Table of Key Lines in X-ray Powder Diffraction Patterns of Minerals in Clays and Associated Rocks

By PEI-YUAN CHEN

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Errata for Indiana Geological Survey's Occasional Paper 21

Page	Line	Column	For	Read
22	10 (siderite)	1	30.50(6)	24.8(6)
24	16 (Biotite)	Degree 2θ	26.52	delete
	16 (Biotite)	d-spacing	3.36	delete
27	19 (Celadonite)	1	28.79	28.79(5)
	19	Degree 2θ	19.16(8-4)	delete
	19	Degree 2θ		add 26.9-26.7
	19	d-spacing	4.63	delete
	19	d-spacing		add 3.31-3.33
28	7 (Calcite)	Degree 2θ	39.34(2)	36.0(2)
	7	d-spacing	2.29	2.49
31	7 (Siderite)	Degree 2θ	32.07(6)	24.8(6)

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Contents

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Table of Key Lines in X-ray Diffraction Patterns of Minerals in Clays and Associated Rocks

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Introduction

X-ray diffraction is a reliable and rapid method of mineral identification. It is useful in academic research as well as in industrial applications, and when used with the petrographic microscope, it forms the backbone of determinative mineralogy and petrography. Although it is useful in identifying all minerals, X-ray diffraction excels when the particles to be identified are too small to be clearly resolved with a microscope, such as clay particles, or when minerals exist as solid solutions or mixtures.

The Hanawalt indexing method is the standard method used in most laboratories for identifying a mineral species from an X-ray diffraction pattern. With this method, after the X-ray diffraction pattern has been obtained and the three strongest reflection peaks converted from 2θ angles to d-spacing values, a search is begun to match the d-spacing values of the unknown pattern to those in a given index book. Indexes commonly used are the "Index Book to the X-ray Powder Diffraction File" (PDF) or the "Fink Index," both published by the American Society for Testing and Materials, or the "Search Manual for Selected PDF for Minerals," published by the Joint Committee on Powder Diffraction Standards (JCPDS, 1974). These indexes are very comprehensive (the Search Manual alone lists 1,900 mineral entries), and so much time and patience are often needed to make the proper mineral identification. An awareness of elemental composition and mode of occurrence of the sample may narrow the search area.

The purpose of this table is to provide a guide to the rapid identification of minerals in clays or other earthy materials and fine-grained rocks by the X-ray powder diffraction method. It includes about 240 names of mineral species and varieties, from such groups as the phyllosilicates, zeolites, authigenic and detrital sedimentary minerals, hydrothermal and weathering minerals, and a few ceramic minerals. The table should find its greatest usefulness with students learning the X-ray diffraction method of analysis, but it should also be valuable to the experienced mineralogist in identifying uncommon specimens. A basic understanding of the X-ray diffraction method of analysis is assumed, but for details of methodology and theory, the reader may want to consult Azároff (1968), Hutchison (1974), Klug and Alexander (1974), Warren (1969), or others. For applications of the X-ray diffraction method to clay minerals analysis, the reader may want to consult Brown (1961), Carroll (1970), Carver (1971), Gibbs (1965), Grim (1968), or Warshaw and Roy (1961).

Acknowledgments

I extend special thanks to my students at National Taiwan University for their help in the initial compilation of this table and to Professors Jen-Ho Fang and Paul Robinson for personal amenities and advice during my stay at Southern Illinois University. Drs. G. W. Brindley, J. B. Droste, W. D. Keller, H. H. Murray, and R. A. Rowland provided suggestions and encouragements that are appreciated. Dr. Robert F. Blakely, Indiana Geological Survey, supervised the computer printing of the table.

How to Use the Table of Key Lines

Each row of the table generally contains five, but sometimes four, diffraction lines of a mineral in both the degree of 2θ angle and the corresponding d-spacing value (Å). Each row is grouped into three sections: first, the assemblage of the 2θ angles for Cu radiation of these lines; second, the corresponding d-spacing values; and third, the name of that mineral. The diffraction lines selected are the lines of high intensity or the lines most useful for distinguishing polymorphic varieties of a mineral. The first column in the first and second sections is the value of the key line used for identifying a mineral. These key line values are arranged in the first column in increasing order of the 2θ angle from 2.9° to 67° and correspondingly in decreasing d-spacing value from 30Å to 1.40Å. The other four (or three) values in each section of the row are reference lines, which are arranged in the order of increasing 2θ degree or decreasing d-value. The relative intensity of the diffraction line, based on a scale of 1 to 10, is given beside the 2θ value in parentheses. A 2θ value which does not have an intensity bracket attached is of the highest intensity 10.

The d-spacing value of one mineral in an entry may vary from the value for the same mineral in the next entry; therefore, in most cases, the user can find more than five diffraction lines for a mineral by using all entries in column 1 for that mineral. Each mineral name will repeat in the column two to five times at different 2θ degrees.

To identify an unknown mineral from an X-ray diffraction pattern, compare the 2θ angle or d-spacing value of any unidentified peak with the corresponding value listed in column 1 of the first or second sections. The name of the mineral species corresponding to that value is listed in the third section. If the table does not provide a matching value, try another strong reflection and repeat the procedure. A failure may occur when a reflection other than one to five significant lines is selected as the "search" peak. If further confirmation is needed, the complete pattern of the tentatively identified mineral can be checked againt the JCPDS powder diffraction data card or other sources.

As an example of using the table, assume that a line of strong intensity was found at $2\theta = 4.9°$ (18.1Å) on the X-ray diffraction pattern. By reading down column 1 to 4.88 (or 18.10 in the first column of the second section), the mineral is tentatively identified as copiapite (third section). If this identification is correct, four more lines, one at 9.61°, which should be the strongest, and three others at 14.35°, 15.88°, and 24.87°, should be present. By checking the row of 2θ values at 15.8°, another additional peak for this mineral at 25.44° can be found. If all the listed peaks are found, the remaining peaks on the pattern can be checked against the ASTM or JCPDS card file for final verification. If any unidentified peaks remain in the unknown pattern, they belong to other component or mineral phases and the identification procedure should be repeated.

A Mineral Index is provided before the Table of Key Lines to facilitate the location of individual mineral entries. Appendixes 1-21 provide data for distinguishing polymorphic varieties of several groups of minerals.

Mineral Index

Mineral	Chemical formula	2θ*	Reference**
Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	32.9	25-157
Adularia (see Orthoclase)			
Akaganeite	Beta-FeO(OH)	26.8	B-386 13-157
Albite	$NaAlSi_3O_8$	27.9	9-466
Aliettite	Regular mixed layer Talc-Saponite	3.7	
Allevardite=Rectorite	Regular mixed layer Pyrophyllite-Montmorillonite	3.6	14-183
Alunite	$KAl_3(SO_4)_2(OH)_6$	15.4	14-136
Alunogen	$Al_2(SO_4)_3 \cdot 18H_2O$	6.6	22-22
Amesite	$(Mg_2Al)(AlSi)O_5(OH)_4$	12.6	9-493 APX-8
Amphiboles	$A_2B_5(Si,Al)_8O_{22}(OH,F)_2$ A=Na,Ca,K; B=Mg,Fe^{+2},Fe^{+3},Ti,Al, Li,Mn	10.4	20-495M
Analcime=Analcite	$NaAlSi_2O_6 \cdot 2H_2O$	25.9	7-363 APX-11
Anatase	TiO_2	25.3	21-1272
Andalusite	Al_2SiO_5	16.0	13-122
Andesine (see Plagioclase)			APX-16
Anhydrite	$CaSO_4$	25.5	6-226
Ankerite	$Ca(Fe,Mg,Mn)(CO_3)_2$	30.8	12-88
Anorthite (see Plagioclase)			APX-16
Anorthoclase (see K-Feldspars)			APX-13
Anthophyllite	$(Mg,Fe)_7Si_8O_{22}(OH)_2$	29.2	9-455M
Antigorite	$(Mg,Fe)_3Si_2O_5(OH)_4$	12.0	11-388M APX-7
Apatite			
Carbonate-Apatite & Carbonate-Fluorapatite	$(Ca,Mg,Na,K)_5(PO_4,CO_3)(OH,F)$	32.9 33.3	21-145 21-141
Fluorapatite	$Ca_5(PO_4)_3F$	31.8	15-876
Chlorapatite	$Ca_5(PO_4)_3Cl$	32.3	2-851 24-214
Aphthitalite	$(K,Na)_3Na(SO_4)_2$	31.4	20-928
Apophyllite	$KCa_4Si_8O_{20}(F,OH) \cdot 8H_2O$	11.3	19-82 19-944
Aragonite	$CaCO_3$ (orthorhombic)	26.2	5-453
Attapulgite=Palygorskite			
Augite	$(Ca,Na)(Mg,Fe,Al)(Si,Al)_2O_6$	29.8	24-203

Footnotes * and ** are on page 10.

Mineral Index—Continued

Mineral	Chemical formula	2θ*	Reference**
Barite=Baryte	$BaSO_4$	25.8	5-448
Basaluminite	$Al_4(SO_4)(OH)_{10}\cdot 5H_2O$	9.4	8-64
Bayerite	$Al(OH)_3$ (monoclinic)	40.6	20-11
Beidellite (see Smectite)	$(Na,Ca/2)_{0.33}Al_2(Al,Si)_4O_{10}(OH)_2$ $\cdot nH_2O$	62.2	APX-9
Berthierine	$(Fe^{+2},Fe^{+3}Mg)_{2\text{-}3}(Si,Al)_2O_5(OH)_4$	12.4	7-315 APX-8
Biotite (see Micas)		26.5	APX-4
Boehmite	$AlO(OH)$ (orthorhombic)	14.5	21-1307
Borax	$Na_2B_4O_7\cdot 10H_2O$	18.4	1-1097 12-258
Brookite	TiO_2	25.3	16-617
Brucite	$Mg(OH)_2$	18.6	7-239
Bytownite (see Plagioclase)			APX-16
Calcite	$CaCO_3$ (trigonal)	29.4	5-586
Calcite, Mg-	$(Ca,Mg)CO_3$	29.8	APX-20
Carnallite	$KMgCl_3\cdot 6H_2O$	26.8	21-1353
Carnotite	$K_2(UO_2)_2(VO_4)_2\cdot 3H_2O$	13.5	8-317 11-338
Celestite=Celestine	$SrSO_4$	30.0	5-593
Celsian	$BaAl_2Si_2O_8$	26.6	A-650
Chabazite	$Ca(Al_2Si_4)O_{12}\cdot 6H_2O$	9.4	19-208 APX-11
Chamosite=Berthierine			
Chlorites	$M_{5\text{-}6}(Al,Si)_4O_{10}(OH)_8$, where M=Mg, Fe^{+2},Ni,Mn,Fe^{+3},Al,Cr,Li	6.2	APX-5
Chrysotile, 2M	$Mg_3Si_2O_5(OH)_4$	12.1	21-543 APX-7
Chrysotile, 2O	$Mg_3Si_2O_5(OH)_4$	12.4	22-1162 APX-7
Clinoptilolite	$(Na,K,Ca)_{2\text{-}3}Al_3(Al,Si)_2,Si_{13}$, $O_{36}\cdot 12H_2O$	9.8	24-319 APX-11
Clinozoisite	$Ca_2Al_3Si_3O_{12}(OH)$	30.9	21-128
Clintonite (Mica group)	$Ca(Mg,Al)_3(Al_3Si)O_{10}(OH)_2$	9.1	20-321
Colemanite	$Ca_2B_6O_{11}\cdot 5H_2O$	28.5	6-331
Copiapite (Aluminocopiapite)	$Fe^{+2}Fe_4{}^{+3}(SO_4)_6(OH)_2\cdot 2OH_2O$ [or $AlFe_6{}^{+3}(SO_4)_9(OH)_3\cdot 3OH_2O$]	9.6	20-659
Coquimbite	$Fe_2(SO_4)_3\cdot 9H_2O$	10.7	6-40
Cordierite	$Mg_2Al_4Si_5O_{18}$	10.3	12-303
Corrensite	Regular mixed layer Chlorite-swelling 14Å mineral	3.1	19-764
Corundum	Alpha-Al_2O_3	25.6	10-173
Cristobalite, high	SiO_2 (tetragonal)	21.4	4-359
Cristobalite, low	SiO_2 (tetragonal)	21.9	11-695
Cronstedtite	$(Fe_2{}^{+2}Fe^{+3})(SiFe^{+3})O_5(OH)_4$	25.6	17-470

Mineral Index—Continued

Mineral	Chemical formula	2θ*	Reference**
Dawsonite	$NaAl(CO_3)(OH)_2$	15.6	19-1175
Diadochite	$Fe_2(PO_4)(SO_4)(OH)\cdot 5H_2O$	10.2	12-209
Diaspore	AlO(OH) (orthorhombic)	22.3	5-355
Dickite	$Al_2Si_2O_5(OH)_4$	12.3	APX-2
Diopside	$CaMgSi_2O_6$	29.9	11-654
Dolomite	$CaMg(CO_3)_2$	30.9	11-78 APX-20
Endellite= Halloysite, hydrated			
Enstatite	$Mg_2Si_2O_6$	28.1	19-605
Epidote	$Ca_2(Al,Fe)_3Si_3O_{12}(OH)$	30.8	17-514
Epistilbite	$Ca(Al_2Si_6)O_{16}\cdot 5H_2O$	9.9	19-213 APX-11
Epsomite	$MgSo_4\cdot 7H_2O$	21.1	8-467
Erionite	$(Ca,Na_2,K_2)(Al_8Si_{28})O_{72}\cdot 27H_2O$	7.7	22-854 APX-11
Fassaite (Al-Augite)	$(Ca,Mg,Fe,Al)(Si,Al)_2O_6$	29.7	A-250
Fayalite (Fe-Olivine)	Fe_2SiO_4	31.6	20-1139
Fibroferrite	$Fe^{+3}(SO_4)(OH)\cdot 5H_2O$	7.3	16-935
Fluorite	CaF_2	28.3	4-864
Forsterite (Mg-Olivine)	Mg_2SiO_4	36.4	7-74
Gamma Alumina	Gamma-Al_2O_3	45.9	B-384 10-425
Garnet			
Pyrope	$Mg_3Al_2Si_3O_{12}$	35.0	15-742
Almandine (Almandite)	$Fe_3Al_2Si_3O_{12}$	34.8	9-427
Spessartine (Spessartite)	$Mn_3Al_2Si_3O_{12}$	34.5	10-354
Glossular (Glossularite)	$Ca_3Al_2Si_3O_{12}$	33.8	3-826
Uvarovite	$Ca_3Cr_2Si_3O_{12}$	33.4	11-696
Andradite	$Ca_3(Fe,Ti)_2Si_{13}O_{12}$	33.3	10-288
Garnierite (1:1 layer)	A group of nickle-bearing hydrous silicates	12.0	15-580M
Garnierite (2:1 layer)	A group of nickle-bearing hydrous silicates	8.8	
Gibbsite	$Al(OH)_3$ (monoclinic)	18.3	7-324
Glaserite=Aphthitalite			
Glauberite	$Na_2Ca(SO_4)_2$	28.5	19-1187
Glauconite	$(K,Na)(Al,Fe^{+3},Mg)_2(Al,Si)_4O_{10}$ $(OH)_2$	8.9	9-439
Goethite	Alpha-FeO(OH)	21.3	17-536
Greenalite	$(Fe^{+2},Fe^{+3})_{2\text{-}3}Si_2O_5(OH)_4$	12.3	2-1012
Graphite	C	26.5	23-64
Gypsum	$CaSO_4\cdot 2H_2O$	11.7	6-46 21-816

Mineral Index—Continued

Mineral	Chemical formula	2θ*	Reference**
Halite	$NaCl$	31.7	5-628
Halloysite, hydrated	$Al_2Si_2O_5(OH)_4 \cdot 2H_2O$	8.8	9-451M
Halloysite, dehydrated	$Al_2Si_2O_5(OH)_4$	7.2	9-453M B-114
Halotrichite	$Fe^{+2}Al_2(SO_4)_4 \cdot 22H_2O$	18.6	11-506
Harmotome	$(Ba,K)(Al,Si)_2Si_6O_{16} \cdot 6H_2O$	13.8	20-468 APX-11
Hectorite (see Smectite)	$Na_{0.33}(Mg,Li)_3Si_4O_{10}(F,OH)_2$		APX-9
Hematite	Alpha-Fe_2O_3	24.2	13-534
Heulandite	$(Na,Ca)_{4-6}Al_6(Al,Si)_4Si_{26}O_{72}$ $\cdot 24H_2O$	9.9	21-131 APX-11
Hornblende	$(Ca,Na)_{2-3}(Mg,Fe^{+2},Fe^{+3},Al)_5$ $(Al,Si)_8O_{22}(OH)_2$	10.4	20-481 21-149
Hydralsite	$2Al_2O_3 \cdot 2SIO_2 \cdot H_2O$ (approx.)	9.9	10-478
Hydrargillite=Gibbsite			
Hydrobasaluminite	$Al_4(SO_4)(OH)_{10} \cdot 36H_2O$	7.0	8-76
Hydrobiotite	Mixed layer Biotite-Vermiculite	7.7	
Hypersthene	$(Mg,Fe)_2Si_2O_6$	28.0	19-606
Idocrase=Vesuvianite			
Illite (see Micas)			
Illite-Montmorillonite	Regular mixed layer Illite-Montmorillonite, 1:1	3.4	7-330
Ilmenite	$FeTiO_3$	23.8	3-781
Inyoite	$Ca_2B_6O_{11} \cdot 13H_2O$	29.4	6-361
Jarosite	$KFe_3(SO_4)_2(OH)_6$	28.9	22-827
Kainite	$MgSO_4 \cdot KCl \cdot 3H_2O$	28.3	14-591
Kaolinite	$Al_2Si_2O_5(OH)_4$	12.3	APX-2
Kernite	$Na_2B_4O_7 \cdot 4H_2O$	11.9	11-258
K-Feldspars	$KAlSi_3O_8$	21.3	APX-13
Kieserite	$MgSO_4 \cdot H_2O$	26.2	13-102
Kutnahorite, calcian	$Ca(Mn,Mg)(CO_3)_2$	29.9	11-345
Kutnahorite, magnesian	(Ca,Mn,Mg,Fe)(CO)	30.6	20-225
Kyanite	Al_2SiO_5	28.0	11-46
Labradorite (see Plagioclase)			APX-14
Langbeinite	$K_2Mg_2(SO_4)_3$	28.4	19-874
Laumontite	$Ca(Al_2Si_4)O_{12} \cdot 4H_2O$	9.3	15-276 APX-11
Lepidolite (see Micas)			
Lepidocrocite	Gamma-FeO(OH)	14.1	8-98
Leucite	$KAlSi_2O_6$	27.2	15-47
Levynite	$(Na,Ca)_2(Al,Si)_9O_{18} \cdot 8H_2O$	10.8	17-535 APX-11
Lime	CaO	37.4	4-777
Lithiophorite	$(Al,Li)Mn^{+4}O_2(OH)_2$	9.3	16-364

Mineral Index—Continued

Mineral	Chemical formula	2θ*	Reference**
Maghemite	Gamma-Fe_2O_3	30.3	15-615
Magnesite	$MgCO_3$	32.6	8-479
Manganite	$MnO(OH)$	26.2	8-99
Marcasite	FeS_2 (orthorhombic)	33.1	3-799
Margarite	$CaAl_2(Al_2Si_2)O_{10}(OH)_2$	9.2	18-276
Melanterite	$FeSO_4 \cdot 7H_2O$	18.1	22-633
Mesolite	$Na_2Ca_2(Al_6Si_9)O_{30} \cdot 8H_2O$	15.2	11-173 APX-11
Metahalloysite =Halloysite, dehydrated			
Micas (10Å member)		8.8	APX-4
Phlogopite	$KMg_3(AlSi_3)O_{10}(F,OH)_2$		B-237
Biotite	$K(Mg,Fe)_3(Al,Fe)Si_3O_{10}(OH,F)_2$		2-45
Muscovite	$KAl_2(AlSi_3)O_{10}(OH)_2$		B-237
Lepidolite	$K(LiAl)_3(AlSi)_4O_{10}(F,OH)_2$		10-484 14-11
Illite	$(K,H_3O)(Al,Mg,Fe)_2(Al,Si)_4O_{10}[(OH)_2,H_2O]$		2-462 9-334
Microcline	$KAlSi_3O_8$ (triclinic)	27.5	19-926M
Mirabilite	$Na_2SO_4 \cdot 10H_2O$	16.2	11-647
Monazite	$(Ce,La,Nd,Th)PO_4$	28.9	11-556
Montmorillonite	$(Na,Ca)_{0.33}(Al,Mg)_2Si_4O_{10}$ $(OH)_2 \cdot nH_2O$	5.8	13-135M APX-9
Montmorillonite, Na-	$Na_{0.33}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$	7.4	
Mordenite	$(Ca,Na_2,K_2)(Al_2Si_{10})O_{24} \cdot 7H_2O$	9.8	6-239 APX-11
Mullite	$Al_6Si_2O_{13}$	25.9	15-776 A-431
Muscovite (see Micas)			
Nacrite	$Al_2Si_2O_5(OH)_4$	12.3	16-606
Natroalunite	$NaAl_3(SO_4)_2(OH)_6$	15.6	14-130
Natrojarosite	$NaFe_3^{+3}(SO_4)_2(OH)_6$	17.5	11-302
Natrolite	$Na_2(Al_2Si_3)O_{10} \cdot 2H_2O$	13.6	19-1185 22-1225
Nepheline	$(Na,K)AlSiO_4$	29.7	9-458 19-1176
Niter	KNO_3	23.5	5-377
Nontronite (see Smectite)	$Na_{0.33}Fe_2^{+3}(Al,Si)_4O_{10}(OH)_2 \cdot nH_2O$		APX-9
Northupite	$Na_3Mg(CO_3)_2Cl$	36.3	19-1213

Mineral Index—Continued

Mineral	Chemical formula	2θ*	Reference**
Offretite	$(K,Ca)_3(Al_5Si_{13})O_{36} \cdot 14H_2O$	7.7	22-803 APX-11
Olivine	$(Mg,Fe^{+2})SiO_4$	32.1	7-159
Oligoclase (see Plagioclase)			APX-16
Orthoclase	$KAlSi_3O_8$ (monoclinic)	26.9	19-931
Palygorskite=Attapulgite	$(Mg,Al)_2Si_4O_{10}(OH) \cdot 4H_2O$	8.4	21-550M APX-6
Paragonite	$NaAl_2(AlSi_3)O_{10}(OH)_2$	9.1	12-165
Periclase	MgO	42.8	4-829
Phillipsite	$(K_2,Na_2,Ca)(Al_2Si_4)O_{12} \cdot 4\text{-}5H_2O$	12.3	20-923 APX-11
Phlogopite (see Micas)			
Pickeringite	$MgAl_2(SO_4)_4 \cdot 22H_2O$	18.4	12-299
Pigeonite	$(Mg,Fe,Ca)(Mg,Fe)Si_2O_6$	29.5	13-421
Pimelite=Garnierite, 2:1			
Plagioclase	$(Na,Ca)Al(Al,Si)Si_2O_8$	22.0	APX-16
Polyhalite	$K_2Ca_2Mg(SO_4)_2 \cdot 2H_2O$	28.0	21-982
Prehnite	$Ca_2Al_2Si_3O_{10}(OH)_2$	28.9	7-333
Pseudobrookite	$Fe^{+3}{}_2TiO_5$	25.5	9-182
Psilomelane=Romanechite	$BaMn^{+2}Mn^{+4}{}_8O_{16}(OH)_4$	25.5	18-174
Ptilolite=Mordenite			
Pyrite	FeS_2 (cubic)	33.1	6-710
Pyrolusite	MnO_2	28.3	12-716
Pyrophyllite	$Al_2Si_4O_{10}(OH)_2$	9.6	APX-3
Quartz, low	Alpha-SiO_2 (low temperature form, trigonal)	26.7	5-490
Quartz, high	Beta-SiO_2 (high temperature form, hexagonal)	26.2	11-252
Rectorite=Allevardite			
Rhodochrosite	$MnCO_3$	24.3	7-268
Rhomboclase	$HFe^{+3}(SO_4)_2 \cdot 4H_2O$	9.6	25-421
Romanechite=Psilomelane			
Römerite=Roemerite	$Fe^{+2}Fe^{+3}{}_2(SO_4)_4 \cdot 14H_2O$	18.5	13-530
Rozenite	$Fe^{+2}SO_4 \cdot 4H_2O$	19.8	16-699
Rutile	TiO_2	27.3	21-1276
Sanidine (see K-Feldspar)			APX-13
Saponite (see Smectite)	$(Ca/2,Na)_{0.33}(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$		APX-9
Sauconite (see Smectite)	$Na_{0.33}Zn_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$	15.0	APX-9
Scapolite	$(Na,Ca,K)_4Al_3(Al,Si)_3Si_6O_{24}(Cl,OH,CO_3,SO_4)$	25.8	
Scolecite	$Ca(Al_2Si_3)O_{10} \cdot 3H_2O$	13.3	21-831
Sepiolite	$Mg_4Si_6O_{15}(OH)_2 \cdot 6H_2O$	7.3	13-595

Mineral Index–Continued

Mineral	Chemical formula	2θ*	Reference**
Serpentine, aluminian	$(Mg_{2.5}Al_{0.5})(Si_{1.5}Al_{0.5})O_5(OH)_4$	12.4	
Serpentines	$A_3Si_2O_5(OH)_4$, A=Mg,Fe^{+2}, Ni	12.0	APX-7
Siderite	$FeCO_3$	24.9	8-133
Sillimanite	Al_2SiO_5	26.0	10-369 A-427
Smectite	Minerals of the Montmorillonite group		APX-9
Air-dry		5.9	
Glycolated	Ethylene-glycol-saturated, clay-organic complex	5.2	13-259
Glycerolated	Glycerol-saturated	4.9	B-201
Soda Niter	$NaNO_3$	29.4	7-271
Sphene=Titanite			
Spinel, magnesian	$MgAl_2O_4$	36.9	21-1152
Spinel, ferrian	$Mg_{6.8}Fe_{0.8}Al_{11}O_{32}$	36.3	21-540
Spodumene	$LiAlSi_2O_6$	30.5	9-468
Stevensite	$Mg_3Si_4O_{10}(OH)_2$	7.1	7-357
Stilbite	$NaCa_2(Al_5Si_{13})O_{36}\cdot 14H_2O$	9.7	22-518M APX-11
Stilpnomelane	$K(Fe^{+2},Fe^{+3},Al)_{10}Si_{12}O_{30}(OH)_{12}$	7.1	17-505
Strontianite	$SrCO_3$	25.1	5-418
Sudoite	$(Al,Mg,Fe)_{4-5}(Si,Al)_4O_{10}(OH)_8$	6.2	19-751
Sulfur, alpha	S (monoclinic, unstable form)	27.1	13-141
Sulfur, beta	S (orthorhombic)	23.1	8-247
Sylvite	KCl	28.3	4-584
Szomolnokite	$Fe^{+2}SO_4\cdot H_2O$	25.3	21-925
Talc	$Mg_3Si_4O_{10}(OH)_2$	9.4	19-770
Thenardite	Na_2SO_4	32.2	5-631
Thomsonite	$NaCa_2(Al_5Si_5)O_{20}\cdot 6H_2O$	31.2	19-1344 APX-11
Titanite=Sphene	$CaTiSiO_5$	27.6	11-142
Topaz	$Al_2Si_4(F,OH)_2$	30.4	12-765
Tosudite	Mixed layer Chlorite-Montmorillonite	2.9	22-765
Tourmaline	$(Na,Ca)(Mg,Fe^{+2},Fe^{+3},Al,Li)_3$ $Al_6(BO_3)_3(Si_6O_{18})(OH,F)_4$	34.7	14-76M
Tremolite	$Ca_2Mg_5Si_8O_{22}(OH)_2$	27.2	13-437
Tridymite	SiO_2 (pseudohexagonal)	20.5	18-1170
Ulexite	$NaCaB_5O_9\cdot 8H_2O$	7.2	12-419
Uraninite	UO_2	28.2	5-550M

Mineral Index—Continued

Mineral	Chemical formula	2θ*	Reference**
Vaterite	$CaCO_3$ (hexagonal)	27.0	13-192
Vermiculite	$(Mg,Fe,Al)_3(Al,Si)_4O_{10}(OH)_2 \cdot 4H_2O$	6.0	16-613 A-544
Vesuvianite	$Ca_{10}Mg_2Al_4(SiO_4)_5(Si_2O_7)_2(OH)_4$	32.4	22-533
Viseite	$NaCa_5Al_{10}(SiO_4)_3(PO_4)_5$ $(OH)_{14} \cdot 16H_2O$	30.6	5-616
Vivianite	$Fe_3^{+2}(PO_4)_2 \cdot 8H_2O$	13.0	3-70
Wairakite	$Ca(Al_2Si_4)O_{12} \cdot 2H_2O$	26.2	7-326 APX-11
Witherite	$BaCO_3$	23.9	5-378
Wollastonite	$CaSiO_3$	29.9	19-249
Xanthophyllite=Clintonite			
Zinnwaldite, 1M	$K(LiFe^{+2}Al)_3(AlSi_3)_4O_{10}(F,OH)_2$	9.0	13-227
Zircon	$ZrSiO_4$	27.0	6-266
Zoisite	$Ca_2Al_3(Si_3O_{12})(OH)$	33.3	13-562
Zunyite	$Al_{13}Si_5O_{20}(OH,F)_{18}Cl$	10.9	14-698

*Denotes the 2θ angle of one of the strong reflections of the mineral given in the first column of the Table of Key Lines.

