2.28	1.0
	2.23	2.0
	2.10	3.0
	1.990	.3
2	1.940	4.0
	1.885	.3
	1.785	.3
	1.725	2.0
3	1.690	4.0
	1.540	1.0
	1.525	1.0
	1.485	.5
	1.442	.5
	1.400	.5
	1.312	.5
	1.291	.5
	1.241	.5
	1.202	.5
	1.188	.5
	1.131	.5
	1.112	.5
	1.083	.5
	1.060	.5
	.985	.3
	.959	.5
	.943	.3
	.915	.5

Cu-Ni 142. Stromeyerite, $(CuAg)_2S$

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.06	.5		2.34	1.0		1.99	.5
1	2.96	3.0		2.30	1.0		1.91	.3
2	2.79	3.0		2.16	.5		1.82	.5
3	2.47	1.0		2.09	.3		1.67	.3

Cu-Ni 143. Sulvanite, Cu_3VS_4. Burra Burra, South Australia. H-85259

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
2	5.2	6.0		1.620	4.0		1.036	.5
	4.15	.5		1.495	1.0		1.000	.2
	3.70	.3		1.345	1.0		.951	.5
3	3.11	6.0		1.302	1.0		.936	.3
	2.84	.3		1.235	1.0		.909	.3
	2.69	1.0		1.175	.5		.851	.2
1	2.40	7.0		1.098	2.0		.812	.3
	1.799	2.0						

Cu-Ni 144. Sylvanite, $(Au, Ag)Te_2$. Nagyág, Transylvania. M-159

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	4.7	.5	2	2.12	6.0		1.525	1.0
	3.95	1.0		2.07	1.0		1.475	1.0
1	3.05	8.0		1.99	.5		1.410	.2
3	2.96	3.0		1.835	.3		1.352	.3
	2.83	.5		1.790	.5		1.322	.3
	2.35	.2		1.695	1.0		1.207	.3
	2.25	1.0						

*Cu-Ni 145. Tellurium, Te. Good Hope Mine, Vulcan, Colorado. M-162

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.85	1.0		1.61	2.0		1.170	3.0
1	3.22	9.0		1.47	1.0		1.125	.3
2	2.33	4.0		1.445	.5		1.048	.3
3	2.22	3.0		1.410	1.0		1.037	.2
	2.07	1.0		1.375	1.0		1.005	.2
	1.965	1.0		1.300	.5		.898	.2
	1.82	2.0		1.252	.3		.864	.2
	1.77	.5		1.230	.3			

Cu-Ni 146. Tellurobismuthite, Bi_2Te_3. Whitehorn, Colorado.

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	3.20	10.0		1.61	4.0		1.265	.5
	2.50	.2		1.56	.2		1.208	.3
2	2.37	8.0		1.485	4.0		1.190	.3
3	2.19	8.0		1.410	.3		1.072	.5
	2.02	2.0		1.395	3.0		1.040	.5
	1.81	4.0		1.340	1.0		.992	.5
	1.70	1.0		1.298	2.0			

*Cu-Ni 147. Tennantite. $5Cu_2S \cdot 2(Cu, Fe, Zn)S \cdot 2As_2S_3$, Cornwall, England. H-87984

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	4.16	2.0		1.77	.3		1.142	.3
	3.70	.5		1.71	.3		1.102	.3
1	2.95	9.0		1.655	1.0		1.042	2.0
	2.74	.5	3	1.541	6.0		.982	.5
	2.56	3.0		1.475	.3		.974	.5
	2.41	2.0		1.445	.5		.910	.5
	2.09	.5		1.277	1.0		.902	.3
	2.01	1.0		1.222	.3		.868	.3
	1.87	3.0		1.190	.5		.863	.3
2	1.81	6.0		1.172	1.0			

*Cu-Ni 148. Tenorite, CuO. Vesuvius, Italy. H-83359

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	2.48	8.0		1.51	2.0		1.090	1.0
2	2.32	8.0		1.41	1.0		.978	1.0
3	1.87	2.0		1.375	2.0		.918	.5
	1.71	.5		1.305	.5		.887	.5
	1.58	1.0		1.260	2.0		.855	.3

Cu-Ni 149. Tetradymite, $Bi_2(Te,S)_3$. Schubkau, Hungary. H-81609

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	3.12	8.0		1.95	1.0		1.440	.1
	2.78	.3		1.84	.1		1.350	.5
	2.60	.3		1.76	1.0		1.300	.3
3	2.30	2.0		1.65	.2		1.255	.2
2	2.12	3.0		1.56	1.0			

Cu-Ni 150. Tetrahedrite, $5Cu_2S \cdot 2(Cu, Fe, Zn)S \cdot 2Sb_2S_3$. Bingham, Utah. H-82545

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	4.15	.5		1.66	1.0		1.190	.5
1	2.96	8.0	3	1.54	5.0		1.175	1.0
	2.56	2.0		1.475	.5		1.105	.5
	2.42	1.0		1.445	.5		1.044	2.0
	2.01	1.0		1.280	1.0		.984	.5
	1.87	1.0		1.222	1.0		.976	.5
2	1.81	6.0						

