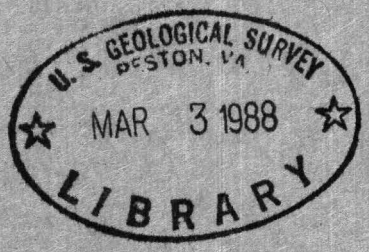
TEI-830

X-RAY CRYSTALLOGRAPHIC DATA FOR MINERALS

By Richard A. Robie, Philip M. Bethke,
Martha S. Toulmin and Jerry L. Edwards



UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

X-RAY CRYSTALLOGRAPHIC DATA FOR MINERALS*

By

Richard A. Robie, Philip M. Bethke,
Martha S. Toulmin and Jerry L. Edwards

February 1963

Report TEI-830

This report is preliminary and has not been edited for conformity with Geological Survey format.

*Prepared on behalf of the U. S. Atomic Energy Commission.

USGS - TEI-830

Distribution	No. of copies
Division of Reactor Development (W. G. Belter)	5
Division of Research (D. R. Miller)	1
Division of Raw Materials (R. D. Nininger)	1
Division of Peaceful Nuclear Explosives (R. Hamburger)	1
Hanford Operations Office (C. L. Robinson)	1
Grand Junction Operations Office	1
Idaho Operations Office (John Horan)	1
Oak Ridge Operations Office (H. M. Roth)	1
Savannah River Operations Office (Karl Herde)	1
Division of Technical Information Extension, Oak Ridge	6
Nevada Operations Office	2
U. S. Naval Radiological Defense Lab., San Francisco	1
Health Physics Division, Oak Ridge National Laboratory (F. L. Parker; E. G. Struxness)	1
Chemistry Division, Argonne National Lab. (W. M. Manning)	1
Chemical Tech. Div., Oak Ridge National Lab. (W. E. Clark)	1
U. S. Bureau of Mines, Bartlesville, Oklahoma (J. W. Watkins)	1
Los Alamos Scientific Laboratory (J. H. Hall)	1
Los Alamos Scientific Laboratory (C. W. Christenson)	1
Earth Sciences Division, NAS-NRC (Linn Hoover)	10
University of Texas, Austin (E. F. Gloyna)	1
General Electric Company, Richland, Washington (E. R. Irish)	2
University of California (W. J. Kaufman)	1
E. I. DuPont deNemours & Company (C. M. Patterson)	1
Lawrence Radiation Laboratory, Technical Information Division (Clovis G. Craig)	1
Lawrence Radiation Laboratory, Livermore (Director)	25
Headquarters Library, USAEC	1
	70
U. S. Geological Survey:	
Geologic Division	97
Water Resources Division	20
	187

Geologic Division distribution	No. of copies
Engineering Geology	3
Geochemical Exploration and Minor Elements	1
Organic Fuels	1
New England	1
Eastern States	1
Regional Geology	1
Southern Rocky Mountains	2
Southwestern Branch	1
Pacific Coast States	1
Alaskan	1
Regional Geophysics	4
Experimental Geochemistry and Mineralogy	1
Theoretical Geophysics	50
Isotope Geology	1
Field Geochemistry and Petrology	2
Analytical Laboratories	1
Foreign Geology	1
Military Geology	1
Library	3
Special Projects	3
Geologic Division	17
	97

X-RAY CRYSTALLOGRAPHIC DATA FOR MINERALS

By

Richard A. Robie, Philip M. Bethke,

Martha S. Toulmin and Jerry L. Edwards

X-ray crystallographic data are of particular importance to the mineralogist. Beyond the considerations of structural chemistry they provide one of the most accurate methods for phase and/or compositional determination and for obtaining the molar volumes and densities of minerals (Robie and Bethke, 1962).

Selected data for approximately 300 minerals are tabulated. These data are taken from the recent literature or from unpublished sources. With minor exceptions we have restricted ourselves to the inclusion of data for chemically and physically well-defined phases for which the unit cell parameters are known with an accuracy of the order of 0.2 percent or better.

The data are presented by mineral groups following Dana's System. Within a group, however, the order may be alphabetical, structural, or for the sulfides, approximately by increasing sulfur-metal ratio.

Temperatures at which the measurements were made are given in the second column from the right. The letter r indicates the data were obtained at an unspecified room temperature and may be taken as $25^{\circ} \pm 5^{\circ}C$. The number of gram formula weights per unit cell is given in the column labeled Z.

Compounds denoted by an asterisk indicate the measurements were made on natural specimens which may have deviated slightly from

the listed formula. Substances of rhombohedral symmetry are denoted by the symbol hex-R to distinguish them from materials of true hexagonal symmetry. The space group is given along with its number in the 1952 International Tables for X-ray Crystallography (Henry and Lonsdale, 1952).

All cell dimensions are given in Angstrom units, 10^{-8} centimeters. Where necessary, older data have been converted from kX units to Angstroms using the conversion factor 1.00204±.000014 of Cohen, Crowe, and DuMond (1957).

Most natural minerals are intermediate members of multicomponent solid solutions. For this reason data have been included for several phases, not known as minerals but which form the end member of a solid solution. We have also included cell parameters, based on the linear extrapolation of data for incomplete solutions, for several hypothetical compounds.

The uncertainties listed are not necessarily those of the original investigator but represent our attempt to evaluate the true accuracy of the data. In this connection it is worthwhile to restate the results of a recent cooperative investigation by the International Union of Crystallography, (Parrish, 1960) involving more than twenty laboratories which has shown that although the reproducibility (that is, precision) of an individual may be a few thousandths of a percent, different investigators working on the same sample showed agreement with one another of only 0.005 percent to 0.015 percent. Data claiming an accuracy of better than 0.01 percent should be considered with these limitations in mind.

For more extensive summaries of X-ray data the reader is referred to the works cited below:

Berry, L. G., and Thompson, R. M., 1962, X-ray powder data for the ore minerals: The Peacock Atlas: Geological Society of America Memoir 85.

Donnay, J. D. H., and Nowacki, W., 1954, Crystal data: Geological Society of America Memoir 60.

International Union of Crystallography, Structure reports: volume 8 through 16 summarize data published from 1940 to 1952.

Pearson, W. B., 1958, Handbook of lattice spacing and structure of alloys: New York, Pergamon Press.

Reference cited

Cohen, E. R., Crowe, K. M., and DuMond, J. W. M., 1957, Fundamental constants of physics: New York, Interscience Publisher.

Henry, N. F. M., and Lonsdale, K., eds., 1952, International tables for X-ray crystallography, v. 1, Symmetry groups: Internat. Union Crystallography, Birmingham, England, Kynoch Press.

Parrish, William, 1960, Results of the International Union of Crystallography precision lattice parameter project: Acta Cryst., v. 13, p. 833.

Robie, R. A., and Bethke, P. M., 1962, Molar volumes and densities of minerals: U. S. Geol. Survey open-file report TEI-822.

ELEMENTS

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref.
Ag	Silver	cub	Fm3m (225)	f.c.c. 1/	4	4.0862 ±.0002						25	146
Au	Gold	cub	Fm3m (225)	f.c.c.	4	4.0786 ±.0002						25	146
C*	Diamond	cub	Fd3m (227)	diamond	8	3.56688 ±.00009						25	131
C*	Graphite	hex	C6/mmc (194)	graphite	4	2.4612 ±.0001		6.7079 ±.0007				14.6	99
Cu	Copper	cub	Fm3m (225	f.c.c.	4	3.6150 ±.0003						25	146
Fe	α-Iron	cub	Im3m (229)	b.c.c. 2/	2	2.8664 ±.0005						25	149
Ni	Nickel	cub	Fm3m (225)	f.c.c.	4	3.5238 ±.0005						25	146
Pt	Platinum	cub	Fm3m (225)	f.c.c.	4	3.9231 ±.0005						25	146
S	α-Sulfur	orth	Fddd (70)	S_8 ring molecules	128	10.4646 ±.001	12.8660 ±.001	24.4860 ±.002				24.7	178, 21
S	β-Sulfur	mon	$P2_1/c$ (14)	S_8 ring molecules	48	11.04 ±.03	10.98 ±.03	10.92 ±.03		96° 44' ±30'		103	32
Pb	Lead	cub	Fm3m (225)	f.c.c.	4	4.9505 ±.0005						25	146
Sn	β-Tin	tet	$I4_1/amd$ (141)		4	5.83146 ±.0005		3.18129 ±.0007				26	69
Sb	Antimony	hex-R	$R\bar{3}m$ (166)	Arsenic	6	4.307 ±.001		11.273 ±.001				26	148, 126
As	Arsenic	hex-R	$R\bar{3}m$ (166)	Arsenic	6	3.760 ±.002		10.548 ±.004				26	148
Bi	Bismuth	hex-R	$R\bar{3}m$ (166)	Arsenic	6	4.5459 ±.0002		11.8622 ±.0005				26	69, 126 148

1/ f.c.c., face-centered cubic.

2/ b.c.c., body-centered cubic.

ELEMENTS continued

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref.
Zn	Zinc	hex	$P6_3/mmc$ (194)	h.c.p.[3/]	2	2.665 ±.001		4.947 ±.0007				25	146
Se	Selenium	hex	$P3_121$ (152) $P3_221$ (154)	chain	3	4.3642 ±.0005		4.9588 ±.0005				26	143
Te	Tellurium	hex	$P3_121$ (152) $P3_221$ (154)	chain	3	4.4570 ±.0007		5.9290 ±.0010				25	146
Si	Silicon	cub	Fd3m (227)	diamond	8	3.56703 ±.00020						25	183

3/ h.c.p., hexagonal close packed.

