TABLES OF MINERALS

INCLUDING THE

Uses of Minerals and Statistics of the Domestic Production

BY

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PREFACE TO FIRST EDITION.

The minerals are arranged in the tables as follows:

I. According to the six systems of crystallization and their prominent subdivisions, the minerals of each subdivision being arranged in accordance with the chemical classification as adopted by Dana.

II. According to the elements, emphasis being given to minerals which are important from an economic standpoint.

III. With reference to geological occurrence and association.

Minerals are given three ranks in the tables, indicated by the type used in printing the names of the species, as follows:—(1) Minerals of the first rank are either very common, or especially important from a scientific or geological standpoint, and their names are printed in heavy type, capital letters. (2) Minerals which are of rather rare occurrence, including some very rare species provided they are especially important from an economic or scientific standpoint, are given a second rank, and their names are printed in heavy type, capital and small letters. (3) The names of rarer and less important species, constituting a third rank, are printed in small type. All of the important minerals (450 species) are included in the tables, and generally very rare species have been omitted, except where chemical composition or some pronounced features have given them special significance. The weighting of the minerals, or assignment to first, second or third rank, is an arbitrary matter, based upon the writer's experience, but it is believed that students will appreciate this feature of the tables, enabling them almost at a glance to form some estimate of the relative importance of the several species.

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PREFACE TO SECOND EDITION.

THE "Tables of Minerals" was written by Prof. Penfield in 1903 for use in connection with lectures on Descriptive Mineralogy in this School and has been used by successive classes since then. The present edition has been carefully revised, chiefly in the matter of bringing the statistics of mineral production down to date. Acknowledgment is gratefully made of the assistance of Dr. George F. Kunz, who kindly furnished the figures for the values of the gem stones.

Part III of the Tables has been rewritten and enlarged, with the purpose of making that section more useful to students who have only a slight knowledge of geology or petrology.

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MINERALOGICAL LABORATORY OF THE SHEFFIELD
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CONTENTS.

PART I.

ARRANGEMENT OF MINERALS ACCORDING TO THE SIX SYSTEMS OF CRYSTALLIZATION.

PART II.

ARRANGEMENT OF THE MINERALS ACCORDING TO THE ELEMENTS, WITH USES AND STATISTICS.

PART III.

USEFUL MINERALS.

PART IV.

LISTS OF MINERALS ACCORDING TO GEOLOGICAL OCCURRENCE AND ASSOCIATION.

SYNOPSIS OF THE CHEMICAL CLASSIFICATION OF DANA.

1. **Native Elements.**
2. **Sulphides, Selenides, Tellurides, Arsenides, Antimonides.**
3. **Sulpharsenites, Sulphantimonites, Sulphobismuthites.**
4. **Chlorides, Bromides, Fluorides.**
5. **Oxides.**
6. **Carbonates.**
7. **Silicates, Titanates.**
8. **Niobates, Tantalates.**
9. **Phosphates, Arsenates, Vanadates.**
10. **Borates.**
11. **Uranates.**
12. **Sulphates, Chromates.**
13. **Tungstates, Molybdates.**

TABLES OF MINERALS.

PART I.

ARRANGEMENT OF MINERALS ACCORDING TO THE SIX SYSTEMS OF CRYSTALLIZATION.

NOTE.—The chief object of tables of this kind is that they may serve as a guide and reference-list to accompany lectures on crystallography and descriptive mineralogy. In a measure, also, the tables may be made the basis of determinative mineralogy, for if it is discovered that a mineral crystallizes in a certain system, the list of minerals in that system may be studied and the name of the species found by comparison either with labeled specimens or with descriptions as given in the texts referred to.

ISOMETRIC SYSTEM; NORMAL GROUP.

NOTE.—The pyritohedral and tetrahedral groups are tabulated separately, while a few minerals belonging to the rarer plagihedral division are included in the normal group.

Elements.

		T. B.	*Sys.
1.	**DIAMOND, C** (perhaps tetrahedral),	271,	3
2.	**GOLD,** Au, always with some Ag,	275,	14
3.	**SILVER,** Ag,	278,	19
4.	**COPPER,** Cu,	278,	20
5.	**Platinum,** Pt,	280,	25
6.	**Iron,** Fe with Ni, both terrestrial and meteoric,	281,	28

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* The columns of numbers headed T. B. and Sys. refer respectively to the pages of Dana's *Text-Book of Mineralogy* and *System of Mineralogy* on which descriptions of the species may be found.

Sulphides, Selenides, Tellurides.

		T. B.	Sys.
1.	**GALENA,** PbS, often carrying Ag,	287,	48
2.	Altaite, $PbTe$,	288,	51
3.	**Argentite,** Ag_2S,	288,	46
4.	Hessite, Ag_2Te,	289,	47
5.	Petzite, $(Ag, Au)_2Te$,	289,	48
6.	Berzelianite, Cu_2Se,	289,	52
7.	Crookesite, $(Cu, Tl, Ag)_2Se$,	289,	54
8.	**Pentlandite,** $(Ni, Fe)S$,	293,	65
9.	**BORNITE,** Cu_5FeS_4,	297,	77
10.	**Linnaeite,** $Co_3S_4 = CoS \cdot Co_2S_3$,	297,	78
11.	Argyrodite, $Ag_8GeS_6 = 4\,Ag_2S \cdot GeS_2$,	316,	150
12.	Canfieldite, $Ag_8SnS_6 = 4\,Ag_2S \cdot SnS_2$,	316,	—

Chlorides, Bromides, Fluorides.

1.	**HALITE,** $NaCl$,	318,	154
2.	**SYLVITE,** KCl (plagihedral),	318,	156
3.	**Cerargyrite,** $AgCl$,	319,	158
4.	**Embolite,** $Ag(Cl, Br)$,	319,	159
5.	Nantokite, $CuCl$,	317,	154
6.	Percylite (Boléite), $PbCuCl_2[OH]_2$,	322,	172
7.	**FLUORITE,** CaF_2,	320,	161
8.	Ralstonite $(Na_2, Mg)F_2 \cdot 3\,Al(F, OH)_3 \cdot 2H_2O$,	323,	181

Oxides.

1.	Arsenolite, As_2O_3,	330,	198
2.	**Senarmontite,** Sb_2O_3,	330,	198
3.	**CUPRITE,** Cu_2O (plagihedral),	331,	206
4.	Periclase, MgO,	331,	207
5.	Manganosite, MnO,	332,	207

Spinel Group. $R''R_2'''O_4$ *or* $R''O \cdot R_2'''O_3$.

6.	**SPINEL,** $MgAl_2O_4$, Fe iso. w. Mg,	338,	220
7.	**Gahnite,** $ZnAl_2O_4$, Fe and Mn iso. w. Zn,	339,	223
8.	**MAGNETITE,** $FeFe_2O_4$,	339,	224
9.	**Franklinite,** $(Fe, Mn, Zn)(Fe, Mn)_2O_4$,	341,	227
10.	**CHROMITE,** $(Fe, Mg)Cr_2O_4$,	341,	228

Carbonates.

		T. B.	Sys.
1.	Northupite, $MgCO_3 . Na_2CO_3 . NaCl$,	364,	—

Metasilicates.

1.	**LEUCITE,** $KAl[SiO_3]_2$,	381,	342
2.	**ANALCITE,** $NaAl[SiO_3]_2 . H_2O$,	460,	595
3.	Pollucite, $H_2Cs_4Al_4[SiO_3]_9$,	382,	343

Orthosilicates.

1.	**Sodalite,** $Na_4[AlCl]Al_2[SiO_4]_3$,	412,	429
2.	Haüynite, $[Na_2, Ca]_2[Al . NaSO_4]Al_2[SiO_4]_3$,	412,	431
3.	**Lazurite,** $Na_4[Al . NaS_3]Al_2[SiO_4]_3$,	413,	432

4.	**GARNET GROUP,** $R_3''R_2'''[SiO_4]_3$	Grossularite, $Ca_3Al_2[SiO_4]_3$,	415,	437
		Pyrope, $Mg_3Al_2[SiO_4]_3$		
		Almandite, $Fe_3Al_2[SiO_4]_3$		
		Spessartite, $Mn_3Al_2[SiO_4]_3$		
		Andradite, $Ca_3Fe_2[SiO_4]_3$		
		Uvarovite, $Ca_3(Cr, Al)_2[SiO_4]_3$		

Titanates, Manganates.

1.	Perovskite, $CaTiO_3$,	487,	722
2.	Bixbyite, $FeMnO_3 = FeO . MnO_2$,	343,	—

Niobates, Tantalates.

1.	Pyrochlore, $RNb_2O_6 . R(Ti, Th)O_3 . R = Ca, Ce,$ and Na_2,	489,	726
2.	Microlite, $Ca_2Ta_2O_7$,	489,	728

Uranates.

1.	**Uraninite,** UO_3 and UO_2, with Th, Y, Ce, Pb, He, Ra,	521,	889

Sulphates.

1.	Sulphohalite, $2Na_2SO_4 . NaCl . NaF$,	530,	917

ISOMETRIC SYSTEM; PYRITOHEDRAL GROUP.

Sulphides, Arsenides, Antimonides.

		T. B.	Sys.
1.	**PYRITE,** Fe S_2,	300,	84
2.	Hauerite, Mn S_2,	301,	87
3.	**Smaltite,** Co As_2,	301,	87
4.	**Chloanthite,** Ni As_2,	301,	87
5.	**Cobaltite,** Co As S,	301,	89
6.	**Gersdorffite,** Ni As S,	302,	90
7.	Ullmannite, Ni Sb S,	302,	91
8.	Sperrylite, Pt As_2,	302,	92

Sulphates.

1.	**Kalinite, Alum,** K Al $[SO_4]_2 \cdot 12\ H_2O$,	535,	951

ISOMETRIC SYSTEM; TETRAHEDRAL GROUP.

Sulphides, Selenides.

1.	**SPHALERITE,** Zn S, with isomorphous Fe and Cd,	291,	59
2.	**Tiemannite,** Hg Se, S iso. w. Se,	292,	63
3.	Onofrite, Hg (S, Se),	292,	64
4.	**Alabandite,** Mn S,	292,	64

Sulphantimonites, Sulpharsenites.

1.	**TETRAHEDRITE,** $Cu_8\ Sb_2\ S_7 = 4\ Cu_2\ S \cdot Sb_2\ S_3$,	312,	137
2.	**TENNANTITE,** $Cu_8\ As_2\ S_7 = 4\ Cu_2\ S \cdot As_2\ S_3$,	313,	137

Chlorides, Bromides, Iodides.

1.	Marshite, Cu I,	317,	—
2.	Miersite, 4 Ag I . Cu I,	319,	—

Orthosilicates.

1.	Helvite, $(Mn, Fe)_2\ (Mn_2\ S)\ Be_3\ [Si\ O_4]_3$,	414,	434
2.	Eulytite, $Bi_4\ [Si\ O_4]_3$,	414,	436
3.	Zunyite, $[Al \cdot 2\ (OH, F, Cl)]_6\ Al_2\ [Si\ O_4]_3$,	414,	436

Phosphates, Arsenates.

1.	Pharmacosiderite, Fe $[Fe \cdot OH]_3\ [As\ O_4]_3 \cdot 6\ H_2O$,	513,	847

Borates.

1.	**Boracite,** $Mg_7\ Cl_2\ B_{16}\ O_{30}$,	518,	879

TETRAGONAL SYSTEM; NORMAL GROUP.

Sulphides.

		T. B.	Sys.
1.	**Stannite,** $Cu_2 Fe Sn S_4 = Cu_2 S . Fe S . Sn S_2$,	315,	83

Chlorides.

1.	Calomel, $Hg Cl$,	317,	153
2.	Matlockite, $Pb_2 O Cl_2$,	322,	169

Oxides, and closely related Silicates and Phosphates.

1.	Hausmannite, $Mn_3 O_4$,	342,	230
2.	Braunite, $Mn Mn O_3$, with $Mn Si O_3$,	343,	232
3.	**Octahedrite,** $Ti O_2$,	346,	240
4.	**CASSITERITE,** $Sn O_2$ or $Sn Sn O_4$,	344,	234
5.	**RUTILE,** $Ti O_2$ or $Ti Ti O_4$,	345,	237
6.	Polianite, $Mn O_2$ or $Mn Mn O_4$,	345,	236
7.	Plattnerite, $Pb O_2$ or $Pb Pb O_4$,	346,	239
8.	**ZIRCON,** $Zr Si O_4$,	429,	482
9.	**Thorite,** $Th Si O_4$,	430,	488
10.	**Xenotime,** $Y P O_4$,	494,	748

Carbonates.

1.	**Phosgenite,** $[Pb Cl]_2 CO_3$,	364,	292

Silicates.

1.	Hardystonite, $Ca_2 Zn Si_2 O_7$,	Appendix	32
2.	Ganomalite, $Pb_4 [Pb . OH]_2 Ca_4 [Si_2 O_7]_3$,	408,	422
3.	Nasonite, $Pb_4 [Pb Cl]_2 Ca_4 [Si_2 O_7]_3$	Appendix	48
4.	**Melilite,** Complex, Ca, Mg, Na, Al, Fe silicate,	426,	474
5.	**VESUVIANITE,** Complex Ca, Al silicate,	427,	477
6.	**Apophyllite,** $H_7 K Ca_4 [Si O_3]_8 . 4\frac{1}{2} H_2O$,	452,	566

Niobates, Tantalates.

1.	Tapiolite, $Fe (Ta, Nb)_2 O_6$,	492,	738

Phosphates, Arsenates.

1.	Torbernite, $Cu [U O_2]_2 [P O_4]_2 . 8 H_2O$,	515,	856
2.	Zeunerite, $Cu [U O_2]_2 [As O_4]_2 . 8 H_2O$,	515,	857

TETRAGONAL SYSTEM; TRI-PYRAMIDAL GROUP.

Silicates.

			T. B.	Sys.
1.	**WERNERITE,** or **SCAPOLITE,**	$Ca_4 Al_6 Si_6 O_{25}$ with $Na_4 Al_3 Si_9 O_{24} Cl$,	425,	468

Niobates, Tantalates.

1.	Fergusonite, R (Nb, Ta) O_4, R = Y, Er, Ce,	490,	729

Tungstates, Molybdates.

1.	**Scheelite,** $Ca W O_4$,	540,	985
2.	Stolzite, $Pb W O_4$,	541,	989
3.	**Wulfenite,** $Pb Mo O_4$,	541,	989

TETRAGONAL SYSTEM; SPHENOIDAL GROUP.

Sulphides.

1.	**CHALCOPYRITE,** $Cu Fe S_2$,	297,	80

Silicates.

1.	Edingtonite, $Ba Al_2 Si_3 O_{10} . 3 H_2O$,	460,	599

HEXAGONAL SYSTEM; NORMAL GROUP.

Elements.

		T. B.	Sys.
1.	Iridosmine, Ir with Os,	280,	27

Sulphides.

1.	**Molybdenite,** $Mo S_2$,	285,	41
2.	Covellite, $Cu S$,	294,	68
3.	**PYRRHOTITE,** $Fe_{11} S_{12}$ ($Fe S$?),	296,	73

Fluorides.

1.	Tysonite, (Ce, La, Di) F_3,	321,	166

Oxides.

1.	Tridymite, $Si O_2$,	328,	192

Carbonates.

1.	Parisite, $[R F]_2 Ca [CO_3]_3$, R = Ce, La, Di,	364,	290

Silicates.

1.	**BERYL,** $Be_3 Al_2 [Si O_3]_6$, with some [OH]?	405,	405
2.	Barysilite, $Pb_3 Si_2 O_7$,	408,	421
3.	**NEPHELITE,** approximately $Na Al Si O_4$,	409,	423
4.	Eucryptite, $Li Al Si O_4$,	410,	426
5.	Cancrinite, $H_6 Na_6 Ca (Na CO_3)_2 Al_8 [Si O_4]_9$,	411,	427

6.	Thaumasite, $Ca Si O_3 . Ca CO_3 . Ca SO_4 . 15 H_2O$,	483,	698

Sulphates.

1.	Hanksite, $9 Na_2 SO_4 . 2 Na_2 CO_3 . K Cl$,	530,	920

HEXAGONAL SYSTEM; HEMIMORPHIC GROUP.

Sulphides, Arsenides, Antimonides.

		T. B.	Sys.
1.	**Greenockite,** Cd S,	294,	69
2.	Wurtzite, Zn S,	295,	70
3.	**Niccolite,** Ni As,	295,	71
4.	Breithauptite, Ni Sb,	296,	72

Chlorides, Iodides.

1.	Iodyrite, Ag I,	319,	160

Oxides.

1.	**Zincite,** Zn O, with Mn O,	332,	208

HEXAGONAL SYSTEM; TRI-PYRAMIDAL GROUP.

Phosphates, Arsenates, Vanadates.

Apatite Group.

1.	**APATITE,**	$Ca_4 [Ca F] [PO_4]_3$,	497,	762
2.	**PYROMORPHITE,**	$Pb_4 [Pb Cl] [PO_4]_3$,	499,	770
3.	**Mimetite,**	$Pb_4 [Pb Cl] [As O_4]_3$,	500,	771
4.	**Vanadinite,**	$Pb_4 [Pb Cl] [VO_4]_3$,	500,	773

HEXAGONAL-RHOMBOHEDRAL SYSTEM; NORMAL GROUP.

NOTE.—A few hemimorphic species are included in the tables with the *Normal Group*. The *Tri-Rhombohedral* and *Trapezohedral* groups are in separate tables.

Elements.

1.	**GRAPHITE,** C,	273,	7
2.	**Arsenic,** As,	274,	11
3.	**Antimony,** Sb,	275,	12
4.	**Bismuth,** Bi,	275,	13
5.	Tellurium, Te,	275,	11

Sulphides, Tellurides.

1.	Tetradymite, $Bi_2 Te_2 S$,	284,	39
2.	**Millerite,** Ni S,	295,	70

Sulphantimonites, Sulpharsenites.

1.	**Pyrargyrite,** $Ag_3 Sb S_3$ or $3 Ag_2 S . Sb_2 S_3$,	311,	131
2.	**Proustite,** $Ag_3 As S_3$ or $3 Ag_2 S . As_2 S_3$,	311,	134

Oxides, Hydroxides.

		T. B.	Sys.
1.	**CORUNDUM,** $Al_2 O_3$,	333,	210
2.	**HEMATITE,** $Fe_2 O_3$,	334,	213
	Ilmenite, see Tri-rhombohedral Group.		
3.	**Brucite,** $Mg [OH]_2$,	351,	252
4.	Pyrochroite, $Mn [OH]_2$,	351,	253
5.	Chalcophanite, $(Zn, Fe) Mn_2 O_5 . 2 H_2O$,	352,	256

Carbonates.

Calcite Group, $R'' CO_3$.

1.	**CALCITE,** $Ca CO_3$,	354,	262
	Dolomite, see Tri-rhombohedral Group.		
2.	**Magnesite,** $Mg CO_3$,	358,	274
3.	**SIDERITE,** $Fe CO_3$,	359,	276
4.	**RHODOCHROSITE,** $Mn CO_3$,	359,	278
5.	**SMITHSONITE,** $Zn CO_3$,	360,	279

Silicates.