**5-866: Indicates JCPDS data card number.
5-866M: The letter "M" indicates a minor modification of the data card.
A-325: "A" denotes X-ray data from Borg and Smith (1969b). The number following the hyphen is the page number.
B-327: "B" denotes data from Brown (1961). The number following the hyphen is the page number.
APX-1: See the appendixes.
Blank: Where the reference is blank, the data are compiled from other published or unpublished sources.

Table of Key Lines in X-ray Powder Diffraction Patterns of Minerals in Clays and Associated Rocks

Numbers in brackets indicate relative peak intensity from 1 to 10. A 2θ value without parentheses is the strongest peak (10). * indicates a mineral of the zeolite group. ** indicates a water-soluble mineral. (syn) indicates a synthetic mineral. Names connected with a hyphen, Illite-Montmorillonite for example, indicate mixed-layer minerals.

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
2.90	5.81 17.70(2) 19.81(3) 62.17(4)	30.4 15.2 5.01 4.48 1.493	TOSUDITE (DIO-CHLORITE-MONTMORILLONITE)
2.94	6.09 12.00(3) 18.10(4) 24.31(8)	30.0 14.5 7.37 4.90 3.66	CHLORITE-SWELLING CHLORITE (= CORRENSITE)
3.04-3.12(10-2)	6.22 12.50(6) 18.76(2) 25.22(2)	29.0-28.3 14.2 7.08 4.73 3.53	CORRENSITE (CHLORITE-SWELLING 14A MINERAL)
3.21	6.96(7) 17.42(2) 19.72(2) 27.61(4)	27.5 12.7 5.09 4.50 3.23	MICA-MONTMORILLONITE, REGULAR 6:4
3.42	7.12(8) 17.91(4) 19.86(8) 28.89(5)	25.8 12.4 4.95 4.47 3.09	ILLITE-MONTMORILLONITE, REGULAR 1:1
3.53-3.68(5)	7.68-7.07 18.02(5) 26.20(5)	25.0-24.0 11.5-12.5 4.92 3.40	HYDROBIOTITE (BIOTITE-VERMICULITE)
3.57	7.12(8) 17.91(2) 25.15(4) 28.79(4)	24.70 12.4 4.95 3.54 3.10	RECTORITE=ALLEVARDITE, (PYROPHYLLITE-MONTMORILLONITE)
3.71-3.60	7.49(8) 19.63 29.57(9) 36.06(8)	23.8-24.5 11.8 4.52 3.02 2.49	ALIETTITE (TALC-SAPONITE)
4.88(8)	9.61 14.35(7) 15.88(8) 24.87(5)	18.10 9.20 6.17 5.58 3.58	COPIAPITE**
4.93	9.89(4) 25.01(5) 19.95(3) 30.29(3)	17.9 8.94 3.56 4.45 2.95	SMECTITE, GLYCEROLATED
5.19	10.46(4) 15.60(5) 26.20(5) 31.84(2)	17.00 8.45 5.68 3.40 2.81	SMECTITE, GLYCOLATED
5.73-6.31	17.70(3) 19.72(6) 29.57(4) 35.92(3)	15.4-14.0 5.01 4.50 3.02 2.50	SMECTITE, AIR-DRY
5.81(7)	2.90 11.72(2) 17.73(7) 19.81(8)	15.2 30.4 7.55 5.00 4.48	TOSUDITE
5.93	2.89 12.00(5) 18.10(9) 24.31(8)	14.9 30.5 7.37 4.90 3.66	CHLORITE-SWELLING CHLORITE
6.09-6.22	12.39(2) 19.29(3) 24.87(3) 31.38(3)	14.5-14.2 7.14 4.60 3.58 2.85	VERMICULITE, AIR-DRY
6.18-6.31(7-3)	12.46 18.80 25.15 31.72	14.3-14.0 7.10 4.72 3.54 2.82	CHLORITES
6.22(8)	12.41(7) 18.68(6) 19.63(9) 35.92(9)	14.2 7.13 4.75 4.52 2.50	SUDOITE (DIO-CHLORITE)
6.22-6.31(7-3)	3.04(3) 12.50(6) 18.80(3) 25.22(2)	14.2-14.0 29.0 7.08 4.72 3.53	CORRENSITE
6.45(5)	9.71(9) 13.39(9) 25.59 27.70	13.7 9.10 6.61 3.48 3.22	MORDENITE*
6.59	13.17(2) 19.81(9) 20.27(1) 26.52(2)	13.4 6.72 4.48 4.38 3.36	ALUNOGEN**
6.96(7)	3.21 17.42(2) 19.72(2) 27.61(2)	12.7 27.50 5.09 4.50 3.23	MICA-MONTMORILLONITE, REGULAR 6:4
7.01	10.94(5) 14.33(5) 16.75(7) 18.88(7)	12.6 8.08 6.18 5.29 4.70	HYDROBASALUMINITE

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
7.12	19.55 25.44(5) 34.22(9) 60.95(3)	12.4 4.54 3.50 2.62 1.520	STEVENSITE
7.12(8)	3.42 17.91(4) 19.86(8) 28.89(4)	12.4 25.80 4.95 4.47 3.09	ILLITE-MONTMORILLONITE, REGULAR 1:1
7.12(8)	3.57 17.91(2) 25.15(4) 28.79(4)	12.4 24.70 4.95 3.54 3.10	RECTORITE (ALLEVARDITE)
7.12	14.28(2) 21.51(3) 28.79(5) 36.22(3)	12.4 6.20 4.13 3.10 2.48	NA-MONTMORILLONITE
7.18-7.30	14.14(5) 21.35 29.47(3) 35.19	12.3-12.1 6.26 4.16 3.03 2.55	STILPNOMELANE
7.24	11.41(8) 14.76(3) 20.51(1) 21.35(3)	12.2 7.75 6.00 4.33 4.16	ULEXITE..
7.30	12.71(6) 14.42(4) 25.97(6) 29.98(8)	12.1 6.96 6.14 3.43 2.98	FIBROFERITE..
7.36-7.24	11.91(2) 19.77(3) 20.60(2) 26.52(2)	12.0-12.2 7.43 4.49 4.31 3.36	SEPIOLITE
7.49(8)	3.71 19.42 29.57(9) 36.06(9)	11.8 23.8 4.57 3.02 2.49	ALIETTITE
7.68	15.38(3) 20.41(6) 23.16(4) 31.05	11.5 5.76 4.35 3.84 2.88	OFFRETITE.
7.68-7.07	3.53-3.68(5) 18.02(5) 26.20(5)	11.5-12.5 25.0-24.0 4.92 3.40	HYDROBIOTITE (BIOTITE-VERMICULITE)
7.75	13.39(8) 20.55(6) 23.72(6) 31.27(7)	11.4 6.61 4.32 3.75 2.86	ERIONITE.
8.42-8.66	13.75(3) 19.86(4) 27.61(3) 35.19(3)	10.5-10.2 6.44 4.47 3.23 2.55	PALYGORSKITE (ATTAPULGITE)
8.75	17.73(2) 26.52 33.69(7) 36.67(5)	10.1 5.00 3.36 2.66 2.45	BIOTITE
8.75-8.87	17.73-17.81(4) 19.81-19.95(4) 26.60-26.85	10.1-9.96 5.00-4.98 4.48-4.45 3.35-3.32	ILLITE AND MICAS
8.84	19.59(5) 24.45(5) 28.79(5-8) 34.77	10.0 4.53 3.64 3.10 2.58	CELADONITE AND GLAUCONITE
8.84(10-4)	19.55(5) 27.88(4) 35.33(3) 60.81(6)	10.0 4.54 3.20 2.54 1.523	GARNIERITE (PIMELITE)
8.84-9.02	19.99 26.68-26.20(5) 35.05(5)	10.0-9.80 4.44 3.34-3.40 2.56	HALLOYSITE, HYDRATED (ENDELLITE)
9.02(8)	26.68(3) 27.10 28.98(4) 34.63(2)	9.80 3.34 3.29 3.08 2.59	ZINNWALDITE, 1M (LI-BIOTITE)
9.11	19.99-20.27(9-3) 20.80(3) 27.88(7) 35.33(9-7)	9.70 4.44-4.38 4.27 3.20 2.54	PARAGONITE
9.13(5)	25.08(1) 27.79(7) 35.05 42.85(6)	9.68 3.55 3.21 2.56 2.11	CLINTONITE=XANTHOPHYLLITE
9.25(5-1)	20.32(1) 28.05 35.62(3) 47.66(4)	9.56 4.37 3.18 2.52 1.908	MARGARITE
9.31	12.82(3) 21.35(6) 25.37(3) 29.47(3)	9.49 6.90 4.16 3.51 3.03	LAUMONTITE.

9.35(5)	18.84 28.42(3) 37.96(7) 48.41(7)	9.45 4.71 3.14 2.37 1.880	LITHIOPHORITE
9.36(4)	10.71 16.26(6) 24.45(4) 26.52(6)	9.44 8.26 5.45 3.64 3.36	COQUIMBITE••
9.40-9.50	14.96(6) 16.50(6) 18.96(8) 24.18(7)	9.40-9.30 5.92 5.37 4.68 3.68	BASALUMINITE
9.45	19.38(5) 28.70(5) 34.08(2) 36.22	9.35 4.58 3.11 2.63 2.48	TALC
9.45(5)	17.66(3) 20.55(7) 30.50 30.94(3)	9.35 5.02 4.32 2.93 2.89	CHABAZITE•
9.60-9.65	19.29-19.42(4) 20.13(4) 29.08-29.37 36.99(4)	9.21-9.16 4.60-4.57 4.41 3.07-3.04 2.43	PYROPHYLLITE
9.61	4.88(8) 14.35(7) 15.88(8) 24.87(5)	9.20 18.1 6.17 5.58 3.58	COPIAPITE•• (ALUMINOCOPIAPITE)
9.63-9.69	18.76(5) 25.08(5) 26.77(6) 28.70(7)	9.18-9.12 4.73 3.55 3.33 3.11	RHOMBOCLASE••
9.66(5)	19.04(3) 21.89 29.37(4) 32.19(2)	9.15 4.66 4.06 3.04 2.78	STILBITE•
9.71(9)	6.45(5) 22.22(9) 25.59 27.70	9.10 13.7 4.00 3.48 3.22	MORDENITE•
9.78	19.04(3) 21.83 29.37(4) 32.19(3)	9.04 4.66 4.07 3.04 2.78	STILBITE•, SODIAN
9.83-9.91	11.18(4) 17.35(5) 22.45(10-5) 30.08(7)	8.99-8.92 7.91 5.11 3.96 2.97	CLINOPTILOLITE•
9.89(4)	4.93 19.95(3) 25.01(5) 30.29(3)	8.94 17.9 4.45 3.56 2.95	SMECTITE, GLYCEROLATED
9.90	19.90(5) 26.20(7) 36.99(6) 43.72(3)	8.93 4.46 3.40 2.43 2.07	HYDRALSITE (SYN)
9.94(9)	18.06(7) 25.82 27.79(9) 30.72(6)	8.89 4.91 3.45 3.21 2.91	EPISTILBITE•
9.99-9.92(8)	11.34(7) 22.58 30.19(9-7)	8.85-8.91 7.80 3.92 2.96	HEULANDITE•
10.16	10.65 20.41 22.74(7) 30.72(5)	8.70 8.30 4.35 3.91 2.91	DIADOCHITE
10.35(10-8)	10.46(8) 28.51 29.37(6) 33.82(5)	8.54 8.45 3.13 3.04 2.65	CORDIERITE
10.40-10.53	27.10-27.35(7-2) 33.17-32.92(3) 28.79-28.42(10-7)	8.50-8.40 3.29-3.26 2.70-2.72 3.10-3.14	AMPHIBOLES (HORNBLENDE, TREMOLITE, ACTINOLITE)
10.46(8)	10.35 21.67(7) 28.51 29.37(6)	8.45 8.54 4.10 3.13 3.04	CORDIERITE
10.46(4)	5.19 15.60(5) 26.20(5) 37.31(2)	8.45 17.0 5.68 3.40 2.41	SMECTITE, GLYCOLATED
10.62-10.71(6)	19.77(3) 24.38(3) 27.52(5) 29.18	8.33-8.26 4.49 3.65 3.24 3.06	ANTHOPHYLLITE
10.65	10.16(8) 20.41 22.74(7) 27.88(3)	8.30 8.70 4.35 3.91 3.20	DIADOCHITE
10.71	9.36(4) 16.26(6) 24.45(4) 32.43(7)	8.26 9.44 5.45 3.64 2.76	COQUIMBITE••

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
10.80(7)	20.75(5) 21.67 28.14(5) 31.72(8)	8.19 4.28 4.10 3.17 2.82	LEVYNITE.
10.92(4)	13.88 21.78(6) 27.52(6) 28.51(8)	8.10 6.38 4.08 3.24 3.13	HARMOTOME.
10.96	21.10 22.11(6) 31.50(5) 33.43(9)	8.07 4.21 4.02 2.84 2.68	ZUNYITE
11.32	22.80-22.50 24.94(6) 30.29-29.98(5) 36.06(5)	7.81 3.90-3.95 3.57 2.95-2.98 2.49	APOPHYLLITE
11.34(7)	9.99(8) 17.38(7) 22.69(10-7) 30.19(8)	7.80 8.85 5.10 3.92 2.96	HEULANDITE.
11.41(8)	7.24 14.76(3) 20.51(1) 21.35(3)	7.75 12.2 6.00 4.33 4.16	ULEXITE..
11.65(7)	18.80(2) 29.47 36.06(2) 39.34(2)	7.59 4.72 3.03 2.49 2.29	INYOITE..
11.70	20.80(5) 29.18(5) 31.16(10-3) 33.43(2)	7.56 4.27 3.06 2.87 2.68	GYPSUM..
11.79-12.29(9-6)	20.04 24.59(4) 35.05(4)	7.50-7.2 4.43 3.62 2.56	HALLOYSITE, DEHYDRATED
11.89(1)	7.36 11.91(2) 20.65(4-1) 26.44-26.60(2)	7.44 12.0 7.43 4.30 3.37-3.35	SEPIOLITE
11.94	13.35(8) 24.05(3) 27.44(2) 36.37(4)	7.41 6.63 3.70 3.25 2.47	KERNITE..
11.95(7)	16.88(3) 26.85 34.22(3) 35.33(7)	7.40 5.25 3.32 2.62 2.54	AKAGANEITE (SYN)
12.00(5)	2.89 6.09 18.10(9) 24.31(8)	7.37 30.5 14.5 4.90 3.66	CHLORITE-SWELLING CHLORITE
12.00-12.46	24.31-25.22 35.62-37.79 41.61-42.02	7.37-7.10 3.66-3.53 2.52-2.38 2.17-2.15	SERPENTINE GROUP
12.04-12.19	19.55(3) 24.38-24.73(5) 36.83(3) 60.51(6-2)	7.35-7.26 4.54 3.65-3.60 2.44 1.530	GARNIERITE (1:1 LAYER)
12.07-12.46	25.22-24.38 35.92-35.62 36.67-36.99(2)	7.33-7.10 3.53-3.65 2.50-2.52 2.45-2.43	ANTIGORITE
12.10	19.42(5) 24.38(7) 41.02(3) 60.29(4)	7.31 4.57 3.65 2.20 1.535	CHRYSOTILE (2M)
12.27-12.43	25.01-24.73(8) 34.91-34.63 41.41-41.02(4) 58.00-57.52(5)	7.21-7.12 3.56-3.60 2.57-2.59 2.18-2.20 1.590-1.602	GREENALITE
12.29	17.52(2) 21.51(4) 27.96(8) 33.30(3)	7.20 5.06 4.13 3.19 2.69	PHILLIPSITE.
12.29-12.55	6.18-6.49(7-3) 25.15(8) 31.72(3)	7.20-7.05 14.3-13.6 3.54 2.82	CHLORITES
12.32	20.36(8) 20.36 36.99(4) 37.63(4)	7.18 4.36 3.59 2.43 2.39	NACRITE
12.36	20.80(3) 24.87(8) 35.77(4) 38.81(7)	7.16 4.27 3.58 2.51 2.32	DICKITE
12.39	20.36(6) 24.87 36.06(6) 38.46(6)	7.14 4.36 3.58 2.49 2.34	KAOLINITE

12.41(7)	6.22(8) 19.63(9) 25.22(4) 44.86(1)	7.13 14.2 4.52 3.53 2.02	SUDOITE
12.43	25.01(8) 34.08(4) 36.22(8-4) 60.33(4)	7.12 3.56 2.63 2.48 1.534	AL-SERPENTINE
12.43-12.55	19.12(5) 25.08-25.22 43.07-42.02(7-4)	7.12-7.05 4.64 3.55-3.53 2.10-2.15	CHAMOSITE
12.46	20.18(4) 25.08(7) 35.92(5) 38.64(7)	7.10 4.40 3.55 2.50 2.33	CHRYSOTILE (2O)
12.46-12.12	25.08 24.31(7) 35.92 42.43-42.02(3)	7.10-7.30 3.55 3.66 2.50 2.13-2.15	LIZARDITE
12.48	25.15(7) 32.92(5) 35.05(7) 36.83(4)	7.09 3.54 2.72 2.56 2.44	CRONSTEDTITE
12.50	3.04(3) 6.22 18.80(4) 25.22(6)	7.08 29.0 14.2 4.72 3.53	CORRENSITE
12.53	25.30 36.22(6) 47.21(7) 60.46(6)	7.06 3.52 2.48 1.925 1.531	AMESITE
12.71(6)	7.30 14.42(4) 25.97(6) 29.98(8)	6.96 12.1 6.14 3.43 2.98	FIBROFERRITE**
12.82(4)	9.31 21.35(6) 25.37(3) 29.47(3)	6.90 9.49 4.16 3.51 3.03	LAUMONTITE*
12.92(5)	16.23(9) 19.86 22.39(7) 27.44(5)	6.85 5.46 4.47 3.97 3.25	ROZENITE
12.92(4)	15.91(8) 19.81(4) 26.28 30.83(5)	6.85 5.57 4.48 3.39 2.90	WAIRAKITE*
13.01	18.06(4) 23.16(4) 30.08(6) 33.05(6)	6.80 4.91 3.84 2.97 2.71	VIVIANITE
13.21(4)	19.25(3) 25.67(7) 26.60 29.57(5)	6.70 4.61 3.47 3.35 3.02	CELSIAN
13.31(2)	23.79(2) 27.10 28.79(1) 29.37(1)	6.65 3.74 3.29 3.10 3.04	SULFUR, MONOCLINIC
13.33	15.06(3) 19.99 30.40(3) 30.94(8)	6.64 5.88 4.44 2.94 2.89	SCOLECITE*
13.35(8)	11.94 24.05(3) 27.44(2) 36.37(4)	6.63 7.41 3.70 3.25 2.47	KERNITE**
13.39(7)	7.75 20.55(6) 23.72(6) 31.27(7)	6.61 11.4 4.32 3.75 2.86	ERIONITE*
13.41-14.05(4)	23.53-23.79(5) 25.52-25.82(5)	6.60-6.30 3.78-3.74 3.49-3.45	FELDSPARS
13.49	19.16(8) 20.90(3) 25.22(5) 28.60(7)	6.56 4.63 4.25 3.53 3.12	CARNOTITE
13.55-13.64	15.01 19.08(4) 20.27(5) 31.38	6.53-6.49 5.90 4.65 4.38 2.85	NATROLITE*
13.75-13.92(2)	8.66-8.42 16.35(3) 19.81(2) 35.19(3)	6.44-6.36 10.2-10.5 5.42 4.48 2.55	PALYGORSKITE
13.88	10.92(4) 12.36(5) 21.78(6) 28.51(8)	6.38 8.10 7.16 4.08 3.13	HARMOTOME*
13.92-13.49	21.05(6) 25.22(8) 27.79(8) 28.60-28.42(5)	6.36-6.56 4.22 3.53 3.21 3.12-3.14	CARNOTITE (SYN)
14.14	27.10(9) 36.37(5) 38.13(1) 46.90(4)	6.26 3.29 2.47 2.36 1.937	LEPIDOCROCITE
14.14(5)	7.18-7.30 21.35 29.47(2) 35.19	6.26 12.3-12.1 4.16 3.03 2.55	STILPNOMELANE

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
14.28(2)	7.12 21.51(2) 28.79(3) 36.22(2)	6.20 12.4 4.13 3.10 2.48	NA-MONTMORILLONITE
14.33(7)	7.01 10.94(5) 16.75(7) 18.88(7)	6.18 12.6 8.08 5.29 4.70	HYDROBASALUMINITE
14.35(7)	4.88(8) 9.61 15.88(8) 24.87(5)	6.17 18.10 9.20 5.58 3.58	COPIAPITE••
14.49	28.24(6) 38.46(5) 48.91(3) 49.08(2)	6.11 3.16 2.34 1.862 1.856	BOEHMITE
14.71(3)	18.60 20.70(5) 21.72(4) 25.59	6.02 4.77 4.29 4.09 3.48	HALOTRICHITE••
14.96(6)	9.40-9.50 16.50(6) 18.96(8) 24.18(7)	5.92 9.40-9.30 5.37 4.68 3.68	BASALUMINITE
15.01	13.62 19.08(4) 20.27(5) 31.38	5.90 6.50 4.65 4.38 2.85	NATROLITE•
15.30(7)	13.75(4) 20.41(5) 31.27 41.22(3)	5.79 6.44 4.35 2.86 2.19	MESOLITE•
15.38(3)	17.81(5) 29.88 30.94 39.34(7)	5.76 4.98 2.99 2.89 2.29	ALUNITE
15.60(9)	16.75(2) 18.40 22.68(3) 35.05(6)	5.68 5.29 4.82 3.92 2.56	BORAX••
15.60(5)	5.20 10.46(4) 29.37 31.84(2)	5.68 16.99 8.45 3.04 2.81	SMECTITE, GLYCOLATED
15.62	26.36(6) 32.19(9) 34.49(7) 35.92(4)	5.67 3.38 2.78 2.60 2.50	DAWSONITE
15.71(5)	22.22(3) 23.10(5) 28.51 35.19(5)	5.64 4.00 3.85 3.13 2.55	COLEMANITE
15.79(8)	25.97 30.50(7) 30.94(3) 35.77(3)	5.61 3.43 2.93 2.89 2.51	ANALCIME•
15.88(8)	4.88(8) 9.61 24.87(5) 25.44(5)	5.58 18.1 9.20 3.58 3.50	COPIAPITE••
15.88(2)	18.10(7) 29.18(8) 30.19 40.63(5)	5.58 4.90 3.06 2.96 2.22	NATROALUNITE
15.91(8)	12.92(4) 26.05(6) 26.28 30.83(5)	5.57 6.85 3.42 3.39 2.90	WAIRAKITE•
15.99	19.59(9) 22.68(7) 32.31(9) 41.61(9)	5.54 4.53 3.92 2.77 2.17	ANDALUSITE
16.14	18.60(4) 27.35(6) 27.79(8) 28.70(6)	5.49 4.77 3.26 3.21 3.11	MIRABILITE••
16.23(9)	12.92(5) 19.86 26.20(6) 27.44(5)	5.46 6.85 4.47 3.40 3.25	ROZENITE••
16.26(6)	9.36(4) 10.71 26.52(6) 32.43(7)	5.45 9.44 8.26 3.36 2.76	COQUIMBITE••
16.44(5)	25.97 26.20 33.30(4) 40.83(6)	5.39 3.43 3.40 2.69 2.21	MULLITE (SYN)
16.53(7)	26.13(9) 33.43(2) 35.48(9) 41.02	5.36 3.41 2.68 2.53 2.20	SILLIMANITE
16.75(7)	7.01 10.94(5) 14.33(7) 23.85(7)	5.29 12.6 8.08 6.18 3.73	HYDROBASALUMINITE
17.38(7)	14.93(4) 15.49(2) 28.70(7) 28.98	5.10 5.93 5.72 3.11 3.08	JAROSITE
17.38(7)	9.93-9.99 11.34-11.21 26.05(7) 30.19(6)	5.10 8.90-8.85 7.80-7.89 3.42 2.96	HEULANDITE•

17.42(2)	3.21 6.96(7) 17.42(5) 27.61(2)	5.09 27.5 12.7 5.09 3.23	MICA-MONTMORILLONITE, REGULAR 6:4
17.52	14.91(4) 28.60(7) 29.18(8) 32.31(4)	5.06 5.94 3.12 3.06 2.77	NATROJAROSITE
17.56(5)	18.52 22.05(9) 28.24(2) 37.79(3)	5.05 4.79 4.03 3.16 2.38	ROEMERITE**
17.70(5)	5.89 19.72(6) 29.57(5) 35.92-34.77(4)	5.01 15.0 4.50 3.02 2.50-2.58	MONTMORILLONITE
17.70(2)	2.90 5.81(7) 8.84(2) 19.81(3)	5.01 30.4 15.2 10.00 4.48	TOSUDITE
17.77(3)	8.84 19.86(4) 26.60 34.91(7)	4.99 10.0 4.47 3.35 2.57	ILLITE AND MICAS
17.81(5)	15.38(3) 25.44(2) 29.88 39.34(8)	4.98 5.76 3.50 2.99 2.29	ALUNITE
17.91(4)	3.42 7.12(8) 19.86(8) 26.77	4.95 25.8 12.4 4.47 3.33	ILLITE-MONTMORILLONITE, REGULAR 1:1
18.02(5)	3.53-3.68(5) 7.68-7.07 26.20(5)	4.92 25.0-24.0 11.5-12.5 3.40	HYDROBIOTITE
18.06(6)	9.94(9) 12.84(6) 22.98(7) 25.82	4.91 8.89 6.89 3.87 3.45	EPISTILBITE*
18.10	16.14(1) 18.21(5) 23.53(6) 27.10(1)	4.90 5.49 4.87 3.78 3.29	MELANTERITE**
18.10(8)	2.89 6.09 12.00(5) 18.10(9)	4.90 30.5 14.5 7.37 4.90	CHLORITE-SWELLING CHLORITE
18.10(7)	15.57(1) 25.52(3) 30.19 40.63(5)	4.90 5.69 3.49 2.96 2.22	NATROALUNITE
18.10(4)	25.59 32.68(8) 37.47(2) 46.04(2)	4.90 3.48 2.74 2.40 1.971	PSEUDOBROOKITE
18.21(5)	16.14(1) 18.10 23.53(6) 27.10(1)	4.87 5.49 4.90 3.78 3.29	MELANTERITE**
18.29	20.32(2) 20.55(2) 36.67(1) 37.79(1)	4.85 4.37 4.32 2.45 2.38	GIBBSITE (HYDRARGILLITE)
18.32	26.13 26.77(9) 29.28(8) 35.48(9)	4.84 3.41 3.33 3.05 2.53	KIESERITE**
18.40	15.60(9) 22.68(3) 31.72(4) 35.05(6)	4.82 5.68 3.92 2.82 2.56	BORAX**
18.40	20.55(4) 21.56(3) 23.47(3) 25.37(9)	4.82 4.32 4.12 3.79 3.51	PICKERINGITE**
18.52	17.56(5) 22.05(9) 28.24(2) 37.79(3)	4.79 5.05 4.03 3.16 2.38	ROEMERITE**
18.60	14.71(3) 20.70(5) 21.72(4) 25.59	4.77 6.02 4.29 4.09 3.48	HALOTRICHITE**
18.60(9)	37.96 50.89(5) 58.69(3)	4.77 2.37 1.794 1.573	BRUCITE
18.60-18.84(3)	12.29-12.55 25.01(9) 31.72(3)	4.77-4.71 7.20-7.05 3.56 2.82	CHLORITES
18.72(8)	6.22(8) 12.41(7) 19.63(8) 35.92	4.74 14.2 7.13 4.52 2.50	SUDOITE
18.76(5)	9.69 18.76(5) 26.77(6) 28.70(7)	4.73 9.12 4.73 3.33 3.11	RHOMBOCLASE**