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	v_o	Temp °C	Ref
β-$Ni_3Pb_2S_2$ *	Shandite	hex-R	$R\bar{3}m$ (166)		3	5.576 ±.01		13.658 ±.01				r	67, 110
Au_2Bi	Maldonite	cub	Fd3m (227)	Cu_2Mg	8	7.958 ±.002						r	73
Ag_2S I	Hi-Argentite	cub			4	6.269 ±.020						600	30
Ag_2S II	Argentite	cub			2	4.870 ±.008						189	30
Ag_2S III	Acanthite	mon	$P2_1/c$ (14)		4	4.228 ±.002	6.928 ±.005	7.862 ±.003		99° 35'		r	30, 155
Ag_2Se	Hi-Naumannite	cub				4.993 ±.016						170	116
Ag_2Te I		cub			2	5.29 ±.01						825	116
Ag_2Te II		cub				6.585 ±.010						250	116
Ag_2Te III *	Hessite	mon	$P2_1/c$ (14)		4	8.09 ±.02	4.48 ±,01	8.96 ±.02		123° 20'		r	45
Cu_2S I *	Hi-Digenite	cub			4	5.725 ±.010						465	29, 119
Cu_2S II *	Hi-Chalcocite	hex				3.961 ±.004		6.722 ±.007				152	29, 119
Cu_2S III *	Chalcocite	orth	Ab2m (39)		96	11.881 ±.004	27.323 ±.008	13.491 ±.004				r	29, 119
$Cu_{1.79}S$ (Cu rich side)	Digenite	pseudo cub		Deformed CaF_2	4	5.5695 ±.001						25	29, 119

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref
$Cu_{1.77}S$ (S rich side)	Digenite	pseudo cub		Deformed CaF_2	4	5.5542 ±.001						25	29, 119
Cu_2Se		cub			4	5.85 ±.01						170	119
$Ag_{1.55}Cu_{0.45}S$ I		cub			4	6.110 ±.010						300	30
$Ag_{1.55}Cu_{0.45}S$ II		cub			2	4.825 ±.005						116	30
$Ag_{1.55}Cu_{0.45}S$ III	Jalpaite	tet			16	8.673 ±.004		11.756 ±.006				r	30
$Ag_{0.93}Cu_{1.07}S$ I		cub			4	5.961 ±.009						196	30
$Ag_{0.93}Cu_{1.07}S$ II		hex			2	4.138 ±.004		7.105 ±.007				100	30
$Ag_{0.93}Cu_{1.07}S$ III	Stromeyerite	orth	Cmcn (63)		4	4.066 ±.002	6.628 ±.003	7.972 ±.004				r	30
AgCuSe	Eucairite	orth, pseudo tet	P4/nmm (129)		10	4.105 ±.010	20.35 ±.20	6.31 ±.01					43
Ag_3AuTe_2*	Petzite	cub	$I4_132$ (214)		8	10.38 ±.02						r	44
Cu_3Se_2*	Umangite	tet	P4/mmm (123)		2	6.402 ±.01		4.276 ±.01				r	8, 36
Ni_3S_2	Heazlewoodite	hex-R	R32 (155)	Ni_3S_2	3	5.746 ±.001		7.134 ±.002					77, 84
Cu_5FeS_4*	Hi-Bornite	cub			1	5.50 ±.01						240	95

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref
Cu_5FeS_4*	Metastable Bornite	cub			8	10.94 ±.02						r	95
Cu_5FeS_4*	Lo-Bornite	tet	$P\bar{4}2_1c$ (144)		16	10.94 ±.02		21.88 ±.04				r	95
$Ni_{11}As_8$	Maucherite	tet	$P4_12_12$ (92)		4	6.870 ±.001		21.81 ±.01				r	176
$(Fe, Ni)_9S_8$ $Fe_{5.25}Ni_{3.75}S_8$	Pentlandite	cub	Fm3m (225)	Co_9S_8	4	10.196 ±.010						r	85
$(Fe, Ni)_9S_8$ $Fe_{3.75}Ni_{5.25}S_8$	Pentlandite	cub	Fm3m (225)	Co_9S_8	4	10.095						r	85
CaS	Oldhamite	cub	Fm3m (225)	NaCl	4	5.689 ±.006						r	152, 62, 115
PbS	Galena	cub	Fm3m (225)	NaCl	4	5.9360 ±.0002						r	10, 147, 167
PbSe	Glausthalite	cub	Fm3m (225)	NaCl	4	6.1255 ±.0005						r	10
PbTe	Altaite	cub	Fm3m (225)	NaCl	4	6.4606 ±.0005						r	9
MnS	Albandite	cub	Fm3m (225)	NaCl	4	5.2234 ±.0005						r	133, 9
MnS	sphalerite structure	cub	$F\bar{4}3m$ (216)	sphalerite	4	5.611 ±.002						r	132
MnS	wurtzite structure	hex	$P6_3mc$ (186)	ZnO	2	3.9858 ±.001		6.4654 ±.002				r	137
PtS	Cooperite	tet	$P4_2/mmc$ (131)	PtS	4	3.4699 ±.0006		6.1098 ±.001				r	9, 56

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	ν_o	Temp °C	Ref
CdS	Greenockite	hex	$P6_3mc$ (186)	ZnO	2	4.1354 ±.0008		6.7120 ±.0007				r	137
CdS	Hawleyite	cub	$F\bar{4}3m$ (216)	Sphalerite	4	5.833 ±.002						r	132, 9, 48 164
CdS	(hypothetical)	cub	Fm3m (225)	NaCl	4	5.516 ±.001						r	10
ZnS	Sphalerite	cub	$F\bar{4}3m$ (216)	Sphalerite	4	5.4093 ±.0002						r	10, 132, 135 136
ZnS	Wurtzite	hex	$P6_3mc$ (186)	ZnO	2	3.8230 ±.0010		6.2565 ±.0010				r	135, 137
ZnSe	Stilleite	cub	$F\bar{4}3m$ (216)	Sphalerite	4	5.6685 ±.0004						r	10, 54
ZnTe		cub	$F\bar{4}3m$ (216)	Sphalerite	4	6.1020 ±.0005						r	9
HgS	Cinnabar	hex	$P3_121$ (152) $P3_221$ (154)	Cinnabar	3	4.149 ±.001		9.495 ±.002				r	9, 149
HgS	Metacinnabar	cub	$F\bar{4}3m$ (216)	Sphalerite	4	5.8517 ±.0010						r	9, 149
HgSe	Tiemannite	cub	$F\bar{4}3m$ (216)	Sphalerite	4	6.0853 ±.0005						r	9, 152
HgTe	Coloradoite	cub	$F\bar{4}3m$ (216)	Sphalerite	4	6.4600 ±.0005						r	9
FeS	(hypothetical)	cub	$F\bar{4}3m$ (216)	Sphalerite	4	5.455 ±.001						r	132, 136

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref
FeS	(hypothetical)	hex	$P6_3mc$ (186)	ZnO	2	3.872 ±.001		6.345 ±.002				r	137
CoS	(hypothetical)	cub	$F\bar{4}3m$ (216)	Sphalerite	4	5.339 ±.001						r	63
CdSe	Cadmoselite	hex	$P6_3mc$ (186)	ZnO	2	4.2977 ±.0004		7.0021 ±.0008				r	9
CdTe		cub	$F\bar{4}3m$ (216)	Sphalerite	4	6.4805 ±.0004						r	9
$CuFeS_2$ $CuFeS_{1.90}$	Chalcopyrite	tet	I42d (122)		4	5.2988 ±.001		10.434 ±.005				r	9
$CuFeS_2S_3$*	Cubanite	orth	Pcmn (62)	Cubanite	4	6.46 ±.01	11.12 ±.01	6.23 ±.01				r	17
$AgFe_2S_3$*	Sternbergite	orth	Ccmm (63)		8	11.60 ±.02	12.675 ±.02	6.63 ±.01				r	109
$AgFe_2S_3$*	Argentopyrite	orth	Pmmm (47)		4	6.64 ±.01	11.47 ±.02	6.45 ±.02				r	98
NiAs	Niccolite	hex	$P6_3/mmc$ (194)	NiAs	2	3.618 ±.001		5.034 ±.001				r	176
NiSb	Breithauptite	hex	$P6_3/mmc$ (194)	NiAs	2	3.942 ±.001		5.155 ±.001				r	66
CuS	Covellite	hex	$P6_3/mmc$ (194)	CuS	6	3.792 ±.001		16.34 ±.01				r	149
CuSe	Klockmannite	hex		Deformed CuS	78	$\sqrt{13}$x3.94 ±.001		17.25 ±.05				r	35, 157