1.	Eudialyte, $Na_{13} (Ca, Fe)_6 Cl (Si, Zr)_{20} O_{52}$?	407,	409
2.	Pyrosmalite, $H_7 [Fe Cl] Fe_4 [Si O_4]_4$, Mn iso. w. Fe,	424,	465
3.	Friedelite, $H_7 [Mn Cl] Mn_4 [Si O_4]_4$,	424,	465
4.	**TOURMALINE,** $R_9' Al_3 [B . OH]_2 Si_4 O_{19}$ (hemimorphic),	447,	551
5.	**Chabazite,** $(Ca, Na_2) Al_2 Si_4 O_{12} . 6 H_2O$?	458,	589
6.	Gmelinite, $(Na_2 Ca) Al_2 Si_4 O_{12} . 6 H_2O$?	459,	593
7.	**Penninite,** $H_8 (Mg, Fe)_5 Al_2 Si_3 O_{18}$,	474,	650

Phosphates, Arsenates.

1.	Hamlinite, $[Al . 2 OH]_3 [Sr . OH] P_2 O_7$,	503,	762
2.	Chalcophyllite, $[Cu . OH]_3 AsO_4 . Cu [OH]_2 . 3\frac{1}{2} H_2O$,	511,	840

Nitrates.

1.	**SODA-NITER,** $Na NO_3$ (homœomorphous with $Ca CO_3$),	517,	870

Sulphates.

1	Spangolite, $Cu_6 Al Cl SO_{10} . 9 H_2O$ (hemimorphic),	530,	919
2.	**Alunite,** $K_2 [Al . 2 OH]_6 [SO_4]_4$, Na iso. w. K,	537,	974
3.	**Jarosite,** $K_2 [Fe . 2 OH]_6 [SO_4]_4$,	537,	974
4.	Natrojarosite, $Na_2 [Fe . 2 OH]_6 [SO_4]_4$,	—,	—
5.	Plumbojarosite, $Pb [Fe . 2 OH]_6 [SO_4]_4$,	—,	—

HEXAGONAL-RHOMBOHEDRAL SYSTEM; TRI-RHOMBOHEDRAL GROUP.

Titanates.

		T. B.	Sys.
1.	**Ilmenite,** $Fe\,Ti\,O_3 = Fe\,O \cdot Ti\,O_2$, Mg iso. w. Fe,	336,	217

Carbonates.

1.	**DOLOMITE,** $Ca\,Mg\,[CO_3]_2$, Fe iso. w. Mg,	357,	271

Silicates.

1.	**Willemite,** $Zn_2\,Si\,O_4$, Mn iso. w. Zn,	422,	460
2.	**Phenacite,** $Be_2\,Si\,O_4$,	423,	462
3.	Dioptase, $H_2\,Cu\,Si\,O_4$,	424,	463

HEXAGONAL-RHOMBOHEDRAL SYSTEM; TRAPEZOHEDRAL GROUP.

Sulphides.

1.	**CINNABAR,** $Hg\,S$,	293,	66

Oxides.

1.	**QUARTZ,** $Si\,O_2$,	324,	183

ORTHORHOMBIC SYSTEM.

Elements.

		T. B.	Sys.
1.	**SULPHUR,** S,	273,	8

Sulphides, Arsenides, Antimonides, Tellurides.

1.	**STIBNITE,** $Sb_2 S_3$,	283,	36
2.	**Bismuthinite,** $Bi_2 S_3$,	284,	38
3.	**CHALCOCITE,** $Cu_2 S$,	290,	55
4.	**Stromeyerite,** Cu Ag S, or $Cu_2 S . Ag_2 S$,	290,	56
5.	**MARCASITE,** $Fe S_2$,	302,	94
6.	Löllingite, $Fe As_2$,	303,	96
7.	**ARSENOPYRITE,** Fe S As, or $Fe S_2 . Fe As_2$,	303,	97
8.	Safflorite, $Co As_2$,	304,	100
9.	Rammelsbergite, $Ni As_2$,	304,	101
10.	Glaucodot, (Co, Fe) S As,	304,	101
11.	Alloclasite, Co S (As, Bi),	304,	102
12.	Wolfachite, Ni S (As, Sb),	304,	102
13.	Krennerite, $Au Te_2$, Ag iso. w. Au,	305,	105

Sulphantimonites, Sulpharsenites, Sulphobismuthites.

1.	Zinkenite, $Pb Sb_2 S_4 = Pb S . Sb_2 S_3$,	307,	112
2.	Sartorite, $Pb As_2 S_4 = Pb S . As_2 S_3$,	308,	112
3.	Emplectite, $Cu_2 Bi_2 S_4 = Cu_2 S . Bi_2 S_3$,	308,	113
4.	Chalcostibite, $Cu_2 Sb_2 S_4 = Cu_2 S . Sb_2 S_3$,	308,	113
5.	Galenobismuthite, $Pb Bi_2 S_4 = Pb S . Bi_2 S_3$,	308,	114
6.	Berthierite, $Fe Sb_2 S_4 = Fe S . Sb_2 S_3$,	308,	114
7.	Matildite, $Ag_2 Bi_2 S_4 = Ag_2 S . Bi_2 S_3$,	308,	115
8.	Cosalite, $Pb_2 Bi_2 S_5 = 2 Pb S . Bi_2 S_3$,	309,	121
9,	Jamesonite, $Pb_2 Sb_2 S_5 = 2 Pb S . Sb_2 S_3$,	308,	122
10.	**Bournonite,** $(Pb, Cu_2)_3 Sb_2 S_6$ or $3 (Pb, Cu_2) S . Sb_2 S_3$,	310,	126
11.	Wittichenite, $Cu_3 Bi S_3$ or $3 Cu_2 S . Bi_2 S_3$,	310,	128
12.	Aikinite, $(Pb, Cu_2)_3 Bi_2 S_6 = 3 (Pb, Cu_2) S . Bi_2 S_3$,	310,	129
13.	Meneghinite, $Pb_4 Sb_2 S_7 = 4 Pb S . Sb_2 S_3$,	313,	142
14.	Geocronite, $Pb_5 Sb_2 S_8$ or $5 Pb S . Sb_2 S_3$,	314,	143
15.	**Stephanite,** $Ag_5 Sb S_4$ or $5 Ag_2 S . Sb_2 S_3$,	314,	143

Sulpharsenates, Sulphantimonates.

		T. B.	Sys.
1.	**Enargite,** Cu_3AsS_4 or $3Cu_2S . As_2S_5$,	315,	147
2.	Famatinite, Cu_3SbS_4 or $3Cu_2S . Sb_2S_5$,	315,	149

Chlorides.

1.	Cotunnite, $PbCl_2$,	321,	165
2.	**Atacamite,** $Cu_2Cl[OH]_3$,	322,	172
3.	**Carnallite,** $KMgCl_3 . 6H_2O$,	323,	177

Oxides, Hydroxides.

1.	Valentinite, Sb_2O_3,	330,	199
2.	**Chrysoberyl,** $BeAl_2O_4$,	342,	229
3.	**Brookite,** TiO_2,	347,	242
4.	**Diaspore,** $Al_2O_2[OH]_2$,	348,	246
5.	**GOETHITE,** $Fe_2O_2[OH]_2$,	349,	247
6.	**MANGANITE,** $Mn_2O_2[OH]_2$,	349,	248
7.	**PYROLUSITE,** MnO_2 with about 2% H_2O (pseudomorphous),	347,	243

Carbonates.

Aragonite Group, $R''CO_3$.

1.	**ARAGONITE,** $CaCO_3$,	361,	281
2.	**STRONTIANITE,** $SrCO_3$,	362,	285
3.	**WITHERITE,** $BaCO_3$,	362,	284
4.	**CERUSSITE,** $PbCO_3$,	363,	286
5.	Nesquehonite, $MgCO_3 . 3H_2O$,	366,	300
6.	Pirssonite, $CaCO_3 . Na_2CO_3 . 2H_2O$ (hemimorphic),	366,	Ap. 53
7.	Lanthanite, $La_2[CO_3]_3 . 9H_2O$,	366,	302

Metasilicates.

1.	Enstatite, $MgSiO_3$,	384,	346
2.	**Bronzite-Hypersthene,** $(Mg, Fe)SiO_3$,	385,	348
3.	**Anthophyllite,** $(Mg, Fe)SiO_3$,	398,	384
4.	Leucophanite, $Na[BeF]Ca[SiO_3]_2$,	407,	417

Mesosilicates.

1.	**Iolite,** $(Mg, Fe)_4Al_6[Al . OH]_2[Si_2O_7]_5$,	407,	419

Orthosilicates or Orthosilicate Derivatives.

		T. B.	Sys.
1.	Monticellite, $Ca Mg Si O_4$,	422,	449
2.	Glaucochroite, $Ca Mn Si O_4$,	Ap. 29	
3.	Forsterite, $Mg_2 Si O_4$,	422,	450
4.	**CHRYSOLITE or OLIVINE,** $(Mg, Fe)_2 Si O_4$,	420,	451
5.	Fayalite, $Fe_2 Si O_4$,	422,	456
6.	Tephroite, $Mn_2 Si O_4$,	422,	457
7.	**Danburite,** $Ca B_2 [Si O_4]_2$,	431,	490
8.	**TOPAZ,** $[Al F]_2 Si O_4$ with isomorphous $[Al . OH]_2 Si O_4$,	431,	492
9.	**Andalusite,** $[Al O] Al Si O_4$,	432,	496
10.	**Zoisite,** $Ca_2 [Al . OH] Al_2 [Si O_4]_3$,	437,	513
11.	**Prehnite,** $H_2 Ca_2 Al_2 [Si O_4]_3$,	442,	529
12.	Humite, $[Mg (F, OH)]_2 Mg_5 [Si O_4]_3$,	443,	535
13.	Ilvaite, $Ca Fe_2 [Fe . OH] [Si O_4]_2$,	445,	541
14.	Kentrolite, $[Mn_4 O_3] Pb_3 [Si O_4]_3$,	446,	544
15.	Melanotekite, $[Fe_4 O_3] Pb_3 [Si O_4]_3$,	446,	545
16.	**CALAMINE,** $H_2 [Zn_2 O] Si O_4$ (hemimorphic),	446,	547
17.	Dumortierite, $Al_4[Al O]_{16}[Si O_4]_7$, H_3 and B iso. w. Al,	449,	558
18.	**STAUROLITE,** $(Mg, Fe)[Al . OH][Al O]_4[Si O_4]_2$,	450,	558

Miscellaneous Silicates.

1.	**Sillimanite,** $Al_2 Si O_5$ (compare Andalusite),	433,	498
2.	Bertrandite, $H_2 Be_4 Si_2 O_9$ (hemimorphic),	446,	545
3.	Ardennite, $H_{10} Mn_{10} Al_{10} V_2 Si_{10} O_{55}$?	445,	542
4.	Cerite, $H_6 Ce_4 Si_3 O_{15}$?	447,	550

Hydrated Silicates.

1.	**NATROLITE,** $Na_2 Al_2 Si_3 O_{10} . 2 H_2O$,	461,	600
2.	**Thomsonite,** $(Na_2, Ca) Al_2 [Si O_4]_2 . 2\frac{1}{2} H_2O$,	462,	607

Niobates, Tantalates.

1.	**COLUMBITE,** $(Fe, Mn) (Nb, Ta)_2 O_6$,	490,	731
2.	Yttrotantalite, $(Fe, Ca) (Y, Er, Ce)_2 (Ta, Nb)_4 O_{15} . 4 H_2O$,	492,	738
3.	Samarskite, $(Fe, UO_2)_3 (Y, Er, Ce)_2 (Nb, Ta)_6 O_{21}$,	492,	739
4.	Æschynite, $R_3 Nb_4 O_{13} . R_2 (Th, Ti)_5 O_{13}$, R = Ce, La, Di, Y,	493,	742
5.	Polynignite, Nb, Zr, Ti, Th, Ce, La, Di, Y, Fe, Ca,	493,	743
6.	Euxenite, Nb, Ti, Y, Er, Ce, UO_2, Fe, H,	493,	744
7.	Polycrase, Nb, Ti, Y, Er, Ce, UO_2, Fe, H,	493,	744

Phosphates, Arsenates, Vanadates.

		T. B.	Sys.
1.	Pucherite, Bi VO_4,	496,	755
2.	**Triphylite,** Li Fe PO_4, Mn iso. w. Fe,	496,	756
3.	**Lithiophilite,** Li Mn PO_4, Fe iso. w. Mn,	496,	756
4.	Natrophilite, Na Mn PO_4,	496,	758
5.	Beryllonite, Na Be PO_4,	496,	758
6.	**Olivenite,** Cu [Cu . OH] As O_4,	504,	784
7.	Libethenite, Cu [Cu . OH] PO_4,	504,	786
8.	Adamite, Zn [Zn . OH] As O_4,	505,	786
9.	Descloizite, R [R . OH] VO_4, R = Pb and Zn	505,	787
10.	Dufrenite, Fe_2 $[OH]_3$ PO_4,	506,	797
11.	Struvite, NH_4 Mg PO_4 . 6 H_2O (hemimorphic)	507,	806
12.	Reddingite, Mn_3 $[PO_4]_2$. 3 H_2O,	508,	813
13.	**Scorodite,** Fe As O_4 . 2 H_2O,	509,	821
14.	Strengite, Fe PO_4 . 2 H_2O,	510,	822
15.	Euchroite, Cu_2 $[Cu . OH]_2$ $[As\ O_4]_2$. 6 H_2O	511	838,
16.	**Wavellite,** $[Al . OH]_3$ $[PO_4]_2$. 5 H_2O,	512,	842
17.	Childrenite, (Fe, Mn) [Al O] PO_4 . 2 H_2O,	513,	850
18.	Autunnite, Ca $[UO_2]_2$ $[PO_4]_2$. 8 H_2O,	515,	857

Nitrates.

1.	**Niter,** K N O_3,	517,	871
2.	Gerhardtite, Cu_4 $[OH]_6$ $[NO_3]_2$,	517,	872

Borates.

1.	Sussexite, H (Mn, Mg, Zn) BO_3,	518,	876
2.	Ludwigite, 3 Mg O . B_2O_3 + Fe O . Fe_2 O_3,	518,	877
3.	Hambergite, Be [Be . OH] BO_3,	518,	878
4.	Warwickite, Fe Mg_6 Ti_2 B_6 O_{20} ?	519,	881
5.	Howlite, H_5 Ca_2 B_5 Si O_{14},	519,	881

Sulphates.

		T. B.	Sys.
1.	Thenardite, $Na_2 S O_4$,	523,	895

Barite Group, $R'' SO_4$.

2.	**BARITE,** $Ba SO_4$,	524,	899
3.	**CELESTITE,** $Sr SO_4$,	526,	905
4.	**ANGLESITE,** $Pb SO_4$,	527,	907
5.	**ANHYDRITE,** $Ca SO_4$,	528,	910

6.	**Brochantite,** $Cu_4 [OH]_6 SO_4$,	530,	925

7.	Epsomite, $Mg SO_4 . 7 H_2O$ (sphenoidal),	533,	938
8.	Goslarite, $Zn SO_4 . 7 H_2O$ (sphenoidal),	533,	939
9.	Morenosite, $Ni SO_4 . 7 H_2O$ (sphenoidal),	533,	940

MONOCLINIC SYSTEM.

Note.—With rare exceptions the minerals of this system all crystallize in the normal group.

Sulphides, Tellurides.

		T. B.	Sys.
1.	**Realgar,** As S,	282,	33
2.	**Orpiment,** $As_2 S_3$,	282,	35
3.	**Sylvanite,** Au Ag Te_4,	304,	103
4.	**Calaverite,** Au Te_2, with Ag iso. w. Au,	305,	105

Sulphantimonites, Sulpharsenites.

1.	Miargyrite, $Ag_2 Sb_2 S_4$ or $Ag_2 S, Sb_2 S_3$,	308,	116
2.	Plagionite, $5 Pb S . 4 Sb_2 S_3$,	308,	118
3.	Baumhauerite, $4 Pb S . 3 As_2 S_3$,	New species	
4.	Dufrenoysite, $Pb_2 As_2 S_5$ or $2 Pb S . As_2 S_3$,	309,	120
5.	Freieslebenite, $(Pb, Ag_2)_5 Sb_4 S_{11}$,	309,	124
6.	Jordanite, $Pb_4 As_2 S_7$ or $4 Pb S . As_2 S_3$,	313,	141
7.	**Polybasite,** $Ag_9 Sb S_6$, with Cu iso. w. Ag,	314,	146
8.	Pearceite, $Ag_9 As S_6$, with Cu iso. w. Ag,	315,	Ap. 50

Fluorides.

1.	**CRYOLITE,** $Na_3 Al F_6$,	321,	166
2.	Pachnolite, Na Ca Al $F_6 . H_2O$,	323,	179
3.	Thomsenolite, Na Ca Al $F_6 . H_2O$,	323,	180

Hydroxides.

1.	**Gibbsite,** Al $[OH]_3$,	351,	254

Carbonates.

1.	Barytocalcite, Ba Ca $[CO_3]_2$,	364,	289
2.	**MALACHITE,** $[Cu . OH]_2 CO_3$,	364,	294
3.	**AZURITE,** Cu $[Cu . OH]_2 [CO_3]_2$,	365,	295
4.	**Aurichalcite,** $2 (Zn, Cu) CO_3 . 3 (Zn, Cu) [OH]_2$,	366,	298
5.	Leadhillite, Pb $[Pb . OH]_2 SO_4 [CO_3]_2$,	529,	921
6.	Dawsonite, Na $[Al . 2 OH] CO_3$,	366,	299
7.	Natron, $Na_2 CO_3 . 10 H_2O$,	366,	301
8.	**Gay-Lussite,** $Na_2 CO_3 . Ca CO_3 . 5 H_2O$,	366,	301
9.	Trona, $Na_2 CO_3 . H Na CO_3 . 2 H_2O$,	367,	303
10.	Hydromagnesite, $3 Mg CO_3 . Mg [OH]_2 . 3 H_2O$,	367,	304

Tetrasilicates.

		T. B.	Sys.
1.	Petalite, $Li\,Al\,Si_4\,O_{10}$,	369,	311

Trisilicates.

1.	Eudidymite, $H\,Na\,Be\,Si_3\,O_8$,	369,	313
2.	**ORTHOCLASE,** $K\,Al\,Si_3\,O_8$,	370,	315
3.	Hyalophane, $2\,K\,Al\,Si_3\,O_8 \,.\, Ba\,Al_2\,Si_2\,O_8$,	373,	321

Metasilicates.