Cu-Ni 151. Tiemannite, HgSe. Marysvale, Utah. H-81896

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	3.38	10.0		1.365	4.0		.950	3.0
	2.95	2.0		1.22	4.0		.917	2.0
2	2.10	8.0		1.15	3.0		.842	2.0
3	1.79	8.0		1.06	2.0		.804	3.0
	1.72	1.0		1.015	2.0		.785	2.0
	1.49	2.0						

Fe-— 152. Troilite, FeS. California. H-90018

O	d	I
	5.11	.2
	4.72	.3
	3.82	.3
3	2.98	3.0
2	2.68	5.0
	2.54	.3
	2.325	2.0
1	2.10	8.0
	1.912	.5
	1.900	.3
	1.755	.3
	1.722	3.0
	1.638	.5
	1.472	1.0
	1.450	.5
	1.370	1.0
	1.320	.5
	1.120	1.0
	1.107	1.0
	1.054	1.0

Cu-Ni 153. Tungstenite, WS_2. Cottonwood, Utah. M-216

O	d	I
1	6.2	9.0
2	2.68	6.0
3	2.28	2.0B
	2.05	1.0
	1.88	1.0B
	1.58	2.0
	1.52	2.0
	1.40	.3
	1.35	.5
	1.30	.3
	1.25	.5
	1.10	1.0
	1.025	1.0
	1.000	1.0
	.960	.5B

*Cu-— 154. Ullmanite, NiSbS. Wissen sur le Sieg, Prussia. M-169

O	d	I
	4.15	1.0
	3.40	.2
	2.94	1.0
1	2.64	8.0
2	2.41	3.0
	2.08	.5
	1.98	.5
	1.87	.5
3	1.78	3.0
	1.701	.2
	1.640	1.0
	1.580	.5
	1.475	.2
	1.430	.3
	1.390	.3
	1.315	.2
	1.290	.5
	1.260	.3
	1.159	.3
	1.135	.3
	1.120	.2
	1.098	.5
	1.080	.3
	1.045	.5
	1.015	.2
	.988	.2
	.971	.2
	.958	.3
	.898	.2
	.888	.2
	.880	.3
	.811	.3

*Cu-Ni 155. Umangite, Cu_3Se_2. Rivja, Argentina. H-81762

O	d	I
1	3.6	6.0
2	3.15	6.0
	2.85	1.0
	2.58	1.0
	2.40	.5
	2.26	3.0
	2.14	2.0
	2.02	3.0
	1.91	3.0
3	1.83	4.0
	1.77	4.0
	1.64	1.0
	1.55	1.0
	1.42	1.0
	1.35	1.0
	1.27	.5
	1.23	.5
	1.20	2.0
	1.185	2.0
	1.165	2.0
	1.130	.5
	1.095	.5
	1.060	.5
	1.050	.3
	1.035	1.0
	1.015	.5
	1.000	.5
	.965	.5
	.941	3.0
	.912	.3
	.904	.3
	.895	.5
	.870	.5
	.818	3.0
	.793	3.0
	.788	3.0
	.781	3.0

Cu-— 156. Violarite, $(NiFe)_3S_4$. Vermilion Mine, Sudbury, Ontario.

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.36	1.0	2	1.678	7.0		1.059	.5
1	2.86	8.0		1.445	.5		.993	.5
3	2.37	3.0		1.370	.5		.969	2.0
	2.08	.3		1.234	.5		.915	.5
	1.93	.5		1.183	.5		.838	.2
	1.83	2.0		1.097	.5			

Cu-Ni 157. Weissite, Cu_5Te_3? Vulcan mine, Gunnison Co., Colorado. M-136

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.58	2.0		2.175	.2		1.755	.1
2	3.22	3.0	1	2.080	4.0		1.438	.3
	2.55	.5	3	2.000	3.0		1.341	.1
	2.28	.3		1.800	1.0		1.184	.1

Cu-Ni 158. Wehrlite, uncertain silver bismuth telluride, Deutsch Pilsen, Hungary. H-81611

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	3.22	6.0		1.40	1.0		1.075	.2
2	2.35	3.0		1.302	.5		1.040	.2
3	2.21	3.0		1.275	.3		.998	.2
	1.99	1.0		1.180	.3		.983	.2
	1.82	1.0		1.140	.3		.942	.2
	1.61	1.0		1.105	.2		.922	.2
	1.478	1.0		1.082	.2			

Cu-— 159. Willyamite, (Co, Ni)SbS. Broken Hill, N.S.W., Australia. M-175

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	4.15	1.0		1.630	1.0		1.132	.3
	3.38	.5		1.570	1.0		1.095	.5
	2.92	1.0		1.530	.2		1.072	.3
1	2.62	6.0		1.470	.3		1.040	.2
2	2.40	3.0		1.420	.2		.968	.2
	2.07	.3		1.384	.2		.896	.2
	1.97	.3		1.315	.2		.880	.2
	1.86	.3		1.285	.5			
3	1.770	2.0		1.255	.3			
	1.700	.3		1.155	.3			