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
18.84	9.35(5) 28.42(3) 37.96(7) 48.41(7)	4.71 9.45 3.14 2.37 1.880	LITHIOPHORITE
18.84(9)	20.41(7) 27.88(3) 40.63 53.15(4)	4.71 4.35 3.20 2.22 1.723	BAYERITE
18.88(7)	7.01 10.94(5) 14.33(7) 18.88(7)	4.70 12.6 8.08 6.18 4.70	HYDROBASALUMINITE
18.96(8)	9.40 14.96(6) 16.50(6) 22.98(6)	4.68 9.40 5.92 5.37 3.87	BASALUMINITE
18.96(4)	12.43 25.08 35.62 59.10(6)	4.68 7.12 3.55 2.52 1.563	CHAMOSITE, FERROUS
19.04(7)	28.05(5) 29.08(5) 32.19 33.82(5)	4.66 3.18 3.07 2.78 2.65	THENARDITE*
19.04(3)	31.38(4) 36.83 44.86(6) 59.43(4)	4.66 2.85 2.44 2.02 1.555	SPINEL, MAGNESIAN
19.12(9)	15.01(4) 25.37(6) 31.27 33.43(8)	4.64 5.90 3.51 2.86 2.68	THOMSONITE*
19.12(5)	12.43-12.55 25.08-25.22 43.07-42.02(5)	4.64 7.12-7.05 3.55-3.53 2.10-2.15	CHAMOSITE, MONOCLINIC
19.16(8)	13.49 20.90(3) 25.22(5) 28.60(7)	4.63 6.56 4.25 3.53 3.12	CARNOTITE
19.33(4)	12.53 25.22 36.52(7) 61.08(5)	4.59 7.06 3.53 2.46 1.517	CHAMOSITE, FERRIC
19.33(4)	9.45 28.60(10-4) 34.63(3) 36.22(3)	4.59 9.35 3.12 2.59 2.48	TALC
19.38	9.65(4) 20.08(5) 26.60(3) 29.28	4.58 9.16 4.42 3.35 3.05	PYROPHYLLITE
19.42	3.71 7.49(8) 29.57(9) 36.06(9)	4.57 23.8 11.8 3.02 2.49	ALIETTITE
19.55	7.12 25.44(5) 34.22(9) 60.95(3)	4.54 12.4 3.50 2.62 1.520	STEVENSITE
19.55(5)	8.84(10-4) 27.88(5-3) 35.33(3) 60.81(6)	4.54 10.0 3.20 2.54 1.523	GARNIERITE (PIMELITE)
19.59(9)	15.99 22.68(7) 32.31(9) 41.61(9)	4.53 5.54 3.92 2.77 2.17	ANDALUSITE
19.59(5)	8.84 28.79(8-5) 34.77 37.47(7)	4.53 10.0 3.10 2.58 2.40	CELADONITE AND GLAUCONITE
19.63(9)	6.22(8) 18.72(8) 25.08(6) 35.92	4.52 14.2 4.74 3.55 2.50	SUDOITE
19.72-19.29(6)	5.89-6.31 17.70(3) 29.57(4) 35.92	4.50-4.60 15-14 5.01 3.02 2.50	SMECTITE, AIR-DRY
19.77-19.90(5)	8.50 13.92(2) 28.05(2) 35.19(3)	4.49-4.46 10.4 6.36 3.18 2.55	PALYGORSKITE
19.77-19.86(4)	7.18-7.36 28.05(3) 35.19(5)	4.49-4.47 12.3-12.0 3.18 2.55	SEPIOLITE
19.81(9)	6.59 13.17(2) 20.22(1)	4.48 13.4 6.72 4.39	ALUNOGEN**
19.81(3)	2.90 5.81(7) 11.72 17.70(2)	4.48 30.4 15.2 7.55 5.01	TOSUDITE
19.86	16.23(9) 22.39(7) 26.20(6) 27.44(5)	4.47 5.46 3.97 3.40 3.25	ROZENITE**
19.86(8)	3.42 7.12(8) 17.91(4) 28.89(4)	4.47 25.8 12.4 4.95 3.09	ILLITE-MONTMORILLONITE, REGULAR 1:1

19.90(5)	8.50 24.11(2) 27.61(3) 35.19(3)	4.46 10.4 3.69 3.23 2.55	PALYGORSKITE
19.99	8.75 26.68(5) 35.05(5)	4.44 10.1 3.34 2.56	HALLOYSITE, HYDRATED
19.99	13.33 15.06(3) 20.18(3) 30.94(8)	4.44 6.64 5.88 4.40 2.89	SCOLECITE*
19.99-20.27(9-3)	9.11 27.88(7) 35.33(9) 62.73(2)	4.44-4.38 9.7 3.20 2.54 1.481	PARAGONITE
20.04	11.94 24.73(4) 35.05(4)	4.43 7.41 3.60 2.56	HALLOYSITE, DEHYDRATED
20.04(5)	27.01 35.62(4) 43.72(2) 53.52(4)	4.43 3.30 2.52 2.07 1.712	ZIRCON
20.08(5)	9.61 19.29(4) 29.08 37.15(5)	4.42 9.20 4.60 3.07 2.42	PYROPHYLLITE
20.27(5)	13.55-13.64 15.01 19.08(4) 31.38	4.38 6.53-6.49 5.90 4.65 2.85	NATROLITE*
20.32-20.46(4)	18.29-18.40 20.32-20.46(2)	4.37-4.34 4.85-4.82 4.37-4.34	GIBBSITE
20.36(7)	12.39 24.94(8) 36.06(6) 38.46(6)	4.36 7.14 3.57 2.49 2.34	KAOLINITE
20.36(7)	12.36 20.85(3) 24.87(9) 38.81(7)	4.36 7.16 4.26 3.58 2.32	DICKITE
20.41	10.16 10.65 22.74(7) 30.72(5)	4.35 8.70 8.30 3.91 2.91	DIADOCHITE
20.41(7)	18.84(9) 27.88(3) 40.63 53.15(4)	4.35 4.71 3.20 2.22 1.723	BAYERITE
20.41(7)	12.32 12.32 36.99(4) 37.47(4)	4.35 7.18 3.59 2.43 2.40	NACRITE
20.41(6)	7.68 15.38(3) 23.16(4) 31.05(6)	4.35 11.5 5.76 3.84 2.88	OFFRETITE*
20.41(5)	13.75(4) 15.30(7) 19.04(3) 31.27	4.35 6.44 5.79 4.66 2.86	MESOLITE*
20.46(2)	26.20 35.92(1) 45.10(1) 49.62(1)	4.34 3.40 2.50 2.01 1.837	QUARTZ, HIGH (β)
20.51(9)	21.67 22.98(2) 23.28(5) 30.08(2)	4.33 4.10 3.87 3.82 2.97	TRIDYMITE, LOW
20.55(7)	9.45(5) 17.66(3) 30.50 30.94(3)	4.32 9.35 5.02 2.93 2.89	CHABAZITE*
20.55(6)	7.75 13.39(8) 23.72(6) 31.27(7)	4.32 11.4 6.61 3.75 2.86	ERIONITE*
20.60(4)	7.30 12.29-12.02(1) 19.77(2) 35.05(6)	4.31 12.1 7.20-7.36 4.49 2.56	SEPIOLITE
20.70(5)	14.71(3) 18.60 21.72(4) 25.59	4.29 6.02 4.77 4.09 3.48	HALOTRICHITE**
20.75(9-5)	11.70-11.62 31.16(10-3) 33.43(3) 43.50(1)	4.28 7.56-7.61 2.87 2.68 2.08	GYPSUM**
20.75(5)	10.80(7) 21.67 28.14(5) 31.84(8)	4.28 8.19 4.10 3.17 2.81	LEVYNITE*
21.05(6)	13.92 21.05(6) 27.79(8) 28.60(5)	4.22 6.36 4.22 3.21 3.12	CARNOTITE
20.85(3)	26.68 36.67(1) 39.52(1) 50.20(1)	4.26 3.34 2.45 2.28 1.817	QUARTZ, LOW

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
20.90-21.62(6)	21.30(7) 23.59-23.79(5) 26.68-27.70	4.25-4.11 4.17 3.77-3.74 3.34-3.22	K-FELDSPARS
21.10	10.96 22.11(6) 33.43(9) 56.07(9)	4.21 8.07 4.02 2.68 1.640	ZUNYITE
21.10	14.78(2) 16.56(3) 31.05(2) 33.43(3)	4.21 5.99 5.35 2.88 2.68	EPSOMITE**
21.20(5)	27.27(6) 29.78 31.05(6) 34.91(3)	4.19 3.27 3.00 2.88 2.57	NEPHELINE
21.25-21.41	33.30(3) 36.06(1) 36.67(3) 41.22(2)	4.18-4.15 2.69 2.49 2.45 2.19	GOETHITE
21.35	7.18 14.14(5) 29.47(2) 35.19	4.16 12.3 6.26 3.03 2.55	STILPNOMELANE
21.35(6)	9.31 12.82 25.37(3) 29.47(3)	4.16 9.49 6.90 3.51 3.03	LAUMONTITE*
21.35(3)	7.24 11.41(8) 14.76(3) 20.51(1)	4.16 12.2 7.75 6.00 4.33	ULEXITE**
21.41	35.48(8) 41.61(1) 43.72(3) 56.11(6)	4.15 2.53 2.17 2.07 1.639	CRISTOBALITE, HIGH
21.41(3)	13.64 15.01 19.08(4) 31.27(4)	4.15 6.49 5.90 4.65 2.86	NATROLITE*
21.51(7)	12.36 24.87 35.77(4) 38.64(7)	4.13 7.16 3.58 2.51 2.33	DICKITE
21.51(4)	12.31 17.81(2) 27.96(8) 28.42(3)	4.13 7.19 4.98 3.19 3.14	PHILLIPSITE*
21.51(3)	7.12 14.28(2) 28.79(5) 36.22(3)	4.13 12.4 6.2 3.10 2.48	NA-MONTMORILLONITE
21.67	8.50(3) 10.80(6) 20.75(5) 31.72(8)	4.10 10.4 8.19 4.28 2.82	LEVYNITE*
21.67	20.51-20.32(9) 23.28(5) 30.08(2) 36.06(2)	4.10 4.33-4.37 3.82 2.97 2.49	TRIDYMITE
21.72(7)	10.35(10-8) 28.51(10-5) 29.67(6)	4.09 8.54 3.13 3.01	CORDIERITE
21.78(6)	10.92(4) 13.88 27.52(6) 28.51(8)	4.08 8.10 6.38 3.24 3.13	HARMOTOME*
21.83	9.77 19.04(3) 29.37(4) 32.19(3)	4.07 9.05 4.66 3.04 2.78	STILBITE*, SODIAN
21.94	28.42(1) 31.50(1) 36.06(2) 36.37(1)	4.05 3.14 2.84 2.49 2.47	CRISTOBALITE, LOW
22.05	28.14-27.79 30.61-30.29(7) 33.82(5)	4.03 3.17-3.21 2.92-2.95 2.65	PLAGIOCLASE
22.05(9)	17.56(5) 18.52 28.24(2) 37.79(3)	4.03 5.05 4.79 3.16 2.38	ROEMERITE**
22.05(5)	10.93(4) 17.70(3) 31.16(6) 33.30	4.03 8.09 5.01 2.87 2.69	ZOISITE
22.11(6)	10.96 21.10 31.50(5) 33.43(9)	4.02 8.07 4.21 2.84 2.68	ZUNYITE
22.22(5)	13.83-13.94(5) 30.08-30.72(8) 34.77-34.63	4.00 6.40-6.35 2.97-2.91 2.58-2.59	TOURMALINE
22.28	35.05(3) 38.81(5) 42.43(5) 43.50(5)	3.99 2.56 2.32 2.13 2.08	DIASPORE

22.39(7)	16.23(9) 19.86 26.20(6) 27.44(5)	3.97 5.46 4.47 3.40 3.25	ROZENITE••
22.45(10-6)	9.88 22.80(5) 30.08(7) 32.80(3)	3.96 8.95 3.90 2.97 2.73	CLINOPTILOLITE•
22.56-22.74(4)	21.30(6) 23.59-23.79(5) 27.01	3.94-3.91 4.17 3.77-3.74 3.30	K-FELDSPARS
22.68	9.99(8) 11.34(7) 17.38(7) 30.19(9)	3.92 8.85 7.80 5.10 2.96	HEULANDITE•
22.68(7)	15.99 19.59(9) 25.30(6) 32.31(9)	3.92 5.54 4.53 3.52 2.77	ANDALUSITE
22.74(7)	10.16(8) 10.65 20.41 30.72(5)	3.91 8.70 8.30 4.35 2.91	DIADOCHITE
22.74(5)	32.07 35.48(6) 36.37(6) 39.70(3)	3.91 2.79 2.53 2.47 2.27	FORSTERITE, FERROAN
22.80-22.50	11.32 24.94(4) 30.29-29.98(9-5)	3.90-3.95 7.81 3.57 2.95-2.98	APOPHYLLITE
22.98(7)	9.94(9) 25.82 27.79(9) 30.61(6)	3.87 8.89 3.45 3.21 2.92	EPISTILBITE•
23.10(5)	15.71(5) 22.22(3) 28.51 35.19(5)	3.85 5.64 4.00 3.13 2.55	COLEMANITE
23.10	25.89(4) 27.79(6) 28.70(2) 28.98(1)	3.85 3.44 3.21 3.11 3.08	SULFUR, ORTHORHOMBIC
23.34(5)	25.67-25.89 28.98-29.47(7) 33.43(3)	3.81 3.47-3.44 3.08-3.03 2.68	SCAPOLITE
23.47(5)	12.36 20.80(3) 24.87 38.64(7)	3.79 7.16 4.27 3.58 2.33	DICKITE
23.79-23.47(5)	20.95-21.67(5) 26.68-27.70	3.74-3.79 4.24-4.10 3.34-3.22	K-FELDSPARS
23.79-23.47(5)	22.11-22.00(5) 28.14-27.79	3.74-3.79 4.02-4.04 3.17-3.21	PLAGIOCLASE
23.53	19.04(2) 23.85(6) 29.47(6) 33.82(5)	3.78 4.66 3.73 3.03 2.65	NITER••
23.53(6)	16.14(1) 18.10 18.21(5)	3.78 5.49 4.90 4.87	MELANTERITE••
23.72(10-5)	14.88(6) 26.05(6) 30.29 35.77	3.75 5.95 3.42 2.95 2.51	MAGHEMITE
23.72(6)	7.75 13.39(8) 20.55(6) 31.27(7)	3.75 11.4 6.61 4.32 2.86	ERIONITE•
23.79-23.53(5)	13.41-14.05(4) 25.82-25.52(5)	3.74-3.78 6.60-6.30 3.45-3.49	FELDSPARS
23.85(7)	7.01 10.94(5) 14.33(7) 16.75(7)	3.73 12.6 8.08 6.18 5.29	HYDROBASALUMINITE
23.85(6)	23.53 29.47(6) 33.82(5) 41.22(4)	3.73 3.78 3.03 2.65 2.19	NITER••
23.85(5)	32.55 35.33(8) 40.25(3) 53.05(10-6)	3.73 2.75 2.54 2.24 1.726	ILMENITE
23.92	24.18(5) 34.08(2) 42.02(3) 44.86(2)	3.72 3.68 2.63 2.15 2.02	WITHERITE
24.11(6)	27.88(6) 29.37(3) 30.40 38.13(7)	3.69 3.20 3.04 2.94 2.36	TOPAZ
24.11(2)	8.50 19.86(4) 27.61(3) 35.19(3)	3.69 10.4 4.47 3.23 2.55	PALYGORSKITE

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
24.18(7)	9.40 14.96(6) 16.50(6) 22.98(6)	3.68 9.40 5.92 5.37 3.87	BASALUMINITE
24.18(5)	23.92 34.08(2) 42.02(3) 44.86(2)	3.68 3.72 2.63 2.15 2.02	WITHERITE
24.25(2)	33.30 35.77(5) 41.02(2) 54.20(6)	3.67 2.69 2.51 2.20 1.692	HEMATITE
24.31(3)	31.50 41.61(2) 45.34(2) 51.85(3)	3.66 2.84 2.17 2.00 1.763	RHODOCHROSITE
24.38-24.59(5)	22.11-22.00(5) 28.14-27.79 30.61-30.29(7)	3.65-3.62 4.02-4.04 3.17-3.21 2.92-2.95	PLAGIOCLASE
24.38-25.08(7)	12.12 19.42(5) 43.28(3)	3.65-3.55 7.30 4.57 2.09	CHRYSOTILE, 2M
24.52-24.66	12.12 19.12-19.21(3) 35.62(5)	3.63-3.61 7.30 4.64-4.62 2.52	ANTIGORITE, 6M
24.66(8)	12.19 34.08(6) 36.83(5) 60.64	3.61 7.26 2.63 2.44 1.527	GARNIERITE (1:1 LAYER)
24.66(6)	22.98(4) 26.85 27.18 30.50(8)	3.61 3.87 3.32 3.28 2.93	CARNALLITE**
30.50(6)	32.07 38.29(5) 42.43(2) 52.79(8)	3.59 2.79 2.35 2.13 1.734	SIDERITE
24.87	12.41-12.34 20.04-19.90(7) 35.05(3)	3.58 7.13-7.17 4.43-4.46 2.56	KAOLIN MINERALS
24.87(9)	27.01 32.80(9) 43.95(6) 49.97(9)	3.58 3.30 2.73 2.06 1.825	VATERITE
24.94(6)	11.32 22.62 30.19(5) 36.06(5)	3.57 7.81 3.93 2.96 2.49	APOPHYLLITE
25.01(8)	12.27 34.91 41.02(9) 57.60(6)	3.56 7.21 2.57 2.20 1.600	GREENALITE
25.01(8)	12.46-12.29 36.22(8-4) 37.79(8)	3.56 7.10-7.20 2.48 2.38	AL-SERPENTINE
25.01(5)	4.93 9.93(4) 19.95(3) 30.29(3)	3.56 17.9 8.90 4.45 2.95	SMECTITE, GLYCEROLATED
25.01-25.15(10-7)	12.46 32.92(3) 36.67(4)	3.56-3.54 7.10 2.72 2.45	CRONSTEDTITE
25.01-24.31	12.07-12.48 19.29-19.33(7) 35.92(5)	3.56-3.66 7.33-7.09 4.60-4.59 2.50	ANTIGORITE, 6O
25.08(7)	12.46 20.18(4) 25.08(7) 38.81(8)	3.55 7.10 4.40 3.55 2.32	CHRYSOTILE, 2O
25.08-25.30	12.43-12.53 33.43(7) 35.62(7)	3.55-3.52 7.12-7.06 2.68 2.52	CHAMOSITE
25.08-24.73(2)	6.18 12.39(2) 19.38(5) 37.63(3)	3.55-3.60 14.3 7.14 4.58 2.39	VERMICULITE
25.08-24.31(6)	12.46-12.12 35.92 42.43-42.02(3)	3.55-3.66 7.10-7.30 2.50 2.13-2.15	LIZARDITE
25.15	25.82(7) 36.22(3) 36.67(3) 44.17(5)	3.54 3.45 2.48 2.45 2.05	STRONTIANITE
25.15(7)	12.48 25.15(7) 32.92(5) 36.83(4)	3.54 7.09 3.54 2.72 2.44	CRONSTEDTITE
25.15-25.30(9)	6.22(3) 12.46 18.88(4) 31.72(3)	3.54-3.52 14.2 7.10 4.70 2.82	CHLORITES
25.22(8)	13.92 21.05(6) 27.79(8) 28.60(5)	3.53 6.36 4.22 3.21 3.12	CARNOTITE

25.22(7)	3.04(3) 6.22 12.50(2) 18.76(2)	3.53 29.0 14.2 7.08 4.73	CORRENSITE
25.30	12.53 19.55(2) 36.22(6) 47.21(7)	3.52 7.06 4.54 2.48 1.925	AMESITE
25.30	36.99(1) 37.79(2) 38.46(1) 48.08(3)	3.52 2.43 2.38 2.34 1.892	ANATASE
25.37	25.67(8) 30.83(9) 36.37(2) 37.31(2)	3.51 3.47 2.90 2.47 2.41	BROOKITE
25.37(9)	14.56(2) 18.40 20.55(4) 23.47(3)	3.51 6.08 4.82 4.32 3.79	PICKERINGITE••
25.37(7)	11.52(5) 23.16(6) 26.93(8) 29.98	3.51 7.68 3.84 3.31 2.98	WOLLASTONITE
25.44(5)	3.68(2) 7.12 19.55 34.22(9)	3.50 24.0 12.4 4.54 2.62	STEVENSITE
25.52	31.38(3) 38.64(2) 40.83(2) 43.28(1)	3.49 2.85 2.33 2.21 2.09	ANHYDRITE
25.59	14.71(3) 18.60 20.70(5) 21.72(4)	3.48 6.02 4.77 4.29 4.09	HALOTRICHITE••
25.59	18.10(4) 32.55(8) 37.47(2) 46.04(2)	3.48 4.90 2.75 2.40 1.971	PSEUDOBROOKITE
25.59	6.45(5) 9.71(9) 13.39(9) 27.70	3.48 13.7 9.10 6.61 3.22	MORDENITE•
25.59(9)	27.18(6) 28.98 31.84(3) 35.19	3.48 3.28 3.08 2.81 2.55	PREHNITE
25.59(7)	35.19(9) 37.79(4) 43.28 52.56(4)	3.48 2.55 2.38 2.09 1.741	CORUNDUM
25.67(8)	25.37 30.83(9) 36.37(2) 37.31(2)	3.47 3.51 2.90 2.47 2.41	BROOKITE
25.67(7)	13.58(4) 25.08(4) 25.67(7) 26.60	3.47 6.52 3.55 3.47 3.35	CELSIAN
25.67(6)	12.77(3) 22.92(4) 37.31(7) 41.22	3.47 6.93 3.88 2.41 2.19	PSILOMELANE (ROMANECHITE)
25.67(5)	17.63(5) 30.94 32.07(8)	3.47 5.03 2.89 2.79	CLINOZOISITE
25.67-25.89	23.34(5) 28.98-29.47(7) 33.43(3)	3.47-3.44 3.81 3.08-3.03 2.68	SCAPOLITE
25.74(5)	15.60(4) 30.61 41.02(2) 52.59(6)	3.46 5.68 2.92 2.20 1.740	VISEITE
25.82	9.94(9) 18.06(6) 27.79(9) 30.61(6)	3.45 8.89 4.91 3.21 2.92	EPISTILBITE•
25.82(7)	25.15 36.22(3) 36.52(4) 44.17(5)	3.45 3.54 2.48 2.46 2.05	STRONTIANITE
25.82(4)	20.27(3) 21.10(6) 30.50 31.96(8)	3.45 4.38 4.21 2.93 2.80	SPODUMENE
25.89	22.80(6) 26.93(7) 28.79(9) 42.64(8)	3.44 3.90 3.31 3.10 2.12	BARITE
25.89	18.29(3) 26.44(2) 28.60(4) 35.62(3)	3.44 4.85 3.37 3.12 2.52	SZOMOLNOKITE••
25.97	16.44(5) 26.28 35.19(4) 40.83(6)	3.43 5.39 3.39 2.55 2.21	MULLITE (SYN)
25.97(6)	7.30 12.71(6) 21.89(4) 29.98(8)	3.43 12.1 6.96 4.06 2.98	FIBROFERITE••

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
25.97	15.79(8) 18.29(4) 30.50(7) 35.77(3)	3.43 5.61 4.85 2.93 2.51	ANALCIME*
26.13	18.32(9) 26.44(5) 26.77(9) 29.28(8)	3.41 4.84 3.37 3.33 3.05	KIESERITE**
26.13	26.52 33.43(3) 35.48(8) 41.02	3.41 3.36 2.68 2.53 2.20	SILLIMANITE
26.20	20.46(2) 35.92(1) 45.10(1) 49.62(1)	3.40 4.34 2.50 2.01 1.837	QUARTZ, HIGH (SYN)
26.20-25.67(5-8)	3.68(5-8) 7.36(10-8) 18.02(5)	3.40-3.47 24.0 12.0 4.92	HYDROBIOTITE
26.20	27.27(5) 33.17(5) 36.22(3) 45.90(7)	3.40 3.27 2.70 2.48 1.977	ARAGONITE
26.20	33.95(6) 37.31(2) 39.52(5) 53.65(4)	3.40 2.64 2.41 2.28 1.708	MANGANITE
26.20	16.44(8) 25.97(6) 33.30(4) 35.33(4)	3.40 5.39 3.43 2.69 2.54	MULLITE (SYN)
26.20(7)	9.90 19.90(5) 26.20(7) 36.99(6)	3.40 8.93 4.46 3.40 2.43	HYDRALSITE (SYN)
26.20(6)	12.92(5) 16.23(9) 19.86 27.70(5)	3.40 6.85 5.46 4.47 3.22	ROZENITE
26.20(5)	5.20 10.46(4) 15.60(5) 31.84(4)	3.40 16.99 8.45 5.68 2.81	SMECTITE, GLYCOLATED
26.20(5)	8.75 19.90(8) 35.05(5)	3.40 10.1 4.46 2.56	HALLOYSITE, HYDRATED
26.28	15.91(8) 18.32(4) 26.05(6) 30.72(5)	3.39 5.57 4.84 3.42 2.91	WAIRAKITE*
26.36(6)	15.62 32.19(9) 34.49(7) 35.92(4)	3.38 5.67 2.78 2.60 2.50	DAWSONITE
26.36(1)	21.25 33.30(3) 36.67(3) 41.22(2)	3.38 4.18 2.69 2.45 2.19	GOETHITE
26.52	8.75 17.73(2) 26.52 33.69(7) 36.67(5)	3.36 10.1 5.00 3.36 2.66 2.45	BIOTITE
26.52	16.53(7) 26.05(8) 33.43(2) 41.02	3.36 5.36 3.42 2.68 2.20	SILLIMANITE
26.52	42.43(1) 44.63(5) 50.71(<1) 54.69(8)	3.36 2.13 2.03 1.800 1.678	GRAPHITE
26.52(6)	9.36(4) 10.71 16.26(6) 32.43(4)	3.36 9.44 8.26 5.45 2.76	COQUIMBITE
26.60	13.58(7) 25.67(7) 29.57(6) 32.31(4)	3.35 6.52 3.47 3.02 2.77	CELSIAN
26.60(7)	20.65(2) 28.05 33.17(2) 35.62(3)	3.35 4.30 3.18 2.70 2.52	KYANITE
26.60-26.44(3)	7.36-7.24 11.91(2) 20.60(2) 27.96(2)	3.35-3.37 12.0-12.2 7.43 4.31 3.19	SEPIOLITE
26.60-26.85	8.75-8.87 17.73-17.81(4) 19.81	3.35-3.32 10.1-9.96 5.00-4.98 4.48	ILLITE AND MICAS
26.68	20.85(3) 36.52(1) 39.52(1) 50.20(1)	3.34 4.26 2.46 2.28 1.817	QUARTZ, LOW
26.68(5)	8.75 19.99 35.05(5)	3.34 10.1 4.44 2.56	HALLOYSITE, HYDRATED
26.68(3)	9.61 19.42(5) 29.08 36.83(2)	3.34 9.20 4.57 3.07 2.44	PYROPHYLLITE