1.	**PYROXENE,** variety Diopside, $Ca\,Mg\,[Si\,O_3]_2$,	387,	352
2.	**PYROXENE,** ordinary, $Ca\,(Mg, Fe)\,[Si\,O_3]_2$,	387,	352
3.	**PYROXENE,** variety Augite, $R\,Si\,O_3$ with $(Al, Fe)_2\,O_3$, $R = Ca, Mg, Fe$ and Mn,	390,	358
4.	**Ægirite,** Acmite, $Na\,Fe\,[Si\,O_3]_2$,	391,	364
5.	**Jadeite,** $Na\,Al\,[Si\,O_3]_2$,	393,	369
6.	**SPODUMENE,** $Li\,Al\,[Si\,O_3]_2$, Na iso. w. Li,	393,	366
7.	**WOLLASTONITE,** $Ca\,Si\,O_3$,	394,	371
8.	**Pectolite,** $H\,Na\,Ca_2\,[Si\,O_3]_3$,	395,	373
9.	**AMPHIBOLE,** variety Tremolite, $R\,Si\,O_3$, $R =$ Mg and Ca,	399,	385
10.	**AMPHIBOLE,** Hornblende, $R\,Si\,O_3$, with $(Fe, Al)_2\,O_3$, $R = Mg, Fe, Ca$,	402,	391
11.	Glaucophane, $Na\,Fe\,[Si\,O_3]_2$ with $(Mg, Fe)\,Si\,O_3$,	403,	399
12.	Carpholite, $Mn\,[Al\,.\,2\,OH]_2\,[Si\,O_3]_2$,	447,	549

Orthosilicate Derivatives.

1.	**DATOLITE,** $Ca\,[B\,.\,OH]\,Si\,O_4$,	435,	502
2.	Homilite, $(Ca, Fe)_3\,[BO]_2\,[Si\,O_4]_2$,	436,	505
3.	Euclase, $Be\,[Al\,.\,OH]\,Si\,O_4$,	436,	508
4.	Gadolinite, $Be_2\,Fe\,[YO]_2\,[Si\,O_4]_2$,	436,	509
5.	**EPIDOTE,** $Ca_2\,[Al\,.\,OH]\,Al_2\,[Si\,O_4]_3$, Fe iso. w. Ca and Al,	438,	516
6.	Piedmontite, $Ca_2\,[Al\,.\,OH]\,(Al, Mn, Fe)_2\,[Si\,O_4]_3$,	440,	521
7.	**Allanite,** $Ca_2\,[Al\,.\,OH]\,(Al, Fe, Ce, La, Di)_2[SiO_4]_3$,	440,	522
8.	Prolectite, $[Mg\,(F, OH)]\,Mg\,[Si\,O_4]$,	443,	Ap. 55
9.	Chondrodite, $[Mg\,(F, OH)]_2\,Mg_3\,[Si\,O_4]_2$,	443,	536
	[Humite, $[Mg\,(F, OH)]_2\,Mg_5\,[Si\,O_4]_3$, see p. 15,]	443,	535
10.	Clinohumite, $[Mg\,(F, OH)]_2\,Mg_7\,[Si\,O_4]_4$,	443,	538
11.	Clinohedrite, $H_2\,[Ca\,Zn\,O]\,Si\,O_4$ (Clinohedral),	447,	Ap. 17

Hydrated Silicates; Zeolite Section.

		T. B.	Sys.
1.	**Heulandite,** $H_4 Ca Al_2 [Si O_3]_6 . 3 H_2O$,	454,	574
2.	Brewsterite, $H_4 (Sr, Ba, Ca) Al_2 [Si O_3]_6 . 3 H_2O$,	454,	576
3.	Wellsite, $(Ba, Ca, K_2) Al_2 Si_3 O_{10} . 3 H_2O$,	455,	Ap. 72
4.	Phillipsite, $(K_2, Ca) Al_2 Si_4 O_{12} . 4 H_2O$,	455,	579
5.	**Harmotome,** $(K_2, Ba) Al_2 Si_5 O_{14} . 5 H_2O$,	456,	581
6.	**STILBITE,** $(Na_2, Ca) Al_2 Si_6 O_{16} . 6 H_2O$,	456,	583
7.	**Laumontite,** $H_4 Ca Al_2 Si_4 O_{14} . 2 H_2O$,	457,	587
8.	**Scolecite,** $Ca Al_2 Si_3 O_{10} . 3 H_2O$,	462,	604

Foliated, Micaceous Silicates.

NOTE.—The crystallization of some of the minerals in this section is uncertain.

1.	**MUSCOVITE,** $H_2 K Al_3 [Si O_4]_3$,	464,	614
2.	Paragonite, $H_2 Na Al_3 [Si O_4]_3$,	467,	623
3.	**LEPIDOLITE,** $K Li [Al . 2 (OH, F)] Al [Si O_3]_3$,	467,	624
4.	**BIOTITE,** $(H, K)_2 (Mg, Fe)_2 Al_2 [Si O_4]_3$,	467,	627
5.	**PHLOGOPITE,** $H_2 K Mg_3 Al [Si O_4]_3$?	469,	632
6.	**Lepidomelane,** $(H, K)_2 Fe_3 (Fe, Al)_4 [Si O_4]_5$?	470,	634
7.	Roscoelite, $H_8 K (Mg, Fe) (Al, V)_4 [Si O_3]_{12}$?	470,	635
8.	**Margarite,** $H_2 Ca Al_4 Si_2 O_{12}$,	470,	636
9.	Seybertite, $H_3 (Mg, Ca)_5 Al_5 Si_2 O_{18}$,	471,	638
10.	Chloritoid, $H_2 (Fe, Mg) Al_2 Si O_7$,	471,	640
11.	**CLINOCHLORE,** Chlorite, $H_8 Mg_5 Al_2 Si_3 O_{18}$,	473,	644
12.	Vermiculite, H, Mg, Al, silicates of uncertain composition,	476,	664
13.	**SERPENTINE,** $H_4 Mg_3 Si_2 O_9$,	476,	669
14.	**KAOLIN,** $H_4 Al_2 Si_2 O_9$,	481,	685
15.	**TALC,** $H_2 Mg_3 [Si O_3]_4$,	479,	678
16.	**Pyrophyllite,** $H_2 Al_2 [Si O_3]_4$,	482,	691

Titanosilicates.

1.	**TITANITE,** $Ca Ti Si O_5$,	485,	712
2.	Astrophyllite, $(Na, K)_4 (Fe, Mn)_4 Ti [Si O_4]_4$,	487,	719

Phosphates, Arsenates.

1.	**Monazite,** $(Ce, La, Di) PO_4$ with $Th Si O_4$,	495,	749
2.	Herderite, $Ca [Be . OH] PO_4$, with F iso. w. OH,	503,	760

		T. B.	Sys.
3.	Wagnerite, $Mg\,[Mg\,F]\,PO_4$,	502,	775
4.	Triplite, $R\,[R\,F]\,PO_4$, $R = Fe$ and Mn,	502,	777
5.	Triploidite, $R\,[R\,.\,OH]\,PO_4$, $R = Fe$ and Mn,	502,	779
6.	Durangite, $Na\,[Al\,F]\,As\,O_4$,	503,	780
7	Clinoclasite, $[Cu\,.\,OH]_3\,As\,O_4$,	505,	795
8.	**Lazulite,** $Mg\,[Al\,.\,OH]_2\,[PO_4]_2$,	506,	798
9.	**Vivianite,** $Fe_3\,[PO_4]_2\,.\,8\,H_2O$,	508,	814
10.	Erythrite, $Co_3\,[As\,O_4]_2\,.\,8\,H_2O$,	509,	817
11.	Annabergite, $Ni_3\,[As\,O_4]_2\,.\,8\,H_2O$,	509,	818
12.	Brushite, $H\,Ca\,PO_4\,.\,2\,H_2O$,	510,	828

Borates.

1.	**Colemanite,** $Ca_2\,B_6\,O_{11}\,.\,5\,H_2O$,	519,	882
2.	**BORAX,** $Na_2\,B_4\,O_7\,.\,10\,H_2O$,	520,	886

Sulphates, Chromates.

1.	**Glauberite,** $Na_2\,Ca\,[SO_4]_2$,	523,	898
2.	**Crocoite,** $Pb\,Cr\,O_4$,	529,	913
3.	**Kainite,** $Mg\,S\,O_4\,.\,K\,Cl\,.\,3\,H_2O$,	530,	918
4.	Linarite, $[Pb\,.\,OH]_2\,SO_4$, with Cu iso. w. Pb,	530,	927
5.	Mirabilite, $Na_2\,SO_4\,.\,10\,H_2O$,	531,	931
6.	**GPYSUM,** $Ca\,SO_4\,.\,2\,H_2O$,	531,	933
7.	Melanterite, $Fe\,SO_4\,.\,7\,H_2O$,	534,	941
8.	Syngenite, $K_2\,Ca\,[SO_4]_2\,.\,H_2O$	534,	945
9.	**Picromerite,** $K_2\,Mg\,[SO_4]_2\,.\,6\,H_2O$,	535,	948
10.	Polyhalite, $K_2\,Mg\,Ca_2\,[SO_4]_4\,.\,2\,H_2O$,	535,	950
11.	Blödite, $Na_2\,Mg\,[SO_4]_2\,.\,4\,H_2O$,	535,	946

Tellurites, Selenites.

1.	Emmonsite, hydrated ferric tellurite,	538,	979
2.	Chalcomenite, $Cu\,Se\,O_3\,.\,2\,H_2O$,	538,	980

Tungstates.

1.	**WOLFRAMITE,** $Fe\,W\,O_4$, with Mn iso. w. Fe,	539,	982
2.	**Hübnerite,** $Mn\,W\,O_4$,	539,	983

Oxalates.

1.	Whewellite, $Ca\,C_2O_4\,.\,H_2O$,	542,	993

TRICLINIC SYSTEM.

Hydroxides.

		T. B.	Sys.
1.	Sassolite, Boracic acid, B $[OH]_3$, ...	352,	255

Carbonates.

1.	Lansfordite, 3 Mg CO_3 . Mg $[OH]_2$. 21 H_2O, . .	367,	305

Silicates.

1.	**MICROCLINE,** K Al Si_3 O_8, ...	373,	322
2.	**ALBITE,** Na Al Si_3 O_8, (Ab), ...	377,	327
3.	**ANORTHITE,** Ca Al_2 Si_2 O_8, (An), ...	380,	337
4.	*Plagioclase Feldspars; Albite-Anorthite Series:* **OLIGOCLASE-ALBITE,** 8 Ab : 1 An,	—,	—
	OLIGOCLASE, 3 Ab : 1 An,	378,	332
	ANDESITE, 1 Ab : 1 An,	379,	333
	LABRADORITE, 1 Ab : 3 An,	379,	334
	BOYTONITE, 1 Ab : 8 An,	—,	—

5.	**RHODONITE,** Mn Si O_3, Ca and F iso. w. Mn, .	395,	378
6.	Babingtonite, (Ca, Fe, Mn) Si O_3, with Fe_2 $[Si\ O_3]_3$,	396,	381
7.	**CYANITE,** Al_2 Si O_5, ...	434,	500
8.	**Axinite,** Ca_7 Al_4 B_2 $[Si\ O_4]_8$, Mn, Fe and H_2 iso. w. Ca, ...	441,	527
9.	Inesite, 2 (Mn, Ca) Si O_3 . H_2O, ...	452,	564

Phosphates, Arsenates.

1.	**Amblygonite,** Li [Al F] PO_4, OH iso. w. F, . .	503,	781
2.	Roselite, (Ca, Co, Mg)$_3$ $[As\ O_4]_2$. 2 H_2O, . .	507,	810
3.	Brandtite, Ca_2 Mn $[As\ O_4]_2$. 2 H_2O, . . .	507,	811
4.	Fairfieldite, Ca_2 Mn $[PO_4]_2$. 2 H_2O, . . .	507,	812

Sulphates.

1.	**Chalcanthite,** Cu SO_4 . 5 H_2O, ...	534,	944
2.	Amarantite, (Fe . OH) SO_4 . 3 H_2O, . . .	536,	967

MINERALS WHICH ARE AMORPHOUS, MASSIVE, OR OF UNCERTAIN CRYSTALLIZATION.

Arsenides.

		T. B	Sys.
1.	Domeykite, Cu_3As,	286,	44
2.	Algodonite, Cu_6As,	286,	45
3.	Whitneyite, Cu_9As,	286,	45

Oxides, Hydroxides.

1.	**Opal,** SiO_2, generally with 3 to 9 % H_2O,	329,	194
2.	**Turgite,** $Fe_4O_5[OH]_2$,	350,	245
3.	**LIMONITE,** $Fe_4O_3[OH]_6$,	350,	250
4.	Xanthosiderite, $Fe_2O[OH]_4$,	350,	251
5.	**BAUXITE,** $Al_2O[OH]_4$,	350,	251
6.	**Psilomelane,** MnO_2 with MnO, BaO, CoO, H_2O?	352,	257

Carbonates.

1.	Bismutosphærite, $[BiO]_2CO_3$,	364,	290
2.	Hydrozincite, $ZnCO_3 . 2 Zn[OH]_2$?	366,	299
3.	Zaratite, $NiCO_3 . 2 Ni[OH]_2 . 4 H_2O$,	367,	306

Silicates.

1.	Deweylite, $Mg_4Si_3O_{10} . 6 H_2O$?	479,	676
2.	**Genthite,** $Ni_2Mg_2Si_3O_{10} . 6 H_2O$?	479,	676
3.	**Garnierite, Noumeaite,** H_2NiSiO_4?	479,	676
4.	Allophane, $Al_2SiO_5 . 5 H_2O$,	483,	693
5.	**CHRYSOCOLLA,** $CuSiO_3 . 2 H_2O$?	483,	699

Phosphates.

1.	**Turquois,** $H[Al . 2 OH]_2PO_4$, with isomorphous $H[Cu . OH]_2PO_4$,	512,	844

PART II.

ARRANGEMENT OF THE MINERALS ACCORDING TO THE ELEMENTS, WITH USES AND STATISTICS.

Note.—The chief object of tables of this kind is to call attention to the various chemical combinations of the elements, especially the metals, met with in the mineral kingdom. In each list of minerals the order of the chemical classification of Dana, given on page 2, is followed, and the names are printed in three kinds of type in order to indicate the relative importance of the various compounds, as explained on page 1. For the sake of convenience, the tables follow in alphabetical order, based upon the elements. Following them will be some lists of useful minerals which do not naturally fall under any specific element. Although the lists of minerals are not to be regarded as complete, the attempt has been made to give all of the principal and commercially important combinations. In the case of minerals which are commercially important, their uses are noted and some statistics are given indicating the amount and value of the production. The statistics have been derived chiefly from *The Mineral Industry for 1905*, published by the Engineering and Mining Journal of New York, and from the *Mineral Resources of the United States for 1905*, published by the United States Geological Survey.

ALUMINIUM.

Occurrence.—The number of aluminium minerals is so large that no attempt is made to give other than the more important compounds.

CRYOLITE, $Na_3 Al F_6$.
CORUNDUM, $Al_2 O_3$.
Gibbsite, $Al [OH]_3$.
BAUXITE, $Al_2 O [OH]_4$.
FELDSPARS, $K Al Si_3 O_8$,
  $Na Al Si_3 O_8$, $Ca Al_2 Si_2 O_3$, etc.
LEUCITE, $K Al [Si O_3]_2$.
NEPHELITE, $Na Al Si O_4$.
TOPAZ, $[Al F]_2 Si O_4$.
CYANITE, $Al_2 Si O_5$.
MICAS, $H_2 K Al_3 [Si O_4]_3$, etc.
KAOLIN, $H_4 Al_2 Si_2 O_9$.
Pyrophyllite, $H_2 Al_2 [Si O_3]_4$.
THE ZEOLITES.
Lazulite, $Mg [Al . OH]_2 [PO_4]_2$.
Wavellite, $[Al . OH]_3 [PO_4]_2 . 5 H_2O$.
Turquois, Approx. $H [Al . 2 OH]_2 PO_4$.
Kalinite, Alum, $K Al [SO_4]_2 . 12 H_2O$.
Alunite, $K_2 [Al . 2 OH]_6 [SO_4]_4$.

Uses.—Metallic aluminium and many of its alloys possess highly useful properties. Alum and aluminium sulphate are used in chemical industries, as mordants in dyeing, and extensively in the manufacture of baking powders. The uses of a number of aluminium minerals (corundum, feldspar, mica, kaolin and clay) are explained later under *Useful Minerals.*

Statistics.—Metallic aluminium is made mostly from bauxite. The domestic consumption in 1905 was 11,347,000 pounds, valued at $3,246,300. Price per pound, about 35 c.

Alum and aluminium sulphate are made from bauxite, cryolite and alunite. The yearly production of alum is about 10,000 tons, valued at about $29.00 per ton, and of aluminium sulphate from 75,000 to 100,000 tons, valued at about $18.00 per ton.

The production of bauxite in 1905, mostly from Georgia, Alabama and Arkansas, was 48,129 tons, valued at about $5.00 per ton, and the importation was 11,726 tons, valued at $46,517.

The importation of cryolite, from Greenland, for 1905, was 1600 tons, valued at $22,482.

ANTIMONY.

Occurrence.

Native Antimony, Sb.
STIBNITE, $Sb_2 S_3$.
Kermesite, $Sb_2 S_2 O$.
Sulphantimonites.
Pyrargyrite, $Ag_3 Sb S_3$.
TETRAHEDRITE, $Cu_8 Sb_2 S_7$, etc.
Senarmontite, $Sb_2 O_3$.
Valentinite, $Sb_2 O_3$.
Stibiconite, $H_2 Sb_2 O_5$.
Cervantite, $Sb_2 O_4$.

Uses.—Metallic antimony is used for making various alloys, type metal, pewter and anti-friction metal. The sulphide is employed in making fireworks, percussion caps, matches, and in vulcanizing rubber. Tartar-emetic and antimony sulphide are used for medicinal purposes.

The United States mined no antimony ore in 1905, although there are good deposits (stibnite) in California, Idaho and South Dakota, but obtained its antimony from imported ores (493 tons; value, $117,433) or from hard lead (antimonial lead from the smelting of silver ores). The total production from these sources amounted to 3240 tons, valued at $705,787.

ARSENIC.

Occurrence.

Native Arsenic, As.
Niccolite, Ni As.
Smaltite, Co As_2.
Chloanthite, Ni As_2.
Gersdorffite, Ni As S.
Löllingite, Fe As_2.
ARSENOPYRITE, Fe S As.

Sulpharsenites.
Proustite, Ag_3 As S_3, etc.
Enargite, Cu_3 As S_4.

Arsenates.
Mimetite, $Pb_4 [Pb\,Cl][As\,O_4]_3$.
Olivenite, Cu [Cu . OH] As O_4.
Scorodite, Fe As $O_4 . 2\,H_2O$.

Uses.—Sulphides of arsenic are used as pigment and for pyrotechnics. The oxide is used in medicine, and for poisoning and preserving. Paris green, an arsenate and acetate of copper, is extensively used as pigment and for poisoning.

Statistics.—In 1905 the production of $As_2\,O_3$ in the United States was 1,507,386 pounds, while the yearly importation, mostly from England and Germany, is about 7,000,000 pounds. The price of $As_2\,O_3$ is from 2¾ c. to 4½ c. per pound.

BARIUM.

Occurrence.

WITHERITE, Ba CO_3.
Barytocalcite, Ba Ca $[CO_3]_2$.
Hyalophane, $2\,K\,Al\,Si_3O_8.BaAl_2Si_2O_8$
Harmotome, $(K_2,Ba)Al_2Si_5O_{14}.5H_2O$.
BARITE, Ba SO_4.