Cu-Ni 160. Wittichenite, $3Cu_2S \cdot Bi_2S_3$. Wittichen, Baden, Germany. H-89173

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
1	3.12	9.0		1.44	1.0		.995	.5
	2.80	.5		1.36	.5		.965	.5
3	2.32	2.0		1.32	1.0		.928	.3
	2.16	2.0		1.27	.5		.905	.3
	1.95	1.0		1.21	.5		.890	.3
	1.86	1.0		1.16	1.0		.878	.3
2	1.78	3.0		1.105	.3		.793	.3
	1.65	2.0		1.090	.3		.781	.3
	1.56	1.0		1.030	.5			

Cu-Ni 161. Wulfenite, $PbMoO_4$. M-124

O	d	I	O	d	I	O	d	I
1	3.17	10.0		1.30	4.0		.945	3.0
	3.00	1.0		1.24	1.0		.918	1.0
	2.67	2.0		1.21	1.0		.890	.5
	2.35	.5		1.182	1.0		.880	.5
	2.20	.2		1.150	1.0		.868	.5
3	2.00	4.0		1.120	2.0		.857	.5
	1.96	2.0		1.075	1.0		.845	3.0
	1.77	4.0		1.045	2.0		.825	3.0
2	1.64	5.0		1.005	1.0		.811	3.0
	1.50	.2		.986	2.0		.800	3.0
	1.35	.2						

Fe-— 162. Wolframite, $(Fe,Mn)WO_4$. Torrington Mine, N.S.W., Australia. M-219

O	d	I	O	d	I	O	d	I
	4.72	1.0	3	2.18	2.0		1.503	1.0
	3.71	1.0		2.04	.5		1.445	.5
	3.21	1.0		1.986	.5		1.428	.5
1	2.917	4.0		1.866	.5		1.365	.5
	2.83	.5		1.810	.3		1.312	.3
	2.70	.5		1.758	1.0		1.178	.2
2	2.46	2.0		1.702	2.0		1.078	.2
	2.35	.3		1.585	.3		1.065	.2
	2.26	.2						

Doubtful Minerals

Cu-Ni 163. Algodonite, Cu_6As. M-110

The specimen studied is a bluish grey copper arsenide corresponding to the description of algodonite but showing only one phase even upon etching. Because of its blue color it is thought to be β-algodonite.

O	d	I	O	d	I	O	d	I
	2.55	.2	2	2.02	3.0		1.18	.5
	2.38	.3		1.78	.3		1.15	.2
	2.21	.3	3	1.44	1.0		1.13	.2
1	2.08	3.0		1.33	.3			

Cu-Ni 164. Domeykite, Cu_3As. M-110

This specimen corresponds to the description of domeykite except that with KCN the mineral effervesces and stains black, bringing out grain structure.

O	d	I	O	d	I	O	d	I
3	2.25	2.0		1.54	.3		1.20	.5
2	2.13	3.0		1.45	.2		1.105	.5
1	2.00	8.0		1.30	.5		1.080	.2

UNIDENTIFIED MINERALS

During this investigation a few minerals have been encountered which cannot be identified. They give distinctive *x*-ray patterns and are regarded as independent species. Still other minerals have been encountered which are variations of recognized species. All these are listed below.

Cu-Ni 165. A Bi, S, Te-bearing mineral from Texas, identical with oruetite and grunlingite in the arrangement and relative intensity of lines but having a slightly larger unit cell. M-166B

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.70	1.0	2	2.31	5.0		1.580	3.0
	3.50	1.0	3	2.17	5.0		1.450	1.0
1	3.16	10.0		2.12	.5		1.380	2.0
	2.81	.3		1.96	1.0		1.275	.3
	2.64	1.0		1.795	4.0		1.245	.3
	2.41	.5						

Cu-Ni 166. A Cu, Fe, S-bearing mineral containing some tin, associated with chalcopyrite in the ore from Moroococha, Peru. In polished section the mineral is orange colored. It shows extreme anisotropism, yielding brilliant colors. Pattern is very similar to sphalerite type.

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	3.8			2.22	.3		1.337	1.0
	3.28	.5		2.11	.2		1.258	1.0
1	3.08	6.0		1.965	.3		1.114	.3
	2.82B	1.0		1.930	.3		1.093	1.0
	2.68	1.0	2	1.890	4.0		1.029	.3
	2.49	1.0		1.642	.3		.946	.2
	2.38	1.0	3	1.613	3.0		.904	.2

Cu-— 167. Hauchecornite, M-74. This specimen from Wissen, Prussia, has tabular crystals resembling pyrrhotite in color, which contain Ni, Bi, and S. The mineral is anisotropic giving the colors blue, pale yellow, brown and white. Hardness, E. Etch reactions: HNO_3, stains brown; HCl, KOH, $FeCl_3$, and KCN, negative; $HgCl_2$, marginal brown ring. The crystals are irregularly replaced by ullmanite and millerite, a fact which caused confusion when the crystals were first analyzed and the name hauchecornite was proposed. Later when the composite nature of the crystals was observed the species was discredited as a mixture. However, when sampled on a micro-scale the crystals prove to be a distinctive species yielding the following unique powder pattern:

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	5.08	.3		1.85	1.0		1.256	.3
	4.75	.3		1.80	1.0		1.245	.2
	4.30	1.0		1.74	.3		1.210	.2
	3.60	1.0		1.71	.3		1.160	.3
	3.22	1.0		1.67	.2		1.151	.2
1.	2.77	4.0		1.565	.5		1.130	.2
	2.62	.5		1.505	.2		1.078	.3
	2.52	.5		1.390	.3		1.057	.3
2	2.37	2.0		1.342	.3		1.007	.2
3	2.28	2.0		1.305	.3		.913	.2
	2.06	.3		1.276	.2			

Cu-Ni 168. Von Diestite. M-237. This material from Sierra Blanca, Colorado, contains tabular crystals of steel greycolor and metallic luster, which have one perfect cleavage providing flexible laminae. In polished section the mineral is galena-white; hardness A; anisotropic, giving the colors grey and brown. Nitric acid causes effervescence and stains it black; HCl and KCN, negative; $FeCl_3$, instantly stains iridescent; KOH and $HgCl_2$, negative. Gives microchemical tests for Bi, Te and S. The mineral is intimately associated with hessite and petzite which probably accounts for its original description as a silver bismuth telluride. Its powder pattern is similar to, but distinct, from the patterns of three other Bi, Te, S-bearing minerals included in this investigation, namely, tetradymite, wehrlite, and oruetite-grunlingite. It is almost identical with that of tellurobismuthite and except for the sulphur would be identified as such.

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
	4.05	.3		1.85	1.0		1.312	1.0
	3.70	.5		1.81	2.0		1.290	1.0
1	3.20	9.0		1.69	.2		1.265	.5
2	2.36	4.0		1.602	3.0		1.138	.3
	2.27	2.0		1.48	2.0		1.072	.5
3	2.18	4.0		1.435	2.0		1.042	.3
	2.01	.5		1.395	2.0		.994	.3

Cu-Ni 169. Chalcocite (Digenite). The following pattern represents a so-called isometric chalcocite from the fire zone at Jerome, Arizona. It is quite different from normal chalcocite.

O	*d*	*I*	*O*	*d*	*I*	*O*	*d*	*I*
2	3.22	1.0		1.68	.5		1.075	.2
3	2.79	1.0		1.135	.2		1.066	.2
1	1.97	4.0						

PATTERN TYPES

The *x*-ray powder pattern given by certain simple structures is easily recognized from the arrangement of the lines in a distinctive sequence of spacings and intensities. It is thus possible to recognize a face centered or body centered cubic pattern, and others by inspection. A number of cases will be pointed out where two or more related minerals yield almost identical patterns, showing a slight difference in cell size only. There is little doubt in such cases but that the atomic structure is similar and variations are due to the substitution of an atom of one chemical element for that of another without distortion, other than an overall change in the size of the unit cell of the crystal. In studying the collection of patterns presented here several groups of minerals have been found to give the same type of powder pattern and it is believed that the atomic arrangement of minerals of such groups is fundamentally the same. Only a small fraction of the total number of patterns could be classified in this way, most of them are too complex for this and have no obvious relationship to one another. However, the following notes give the results of comparing the patterns of some groups of similar minerals.

Native Elements

Copper
Gold
Silver
Lead

Galena Group	*Chemical Type*	*A B*
Galena	PbS	
Cerargyrite	AgCl	
Metacinnabar	HgS	
Tiemannite	HgSe	
Clausthalite	PbSe	

Altaite Group	*Chemical Type A*	*B*
Altaite	Pb	Te
Alabandite	Mn	S

Sphalerite Group	*Chemical Type* *A*	*B*
Sphalerite	Zn	S
Chalcopyrite	CuFe	S_2
Stannite	Cu_2FeSn	S_4
Famatinite	Cu_3Sb	S_4
Germanite	$Cu_3(FeGe)$	S_4
Colusite	(Cu, Fe, Mo, Sn)	$(S, As, Te)_{3-4}$

Niccolite, millerite, pyrrhotite, breithauptite, cinnabar, cubanite, sternbergite and covellite show no correspondence. Pyrrhotite and troilite are the same except for cell size.

Tetradymite group	*Chemical Type*	A_m	B_n	
Grunlingite		Bi_4	TeS_3	Identical.
Oruetite				
Wehrlite		Bi,	Te, S	Same cell but larger.
Tetradymite		Bi_2	Te_2S	Very similar to the above but differs in the separation of a prominent pair of lines.
Von Diestite		Bi,	Te, S	Similar but different.

Chemical Type A_2B

Chalcocite, and stromeyerite show no correspondence.

Chemical Type A_3B_2

Maucherite and wehrlite show no correspondence.

Linnaeite Group	*Chemical Type* A_3	B_4	
Linnaeite	Co_3	S_4	Identical patterns.
Siegenite	$(Co, Ni)_3$	S_4	
Carrollite	$(Co, Cu)_3$	S_4	
Polydymite	Ni_3	S_4	
Violarite	$(Ni, Fe)_3$	S_4	
Daubreelite	$FeCr_2$	S_4	Same pattern, larger cell.