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref
SnS	Herzenbergite	orth	Pbnm (62)	GeS	4	4.328 ±.002	11.190 ±.004	3.978 ±.001				r	96
$PbSnS_2$	Teallite	orth	Pbnm (62)	GeS	2	4.266 ±.003.	11.419 ±.007	4.090 ±.002				r	96
AsS*	Realgar	mon	$P2_1/m$ (11)		16	9.29 ±.05	13.53 ±.05	6.57 ±.03		106°33'		r	13, 181
NiS	Millerite	hex-R	R3m (160)	Millerite	9	9.616 ±.001		3.152 ±.001				r	9, 156 77, 84
Sb_2S_3	Stibnite	orth	Pbnm (62)	Sb_2S_3	4	11.229 ±.004	11.310 ±.004	3.8389 ±.0010				25	150
Bi_2S_3	Bismuthinite	orth	Pbnm	Sb_2S_3	4	11.150 ±.004	11.300 ±.004	3.981 ±.001				26	149
Bi_2Te_3	Tellurobismuthite	hex-R	$R\bar{3}m$ (166)	Bi_2Te_2S	3	4.3835 ±.0005		30.487 ±.001				r	41, 168
As_2S_3	Orpiment	mon	$P2_1/n$ (14)	As_2S_3	4	11.49 ±.02	9.59 ±.02	4.25 ±.01		90° 27'		r	16
Co_3S_4	Linnaeite	cub	Fd3m (227)	Cu_3S_4	8	9.401 ±.005						r	87
Ni_3S_4	Polydymite	cub	Fd3m (227)	Ni_3S_4	8	9.480 ±.001						r	77
$FeNi_2S_4$	Violarite	cub	Fd3m (227)	Spinel	8	9.464 ±.005						r	86
$FeCr_2S_4$	Daubreeite	cub	Fd3m (227)	Spinel	8	9.966 ±.005						r	83

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref
FeS_2	Pyrite	cub	Pa3 (205)	Pyrite	4	5.4175 ±.0005						r	133, 81, 53
FeS	Troilite	hex	$P6_3/mmc$ (194)	NiAs	2	3.446 ±.003		5.877 ±.001				28 ±2	162
$Fe_{.980}S$	Pyrrhotite	hex	$P6_3/mmc$ (194)	defect NiAs	2	3.4461 ±.001		5.8479 ±.002				28 ±2	162
$Fe_{.885}S$	Pyrrhotite	hex	$P6_3/mmc$ (194)	defect NiAs	2	3.4401 ±.001		5.7090 ±.003				28 ±2	162
FeS_2*	Marcasite	orth	Pnnm (58)	Marcasite	2	4.443 ±.002	5.423 ±.002	3.3876 ±.0015				25	133, 14
$FeSe_2$	Ferroselite	orth	Pnnm (58)	Marcasite	2	4.801 ±.005	5.778 ±.005	3.587 ±.004				r	60, 8
$FeTe_2$	Frohbergite	orth	Pnnm (58)	Marcasite	2	5.265 ±.005	6.265 ±.005	3.869 ±.002				r	57
CoS_2	Cattierite	cub	Pa3 (205)	Pyrite	4	5.535 ±.005						r	87
$CoSe_2$	Trogtalite	cub	Pa3 (205)	Pyrite	4	5.8588 ±.001						r	20
NiS_2	Vaesite	cub	Pa3 (205)	Pyrite	4	5.6873 ±.0005						r	9, 77, 84
$NiSe_2$		cub	Pa3 (205)	Pyrite	4	5.9604 ±.001						20	58
$NiTe_2$	Melonite	hex	$P\bar{3}ml$ (164)	CdI_2	1	3.869 ±.01		5.308 ±.01				84	158
MnS_2	Hauerite	cub	Pa3 (205)	Pyrite	4	6.1014 ±.0006						28	133
$PtAs_2$*	Sperrylite	cub	Pa3 (205)	Pyrite	4	5.968 ±.005						r	53, 159

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref
RuS_2	Laurite	cub	Pa3 (205)	Pyrite	4	5.60 ±.02						r	7, 8, 28, 101
$NiAs_2$	Rammelsbergite	ortho	Pnnm (58)	Marcasite	2	4.757 ±.002	5.797 ±.004	3.542 ±.002				26	119, 155, 176
$NiAs_2$	Pararammels-bergite	ortho	Pbca (61)		8	5.75 ±.01	5.82 ±.01	11.428 ±.02				r	107, 76
$FeAs_2$	Loellingite	ortho	Pa3 (205)	Marcasite	2	5.300 ±.002	5.981 ±.002	2.882 ±.001				26	119, 155
$CoAs_2$	Co-safflorite	mono		Deformed Marcasite	2	5.049 ±.002	5.872 ±.002	3.127 ±.001		90° 27'		26	119, 155
$(Co, Fe)As_2$ $Co_{0.5}Fe_{0.5}As_2$	Safflorite	ortho	Pnnm (58)	Marcasite	2	5.231 ±.002	5.953 ±.002	2.962 ±.005				26	119, 155
MoS_2	Molybdenite	hex	$P6_3/mmc$ (194)	MoS_2	2	3.1604 ±.0005		12.295 ±.002				26	150
WS_2	Tungstenite	hex	$P6_3/mmc$ (194)	MoS_2	2	3.154 ±.001		12.362 ±.004				26	153
FeAsS*	Arsenopyrite	tri	$P\bar{1}$ (2)		4	5.760 ±.010	5.690 ±.005	5.785 ±.005	90°	112°14'	90°	r	94
FeSbS*	Gudmundite	mono	$B2_1/d$ (14)		8	10.00 ±.05	5.93 ±.03	6.73 ±.03		~90°		r	15
(Co, Fe)AsS*	Glaucodot	ortho	Cmmm (65)		24	6.64 ±.05	28.39 ±.10	5.64 ±.05				r	8
CoAsS*	Cobaltite	cub	$P2_13$ (198)	NiSbS	4	5.60 ±.05						r	8

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref
NiAsS	Gersdorfite	cub	$P2_13$ (198)	NiAsS	4	5.693 ±.001						26	156
$FeAs_{3-x}$ $FeAs_{2.95}$	Fe-Skutterudite hypothetical	cub	Im3 (204)	$CoAs_3$	8	8.1814 ±.0009						r	118
$CoAs_{3-x}$ $CoAs_{2.95}$	Co-Skutterudite	cub	Im3 (204)	$CoAs_3$	8	8.2060 ±.0009						r	118
$NiAs_{3-x}$ $NiAs_{2.95}$	Ni-Skutterudite hypothetical	cub	Im3 (204)	$CoAs_3$	8	8.3300 ±.0009						r	118
Cu_3AsS_3	Tennantite	cub	$I\bar{4}3m$ (217)		8	10.190 ±.004						26	133
Cu_3SbS_3	Tetrahedrite	cub	$I\bar{4}3m$ (217)		8	10.327 ±.004						26	133
Cu_3AsS_4	Enargite	orth	Pnn2 (34)		2	6.426	7.422	6.144				26	133
Cu_3AsS_4	Luzonite	tet	$I\bar{4}2m$ (121)		2	5.289		10.440				26	133, 47
Cu_3SbS_4	Famatinite	tet	$I\bar{4}2m$ (121)		2	5.384		10.770				26	133, 47
Ag_3AsS_3	Proustite	hex-R	R3c (161)		6	10.8160 ±.0010		8.6948 ±.0013				26	162
Ag_3SbS_3	Pyrargyrite	hex-R	R3c (161)		6	11.0520 ±.0015		8.7177 ±.0016				26	162

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref.
Al_2O_3	Corundum	hex-R	$R\bar{3}c$ (167)	α-Al_2O_3	6	4.7591 ±.0004		12.9894 ±.003				25	70, 179
AlO(OH)	Boehmite	orth	Cmcm (63)	γ-FeO(OH)	4	2.868 ±.003	12.227 ±.003	3.700 ±.003				26	148
AlO(OH)*	Diaspore	orth	Pbnm (62)		4	4.401 ±.005	9.421 ±.005	2.845 ±.002				r	19, 148
$Al(OH)_3$	Gibbsite	mon	$P2_1/n$ (14)		8	9.719 ±.002	5.0705 ±.0010	8.6412 ±.0010		94° 34' ± 15'		r	32
AS_2O_3	Arsenolite	cub	Fd3m (227)	diamond	16	11.074 ±.005						25	146
BeO	Bromellite	hex	$P6_3mc$ (186)		2	2.698 ±.005		4.380 ±.005				26	146
CaO	Lime	cub	Fm3m (225)	NaCl	4	4.8108 ±.0005						26	12, 146
$Ca(OH)_2$	Portlandite	hex	$P\bar{3}ml$ (164)	CdI_2	1	3.5933 ±.0005		4.9086 ±.002				26	12, 146
CdO		cub	Fm3m (225)	NaCl	4	4.6953 ±.001						27	147
CeO_2	Cerianite	cub	Fm3m (225)	CaF_2	4	5.4110 ±.002						26	146
CoO		cub	Fm3m (225)	NaCl	4	4.260 ±.002						26	154
Cr_2O_3	Eskolaite	hex-R	$R\bar{3}c$ (167)	α-Al_2O_3	6	4.954 ±.002		13.584 ±.002				26	150
CuO	Tenorite	mon	C2/c (15)		4	4.684 ±.005	3.425 ±.005	5.129 ±.005		99° 28' ±10'		26	146
Cu_2O	Cuprite	cub	Pn3m (224)	Cu_2O	2	4.2696 ±.001						26	147
$Fe_{.953}O$	Wustite	cub	Fm3m (225)	NaCl(defect)	4	4.3088 ±.0003						17	170