Uses.—Barite is used chiefly for the production of barium hydroxide, employed in the refining of sugar. Ground barites and precipitated Ba SO_4 are employed as white pigment, for adulterations, and for giving weight and finish to certain grades of paper.

Statistics.—Barite (or barytes) produced in 1905 amounted to nearly 50,000 tons, valued at $150,000. The supply was obtained from Missouri, Virginia, Tennessee, North Carolina and Georgia. The importation was 19,000 tons, valued at $102,000.

BERYLLIUM.

Occurrence.

Chrysoberyl, Be $Al_2\,O_4$.
BERYL, $Be_3\,Al_2\,[Si\,O_3]_6 . \frac{1}{2}\,H_2O$?
Leucophanite, Na [Be F] Ca $[Si\,O_3]_2$.
Helvite, $(Mn, Fe)_2[Mn_2S]Be_3[SiO_4]_3$.
Phenacite, Be_2 Si O_4.
Euclase, Be [Al . OH] Si O_4.
Gadolinite, Be_2 Fe $Y_2\,Si_2\,O_{10}$.
Bertrandite, $H_2\,Be_4\,Si_2\,O_9$.
Beryllonite, Na Be PO_4.
Herderite, Ca [Be (OH, F)] PO_4.

Uses.—Some of the beryllium minerals used as gems are noted under a special heading, *gem minerals.* At the present time there is no demand commercially for beryllium or its salts.

BISMUTH.

Occurrence.

Native Bismuth, Bi.
Bismuthinite, $Bi_2 S_3$.
Tetradymite, $Bi_2 Te_2 S$.
Sulpho-bismuthinites,
Emplectite, $Cu_2 S \cdot Bi_2 S_3$, etc.
Bismutosphærite, $[Bi O]_2 CO_3$.
Bismutite, $[Bi O] [Bi \cdot 2 OH] CO_3$.
Eulytite, $Bi_4 [Si O_4]_3$.
Pucherite, $Bi V O_4$.

Uses.—Bismuth is used for making numerous alloys of low fusing point (solders, safety plugs for boilers and fire extinguishers, and Wood's metal, fusing as low as 60.5° C.). Its salts are employed in medicine.

Statistics.—The domestic production of bismuth in 1905, mostly from Colorado, amounted to 2,288 pounds and the importation to 148,589 pounds. The price of refined bismuth is about $1.28 per pound.

BORON.

Occurrence.

Sassolite, $B [OH]_3$.
Danburite, $Ca B_2 [Si O_4]_2$.
DATOLITE, $Ca [B \cdot OH] Si O_4$.
Axinite, $R''_7 Al_4 B_2 [Si O_4]_8$.*
TOURMALINE, $R'_9 Al_3 [B \cdot OH]_2 Si_4 O_{19}$.†

Borates.
Boracite, $Mg_7 Cl_2 B_{16} O_{30}$.
Colemanite, $Ca_2 B_6 O_{11} \cdot 5 H_2O$.
BORAX, $Na_2 B_4 O_7 \cdot 10 H_2O$.
Ulexite, $Na Ca B_5 O_9 \cdot 8 H_2O$.

* R'' = Ca chiefly, with some Fe, Mn and H_2.
† R' replaced by various elements, Al, Fe, Mg, Mn, Ca, K, Li, Na, H.

Uses.—Borax is used for washing and cleansing; as a solvent of metallic oxides in soldering and welding; and as a flux in numerous smelting and laboratory operations. Borax and boracic acid are also extensively used in pharmaceutical preparations and for their antiseptic properties.

Statistics.—Borax and boracic acid are obtained from the colemanite and native borax deposits of California, Oregon and Nevada. The total value of the products in 1905 amounted to over $1,000,000.

BROMINE.

Occurrence.

Embolite, Ag (Br, Cl).

Bromyrite, Ag Br.

The element is contained also in small quantity in salt brines from which the supply of bromine is obtained.

Uses.—Liquid bromine is employed in numerous chemical industries and in laboratories, and potassium bromide is used extensively in medicine.

Statistics.—The production of bromine in 1905, mostly from Michigan, Ohio, Pennsylvania and West Virginia, was over 1,000,000 pounds, valued at over $175,000.

CADMIUM.

Occurrence.—Greenockite, Cd S.

The cadmium of commerce is obtained from zinc ores which frequently contain a small quantity of this rare element.

Uses.—The metal is used in making alloys for dental and other purposes. The sulphide is used as a yellow pigment.

Statistics.—Most of the cadmium is produced in Germany. There is no domestic production.

CÆSIUM.

Occurrence.—Pollucite, $H_2 Cs_4 Al_4 [SiO_3]_9$.

This exceptionally rare element is also found in small quantities in beryl and lepidolite, and in the waters of some mineral springs.

CALCIUM.

Occurrence.—Calcium occurs in such a variety of combinations that no attempt is made to give a complete list of its compounds. The typical and more important calcium minerals are as follows:

FLUORITE, $Ca F_2$.
CALCITE, limestone, and marble, $Ca CO_3$.
DOLOMITE, $Ca Mg [CO_3]_2$.
ARAGONITE, $Ca CO_3$.
Gay-Lussite, $Na_2 Ca [CO_3]_2 . 5 H_2O$.
ANORTHITE, $Ca Al_2 [Si O_4]_2$.
WOLLASTONITE, $Ca Si O_3$.
TITANITE, $Ca Ti Si O_5$.
Perovskite, $Ca Ti O_3$.
APATITE, $Ca_4 [Ca F] [PO_4]_3$.
Colemanite, $Ca_2 B_6 O_{11} . 5 H_2O$.
Glauberite, $Na_2 Ca [SO_4]_2$.
ANHYDRITE, $Ca SO_4$.
GYPSUM, $Ca SO_4 . H_2O$.
Scheelite, $Ca W O_4$.

In addition to the foregoing, calcium is an essential constituent of the following common and important silicates: The lime-soda feldspars, pyroxene, amphibole, grossular and andradite garnets, scapolite, vesuvianite, datolite, epidote, axinite, prehnite and most zeolites.

Uses.—Lime, Ca O, is made by igniting marble and limestone, and is used in mortars and cements, and in a large number of chemical and domestic industries. Marble and limestone rock are extensively quarried for building material and ornamental purposes. Calcium oxide combines with silica and other impurities of ores to form fusible silicates, hence the extensive use of limestone as a *flux* in blast-furnace and other smelting operations. Chalk is Ca CO_3, and ground chalk, known as *whiting*, is used in putty, for scouring and polishing and for adulterating. Numerous uses are found for precipitated calcium carbonate and for marble dust. Carbon dioxide gas, extensively employed in making effervescent drinks, is largely derived from calcite or marble.

Plaster of Paris is made from gypsum, by heating it at a moderate temperature until about half of its water of crystallization is driven off. Plaster of Paris is extensively used as hard finish in plastering, in making "staff" for the construction of exhibition buildings, and for moulds and casts. Ground gypsum is used to some extent as *land plaster* for fertilizing. Some fibrous and granular varieties of gypsum (satin spar and alabaster) are polished or carved as ornaments.

Statistics.—The yearly consumption of lime is very great, the domestic product being valued at over $11,000,000. Lime is worth about $1.00 per barrel of 250 lbs. The domestic production of limestone in 1905 was valued as follows: Building and structural stone, $6,000,000; broken stone for railroad ballast, macadam, concrete and rubble, $10,000,000; for blast-furnace flux, $7,000,000—a total of over $30,000,000.

The production of gypsum in 1905 amounted to 1,000,000 tons, valued at $821,967, the supply coming chiefly from Michigan, New York, Iowa, Kansas, Oklahoma, Texas and Virginia. The importation of gypsum and plaster of Paris is valued at $360,000. Ground gypsum for land plaster is worth about $2 per ton, plaster of Paris about $3.50 per ton.

CARBON.

Occurrence.

DIAMOND, C. **GRAPHITE, C.**

Carbon is the characteristic non-metallic constituent of all *carbonates*, see pages 353 to 367 of Dana's Text-Book of Mineralogy. Although not regarded as minerals in the strict sense of being definite chemical compounds, the various forms of coal, petroleum, natural gas, asphaltum and mineral wax (ozokerite) are exceedingly important substances, generally classed as mineral products.

Uses.—Diamonds are used as gems and for cutting and polishing hard materials. Graphite is used for pencils, for making refractory crucibles, as a lubricant, and as stove polish and pigment for brightening and protecting iron surfaces. Heavy mineral oils are used as lubricants; solid products, such as paraffin and ozokerite, for candles, wax papers, and as protecting and insulating substances. Asphaltum is extensively employed in making pavements and asphaltum varnishes.

Statistics.—The value of the diamonds imported into the United States in 1905 was over $30,000,000, including about $200,000 worth of diamond dust.

The graphite produced in 1905 was 6,000,000 pounds, valued at $318,211, mostly derived from Ticonderoga, N. Y.; Chester Co., Pa., and Barton Co., Ga. The value of imported graphite was $983,034. At Niagara Falls 4,591,550 pounds of artificial graphite were produced by electricity.

For coal and fuel the figures for 1905 are as follows: Anthracite from Pennsylvania, 69,000,000 tons, $142,000,000; bituminous coal, mostly from Pennsylvania, Illinois, Ohio, West Virginia and Alabama, 315,000,000 tons, $335,000,000; crude petroleum, mostly from Pennsylvania, Ohio, California, Indiana and Texas, 135,000,000 barrels of 42 gallons, $84,000,000. The value of illuminating oil exported was $55,000,000; of other grades, $34,000,000. Natural gas, mostly from Pennsylvania, Ohio and Indiana, had a value of $41,500,000.

Asphaltum obtained in 1905, mostly from California, Utah, and Texas, was valued at over $750,000. Over 100,000 tons of asphaltum were imported into the United States, mostly from Trinidad.

Large quantities of mineral wax, ozokerite, are imported from Austria, where it occurs in extensive deposits.

CERIUM.

Together with cerium the so-called *Rare Earth Metals*, lanthanum, didymium, yttrium, erbium and thorium, will be considered. In the chemical formulas it is understood that Ce expresses the elements of the cerium group, Ce, La and Di; and Y the elements of the yttrium group, Y and Er.

Occurrence.

Tysonite, $Ce F_3$.
Parisite, $Ca [Ce F]_2 [CO_3]_3$.
Bastnäsite, $[Ce F] CO_3$.
Lanthanite, $La_2 [CO_3]_3 \cdot 9 H_2O$.
Thorite, $Th Si O_4$.
Allanite, $Ca_2 [R . OH] R_2 [Si O_4]_3$.
R = Al, Fe, Ce and Y.
Gadolinite, $Be_2 Fe Y_2 Si_2 O_{10}$.
Cerite, $H_6 Ce_4 Si_3 O_{15}$?
Most niobates and tantalates.
Xenotime, $Y PO_4$.
Monazite, $Ce PO_4$, with $Th Si O_4$.

Uses.—Thorium, an exceedingly rare element, is used for making incandescent mantles for Welsbach and other lights. The incandescent material is *thoria*, $Th O_2$, mixed with a little oxide of cerium, and is mostly obtained from monazite.

Statistics.—The production of monazite in 1905, mostly from North Carolina, was 1,352,418 pounds, valued at $163,908.

CHLORINE.

Chlorine is the characteristic non-metallic constituent of the chlorides, see Dana's Text-Book of Mineralogy, pages 317 to 323. Halite or rock salt, $Na Cl$, is the most important mineral containing it.

Uses.—Hydrochloric or muriatic acid and bleaching powder, chloride of lime, are extensively used in chemical, metallurgical and manufacturing industries, and their production is generally connected with that of caustic soda. Large quantities of bleaching powder are used in the chlorination process of extracting gold from ores.

CHROMIUM.

Occurrence.

CHROMITE, $Fe Cr O_4$ with $Mg CrO_4$.
Crocoite, $Pb Cr O_4$.
Uvarovite, $Ca_3 (Al, Cr)_2 [Si O_4]_3$.

Uses.—The oxides $Cr_2 O_3$ (green) and $Cr O_3$ (red), potassium dichromate, lead chromate, and chrome alum are used as pigments and for dyeing and calico printing. Another demand for chrome ore is for making *chrome-steel*, which possesses superior hardness and toughness, and is used in making projectiles, armor plate and safes. For this purpose an alloy of iron and chromium (ferro-chromium) is made in electric furnaces and this is added to molten steel. Considerable chromite is also employed in making *chrome bricks*, which are very refractory and are used for lining furnaces.

Statistics.—Deposits of chrome ore are known in the United States in California and North Carolina, but the annual production is very small. The importation was 54,000 tons, valued at $725,000.

Cobalt.

Occurrence.

Linnæite, $Co_3 S_4$.
Smaltite, $Co As_2$.
Cobaltite, Co S As.
Glaucodot, (Co, Fe) S As.
Erythrite, $Co_3 [As O_4]_2 . 8 H_2O$.

Some cobalt is found in most nickel minerals, and the most abundant supply of this rare metal is derived from cobaltiferous manganese oxide found in New Caledonia.

Uses.—Cobalt oxide is the chief product demanded by the trade and is used for giving blue colors to glass and porcelain. Smalt is a blue pigment made by grinding glass and other silicates colored by cobalt oxide.

Statistics.—The domestic production of cobalt oxide is small, being all derived as bi-product in the treatment of lead ores at Mine La Motte, Mo. The importation was 70,000 pounds. Cobalt oxide is worth about $2.00 per pound.

Columbium,—See Niobium.

Copper.

NATIVE COPPER, Cu.
Domeykite, $Cu_3 As$.
Algodonite, $Cu_6 As$.
Whitneyite, $Cu_9 As$.
Berzelianite, $Cu_2 Se$.
Rickardite, $Cu_4 Te_3$.
CHALCOCITE, $Cu_2 S$.
Stromeyerite, Cu Ag S.
Covellite, Cu S.
BORNITE, $Cu_5 Fe S_4$.
CHALCOPYRITE, $Cu Fe S_2$.
Chalcostibite, $Cu Sb S_2$.
Emplectite, $Cu Bi S_2$.
TETRAHEDRITE, $Cu_8 Sb_2 S_7$.
Tennantite, $Cu_8 As_2 S_7$.
Enargite, $Cu_3 As S_4$.
Atacamite, $Cu_2 Cl [OH]_3$.
CUPRITE, $Cu_2 O$.
Tenorite (Melaconite), Cu O.
MALACHITE, $[Cu . OH]_2 CO_3$.
AZURITE, $[Cu . OH]_2 Cu [CO_3]_2$.
Dioptase, $H_2 Cu Si O_4$.
CHRYSOCOLLA, $Cu Si O_3 . 2 H_2O$?
Olivenite, $Cu [Cu . OH] As O_4$.
Libethenite, $Cu [Cu . OH] PO_4$.
Clinoclasite, $[Cu . OH]_3 As O_4$.
Euchroite, $Cu [Cu . OH] As O_4 . 3 H_2O$.
Chalcophyllite, $Cu_4 [OH]_5 As O_4 . 3\frac{1}{2} H_2O$.
Gerhardtite, $Cu_4 [OH]_6 [NO_3]_2$.
Spangolite, $Cu_6 Al Cl SO_{10} . 9 H_2O$.
Brochantite, $Cu_4 [OH]_6 SO_4$.
Chalcanthite, $Cu SO_4 . 5 H_2O$.
Chalcomenite, $Cu Se O_3 . 2 H_2O$.

Uses.—Copper wire, sheet and nails are used extensively, wire especially for conductors of electricity and in electrical apparatus. One of the chief uses of copper is in making alloys: notably brass, copper and zinc; bronze, copper and tin, frequently also zinc; German silver or white metal, copper, zinc and nickel. Some alloys with aluminium are useful because of their color and high tensile strength. Copper sulphate or blue vitriol is employed in calico printing, in the manufacture of various copper salts, in galvanic cells, and in numerous manufacturing industries.

Statistics.—The domestic production of copper in 1905 was about 901,000,000 pounds, valued (at 15½ c. per pound) at $140,000,000, and mostly derived from the following states, in the order named: Montana, Michigan, Arizona, California, Utah and Colorado. Just about one-half of the world's production of copper is from the United States. The price of copper in 1905 ranged from 14.8c. to 18.4c per pound, while the average price for 1906 was over 19c. The production of copper sulphate, blue vitriol, in 1905 was 52,000,000 pounds, valued at $2,350,000.

$\left.\begin{array}{l}\text{DIDYMIUM}\\ \text{ERBIUM}\end{array}\right\}$ See Cerium, page 32.

FLUORINE.

Occurrence.—Fluorine is the characteristic non-metallic constituent of the fluorides, see Dana's Text-Book of Mineralogy, pages 317 to 323. Fluorite, $Ca F_2$, and cryolite, $Na_3 Al F_6$, are the only commercially important fluorides. Fluorine occurs as a constituent of several carbonates, silicates and phosphates, frequently with hydroxyl or chlorine isomorphous with it. Some notable examples are as follows:

Parisite, $Ca [Ce F]_2 [CO_3]_3$.
Bastnäsite, $[Ce F] CO_3$.
Zunyite, $[Al.2 (OH,F,Cl)]_6 Al_2 [SiO_4]_3$.
TOPAZ, $[Al F]_2 Si O_4$, often with $[Al . OH]_2 Si O_4$.
LEPIDOLITE, $K Li [Al . 2 (OH,F)] Al [Si O_3]_3$.
Herderite, $Ca [Be (OH, F)] PO_4$.
APATITE, $Ca_4 [Ca F] [PO_4]_3$ and $Ca_4 [Ca (F, Cl)] [PO_4]_3$.
Wagnerite, $[Mg F] Mg PO_4$.
Triplite, $[R F] R PO_4$; R = Fe and Mn.
Durangite, $Na [Al F] As O_4$.
Amblygonite, $Li [Al F] PO_4$ and $Li [Al (OH, F)] PO_4$.

Uses.—Fluorite is used chiefly as a flux in furnaces in which steel and iron are melted; also in the manufacture of opalescent glass and for making hydrofluoric acid, H F, for etching glass. The uses of cryolite are noted on page 26.

Statistics.—The production of fluorite in 1905 was 57,385 tons, valued at $362,488, the mineral coming from Eastern Kentucky and Southern Illinois. Fluorite is worth about $6 per ton, $10 to $12 when ground.

GALLIUM.

Occurrence.—Traces of this very rare element have been found in sphalerite from a few localities.

GERMANIUM.

Occurrence.

Argyrodite, Ag_8GeS_6.	Canfieldite, $Ag_8(Sn, Ge)S_6$.

GOLD.

Occurrence.

NATIVE GOLD, Au, but always containing some silver.	**Sylvanite,** $AuAgTe_4$.
	Krennerite, $AuTe_2$.
Petzite, $[Ag, Au]_2Te$.	**Calaverite,** $AuTe_2$.

Gold is found in many pyritiferous and other sulphide ores, and often it is impossible to tell in just what combination it occurs. This is because of the small amount of gold in most ores; thus a ton of ore having one per cent. of gold would contain 291.66 troy ounces of the precious metal, worth $6,028, hence what may be called a rich ore, with gold value of $60 per ton, would contain but 0.01 per cent. of gold. The occurrence of gold in combination with tellurium and associated with tellurium minerals is worthy of note.