Chemical Type A_4B_3

Rickardite and weissite give very similar patterns which differ in detail.

Stibnite Group	*Chemical Type* A_2	B_3	
Stibnite	Sb_2	S_3	Identical except for cell size.
Bismuthinite	Bi_2	S_3	
Guanajuatite	Bi_2	$(Se, S)_3$	
Kermesite	Sb_2	S_2O	

Orpiment does not correspond.

Pyrite Group	*Chemical Type* A	B_2	
Pyrite	Fe	S_2	Identical except for cell size.
Bravoite	(Fe, Ni)	S_2	
Hauerite	Mn	S_2	
Sperrylite	Pt	As_2	
Penroseite	(Ni, Cu)	Se_2	
Cobaltite	Co	AsS	
Gersdorffite	Ni	AsS	
Plessite	(Ni, Fe)	AsS	
Corynite	Ni	(As, Sb)S	
Kallilite	Ni	(Sb, Bi)S	
Ullmanite	Ni	SbS	
Willyamite	(Co, Ni)	SbS	

Marcasite Group. This group does not show any uniformity similar to the pyrite group. Safflorite and glaucodote are very similar but do not have a common cell. Marcasite, rammelsbergite, and pararammelsbergite give unique patterns not readily related to the rest of the group.

Ditelluide Group *Chemical Type* $A\ B_2$

Sylvanite, krennerite and calaverite are very similar. Melonite is different.

Smaltite, chloanthite, skutterudite. These minerals give the same pattern.

Sulphosals In general they give very complex powder patterns in which similarities are not easily recognized.

Polybasite	AgSbS	Similar
Argyrodite	AgGeS	

Pearceite is different.

Jordanite	$Pb_1\ As_7\ S_{24}$	Nearly identical except for cell size.
Guitermannite	$Pb_{10}As_6S_{19}$	
Geocronite	$Pb_5Sb_2S_8$	

Meneghenite and kobellite are very similar; boulangerite is different.

Emplectite	$CuBiS_2$	Identical except for cell size.
Chalcostibite	$CuSbS_2$	

Klaprotholite is similar; miargyrite, aramayoite, lorandite are all different.

Jamesonite, dufrenoysite, kobellite and cosalite are all different.

Bournonite	$PbCuSbS_3$	Identical.
Seligmanite	$PbCuAsS_3$	

Aikenite is quite different.

Keeleyite	$PbSb_2S_4$	Identical?
Boulangerite	$Pb_5Sb_4S_{11}$	

A curious fact brought out during this comparison is the following:

Enargite Cu_3AsS_4
Greenockite CdS
} Identical except for cell size.

Some Observations and Conclusions Based on the Study of Minerals and Their Powder Patterns

Berthonite $(Pb, Cu_2)_2Sb_2S_5$
Bournonite $PbCuSbS_3$

Berthonite from the type locality of Slata, Tunisia, gives the pattern of bournonite. Note that the properties of these two minerals are identical.

Ramdohrite $Ag_2Pb_3Sb_6S_{13}$
Andorite $Ag_2Pb_2Sb_6S_{12}$

The pattern given by a specimen of ramdohrite from Potosi, Bolivia, is the same as that of andorite. Ramdohrite needs further checking.

Beegerite $Pb_6Bi_2S_9$

A specimen from the Auld Lout Mine, Ouray, Colorado, contains two isotropic grey minerals, one lighter in color than the other. The pattern of the light grey mineral corresponds to schapbachite. The properties of these two minerals and qualitative analyses check except that schapbachite is anisotropic. The mineral (schapbachite) is apparently like pyrite in that it may or may not show anisotropism. The dark grey mineral has been identified as schirmerite, the properties of which in polished section are as follows: Isotropic; color, tetrahedrite grey; hardness, C; HNO_3, light mottled stain; HCl, KCN, $FeCl_3$, KOH and $HgCl_2$, negative.

Kobellite $Pb_2(Bi, Sb)_2S_5$

The properties of this mineral in polished section are as follows: Color, grey similar to galena; hardness, B; anisotropic giving light and dark grey; HNO_3, quickly blackens; HCl, KCN, $FeCl_3$, KOH, and $HgCl_2$, negative.