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o or α_r	β_o	γ_o	Temp °C	Ref.
Fe_2O_3	Hematite	hex-R	$R\bar{3}c$ (167)	α-Al_2O_3	6	5.0329 ±.001 a_r = 5.4266		13.749$_2$ ±.001	55° 15.4' ±5'			25	59, 169
Fe_3O_4	Magnetite	cub	Fd3m (227)	spinel	8	8.3940 ±.0005						22	1, 161
α-FeO(OH)*	Goethite	orth	Pbnm (62)		4	4.596 ±.05	9.957 ±.010	3.021 ±.003				r	108
γ-FeO(OH)*	Lepidocrocite	orth	Amam (63)		4	3.868 ±.010	12.52$_5$ ±.010	3.066 ±.010				r	108
H_2O	Ice	hex	$P6_3/mmc$ (194)		4	4.5212 ±.0010		7.3666 ±.0010				0	79
HfO_2	Hafnia	mon	$P2_1/c$ (14)	ZrO_2	4	5.1156 ±.001	5.1722 ±.001	5.2948 ±.001		99° 11' ± 5'		r	2
HgO	Montroydite	orth	Pnma (62)		4	6.608 ±.003	5.518 ±.003	3.519 ±.003				25	154
MgO	Periclase	cub	Fm3m (225)	NaCl	4	4.2117 ±.0005						25	131, 146
$Mg(OH)_2$	Brucite	hex	$P\bar{3}ml$ (164)	CdI_2	1	3.147 ±.004		4.769 ±.004				26	151
MnO	Manganosite	cub	Fm3m (225)	NaCl	4	4.4448 ±.0005						26	150, 49
MnO_2	Pyrolusite	tet	P4/mnm (136)	rutile	2	4.388 ±.003		2.865 ±.002				r	145, 32
Mn_2O_3	Bixbyite	cub	Ia3 (206)	Tl_2O_3	16	9.411 ±.005						25	154
Mn_3O_4	Hausmanite	tet	$I4_1/amd$ (141)		4	8.136 ±.005		9.422 ±.005				20	165
MoO_3	Molybdite	orth	Pbnm (62)		4	3.962 ±.002	13.858 ±.005	3.697 ±.004				26	148

OXIDES AND HYDROXIDES continued

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref.
NiO	Bunsenite	cub	Fm3m (225)	NaCl	4	4.177 ±.002						26	146
PbO	Litharge	tet	P4/nmm (129)		2	3.9759 ±.004		5.023 ±.004				27	147
PbO	Massicot	orth	Pb2a (32)		4	5.489 ±.003	4.755 ±.004	5.891 ±.004				27	147
Sb_2O_3	Senarmontite	cub	Fm3m (225)	arsenic trioxide	16	11.152 ±.003						26	148
Sb_2O_3	Valentinite	orth	Pccn (56)	antimony trioxide	4	4.914 ±.002	12.468 ±.005	5.421 ±.004				25	155
SiO_2*	α-Quartz	hex	$P3_121$ (152) $P3_221$ (154)		3	4.91355 ±.0001		5.40512 ±.0001				25	42, 179
SiO_2*	β-Quartz	hex	$P6_422$ (181) $P6_222$ (180)		3	4.9990 ±.0005		5.4592 ±.0005				575	42, 71
SiO_2	α-Cristobalite	tet	$P4_12_12$ (92) $P4_32_12$ (96)		4	4.971 ±.003		6.918 ±.003				25	155
SiO_2	β-Cristobalite	cub	Fd3m (227)		8	7.1382 ±.0010						405	139
SiO_2	Keatite	tet	$P4_12_12$ (92) $P4_32_12$ (96)		12	7.456 ±.003		8.604 ±.005				r	129, 182
SiO_2	β-Tridymite	hex	$P\bar{6}2c$ (172) $P6_3/mmc$ (194)		4	5.0463 ±.0020		8.2563 ±.0030				405	139
SiO_2*	Coesite	mon	B2/b (15)		16	7.152 ±.001	12.379 ±.002	7.152 ±.001		120° 00' ±10'		25	133
SiO_2*	Stishovite	tet	P4/mnm (136)	rutile	2	4.1790 ±.001		2.6649 ±.001				r	23
SiO_2*	Melanophlogite	cub	$P4_232$ (208)		48	13.402 ±.004						r	180
SnO_2	Cassiterite	tet	P4/mnm (136)	rutile	2	4.738 ±.003		3.188 ±.003				26	146

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref.
TeO_2*	Tellurite	orth	Pbca (61)	tellurite	8	5.607 ±.003	12.034 ±.005	5.463 ±.003				25	154
TeO_2	Para-tellurite	tet	$P4_12_12$ (92) $P4_32_12$ (96)		4	4.810 ±.002		7.613 ±.002				25	155
ThO_2	Thorianite	cub	Fm3m (225)	CaF_2	4	5.59525 ±.0005						25	131, 146
TiO_2	Rutile	tet	P4/mnm (136)	rutile	2	4.59374 ±.0005		2.9617$_7$ ±.002				25	144, 27, 146
TiO_2	Anatase	tet	$I4_1/amd$ (141)		4	3.785 ±.002		9.514 ±.006				r	27, 146
TiO_2*	Brookite	orth	Pcab (61)		8	5.447 ±.010	9.185 ±.010	5.145 ±.010				r	32
UO_2	Uraninite	cub	Fm3m (225)	CaF_2	4	5.4682 ±.001						26	147
ZnO	Zincite	hex	$P6_3mc$ (186)	ZnO	2	3.2495 ±.0005		5.2069 ±.0005				25	64
ZrO_2	Baddeleyite	mon	$P2_1/c$ (14)	ZrO_2	4	5.1454 ±.001	5.2075 ±.001	5.3107 ±.001		99° 14' ±5'		r	2

SPINELS, ALUMINATES AND TITINATES

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref.
$BeAl_2O_4$	Chrysoberyl	orth	Pnma (62)	olivine	4	9.4041 ±.003	5.4756 ±.002	4.4267 ±.002				25	154
$MgAl_2O_4$	Spinel	cub	Fd3m (227)	spinel	8	8.0800 ±.002						26	147
$FeAl_2O_4$	Hercynite	cub	Fd3m (227)	spinel	8	8.154 ±.003						25	163
$MnAl_2O_4$	Galaxite	cub	Fd3m (227)	spinel	8	8.258 ±.002						25	154
$ZnAl_2O_4$	Gahnite	cub	Fd3m (227)	spinel	8	8.0848 ±.002						26	147
$FeFe_2O_4$	Magnetite	cub	Fd3m (227)	spinel	8	8.3940 ±.0005						22	1, 161
$MnFe_2O_4$	Jacobsite	cub	Fd3m (227)	spinel	8	8.499 ±.005						25	154
$NiFe_2O_4$	Trevorite	cub	Fd3m (227)	spinel	8	8.339 ±.005						25	155
$MgCr_2O_4$	Picrochromite	cub	Fd3m (227)	spinel	8	8.333 ±.005						26	154
$CaTiO_3$	Perovskite	orth	Pcmn (62)	perovskite	4	5.3670 ±.0001	7.6438 ±.0001	5.4439 ±.0001				r	74
$FeTiO_3$*	Ilmenite	hex-R	$R\bar{3}$ (148)	ilmenite	6	5.018 ±.005		14.055 ±.010				r	104
$MgTiO_3$	Geikielite	hex-R	$R\bar{3}$ (148)	ilmenite	6	5.054 ±.005		13.898 ±.005				26	150

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref.
NaCl	Halite	cub	Fm3m (225)	NaCl	4	5.6402 ±.0002						26	147
KCl	Sylvite	cub	Fm3m (225)	NaCl	4	6.2931 ±.0002						25	146
NaF	Villiaumite	cub	Fm3m (225)	NaCl	4	4.6342 ±.0005						25	146
AgBr	Bromyrite	cub	Fm3m (225)	NaCl	4	5.7745 ±.0005						26	149
AgCl	Cerargyrite	cub	Fm3m (225)	NaCl	4	5.5491 ±.0005						26	149
AgI	Iodyrite	hex	$P6_3mc$ (186)	ZnO	2	4.5922 ±.002		7.510 ±.005				25	153
AgI	Miersite	cub	$F\bar{4}3m$ (216)	Sphalerite	4	6.495 ±.005						r	166
CaF_2	Fluorite	cub	Fm3m (225)	CaF_2	4	5.4626 ±.0003						25	146, 4
MgF_2	Sellaite	tet	$P4_2/mnm$ (136)	Cassiterite	2	4.621 ±.001		3.050 ±.001				18	34, 149
HgCl	Calomel	tet	$I4/mm$ (139)		4	4.478 ±.005		10.91 ±.005				26	146
Na_3AlF_6*	Cryolite	mon	$P2_1/n$ (14)		2	5.40_0 ±.01	5.60_1 ±.01	7.77_6 ±.01		90° 11' +15'		r	104
$NaMgF_3$	Neighborite	orth	Pcmn (62)	Perovskite	4	5.363 ±.001	7.676 ±.001	5.503 ±.001				18	22