26.77(9)	18.32(9) 26.13 29.28(8) 44.17(9)	3.33 4.84 3.41 3.05 2.05	KIESERITE••
26.77(6)	9.69 18.76(5) 25.08(5) 28.70(7)	3.33 9.12 4.73 3.55 3.11	RHOMBOCLASE••
26.85	11.95(7) 16.88(3) 35.33(7) 39.52(3)	3.32 7.40 5.25 2.54 2.28	AKAGANEITE (SYN)
26.85	22.98(4) 23.72(7) 24.66(6) 30.50(8)	3.32 3.87 3.75 3.61 2.93	CARNALLITE••
26.93-27.10	21.67-20.95(7) 22.74-22.56(4)	3.31-3.29 4.10-4.24 3.91-3.94	K-FELDSPARS
26.93	21.05(7) 23.59(8) 27.10(6) 29.98(4)	3.31 4.22 3.77 3.29 2.98	ORTHOCLASE
26.93(8)	11.52(5) 23.22(7) 25.37(8) 29.98	3.31 7.68 3.83 3.51 2.98	WOLLASTONITE
27.01	24.87(9) 32.80(9) 43.95(6) 49.97(9)	3.30 3.58 2.73 2.06 1.825	VATERITE
27.01	20.04(5) 35.62(4) 43.72(2) 53.52(4)	3.30 4.43 2.52 2.07 1.712	ZIRCON
27.01(9)	23.59(3) 28.14(6) 30.08 32.80(6)	3.30 3.77 3.17 2.97 2.73	CELESTITE
27.01(2)	18.40 20.46(4) 37.79(2)	3.30 4.82 4.34 2.38	GIBBSITE
27.10	13.31(2) 23.79(2) 28.79(1) 29.37(1)	3.29 6.65 3.74 3.10 3.04	SULFUR, MONOCLINIC
27.10	9.02(8) 26.68(5) 28.98(4) 34.63(2)	3.29 9.80 3.34 3.08 2.59	ZINNWALDITE, 1M
27.10(9-4)	14.14 36.37(5) 38.13(1) 46.90(7)	3.29 6.26 2.47 2.36 1.937	LEPIDOCROCITE
27.10(5)	10.44 28.42(7) 32.92 35.33	3.29 8.47 3.14 2.72 2.54	ACTINOLITE
27.18(7)	18.92(3) 23.72(7) 24.66(6) 26.85	3.28 4.69 3.75 3.61 3.32	CARNALLITE••
27.18(6)	25.59(9) 28.98 35.19 37.96(4)	3.28 3.48 3.08 2.55 2.37	PREHNITE
27.27	10.55 26.36(4) 28.60 33.17(9)	3.27 8.38 3.38 3.12 2.70	TREMOLITE
27.27(6)	21.20(5) 27.27(6) 29.78 31.05(6) 34.91(3)	3.27 4.19 3.27 3.00 2.88 2.57	NEPHELINE
27.27(5)	26.20 33.17(5) 37.96(4) 45.90(6)	3.27 3.40 2.70 2.37 1.977	ARAGONITE
27.35(6)	16.14 27.35(6) 27.79(8) 28.70(6)	3.26 5.49 3.26 3.21 3.11	MIRABILITE••
27.44	36.06(5) 41.22(2) 44.17(1) 54.38(6)	3.25 2.49 2.19 2.05 1.687	RUTILE
27.44(5)	16.23(9) 12.92(5) 19.86 26.20(6)	3.25 5.46 6.85 4.47 3.40	ROZENITE
27.52	21.05(6) 23.40(2) 27.10(4) 29.57(2)	3.24 4.22 3.80 3.29 3.02	MICROCLINE
27.52(6)	10.71 19.77(3) 24.38(3) 29.28	3.24 8.26 4.49 3.65 3.05	ANTHOPHYLLITE
27.61	17.99(3) 29.88(9) 34.63(9) 44.17(4)	3.23 4.93 2.99 2.59 2.05	TITANITE (SPHENE)

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
27.61(8)	30.29(7) 29.88 34.91(6) 35.62(6)	3.23 2.95 2.99 2.57 2.52	AUGITE
27.61(4)	21.67 20.51(9) 23.28(5) 30.08(2)	3.23 4.10 4.33 3.82 2.97	TRIDYMITE
27.61(2)	8.50 13.75(2) 19.86(3) 35.19(3)	3.23 10.4 6.44 4.47 2.55	PALYGORSKITE
27.70	6.45(5) 9.71(9) 13.39(9) 25.59	3.22 13.7 9.10 6.61 3.48	MORDENITE*
27.79(9)	9.94(9) 18.06(7) 25.82 27.79(9)	3.21 8.89 4.91 3.45 3.21	EPISTILBITE
27.79(8)	16.14 18.60(4) 27.35(6) 28.70(6)	3.21 5.49 4.77 3.26 3.11	MIRABILITE**
27.79(8)	29.57 30.83 34.91(6) 42.02(4)	3.21 3.02 2.90 2.57 2.15	PIGEONITE
27.79(8)	13.92 21.05(6) 25.22(8) 28.51(5)	3.21 6.36 4.22 3.53 3.13	CARNOTITE (SYN)
27.79(7)	9.13(5) 25.08(1) 35.05 42.85(6)	3.21 9.68 3.55 2.56 2.11	CLINTONITE
27.79(6)	15.38(1) 23.10 25.89(4) 28.70(2)	3.21 5.76 3.85 3.44 3.11	SULFUR, ORTHORHOMBIC
27.79-28.05	22.05 30.61-30.29(4) 33.82(5)	3.21-3.18 4.03 2.92-2.95 2.65	PLAGIOCLASE
27.88(10-7)	9.11 19.99(9-3) 35.33(9) 62.73(2)	3.20 9.70 4.44 2.54 1.481	PARAGONITE
27.88(6)	24.11(6) 29.37(3) 30.40 38.13(7)	3.20 3.69 3.04 2.94 2.36	TOPAZ
27.88(3)	18.84(9) 20.41(7) 40.63 53.15(4)	3.20 4.71 4.35 2.22 1.723	BAYERITE
27.96	22.05(6) 24.31(7) 27.70(6) 28.33(5)	3.19 4.03 3.66 3.22 3.15	ALBITE, LOW
27.96(8)	12.29 17.73(2) 21.51(4) 28.42(3)	3.19 7.20 5.00 4.13 3.14	PHILLIPSITE*
28.05	14.76(4) 30.72(10-3) 31.05(3) 51.01(2)	3.18 6.00 2.91 2.88 1.790	POLYHALITE**
28.05	9.25(1) 30.94(4) 35.62(10-2) 47.66(3)	3.18 9.56 2.89 2.52 1.908	MARGARITE
28.05	20.65(2) 23.59(2) 26.60(7) 35.62(3)	3.18 4.30 3.77 3.35 2.52	KYANITE
28.05	30.19(3) 31.05(5) 35.05(4) 36.22(3)	3.18 2.96 2.88 2.56 2.48	HYPERSTHENE
28.05(8)	14.23(8-2) 28.51 28.70(8) 31.96(7)	3.18 6.22 3.13 3.11 2.80	GLAUBERITE**
28.05(5)	19.04(7) 29.08(5) 32.19 33.82(5)	3.18 4.66 3.07 2.78 2.65	THENARDITE**
28.14-28.33	27.01(3) 31.16 35.48(3) 36.06(5)	3.17-3.15 3.30 2.87 2.53 2.49	ENSTATITE
28.24	29.57(7) 32.80(3) 41.41(2) 43.28(2)	3.16 3.02 2.73 2.18 2.09	KAINITE**
28.24(6)	14.49 38.29(5) 48.91(3) 49.08(2)	3.16 6.11 2.35 1.862 1.856	BOEHMITE
28.24-28.89	32.68(5) 47.87-46.82(6) 56.83-55.70(4)	3.16-3.09 2.74 1.90-1.94 1.62-1.65	URANINITE

28.33	40.63(6) 50.23(2) 66.44(2)	3.15 2.22 1.816 1.407	SYLVITE..
28.33(1)	21.94 31.50(1) 36.06(2) 36.37(1)	3.15 4.05 2.84 2.49 2.47	CRISTOBALITE, LOW
28.33(9)	47.05 55.81(3) 68.71(1)	3.15 1.931 1.647 1.366	FLUORITE
28.42	37.31(5) 40.83(1) 42.43(2) 56.45(5)	3.14 2.41 2.21 2.13 1.63	PYROLUSITE
28.42	21.94(3) 29.88(2) 32.55(1) 33.82(4)	3.14 4.05 2.99 2.75 2.65	LANGBEINITE..
28.51	10.35(8) 21.72(8) 26.28(7) 33.82(5)	3.13 8.54 4.09 3.39 2.65	CORDIERITE
28.51	14.23(8-2) 28.05(8) 28.70(8) 33.43(6)	3.13 6.22 3.18 3.11 2.68	GLAUBERITE..
28.51	15.71(5) 22.22(3) 23.10(5) 35.19(5)	3.13 5.64 4.00 3.85 2.55	COLEMANITE
28.51(8)	10.92(4) 13.88 21.78(6) 27.52(6)	3.13 8.10 6.38 4.08 3.24	HARMOTOME.
28.60	10.55 27.27 30.40(4) 33.17(9)	3.12 8.38 3.27 2.94 2.70	TREMOLITE
28.60(10-4)	9.45 19.33(4) 34.49(2) 36.22(7-3)	3.12 9.35 4.59 2.60 2.48	TALC
28.60(10-4)	18.29(3) 25.89 28.60(4) 35.62(3)	3.12 4.85 3.44 3.12 2.52	SZOMOLNOKITE..
28.60(7)	13.49 19.16(8-4) 20.90(3) 25.22(5)	3.12 6.56 4.63 4.25 3.53	CARNOTITE
28.60(7)	14.91(4) 17.52 29.18(8) 32.31	3.12 5.94 5.06 3.06 2.77	NATROJAROSITE
28.70(7)	9.63-9.69 18.76(5) 26.77(6) 28.70(7)	3.11 9.18-9.12 4.73 3.33 3.11	RHOMBOCLASE
28.70(7)	15.49(2) 17.38(7) 28.98 30.08(3)	3.11 5.72 5.10 3.08 2.97	JAROSITE
28.70(6)	16.14 18.60(4) 27.35(6) 27.79(8)	3.11 5.49 4.77 3.26 3.21	MIRABILITE..
28.79	10.39-10.53 27.10-27.35(2) 32.92-33.17(2)	3.10 8.51-8.40 3.29-3.26 2.72-2.70	HORNBLENDE
28.79	8.84 19.16(8-4) 19.59(5) 34.77	3.10 10.0 4.63 4.53 2.58	CELADONITE AND GLAUCONITE
28.79	22.80(6) 25.89 26.93(7) 42.64(8)	3.10 3.90 3.44 3.31 2.12	BARITE
28.79(5)	7.12 14.28(2) 21.51 36.22(3)	3.10 12.4 6.20 4.13 2.48	NA-MONTMORILLONITE
28.79(4)	3.53 7.12(8) 17.91(4) 25.15(1)	3.10 25.0 12.4 4.95 3.54	RECTORITE
28.89	21.30(2) 27.01(5) 31.16(7)	3.09 4.17 3.30 2.87	MONAZITE
28.98	25.59(9) 27.18(6) 35.19 37.96(4)	3.08 3.48 3.28 2.55 2.37	PREHNITE
28.98	14.93(4) 15.49(3) 17.42(7) 28.70(7)	3.08 5.93 5.72 5.09 3.11	JAROSITE
28.98(4)	9.03(8) 26.68(3) 27.10 34.63(2)	3.08 9.79 3.34 3.29 2.59	ZINNWALDITE

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
28.98-29.47(7)	23.34(5) 25.67-25.89 33.43(3)	3.08-3.03 3.81 3.47-3.44 2.68	SCAPOLITE
29.08-29.37	9.60 19.42(4) 20.08(4) 37.15(4)	3.07-3.04 9.21 4.57 4.42 2.42	PYROPHYLLITE
29.18	10.62-10.71(6) 19.77(3) 27.52(5) 31.50(2)	3.06 8.33-8.26 4.49 3.24 2.84	ANTHOPHYLLITE
29.18(8)	14.91(4) 17.52 28.60(7) 32.31(4)	3.06 5.94 5.06 3.12 2.77	NATROJAROSITE
29.18(5)	11.70 20.80(5) 31.16(10-3) 33.43(2)	3.06 7.56 4.27 2.87 2.68	GYPSUM••
29.28(8)	18.32(9) 26.13 26.44(5) 26.77(9)	3.05 4.84 3.41 3.37 3.33	KIESERITE••
29.37	23.04(1) 39.34(2) 39.52(2) 43.07(2)	3.04 3.86 2.29 2.28 2.10	CALCITE
29.37(6)	10.35(10-8) 10.46(8) 28.51 33.82(5)	3.04 8.54 8.45 3.13 2.65	CORDIERITE
29.37(4)	9.66 19.04(3) 21.89 32.19(2)	3.04 9.15 4.66 4.06 2.78	STILBITE•
29.47	11.65(7) 18.80(2) 36.06(1) 39.34(2)	3.03 7.59 4.72 2.49 2.29	INYOITE••
29.47	31.84(2) 38.98(2) 47.92(2)	3.03 2.81 2.31 1.898	SODA NITER••
29.47(6)	19.04(2) 23.53 23.85(6) 33.82(5)	3.03 4.66 3.78 3.73 2.65	NITER••
29.47-29.78	21.20(5) 27.27(6) 31.05(6) 34.91(3)	3.03-3.00 4.19 3.27 2.88 2.57	NEPHELINE
29.57	19.21(2) 27.79(8) 30.83 34.91(6)	3.02 4.62 3.21 2.90 2.57	PIGEONITE
29.57(9)	3.71 7.49(8) 19.42 36.06(9)	3.02 23.8 11.8 4.57 2.49	ALIETTITE (TALC-SAPONITE)
29.57(7)	28.24 32.80(3) 41.41(2) 43.28(2)	3.02 3.16 2.73 2.18 2.09	KAINITE••
29.57(4)	5.89 17.70(5) 19.72(6) 23.04(1)	3.02 15.0 5.01 4.50 3.86	SMECTITE (MONTMORILLONITE)
29.67(6)	33.17 34.91(2) 36.52(4) 57.17(6)	3.01 2.70 2.57 2.46 1.611	ANDRADITE
29.67-29.88(10-8)	17.88-17.77(4) 25.44(3) 39.34(7) 47.87	3.01-2.99 4.96-4.99 3.50 2.29 1.900	ALUNITE
29.78	30.19(3) 34.91(5) 35.62(4)	3.00 2.96 2.57 2.52	FASSAITE
29.78(7)	30.19 35.05(2) 36.67(5) 57.48(6)	3.00 2.96 2.56 2.45 1.603	UVAROVITE
29.88	27.61(8) 30.29(7) 34.91(6) 35.62(6)	2.99 3.23 2.95 2.57 2.52	AUGITE
29.88	27.61(2) 30.29(2) 30.94(3) 35.48(4)	2.99 3.23 2.95 2.89 2.53	DIOPSIDE
29.88-30.29	23.53(1) 36.67(2) 39.88(2)	2.99-2.95 3.78 2.45 2.26	MG-CALCITE
29.88(9)	27.61 34.63(9) 39.70(3) 44.17(4)	2.99 3.23 2.59 2.27 2.05	TITANITE (SPHENE)

29.98	11.52(5) 23.22(8) 25.37(7) 26.93(8)	2.98 7.68 3.83 3.51 3.31	WOLLASTONITE
29.98	23.59(3) 36.52(3) 49.53(5)	2.98 3.77 2.46 1.840	KUTNAHORITE, CALCIAN
29.98(8)	7.30 12.71(6) 14.42(4) 25.97(6)	2.98 12.1 6.96 6.14 3.43	FIBROFERRITE..
29.98-30.29(5)	11.32 22.80-22.50 24.94(6)	2.98-2.95 7.81 3.90-3.95 3.57	APOPHYLLITE
29.98-30.72(10-8)	13.83(5) 21.00(5) 34.77	2.98-2.91 6.4 4.23 2.58	TOURMALINE
30.08(5-3)	13.41-14.05(4) 22.11-20.95(5) 23.79-23.47(5)	2.97 6.60-6.30 4.02-4.24 3.74-3.79	FELDSPARS
30.08	23.59(3) 27.01(9) 28.05(6) 32.80(6)	2.97 3.77 3.30 3.18 2.73	CELESTITE
30.08(7)	9.88 17.35(3) 22.45(5) 30.08(7)	2.97 8.95 5.11 3.96 2.97	CLINOPTILOLITE.
30.08(6)	13.01 18.06(4) 27.88(5) 33.05(6)	2.97 6.80 4.91 3.20 2.71	VIVIANITE
30.19	18.10(7) 25.52(3) 30.08(7) 40.63(5)	2.96 4.90 3.49 2.97 2.22	NATROALUNITE
30.19(9)	9.99(8) 11.34(7) 22.68 30.19(9)	2.96 8.85 7.80 3.92 2.96	HEULANDITE.
30.19(8)	33.82 36.83 38.64 55.70(8)	2.96 2.65 2.44 2.33 1.65	GROSSULAR
30.29	14.88(6) 23.72(10-5) 35.77 43.28	2.95 5.95 3.75 2.51 2.09	MAGHEMITE (SYN)
30.29(7)	27.61(8) 29.88 34.91(6) 35.62(6)	2.95 3.23 2.99 2.57 2.52	AUGITE
30.29(6)	14.99(4) 25.52(4) 32.43 34.49(8)	2.95 5.91 3.49 2.76 2.60	VESUVIANITE
30.29(3)	4.93 9.93(4) 19.95(3) 25.01(5)	2.95 17.9 8.90 4.45 3.56	SMECTITE, GLYCEROLATED
30.40	24.11(6) 27.88(6) 29.37(3) 38.13(7)	2.94 3.69 3.20 3.04 2.36	TOPAZ
30.40	23.72(3) 40.25(2) 49.53(3) 50.41(3)	2.94 3.75 2.24 1.840 1.810	KUTNAHORITE
30.40(7)	21.72(3) 24.25(2) 31.50 44.40(4)	2.94 4.09 3.67 2.84 2.04	APHTHITALITE..
30.50	9.45(5) 17.66(3) 20.55(7) 22.98(3)	2.93 9.35 5.02 4.32 3.87	CHABAZITE.
30.50	21.10(6) 25.82(4) 31.96(8) 36.67(6)	2.93 4.21 3.45 2.80 2.45	SPODUMENE
30.50(8)	23.72(7) 24.66(6) 25.01(7) 26.85	2.93 3.75 3.61 3.56 3.32	CARNALLITE..
30.50(7)	15.79(8) 18.29(4) 30.50(7) 33.17(4-2)	2.93 5.61 4.85 2.93 2.70	ANALCIME.
30.61	15.60(4) 25.74(5) 41.02(2) 52.59(6)	2.92 5.68 3.46 2.20 1.740	VISEITE
30.72	23.85(1) 41.02(1) 50.11(3) 50.59(1)	2.91 3.73 2.20 1.820 1.804	KUTNAHORITE, MAGNESIAN

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
30.72(10-3)	14.76(2) 28.05 31.05(3) 51.01(2)	2.91 6.00 3.18 2.88 1.790	POLYHALITE••
30.72-30.83(4)	22.56-22.74(5) 26.85-27.79	2.91-2.90 3.94-3.91 3.32-3.21	K-FELDSPARS
30.83	27.79(8) 29.57 30.72(8) 34.91(6)	2.90 3.21 3.02 2.91 2.57	PIGEONITE
30.83	22.11(5) 33.30(7) 33.43 34.63(4)	2.90 4.02 2.69 2.68 2.59	EPIDOTE
30.83	41.02(1) 50.35(1) 50.95(<1)	2.90 2.20 1.812 1.792	ANKERITE
30.83(9)	25.37 25.67(8) 36.37(2) 37.31(2)	2.90 3.51 3.47 2.47 2.41	BROOKITE
30.83(4)	18.76(2) 36.37 44.17(4) 64.33(6)	2.90 4.73 2.47 2.05 1.448	SPINEL, FERRIAN
30.94	33.56(1) 41.22(3) 45.10(1) 51.14(2)	2.89 2.67 2.19 2.01 1.786	DOLOMITE
30.94	11.04(4) 22.22(4) 25.67(5) 32.07(8)	2.89 8.01 4.00 3.47 2.79	CLINOZOISITE
30.94(8)	13.33 15.06(3) 19.99 20.18(3)	2.89 6.64 5.88 4.44 4.40	SCOLECITE•
31.05(6)	7.68 15.38(3) 20.41(6) 23.16(4)	2.88 11.5 5.76 4.35 3.84	OFFRETITE•
31.05(5)	28.05 30.19(3) 35.05(4) 35.77(3)	2.88 3.18 2.96 2.56 2.51	HYPERSTHENE
31.16	28.33 35.48(3) 30.40(4) 36.06(5)	2.87 3.15 2.53 2.94 2.49	ENSTATITE
31.16	13.62 15.04 20.27(5) 31.38	2.87 6.50 5.89 4.38 2.85	NATROLITE•
31.16(10-3)	11.70 20.75(9) 29.18(5) 33.43(5)	2.87 7.56 4.28 3.06 2.68	GYPSUM••
31.16(7)	21.30(2) 27.01(5) 28.89	2.87 4.17 3.30 3.09	MONAZITE
31.16(6)	10.93(4) 17.70(3) 22.05(5) 33.30	2.87 8.09 5.01 4.03 2.69	ZOISITE
31.27	13.41(6) 19.12(9) 30.29(7) 33.43(8)	2.86 6.60 4.64 2.95 2.68	THOMSONITE•
31.27	13.75(4) 15.30(7) 20.41(5) 28.05(3)	2.86 6.44 5.79 4.35 3.18	MESOLITE•
31.38	13.62 15.04 20.27(5) 31.16	2.85 6.50 5.89 4.38 2.87	NATROLITE•
31.38(9-6)	25.97(2) 32.19 38.98(3) 46.57(4)	2.85 3.43 2.78 2.31 1.950	CHLORAPATITE
31.38(3)	25.52 38.64(2) 41.02(2) 48.71(1)	2.85 3.49 2.33 2.20 1.869	ANHYDRITE
31.38(1)	21.94 28.42(1) 36.06(2)	2.85 4.05 3.14 2.49	CRISTOBALITE, LOW
31.38-31.72(3)	6.22(3) 12.29 18.80(4) 25.08(8)	2.85-2.82 14.2 7.20 4.72 3.55	CHLORITES
31.38-31.84(3)	6.22 12.39(2) 19.29(3)	2.85-2.81 14.2 7.14 4.60	VERMICULITE
31.50	24.31(3) 41.61(2) 45.34(2) 51.85(3)	2.84 3.66 2.17 2.00 1.763	RHODOCHROSITE

31.50	21.72(3) 30.40(7) 36.83(2) 44.40(4)	2.84 4.09 2.94 2.44 2.04	APHTHITALITE (GLASERITE)••
31.61(10-9)	16.95(4) 25.08(8-3) 34.08(5) 35.92(10-7)	2.83 5.23 3.55 2.63 2.50	FAYALITE (FE-OLIVINE)
31.72	27.35(1) 45.48(5) 56.52(2)	2.82 3.26 1.994 1.628	HALITE••
31.72(8)	10.80(7) 20.75(5) 21.67 28.14(5)	2.82 8.19 4.28 4.10 3.17	LEVYNITE•
31.84(10-8)	25.89(4) 32.31(6-2) 32.92-33.17(10-6)	2.81 3.44 2.77 2.72-2.70	FLUORAPATITE
31.96(8)	21.10(6) 25.82(4) 30.50 36.67(6)	2.80 4.21 3.45 2.93 2.45	SPODUMENE
32.07	32.07(6) 38.46(1) 42.43(6) 52.79(8)	2.79 3.59 2.34 2.13 1.734	SIDERITE
32.07(8)	11.04(4) 22.22(4) 22.33(4) 30.94	2.79 8.01 4.00 3.98 2.89	CLINOZOISITE
32.07-32.31	22.74(5) 25.37(3) 35.48(6) 36.37(6)	2.79-2.77 3.91 3.51 2.53 2.47	FORSTERITE, FERROAN
32.19	19.04(7) 29.08(5) 28.05(5) 33.82(5)	2.78 4.66 3.07 3.18 2.65	THENARDITE••
32.19(9)	15.62 26.36(6) 34.49(7) 35.92(4)	2.78 5.67 3.38 2.60 2.50	DAWSONITE
32.19(4)	37.47 53.93(5) 64.23(1)	2.78 2.40 1.700 1.450	LIME (SYN)
32.19-32.43	26.28(1) 31.38(9-6) 38.98(3) 46.57(5)	2.78-2.76 3.39 2.85 2.31 1.950	CHLORAPATITE
32.19-32.92	25.74(3) 29.28(4) 33.30-33.43(10-4) 40.07(4)	2.78-2.72 3.46 3.05 2.69-2.68 2.25	CARBONATE-APATITE AND CARBONATE-FLUORAPATITE
32.31(9)	15.99 19.59(9) 25.30(6) 41.61(9)	2.77 5.54 4.53 3.52 2.17	ANDALUSITE
32.43(7)	9.36(4) 10.71 16.26(6) 24.45(4)	2.76 9.44 8.26 5.45 3.64	COQUIMBITE••
32.55	14.99(4) 25.52(4) 30.29(6) 34.49(8)	2.75 5.91 3.49 2.95 2.60	VESUVIANITE
32.55	23.85(3) 35.33(8) 40.25(3) 53.05	2.75 3.73 2.54 2.24 1.726	ILMENITE
32.55(8)	18.10(4) 25.59 37.47(2) 46.04(2)	2.75 4.90 3.48 2.40 1.971	PSUEDOBROOKITE
32.68	35.92(2) 43.07(4) 46.85(1) 53.93(3)	2.74 2.50 2.10 1.939 1.700	MAGNESITE
32.68-34.49(5)	28.24 33.43(5) 46.95-47.87	2.74-2.60 3.16 2.68 1.935-1.900	URANINITE
32.80(9)	24.87(9) 27.01 43.95(9) 49.97(9)	2.73 3.58 3.30 2.06 1.825	VATERITE
32.80(6)	23.59(3) 25.97(3) 28.14(6) 30.08	2.73 3.77 3.43 3.17 2.97	CELESTITE
32.92	10.44(7) 18.06(7) 28.42(7) 35.33	2.72 8.47 4.91 3.14 2.54	ACTINOLITE
32.92-33.17(3)	10.40-10.53(10-5) 27.10-27.35(2) 28.42-28.79	2.72-2.70 8.50-8.40 3.29-3.26 3.14-3.10	HORNBLENDE (SEE AMPHIBOLES)