Uses.—The uses of gold for coin, ornaments and plating are well known. The standard gold for United States coin is 9-10ths fine, 9 parts of gold to 1 of copper. The gold used in jewelry is hardened by alloying it with copper and silver; 18 carat fine being 18-24ths gold and 6-24ths other metals.

Statistics.—The domestic production of gold in 1905 was 4,265,742 fine ounces, valued at $88,180,700, derived from the following states, the numbers giving the nearest million dollars: Colorado 25, California 19, Alaska 14, South Dakota 7, Montana 5, Arizona 3, Utah 5, Nevada 5, Idaho 1, and Oregon 1. The world's production in 1905 was valued at $380,000,000. Gold is the standard of value and a troy ounce is worth $20.67, equivalent to $301.44 per pound avoirdupois.

HYDROGEN.

Occurrence.—Hydrogen occurs in combination with oxygen in water and ice, and in the water of crystallization and hydroxyl radicals of many minerals. In combination with carbon it occurs in hydrocarbons, bituminous coal, petroleum and natural gas.

INDIUM.

Occurrence.—This excessively rare metal is found in small quantity in sphalerite from a few localities.

Iodine.

Occurrence.

Marshite, $Cu\,I$.
Miersite, $4\,Ag\,I\,.\,Cu\,I$.
Iodyrite, $Ag\,I$.
Lautarite, $Ca\,[IO_3]_2$.

Uses.—Iodine and its compounds are used in chemical industries and laboratories, and in pharmaceutical preparations.

Statistics.—At the present time most of the iodine of commerce comes from Chile. Iodine is worth about $2.75 per pound.

Iridium.

Occurrence.—This rare metal is found sparingly with platinum ores as platiniridium and iridosmine.

Uses.—On account of stability and superior hardness platinum-iridium alloys have been employed for making standard weights and measures of the highest grade. Hard iridium alloys are used for tipping gold pens.

Statistics.—A small amount of iridium is obtained from California ores.

Iron.

Occurrence.—Only typical iron compounds are included in the accompanying table, and it should be noted that iron occurs as an isomorphous constituent in many minerals, especially silicates and phosphates, replacing magnesium and manganese when *ferrous*, and aluminium when *ferric*.

Native Iron, Fe with Ni.
PYRRHOTITE, $Fe_{11}\,S_{12}$.
PYRITE, $Fe\,S_2$.
MARCASITE, $Fe\,S_2$.
HEMATITE, $Fe_2\,O_3$.
ILMENITE, $Fe\,Ti\,O_3$.
MAGNETITE, $Fe_3\,O_4$.
Turgite, $Fe_4\,O_5\,[OH]_2$.
GÖTHITE, $Fe_2\,O_2\,[OH]_2$.
LIMONITE, $Fe_4\,O_3\,[OH]_6$.
SIDERITE, $Fe\,CO_3$.
ALMANDITE, $Fe_3\,Al_2\,[Si\,O_4]_3$.
ANDRADITE, $Ca_3\,Fe_2\,[Si\,O_4]_3$.
Fayalite, $Fe_2\,Si\,O_4$.
Ilvaite, $Ca\,Fe_2\,[Fe\,.\,OH][Si\,O_4]_2$.
COLUMBITE, $(Fe,Mn)\,(Nb,Ta)_2O_6$.
Triphylite, $Li\,Fe\,PO_4$.
Vivianite, $Fe_3\,[PO_4]_2\,.\,8\,H_2O$.
Scorodite, $Fe\,As\,O_4\,.\,2\,H_2O$.
Melanterite, $Fe\,SO_4\,.\,7\,H_2O$.
Jarosite, $K_2\,Fe_6\,[OH]_{12}\,[SO_4]_4$.
WOLFRAMITE, $Fe\,W\,O_4$.

In connection with the iron industry it should be noted that ores must contain a high percentage of iron; thus an average Lake Superior ore contains in the neighborhood of 60% Fe. Practically the only minerals which are mined as iron ores are hematite, magnetite and limonite, rarely siderite. It should also be noted that phosphorus, sulphur and titanium are injurious constituents of ores, notably phosphorus, which in a high-grade Bessemer ore should not exceed 0.05 per cent. The importance of limestone as a blast-furnace flux is noted on page 30. The importance of manganese is noted on page 40.

Uses.—The customary uses of iron and steel in the arts need no special comment. The most important commercial salt of iron is copperas, green vitriol, $Fe\,SO_4 . 7\,H_2O$, employed in dyeing, in making rouge, inks and Prussian blue, and as a disinfectant. Rouge, $Fe_2\,O_3$, made from copperas, is used as polishing powder and pigment, when it is known as Venetian and Indian red. Considerable soft iron ore is ground for mineral paint, ocher, umber, sienna and iron oxide.

Iron oxides may be made to combine with silica to form fusible silicates, hence the uses of iron ores as fluxes in some smelting operations, notably in the smelting of silver ores.

Much attention is now being paid to the combination of small quantities of nickel, chromium, tungsten, titanium and molybdenum with steel in order to obtain metal of superior hardness, toughness and tempering qualities.

Statistics.—The total production of domestic ores in 1905, mostly hematite, was nearly 42,500,000 long tons (2,240 lbs.); 21,700,000 from Minnesota, 11,600,000 from Michigan and Wisconsin, 3,700,000 from Alabama and southern states, and 5,500,000 from other sources. The iron ore imported was about 845,000 tons.

The domestic production of pig iron was over 23,000,000 tons, which had a value of $382,450,000.

The production of Bessemer and open-hearth steel in 1905 was 20,350,000 tons, worth about $28 per ton when rolled into rails.

The world's production of pig iron in 1905 was 54,000,000 tons, and of steel 43,900,000 tons.

The yearly production of pig iron in the United States has practically doubled with every decade since 1872, as shown by the following, the amount being long tons:

Year,	1872	1882	1892	1902
Tons,	2,500,000	4,500,000	8,300,000	16,100,000

The production of copperas, mostly as a by-product, amounted in 1905 to 21,100 tons, valued at $147,721.

The production of iron ores ground as mineral paint was 14,000 tons, valued at $140,000. The value of similar imported products amounted to about $140,000.

Lead.

Occurrence.

Native lead, Pb.
GALENA, PbS.
Altaite, $PbTe$.
Clausthalite, $PbSe$.
Zinkenite, $PbSb_2S_4$.
Sartorite, $PbAs_2S_4$.
Jamesonite, $Pb_2Sb_2S_5$.
Dufrenoysite, $Pb_2As_2S_5$.
Cosalite, $Pb_2Bi_2S_5$.
Meneghinite, $Pb_4Sb_2S_7$.
Cotunnite, $PbCl_2$.
Percylite, $PbCu[OH]_2Cl_2$.
Matlockite, Pb_2OCl_2.
Massicot, PbO.
Minium, Pb_3O_4.
Plattnerite, PbO_2.
CERUSSITE, $PbCO_3$.
Phosgenite, $[PbCl]_2CO_3$.
Leadhillite, $Pb_2[Pb.OH]_2[CO_3]_2SO_4$.
Barysilite, $Pb_3Si_2O_7$.
Nasonite, $Pb_4[PbCl]_2Ca_4[Si_2O_7]_3$.
Ganomalite, $Pb_4[Pb.OH]_2Ca_4[Si_2O_7]_3$.
Melanotekite, $[Fe_4O_3]Pb_3[SiO_4]_3$.
Kentrolite, $[Mn_4O_3]Pb_3[SiO_4]_3$.
PYROMORPHITE, $Pb_4[PbCl][PO_4]_3$.
Mimetite, $Pb_4[PbCl][AsO_4]_3$.
Vanadinite, $Pb_4[PbCl][VO_4]_3$.
Descloizite, $(Pb, Zn)_2[OH]VO_4$.
ANGLESITE, $PbSO_4$.
Crocoite, $PbCrO_4$.
Wulfenite, $PbMoO_4$.
Stolzite, $PbWO_4$.

The almost universal association of minerals containing silver and zinc with lead ores is worthy of special note; in fact a large part of the lead of commerce is so-called *desilverized lead*, obtained from the smelting of silver ores.

Uses.—Lead is extensively used as sheet and pipe by plumbers, as ballast for small vessels, for making weights, bullets, shot and washers, and numerous useful alloys. Ordinary solder is made of lead and tin, type metal of lead and antimony, low-fusion alloys of lead, bismuth and tin. Much so-called tin foil contains considerable lead. Litharge, PbO, is largely employed in making flint glass and glazing earthenware. Minium, Pb_3O_4, is a red pigment and is used in glass making. White lead, $[Pb.OH]_2Pb[CO_3]_2$, is the basis of the best white paint, having great covering power. Lead chromates are employed as yellow and red pigments. Lead acetate, sugar of lead, is the most important soluble salt, used largely in the arts.

Statistics.—The production from domestic ores in 1905 was 302,000 tons of lead, valued at $28,690,000, of which 296,000 tons was desilverized lead. The states producing the largest quantities are Colorado, Idaho, Missouri, Utah and Montana. The average price of lead in New York during 1905 was 4.7c. per pound. The production of litharge was 40,000 tons, valued at $2,300,000; of red lead 32,000 tons, valued at $2,000,000; and of white lead 263,000 tons, valued at $16,000,000.

LITHIUM.

Occurrence.

Petalite, $Li\,Al\,Si_4\,O_{10}$.
SPODUMENE, $Li\,Al\,Si_2\,O_6$.
Eucryptite, $Li\,Al\,Si\,O_4$.
LEPIDOLITE, $Li\,K\,[Al\,.\,2\,(OH, F)]\,Al\,[Si\,O_3]_3$.
Triphylite, $Li\,Fe\,PO_4$.
Lithiophilite, $Li\,Mn\,PO_4$.
Amblygonite, $Li\,[Al\,F]\,PO_4$, with $Li\,[Al\,(OH, F)]\,PO_4$.

Small quantities of lithia are found in some natural spring waters and in a number of silicates, notably the micas, tourmaline and beryl.

Uses.—Lithia waters and lithia salts have medicinal properties, used especially in the treatment of rheumatism and gout. Pure lithia salts are valuable in the laboratory for making monochromatic red light.

Statistics.—Lepidolite is the most important commercial source of lithia, being chiefly found in San Diego County, California, the annual production, however, being small.

MAGNESIUM.

Occurrence.—Magnesium is an element of very common occurrence, especially as a component of a number of silicates which play an important rôle as rock constituents. The isomorphous replacement of some magnesium by ferrous iron is very common. All of the more important types of magnesium compounds are given in the accompanying table, but the list is not a complete one.

Sellaite, $Mg\,F_2$.
Bischofite, $Mg\,Cl_2\,.\,6\,H_2O$.
Carnallite, $K\,Cl\,.\,Mg\,Cl_2\,.\,6\,H_2O$.
Tachydrite, $Ca\,Cl_2\,.\,2\,Mg\,Cl_2\,.\,12\,H_2O$.
Periclase, $Mg\,O$.
SPINEL, $Mg\,Al_2\,O_4$.
BRUCITE, $Mg\,[OH]_2$.
DOLOMITE, $Ca\,Mg\,[CO_3]_2$.
MAGNESITE, $Mg\,CO_3$.
Nesquehonite, $Mg\,CO_3\,.\,3\,H_2O$.
Hydromagnesite, $Mg_4\,[OH]_2\,[CO_3]_3\,.\,3\,H_2O$.
Lansfordite, $Mg_4[OH]\,[CO_3]_3\,.\,21\,H_2O$.
ENSTATITE-BRONZITE, $(Mg, Fe)\,Si\,O_3$.
Pyroxene, $Ca\,[Mg, Fe]\,[Si\,O_3]_2$.
Anthophyllite, $(Mg, Fe)\,Si\,O_3$.
AMPHIBOLE, $R\,Si\,O_3$, $R = Mg$, Fe and Ca.
Monticellite, $Ca\,Mg\,Si\,O_4$.
CHRYSOLITE, $[Mg, Fe]_2\,Si\,O_4$.
Chondrodite, $[Mg\,(F, OH)]_2\,Mg_3\,[Si\,O_4]_2$.
Humite, $[Mg.\,(F, OH)]_2\,Mg_5\,[Si\,O_4]_3$.
Clinohumite, $[Mg\,(F, OH)]_2\,Mg_7\,[Si\,O_4]_4$.
THE MICAS, BIOTITE AND PHLOGOPITE.
THE CHLORITES, CLINOCHLORE.
SERPENTINE, $H_4\,Mg_3\,Si_2\,O_9$.
TALC, $H_2\,Mg_3\,[Si\,O_3]_4$.
Wagnerite, $[Mg\,F]\,Mg\,PO_4$.
Boracite, $Mg_7\,Cl_2\,B_{16}\,O_{30}$.
Kainite, $Mg\,SO_4\,.\,K\,Cl\,.\,3\,H_2O$.
Schoenite, $K_2\,Mg\,[SO_4]_2\,.\,6\,H_2O$.
Epsomite, $Mg\,SO_4\,.\,7\,H_2O$.
Blödite, $Mg\,SO_4\,.\,Na_2\,SO_4\,.\,4\,H_2O$.

Uses.—Magnesite when calcined yields magnesia, MgO, which when compressed into bricks is used for refractory furnace lining. Magnesia is also used in making non-conductive covering for boilers and steam pipes. Magnesia salts, especially the sulphate, are used in the arts and to some extent in pharmaceutical preparations. Many limestones and marbles approximate to dolomite in composition, when they are called dolomitic, and some of them are valuable building stones. Some varieties of magnesia mica, serpentine and talc are used in the arts, and will be referred to in a later paragraph.

Statistics.—The production of magnesite is limited to California, where 3,900 tons were produced in 1905, valued at $15,000. The importation of magnesite was valued at about $650,000. The importation of Epsom salts, $MgSO_4 \cdot 7\,H_2O$, had a value of $38,000 in 1905.

MANGANESE.

Alabandite, MnS.
Hauerite, MnS_2.
Manganosite, MnO.
Franklinite, $(Fe, Mn, Zn)(Fe, Mn)_2O_4$.
Hausmannite, Mn_3O_4.
Braunite, $Mn, (Mn, Si)O_3$.
Bixbyite, $FeMnO_3$.
Polianite, MnO_2.
MANGANITE, $Mn_2[OH]_2O_2$.
PYROLUSITE, MnO_2 with water?
Pyrochroite, $Mn[OH]_2$.
Psilomelane, MnO_2, MnO, etc.
RHODOCHROSITE, $MnCO_3$.
RHODONITE, $MnSiO_3$.
Helvite, $(Mn, Fe)_2[Mn_2S]Be_3[SiO_4]_3$.
Spessartite, $Mn_3Al_2[SiO_4]_3$.
Glaucochroite, $CaMnSiO_4$.
Tephroite, Mn_2SiO_4.
Friedelite, $H_7[MnCl]Mn_4[SiO_4]_4$.
Piedmontite, $Ca_2[Al \cdot OH](Al, Mn)_2[SiO_4]_3$.
Inesite, $3(Mn, Ca)SiO_3 \cdot 2H_2O$.
Lithiophilite, $LiMnPO_4$.
Triplite, $[RF]RPO_4$, $R = Mn$ & Fe.
Triploidite, $[R \cdot OH]RPO_4$, $R = Mn$ and Fe.
Sussexite, $HRBO_3$, $R = Mn$, Mg & Zn.
Hübnerite, $MnWO_4$.

A number of common minerals, notably silicates, contain from traces to several per cent. of oxide of manganese, which is isomorphous with the oxides of iron and magnesium.

Uses.—Manganese ores are used chiefly in making ferro-manganese and spiegeleisen, compounds which are employed in the manufacture of steel. A little metallic manganese is produced by the electrical furnace and alloyed with copper for making manganese bronze. Some oxide of manganese is employed by glass makers. When added in proper amount to molten glass the violet color which manganese tends to impart destroys (complements) the yellow caused by oxide of iron, and thus a nearly colorless product is obtained. The higher oxides of manganese are used in laboratories for obtaining oxygen gas and for liberating chlorine from hydrochloric acid. In some regions, notably Colorado, silver ores contain sufficient manganese (generally rhodochrosite) to make it of decided value as a flux.

Statistics.—The production of manganese ores in 1905, mostly from Virginia, amounted to 4,118 long tons (2,240 lbs.), valued at $36,000. The larger part of the manganese produced comes from manganiferous iron ores obtained chiefly from the Lake Superior District or Colorado. The value of such ores for 1905 was $1,500,000. The importation was 257,000 tons, valued at $1,900,000. It is very important that manganese ores should be low in phosphorus, less than 0.10 per cent.

MERCURY, QUICKSILVER.

Occurrence.

Native Mercury, Hg.
Native Amalgam, Hg with Ag.
Metacinnabarite, Hg S.
Tiemannite, Hg Se.
Onofrite, Hg (S, Se).
Coloradoite, Hg Te.
CINNABAR, Hg S.
Calomel, Hg Cl.

Uses.—Metallic mercury is used extensively in the amalgamation processes of extracting gold and silver from ores, in the manufacture of physical and chemical apparatus, and in a variety of chemical and electrical industries. The silvering on mirrors is an amalgam of tin and mercury. Mercury salts are extensively employed in pharmaceutical preparations, and the sulphide is the red pigment vermilion.

Statistics.—Quicksilver is generally sold in bulk by the flask of 76½ lbs. The production in 1905 was over 30,000 flasks, or 1,100 tons, valued at about $1,103,000, six-sevenths of the supply coming from California, the remainder from Texas. A little less than one-third of the world's production of quicksilver in 1905 was produced in the United States. The price of mercury per flask at San Francisco is about $40.

MOLYBDENUM.

Occurrence.

MOLYBDENITE, Mo S_2.
Molybdite, Mo O_3.
Wulfenite, Pb Mo O_4.
Powellite, Ca Mo O_4.

Uses.—Ammonium molybdate is used in all chemical laboratories for the detection and estimation of phosphoric acid. A recent and large demand for molybdenum is for making ferro-molybdenum. This when combined with chrome-steel gives a product which is self-hardening.

Statistics.—Only a little molybdenite is produced in the United States; the price, however, for nearly pure mineral is about $400 per ton.

NICKEL.

Meteoric and native nickel-iron, awaruite and josephinite, Fe with Ni.
Pentlandite, $(Ni, Fe) S$.
Millerite, $Ni S$.
Niccolite, $Ni As$.
Breithauptite, $Ni Sb$.
NICKELIFEROUS PYRRHOTITE.
Linnæite, $(Co, Ni, Fe)_3 S_4$.
Melonite, $Ni_2 Te_3$.
Chloanthite, $Ni As_2$.
Gersdorffite, $Ni As S$.
Ullmanite, $Ni Sb S$.
Rammelsbergite, $Ni As_2$.
Zaratite, $Ni_3 [OH]_4 CO_3 . 4 H_2O$.
Genthite, $Ni_2 Mg_2 Si_3 O_{10} . 6 H_2O$?
Garnierite, noumeaite, H_2NiSiO_4?
Annabergite, $Ni_3 [As O_4]_2 . 8 H_2O$.
Morenosite, $Ni SO_4 . 7 H_2O$.