Formula	Name	Cry Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o or α_r	β_o	γ_o	Temp °C	Ref.
$BaMg(CO_3)_2$*	Norsethite	hex-R	R32 (155)	calcite	3	5.020 ±.005 a_r = 6.29		16.75 ±.02	±05' 47° 02'			r	97
$CaCO_3$	Calcite	nex-R	R$\bar{3}$c (167)	calcite	6	4.9899 ±.0002 a_r = 6.3760		17.064 ±.001	46° 4.3'			26±3	55
$CaMg(CO_3)_2$*	Dolomite	hex-R	R$\bar{3}$ (148)	calcite	3	4.8079 ±.0010 a_r = 6.0154		16.010 ±.003	47° 6.6'			26±3	55
$CdCO_3$	Otavite	hex-R	R$\bar{3}$c (167)	calcite	6	4.9204 ±.0005 a_r = 6.1306		16.298 ±.003	47° 19.2'			26±3	55
$CoCO_3$	Cobalticalcite	hex-R	R$\bar{3}$c (167)	calcite	6	4.6581 ±.0005 a_r = 5.6650		14.958 ±.002	48° 33.1'			26±3	55
$FeCO_3$	Siderite	hex-R	R$\bar{3}$c (167)	calcite	6	4.6887 ±.0004 a_r = 5.7954		15.373 ±.004	47° 43.3'			26±3	55
$MgCO_3$	Magnesite	hex-R	R$\bar{3}$c (167)	calcite	6	4.6330 ±.0003 a_r = 5.6752		15.016 ±.002	48° 10.9'			26±3	55
$Mg_3Ca(CO_3)_4$*	Huntite	hex-R	R32 (155)	calcite	3	9.5062 ±.003 a_r = 6.0762		7.8219 ±.004	102° 55.9'			26±3	55
$MnCO_3$	Rhodochrosite	hex-R	R$\bar{3}$c (167)	calcite	6	4.7771 ±.0003 a_r = 5.9050		15.664 ±.003	47° 43.2'			26±3	55
$NiCO_3$		hex-R	R$\bar{3}$c (167)	calcite	6	4.5975 ±.0005 a_r = 5.5795		14.723 ±.002	48° 39.7'			26±3	55

Formula	Name	Cry. Sys	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o or α_r	β_o	γ_o	Temp °C	Ref.
$ZnCO_3$	Smithsonite	hex-R	$R\bar{3}c$ (167)	calcite	6	4.6528 ±.0003		15.025 ±.003				26±3	55
						a_r = 5.6833			48° 19.6'				
$BaCO_3$	Witherite	orth	Pmcn (62)	aragonite	4	5.314 ±.005	8.904 ±.005	6.430 ±.005				26	147
$CaCO_3$	Aragonite	orth	Pmcn (62)	aragonite	4	4.959 ±.005	7.968 ±.005	5.741 ±.005				26	148
$PbCO_3$	Cerussite	orth	Pmcn (62)	aragonite	4	5.195 ±.005	8.436 ±.005	6.152 ±.005				26	147
$SrCO_3$	Strontianite	orth	Pmcn (62)	aragonite	4	5.107 ±.005	8.414 ±.005	6.029 ±.005				26	148
$Cu_2(OH)_2CO_3$	Malachite	mon	$P2_1/a$ (14)	complex	4	9.502 ±.007	11.974 ±.007	3.240 ±.003		98° 45' ±15'		25	155
$Cu_3(OH)_2(CO_3)_2$	Azurite	mon	$P2_1/c$ (14)	complex	2	5.008 ±.005	5.844 ±.005	10.336 ±.005		92° 27' ±15'		25	155
$CaCO_3$	Vaterite	hex			6	7.135 ±.005		8.524 ±.007				r	88
KNO_3	Niter	orth	Pmcn (62)	aragonite	4	5.414 ±.005	9.164 ±.005	6.431 ±.005				26	148
$NaNO_3$	Soda Niter	hex-R	$R\bar{3}c$ (167)	calcite	6	5.0696 ±.0010		16.829 ±.005				25	151
						a_r = 6.3273			47° 9.8'				
$Cu_2(NO_3)(OH)_3$	Gerhardite	orth	$P2_12_12_1$ (41)		4	5.592 ±.004	6.075 ±.004	13.812 ±.008				r	111

SULFATES AND BORATES

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref.
$BaSO_4$	Barite	orth	Pnma (62)	$BaSO_4$	4	8.878 ±.005	5.450 ±.005	7.152 ±.003				26	148
$CaSO_4$	Anhydrite	orth	Ccmm (63) Bbmm	$CaSO_4$	4	6.238 ±.005	6.991 ±.005	6.996 ±.005				26	149
$PbSO_4$	Anglesite	orth	Pnma (62)	$BaSO_4$	4	8.480 ±.005	5.398 ±.005	6.958 ±.003				25	148
$SrSO_4$	Celestite	orth	Pnma (62)	$BaSO_4$	4	8.359 ±.005	5.352 ±.005	6.866 ±.005				26	147
$ZnSO_4$	Zinkosite	orth	Pnma (62)	$BaSO_4$	4	8.588 ±.008	6.740 ±.006	4.770 ±.005				25	152
K_2SO_4	Arcanite	orth	Pnma (62)	K_2SO_4	4	5.772 ±.005	10.072 ±.005	7.483 ±.004				25	148
Na_2SO_4	Thenardite	orth	Fddd (70)	Na_2SO_4	8	5.863 ±.005	12.304 ±.005	9.821 ±.005				25	147
$CaSO_4 \cdot 2H_2O$*	Gypsum	mon	C2/c (15)		4	6.58 ±.010	15.18 ±.010	6.29 ±.010		113° 50' ±15'		r	104
$MgSO_4 \cdot 7H_2O$	Epsomite	orth	$P2_12_12_1$ (41)		4	11.964 ±.01	12.054 ±.01	6.879 ±.01				25	104
$Na_2SO_4 \cdot 10H_2O$	Mirabilite	mon	$P2_1/c$ (14)		4	11.51 ±.01	10.38 ±.01	12.83 ±.01		107° 45' ±10'		24	121
$CuSO_4 \cdot 5H_2O$	Chalcanthite	tri	$P\bar{1}$ (2)		2	6.104_5 ±.005	10.72 ±.01	5.949 ±.007	97° 34' ±10'	107° 17' ±10'	77° 26' ±10'	r	39
$Cu_4SO_4(OH)_6$*	Brochantite	mon	$P2_1/c$ (14)		4	13.06_6 ±.01	9.85 ±.01	6.02_2 ±.01		103° 16' ±15'		r	32
$K_2Ca(SO_4)_2 \cdot H_2O$	Syngenite	mon	$P2_1/m$ (11)		2	9.775 ±.005	7.156 ±.005	6.251 ±.005		104° 00' ±15'		r	6
$CaB_3O_4(OH)_3 \cdot H_2O$*	Colemanite	mon	$P2_1/a$ (14)			8.743 ±.004	11.264 ±.002	6.102 ±.003		110° 7' ±5'		r	24
$Na_2B_4O_7 \cdot 10H_2O$	Borax	mon	C2/c (15)		4	11.858 ±.005	10.674 ±.005	12.197 ±.005		106° 41' ±2'		r	92

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp. °C	Ref.
$Na_2B_4O_7 \cdot 4H_2O$	Kernite	mon	$P2_1/c$ (14)		4	7.022 ±.003	9.151 ±.004	15.676 ±.008		108° 50' ± 15'		r	120
$KAl_3(SO_4)_2(OH)_6$	Alunite	hex-R	R3m (160)		3	6.982 ±.005		17.32 ±.01				r	11, 105
$NaAl_3(SO_4)_2(OH)_6$	Natroalunite	hex-R	R3m (160)		3	6.974 ±.005		16.69 ±.01				r	105

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref.
$AlPO_4$	Berlinite	hex	$P3_121$ (152) or $P3_221$(154)	α-quartz	3	4.942 ±.005		10.97 ±.007				25	155
$Ca_5(PO_4)_3OH$	Hydroxylapatite	hex	$P6_3/m$ (176)	apatite	2	9.432 ±.005		6.881 ±.005				r	114
YPO_4	Xenotime	tet	$I4_1/amd$ (141)	zircon	4	6.885 ±.005		5.982 ±.005				26	153
$CaMoO_4$	Powellite	tet	$I4_1/a$ (100)	calcium tungstate	4	5.226 ±.005		11.43 ±.007				25	151
$PbMoO_4$	Wulfenite	tet	$I4_1/a$ (100)	calcium tungstate	4	5.435 ±.007		12.11 ±.007				25	152
$CaWO_4$	Seheelite	tet	$I4_1/a$ (100)	calcium tungstate	4	5.242 ±.005		11.372 ±.005				25	151
$PbWO_4$	Stolzite	tet	$I4_1/a$ (100)	calcium tungstate	4	5.4616 ±.0020		12.046 ±.002				25	152
$FeWO_4$	Ferberite	mon	P2/c (13)	wolframite	2	4.732 ±.004	5.708 ±.003	4.965 ±.004		90° 00' ±03'		r	127
$MnWO_4$	Huebnerite	mon	P2/c (13)	wolframite	2	4.834 ±.004	5.758 ±.003	4.999 ±.004		91° 11' ±03'		r	127
$Fe_5Mn_5WO_4$	Wolframite	mon	P2/c (13)	wolframite	2	4.782 ±.004	5.731 ±.003	4.982 ±.004		90° 34' ±03'		r	127
$Ca_5(PO_4)_3F$	Fluorapatite	hex	$P6_3/m$ (176)	apatite	2	9.369 ±.005		6.884 ±.003				r	89
$Ca_5(PO_4)_3Cl$	Chlorapatite	hex	$P6_3/m$ (176)	apatite	2	9.629 ±.005		6.777 ±.003				r	89