Table 2. Index of Powder Patterns

Strongest Lines and their Relative Intensities			Name	Pattern Number (In Table 1)
1	2	3		
1.485 (9)	2.84 (8)	1.74 (7)	Lead	90
1.645 (4)	2.76 (3)	2.46 (3)	Pyrite	117
1.77 (6)	3.03 (4)	1.95 (3)	Pentlandite	110
1.788 (4)	1.144 (4)	1.050 (3)	Sperrylite	136
1.833 (8)	2.485 (5)	2.76 (4)	Rammelsbergite	120
1.90 (9)	2.82 (8)	3.02 (7)	Covellite	45
1.94 (8)	3.31 (2)	3.15 (2)	Bornite	20
1.95 (8)	1.865 (8)	2.38 (6)	Chalcocite	31
1.97 (4)	3.22 (1)	2.79 (1)	Chalcocite (isometric), Digenite	169
1.98 (7)	3.20 (4)	1.84 (3)	Berzelianite	17
2.00 (8)	2.13 (3)	2.25 (2)	Domeykite	164
2.02 (3)	2.82 (1)	3.10 (.5)	Chromite	35
2.03 (5)	2.49 (4)	2.76 (3)	Hausmannite	77
2.03 (3)	3.80 (3)	3.00 (3)	Cannizarite	27

TABLE 2. INDEX OF POWDER PATTERNS—*Continued*

Strongest Lines and their Relative Intensities			Name	Pattern Number (In Table 1)
1	2	3		
2.06 (3)	3.32 (4)	2.55 (1)	Rickardite	125
2.06 (8)	2.63 (4)	1.718 (3)	Pyrrhotite	119
2.08 (8)	1.81 (4)	1.275 (3)	Copper	42
2.08 (3)	2.02 (3)	1.44 (1)	Algodonite	163
2.08 (4)	3.22 (3)	2.00 (3)	Weissite	157
2.10 (8)	2.68 (5)	2.98 (3)	Troilite	152
2.22 (3)	2.10 (2)	1.815 (2)	Jordanite	83
2.22 (2)	1.82 (2)	3.18 (3)	Guitermanite	75
2.23 (5)	1.830 (3)	3.19 (1)	Geocronite	64
2.26 (4)	2.39 (2)	2.55 (1)	Dyscrasite	54
2.27 (8)	1.82 (7)	1.53 (6)	Molybdenite	104
2.27 (5)	3.20 (4)	1.435 (3)	Altaite	5
2.28 (10)	1.955 (7)	1.320 (4)	Coloradoite	39
2.34 (6)	1.360 (4)	1.239 (3)	Moschellandsbergite	102
2.35 (9)	1.228 (6)	2.04 (5)	Silver	134
2.36 (9)	2.04 (6)	1.23 (5)	Gold	69
2.40 (7)	5.20 (6)	3.11 (6)	Sulvanite	143
2.425 (4)	2.665 (1)	1.81 (1)	Löllingite	93
2.43 (3)	1.82 (2)	2.82 (1)	Arsenopyrite	12
2.45 (8)	2.72 (5)	1.82 (4)	Glaucodot	67
2.46 (5)	2.13 (1)	1.51 (.5)	Cuprite	47
2.48 (8)	2.32 (8)	1.87 (2)	Tenorite	148
2.51 (5)	2.84 (1)	2.23 (1)	Delafossite	51
2.53 (5)	1.475 (2)	2.96 (1)	Magnetite	95
2.53 (6)	1.715 (6)	2.31 (5)	Gersdorffite	66
2.55 (7)	1.49 (4)	1.62 (2)	Franklinite	60
2.55 (6)	1.71 (5)	2.33 (4)	Corynite	43
2.55 (8)	2.86 (3)	2.37 (2)	Pararammelsbergite	121
2.59 (4)	2.83 (3)	2.43 (3)	Argentite	9
2.61 (7)	1.845 (4)	1.502 (1)	Alabandite	3
2.60 (10)	2.37 (4)	1.635 (4)	Safflorite	127
2.60 (4)	2.84 (3)	2.44 (3)	Jalpaite (copper bearing argentite)	
2.60 (5)	3.62 (4)	3.15 (4)	Berthierite	16
2 62 (5)	2.40 (2)	1.78 (1)	Kallilite	84
2.62 (6)	2.40 (3)	1.77 (2)	Willyamite	159
2.62 (5)	3.65 (4)	3.18 (3)	Berthierite	
2.64 (10)	1.86 (3)	1.62 (3)	Skutterudite	135
2.64 (9)	1.87 (4)	2.22 (3)	Smaltite-chloanthite	34