Uses.—The chief demand for nickel is for making *nickel-steel,* which contains about 3½ per cent. of nickel, possesses great strength and toughness, and is used for armor plate. For various uses in the steel industry products known as ferro-nickel, chrome-nickel, tungsten-nickel and molybdenum-nickel are manufactured. There are numerous important alloys of nickel: German silver, containing Cu, Zn and Ni; metal for coinage, containing Cu and Ni; and also some alloys with aluminium which possess great strength. Considerable metal is used in nickel plating.

Statistics.—Owing to the rare occurrence of nickel minerals the production of nickel from domestic ores amounts to but a few thousand pounds a year, mostly obtained as a by-product from the treatment of lead ores at Mine La Motte, Mo. The production from foreign ores, chiefly pyrrhotite and pentlandite from Sudbury, Canada, amounted in 1905 to about 18,876,000 pounds, valued at $7,500,000. Next in importance to the sulphide ores of Sudbury come the silicate (garnierite) deposits of New Caledonia. The world's production of nickel in 1905 amounted to about 20,000,000 pounds. An average price for nickel is about 40c. per pound.

NIOBIUM, called also COLUMBIUM.

Occurrence.—Niobium is a rare non-metallic or acid constituent found in the niobates and tantalates, see Dana's Text-Book of Mineralogy, pages 489 to 493.

There are no uses for niobium or its compounds.

NITROGEN.

Occurrence.—Nitrogen is the characteristic non-metallic constituent of the nitrates, which, owing to their solubility, are of exceptional occurrence as minerals. Nitrogen is a constituent also of ammonia and its compounds, which occur rarely as minerals. Air is essentially a mixture of nitrogen and oxygen gases, in about the proportion of four volumes of nitrogen to one of oxygen.

Uses.—Nitric acid and its salts and ammonia compounds are extensively used in argiculture, and in chemical industries and laboratories. Explosives, such as gunpowder, guncotton, nitroglycerin, dynamite, material for fireworks, etc., contain either nitric acid derivatives or niter. Ammonia gas is used in artificial refrigerating plants. Nitrogen, either in nitrates or ammonia salts, or in refuse organic matter, is essential for plant nutrition, nitrogen of the air not being available for this purpose, except under conditions which do not ordinarily prevail.

Statistics.—Practically the world's supply of crude mineral material for making nitric acid and nitrates is sodium nitrate, the so-called *Chile saltpeter*, found in almost rainless regions in Chile and Bolivia. Ammonia is almost wholly derived as by-product from coke and gas ovens in which bituminous coal is distilled. The salt most in demand is ammonium sulphate, the larger part of which is used in fertilizers. The domestic production of ammonium sulphate in 1905 was 38,000,000 pounds, value $1,000,000. The price of commercial fertilizers is based upon the amount of plant nutriment they contain. Of the three important nutritive elements, nitrogen, phosphorus and potassium, nitrogen heads the list, its value per pound being about 14.5c.

OSMIUM.

Occurrence.—A very rare element found in iridosmium and in traces with the metals of the platinum group.

Uses.—The use of osmium for filaments for incandescent electric lights, in place of the ordinary carbon filaments, is causing a demand for this rare element. Osmium is worth about $21 per troy ounce.

OXYGEN.

Occurrence.—Most minerals contain oxygen, the exceptions being the native elements; the sulphides, tellurides and selenides; the sulpho-salts (sulphantimonites, sulpharsenites) and the halogen-salts.

Uses.—Special importance is attached to certain higher oxides, notably those of manganese and lead, and to nitrates and chlorates which contain *available oxygen* for bringing about oxidations or obtaining oxygen gas. Oxygen and hydrogen gases are now made by the electrolysis of water, the oxygen, compressed in cylinders, being sold for use in medicine and for oxyhydrogen blowpipes.

PALLADIUM.

Occurrence.—A rare metal of the platinum group, found native and in traces in native platinum.

PHOSPHORUS.

Occurrence.—Phosphorus is the characteristic non-metallic constituent of the phosphates; see Dana's Text-Book of Mineralogy, pages 494 to 516.

Uses.—There are two modifications of the element phosphorus: the common colorless variety, cast generally in sticks, which finds limited uses in laboratories and various chemical industries, and the red, amorphous variety used to some extent in chemical industries, but extensively along with other substances in the manufacture of matches.

Phosphates are essential for plant nutrition and are important in the manufacture of commercial fertilizers; phosphorus, reckoned generally as phosphoric anhydride, $P_2 O_5$, ranking next to nitrogen in importance (compare page 43). The mineral phosphates mined for making fertilizers are either apatite, $Ca_4 [Ca F] [PO_4]_3$, or so-called *phosphate rock*, which is a calcium phosphate closely related to apatite in chemical composition. Phosphate rock is generally treated with sulphuric acid to make the phosphoric acid soluble and thus available to the roots of plants. The inorganic material of the bones of mammals is essentially calcium phosphate, and phosphorus is contained in animal-tissues and excreta; hence the extensive use of refuse animal matter and manure as fertilizers. Phosphoric acid and various phosphates are used in pharmaceutical preparations. The harmful influence of phosphorus, even in very small quantity, on iron and steel should be noted (see page 36).

Statistics.—The domestic production of phosphate rock, mined chiefly in Florida, Tennessee and South Carolina, amounted in 1905 to over 2,000,000 tons, valued at about $6,700,000. About one-fourth of the product was exported, mostly to Germany. The world's production of phosphate rock in 1904 was about 3,500,000 tons. The valuation of commercial fertilizers is based upon the amounts of plant nutriment they contain, which must be determined by chemical analysis. The three important constituents are phosphoric anhydride, P_2O_5, nitrogen, and potash, K_2O. Soluble or available P_2O_5 is valued at a trifle over 3c. per pound, or 62½ c. per unit of 20 pounds (one per cent.) per ton.. Insoluble phosphate rock, even if finely ground, is of very little agricultural value, unless treated with sulphuric acid so as to make the P_2O_5 available.

PLATINUM.

Occurrence.

Native Platinum, Pt, with some Fe and traces of rare platinum metals.
Sperrylite, $Pt\,As_2$.

Uses.—Owing to its difficult fusibility and insolubility in acids, platinum, manufactured into wire, foil, crucibles, dishes, stills, and various forms of apparatus, is indispensable to the chemist and in certain chemical industries. There are numerous uses for it in connection with electricity: thus for making connections where a metal is needed which does not corrode; and fine platinum wire fused into glass is used in carrying the electric current to the incandescent filaments of electric lights. The incandescent thoria mantles of the Welsbach light are generally hung on platinum wire. Potassium chloro-platinate, $2\,K\,Cl\,.\,Pt\,Cl_2$, is used to a considerable extent in photography. A noteworthy feature of the platinum industry is that demands for the metal are multiplying, with no appreciable increase in the supply.

Statistics.—The domestic production of platinum in 1905 was 318 ounces, valued at $5,320, the supply coming almost wholly from gold placer deposits in California. The importation in 1905 was valued at over $2,000,000. The world's supply of platinum comes from the Urals, where nearly 200,000 ounces are produced annually. The price of platinum has been steadily rising, being worth in September, 1906, $34 per ounce, about three times what it was in 1895.

POTASSIUM.

Occurrence.

SYLVITE, $K Cl$.
CARNALLITE, $K Mg Cl_3 . 6 H_2O$.
FELDSPAR, ORTHOCLASE and MICROCLINE, $K Al Si_3 O_8$.
LEUCITE, $K Al [Si O_3]_2$.
Apophyllite, and a few Zeolites.
MUSCOVITE, $H_2 K Al_3 [SiO_4]_3$.
BIOTITE, and other Micas.
Langbeinite, $K_2 Mg_2 [SO_4]_3$.
KAINITE, $K Cl . Mg SO_4 . 3 H_2O$.
SCHOENITE, $K_2 Mg [SO_4]_2 . 6 H_2O$.
Polyhalite, $K_2 Ca_2 Mg [SO_4]_4 . 2 H_2O$.
Kalinite, $K Al [SO_4]_2 . 12 H_2O$.
Alunite, $K_2 Al_6 [OH]_{12} [SO_4]_4$.
Jarosite, $K_2 Fe_6 [OH]_{12} [SO_4]_4$.

Uses.—Potash salts are essential for plant nutrition and are more largely employed in agriculture than in any single industry. The potash salts most in demand are as follows: The *chloride*, used in fertilizers and in making other potash salts; the *carbonate*, *bicarbonate* and *caustic potash*, used in making soft soaps and flint and Bohemian glass; the *nitrate*, niter, for making gunpowder; the *chlorate*, for making matches and oxygen gas, and used also in medicine; the *cyanide*, employed in large quantities in the extraction of gold from ores; the *bromide* and *iodide*, used in medicine.

Statistics.—It is a noteworthy fact that no commercially important deposits of potash minerals have as yet been found in the United States. The world's supply of potash at the present time is mostly derived from deposits round about Stassfurt in Germany, though some potash is obtained from what was at one time almost the only source, the leaching of the ashes of plants, some from brines left over after separating common salt from sea water, and some from the washing of sheep's wool, the salty perspiration retained by the wool containing a rather large proportion of potash salts. The slow decay of the common rock-making silicates, feldspars and micas, undoubtedly gives rise to the potash of soils, needed as plant nutriment, but attempts to get potash from feldspars on a commercial scale have failed, as the processes are so costly as not to be able to compete with the production in Germany.

The production of potassium salts in Germany had a total value of $31,000,000. The importation of potash salts into the United States in 1905 was valued at $5,300,000.

For agricultural purposes, potash, reckoned as K_2O, is worth about 4 to 4½ c. per pound (compare nitrogen and phosphorus).

RHODIUM.

Occurrence.—This rare metal of the platinum group is found in native platinum, iridium and iridosmine.

RUBIDIUM.

Occurrence.—This rare alkali metal is found in small quantity in lepidolite, and in minute traces in a few other silicates and some mineral spring waters.

RUTHENIUM.

Occurrence.—This rare metal of the platinum group is found in laurite, $Ru S_2$, and in iridosmine.

SELENIUM.

Occurrence.

Selen-Tellurium, Te with Se.
Guanajuatite, $Bi_2 Se_3$.
Clausthalite, $Pb Se$.
Naumannite, $(Ag_2, Pb) Se$.
Berzelianite, $Cu_2 Se$.
Eucairite, $Cu Ag Se$.
Crookesite, $(Cu, Tl, Ag)_2 Se$.
Aguilarite, $Ag_2 S . Ag_2 Se$.
Tiemannite, $Hg Se$.
Onofrite, $Hg (S, Se)$.
Umangite, $Cu_3 Se_2$.
Chalcomenite, $Cu Se O_3 . 2 H_2O$.

Uses.—As far as known there are no uses for this element except in the laboratory for making rare chemical preparations.

SILICON.

Occurrence.—Silicon is the characteristic non-metallic constituent of the silicates, salts of silicic acid (see Dana's Text-Book of Mineralogy, pages 368 to 488). Silicon occurs also as oxide, quartz, agate, flint, chalcedony and tridymite, and as hydroxide, opal.

Uses.—There are no uses for the element silicon. In ordinary pig iron silicon occurs in varying proportions, up to 5 or 6 per cent., generally about 2 per cent., and plays an important rôle in the metallurgy of iron and steel. For use in steel metallurgy, ferro-silicon (Fe with 10% to 25% Si) is now made in electric furnaces. The burning of the silicon to $Si O_2$ gives an intense heat which is needed in certain operations. There are uses for various silicates which are noted either under the metallic constituents or under the heading *Useful Minerals*. The uses of oxide of silicon in various forms, quartz, quartzite, sandstone, flint, etc., are given below.

Uses of $Si O_2$.—White beach sand is composed almost wholly and ordinary sand mostly of quartz, and has many uses, especially in making mortar, while very pure grades are used in the glass industry. Quartzite and sandstone consist of quartz grains more or less firmly united, and are quarried for building materials, flagstones, grindstones, millstones, whetstones and other uses. Well rounded beach pebbles put into revolving cylinders are used for pulverizing many substances. Ground quartz and flint are used extensively in the manufacture of pottery, to some extent as abrasive material in scouring soaps, marble cutting and sandpaper, and, when ground to impalpable powder and mixed with oils, as *wood filler* in finishing fine carpenter work. Pure transparent quartz is used for cutting into ornaments, rock-crystal dishes, vases, spheres, etc.; for making eye-glasses (pebbles) which are superior to glass in being harder; and for making prisms and optical preparations.

Opals, amethyst and smoky-quartz, and moss, banded and variously colored agates are used in jewelry. Mortars for the laboratory are made of agate.

Infusorial earth is a very fine earthy material consisting of microscopic silicious shells of vegetable organisms known as diatoms. The material, sold often as tripoli and electro-silicon, is used for polishing articles of metal, and in the manufacture of giant powder, when the infusorial earth is used as an absorbent for nitro-glycerin.

Statistics.—The domestic production of buhrstones and millstones in 1905 was valued at $37,000. The stones, generally made from quartzite or conglomerate, are used for grinding grain, mineral-paint, fertilizers, cement rock, barites and other minerals, and come mostly from the Eastern Appalachian region in New York, Pennsylvania, Virginia and North Carolina. The value of grindstones was $777,000, while that of whetstones and scythe-stones was $244,000, the finest whetstone, known as novaculite, coming from Arkansas.

The production of pure quartz for grinding is confined mostly to Connecticut and amounted in 1905 to 19,000 tons, valued at $88,000.

SILVER.

Occurrence.

Native Silver, Ag.
Amalgam, Ag with Hg.
Dyscrasite, $Ag_6 Sb$.
Argentite, $Ag_2 S$.
Hessite, $Ag_2 Te$.
Petzite, $(Ag, Au)_2 Te$.
Stromeyerite, $Ag_2 S . Cu_2 S$.
Sylvanite, $Ag Te_2 . Au Te_2$.
Matildite, $Ag_2 S . Bi_2 S_3$.
Miargyrite, $Ag_2 S . Sb_2 S_3$.
Pyrargyrite, $3 Ag_2 S . Sb_2 S_3$.
Proustite, $3 Ag_2 S . As_2 S_3$.
Stephanite, $5 Ag_2 S . Sb_2 S_3$.
Polybasite, $9 Ag_2 S . Sb_2 S_3$, Cu iso. w. Ag.
Pearceite, $9 Ag_2S . As_2S_3$, Cu iso. w. Ag.
Polyargyrite, $12 Ag_2 S . Sb_2 S_3$.
Argyrodite, $4 Ag_2 S . Ge S_2$.
Canfieldite, $4 Ag_2 S . Sn S_2$, Ge iso. w. Sn.
Cerargyrite, Ag Cl.
Embolite, Ag (Cl, Br).
Bromyrite, Ag Br.
Iodyrite, Ag I.

In addition to the foregoing there are argentiferous varieties of many minerals, notably those containing lead and copper, which are especially valuable as ores, as galena, chalcocite, bornite, chalcopyrite and tetrahedrite. It is difficult in many cases to decide whether the small amount of silver in argentiferous lead and copper minerals is truly isomorphous with the lead and copper, or due to traces of associated silver minerals mechanically mixed with them.

Uses.—The uses of silver for coin, for various domestic and ornamental objects, and for plating are well known. Generally an alloy is used instead of pure silver. The standard coin of the United States contains 9 parts of silver to one of copper. Silver salts are used extensively in photography, and the nitrate in medicine for cauterization.

Statistics.—The domestic production of silver in 1905 was 56,000,000 troy ounces, valued at $34,000,000. The production of the several states in million ounces was about as follows: Colorado 13, Montana 13, Utah 10, Idaho 8, Nevada 5, and Arizona 2¾. The world's production amounted to 189,000,000 ounces. The average value of the metal for the year was about 60 c. per fine ounce.

Metallurgical.—In connection with the metallurgy of silver a few points are of importance: Owing to the price of silver, a small amount of the metal in an ore, expressed as per cent., is of considerable value. Thus an ore containing 0.34 per cent. Ag would yield 100 ounces per ton, which is far above the average run of silver ores. In assaying, the amount of silver is generally given as ounces per ton. The metallurgy of silver is intimately connected with that of lead, ores containing both metals being smelted so that silver may be taken up by the lead (see page 38). In the smelting process, lime, $Ca\ O$, and oxides of iron and manganese add to the value of ores because of their quality as fluxes, and zinc, which scarcely ever fails, is especially harmful, as it interferes with the proper running of the furnaces.

SODIUM.

Occurrence.

HALITE, $Na\ Cl$.
CRYOLITE, $Na_3\ Al\ F_6$.
Pachnolite, $Na\ Ca\ Al\ F_6 \cdot H_2O$.
Thomsenolite, $Na\ Ca\ Al\ F_6 \cdot H_2O$.
Dawsonite, $Na\ [Al \cdot 2\ OH]\ CO_3$.
Thermonatrite, $Na_2\ CO_3 \cdot H_2O$.
Northupite, $Na_2\ Mg\ [CO_3]_2 \cdot Na\ Cl$.
Natron, $Na_2\ CO_3 \cdot 10\ H_2O$.
Trona, $Na_2\ CO_3 \cdot H\ Na\ CO_3 \cdot 2\ H_2O$.
Pirssonite, $Na_2\ Ca\ [CO_3]_2 \cdot 2\ H_2O$.
Gay-Lussite, $Na_2\ Ca\ [CO_3]_2 \cdot 5\ H_2O$.
Eudidymite, $H\ Na\ Be\ Si_3\ O_8$.
ALBITE, $Na\ Al\ Si_3\ O_8$, and Albite-Anorthite series of triclinic feldspars.
Ægirite, $Na\ Fe\ [Si\ O_3]_2$.
Jadeite, $Na\ Al\ [Si\ O_3]_2$.
Pectolite, $H\ Na\ Ca_2\ [Si\ O_3]_2$.
Glaucophane, $Na\ Al\ [Si\ O_3]_2 \cdot (Fe,Mg)\ Si\ O_3$.
Eudyalite, $Na_{13}(Ca,Fe)_6Cl(Si,Zr)_{20}O_{52}$?
NEPHELITE, approximately $Na\ Al\ Si\ O_4$.
Cancrinite, $H_6\ Na_6\ Ca\ [Na\ CO_3]_2\ Al_8\ [Si\ O_4]_9$.
Sodalite, $Na_4\ [Al\ Cl]\ Al_2\ [Si\ O_4]_3$.
Haüynite, $(Na_2, Ca)_2\ [Al \cdot Na\ SO_4] Al_2\ [Si\ O_4]_3$.
Noselite, $Na_4\ [Al \cdot NaSO_4]\ Al_2\ [SiO_4]_3$.
Lazurite, $Na_4\ [Al \cdot NaS_3]\ Al_2\ [SiO_4]_3$.
WERNERITE or SCAPOLITE, $\left.\begin{array}{l} Ca_4\ Al_6\ Si_6\ O_{25} \\ Na_4\ Al_3\ Si_9\ O_{24}\ Cl. \end{array}\right.$
ANALCITE, $Na\ Al\ [Si\ O_3]_2 \cdot H_2O$.
NATROLITE, $Na_2Al_2Si_3O_{10} \cdot 2\ H_2O$.
Paragonite, $H_2\ Na\ Al_3\ [Si\ O_4]_3$.
Natrophilite, $Na\ Mn\ PO_4$.
Beryllonite, $Na\ Be\ PO_4$.
Durangite, $Na\ [Al\ F]\ As\ O_4$.
SODA-NITER, $Na\ NO_3$.
Darapskite, $Na\ NO_3 \cdot Na_2\ SO_4 \cdot H_2O$.
BORAX, $Na_2\ B_4O_7 \cdot 10\ H_2O$.
Ulexite, $Na\ Ca\ B_5\ O_9 \cdot 8\ H_2O$?
Thenardite, $Na_2\ SO_4$.
Glauberite, $Na_2\ Ca\ [SO_4]_2$.
Sulphohalite, $2\ Na_2\ SO_4 \cdot Na\ Cl \cdot NaF$.
Hanksite, $9\ Na_2\ SO_4 \cdot 2\ Na_2\ CO_3 \cdot K\ Cl$.
Mirabilite, $Na_2\ SO_4 \cdot 10\ H_2O$.
Natrojarosite, $Na_2\ Fe_6\ [OH]_{12}[SO_4]_4$.