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
32.92(5)	12.48 25.15 35.05(7) 36.83(4)	2.72 7.09 3.54 2.56 2.44	CRONSTEDTITE
32.92-32.07(10-6)	25.89(3) 31.84(10-8) 39.88(4)	2.72-2.79 3.44 2.81 2.26	CARBONATE-APATITE
33.05	25.89(4) 38.81(2) 47.47(3) 51.95(6)	2.71 3.44 2.32 1.915 1.760	MARCASITE
33.05(8)	28.60(3) 37.15(6) 40.83(5) 56.33	2.71 3.12 2.42 2.21 1.633	PYRITE
33.05(6)	11.05(3) 13.01 18.06(4) 30.08(6)	2.71 8.00 6.80 4.91 2.97	VIVIANITE
33.17(9)	10.55 27.27 28.60 35.48(4)	2.70 8.38 3.27 3.12 2.53	TREMOLITE
33.17(8)	10.94(4) 33.17(8) 33.30(6) 36.37	2.70 8.08 2.70 2.69 2.47	NORTHUPITE••
33.17(5)	26.20 27.27(5) 37.96(4) 45.90(7)	2.70 3.40 3.27 2.37 1.977	ARAGONITE
33.30	25.97(2) 29.28(3) 32.07(10-5) 40.25(4)	2.69 3.43 3.05 2.79 2.24	APATITE (CARBONATE-FLUORAPATITE)
33.30	24.25(2) 35.77(6) 41.02(2) 54.20(4)	2.69 3.67 2.51 2.20 1.692	HEMATITE
33.30	10.93(4) 17.70(3) 22.05(5) 31.16(6)	2.69 8.09 5.01 4.03 2.87	ZOISITE
33.30	29.67(6) 34.91(2) 36.52(4) 57.17(6)	2.69 3.01 2.57 2.46 1.611	ANDRADITE
33.30-33.43	22.11(5) 30.83 33.30(7) 34.49(5)	2.69-2.68 4.02 2.90 2.69 2.60	EPIDOTE
33.43	29.78(7) 35.05(2) 36.67(5) 57.48(6)	2.68 3.00 2.56 2.45 1.603	UVAROVITE
33.43(9)	10.96 21.10 22.11(6) 31.50(5)	2.68 8.07 4.21 4.02 2.84	ZUNYITE
33.43(8)	13.41(6) 19.12(9) 30.29(7) 31.27	2.68 6.60 4.64 2.95 2.86	THOMSONITE•
33.69-33.95(5)	8.75 17.73(2) 26.52 36.67(5)	2.66-2.64 10.1 5.00 3.36 2.45	BIOTITE
33.82	30.19(8) 36.83(4) 38.64 55.70(8)	2.65 2.96 2.44 2.33 1.650	GROSSULAR
33.82(5)	19.04(7) 28.05(5) 29.08(5) 32.19	2.65 4.66 3.18 3.07 2.78	THENARDITE••
33.82(5)	19.04(2) 23.53 23.85(6) 29.47(6)	2.65 4.66 3.78 3.73 3.03	NITER••
33.82(4)	21.94(3) 28.42 32.55(1) 29.88(2)	2.65 4.05 3.14 2.75 2.99	LANGBEINITE••
33.95(6)	26.20 37.31(2) 39.52(5) 53.65(4)	2.64 3.40 2.41 2.28 1.708	MANGANITE
34.08(6)	12.12 24.66(8) 36.83(5) 60.64	2.63 7.30 3.61 2.44 1.527	GARNIERITE (1:1 LAYER)
34.22-34.49(5)	6.22 19.42(6) 24.87(2) 35.05(5)	2.62-2.60 14.2 4.57 3.58 2.56	VERMICULITE
34.22(9)	7.12 19.55 25.44(5) 60.95(3)	2.62 12.4 4.54 3.50 1.520	STEVENSITE
34.35(3)	7.30 11.91(1) 20.60(4) 25.01(5)	2.61 12.1 7.43 4.31 3.56	SEPIOLITE

34.35(2)	3.68(3) 7.55 18.02(5) 26.20(3)	2.61 24.0 11.7 4.92 3.40	HYDROBIOTITE
34.49	30.72(3) 37.96(2) 57.06(3)	2.60 2.91 2.37 1.614	SPESSARTINE
34.49(8)	14.99(4) 25.52(4) 30.29(6) 32.43	2.60 5.91 3.49 2.95 2.76	VESUVIANITE
34.49(6)	15.62 26.36(6) 32.19(9) 35.92(4)	2.60 5.67 3.38 2.78 2.50	DAWSONITE
34.49(2)	9.45 19.33(5) 28.60(4) 36.22	2.60 9.35 4.59 3.12 2.48	TALC
34.49-35.19(5)	5.89 17.70(3) 19.95-19.29(5)	2.60-2.55 15.0 5.01 4.45-4.6	MONTMORILLONITE
34.63(9)	17.99(3) 27.61 29.88(9) 44.17(4)	2.59 4.93 3.23 2.99 2.05	TITANITE
34.63-34.77	13.94(6) 21.00(5) 29.98-30.72(8)	2.59-2.58 6.35 4.23 2.98-2.91	TOURMALINE
34.63-34.91	12.27 25.01(8) 41.02(4) 57.52(5)	2.59-2.57 7.21 3.56 2.20 1.602	GREENALITE
34.77	8.84 19.59(5) 24.45(5) 26.85(6)	2.58 10.0 4.53 3.64 3.32	CELADONITE AND GLAUCONITE
34.91	22.00(3) 31.16(4) 39.88(2) 57.64(4)	2.57 4.04 2.87 2.26 1.599	ALMANDINE
34.91(5)	8.93 17.73(4) 19.86(4) 26.85	2.57 9.90 5.00 4.47 3.32	ILLITE AND MICAS
34.91(5)	29.78 30.19(3) 35.62(4)	2.57 3.00 2.96 2.52	AL-AUGITE (FASSAITE)
34.91-35.05(7)	12.37 20.36(6) 24.87(9)	2.57-2.56 7.15 4.36 3.58	KAOLIN MINERALS
35.05	36.67(4) 38.64(2) 54.62(8) 57.80(3)	2.56 2.45 2.33 1.680 1.595	PYROPE
35.05	9.13(5) 25.08(1) 27.79(7) 42.85(6)	2.56 9.68 3.55 3.21 2.11	CLINTONITE
35.05(7)	12.55 25.15(7) 32.92(5) 36.83(4)	2.56 7.05 3.54 2.72 2.44	CRONSTEDTITE
35.05(6)	15.60(9) 18.40 22.68(3) 31.72(4)	2.56 5.68 4.82 3.92 2.82	BORAX**
35.05(5)	7.30 19.77(2) 20.60(4) 27.96(2)	2.56 12.1 4.49 4.31 3.19	SEPIOLITE
35.05(4)	11.94(9-6) 20.04 24.59(4)	2.56 7.41 4.43 3.62	HALLOYSITE, DEHYDRATED
35.19	7.18 14.14(5) 21.35 29.47(3)	2.55 12.3 6.26 4.16 3.03	STILPNOMELANE
35.19	19.29(2) 25.59(9) 28.98 37.96(4)	2.55 4.60 3.48 3.08 2.37	PREHNITE
35.19(3)	8.42 13.75(3) 19.86(4) 27.44(7)	2.55 10.5 6.44 4.47 3.25	PALYGORSKITE
35.19(5)	15.71(5) 22.22(3) 23.10(5) 28.51	2.55 5.64 4.00 3.85 3.13	COLEMANITE
35.19(9)	25.59(7) 43.28 52.59(4) 57.56(8)	2.55 3.48 2.09 1.74 1.601	CORUNDUM
35.33	10.44 18.06(7) 26.20(8) 32.92	2.54 8.47 4.91 3.40 2.72	ACTINOLITE

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
35.33(9)	9.11 19.99(9-3) 23.47(5) 27.88(7)	2.54 9.70 4.44 3.79 3.20	PARAGONITE
35.33(8)	23.85(3) 32.55 40.25(3) 53.05(6)	2.54 3.73 2.75 2.24 1.726	ILMENITE
35.33(7)	11.95(7) 16.88(3) 26.85 34.22(3)	2.54 7.40 5.25 3.32 2.62	AKAGANEITE (SYN)
35.48	18.29(1) 30.08(3) 43.07(2) 62.54(4)	2.53 4.85 2.97 2.10 1.485	MAGNETITE
35.48(9)	16.53(7) 26.13(9) 26.52 41.02	2.53 5.36 3.41 3.36 2.20	SILLIMANITE
35.48(8)	21.41 41.61(1) 43.72(3) 56.11(6)	2.53 4.15 2.17 2.07 1.639	CRISTOBALITE, HIGH
35.48(6)	17.38(5) 22.86(5) 32.07 36.52(6)	2.53 5.10 3.89 2.79 2.46	FORSTERITE
35.48(4)	27.61(2) 29.88 30.29(2) 30.94(3)	2.53 3.23 2.99 2.95 2.89	DIOPSIDE
35.48-35.62(10-3)	12.43-12.55(10-5) 42.02-42.85(7-4) 51.38-52.20(5)	2.53-2.52 7.12-7.05 2.15-2.11 1.778-1.752	CHAMOSITE, ORTHOGONAL
35.62(10-2)	20.27(1) 28.05(10-5) 30.94(4)	2.52 4.38 3.18 2.89	MARGARITE
35.62(3)	18.29(3) 25.89 28.60(4) 40.83(6)	2.52 4.85 3.44 3.12 2.21	SZOMOLNOKITE**
35.62-35.92(7)	12.12 24.59(10-7) 36.83(5) 41.61(2)	2.52-2.50 7.30 3.62 2.44 2.17	ANTIGORITE, 6M
35.77	30.29 32.19(2) 43.28(3) 57.60(2)	2.51 2.95 2.78 2.09 1.600	MAGHEMITE (SYN)
35.77(7)	24.25(3) 33.30 41.02(3) 54.20(4)	2.51 3.67 2.69 2.20 1.692	HEMATITE
35.77(3)	12.36 20.80(3) 24.87(9) 38.81(5)	2.51 7.16 4.27 3.58 2.32	DICKITE
35.92	12.46-12.12 25.08-24.31(6) 42.43-41.81(8-3)	2.50 7.10-7.30 3.55-3.66 2.13-2.16	LIZARDITE
35.92	25.08(8) 31.61(9) 35.05(7) 51.42(9)	2.50 3.55 2.83 2.56 1.777	FAYALITE (FE-OLIVINE)
35.92	6.22(8) 12.41(7) 19.63(9) 61.39(2)	2.50 14.2 7.13 4.52 1.510	SUDOITE (AL-CHLORITE)
35.92(5)	12.46-12.12 25.08-24.38(7) 39.70-39.16(5) 43.28-42.43(5)	2.50 7.10-7.30 3.55-3.65 2.27-2.30 2.09-2.13	CHRYSOTILE
35.92-36.06(3)	12.37 24.94(9) 38.46(4)	2.50-2.49 7.15 3.57 2.34	KAOLINITE
36.06(9)	3.71 7.49(8) 19.42 29.57(9)	2.49 23.8 11.8 4.57 3.02	ALIETTITE
36.06(9)	11.32 19.68(4) 22.80(10-5) 24.94(6)	2.49 7.81 4.51 3.90 3.57	APOPHYLLITE
36.06(5)	27.44 41.22(2) 44.17(1) 54.38(6)	2.49 3.25 2.19 2.05 1.687	RUTILE
36.06(2)	21.94 28.42(1) 31.50(1) 36.37(<1)	2.49 4.05 3.14 2.84 2.47	CRISTOBALITE, LOW
36.06(4)	27.01(3) 28.33 31.16 35.48(3)	2.49 3.30 3.15 2.87 2.53	ENSTATITE

36.22(6)	12.53 25.30 38.81(5) 47.21(7)	2.48 7.06 3.52 2.32 1.925	AMESITE
36.22-36.37(10-3)	9.45 19.33(5) 28.70(6) 34.63(4)	2.48-2.47 9.35 4.59 3.11 2.59	TALC
36.37	10.94(4) 27.79(4) 33.17(8) 42.85(6)	2.47 8.08 3.21 2.70 2.11	NORTHUPITE..
36.37	18.76(2) 30.83(4) 44.17(4) 64.33(6)	2.47 4.73 2.90 2.05 1.448	SPINEL, FERRIAN
36.37(8)	14.14 27.10(9) 38.13(1) 46.90(7)	2.47 6.26 3.29 2.36 1.937	LEPIDOCROCITE
36.37(6)	17.21(2) 22.86(5) 32.07 35.48(6)	2.47 5.15 3.89 2.79 2.53	FORSTERITE, FERROAN
36.37(4)	11.94 13.35(8) 24.05(3) 27.44(2)	2.47 7.41 6.63 3.70 3.25	KERNITE..
36.52(7)	12.53 19.33(4) 25.22 36.52(7) 61.08(5)	2.46 7.06 4.59 3.53 2.46 1.517	CHAMOSITE, FERRIC
36.52	17.38(5) 22.92(7) 32.43(6) 35.77(7)	2.46 5.10 3.88 2.76 2.51	FORSTERITE
36.52(1)	20.85(3) 26.68 39.52(1) 50.20(2)	2.46 4.26 3.34 2.28 1.817	QUARTZ, LOW
36.67-37.15(4)	12.10 24.73(7) 35.62-35.92(4)	2.45-2.42 7.31 3.60 2.52-2.50	ANTIGORITE
36.83(3)	21.25 33.30(3) 36.06(1) 41.22(2)	2.44 4.18 2.69 2.49 2.19	GOETHITE
36.83	19.04(3) 31.38(4) 44.86(6) 59.43(4)	2.44 4.66 2.85 2.02 1.555	SPINEL, MAGNESIAN
36.83	30.19(8) 33.82 38.64 55.70(8)	2.44 2.96 2.65 2.33 1.65	GROSSULAR
36.99(6)	9.90 19.90(5) 26.20(7) 43.72(3)	2.43 8.93 4.46 3.40 2.07	HYDRALSITE (SYN)
36.99(4)	12.32 20.36(7) 20.36(9) 37.47(4)	2.43 7.18 4.36 3.59 2.40	NACRITE
37.15-37.31(5)	9.60 19.38(5) 20.08(6) 28.98	2.42-2.41 9.21 4.58 4.42 3.08	PYROPHYLLITE
37.31(10-7)	12.73(5) 25.59(6) 31.05(4) 41.22(8)	2.41 6.95 3.48 2.88 2.19	PSILOMELANE
37.31(5)	25.59(1) 28.42 42.43(2) 56.45(5)	2.41 3.48 3.14 2.13 1.630	PYROLUSITE
37.31(4)	12.55 25.30 33.43(4) 59.10(6)	2.41 7.05 3.52 2.68 1.563	CHAMOSITE, MONOCLINIC
37.47	32.19(4) 53.89(5) 64.18(1)	2.40 2.78 1.701 1.451	LIME (SYN)
37.79(7)	25.30 36.99(1) 37.96(1) 48.08(3)	2.38 3.52 2.43 2.37 1.892	ANATASE
37.79(3)	12.39 20.36(5) 24.87(9) 39.34(3)	2.38 7.14 4.36 3.58 2.29	KAOLINITE
37.96	18.60 50.89(5) 58.69(3)	2.37 4.77 1.794 1.573	BRUCITE
37.96(7)	9.35(5) 18.84 28.42(3) 48.41(7)	2.37 9.45 4.71 3.14 1.880	LITHIOPHORITE
38.46(6)	12.39 20.36(6) 24.87 36.06(6)	2.34 7.14 4.36 3.58 2.49	KAOLINITE

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
38.46(5)	14.49 28.24(6) 48.91(3) 49.08(3)	2.34 6.11 3.16 1.862 1.856	BOEHMITE
38.64	30.19(8) 33.82 36.83 55.70(8)	2.33 2.96 2.65 2.44 1.650	GROSSULAR
38.64(7)	12.46 20.18(4) 25.08(7) 35.92(5)	2.33 7.10 4.40 3.55 2.50	CHRYSOTITE (20)
38.64-38.81(7)	12.36 23.79(4) 24.87(9) 35.77(5)	2.33-2.32 7.16 3.74 3.58 2.51	DICKITE
38.81(5)	22.28 35.19(3) 42.43(5) 43.50(5)	2.32 3.99 2.55 2.13 2.08	DIASPORE
39.34(7)	17.81(5) 15.38(3) 29.88 47.87(10-3)	2.29 4.98 5.76 2.99 1.900	ALUNITE
39.34(2)	23.04(1) 29.37 39.52(2) 43.07(2)	2.29 3.86 3.04 2.28 2.10	CALCITE
39.52(5)	26.20 33.95(6) 37.31(2) 53.65(4)	2.28 3.40 2.64 2.41 1.708	MANGANITE
40.07(5)	23.53(4) 29.98 36.52(4) 49.53(6)	2.25 3.78 2.98 2.46 1.840	KUTNAHORITE CALCIAN
40.63	18.84(9) 20.41(7) 27.88(3) 53.15(4)	2.22 4.71 4.35 3.20 1.723	BAYERITE
40.63(6)	28.33 50.23(2) 66.44(2)	2.22 3.15 1.816 1.407	SYLVITE••
40.63(5)	15.88(2) 18.10(7) 25.52(3) 30.19	2.22 5.58 4.90 3.49 2.96	NATROALUNITE
40.83(6)	16.44(8) 25.97(6) 26.20 33.30(4)	2.21 5.39 3.43 3.40 2.69	MULLITE (SYN)
41.02	16.53(7) 26.05(8) 26.52 33.43(2)	2.20 5.36 3.42 3.36 2.68	SILLIMANITE
41.02(3)	24.25(2) 33.30 35.77(6) 54.20(4)	2.20 3.67 2.69 2.51 1.692	HEMATITE
41.22(8)	22.45(5) 25.59(6) 31.05(4) 37.31	2.19 3.96 3.48 2.88 2.41	PSILOMELANE
41.22(3)	30.94 33.56(1) 45.10(1) 51.35(3)	2.19 2.89 2.67 2.01 1.779	DOLOMITE
41.61-43.07(7-2)	12.00-12.46 24.31-25.22 35.62-37.79(8)	2.17-2.10 7.37-7.10 3.66-3.53 2.52-2.38	SERPENTINE GROUP
42.43(5)	22.28 35.05(3) 38.81(5) 43.50(5)	2.13 3.99 2.56 2.32 2.08	DIASPORE
42.85	36.99(1) 62.35(5) 78.68(1)	2.11 2.43 1.489 1.216	PERICLASE
43.07-42.02(7-4)	12.43-12.55 19.12(5) 25.08-25.22	2.10-2.15 7.12-7.05 4.64 3.55-3.53	CHAMOSITE
43.28	25.59(7) 35.19(9) 52.59(4) 57.56(8)	2.09 3.48 2.55 1.740 1.601	CORUNDUM
43.50(5)	22.28 35.19(2) 38.81(5) 42.43(5)	2.08 3.99 2.55 2.32 2.13	DIASPORE
43.95(9)	24.87 27.01 32.80 49.97(9)	2.06 3.58 3.30 2.73 1.825	VATERITE
44.40(4)	22.05(3) 30.40(7) 31.50 36.83(2)	2.04 4.03 2.94 2.84 2.44	APHTHITALITE••
44.63(5)	26.52 42.43(1) 54.69(8)	2.03 3.36 2.13 1.678	GRAPHITE

44.86(6)	19.04(3) 31.38(4) 36.99 59.43(4)	2.02 4.66 2.85 2.43 1.555	SPINEL, MAGNESIAN
45.34(4)	3.53-3.68(5) 7.55 18.02(5) 26.20(5)	2.00 25.0-24.0 11.7 4.92 3.40	HYDROBIOTITE
45.48(5)	27.35(1) 31.72 56.52(2)	1.994 3.26 2.82 1.628	HALITE..
45.82-45.58(5)	8.84 17.81(4) 26.68 35.05-34.49(5)	1.980-1.990 10.00 4.98 3.34 2.56-2.60	ILLITE AND MICAS
45.90	37.79(3) 39.52(2) 66.92(9)	1.977 2.38 2.28 1.398	GAMMA ALUMINA (SYN)
45.90(6)	26.20 27.27(5) 33.17(5) 37.96(4)	1.977 3.40 3.27 2.70 2.37	ARAGONITE
46.90(7)	14.14 27.10(9) 36.37(8) 38.13(1)	1.937 6.26 3.29 2.47 2.36	LEPIDOCROCITE
46.95(5)	28.24 32.68(5) 55.77(5)	1.935 3.16 2.74 1.648	URANINITE
47.05	28.33(9) 55.81(3) 68.71(1)	1.931 3.15 1.647 1.366	FLUORITE
47.47(3)	25.89(4) 33.05 38.81(3) 51.95(6)	1.915 3.44 2.71 2.32 1.760	MARCASITE
47.66(4)	9.25(1) 28.05 30.94(4) 35.62(3)	1.908 9.56 3.18 2.89 2.52	MARGARITE
47.87(10-3)	17.81(5) 29.67 39.34(7) 52.27(7)	1.900 4.98 3.01 2.29 1.750	ALUNITE
48.08(3)	25.30 36.99(1) 37.79(2) 53.96(2)	1.892 3.52 2.43 2.38 1.699	ANATASE
48.41(7)	9.35(5) 18.84 28.42(3) 37.96(7)	1.880 9.45 4.71 3.14 2.37	LITHIOPHORITE
48.69(4)	9.45 19.04(2) 28.60(10-4) 36.22	1.870 9.35 4.66 3.12 2.48	TALC
49.08(3)	14.49 28.24(6) 38.46(5) 48.91(3)	1.856 6.11 3.16 2.34 1.862	BOEHMITE
49.53(6)	23.53(4) 29.98-30.40 40.07(5)	1.840 3.78 2.98-2.94 2.25	KUTNAHORITE, CALCIAN
49.59(4)	33.30 35.77(5) 41.02(2) 54.20(4)	1.838 2.69 2.51 2.20 1.692	HEMATITE
49.97	24.87 27.01 32.80 42.43(5) 43.95	1.825 3.58 3.30 2.73 2.13 2.06	VATERITE
50.20(2)	20.85(3) 26.68 36.52(1) 42.43(1)	1.817 4.26 3.34 2.46 2.13	QUARTZ, LOW
50.71(3)	30.72 40.83(1) 50.11(3) 50.71(4)	1.800 2.91 2.21 1.820 1.800	KUTNAHORITE, MAGNESIAN
50.89(5)	18.60 37.96 58.69(3)	1.794 4.77 2.37 1.573	BRUCITE
51.42(9)	25.08(8-3) 31.61 34.08(5) 35.92(10-5)	1.777 3.55 2.83 2.63 2.50	FAYALITE
51.85(3)	24.31(3) 31.50 41.61(2) 45.34(2)	1.763 3.66 2.84 2.17 2.00	RHODOCHROCITE
51.95(6)	25.89(4) 33.05 38.81(3) 47.47	1.760 3.44 2.71 2.32 1.915	MARCASITE
52.59(4)	25.59(7) 35.19(9) 43.28 57.56(8)	1.740 3.48 2.55 2.09 1.601	CORUNDUM

Table of Key Lines–Continued

	Degrees 2θ (CuKα)	d-spacing values (Å)	Mineral
52.59(6)	15.60(4) 25.74(5) 30.61 41.02(2)	1.740 5.68 3.46 2.92 2.20	VISEITE
52.79(8)	52.79(6) 32.07 38.46(1) 42.43(6)	1.734 3.59 2.79 2.34 2.13	SIDERITE
53.05(6)	23.85(5) 32.68 35.33(8) 40.25(3)	1.726 3.73 2.74 2.54 2.24	ILMENITE
53.15(4)	18.84(9) 20.41(7) 27.88(3) 40.63	1.723 4.71 4.35 3.20 2.22	BAYERITE
53.93(5)	32.19(4) 37.47 64.23(1)	1.700 2.78 2.40 1.450	LIME
53.93(3)	32.68 35.92(2) 43.07(4) 46.85(1)	1.700 2.74 2.50 2.10 1.939	MAGNESITE
54.20(5)	33.30 35.77(5) 41.02(2) 49.59(4)	1.692 2.69 2.51 2.20 1.838	HEMATITE
54.38(6)	27.44 36.22(5) 41.41(2) 44.17(1)	1.687 3.25 2.48 2.18 2.05	RUTILE
54.69(8)	26.52 42.43(1) 44.63(5)	1.678 3.36 2.13 2.03	GRAPHITE
56.33	33.05(8) 37.15(6) 40.83(5) 47.47(4)	1.633 2.71 2.42 2.21 1.915	PYRITE
56.33(4)	22.28 38.81(5) 42.43(5) 43.50(5)	1.633 3.99 2.32 2.13 2.08	DIASPORE
56.45(5)	25.59(1) 28.42 37.31(5) 42.43(2)	1.630 3.48 3.14 2.41 2.13	PYROLUSITE
57.56(8)	25.59(7) 35.19(9) 43.28 52.59(4)	1.601 3.48 2.55 2.09 1.740	CORUNDUM
58.16(4)	12.48 25.15(8) 32.92(5)	1.586 7.09 3.54 2.72	CRONSTEDTITE (060)
59.10(5)	12.43 25.08 35.62	1.563 7.12 3.55 2.52	CHAMOSITE, FERROUS (060)
59.64-60.07(6)	6.24 18.56(4) 25.08(8)	1.550-1.540 14.15 4.78 3.55	CHLORITES (060)
60.03(1)	20.85(3) 26.68 36.67(1) 50.20(1)	1.541 4.26 3.34 2.45 1.817	QUARTZ, LOW
60.07-60.51(6-3)	12.00-12.46 24.31-25.22 35.62-37.79(8)	1.540-1.530 7.37-7.10 3.66-3.53 2.52-2.38	SERPENTINES (060)
60.07-60.51(5)	8.84 26.85(9) 34.22(5)	1.540-1.530 10.0 3.32 2.62	MICAS, TRIO- (060)
60.20-60.59(6)	6.18 19.29(6) 37.63(3)	1.537-1.528 14.3 4.60 2.39	VERMICULITE (060)
60.51(4)	5.89 19.72 35.19-33.69(4)	1.530 15.0 4.5 2.55-2.66	SMECTITE, TRIO- (060)
60.64(5)	9.45 19.33(4) 28.60(10-5)	1.527 9.35 4.59 3.12	TALC (060)
60.95(5)	6.09 19.72 34.91-34.08(6)	1.520 14.5 4.50 2.57-2.63	NONTRONITE (060)
61.08(4)	12.53 25.30 36.52(7)	1.517 7.06 3.52 2.46	CHAMOSITE, FERRIC (060)

61.35(6)	6.22(8) 19.63(8) 25.08(6)	1.511 14.2 4.52 3.55	SUDOITE (060)
61.39-61.94(6)	8.84 17.73(5) 26.85	1.510-1.498 10.0 5.0 3.32	MICAS, DIO- (060) (INCLUDES CELADONITE)
61.85(5)	5.89 19.72(7) 29.57(5)	1.500 15.0 4.50 3.02	MONTMORILLONITE (060)
62.17(3)	9.61 20.08(4) 29.08 37.31(5)	1.493 9.20 4.42 3.07 2.41	PYROPHYLLITE (060)
62.26(5)	6.22 19.90 34.35-35.92	1.491 14.2 4.46 2.61-2.50	BEIDELLITE (060)
62.35(5)	36.99(1) 43.07 78.68(1)	1.489 2.43 2.10 1.216	PERICLASE
62.35(4)	12.37 20.36(5) 24.87	1.489 7.15 4.36 3.58	KAOLIN MINERALS (060)
62.49(8)	9.11(8) 19.99 35.33(9)	1.486 9.7 4.44 2.54	PARAGONITE (060)
62.54(4)	30.08(3) 35.48 56.98(3)	1.485 2.97 2.53 1.616	MAGNETITE
62.59(3)	33.30 35.77(5) 49.59(4)	1.484 2.69 2.51 1.838	HEMATITE
63.06(5)	30.29 35.62 57.29(3)	1.474 2.95 2.52 1.608	MAGHEMITE (SYN)
64.33(6)	36.37 44.17(4) 58.56(4)	1.448 2.47 2.05 1.576	SPINEL, FERRIAN
65.29(5)	36.99 44.86(6) 59.39(4)	1.429 2.43 2.02 1.556	SPINEL, MAGNESIAN
66.92(9)	37.79(3) 39.52(2) 45.90	1.398 2.38 2.28 1.977	GAMMA ALUMINA (SYN)

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Appendixes

Appendix 1. Changes in the 2θ angle of (001) diffraction line for various clay minerals with glycolation and thermal treatments.