TABLE 2. INDEX OF POWDER PATTERNS—*Continued*

Strongest Lines and their Relative Intensities			Name	Pattern Number (In Table 1)
1	2	3		
2.64 (6)	1.95 (5)	1.795 (3)	Niccolite	106
2.64 (8)	2.41 (3)	1.78 (3)	Ullmanite	154
2.68 (6)	2.45 (5)	1.81 (4)	Penroseite	109
2.69 (9)	1.65 (6)	1.415 (3)	Braunite	24
2.69 (7)	1.68 (5)	2.51 (4)	Hematite	78
2.70 (6)	3.80 (4)	1.755 (2)	Bournonite	
2.715 (6)	1.762 (4)	3.47 (3)	Marcasite	96
2.72 (10)	2.035 (9)	1.73 (7)	Maucherite	97
2.72 (2)	2.53 (2)	2.025 (2)	Ilmenite	81
2.72 (4)	3.85 (3)	1.77 (2)	Seligmannite	131
2.73 (2)	2.30 (2)	2.11 (1)	Baumhauerite	14
2.74 (8)	1.867 (6)	2.04 (5)	Arsenic	11
2.74 (5)	3.90 (1)	1.765 (1)	Bournonite	22
2.77 (4)	1.675 (3)	2.49 (2)	Bravoite	23
2.77 (5)	1.85 (4)	2.50 (3)	Millerite	103
2.77 (3)	1.97 (1)	3.20 (.5)	Cerargyrite	30
2.77 (6)	2.11 (3)	2.03 (3)	Petzite	111
2.77 (4)	2.37 (2)	2.28 (2)	Hauchecornite	167
2.79 (7)	2.55 (6)	3.20 (5)	Pyrargyrite	116
2.80 (3)	3.68 (2)	2.00 (1)	Boulangerite	21
2.81 (4)	2.47 (3)	2.94 (2)	Polybasite	113
2.81 (4)	2.01 (3)	2.49 (2)	Cobaltite	39
2.82 (6)	1.68 (5)	2.38 (2)	Linnaeite	91
2.82 (8)	1.93 (4)	2.075 (3)	Melonite	98
2.82 (4)	2.44 (3)	1.99 (2)	Aguilarite	1
2.82 (5)	3.22 (1)	3.41 (1)	Aramayoite	
2.82 (5)	3.28 (4)	3.42 (3)	Schapbachite	129
2.83 (8)	3.02 (7)	2.09 (4)	Nagyagite	105
2.84 (5)	1.661 (3)	2.35 (2)	Violarite	
2.84 (1)	3.00 (.5)	3.09 (.3)	Pearceite	108
2.84 (3)	3.21 (3)	1.85 (2)	Enargite	
2.84 (10)	3.24 (5)	3.43 (4)	Aramayoite	8
2.85 (2)	1.67 (2)	2.36 (1)	Siegenite	133
2.85 (6)	1.67 (5)	2.47 (4)	Carrollite	28
2.85 (5)	2.05 (2)	1.97 (2)	Breithauptite	25
2.85 (8)	3.22 (7)	1.855 (5)	Enargite	
2.85 (9)	3.34 (9)	1.68 (4)	Cinnabar	36
2.85 (3)	3.48 (2)	2.01 (2)	Benjaminite	15
2.86 (8)	1.678 (7)	2.37 (3)	Violarite	156
2.86 (3)	3.55 (2)	3.38 (2)	Kobellite	88
2.87 (7)	1.67 (6)	2.37 (4)	Polydymite	114
2.87 (6)	2.30 (6)	2.24 (5)	Hessite	79
2.88 (5)	3.42 (4)	2.74 (3)	Miargyrite	101

TABLE 2. INDEX OF POWDER PATTERNS—*Continued*

Strongest Lines and their Relative Intensities			Name	Pattern Number (In Table 1)
1	2	3		
2.88 (5)	3.43 (3)	2.06 (2)	Franckeite	59
2.89 (4)	2.03 (1)	1.81 (1)	Cylindrite	49
2.90 (4)	3.24 (3)	2.74 (2)	Meneghinite	99
2.917 (4)	2.46 (2)	2.18 (2)	Wolframite	162
2.94 (8)	4.71 (4)	1.71 (4)	Ferberite	58
2.95 (9)	1.81 (6)	1.541 (6)	Tennantite	147
2.95 (4)	3.40 (2)	2.02 (2)	Cosalite	44
2.96 (8)	1.81 (6)	1.54 (5)	Tetrahedrite	150
2.96 (6)	2.08 (5)	1.785 (5)	Galena	63
2.96 (2)	2.72 (2)	2.32 (1)	Rathite	122
2.96 (3)	2.79 (3)	2.47 (1)	Stromeyerite	142
2.965 (8)	4.83 (6)	3.77 (5)	Hübnerite	80
2.99 (5)	3.75 (3)	3.45 (2)	Livingstonite	92
2.99 (5)	2.09 (4)	1.77 (1)	Calaverite	26
3.00 (10)	1.72 (4)	1.45 (3)	Columbite-tantalite	40
3.00 (10)	1.83 (7)	1.56 (5)	Schirmerite	130
3.01 (4)	2.84 (3)	2.09 (2)	Dufrenoysite	53
3.02 (6)	1.77 (6)	2.50 (3)	Daubreelite	50
3.03 (7)	1.86 (4)	1.59 (1)	Chalcopyrite	32
3.035 (3)	2.715 (1)	2.49 (1)	Hauerite	76
3.05 (8)	2.12 (6)	2.96 (3)	Sylvanite	144
3.05 (8)	2.12 (5)	2.95 (3)	Krennerite	89
3.05 (3)	2.68 (2)	2.45 (1)	Argyrodite	10
3.06 (10)	1.87 (8)	1.59 (4)	Famatinite (luzonite)	57
3.06 (9)	2.165 (7)	1.370 (4)	Clausthalite	37
3.06 (4)	2.56 (3)	2.90 (2)	Stephanite	139
3.06 (8)	3.20 (7)	2.34 (3)	Emplectite	55
3.07 (8)	1.875 (4)	1.60 (2)	Germanite	65
3.07 (7)	1.88 (5)	1.601 (3)	Colusite	41
3.07 (6)	2.13 (2)	2.23 (2)	Antimony	7
3.08 (10)	1.89 (7)	1.61 (5)	Famatinite (luzonite)	
3.08 (6)	1.89 (4)	1.613 (3)	Cu, Fe, S	166
3.09 (6)	2.91 (4)	2.57 (4)	Stephanite	
3.10 (9)	2.13 (3)	2.25 (2)	Grunlingite and Oruetite	73
3.11 (10)	1.625 (6)	2.41 (5)	Pyrolusite	118
3.11 (8)	1.91 (5)	1.63 (2)	Stannite	138
3.12 (9)	1.78 (3)	2.32 (2)	Wittichenite	160
3.12 (6)	1.91 (5)	1.63 (4)	Sphalerite	137
3.12 (4)	2.06 (3)	1.89 (3)	Greenockite	72
3.12 (8)	2.12 (3)	2.30 (2)	Tetradymite	149
3.13 (8)	2.99 (8)	1.76 (4)	Chalcostibite	33
3.14 (5)	2.92 (4)	2.70 (3)	Kermesite	85
3.16 (10)	2.31 (5)	2.17 (5)	Bi, S, Te	165
3.17 (10)	1.64 (5)	2.00 (4)	Wulfenite	161
3.17 (2)	2.99 (2)	2.85 (1)	Samsonite	126