In addition to the foregoing compounds sodium is found in variable quantities in a number of common minerals where it plays the rôle of an isomorphous constituent.

Uses.—There is some demand for metallic sodium in chemical industries and laboratories, and it is now generally made by electrolytic methods. Halite, or rock salt, is used in enormous quantities in the manufacture of soda-ash, caustic-soda and various soda salts, in addition to its uses in every household, and for packing and preserving meats and fish. Sodium hydroxide, caustic-soda or lye, has various uses, but is chiefly employed in the manufacture of soap. Crude sodium carbonate or soda-ash is used in the manufacture of glass and in the preparation of sodium compounds. Crystallized sodium carbonate or sal-soda, $Na_2\ CO_3 \cdot 10\ H_2O$, is used for cleansing and is mixed with powdered soaps for giving added cleansing quality. Sodium bicarbonate, or baking soda, $H\,Na\,CO_3$, is used in every household, and extensively in making baking powders and in medicine.

The ordinary glaze on cheap stoneware and tile is produced by throwing salt into kilns where the ware is burned. The salt volatilizes and reacts with various silicates of the ware, giving rise to a glaze of fused sodium silicate. This glaze is quite different from that produced by feldspar on more costly ware.

Statistics.—Common salt or halite is practically the basis of all soda industries, consequently of glass and soap making. The domestic production of salt in 1905 was 26,000,000 barrels of 280 pounds, valued at the works at about $6,000,000. The leading salt-producing states and their approximate production in million barrels are as follows: Michigan 9½, New York 8¼, Ohio 2½, Kansas 2, and Louisiana 1. At the present time the United States is the leading salt-producing country of the world, and furnishes about one-fourth of the total production. Salt is worth about $1.50 to $2 per barrel in New York.

Sodium bicarbonate produced from natural deposits in the arid regions of California and Nevada amounted in 1904 to 12,000 tons, valued at $18,000, and considerable soda is made from cryolite brought from Greenland, but the total amounts from these sources are small compared with the production from common salt.

STRONTIUM.

Occurrence.

STRONTIANITE, $Sr\,CO_3$.
Brewsterite,
$H_4\,(Sr, Ca, Ba)\,Al_2\,[Si\,O_3]_6 \cdot 3\,H_2O$.
Hamlinite, $[Sr \cdot OH]\,[Al \cdot 2OH]_3P_2O_7$.
CELESTITE, $Sr\,SO_4$.

Uses.—Strontium oxide and hydroxide are used in refining beet sugar, and other salts, especially the nitrate, $Sr\,[NO_3]_2$, are employed for making red fire in pyrotechnics.

Statistics.—There is practically no production of strontium minerals in the United States, though they would command good prices. The supply of strontium salts comes almost wholly from Germany, and as an indication of their value strontium nitrate is quoted in New York at about $140 per ton.

SULPHUR.

Occurrence.—Sulphur is found native, which is one of its most important occurrences from an economic standpoint. In combination with metals sulphur forms sulphides and sulpho-salts (sulphantimonites, etc.), many of which are of great importance as ores (see Dana's Text-Book of Mineralogy, pages 281 to 316). Sulphur in combination with the metals and oxygen forms sulphates (see Dana, pages 523 to 538).

Uses.—Sulphur (brimstone) and pyrite, $Fe\,S_2$, are used in the manufacture of sulphuric acid (oil of vitriol) which is employed in numerous chemical and metallurgical industries, in the manufacture of fertilizers and in the refining of petroleum. Sulphur dioxide, formed by burning sulphur, is used in enormous quantity in the preparation of wood pulp for paper stock, also to some extent as an antiseptic and disinfectant, and for bleaching silk, wool and straw materials. The element sulphur is used in vulcanizing rubber, in making gunpowder, for tipping matches, and in a finely divided condition (flowers of sulphur) in medicine.

Statistics.—The domestic production of sulphur in 1905 was 181,677 tons, valued at $3,706,560, the supply coming from Louisiana, Nevada and Utah. There were also produced 250,000 tons of pyrite, valued at about $1,000,000. The importation of sulphur in 1905 amounted to nearly 85,000 tons, valued at $1,567,485, and of pyrite 511,946 tons, valued at $1,774,379. The world's production of sulphur (brimstone) is about 600,000 tons, more than 90 per cent. coming from the island of Sicily.

Most of the sulphur (brimstone) consumed in the United States is used in the manufacture of paper stock. The pyrite is used in the manufacture of sulphuric acid, consumed largely by chemical and agricultural companies and by the Standard Oil Company.

TANTALUM.

Occurrence.—The rare element tantalum is found in connection with niobium in the niobates and tantalates (see Dana's Text-Book of Mineralogy, pages 489 to 493). There are no uses for tantalum.

TELLURIUM.

Occurrence.

Native Tellurium, Te.
Selen-tellurium, (Te, Se).
Tetradymite, $Bi_2 Te_2 S$.
Hessite, $Ag_2 Te$.
Petzite, $(Ag, Au)_2 Te$.
Altaite, Pb Te.
Coloradoite, Hg Te.
Melonite, $Ni_2 Te_3$.
Rickardite, $Cu_4 Te_3$.
Sylvanite, $Au Ag Te_4$.
Krennerite, $Au Te_2$ } with some Ag
Calaverite, $Au Te_2$ } iso. w. Au.
Nagyagite, $Au_2 Sb_2 Pb_{10} Te_6 S_{15}$?
Tellurite, $Te O_2$.
Montanite, $[Bi . 2 OH]_2 TeO_4$.
Durdenite, $Fe_3 [Te O_3]_3 . 4 H_2O$.
Emmonsite, hydrated ferric tellurite.

Uses.—There is no demand for tellurium, except a very limited one for making rare laboratory preparations.

THALLIUM.

Occurrence.

Crookesite, $(Cu, Tl, Ag)_2 Se$.
Lorandite, $Tl As S_2$ or $Tl_2 S . As_2 S_3$.

Uses.—Thallium is occasionally used in the laboratory for making monochromatic green light, and also rare chemical preparations.

THORIUM.

The occurrences and uses of this rare earth metal are noted on page 32, under Cerium.

TIN.

Occurrence.

Stannite, $Cu_2 Fe Sn S_4$.
Candfieldite, $Ag_4 (Sn, Ge) S_6$.
Cylindrite, $Pb_6 Sb_2 Sn_6 S_{21}$.
Franckeite, $Pb_5 Sb_2 Sn_2 S_{12}$.
CASSITERITE, $Sn O_2$ or $Sn Sn O_4$.
Nordenskiöldine, $Ca Sn [B O_3]_2$.

In addition to the foregoing minerals small quantities of tin are often met with in niobates, tantalates and tungstates.

Uses.—The chief use of tin is for coating or tinning metals, especially iron, thus making what is commonly called *sheet tin* used for roofing and tin ware. The silvering of mirrors is accomplished by covering glass with an amalgam of tin and mercury. Tin is used in making alloys: solder, which contains tin and lead; and bell metal and bronze, which contain copper and tin. Artificial tin oxide is used as a polishing powder; stannic chloride as a mordant in dyeing.

Statistics.—There is practically no production of tin ore in the United States, though some has been mined in the Black Hills, South Dakota, and deposits are known in Alaska. The importation of metallic tin amounted, in 1905, to 44,188 tons, valued at $26,316,023. The world's production of tin amounted to about 100,000 tons, derived from the following sources: Straits of Malacca (Malay Peninsula) 65,000; Banka and Billiton, near Sumatra, 14,000; Bolivia 13,000, England 5,000, Australia 5,000. The price of tin in New York is about 30 c. per pound.

Titanium.

Occurrence.

ILMENITE, titanic iron, $Fe\,Ti\,O_3$, containing also $Mg\,Ti\,O_3$ and $Fe_2\,O_3$.
Pseudobrookite, $2\,Fe_2\,O_3\,.\,3\,Ti\,O_2$.
RUTILE, $Ti\,O_2$ or $Ti\,Ti\,O_4$.
Octahedrite, $Ti\,O_2$.
Brookite, $Ti\,O_2$.
Schorlomite, $Ca_3(Fe,Ti)_2[(Si, Ti)O_4]_3$.
TITANITE, $Ca\,Ti\,Si\,O_5$.
Astrophyllite, $(Na, K)_4\,(Fe, Mn)_4\,Ti\,[Si\,O_4]_4$.
Perovskite, $Ca\,Ti\,O_3$.

Titanium is found in numerous niobates and tantalates, especially æschenite, polymignite, euxenite and polycrase, and in small quantities in many silicates.

Uses.—Titanium has long been used for imparting a yellow color to porcelain, employed mostly by dentists in coloring false teeth, of which it is estimated that over 8,000,000 are made annually in the United States. Steel containing a little titanium has been found to have a high limit of elasticity and great ductility, hence ferro-titanium alloys are now made by means of the electric furnace for use in the steel industry.

Many iron ores are titaniferous and as yet have proved practically valueless, as they are too refractory to be smelted successfully in blast-furnaces.

Statistics.—The domestic production of titanium is small, being mostly obtained from Virginia in the form of the mineral rutile. The value of the output for 1904 was $7,000.

Tungsten.

Occurrence.

Tungstite, $W\,O_3$.
WOLFRAMITE, $(Fe, Mn)\,W\,O_4$.
Hubnerite, $Mn\,W\,O_4$.
Raspite, $Pb\,W\,O_4$.
Scheelite, $Ca\,W\,O_4$.
Cuprotungstite, $(Cu, Ca)\,W\,O_4$.
Stolzite, $Pb\,W\,O_4$.
Reinite, $Fe\,W\,O_4$.

Small quantities of tungsten are met with in several of the rare niobates and tantalates.

Uses.—The element tungsten and an alloy with iron, ferrotungsten, are used in the production of self-hardening tungsten steel, also for giving toughness to a copper aluminium alloy used for propeller blades. Sodium tungstate is used for making certain colors "fast" in dyeing cotton goods, and is applied to fabrics to make them non-inflammable. A little tungstic oxide is used for coloring glass. Calcium tungstate is used in Röntgen-ray apparatus on account of its phosphorescence.

Statistics.—The domestic production of concentrated tungsten ores in 1905 was 803 tons, valued at $268,676. The ore was mostly wolframite from Colorado.

URANIUM.

Occurrence.

Uranothalite, $Ca_2U[CO_3]_4 \cdot 10H_2O$.
Torbernite, $Cu[UO_2]_2[PO_4]_2 \cdot 8H_2O$.
Zeunerite, $Cu[UO_2]_2[AsO_4]_2 \cdot 8H_2O$.
Autunite, $Ca[UO_2]_2[PO_4]_2 \cdot 8H_2O$.
Uranophane, $CaU_2Si_2O_{11} \cdot 6H_2O$.
Uraninite, pitchblende, UO_3, UO_2, ThO_2, PbO, He, Ra, etc.?
Gummite, $UO_3 + H_2O$ and other oxides.
Carnotite, $K_2[UO_2]_2[VO_4]_2 \cdot 3H_2O$?

Uses.—Uranium compounds are used for coloring glass and as pigments for painting on porcelain. Uranium minerals have special interest at the present time as they contain radium, helium, thorium and other rare elements which are receiving unusual attention from chemists.

Statistics.—The uranium ore, carnotite, has been mined in Colorado to some extent, but there was practically no production of the metal in 1905.

VANADIUM.

Occurrence.

Roscoelite, $H_8K_2(Mg, Fe)(Al, V)_4[SiO_3]_{12}$?
Ardennite, $H_5Mn_4Al_4VSi_4O_{23}$?
Pucherite, $BiVO_4$.
Vanadinite, $Pb_4[PbCl][VO_4]_3$.
Descloizite, $(Pb, Zn)_2[OH]VO_4$.
Volborthite, $(Cu, Ca, Ba)_3[OH]_3VO_4 \cdot 6H_2O$?
Carnotite, $K_2[UO_2]_2[VO_4]_2 \cdot 3H_2O$?

Uses.—It is claimed that the addition of a little vanadium to steel increases enormously its tensile strength and elastic limit. Metavanadic acid, HVO_3, is a fine yellow pigment known as vanadium bronze. Vanadium oxide is used as mordant in dyeing.

Statistics.—Vanadium has been obtained from the carnotite deposits of Colorado. See Uranium.

Yttrium.

Occurrence.—For the occurrence of this rare metal, see Cerium and the Rare Earth Metals, page 32.

Zinc.

Occurrence.

SPHALERITE, $Zn S$, also $(Zn, Fe) S$.
Wurtzite, $Zn S$.
Zincite, $Zn O$.
Gahnite, $Zn Al_2 O_4$.
Franklinite, $(Fe, Zn, Mn) (Fe, Mn)_2 O_4$.
SMITHSONITE, $Zn CO_3$.
Aurichalcite, $(Zn, Cu)_5 [OH]_6 [CO_3]_2$.
Hydrozincite, $Zn_3 [OH]_4 CO_3$.
Hardystonite $Ca_2 Zn Si_2 O_7$.
Willemite, $Zn_2 Si O_4$, Mn iso. w. Zn.
CALAMINE, $H_2 [Zn_2 O] Si O_4$.
Clinohedrite, $H_2 [Ca Zn O] Si O_4$.
Adamite, $Zn_2 [OH] As O_4$.
Hopeite, $Zn_3 [PO_4]_2 . H_2O$.
Goslarite, $Zn SO_4 . 7 H_2O$.

Uses.—The chief uses for metallic zinc, commonly known as spelter, are for galvanizing iron; making brass, an alloy of copper and zinc; and making parts of telegraph and storage batteries. There are also numerous uses for sheet zinc. Zinc oxide or zinc white, either alone or mixed with white lead, is extensively used for making paint, and is also compounded with rubber. Zinc chloride is used as preservative, many railroad ties being treated with it. Zinc sulphate has numerous uses, in dyeing and in medicine.

Statistics.—The domestic production of zinc or spelter in 1905 was 203,849 tons, valued at about $24,000,000, the ore being mostly sphalerite from Kansas and Missouri. At the present time there is considerable activity in the treatment of the zinc-lead-silver ores of Colorado and other western states, in which formerly the zinc was a waste product. The production of zinc oxide in 1905 was 68,603 tons, valued at $5,520,240, made mostly in New Jersey and Pennsylvania. About one-fourth of the world's production of zinc is obtained in the United States. The price of zinc in 1905 was about 6 c. per pound.

Zirconium.

Occurrence.

Baddeleyite, $Zr O_2$.
Wöhlerite, $(Ca, Na_2) (Si, Zr) O_3$, with $(Ca, Na_2) Nb_2 O_6$.
Eudyalite, $Na_{13} (Ca, Fe)_6 Cl (Si, Zr)_{20} O_{52}$?
Catapleiite, $H_4 (Na_2, Ca) Zr Si_3 O_{11}$.
ZIRCON, $Zr Si O_4$.
Polymignite, Nb, Ti, Zr, Ce, Fe, Ca, etc.?

Uses.—Oxide of zirconium glows when heated, but its use for incandescent lights is very limited.

PART III.

USEFUL MINERALS.

UNDER this heading a number of minerals are given which have not been included in foregoing pages because their uses are not suggested by the constituents they contain. For convenience an alphabetical arrangement is adopted.

ABRASIVES.

Minerals possessing superior hardness are used for cutting, grinding and polishing other substances, and are known commercially as abrasives. They enter the market in grains of various sizes, down to dust; are made up into special shapes demanded by the trade, generally wheels; and are cemented to belting, cloth and paper. The minerals used are as follows:

Diamond, hardness 10.—Crystals and grains of diamond, when firmly embedded in steel tubes and wheels, are used for drilling and sawing, and diamond dust is used on wheels and laps for grinding and polishing. The value of diamond dust imported into the United States in 1905 was nearly $200,000. Carbonado or black diamond, found only in Brazil, is the most effective of all abrasives and is valued at from $50 to $55 per carat, equivalent to $7,000 per ounce avoirdupois. The glazier's diamond is always a crystal with natural faces.

Corundum and Emery.—Corundum is crystallized Al_2O_3, having a hardness of 9. Emery is a commercial term for corundum more or less impure from admixture with oxides of iron. The domestic production of corundum and emery in 1905 was a little over 2,000 tons, valued at $61,000. Corundum is produced mostly in western North Carolina and best grades are worth from 7 c. to 10 c. per pound. Emery, the chief product, is mostly produced at Chester, Mass., and Peekskill, N. Y., and brings from 2 c. to 5 c. per pound according to quality. The importation of emery, mostly from Turkey, is about 25,000 tons annually, valued at about $300,000.

Artificial corundum is now being manufactured in electric furnaces from bauxite, the production for 1905 having a value of $250,000. Another artificial abrasive is carborundum, C Si, having a hardness about like that of corundum. Carborundum is made in electric furnaces from coke and sand, and the production in 1905 was 5,600,000 pounds, valued at about 8 c. per pound.

Garnet, hardness 7 to 7.5.—The domestic production in 1905 amounted to 5,000 tons, valued at nearly $150,000. The material came mostly from near Ticonderoga, N. Y., some from Connecticut, Pennsylvania and North Carolina.

Quartz, hardness 7.—The various uses of this mineral are noted on pages 47 and 48.

Pumice.—This is a name given to volcanic ash, used in lump and powder for polishing. The commercial product comes mostly from the island of Lipari, north of Sicily, and the value of the product imported into the United States in 1905 was $77,489.

ASBESTOS.

Asbestos is a name given to several fibrous minerals, generally tremolite, a variety of hornblende; anthophyllite, a closely related mineral; and chrysotile, a variety of serpentine. The material is used largely as a non-conductor of heat for covering boilers and steam pipes, and packing safes. Fine-fibrous varieties, generally chrysotile, are woven into cloth, twine and rope, and made up into paper, felt, board, washers and various shapes. The domestic production of asbestos in 1905, mostly tremolite from Georgia, was about 3,000 tons, valued at $43,000. The bulk of best quality chrysotile-asbestos comes from Canada, though some is produced in the United States. There is a large domestic production of artificial material known as "mineral wool," made from furnace slag.

CEMENT.

Cements are products obtained by burning limestones containing proper amounts of argillaceous (clay) material, or finely ground mixtures of limestone and clay. The industry is one of great magnitude, the domestic production in 1905 being 40,000,000 barrels of from 300 to 400 pounds, valued at over $36,000,000. The importations amounted to over 800,000 barrels.