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref.
Al_2SiO_5*	Andalusite	orth	Pnnm (58)		4	7.7959 ±.005	7.8983 ±.002	5.5583 ±.002				25	134
Al_2SiO_5*	Kyanite	tri	$P\bar{1}$ (2)		4	7.123 ±.001	7.848 ±.002	5.564 ±.008	89° 55' ±09'	101° 15' ±05'	105° 58' ±05'	25	134
Al_2SiO_5*	Sillimanite	orth	Pbnm (62) Pnma		4	7.4843 ±.003	7.6730 ±.003	5.7711 ±.004				25	134
$Ca_3Al_2Si_3O_{12}$	Grossularite	cub	Ia3d (230)	garnet	8	11.851 ±.001						25	130
$Ca_3Cr_2Si_3O_{12}$	Uvarovite	cub	Ia3d (230)	garnet	8	11.999 ±,002						26	155
$Ca_3Fe_2Si_3O_{12}$	Andradite	cub	Ia3d (230)	garnet	8	12.048 ±.001						25	130
$Fe_3Al_2Si_3O_{12}$	Almandite	cub	Ia3d (230)	garnet	8	12.526 ±.001						25	130
$Mg_3Al_2Si_3O_{12}$	Pyrope	cub	Ia3d (230)	garnet	8	11.459 ±.001						25	130
$Mn_3Al_2Si_3O_{12}$	Spessartite	cub	Ia3d (230)	garnet	8	11.621 ±.001						25	130
γ-Ca_2SiO_4*	Lime Olivine	orth	Pbnm (62)	olivine	4	5.07_0 ±.020	11.30_3 ±.020	6.79_4 ±.020				r	102
Fe_2SiO_4	Fayalite	orth	Pbnm (62)	olivine	4	4.817 ±.005	10.477 ±.005	6.105 ±.010				r	175
Mg_2SiO_4	Forsterite	orth	Pbnm (62)	olivine	4	4.758 ±.002	10.214 ±.003	5.984 ±.002				25	133
Mn_2SiO_4*	Tephroite	orth	Pbnm (62)	olivine	4	4.871 ±.005	10.636 ±.005	6.232 ±.005				r	68
$CaMgSiO_4$*	Monticellite	orth	Pbnm (62)	olivine	4	4.827 ±.005	11.084 ±.005	6.376 ±.005				r	124
$CaFeSiO_4$	Kirschsteinite	orth	Pbnm (62)	olivine	4	4.886 ±.005	11.146 ±.005	6.434 ±.010				r	124
β-Ca_2SiO_4*	Larnite	mon	$P2_1/n$ (14)		4	5.48 ±.02	6.76 ±.02	9.28 ±.02		94° 33' ±20'		r	91

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o or α_r	β_o	γ_o	Temp °C	Ref.
Be_2SiO_4*	Phenacite	hex-R	$R\bar{3}$ (148)	phenacite	18	12.472 ±.005 $a_r = 7.708_2$		8.252 ±.005	108° 0.42'			25	153
Zn_2SiO_4	Willemite	hex-R	$R\bar{3}$ (148)	phenacite	18	13.94 ±.01 $a_r = 8.123$		3.309 ±.003	118° 11'			25	152
$ThSiO_4$	Thorite	tet	I4/amd (141)	zircon	4	7.143 ±.004		6.327 ±.003				r	46
$ZrSiO_4$	Zircon	tet	I4/amd (141)	zircon	4	6.604 ±.005		5.979 ±.005				25	149
$USiO_4$	Coffinite	tet	I4/amd (141)	zircon	4	6.995 ±.004		6.263 ±.005 7.07 ±.01				r	46
$KAl_2(AlSi_3O_{10})(OH)_2$*	Muscovite	mon	C2/c (15)	mica (2M)	4	5.203 ±.005	8.995 ±.007	20.030 ±.005		94° 28' ±30'		27	174, 40
$KMg_3(AlSi_3O_{10})(OH)_2$*	Phlogopite	mon	Cm (8)	mica (1M)	2	5.314 ±.01	9.204 ±.02	10.314 ±.005		99° 54' ±10'		r	173
$KMg_3(AlSi_3O_{10})F_2$	Fluor-Phlogopite	mon	Cm (8)	mica (1M)	2	5.299 ±.004	9.188 ±.002	10.135 ±.002		99° 55' ±3'		r	75
$KFe_3(AlSi_3O_{10})(OH)_2$	Annite	mon	Cm (8)	mica (1M)	2	5.391 ±.01	9.350 ±.004	10.313 ±.02		99° 42' ±15'		26	172
$Al_2Si_4O_{10}(OH)_2$*	Pyrophyllite	mon	C2/c (15)	sheet	4	5.14 ±.02	8.90 ±.02	18.55 ±.03		99° 55' ±5'		r	61
$Mg_3Si_4O_{10}(OH)_2$*	Talc	mon	C2/c (15)	sheet	4	5.287 ±.007	9.15_8 ±.008	18.95 ±.01		99° 30'		r	142
$Al_2Si_2O_5(OH)_4$*	Kaolinite	tri				5.155 ±.007	8.959 ±.010	7.407 ±.008	91° 41' ± 20'	104° 52' ± 20'	89° 56' ± 20'	r	52
$Al_2Si_2O_5(OH)_4$*	Dickite	mon	Cc (9)	sheet	4	5.150 ±.002	8.940 ±.003	14.424 ±.005		96° 44' ±5'		r	100

SILICATES continued

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref
$CaSiO_3$*	Parawollastonite	mon	$P2_1$ (4)		12	15.417 ±.004	7.321 ±.002	7.066 ±.002		95° 24' ±3'		r	160, 106
$CaSiO_3$*	Pseudowollastonite	tri (mon)			24	6.90 ±.02	11.78 ±.02	19.65 ±.02		90° 48' ±15'		r	72
$Ca_2NaHSi_3O_9$*	Pectolite	tri	$P\bar{1}$ (2)	wollastonite	2	7.99 ±.01	7.04 ±.01	7.02 ±.01	90° 03' ±15'	95° 17' ±15'	102° 28' ±15'	r	18
$CaSiO_3$*	Wollastonite	tri	$P\bar{1}$ (2)	wollastonite	6	7.94 ±.01	7.32 ±.01	7.07 ±.01	90°02' ± 15'	95°22' ± 15'	103°26' ± 15'	r	18, 106
$MgSiO_3$*	Clino-Enstatite	mon	C2/c (15)	diopside	8	9.618 ±.005	8.825 ±.005	5.186 ±.005		108° 21' ±5'		r	93
$MgSiO_3$*	Enstatite	orth	Pcab (61)		16	8.829 ±.01	18.22 ±.01	5.192 ±.01				26	151, 65
$MnSiO_3$*	Rhodonite	tri	$P\bar{1}$ (2)	wollastonite	10	6.68 ±.02	7.66 ±.03	12.20 ±.04	111° 06' ±20'	86° 00' ±20'	93° 12' ±20'	r	82
$CaMg(SiO_3)_2$	Diopside	mon	C2/c (15)	diopside	4	9.743 ±.005	8.923 ±.005	5.251 ±.005		74° 04' ±15'		r	125
$CaFe(SiO_3)_2$*	Hedenbergite	mon	C2/c (15)	diopside	4	9.854 ±.010	9.024 ±.010	5.263 ±.010		75° 46' ±20'		r	78
$NaAlSi_2O_6$*	Jadeite	mon	C2/c (15)	diopside	4	9.499 ±.020	8.608 ±.010	5.241 ±.020		107° 26' ±15'		r	171
$Ca_2Mg_5Si_8O_{22}(OH)_2$*	Tremolite	mon	C2/m (12)	tremolite	2	9.840 ±.006	18.052 ±.005	5.275 ±.005		104° 42' ±15'		r	177
$Ca_2Mg_5Si_8O_{22}F_2$	Fluor-Tremolite	mon	C2/m (12)	tremolite	2	9.781 ±.005	18.007 ±.004	5.267 ±.006		104° 30		20	26
$Na_2Mg_3Fe_2Si_8O_{22}(OH)_2$	Mg-Riebecite	mon	I2/m (12)	hornblende	2	10.04 ±.01	18.02 ±.01	5.28 ±.01		72° 00' ±30'		r	37
$Na_2Mg_3Al_2Si_8O_{22}(OH)_2$	Glaucophane	mon		hornblende	2	9.99 ±.01	17.92 ±.01	5.27 ±.01		71° 38' ±15'		r	38
$Be_3Al_2(Si_6O_{18})$*	Beryl	hex	P6/mmc (192)		2	9.215 ±.005		9.192 ±.005				25	154
$Mg_2Al_3(AlSi_5O_{18})$	Hi-Cordierite	hex	P6/mmc (192)		2	9.7698 ±.003		9.3517 ±.003				r	128