Appendix 2. X-ray powder diffraction patterns for distinguishing polytypes of the kandite group. From Brown (1961) and Borg and Smith (1969b). Indexing of nacrite by Bailey (1963) and Borg and Smith (1969b); indexing by Borg and Smith is in parentheses.

Appendix 3. X-ray powder diffraction patterns for monoclinic and triclinic pyrophyllite in the range of 2θ angle from 18° to 38° (Brindley and Wardle, 1970).

Appendix 4. X-ray powder diffraction patterns for distinguishing mica polytypes. Upper three patterns are muscovite and illite (dashed lines). Muscovite and phlogopite are from Brown (1961) and Yoder and Eugster (1955). Illite is from JCPDS cards 2-462 and 9-334. Lepidolite is modified from cards 10-484 and 14-11.

Appendix 5. X-ray powder diffraction patterns for distinguishing chlorite polytypes: Ia, Ib, and IIb. From Brown and Bailey (1962).

Appendix 6. Diffractometer pattern for the palygorskite polytypes. S = orthorhombic; G and M = monoclinic. Note the splitting of the 121 and 161 peaks of the orthorhombic palygorskite samples into the 121 and $12\bar{1}$ and 161 and $16\bar{1}$ of the monoclinic samples. Peaks due to impurities are denoted as C = calcite, Py = pyrite, and Q = quartz. From Christ and others (1969).

Appendix 7. X-ray powder diffraction data for distinguishing serpentine minerals.

Appendix 8. X-ray powder diffraction data for distinguishing septechlorite minerals.

Appendix 9. Data for distinguishing smectite minerals.

Appendix 10. Data for distinguishing mixed layers of clay minerals. Schematic representation of the behavior of the (001) reflections during X-ray diffraction after different treatments (from Lucas, Camez, and Millot, 1959). G = treatment with glycerol; N = normal (untreated); Ch = heating at 490°C; C = chlorite; I = illite; M = montmorillonite; V = vermiculite; M-V = mixed layer of montmorillonite and vermiculite.

Appendix 11. X-ray powder diffraction data for distinguishing zeolite minerals. Minerals are arranged in order of decreasing d-value (increasing 2θ angle) of the strongest peaks.

Appendix 12. X-ray powder diffraction data for distinguishing K-feldspars and plagioclases.

Appendix 13. Angular positions (2θ CuKα degree) and Miller indices of some significant diffraction peaks useful in determining the composition and structure of the K-feldspars. (See appendixes 14 and 15.)

Appendix 14. X-ray determinative curve for orthoclase (Or) content in K-feldspars as determined from the 2θ $(\bar{2}01)$ diffraction. The ordinate $\Delta 2\theta$ is the difference between the 2θ angle for the $(\bar{2}01)$ diffraction and the (101) diffraction of $KBrO_3$ (internal standard) which lies at 20.212 2θ for CuKα radiation. The microcline-low albite series is shown by two dashed lines that meet at 45 mole % Or. The sanidine-high albite series is shown by the two straight lines that meet at 75 mole % Or. From Orville (1967).

Appendix 15. Diagram relating 2θ (060) and 2θ $(\bar{2}04)$ angles in the "three-peak" method of Wright (1968) for alkali feldspar determination. The four squares show the approximate position of the extreme end-members. The three major series (maximum microcline-low albite, orthoclase, and high sanidine-high albite) are shown in solid lines. Dashed lines are equivalent structural state (ion-exchanged paths) for specific alkali feldspars which have been well studied. The crossing contours show the expected values for 2θ $(\bar{2}01)$ angles. If this value agrees within 0.1° 2θ of the observed 2θ value, the feldspar is assumed to have normal cell dimensions. If not, it may be anomalous.

The orthoclase (Or) content (wt. %) of normal feldspars can be obtained once the structural state has been determined from this diagram by using the following equations:

		Error in Or
high-sanidine series	$= 2030.05 - 92.18 \times 2\theta_{201}$	1.2
orthoclase series	$= 1930.77 - 87.69 \times 2\theta_{201}$	1.4
maximum microcline series	$= 2031.77 - 92.19 \times 2\theta_{201}$	2.4

For example, if a specimen has a $2\theta_{\bar{2}01} = 21.18°$, its structural state is determined to be sanidine by using the diagram. Accordingly, the Or content is calculated to be 76%.

Appendix 16. Angular positions (2θ CuKα degree) and Miller indices of some X-ray powder diffraction peaks useful in determining the composition and structural phase of the plagioclases. (See also appendixes 17 and 18.)

Appendix 17. Relationship among indicators of structural state $\Delta(\theta)_1$ and $\Delta(\theta)_2$ and the plagioclase composition. $\Delta(\theta)_1 = 2\theta_{131} - 2\theta_{1\bar{3}1}$ (graph A) and $\Delta(\theta)_2 = 2\theta_{\bar{2}41} - 2\theta_{\overline{24}1}$ (graph B). Note the linear scale for the Si/Al ratio and the nonlinear scale for molecular % An. These determinative graphs are most suitable for plagioclase with An_{20-70}, assuming only one plagioclase phase present and a homogeneous An content. Solid lines are for plagioclase with Or $<$ 0.5-0.8%. Dashed lines are for plagioclase with Or $\sim$ 4% and with An_{40-60}. Graph C shows the relationship between the $131/1\bar{3}1$ and $\bar{2}41/\overline{24}1$ indicators for ordered (O) and intermediate (O/D) plagioclases. Solid line for Or $<$ 0.5-0.8%. Dashed line with Or_{2-5}%. An-calibration is given for low plagioclases. From Bambauer and others (1967).

Appendix 18. Graph showing the relationship between the gamma (Γ) and An content for plagioclase with An_{60-85}. From Jackson (1961).

Appendix 19. X-ray powder diffraction pattern of alpha quartz.

Appendix 20. X-ray powder diffraction patterns of carbonate minerals: aragonite, calcite, Mg-calcite ($\sim$17 mol. % $MgCO_3$), dolomite, and magnesite. Samples of aragonite and Mg-calcite are of coral *Acropora* sp. and *Tubiopora* sp., respectively, from Tungsha (Paracel) Islands, China.

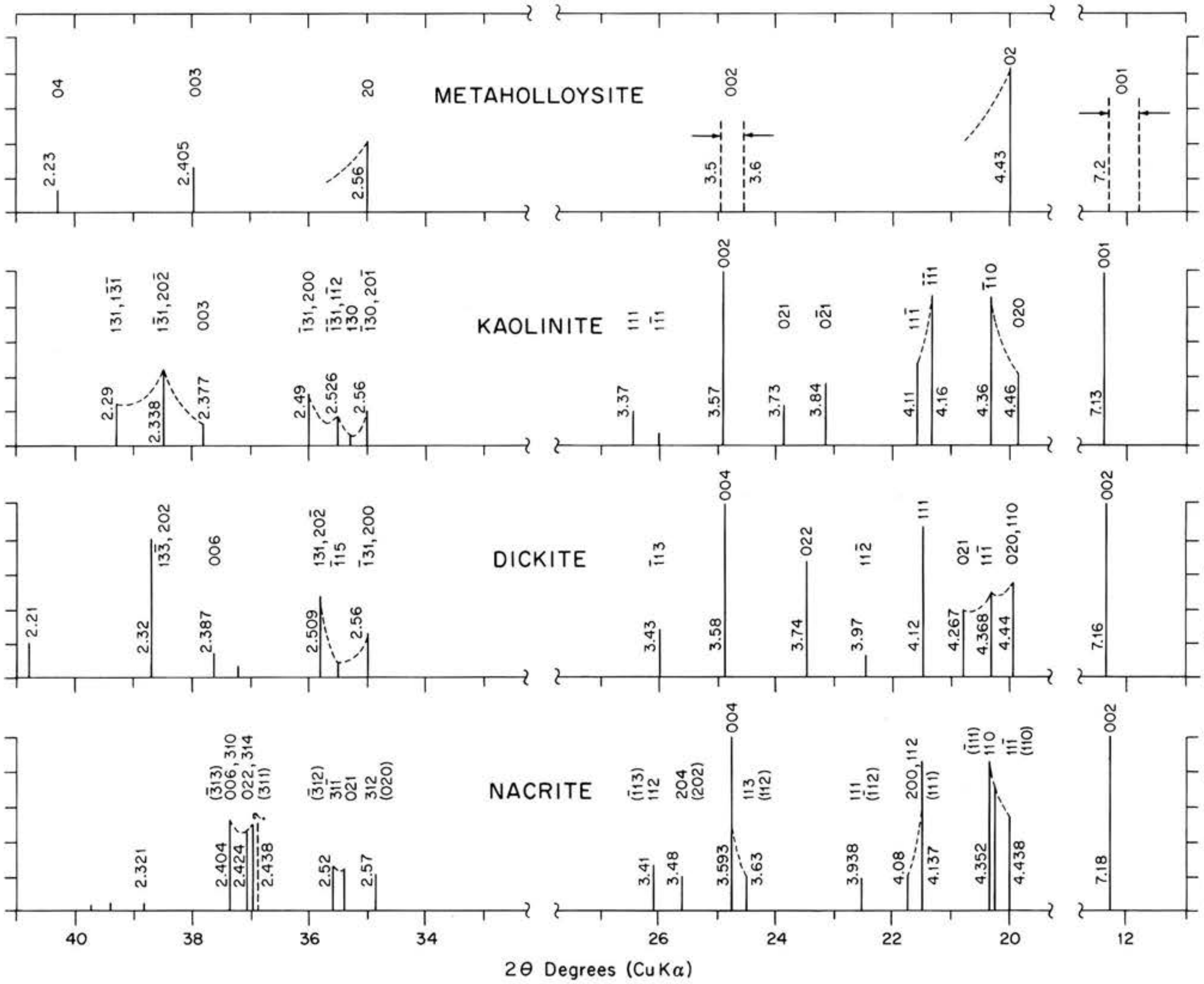
Appendix 21. Table for conversion of 2θ angles (CuKα) to interplanar spacing (d). From Switzer and others (1948).

Appendix 1. Changes in the 2θ angle of (001) diffraction line for various clay minerals with glycolation and thermal treatments

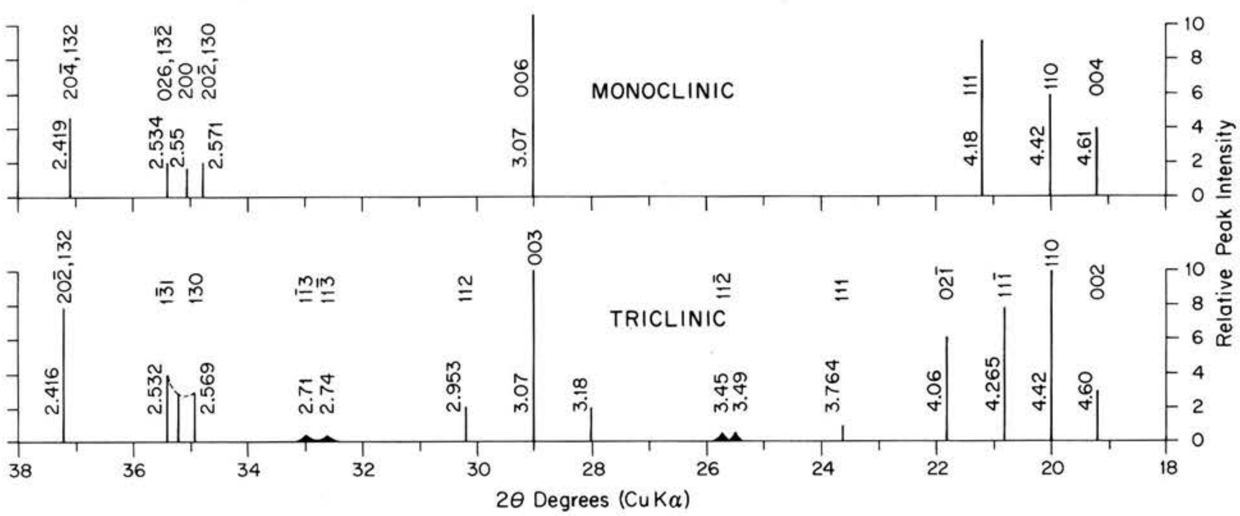
Mineral	Spacing and 2θ angle of (001) peak	Dehydration change at 300° C	Temperature for collapsing structure (C°)	Change due to glycolation
Allophane and Imogolite	Amorphous to X-ray	–	–	–
Kaolinite, well-crystallized	7.15 Å (12.3°)	–	550-600	–
Kaolinite, disordered	7.15 Å (broad)	–	520-560	–
Dickite	7.15 Å	–	600-680	–
Nacrite	7.15 Å	–	580-650	–
Halloysite, hydrated	10 Å (8.8°, broad)	7.2 Å (12.2°)	540-580	–
Halloysite, dehydrated*	7.2-7.4 Å (12.2-11.9°, broad)	–	540-570	Some expand to 10 Å
Micas, well-crystallized	10 Å (8.8°)	–	∿700, (001) may remain to 1,000° C	–
Illite (Clay Micas)	10 Å (may be broad)	May be sharpened and intensified	∿700	(001) may become asymmetrical at low angle side
Smectites	14-15 Å (6.2-5.7°)	9.4 Å	600-800	17 Å (5.2°)
Na-Montmorillonite	12.4 Å (7.1°)	9.4 Å	∿800	17 Å
Vermiculite	14.5 Å (6.1°), the strongest peak	13.8-11.6 Å, changes in steps	700-800	Expands to 14.5 Å or no change
Swelling Chlorite	14.2 Å (broad)	–	?	16-18 Å
Mg-Chlorite	14.2 Å (6.2°)	–	∿800, (001) intensified at 600° C and shifts to 13.8 Å	–
Fe-Chlorite (Sedimentary Chlorite)	∿14.2 Å (6.2°)	–	450-500	–
Mixed layer, regular	Variable 20-30 Å, integral series of (00*l*) spacing present	Contracts when expandable components are present	< 800; variable depends on minerals present	Expands if expandable components are present
Mixed layer, random	Variable, nonintegral series of (00*l*) spacings present	Variable	Variable	Expands if expandable components are present
Palygorskite	10.5 Å (8.4°), (110)	–	800	–
Sepiolite	12.1 Å (7.3°), (001)	12 Å peak may be either weakened or not changed	700	–

– Indicates no change.

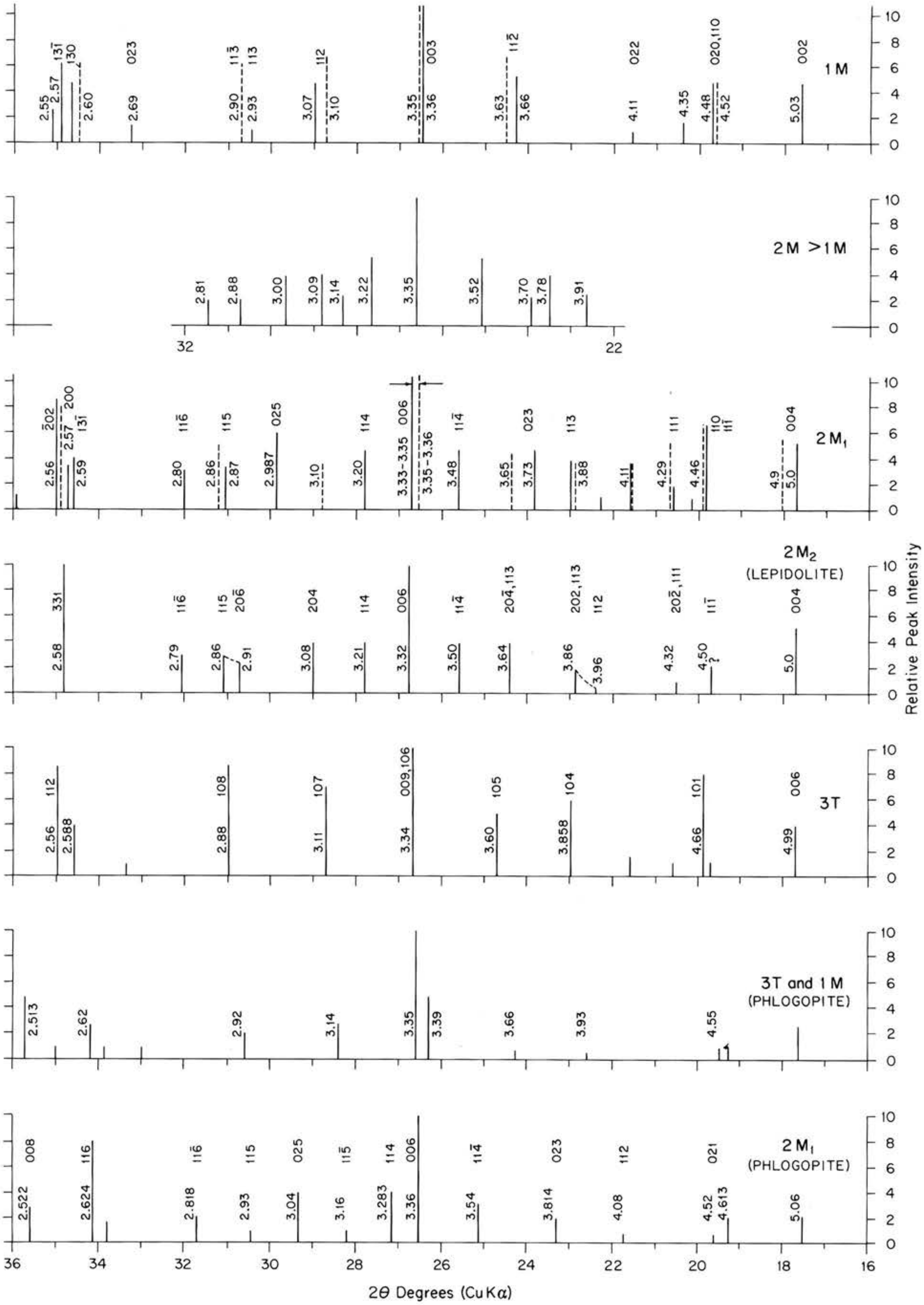
* Dehydrated halloysite is distinguishable from kaolinite by potassium acetate treatment (Wada, 1961).



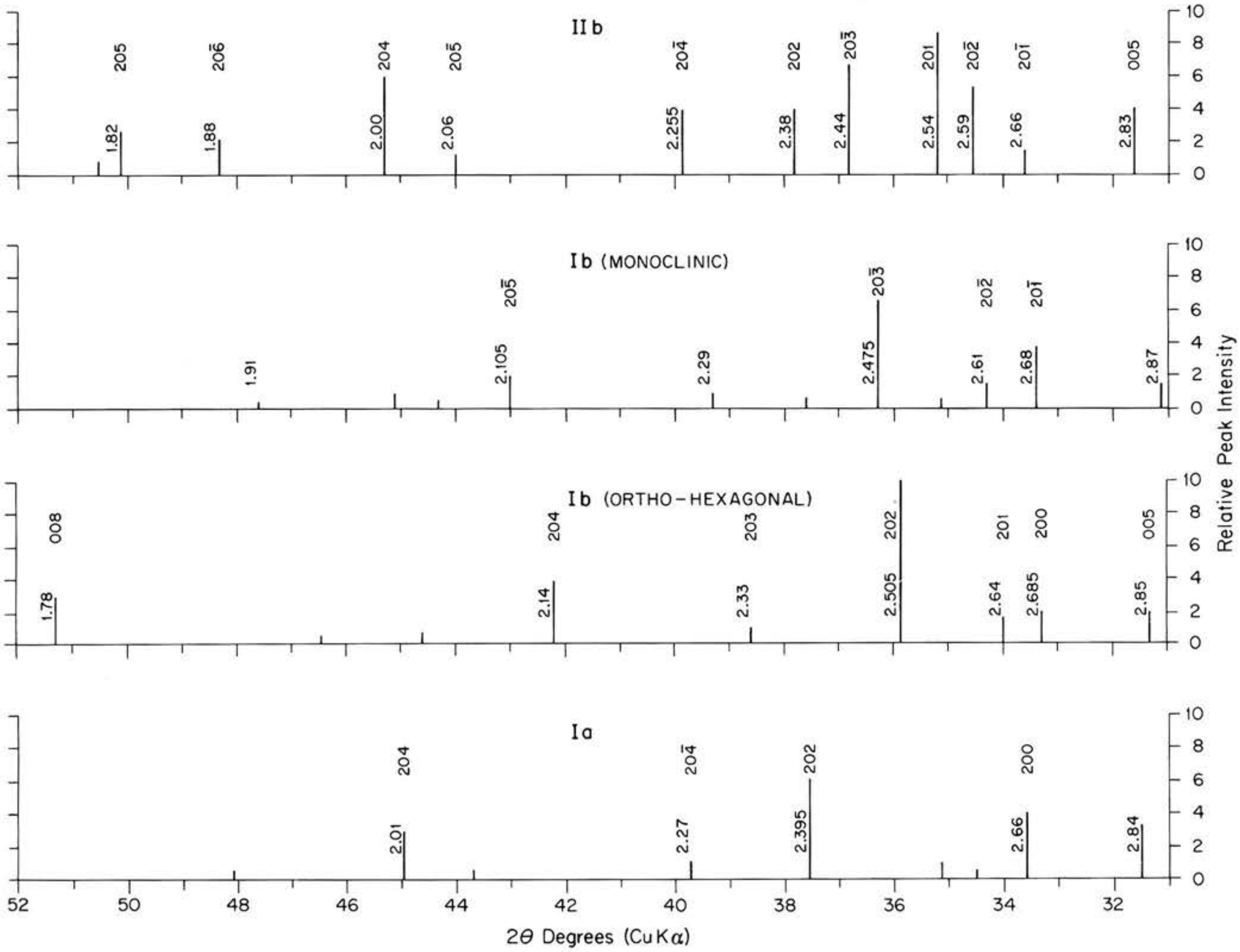
Appendix 2. X-ray powder diffraction patterns for distinguishing polytypes of the kandite group.



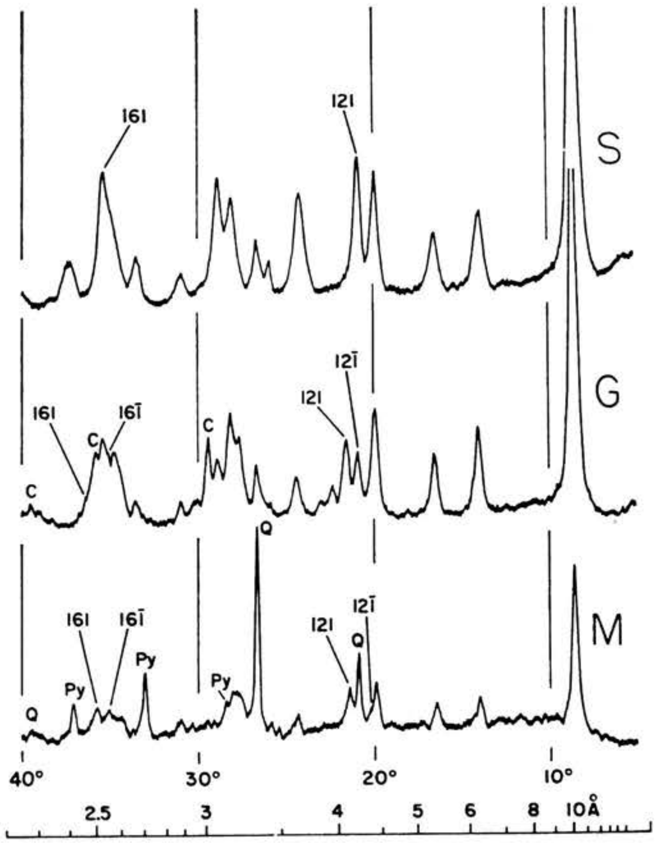
Appendix 3. X-ray powder diffraction patterns for monoclinic and triclinic pyrophyllite in the range of 2θ angle from 18° to 38°.



Appendix 4. X-ray powder diffraction patterns for distinguishing mica polytypes. Upper three patterns are muscovite and illite (dashed lines).



Appendix 5. X-ray powder diffraction patterns for distinguishing chlorite polytypes: Ia, Ib, and IIb.



Appendix 6. Diffractometer pattern for the palygorskite polytypes. S = orthorhombic; G and M = monoclinic. Note the splitting of the 121 and 161 peaks of the orthorhombic palygorskite samples into the 121 and $12\bar{1}$ and 161 and $16\bar{1}$ of the monoclinic samples. Peaks due to impurities are denoted as C = calcite, Py = pyrite, and Q = quartz.

Appendix 7. X-ray powder diffraction data for distinguishing serpentine minerals

Indices HKL	Antigorite 6M Å	Antigorite 6M 2θ Cu	Antigorite 6M I	Antigorite 6O Å	Antigorite 6O I	Chrysotile 2M Å	Chrysotile 2M I	Chrysotile 2O Å	Chrysotile 2O 2θ Cu	Chrysotile 2O I	Lizardite 1T Å	Lizardite 1T I	Lizardite 1M Å	Lizardite 1M I	Lizardite 1O (Al) Å	Lizardite 1O (Al) I
001, 002, 006	7.30	12.1	VS	7.33-7.09	10	7.31	10	7.10	12.45	10	7.10	8	7.40	10	7.25-7.30	6
020, 100	4.64-4.62	19.1-19.2	WM	4.60-4.59	6-3	4.57	5	4.63	19.18	2	4.63	4	4.60	6	4.60-4.55	2
111, 023	--			4.40*	1	4.05	1	4.40	20.19	4	--		--		--	
021, 022, 112	--			3.86*	2	--		3.88	22.92	3	3.88	∼5	3.91	5	--	
002, 004, 0, 0, 12	3.63-3.61	24.5-24.6	VS	3.66-3.55	∼10	3.65	7	3.55	25.08	7	3.55	7	3.67		3.66-3.62	6
022, 024	--			2.81	1	--		--			2.82		2.87*	1	--	
201, 203, 200	--			2.65-2.61	10-2	--		2.62	34.2	3	2.67	<1	2.66	3	--	
204	--			2.57*	4	--		--			--		--		--	
202, 206, 112	2.52	35.6	MS	2.50-2.49	10-3	--		2.499	35.93	5	2.499	10	2.50	10	2.50	10
003, 207, 18, 0, 0	2.45-2.42	36.7-37.15	MW	2.43*	1.5	--		--			--		--		2.41	1
203, 208	--			2.38-2.34	7-2	2.27	3	2.326	38.65	8	--		--		--	
204, 116	--			2.25*	1.5	2.20	3	--			--		--		--	
204, 114, 16, 0, 2	2.16-2.17	41.8-41.6	WM	2.15*	6	2.09	3	2.134	42.40	2	2.133	4	2.156	8	2.148	3
	2.15-2.17 (42.0-41.6)					2.09-2.13 (43.25-4.24)					2.13-2.156 (42.4-41.9)					
2, 0, 15, 205	--			2.00-1.96	7-2	--		1.945	46.70	1	--		--		--	
004, 008, 205	1.81	50.4	W	1.882*	1.5	1.827	3	--			--		1.835	1	--	
203, 206, 116	--			--		1.744	3	1.771	51.60	2	1.771	2	1.799	5	1.788	1.5
310	--			--		--		--			--		1.743	∼3	--	

Appendix 7. X-ray powder diffraction data for distinguishing serpentine minerals–Continued

Indices HKL	Antigorite					Chrysotile					Lizardite					
	6M			6O		2M		2O			1T		1M		1O (Al)	
	Å	2θ Cu	I	Å	I	Å	I	Å	2θ Cu	I	Å	I	Å	I	Å	I
207	--			1.662*	2	--		1.615	57.0	3	--		--		--	
060, 300	1.540	60.1	W	1.535-1.528	8-6	1.535	5	1.542	59.99	3	1.542	3	1.538	8	1.540-1.530	6
***	29			10-20		1		16			9		4		3	
References	JCPDS file nos. 7-417, 21-963			File nos. 9-444, 11-388, 12-583, 13-4 and Borg and Smith (1969b)		File no. 21-543		File no. 22-1162			File no. 22-1161		File no. 18-779		File no. 11-386 and Borg and Smith (1969b)	

*** Number of reflections which are weak and are omitted from this appendix.
* Indicates the reflections which are not always observed.
--- Indicates diagnostic peaks.
VS - very strong; MS - medium to strong; MW - medium to weak; W - weak.