TABLE 2. INDEX OF POWDER PATTERNS—*Continued*

Strongest Lines and their Relative Intensities			Name	Pattern Number (In Table 1)
1	2	3		
3.17 (8)	3.62 (8)	2.86 (7)	Aikinite	2
3.18 (3)	2.22 (2)	1.82 (2)	Guitermanite	75
3.20 (9)	2.36 (4)	2.18 (4)	Von Diestite	168
3.20 (10)	2.37 (8)	2.19 (8)	Tellurobismuthite	146
3.20 (6)	2.53 (4)	2.75 (2)	Proustite	115
3.20 (7)	3.08 (8)	2.34 (3)	Emplectite	55
3.21 (3)	1.435 (3)	2.245 (2)	Bismuth	18
3.21 (8)	2.85 (8)	1.86 (7)	Enargite	56
3.22 (9)	2.33 (4)	2.22 (3)	Tellurium	145
3.22 (6)	2.35 (3)	2.21 (3)	Wehrlite	158
3.22 (4)	2.67 (2)	1.64 (2)	Cuprodescloizite	48
3.22 (3)	3.01 (3)	3.60 (2)	Rezbanyite	124
3.23 (5)	1.875 (4)	1.75 (3)	Cubanite	46
3.23 (1)	3.82 (.5)	3.38 (.5)	Fuloppite	62
3.25 (8)	2.00 (8)	2.90 (7)	Klockmannite	87
3.28 (5)	2.80 (4)	2.04 (2)	Diaphorite	52
3.28 (4)	2.90 (3)	2.75 (2)	Andorite, Ramdohrite	6
3.28 (5)	3.00 (3)	2.74 (1)	Semseyite	132
3.30 (9)	2.40 (2)	2.20 (2)	Wehrlite	
3.32 (6)	2.62 (6)	1.75 (6)	Cassiterite	29
3.34 (9)	2.85 (9)	1.68 (4)	Cinnabar	36
3.35 (5)	2.88 (4)	2.08 (2)	Schapbachite	129
3.36 (10)	2.07 (5)	1.77 (5)	Metacinnabar	100
3.38 (10)	2.10 (8)	1.79 (8)	Tiemannite	151
3.40 (10)	2.06 (3)	1.68 (2)	Graphite	71
3.40 (3)	2.81 (2)	2.72 (2)	Jamesonite	82
3.42 (4)	2.78 (3)	1.99 (1)	Plagionite	112
3.45 (5)	2.82 (5)	2.96 (2)	Freieslebenite	61
3.48 (3)	2.95 (2)	2.76 (2)	Sartorite	128
3.50 (9)	3.08 (6)	1.935 (5)	Bismuthinite	19
3.55 (6)	1.94 (4)	1.69 (4)	Stibnite	141
3.57 (5)	2.85 (3)	2.95 (2)	Lorandite	94
3.60 (6)	3.15 (6)	1.83 (4)	Umangite	155
3.61 (9)	3.16 (8)	2.86 (4)	Guanajuatite	74
3.62 (8)	3.17 (8)	2.86 (7)	Aikinite	2
3.80 (3)	3.00 (3)	2.03 (3)	Cannizarite	27
3.80 (5)	3.47 (5)	2.94 (3)	Gratonite	70
4.17 (9)	2.46 (4)	1.73 (3)	Goethite	68
4.25 (6)	3.25 (3)	2.79 (3)	Sternbergite	140
4.57 (4)	2.85 (3.5)	3.07 (3)	Klaprotholite	86
4.80 (6)	2.82 (3)	2.70 (3)	Orpiment	107
5.2 (6)	2.40 (7)	3.11 (6)	Sulvanite	143
5.4 (3)	3.15 (3)	2.93 (3)	Realgar	123
6.2 (9)	2.68 (6)	2.28 (2)	Tungstenite	153