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o or α_r	β_o	γ_o	Temp °C	Ref.
$Mg_2Al_3(AlSi_5O_{18})$	Lo-Cordierite	orth	Cccm (66)		4	17.0621 ±.005	9.7208 ±.003	9.3389 ±.003				r	128
$CaAl_2Si_2O_8$*	Anorthite	tri	$C\bar{1}$ (2)	feldspar	4	8.1768 ±.002	12.8768 ±.003	7.0845 ±.002	93° 10.0' ±2'	115° 50.8' ±2'	91° 13.3' ±2'	r	25, 51
$NaAlSi_3O_8$*	Albite	tri	$C\bar{1}$ (2)	feldspar	4	8.1353 ±.002	12.7883 ±.003	7.1542 ±.002	94° 13.6' ±1'	116° 31.1' ±1'	87° 42.5' ±1'	r	25, 140 80
$NaAlSi_3O_8$	Hi-Albite	tri		feldspar	4	8.171 ±.005	12.872 ±.005	7.108 ±.005	93° 28' ±10'	116° 23' ±10'	90° 14' ±10'	r	140, 80
$KAlSi_3O_8$*	Microcline	tri	$C\bar{1}$ (2)	feldspar	4	8.577 ±.01	12.967 ±.01	7.223 ±.01	90° 39' ±5'	115° 56' ±5'	87° 42' ±5'	r	80
$KAlSi_3O_8$	Sanidine	mon	C2/m (12)	feldspar	4	8.617 ±.005	13.030 ±.005	7.176 ±.005		116° 4.6' ±10'		r	31
$CaTiSiO_5$*	Sphene	mon	A2/a (15)		4	7.07_4 ±.010	8.71_8 ±.010	6.56_3 ±.010		113° 57' ±15'		r	32
$Zn_4(OH)_2Si_2O_7 \cdot H_2O$*	Hemimorphite	orth	Imm2 (35)	hemimorphite	2	8.370 ±.005	10.719 ±.005	5.120 ±.005				25	147
$(AlF)_2SiO_4$*	Topaz	orth	Pmnb (62)		4	8.394 ±.005	8.792 ±.007	4.649 ±.003					156
$NaMg_3Al_6B_3Si_6O_{27}(OH)_4$	Dravite (Tourmaline)	hex-R	R3m (160)	tourmaline	3	15.93 ±.01 a_r = 9.50		7.18 ±.01	113° 53'			r	117
$CaMg_4Al_5B_3Si_6O_{27}(OH)_4$	Uvite (Tourmaline)	hex-R	R3m (160)	tourmaline	3	15.86 ±.01 a_r = 9.465		7.19 ±.01	114° 5'			r	117
$NaAlSi_2O_6 \cdot H_2O$	Analcite	cub	Ia3d (230)	zeolite	16	13.733 ±.005						r	123
$Na_2Al_2Si_3O_{10} \cdot 2H_2O$	Natrolite	orth	Fdd2 (43)			18.30 ±.01	18.63 ±.01	6.60 ±.01				r	90

Formula	Name	Cry. Sys.	Space Group	Structure Type	Z	a_o	b_o	c_o	α_o	β_o	γ_o	Temp °C	Ref.
$NaAlSiO_4$	Lo-Nepheline	hex	$C6_3$ (178)		8	9.986 ±.005		8.330 ±.004				r	33, 141
$NaAlSiO_4$	Hi-Carnegeite	cub			4	7.325 ±.007						750	141
$KAlSiO_4$*	Kaliophilite natural	hex	$P6_322$ (182)		54	26.930 ±.010		8.522 ±.004				r	141
$KAlSiO_4$	Kaliophilite synthetic	hex	$P6_3$ (173) $P6_322$ (182)		2	5.180 ±.002		8.559 ±.004				r	141
$KAlSiO_4$	Kalsilite	hex			2	5.159_7 ±.002		8.7032 ±.002				r	141
$KAlSi_2O_6$*	Hi-Leucite	cub				13.43 ± .01						625	32
$LiAlSi_2O_6$	β-Spodumene	tet	$P4_32_12$ (96)			7.5332 ±.0008		9.1540 ±.0008				25	138
$Ca_2MgSi_2O_7$	Akermanite	tet			2	7.843_5 ±.003		5.010 ±.003				r	5
$Ca_2Al_2Si_2O_7$	Gehlenite	tet			2	7.690 ±.003		5.067_5 ±.003				r	5
$CaAl_2Si_2O_7(OH)_2 \cdot H_2O$	Lawsonite	orth	Ccmm (63)		4	8.787 ±.005	5.836 ±.005	13.123 ±.008				r	112, 103
$3Al_2O_3 \cdot 2SiO_2$	3·2 Mullite	orth			3	7.557 ±.002	7.687_6 ±.002	2.884_2 ±.001				r	3
$2Al_2O_3 \cdot SiO_2$	2·1 Mullite	orth	Pbam (55)		6/5	7.578_8 ±.001	7.690_9 ±.002	2.888_3 ±.001				r	3, 122
$Ca_2Al_3(SiO_4)_3(OH)$	Zoisite	orth	Pnma (62)		4	16.15 ±.01	5.581 ±.005	10.06 ±.01				r	113
$Ca_2Al_3(SiO_4)_3(OH)$	Clino zoisite	mon	$P2_1/m$ (11)		2	8.887 ±.007	5.581 ±.005	10.14 ±.01		115°56' ±20'		r	113

REFERENCES

1. Abrahams and Calhoun, Acta Cryst. 6 , 105, 1953.
2. Adam and Rodgers, Acta Cryst. 12, 951, 1959.
3. Agrell and Smith, J. Am. Ceram. Soc. 43 69, 1960.
4. Allen, Am. Min. 37, 910, 1952.
5. Andrews, Min. Mag. 28, 374, 1948.
6. Aruja, Min. Mag. 31, 943, 1958.
7. Bannister, Min. Mag. 23, 195, 1932.
8. Berry and Thompson, Mem. 85, Geol. Soc. Am., 281p., 1962.
9. Bethke, P. M., unpublished data.
10. Bethke and Barton, U. S. Geol. Surv. Prof. Paper 424B, 266, 1961.
11. Brophy, Scott, Snellgrove, Am. Min. 47, 112, 1962.
12. Brunauer, Kantro, and Weise, Can. J. Chem. 34, 729, 1956.
13. Buerger, Am. Min. 20, 36, 1935.
14. ———, Zeit. Krist. 97, 504, 1937.
15. ———, Am. Min. 23, 4, 1939.
16. ———, Am. Min. 27, 301, 1942.
17. ———, Am. Min. 32, 415, 1945.
18. ———, Pro. Nat. Acad. Sci. 42, 113, 1956.
19. Busing and Levey, Acta Cryst. 11, 798, 1958.
20. Bøhm and others, Acta. Chem. Scand. 9, 1510, 1955.
21. Caron and Donohue, Acta Cryst. 14, 548, 1961.
22. Chao, Evans, Skinner, and Milton, Am. Min. 46, 379, 1961.
23. Chao, Fahey, Littler, and Milton, J. Geophys. Res. 67, 419, 1962.
24. Christ, Am. Min. 41, 569, 1956.
25. Cole, Sorum and Taylor, Acta Cryst. 4, 20, 1951.
26. Comeforo and Kohn, Am. Min. 39, 537, 1954.
27. Cromer and Herrington, J. Am. Chem. Soc. 77, 4708, 1955.
28. deJong and Hoog, Rec. Trav. Chim. 46, 173, 1927.

29. Djurle, Acta Chem. Scand. 12, 1415, 1958.

30. ———, Acta Chem. Scand. 12, 1427, 1958.

31. Donnay and Donnay, Am. J. Sci. Bowen vol., 115, 1952.

32. Donnay and Nowacki, Crystal Data, Memoir 60, Geol. Soc. Am., 1954.

33. Donnay, Schairer, and Donnay, Min. Mag. 32, 93, 1959.

34. Duncanson and Stevenson, Pro. Phys. Soc. 72, 1001, 1958.

35. Earley, Am. Min. 34, 433, 1949.

36. ———, Am. Min. 35, 337, 1950.

37. Ernst, Geochim. et. Cosmochim. Acta. 19, 10, 1960.

38. Ernst, Am. J. Sci. 259, 735, 1961.

39. Fisher, Am. Min. 37, 95, 1952.

40. Fournier, R. O., private communication June 1960.

41. Francombe, Brit. J. Appl. Phys. 9, 415, 1958.

42. Frondel and Hurlburt, J. Chem. Phys. 23, 1215, 1955.

43. Frueh, Geol. Soc. Am. Bull. 67, 1697, 1956.

44. ———, Am. Min. 44, 693, 1959.

45. ———, Zeit. Krist. 112, 44, 1959.

46. Fuchs and Gebert, Am. Min. 43, 243, 1958.

47. Gaines, Am. Min. 42, 766, 1957.

48. Goldschmidt, Norsk. Videns, Akad. Oslo I Maf. Nat. Klasse, no. 8, 1927.

49. Goldsmith and Graf, Geochim. et Cosmochima. Acta 11, 310, 1957.

50. Goldsmith and Laves, Geochim. et. Cosmochim. Acta 5, 1, 1954.

51. ———, Zeit. f. Krist. 106, 213, 1955.

52. Goodyear and Duffin, Min. Mag. 32, 902, 1961.

53. Gordon, Am. Min. 36, 918, 1951.

54. Goryunova and Fedorova, Sov. Phys. Solid State, 1, 307, 1959.

55. Graf, Am. Min. 46, 1283, 1961.

56. Grønvold, Haraldson and Vinovde, Acta Chem. Scand. 14, 1879, 1960.

57. Grønvold, Haraldson and Vihovde, Acta Chem. Scand. 8, 1927, 1954.

58. Grønvold and Jacobsen, Acta Chem. Scand. 10, 1440, 1956.

59. Gronvøld and Westrum, J. Am. Chem. Soc. 81, 1780, 1959.

60. ———, Inorg. Chem. 1, 36, 1962.