Appendix 8. X-ray powder diffraction data for distinguishing septechlorite minerals

Indices	Amesite			Chamosite (Berthierine)						Cronstedtite			Greenalite	
				Monoclinic		Orthogonal								
						Ferrous		Ferric						
	Å	2θ (Cu)	I	Å	I	Å	I	Å	I	Å	2θ (Fe)	I	Å	I
001, 002	7.06-7.02	12.5 -12.6	10	7.05	10	7.12	10	7.06	9	7.09	15.7	10	7.21	7
020, 100	4.54-4.60	19.55-19.3	2	4.64	2	4.68	4	4.54	4	4.75	23.5	1	--	
101, $11\bar{1}$	4.37*	20.3	4	4.58	2	4.30	1	--		--			--	
021	--			3.90	1	3.93	2	--		3.94*	28.4	2	--	
002, 004	3.52-3.51	25.35	10-5	3.52	10	3.55	10	3.53	9	3.54	31.7	8-6	3.60	4
110, 130, $20\bar{1}$, 200	2.61	34.35	2	2.68	4	2.70	4	2.627	5	2.72	41.7	5	--	
201	--			--		2.525	10	--		2.56	44.46	7-1	2.59	10
202	2.48	36.20	6	--		--		--		--			--	
201, $20\bar{2}$, 131	--			2.41	4	--		2.465	7	2.44	46.75	4	--	
132, 201, 006, 203	2.32-2.31	38.8 -39.0	5	--		--		--		2.305	49.70	1.6	--	
202, 112	2.11	42.85	3	--		2.15-2.14	7	2.107	4	2.17*	53.0	3	2.20	9
132, $20\bar{3}$	--			2.01	1	--		--		2.036*	56.8	1.6	--	
205, 115	1.925	47.2	7	--		--		--		--			--	
203, 206, 008	1.749*	52.3	5	--		1.778	5	1.752	3	1,790*	65.46	2	1.818	5
16, 00	1.596	57.75	6	--		--		--		--			--	
060, 300	1.531	60.45	6	1.563	7	1.563	7	1.517	5	1.586	75.3	4-2	1.602	6
***	0∿10			6		0		0		8			0	
References	JCPDS file no. 9-493; Borg and and Smith (1969b)			File no. 7-315		File no. 7-339		Brindley, 1961, Table II 20 (in Brown, 1961)		File no. 17-470; Borg and Smith (1969b)			File no. 2-1012	

For notations see appendix 7.

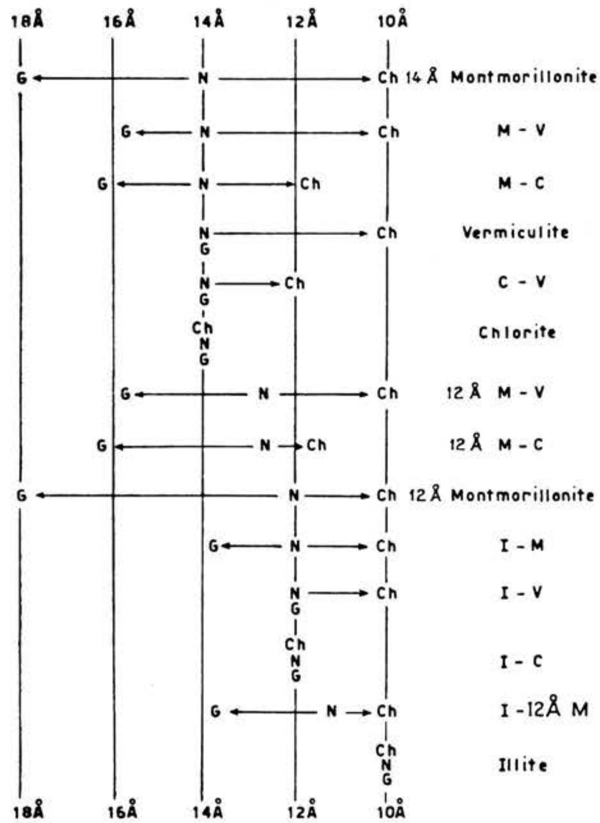
Appendix 9. Data for distinguishing smectite minerals

Mineral	(060) d-value[1] Å	(001) d-value of glycerolated Li-saturated clay after pre-heated at 300° C[2] Å	Temperature of main dehydroxylation (endothermic) peak in DTA curve (° C)	Dominant octahedral ions
Montmorillonite	1.500	9.5	500-700	Al,Mg
Beidellite	1.491	17.8	500-700	Al
Nontronite	1.522	17.8	400-500	Mainly Fe^{+3}
Saponite	1.520	17.8	∿900	Mg
Hectorite	1.530	17.8	∿800	Mg,Li
Sauconite	1.547	17.8	∿700	Zn,Mg,Al,Fe^{+3}

1Brown (1961, p. 192-193).

2Greene-Kelly (1953) and Brown (1961, p. 190).

	N (*normal*)	Ch (*heating*)	G (*glycerol*)
Illite	10	10	10
Chlorite	14	14	14
Montmorillonite	14	10	17.7
Vermiculite	14	10	14



Appendix 10. Data for distinguishing mixed layers of clay minerals. Schematic representation of the behavior of the (001) reflections during X-ray diffraction after different treatments (from Lucas, Camez, and Millot, 1959). G = treatment with glycerol; N = normal (untreated); Ch = heating at 490°C; C = chlorite; I = illite; M = montmorillonite; V = vermiculite; M-V = mixed layer of montmorillonite and vermiculite.

Appendix 11. X-ray powder diffraction data

Mineral	17-11Å	10-8Å	7.9-7Å	6.9-6Å	5.9-5Å
Faujasite	6.12(10)	10.05(8)	11.96(6)		15.55(10-8)
Offretite	7.65(10)			13.33(2)	15.40(3.5)
Erionite	7.75(10)			13.40(7)	15.50(3.5)
Laumontite		9.33(10)		12.9 (3.5)	
Stilbite, Na		9.78(10)			
Heaulandite		9.92(10)	11.14(6)	13.0 (3)	17.30(5)
		9.99(8)	11.35(7)	13.35(6)	16.80(5)
Clinoptilolite		9.91(10)	11.14(8-4)		
Paulingite	5.04(8-1)	10.68(10)		12.87(10-8)	15.57(5)
Gismondine			12.15(10-5)		
Phillipsite			12.30(10)		17.51(2.5)
Scolecite				13.33(10)	15.05(3.5)
Natrolite				13.65(10)	15.00(10-6)
				13.50(6)	15.04(10-8)
Harmotome		10.92(4)	12.35(5)	13.85(10)	17.63(4)
Brewsterite			13.10(3)	14.0 (10)	17.55(6)
				14.0 (3)	17.55(6)
Yugawaralite				12.65(6)	15.20(9)
Garronite			12.37(8)		
Gmelinite	7.35(9)			13.0 (10-4)	17.5 (10-6)
Levynite	8.50(3.5)	10.80(6)	11.50(2)	13.17(2)	17.08(3)
Stilbite		9.66(5)			
Mordenite	6.45(5)	9.71(9)		14.50(5)	
Ferrierite		9.30(5)	12.51(4)		15.40(2)
		9.20(10)	12.65(3)		15.16(5)
Dachiardite		9.93(5)		12.80(5)	
Epistilbite		9.94(9)		12.85(6)	
Analcite	35.7 (4)	47.75(2)	52.50(2.5)		15.81(8)
Pollucite	45.1 (4)	49.10(8)	52.88(8)		
Wairakite				12.99(4)	15.91(9)
				12.92(4)	16.07(8)
Chabazite		9.46(5)			17.66(3)
Herschelite		9.45(5)		12.84(2)	17.62(4)
Gonardite				13.20(6)	14.93(8)
Mesolite				13.75(4)	15.30(7)
Thomsonite				13.40(6)	15.00(4)
Edingtonite	34.6 (9)			13.64(8)	15.50(8)
Gismondine			12.10(10)		

[1] Data from JCPDS (1974) and Deer and others (1963). Minerals are arranged in order of decreasing d-value (increasing 2θ angle) of the strongest peaks.

for zeolite minerals[1]

5-4.5Å	4.6-4Å	4.5-3.5Å	4.1-2.9Å		3.1-2Å	
	20.2 (6)	23.3 (6)	23.63(10)		31.05(8)	
	20.4 (6)	23.15(4)	26.85(2)		31.05(6)	31.29(1)
	20.55(6)	23.3 (3)	23.70(6)	27.0 (4)		31.29(7)
18.75(2)	21.4 (6)	24.27(2)	25.37(3)	27.25(2)	29.47(3)	
19.08(4)	21.8 (9.5)	23.7 (2)	26.15(2)	27.92(2)	29.37(7)	32.20(3.5)
17.50(3)	19.1 (3.5)	22.3 (8)	22.68(2)			
17.38(7)	19.05(6)		22.68(10)	26.0 (7-3)	30.20(9)	
17.35(5)	19.05(2)	22.45(10-5)	22.8 (9-5)	28.60(2)	30.10(8-2)	32.90(3)
17.98(5-2)			26.6 (8-3)	27.37(9-3)	29.0 (9-5)	
18.06(6-2)	20.8 (7-3)	21.1 (3.5)	26.65(10-4)	27.95(6-2)		33.15(10-2)
17.80(2)	21.5 (4)		27.35(3)	27.92(8)	28.40(3.5)	33.20(3.5)
19.15(3)	20.0 (10)	20.2 (3)	21.0 (2)		31.27(4)	31.53(3)
19.08(4)	20.4 (3)	21.4 (5)		28.30(2)	31.27(4.5)	31.53(3)
			27.95(4)	28.20(5)	31.22(8)	31.40(10)
20.65(4)	21.75(6)		27.5 (6)	28.50(8)		33.55(7)
18.80(3)	19.10(10-7)	19.6 (7)	22.7 (3)	27.35(6)	30.60(8)	
19.04(10-7)						
18.96(10-8)	19.10(8)	20.6 (6)	21.23(3)	27.57(5)	29.28(10-6)	
17.9 (8)	21.55(10)	21.8 (6)	27.70(6)	28.40(10)	31.05(2)	33.7 (10)
	21.85(10)		27.70(6)	30.15(8)	31.35(6)	33.55(6)
20.75(5)	21.65(10)		28.10(5)		31.85(8)	
19.02(2)	21.85(10)	23.75(4)	26.20(2)	27.96(3)	29.40(5)	32.23(2)
19.60(8)	22.20(9)	25.55(10)	26.30(9)	27.70(10)		
	22.30(3)	23.52(6)	25.5 (10)	25.60(2)	26.95(3)	
19.35(1)	22.25(9)	23.45(2)	24.1 (5)	25.15(8)	25.50(8)	
18.15(5)	22.60(5)	23.38(5)	25.8 (10)	27.84(10)	30.15(5)	
18.05(6)		22.95(7)	25.82(10)	27.80(9)	30.65(6)	
18.28(3)			25.97(10)		30.50(6)	33.30(3)
		24.35(8)	26.05(10)	30.70(10)	37.36(8)	40.80(6)
18.36(4)		24.42(3)	26.13(10)	30.80(5)	33.50(4)	36.10(5)
18.30(4)		24.42(3)	26.05(5)	26.3 (10)	30.72(5)	30.95(3)
20.55(7)	22.95(3)	24.80(2)			30.50(10)	30.95(3)
20.55(6)	22.90(2)	24.70(2)			30.55(10)	30.95(3)
18.70(5)	19.98(6)		27.60(5)	28.60(4)	30.62(10)	34.4 (4)
19.02(3)	20.40(5)		28.05(3)	29.00(2)	31.30(10)	41.20(3)
19.10(9)		25.34(6)	27.95(4)	30.30(7)	31.30(10)	41.20(3)
18.46(9)	18.90(9)	20.68(4)	24.86(10)	26.30(6)	29.67(8)	32.55(10)
18.10(4)	21.20(8)	25.05(4)	27.50(10)	29.90(4)		32.80(10)

Appendix 12. X-ray powder diffraction data for distinguishing K-feldspars and plagioclases

	K-feldspars			HKL	Plagioclases			
	2θ CuKα	Å	I		2θ CuKα	Å	I	
**	13.55-13.75	6.53 -6.44	2	110, 1$\bar{1}$0	13.58-13.80	6.52 -6.41	4	**
				020, 001	(Albite: 13.9)			
				0$\bar{2}$1	18.98-18.9	4.68 -4.69	5-2	*
	20.95-21.65	4.24 -4.10	10-5	$\bar{2}$01				
	(Anorthoclase: 21.6-21.9)							
				20$\bar{1}$	21.99-22.1	4.04 -4.02	8	
M	22.25-22.45	3.99 -3.96	3-1	111				
O	22.54-22.70	3.94 -3.91	2					
M	23.20-23.40	3.83 -3.80	5-2	130				
	23.75-24.05	3.74 -3.70	4-2	$\bar{1}$30				
O	23.50-23.76	3.78 -3.74	∼6	130	23.50-23.76	3.78 -3.74	∼6	**
MP	24.30-24.52	3.66 -3.63	∼6	13$\bar{1}$, $\bar{1}\bar{3}$1	24.30-24.52	3.66 -3.63	10-2	M-P
	24.51-24.72	3.63 -3.60	∼2	$\bar{1}$31, $\bar{1}\bar{3}$1				
	25.05-25.45	3.55 -3.50	1	$\bar{2}$21, $\bar{1}$31				
**	25.5 -25.8	3.49 -3.45	5	$\bar{1}$12, $\bar{1}\bar{1}$2	25.5 -25.7	3.49 -3.46	∼5	**
				221	25.9 -26.15	3.44 -3.41	∼3	*
M-P	26.41-26.71	3,37 -3.33	5	220, $\bar{1}$12	26.41-26.5	3.37 -3.36	6-2	M-P
	26.8 -27.8	3.34 -3.22	10-6	220				
	(triplet or quadruplet)			20$\bar{2}$				
	The strongest peak:			040				
				002				
	Orthoclase	26.9°						
	Sanidine, high	26.8°		002	27.78-28.1	3.21 -3.17	10-8	
	Sanidine, low	27.4°		040	(double or triplet)			
	Microcline	27.5°		220				
	Anorthoclase	27.8°		$\bar{2}$02				
M	29.45-29.65	3.03 -3.01	3-1	131, 1$\bar{3}$1	29.35-29.7	3.04 -3.00	5	
O	29.83-30.06	2.99 -2.97	5-3	131				
M	30.12-30.24	2.97 -2.96	3	1$\bar{3}$1				
				2$\bar{2}\bar{2}$, 0$\bar{2}\bar{4}$	30.3 -30.6	2.95 -2.92	5-2	
				131, 132	31.25-31.6	2.86 -2.83	5-2	
	30.8	2.90	3-2	022, 041				
	32.3 -32.4	2.77 -2.76	2-1	$\bar{3}$12				
				$\bar{1}$32, $\bar{1}$34	33.8	2.65	5	
	34.7 -34.85	2.58 -2.56	2	221				
				$\bar{2}$41				
				112				
				24$\bar{1}$	35.45-35.55	2.53 -2.52	5-2	
				2$\bar{2}$1, 1$\bar{1}$2				
	41.6 -41.9	2.17 -2.16	2	060				
				060	42.15-42.6	2.14 -2.12	2	
	50.5 -51.1	1.805-1.786	3	$\bar{2}$04				
	(Anorthoclase: 51.1-51.3)			$\bar{2}$04	51.2 -51.6	1.783-1.772	3	

** Peak observed in all feldspars.
* All plagioclases except albite.
M Microcline only.
M-P Peak common in microcline and plagioclase.
O All K-feldspars except microcline.

Appendix 13. Angular positions (2θ CuKα degree) and Miller indices of some significant diffraction peaks useful in determining the composition and structure of the K-feldspars

[See appendixes 14 and 15]

Indices HKL	Anorthoclase[1] 2θ	Microcline[1,2] 50% Or	Microcline[1,2] 98% Or	Orthoclase, low and high sanidine[1,2] 53% Or		90-91% Or		100% Or	
		2θ	2θ (Å)	O & Ls	Hs	O & Ls	Hs	O & Ls	Hs
$20\bar{1}$	21.65-21.9*	21.46	21.08(4.21)	21.44		21.06*		20.95	
$1\bar{1}1$	22.85	–	22.66(3.92)	–		–		–	
$\Delta 2\theta$ (111-$1\bar{1}1$)	∿0.55	–	-0.36	–		–		–	
111	23.11-23.56*	–	22.30(3.98)	–		22.54*		–	
$\bar{2}02$, 040	$\underline{27.48\text{-}27.66}$*	–	27.12*(3.29)	–		27.16*		–	
002	$\underline{27.78\text{-}27.98}$*	–	$\underline{27.46}$*(3.24)	–		$\underline{27.58}$	$\underline{27.64}$*	–	
220	27.75-28.3*	–	26.44*(3.37)	–		$\underline{26.92}$	$\underline{26.88}$*	–	
$1\bar{3}1$	29.64-29.9*	30.28	∿30.22(2.95)	–		–		–	
$\Delta 2\theta$ (131-131)	∿0.65	-0.53	-0.78	–		–		–	
131	30.50-31.28	29.75	29.44(3.03)	–	30.06*	29.84*		–	29.82*
132	32.75-33.48	–	32.48(2.755)	–		32.48*		–	
$24\bar{1}$ ($\bar{2}41$)	35.20-35.5*	–	34.26(2.615)	–		–		–	
$\Delta 2\theta$ ($\bar{2}41$-$24\bar{1}$)	∿(-0.08)	–	1.32	–		–		–	
$\bar{2}41$	35.25-35.6*	–	35.58(2.521)	–		34.84	34.78*	–	34.78*
060	41.74-42.03	41.93	∿41.80*(2.159)	41.76*	41.71*	41.66	41.56*	41.69	41.61*
400	48.9 -48.6	48.14	47.18(1.924)	–	48.26	47.22	47.20	–	47.00
$\bar{2}04$	51.0 -51.31*	50.68	50.56*(1.804)	50.83*	51.0*	50.74*	50.86*	50.75	50.90*

[1]Wright and Stewart (1968).

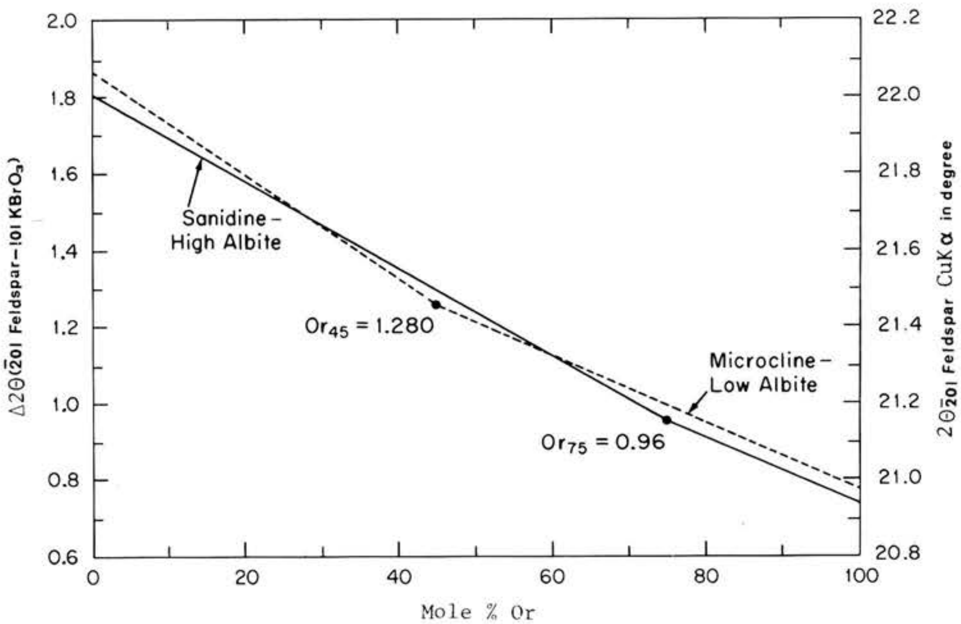
[2]Borg and Smith (1969b).

*Reflections that have peak intensities of 20 or larger on a scale of 100. The underlined figure indicates the strongest peak.

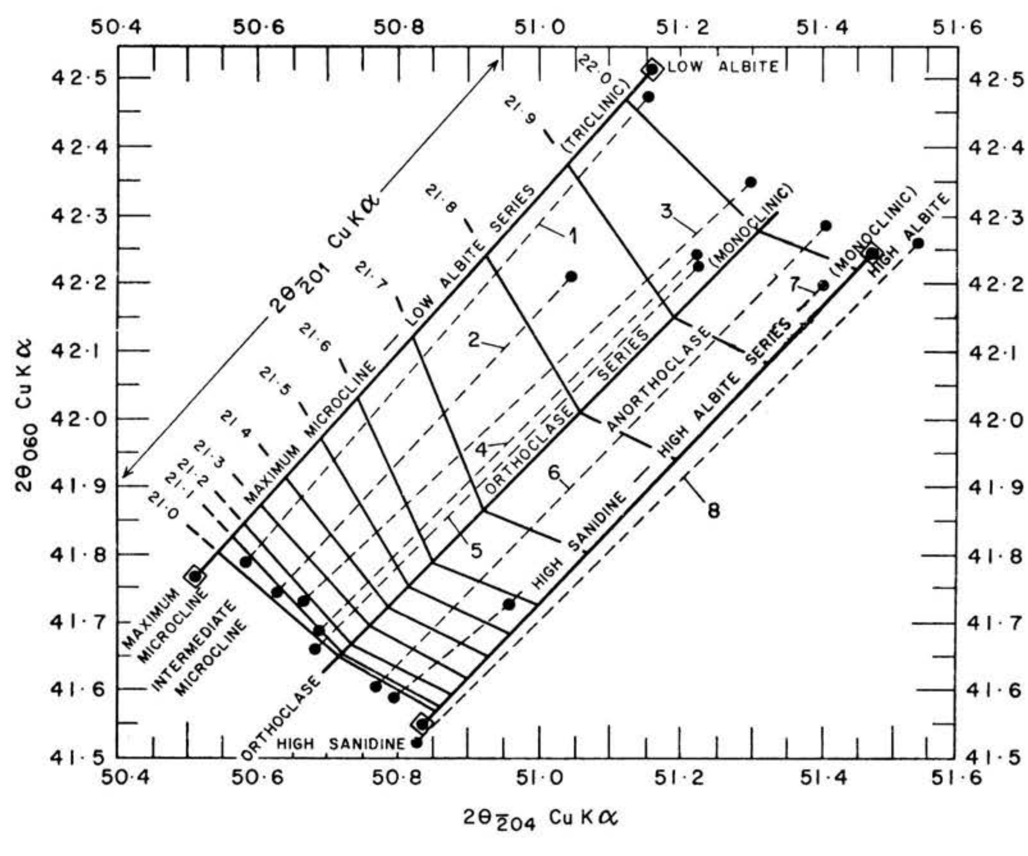
O Orthoclase.

Ls Low sanidine.

Hs High sanidine.



Appendix 14. X-ray determinative curve for orthoclase (Or) content in K-feldspars as determined from the 2θ ($\bar{2}01$) diffraction. The ordinate $\Delta 2\theta$ is the difference between the 2θ angle for the ($\bar{2}01$) diffraction and the (101) diffraction of $KBrO_3$ (internal standard) which lies at 20.212 2θ for CuKα radiation. The microcline-low albite series is shown by two dashed lines that meet at 45 mole % Or. The sanidine-high albite series is shown by the two straight lines that meet at 75 mole % Or.



Appendix 16. Angular positions (2θ CuKα degree) and Miller indices of some X-ray powder diffraction peaks useful in determining the composition and structural phase of the plagioclases

[See also appendixes 17 and 18]

Indices HKL	High Albite An_0 2θ	Anorthite An_{100} 2θ	Å	Bytownite An_{80} 2θ	Labradorite An_{64} 2θ	Andesine An_{38} 2θ	Oligoclase An_{22} 2θ	Low Albite An_{98} 2θ	Å
201 (202)	22.04*	22.0*	(4.039)	21.98*	22.02*	21.99*	22.0*	22.05*	(4.030)
111 (112)	22.9*	22.70	(3.916)	22.73*	22.89*	22.98*	22.93*	23.06	(3.857)
$\Delta 2\theta$ (111-111)	0.5	0.96	–	0.91	0.83	0.74	0.7	0.48	–
111 (130, 112)	23.7*	∿23.66*	(3.756)	23.64*	23.72*	23.72*	23.63	23.54*	(3.780)
202 (204)	27.84*	27.92*	(3.194)	27.91*	27.70*	27.89*	27.82*	27.75*	(3.214)
040, 002, 004	28.06	28.04*	(3.180)	28.04	27.89* 28.15*	28.15	28.03*	27.95*	(3.196)
220	28.54*	28.57*	(3.122)	28.49*	28.51*	28.48*	28.34*	28.3*	(3.151)
131 (132)	29.62	29.34*	(3.042)	29.40	29.65*	29.78*	29.83*	30.1	(2.964)
$\Delta 2\theta$ (131-131)	1.98	2.28		2.16	1.88	1.80	1.53	1.1	–
131 (132)	31.56	31.62*	(2.828)	31.56	31.53*	31.58*	31.36*	31.2	(2.866)
132 (132, 134)	33.73	33.7	(2.655)	33.82	33.81*	33.86*	33.83	33.8	(2.639)
241 (241, 242)	35.64*	35.88*	(2.504)	35.70*	35.59*	35.50*	35.27	35.0	(2.563)
$\Delta 2\theta$ (241-241)	0.16(?)	-0.35	–	0.0	0.27	0.58	0.95	1.8	–
241 (242)	35.80(?)	35.52*	(2.525)	35.70	35.86	36.08*	36.22	36.80	(2.443)
060	42.19	42.14	(2.143)	42.26	∿42.23	42.27	42.31	42.5	(2.125)
400 (064)	49.96	49.57	(1.837)	49.56	∿49.68	–	49.86	50.08	(1.819)
204 (208)	51.53	51.64	(1.768)	51.60	∿51.58	51.40	51.33	51.16	(1.783)

[1] Borg and Smith (1968).