61. Gruner, Zeit. f. Krist. 88, 412, 1934.

62. Güntert and Faessler, Zeit. Krist. 107, 357, 1956.

63. Hall, U. S. Geol. Surv. Prof. Paper 424B, 271, 1961.

64. Heller, McGannon, and Weber, J. Appl. Phys. 21, 1283, 1950.

65. Hess, Am. J. Sci. Bowen vol., 173, 1952.

66. Hewitt, Econ. Geol. 43, 408, 1948.

67. Hiller, Neues Jahrb. Mineral. Monatsch, 265, 1951.

68. Hurlburt, Am. Min. 46, 549, 1961.

69. Ievins, Straumanis, and Karlsons, Zeit. f. Phys. Chem. 40B, 347, 1938.

70. Jan, Steinman, and Dinichert, J. Phys. Chem. Solids 12, 349, 1960.

71. Jay, Pro. Roy. Soc. A142, 237, 1933.

72. Jeffery and Heller, Acta Cryst. 6, 807, 1953.

73. Jurriaanse, Zeit. Krist. 90, 322, 1953.

74. Kay and Bailey, Acta Cryst. 10, 219, 1957.

75. Kohn and Hatch, Am. Min. 40, 10, 1955.

76. Kullerud, Unpublished data.

77. Kullerud and Yund, J. Petrology 3, 126, 1962.

78. Kuno and Hess, Am. J. Sci. 251, 741, 1953.

79. LaPlaca and Post, Acta Cryst. 13, 503, 1960.

80. Laves, J. Geol. 60, 549, 1952.

81. Lepp, Am. Min. 41, 347, 1956.

82. Liebau, Hilmer and Lindeman, Acta Cryst. 12, 182, 1959.

83. Lundquist, Ark. Kem. Min. Geol. 17B, n.12, 1943.

84. ———, Ark. Kem. Min. Geol. 24A, n.21, 1947.

85. ———, Ark. Kem. Min. Geol. 24A, n.22, 1947.

86. ———, Ark. Kem. Min. Geol. 24A, n.23, 1947.

87. Lundquist and Westgren, Zeit. anorg. Chem. 239, 85, 1938.

88. McConnel, Min. Mag. 32, 534, 1960.

89. McConnell, Science 136, 241, 1962.

90. Meier, Zeit.f. Krist. 113, 430, 1960.

91. Midgley, Acta, Cryst. 5, 307, 1952.

92. Morimoto, Min. J. (Japan) 2, 1, 1956.

93. ———, Ann. Rept. Dir. Geophys. Lab. 58, 193, 1959.

94. Morimoto and Clark, Am. Min. 46, 1448, 1961.

95. Morimoto and Kullerud, Am. Min. 46, 1270, 1961.

96. Mosberg and others, U. S. Gol. Surv. Prof. Paper 424C, 347, 1961.

97. Mrose, Chao, Fahey, and Milton, Am. Min. 46, 420, 1961.

98. Murdoch and Berry, Am. Min. 39, 475, 1954.

99. Nelson and Riley, Pro. Phys. Soc. 57, 477,1945.

100. Newman, Min. Mag. 32, 683, 1961.

101. Oftedal, Zeit. Phys. Chem. 135, 291, 1928.

102. O'Daniel and Tscheischwili, Zeit.f. Krist. 104, 124, 1942.

103. Pabst, Zeits, Krist. 115, 307, 1961. (Min. Abstracts 15, 337, 1962.)

104. Palache, Berman, and Frondel, Dana's System of Mineralogy 7th Ed. 2 volumes, John Wiley, New York 1944, 1951.

105. Parker, Am. Min. 47, 127, 1962.

106. Peacock, Am. J. Sci. XXX, 495, 1935.

107. ———, Univ. Toronto Stud. Geol. Ser. 42, 101, 1939.

108. ———, Trans. Roy. Soc. Can. IV 36, 107, 1942.

109. ———, Am. Min. 27, 229, 1942.

110. Peacock and McAndrew, Am. Min. 35, 425, 1950.

111. Oswald, Z. Krist. 116, 210, 1961.

112. Pistorious, Am. Min. 46, 982, 1961.

113. ———, J. Geol. 69, 604, 1961.

114. Posner, Perloff, and Diorio, Acta Cryst. 11, 308, 1958.

115. Primak, Kaufman and Ward, J. Am. Chem. Soc. 70, 2043, 1948.

116. Rahlfs, Zeit. Phys. Chem. B31, 157, 1936.

117. Robbins, Ann. Rept. Dir. Geophys. Lab. 58, 137, 1959.

118. Roseboom, Am. Min. 47, 310, 1962.

119. ———, unpublished data

120. Ross and Edwards, Acta Cryst. 12, 258, 1959.

121. Ruben and Others, J. Am. Chem. Soc. 83, 821, 1961.

122. Sadanga, Tokonami and Takeuchi, Acta Cryst. 15, 65, 1962.

123. Saha, Am. Min. 44, 300, 1959.

124. Sahama and Hytonen, Am. Min. 43, 862, 1958.

125. Sakata, Jap. J. Geol. Geog. 28, 161, 1957.

126. Salkovitz, J. Metals 8, 176, 1956.

127. Sasaki, Min. J. (Japan) 2, 375, 1959.

128. Schreyer, J. Pet. 2, XXX, 1961.

129. Shropshire, Keat, and Vaughan, Zeit. f. Krist, 112, 409, 1959.

130. Skinner, Am. Min. 41, 428, 1956.

131. ———, Am. Min. 42, 39, 1957.

132. ———, Am. Min. 46, 1399, 1961.

133. ———, unpublished data.

134. Skinner, Appelman, and Clark, Am. J. Sci. 259, 651, 1961.

135. Skinner and Barton, Am. Min. 45, 612, 1960.

136. Skinner, Barton, and Kullerud; Econ. Geol. 54, 1040, 1959.

137. Skinner and Bethke, Am. Min. 46, 1382, 1961.

138. Skinner and Evans, Am. J. Sci. 258A, 312, 1960.

139. Smith, Ann. Rept. Dir. Geophys. Lab. 52, 61, 1953.

140. ———, Min. Mag. 31, 47, 1956.

141. Smith and Tuttle, Am. J. Sci. 255, 282, 1957.

142. Stemple and Brindley, J. Am. Ceram. Soc. 43, 34, 1960.

143. Straumanis, J. Appl. Phys. 20, 726, 1949.

144. Straumanis, Ejima, and James, Acta Cryst. 13, 1022 1960.

145. Structure Reports, 184, 1951.

146. Swanson and Tatge, U. S. Nat. Bur. Stds. Circular 539, v. 1, Washington, D. C., 1953.

147. Swanson and Fuyat, U. S. Nat. Bur. Stds. Circular 539, v.2, Washington, D. C., 1953.

148. Swanson, Fuyant, and Ugrinie, U. S. Nat. Bur. Stds. Circular 539, v. 3, Washington, D. C., 1954.

149. ———, U. S. Nat. Bur. Stds Circular 539, v.4, Washington, D. C., 1955.

150. Swanson, Gilfrich, and Ugrinic, U. S. Nat. Bur. Stds. Circular 539, v. 5, Washington, D. C., 1955.

151. Swanson, Gilfrich, and Cook, U. S. Nat. Bur. Stds. Circular 539, v.6, Washington, D. C., 1956.

152. ———, U. S. Nat. Bur. Stds. Curcular 539, v. 7, Washington, D. C. 1957.

153. Swanson and others, U. S. Nat. Bur. Stds Circular 539, v. 8, Washington, D. C., 1959.

154. ———, U. S. Nat. Bur. Stds. Circular 539, v. 9, Washington, D. C. 1960.

155. ———, U. S. Nat. Bur. Stds. Circular 539, v.10, Washington, D.C. 1960.

156. ———, U. S. Nat. Bur. Stds. Monogr. 25, sec. 1, Washington, D. C. 1962.

157. Taylor and Underwood, Acta Cryst. 13, 361, 1960.

158. Tengner, Zeit. anorg. Chem. 239, 126, 1938.

159. Thomassen, Zeit. Phys. Chem. 4, Abt. B, 277, 1929.

160. Tolliday, Nature 182, 1012, 1958.

161. Tombs and Rooksby, Acta Cryst. 4, 474, 1951.

162. Toulmin, Priestley, 3d, in press.

163. Turnock, A. C., private communication, February 1961.

164. Ulrich and Zachariasen, Zeit. Krist, 62, 260, 1925.

165. Van Hook and Keith, Am. Min. 43, 69, 1958.

166. Waldbaum, D. R., private communication,August 1961.

167. Wasserstein, Am. Min. 36, 102, 1951.

168. Wiese and Muldower, Phy. and Chem. Solids 15, 13, 1960.

169. Willis and Rooksby, Pro. Phys. Soc. 65B, 950, 1952.

170. ———, Acta Cryst. 6, 827, 1953.

171. Wolfe, Am. Min. 40, 249, 1955.

172. Wones, D. R., private communication,February 1961.

173. Yoder and Eugster, Geochim. et. Cosmochim. Acta 6, 157, 1954.

174. ———, Geochim. et. Cosmochim. Acta 8, 225, 1955.

175. Yoder and Sahama, Am. Min. 42, 475, 1957.

176. Yund, Ann. Rept. Dir.Geophys. Lab. Wash. 56, 148, 1959.

177. Zussman, Acta Cryst. 12, 309, 1959.

178. Cooper, Bond and Abrahams, Acta Cryst. 14, 1008, 1961.

179. Cooper, Acta Cryst. 15, 578, 1962.

180. Skinner and Appleman, Abstract, Geol. Soc. America, Houston, Texas meeting, 1962.

181. Ito, Morimoto and Sadanaga, Acta Cryst. 5, 775, 1952.

182. Frondel, Dana's System of Mineralogy, 7th ed., vol. 111, Silica Minerals, John Wiley, New York, 1962.

183. Parrish, Acta Cryst. 13, 838, 1960.