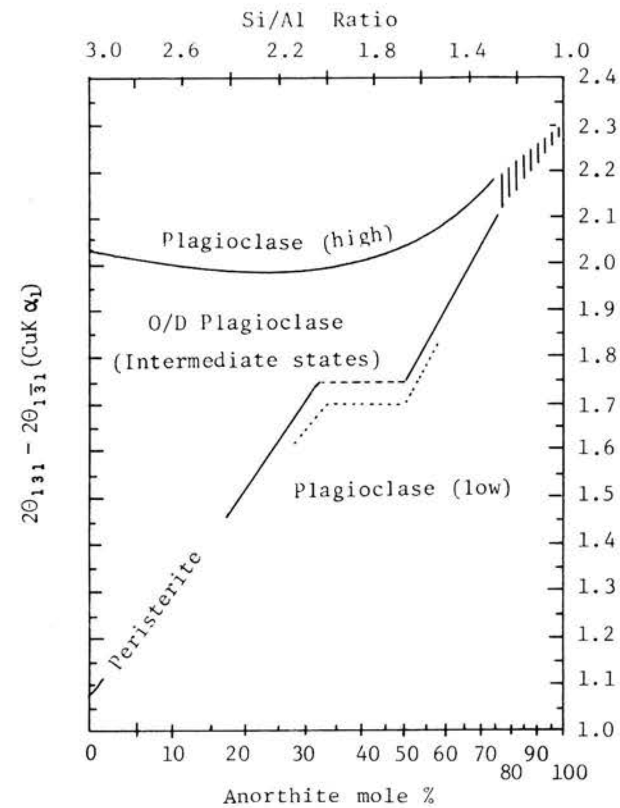
[2] Goodyear and Duffin (1953).

[3] Smith (1956).

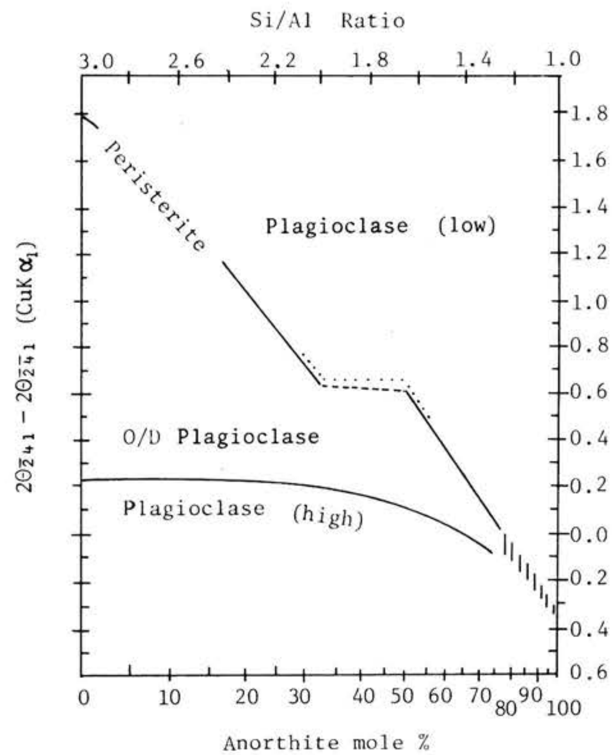
[4] Van der Plas (1966).

*Reflections that have peak intensities of 20 or larger on a scale of 100. The underlined figure indicates the strongest peak.

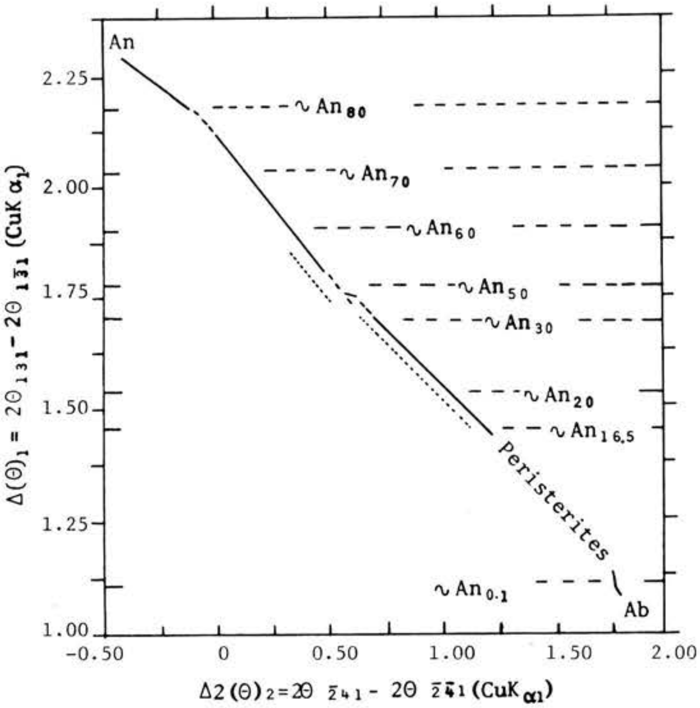
Appendix 15 (*on facing page*). Diagram relating 2θ (060) and 2θ ($\bar{2}04$) angles in the "three-peak" method of Wright (1968) for alkali feldspar determination. The four squares show the approximate position of the extreme end-members. The three major series (maximum microcline-low albite, orthoclase, and high sanidine-high albite) are shown in solid lines. Dashed lines are equivalent structural state (ion-exchanged paths) for specific alkali feldspars which have been well studied. The crossing contours show the expected values for 2θ ($\bar{2}01$) angles. If this value agrees within 0.1° 2θ of the observed 2θ value, the feldspar is assumed to have normal cell dimensions. If not, it may be anomalous. The orthoclase (Or) content (wt. %) of normal feldspars can be obtained once the structural state has been determined from this diagram by using the equations indicated on page 44.


Si/Al Ratio
3.0 2.6 2.2 1.8 1.4 1.0
Plagioclase (high)
O/D Plagioclase
(Intermediate states)
Plagioclase (low)
Peristerite
$2\Theta_{131} - 2\Theta_{1\bar{3}1}$ (CuK α_1)
2.4 2.3 2.2 2.1 2.0 1.9 1.8 1.7 1.6 1.5 1.4 1.3 1.2 1.1 1.0
0 10 20 30 40 50 60 70 80 90 100
Anorthite mole %

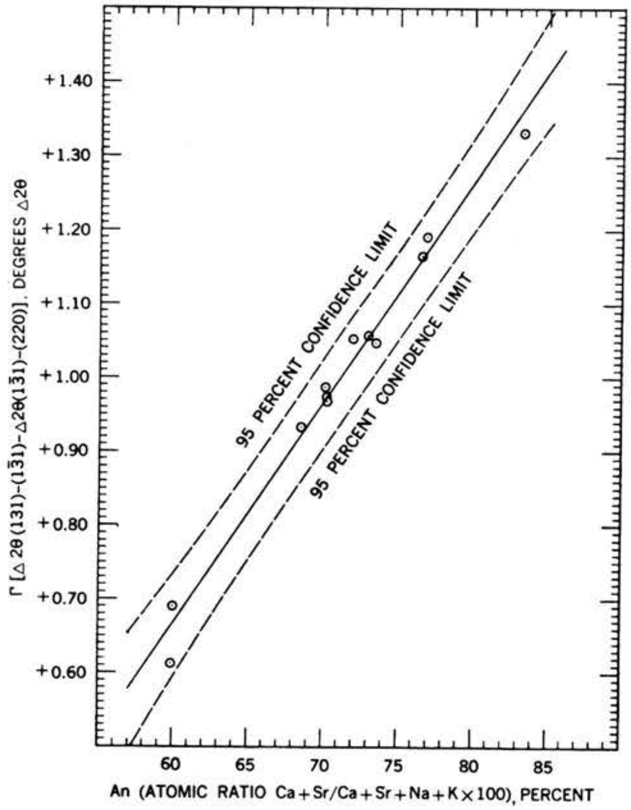
A


Si/Al Ratio
3.0 2.6 2.2 1.8 1.4 1.0
Peristerite
Plagioclase (low)
O/D Plagioclase
Plagioclase (high)
$2\Theta_{\bar{2}41} - 2\Theta_{\bar{2}\bar{4}1}$ (CuK α_1)
1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 0.0 0.2 0.4 0.6
0 10 20 30 40 50 60 70 80 90 100
Anorthite mole %

B

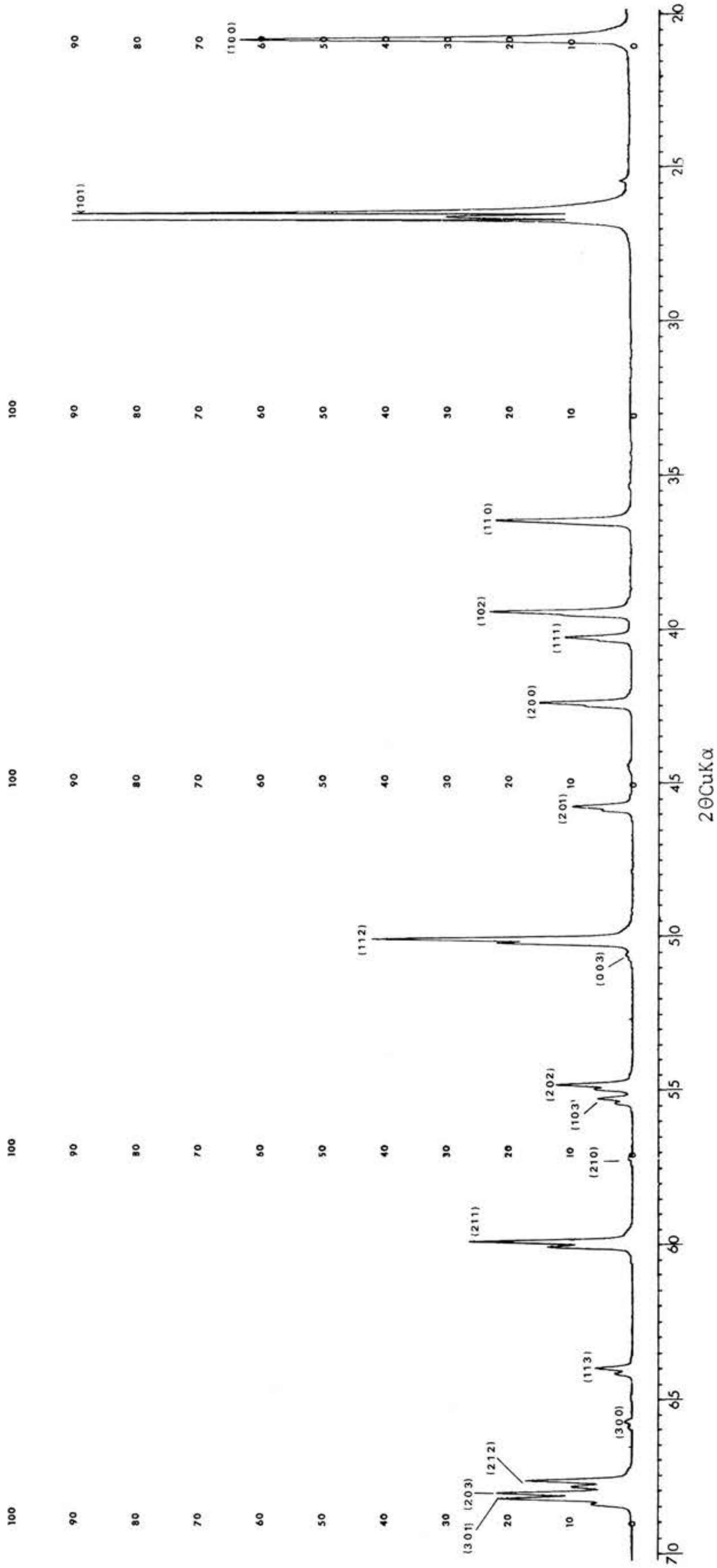

An
~An80
~An70
~An60
~An50
~An30
~An20
~An16.5
Peristerites
~An0.1
Ab
2.25 2.00 1.75 1.50 1.25 1.00
-0.50 0 0.50 1.00 1.50 2.00
$\Delta(\Theta)_1 = 2\Theta_{131} - 2\Theta_{1\bar{3}1}$ (CuK α_1)
$\Delta 2(\Theta)_2 = 2\Theta_{\bar{2}41} - 2\Theta_{\bar{2}\bar{4}1}$ (CuK α_1)

C

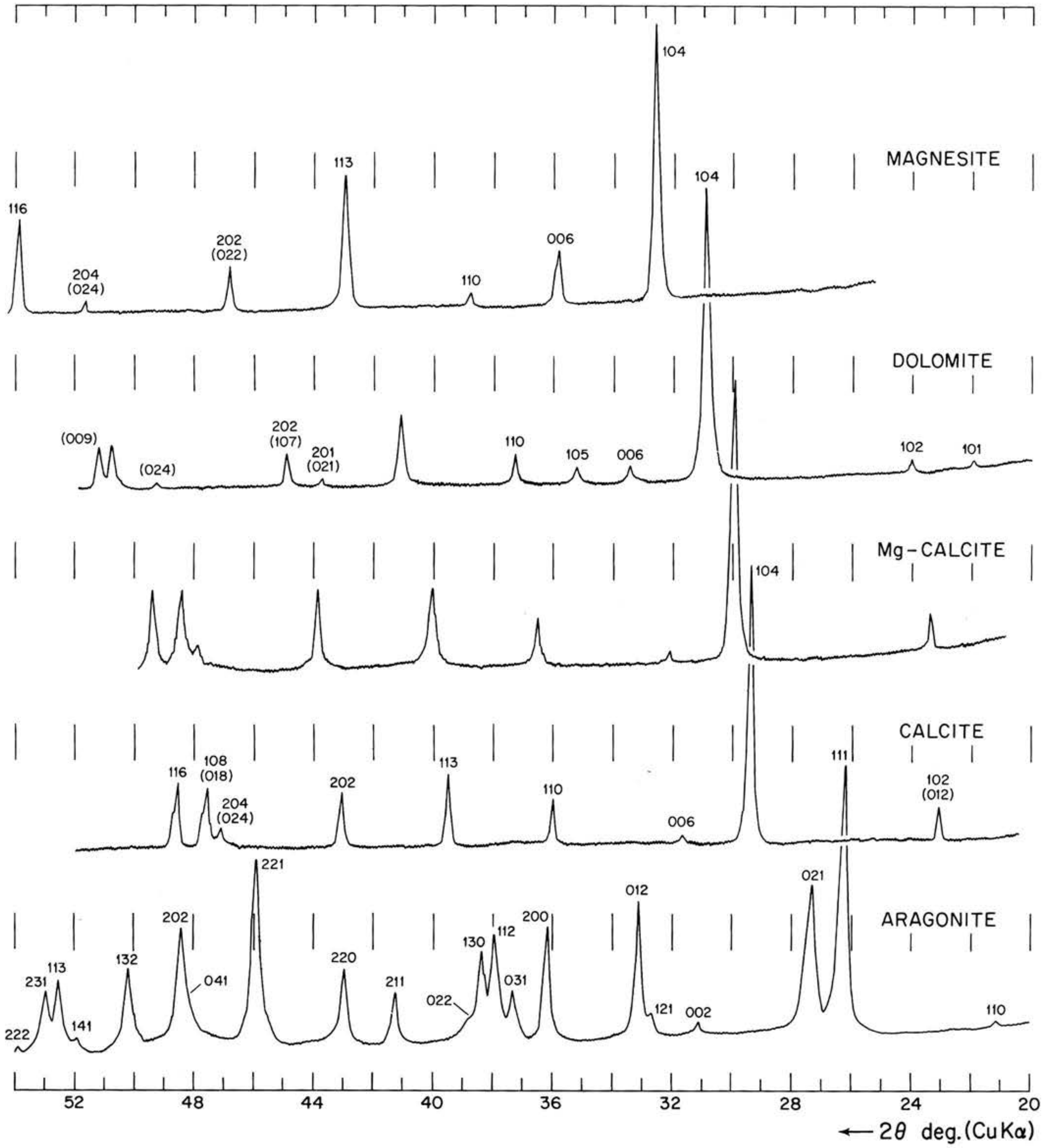


Appendix 18. Graph showing the relationship between the gamma (Γ) and An content for plagioclase with An_{60-85}.

Appendix 17 (*on facing page*). Relationship among indicators of structural state $\Delta\ (\theta)_1$ and $\Delta\ (\theta)_2$ and the plagioclase composition. $\Delta\ (\theta)_1 = 2\theta_{131} - 2\theta_{1\bar{3}1}$ (graph A) and $\Delta\ (\theta)_2 = 2\theta_{\bar{2}41} - 2\theta_{\overline{241}}$ (graph B). Note the linear scale for the Si/Al ratio and the nonlinear scale for molecular % An. These determinative graphs are most suitable for plagioclase with An_{20-70}, assuming only one plagioclase phase present and a homogeneous An content. Solid lines are for plagioclase with Or <0.5-0.8%. Dashed lines are for plagioclase with Or $\sim 4\%$ and with An_{40-60}. Graph C shows the relationship between the 131/1$\bar{3}$1 and $\bar{2}$41/$\overline{241}$ indicators for ordered (O) and intermediate (O/D) plagioclases. Solid line for Or <0.5-0.8%. Dashed line with Or_{2-5}%. An-calibration is given for low plagioclases.



Appendix 19. X-ray powder diffraction pattern of alpha quartz.



Appendix 20. X-ray powder diffraction patterns of carbonate minerals: aragonite, calcite, Mg-calcite, dolomite, and magnesite. Samples of aragonite and Mg-calcite are of coral *Acropora* sp. and *Tubiopora* sp., respectively, from Tungsha (Paracel) Islands, China.

Appendix 21. Table for conversion of 2θ angles (CuKα) to interplanar spacing (d)
[From Switzer and others (1948)]

2θ	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2	44.171	42.068	40.156	38.410	36.180	35.338	33.979	32.721	31.552	30.464
3	29.449	28.499	27.609	26.773	25.985	25.243	24.542	23.879	23.251	22.655
4	22.089	21.550	21.037	20.548	20.082	19.636	19.209	18.800	18.409	18.034
5	17.673	17.327	16.994	16.673	16.365	16.068	15.781	15.504	15.237	14.979
6	14.730	14.488	14.255	14.029	13.810	13.598	13.392	13.192	12.998	12.810
7	12.628	12.450	12.277	12.109	11.946	11.787	11.632	11.481	11.334	11.191
8	11.051	10.915	10.782	10.652	10.526	10.402	10.281	10.163	10.048	9.9355
9	9.8254	9.7176	9.6122	9.5091	9.4082	9.3093	9.2126	9.1178	9.0250	8.9341
10	8.8450	8.7576	8.6720	8.5880	8.5057	8.4249	8.3456	8.2678	8.1915	8.1166
11	8.0430	7.9708	7.8998	7.8302	7.7617	7.6944	7.6283	7.5634	7.4995	7.4367
12	7.3750	7.3142	7.2545	7.1957	7.1379	7.0810	7.0251	6.9699	6.9157	6.8624
13	6.8098	6.7580	6.7071	6.6569	6.6074	6.5587	6.5107	6.4634	6.4168	6.3708
14	6.3256	6.2809	6.2369	6.1935	6.1507	6.1085	6.0669	6.0259	5.9854	5.9454
15	5.9060	5.8671	5.8288	5.7909	5.7535	5.7166	5.6802	5.6442	5.6088	5.5737
16	5.5391	5.5049	5.4711	5.4378	5.4049	5.3723	5.3402	5.3084	5.2771	5.2461
17	5.2154	5.1852	5.1552	5.1257	5.0964	5.0675	5.0390	5.0107	4.9828	4.9552
18	4.9279	4.9009	4.8742	4.8478	4.8216	4.7958	4.7702	4.7450	4.7199	4.6952
19	4.6707	4.6465	4.6225	4.5988	4.5753	4.5521	4.5291	4.5063	4.4838	4.4615
20	4.4394	4.4175	4.3959	4.3744	4.3532	4.3322	4.3114	4.2908	4.2704	4.2502
21	4.2302	4.2104	4.1907	4.1713	4.1520	4.1329	4.1140	4.0953	4.0767	4.0583
22	4.0401	4.0220	4.0042	3.9864	3.9689	3.9515	3.9342	3.9171	3.9001	3.8833
23	3.8667	3.8502	3.8338	3.8176	3.8015	3.7855	3.7697	3.7540	3.7385	3.7231
24	3.7078	3.6926	3.6776	3.6627	3.6479	3.6332	3.6187	3.6043	3.5900	3.5758
25	3.5617	3.5477	3.5339	3.5201	3.5065	3.4930	3.4796	3.4662	3.4530	3.4399
26	3.4269	3.4140	3.4012	3.3885	3.3759	3.3634	3.3510	3.3386	3.3264	3.3143
27	3.3022	3.2903	3.2784	3.2666	3.2549	3.2433	3.2318	3.2203	3.2090	3.1977
28	3.1865	3.1754	3.1644	3.1534	3.1426	3.1318	3.1210	3.1104	3.0998	3.0893
29	3.0789	3.0685	3.0582	3.0480	3.0379	3.0278	3.0178	3.0079	2.9980	2.9882
30	2.9785	2.9688	2.9592	2.9497	2.9402	2.9308	2.9214	2.9122	2.9029	2.8938
31	2.8847	2.8756	2.8666	2.8577	2.8488	2.8400	2.8312	2.8225	2.8139	2.8053
32	2.7968	2.7883	2.7798	2.7715	2.7631	2.7549	2.7466	2.7385	2.7303	2.7223
33	2.7143	2.7063	2.6984	2.6905	2.6827	2.6749	2.6671	2.6595	2.6518	2.6442
34	2.6367	2.6292	2.6217	2.6143	2.6069	2.5996	2.5923	2.5851	2.5779	2.5707
35	2.5636	2.5565	2.5495	2.5425	2.5355	2.5286	2.5218	2.5149	2.5081	2.5014
36	2.4947	2.4880	2.4813	2.4747	2.4682	2.4616	2.4551	2.4487	2.4422	2.4358
37	2.4295	2.4232	2.4169	2.4106	2.4044	2.3982	2.3921	2.3860	2.3799	2.3738
38	2.3678	2.3618	2.3559	2.3500	2.3441	2.3382	2.3324	2.3266	2.3208	2.3151
39	2.3094	2.3037	2.2981	2.2924	2.2869	2.2813	2.2758	2.2703	2.2648	2.2593
40	2.2539	2.2485	2.2432	2.2378	2.2325	2.2273	2.2220	2.2168	2.2116	2.2064
41	2.2012	2.1961	2.1910	2.1859	2.1809	2.1759	2.1709	2.1659	2.1609	2.1560
42	2.1511	2.1462	2.1414	2.1365	2.1317	2.1270	2.1222	2.1175	2.1127	2.1080
43	2.1034	2.0987	2.0941	2.0895	2.0849	2.0804	2.0758	2.0713	2.0668	2.0623
44	2.0579	2.0534	2.0490	2.0446	2.0402	2.0359	2.0316	2.0273	2.0230	2.0187
45	2.0144	2.0102	2.0060	2.0018	1.9976	1.9935	1.9893	1.9852	1.9811	1.9770
46	1.9729	1.9689	1.9649	1.9609	1.9569	1.9529	1.9489	1.9450	1.9411	1.9372
47	1.9333	1.9294	1.9255	1.9217	1.9179	1.9141	1.9103	1.9065	1.9028	1.8990
48	1.8953	1.8916	1.8879	1.8842	1.8806	1.8769	1.8733	1.8697	1.8661	1.8625
49	1.8589	1.8554	1.8519	1.8483	1.8448	1.8413	1.8378	1.8344	1.8309	1.8275
50	1.8241	1.8207	1.8173	1.8139	1.8105	1.8072	1.8039	1.8005	1.7972	1.7939

Appendix 21. Table for conversion of 2θ angles (CuKα) to interplanar spacing (d)—Continued

2θ	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
51	1.7906	1.7874	1.7841	1.7809	1.7776	1.7744	1.7712	1.7680	1.7648	1.7617
52	1.7585	1.7554	1.7523	1.7491	1.7460	1.7430	1.7399	1.7368	1.7338	1.7307
53	1.7277	1.7247	1.7217	1.7187	1.7157	1.7127	1.7098	1.7068	1.7039	1.7009
54	1.6980	1.6951	1.6922	1.6894	1.6865	1.6836	1.6808	1.6779	1.6751	1.6723
55	1.6695	1.6667	1.6639	1.6612	1.6584	1.6556	1.6529	1.6502	1.6474	1.6447
56	1.6420	1.6393	1.6367	1.6340	1.6313	1.6287	1.6260	1.6234	1.6208	1.6182
57	1.6156	1.6130	1.6104	1.6078	1.6053	1.6027	1.6002	1.5976	1.5951	1.5926
58	1.5901	1.5876	1.5851	1.5826	1.5801	1.5777	1.5752	1.5728	1.5703	1.5679
59	1.5655	1.5631	1.5607	1.5583	1.5559	1.5535	1.5512	1.5488	1.5465	1.5441
60	1.5418	1.5395	1.5371	1.5348	1.5325	1.5302	1.5279	1.5257	1.5234	1.5211
61	1.5189	1.5166	1.5144	1.5122	1.5099	1.5077	1.5055	1.5033	1.5011	1.4989
62	1.4968	1.4946	1.4924	1.4903	1.4881	1.4860	1.4839	1.4817	1.4796	1.4775
63	1.4754	1.4733	1.4712	1.4691	1.4670	1.4650	1.4629	1.4609	1.4588	1.4568
64	1.4547	1.4527	1.4507	1.4487	1.4467	1.4447	1.4427	1.4407	1.4387	1.4367
65	1.4347	1.4328	1.4308	1.4289	1.4269	1.4250	1.4231	1.4211	1.4192	1.4173
66	1.4154	1.4135	1.4116	1.4097	1.4079	1.4060	1.4041	1.4023	1.4004	1.3985
67	1.3967	1.3949	1.3930	1.3912	1.3894	1.3876	1.3858	1.3840	1.3822	1.3804
68	1.3786	1.3768	1.3750	1.3733	1.3715	1.3697	1.3680	1.3662	1.3645	1.3628
69	1.3610	1.3593	1.3576	1.3559	1.3542	1.3524	1.3507	1.3491	1.3474	1.3457
70	1.3440	1.3423	1.3407	1.3390	1.3373	1.3357	1.3340	1.3324	1.3308	1.3291
71	1.3275	1.3259	1.3243	1.3227	1.3211	1.3195	1.3179	1.3163	1.3147	1.3131
72	1.3115	1.3099	1.3084	1.3068	1.3053	1.3037	1.3022	1.3006	1.2991	1.2975
73	1.2960	1.2945	1.2930	1.2914	1.2899	1.2884	1.2869	1.2854	1.2839	1.2824
74	1.2809	1.2795	1.2780	1.2765	1.2750	1.2736	1.2721	1.2707	1.2692	1.2678
75	1.2663	1.2649	1.2635	1.2620	1.2606	1.2592	1.2578	1.2563	1.2549	1.2535

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CHARACTERISTIC WAVELENGTHS, FILTERS, AND CONVERSION FACTORS

Radiation	Wavelength (Å)	Filter	Factors to convert d-values for $K\alpha$ to $K\alpha_1$ (Divide unresolved d-value ($K\alpha$) for observed 2θ angle by the corresponding factor.)
$MoK\alpha$	0.7106	Zr	1.0020
$CuK\alpha$	1.5418	Ni	1.0008
$CoK\alpha$	1.7902	Fe	1.0007
$FeK\alpha$	1.9373	Mn	1.0007
$CrK\alpha$	2.2909	V	1.0006

SOME DEFINED QUANTITIES

Unit	Symbol	Equivalents
kilo-x-units	kX	1000 X.U.; 0.99798Å
angstrom	Å	1.00202kX 10^{-7} mm (10^{-10} m)
millimicron (nanometer)	$m\mu$ (nm)	0.001μ (10^{-9} m) or 10Å
micron (micrometer)	μ or μm	0.001 mm (10^{-6} m) or 10^4 Å
millimeter	mm	0.001 m (10^{-3} m)