CLAY.

Clays are essentially hydrated silicates of aluminium, resulting from the decomposition of other minerals, especially feldspars. The decomposition of feldspar alone, *in situ*, gives rise to a pure white mineral, kaolinite, $H_2 Al_2 Si_2 O_9$. Ordinary clays are variously colored, and consist of kaolinite compounded with other materials resulting from the decomposition of rocks, and they are commonly found in secondary deposits where they have been laid down as sediments from water. Most clays have the property of becoming plastic when mixed in proper proportions with water, so that they may be moulded, pressed and wrought into shapes, hence their use in the manufacture of brick, terra-cotta, tile, earthenware and pottery. The importance of the domestic clay industries is evident from the values of the several products produced in 1905, as follows: Brick $61,000,000; front brick $7,000,000; fire brick $13,000,000; paving and vitrified brick $6,700,000; sewer and drain tile $16,000,000; terra-cotta and ornamental brick $6,000,000; pottery $28,000,000—a total of nearly $150,000,000. The value of the domestic production of kaolinite for the pottery industry amounted to over $300,000, while the value of the imports of kaolinite was over $1,000,000. Feldspar, quartz and fine qualities of clay also entered into the composition of pottery.

FELDSPAR.

Feldspar is mined almost exclusively for use in the porcelain and chinaware industry. It is compounded with kaolin and other materials for making the body of the ware, and when applied to the outside and fused it produces the glaze. Potash feldspar, orthoclase or microcline, $K Al Si_3 O_8$, is the kind generally used, though albite, $Na Al Si_3 O_8$, is probably equally good. To be of satisfactory quality feldspar must be practically free from quartz, mica and oxides of iron, and when ground is worth from $8 to $9 per ton. The domestic production of feldspar in 1905 was about 35,000 tons, valued at $220,000, the supply coming from Pennsylvania, Maryland, Connecticut and New York.

Feldspar is of importance agriculturally, for undoubtedly much of the available potash in soils has resulted from the slow decomposition of orthoclase.

FLINT.

Flint is a recognized variety of silica, related to chalcedony, usually of dull gray, brown or black color. In commerce the ordinary varieties of quartz are commonly called flint. See Silica, pages 47 and 48.

FULLER'S EARTH.

Fuller's earth is a fine clay-like material, which lacks the plasticity of ordinary clay, and is remarkable for its absorbent qualities. It was formerly used by fullers as an absorbent for grease in cleansing cloth, but its chief use at the present time is as a substitute for boneblack in bleaching and clarifying cottonseed and mineral oils. The domestic production in 1905, chiefly from Florida, was 25,000 tons, valued at $214,000. The importation was valued at $106,000.

GARNET.

Garnet is used to a considerable extent as an abrasive (page 58), and commonly as a gem mineral (see page 62).

GEM MINERALS OR PRECIOUS STONES.

NOTE.—For ornamental stones, other than gems, see page 65.

Gem minerals must satisfy the following conditions: (1) They must be hard, so as to withstand without scratching or defacement the wear to which they are subjected. (2) They must have a pleasing color, or be white or colorless. (3) If transparent, they should have a high index of refraction, on which largely depend their flash, brilliancy and beauty. Gems are generally sold by the carat, less often by the pennyweight. The international carat is equal to 205 milligrams, or about 1-138th of an ounce avoirdupois, and to give an idea of this weight a one-carat diamond, cut round in the customary form of a brilliant, is a stone of fair size, measuring 6.25 mm. in diameter and 4 mm. in depth. The values of gems are subject to great variation; thus a gem of exceptional perfection in color and lustre will command a price far above that of a stone of the same kind but of only fair quality; moreover, rarity and size are important factors. Bearing variation in mind, however, an attempt will be made in the following pages to convey some idea of the relative values of different gems by giving usually for each the approximate prices of three grades of stones, of poor, medium and fine quality and of one-carat weight.

The minerals generally used as gems are as follows:

Agate.—A translucent, banded, variously colored variety of quartz or chalcedony. Inexpensive.

Amethyst.—A transparent purple or bluish-violet variety of quartz. Comparatively inexpensive, except when large and of unusually fine quality or color.

Aquamarine.—A name applied to transparent pale-green or bluish-green varieties of beryl. Green gems of one-carat size are valued at from $1 to $5; those of rare blue color as high as $15.

Beryl, $Be_3 Al_2 [Si O_3]_6$ + a little H_2O.—Aquamarine and emerald are names by which light and dark green gem varieties of this mineral are known. Some very beautiful gems are cut from beryl of yellow color, sometimes called golden beryl. A one-carat golden beryl would be valued at $1—$5—$10.

Chrysoberyl, $Be Al_2 O_4$.—Handsome gems are cut from transparent yellowish or yellowish-green crystals of this mineral, and a one-carat stone is valued at from $3 to $5. A far rarer and more highly prized variety, which is green by day and garnet-red by lamplight, is known as Alexandrite, and commands a value of from $50 to $60 for a one-carat stone. Some translucent stones when cut with rounded surfaces, *en cabochon*, exhibit a beautiful opalescent radiation or chatoyant effect, when they are called cat's eye. Other minerals, quartz, corundum, feldspar and tourmaline, likewise give chatoyant effects, but chrysoberyl is generally considered as the true or oriental cat's eye. A cat's eye of one-carat weight may be valued at $5—$10—$50 according to quality.

Chrysolite, $(Mg Fe)_2 Si O_4$.—Transparent green or yellowish-green varieties of this mineral yield handsome gems, which are generally known and sold as peridot. A one-carat stone is valued at $1—$3—$5.

Chrysoprase.—This is a name given to a translucent apple-green variety of quartz or chalcedony. One-carat stones have the following values according to quality, $0.50—$2—$5.

Diamond, C.—A mineral remarkable for its brilliancy and hardness; index of refraction, $n = 2.42$, hardness $= 10$. Colorless or transparent white stones are most in demand, but variously colored ones are used, straw-yellow being most common. An ordinary white brilliant of one-carat weight and of good quality is valued at from $150 to $175, while extra blue-white and fancy colored stones of like weight may be valued as high as $400 to $500. One-carat diamonds of the ordinary straw-yellow color are worth about $50.

Emerald.—This is a name given to deep-green varieties of beryl, the color being due supposedly to traces of chromium. Because of the rarity and great beauty of this stone, a fine gem of one-carat weight may be valued as high as $1,000, the prices of the stones ranging from $20—$100—$200 to $1,000.

Garnet.—Various kinds of garnet (page 5) are used as gems, and the stones exhibit a great variety of colors. Pyrope and almandite are the kinds most often used and the colors are generally deep tones of red. Stones are valued at $1—$2—$5 per carat. A variety intermediate between pyrope and almandite, known as rhodolite, has a delicate rose to purplish-red color, and a one-carat stone may be valued as high as $15. Another very beautiful and still more costly garnet is a variety of andradite, known as demantoid, having a grass-green to emerald-green color, one-carat stones having the values according to quality of $3—$10—$40.

Jasper.—This is a name applied to quartz which is colored red by oxide of iron. The stone is an inexpensive one, used to a limited extent in jewelry. Its value is about $1 per dwt.

Kunzite.—A rare and beautiful pink to violet-colored variety of spodumene, which has been found at Pala, California. A one-carat stone would have the following values: $3—$5—$8.

Lazurite or Lapis-Lazuli, $Na_4 [Al . Na S_3] Al_2 [SiO_4]_3$.—A translucent stone of deep ultramarine-blue color, only occasionally used in jewelry, one-carat stones being valued at $1—$5—$10.

Moonstone.—Some feldspars, when cut with rounded surfaces, show chatoyancy and delicate variations of color and are known as *moonstones*. The kind used in jewelry is generally potash feldspar, orthoclase, although other feldspars show a play of colors, notably labradorite and a variety of albite-oligoclase called *peristerite*. Moonstones of one-carat size are valued at $0.50—$1—$3.

Opal.—This is an amorphous form of silica, differing from quartz in having a much lower specific gravity and containing considerable hydroxyl, equivalent generally to from 3 per cent. to 9 per cent. of water. Opals are translucent to transparent, and many varieties are remarkable for their magnificent play of colors, which on some stones are soft and subdued, on others fiery and brilliant. Opals are generally cut *en cabochon*, and stones of one-carat size have values of $1—$3—$20. Stones of large size and exceptionally fine quality are very highly prized.

Peridot.—See Chrysolite.

Pyroxene.—A transparent variety of pyroxene, known as *diopside*, is occasionally cut as a gem. The color is generally some light shade of green, and is very pleasing, but the stone is almost too soft to be serviceable. A stone of one-carat size is valued at from $2 to $3.

Quartz.—Various transparent varieties of this mineral are cut rather as ornaments than as gems. The kinds generally used are colorless rock crystal, amethyst, smoky quartz or cairngorm stone, and yellow quartz, which is sometimes called false topaz.

Ruby.—This is a name given to red varieties of corundum. A ruby of fine quality and color is one of the rarest and most beautiful of gems, and a stone of one-carat weight may be valued as high as $1,500.

Sapphire.—This is a name by which the transparent, blue variety of corundum is generally known, although the name is also applied to gem corundums of various colors. A one-carat sapphire of fine blue color has a value according to quality of $6—$10—$125, while fancy colored stones other than blue range from $6 to $30.

Spinel, $Mg\ Al_2\ O_4$.—This mineral exhibits a variety of colors, deep red, rose-red, orange and violet. The red varieties are known as *spinel-ruby*, but are inferior to the true corundum ruby. One-carat gems range in value as follows: $3—$10—$100.

Spodumene, $Li\ Al\ [Si\ O_3]_2$.—Gems of yellowish or pale yellowish-green color are most common and are inexpensive. An emerald-green variety known as *hiddenite*, found in North Carolina, is very choice, and a one-carat stone would be worth about $150. See also Kunzite, p. 62.

Topaz, $[Al\ (F, OH)]_2\ Si\ O_4$.—This mineral may be colorless, straw-yellow, wine-yellow, bluish or greenish. The kind generally used for gems is yellow. The color of some yellow crystals is changed to a delicate rose by heating. Gems of one-carat size are valued at $2—$5—$10.

Tourmaline, a complex boro-silicate of aluminium and other bases.—This mineral exhibits a greater variety of colors than almost any other. As gems, green is the prevailing color, though delicate rose, wine-red (rubellite), blue and brown varieties are cut. Gems of one-carat size are valued about as follows: Green or rose, \$2—\$5—\$10; rubellite, \$2—\$5—\$15.

Turquois, a basic phosphate of aluminium, colored by a little copper.—This is a non-transparent stone, of robin's-egg blue or bluish-green color, generally cut *en cabochon.* A one-carat stone is valued at \$1—\$3—\$10.

Zircon, $ZrSiO_4$.—Transparent zircon exhibits a great variety of colors, from almost colorless to yellow, orange, red and brownish red. One-carat stones are valued at \$2—\$5—\$10.

Statistics.—The production of precious stones in the United States is comparatively small, their total value in 1905 amounting to \$326,350, while the importation into the United States is given as \$35,000,000. For 1905 the valuations of the several domestic products which are worthy of special note are as follows: Turquois, mostly from New Mexico, Nevada and Arizona, \$65,000; sapphires, mostly from Montana, \$125,000; tourmaline, from Maine and California, \$50,000; beryl, aquamarine and emerald, from North Carolina, \$6,000.

GRANITE.

Granite is a crystalline rock consisting chiefly of feldspar and quartz, with biotite, hornblende and other minerals as accessories. It is extensively used for building and monumental work, for paving blocks, and as crushed stone for railroad ballast and road making. The value of the domestic production in 1905 for all purposes was estimated at \$20,000,000.

GRAPHITE.

For uses and statistics, see page 31.

GYPSUM.

For uses and statistics, see Plaster of Paris and Land Plaster, page 30.

LIMESTONE AND MARBLE.

For uses and statistics of limestone, see page 30; of marble, see pages 65 and 66.

MICA.

The micas are silicates possessing a remarkable basal cleavage which makes it possible to split them into exceedingly thin sheets. The plates of true micas are tough and elastic. There are several kinds of mica, but only the light-colored ones, muscovite and phlogopite, have commercial value.

Uses.—When obtained in sheets of sufficient size, mica is used in stove and furnace doors, and in making chimneys for lamps and incandescent gaslights. Small sheets are used for purposes of insulation in electrical apparatus. Broken and scrap mica is used as a non-conducting covering for boilers and steam pipes, and, when finely ground, is used for giving lustre to wall paper, and as a lubricant. One kind of mica, lepidolite, is used for obtaining lithia (see page 39).

Statistics.—The domestic production of sheet mica (muscovite) in 1905 was 851,000 pounds, valued at nearly $185,900. The supply came mostly from North Carolina, some from New Hampshire and South Dakota. The production of scrap mica was 856 tons, valued at $15,000. The importation of sheet mica in 1905 amounted to 1,600,000 pounds, valued at $403,000. The imported mica comes mostly from India, some from Canada, that from the latter country being chiefly phlogopite.

ORNAMENTAL OR DECORATIVE STONES.

There is an ever-growing demand for rocks or minerals of almost any kind which, when polished or worked into various shapes, may be used for ornamental purposes. The chief uses to which they are put are for making wainscotings for halls and offices, mantels, table tops, columns, vases and ornaments of endless variety. The materials generally used are as follows:

Marble, generally calcite, $CaCO_3$, white, mottled and variously colored.

Mexican Onyx.—This beautiful stone is a kind of translucent marble (calcite), formed by deposition from water. It generally is veined, clouded or mottled and shows delicate shades of color, varying from yellow, pink and green to pure white.

Verd-antique Marble, generally a mixture of white marble and green serpentine, often very decorative.

Granite, of great variety of color and size of grain.

Porphyry.—This is a name applied to rocks which contain regularly formed and comparatively large crystals embedded in a ground-mass of finer-grained rock material. Porphyries are of various kinds and colors, and, when polished, the contrast between the crystals and ground-mass may give pleasing and decorative effects.

Breccia.—This is a name given to material made up of irregular fragments of rocks and minerals, firmly cemented into a solid mass. When polished, the fragments of various kinds may give contrasts in color and structure which are effective and decorative.

Jade.—This is a compact, tough stone, generally of green or greenish-white color, especially prized by the Orientals. The material may be either nephrite, a variety of hornblende, or a rarer and more highly prized mineral, jadeite. Some oriental jade ornaments are of wonderful workmanship and almost inestimable value.

Serpentine, a compact mineral, generally of green color.

Quartz.—Transparent, colorless quartz (rock crystal), and various colored varieties of quartz, agate, jasper and chalcedony are often used.

Malachite, a basic carbonate of copper of bright-green color.

Lapis-Lazuli, a silicate of ultramarine-blue color.

Rhodonite, a silicate of manganese of rose-pink color.

Alabaster, a compact, even-grained variety of gypsum, often worked into ornaments resembling marble.

Satin Spar, a variety of fibrous gypsum, showing chatoyancy when polished.

Statistics.—The total value of the mineral products used for decorative purposes must be very great, but no statistics are available except for marble. The domestic production of marble in 1905 was valued at $7,000,000, and it is estimated that about one-fourth of the product was used for interior and decorative work.

SANDSTONE.

For uses and statistics, see pages 47 and 48.

SLATE.

Slate is an argillaceous rock which may be split readily into slabs of nearly uniform thickness. Slate is used mostly for roofing, also for making billiard tables, mantels, floor tiles, stair treads and flagging. Ground slate is used as a pigment. The domestic production of roofing slate in 1905 was valued at over $4,500,000, of manufactured products at about $900,000.

TALC AND SOAPSTONE.

Talc, $H_2 Mg_3 [Si O_3]_4$, is a soft, white or greenish-white mineral possessing a greasy feel. There is also an aluminium silicate, pyrophyllite, $H_2 Al_2 [Si O_3]_4$, which is practically identical with talc in its physical properties, and is equally useful, although being rare it is not so well known as a commercial article.

Uses.—The uses of talc are quite varied. As powder or flour, talc is used in the manufacture of paper as a filler, and, when fibrous, it is claimed that it gives strength; it is used also as a base for fire-proof paints, as non-conducting covering for boilers and steam pipes, for making toilet powders, for dressing leather, and as a lubricant. Soapstone is manufactured into shapes suitable for hearth stones, furnace linings, table tops, slate pencils, gas-burner tips and a variety of articles.

Statistics.—In 1905 the production of ground, fibrous talc, suitable for paper making was 19,000 tons, valued at $142,000, the supply coming almost wholly from northern New York. Better grades of talc and soapstone, suitable for manufactured articles and flour talc, were obtained mostly in Virginia and North Carolina, the product being valued at about $400,000.

PART IV.

LISTS OF MINERALS ACCORDING TO GEOLOGICAL OCCURRENCE AND ASSOCIATION.

NOTE.—Although minerals occur associated with one another in almost endless variety, there are certain associations which are very often observed, and it is to call attention to these that the few remaining tables have been prepared.

ROCKS AND ROCK-MAKING MINERALS.

By far the greater amount of our minerals occur as component parts of rocks. A rock may be formed essentially of but one mineral species, as in the case of limestone (calcite) or quartzite (quartz), but more frequently is composed of a mixture of several minerals. A brief discussion of the various kinds of rocks and their origin will be given, followed by a list of the more important rock-making minerals, with a few words in each case descriptive of their occurrence and association.

Rocks are divided into three main divisions:

I. Igneous.
II. Sedimentary.
III. Metamorphic.

I. ***Igneous Rocks*** are those which have resulted from the cooling and consequent solidification of a hot and liquid mass of rock material. During the cooling process various minerals crystallize out from this liquid mass (called a magma) in a more or less definite order, the more insoluble compounds being the first to form. The resulting mineral composition of the rock will depend directly upon the chemical composition of the original magma, and the structure of the rock upon the conditions under which it cooled. A magma high in its percentage of SiO_2 and low in percentages of MgO and FeO will yield a rock composed of light-colored silicates, and will be spoken of as an acid rock: On the other hand a magma low in percentage of SiO_2 and rich in MgO and FeO will result in a rock composed of dark-colored minerals and will be called basic. A rock which has been formed by the cooling of a magma deep down in the crust of the earth has formed very slowly, while under great pressure, and will be coarse-grained in structure, the different minerals being easily distinguished from each other and recognized by the eye. Such rocks are called *Plutonic*. But if a liquid rock mass is intruded into the upper portion of the earth's crust or extruded upon its surface it cools quickly and under little pressure and consequently the crystallizing minerals have not time to grow into large particles and the resulting rock is fine-grained in structure. Such rocks are called *Volcanic*. The mineral constituents of such a rock can only be definitely determined by examining a thin section of the rock under the microscope.

PLUTONIC, COARSE-GRAINED IGNEOUS ROCK TYPES.

1. **Granite.** — A coarse-grained, light-colored rock consisting chiefly of orthoclase, quartz, biotite, and muscovite. As accessory minerals and usually in quite small amounts are found magnetite, apatite, and zircon.

2. **Syenite.** — A coarse-grained light-colored rock resembling a granite in appearance but containing no quartz. Its chief minerals are orthoclase, a plagioclase feldspar, with hornblende and sometimes biotite. Magnetite, apatite, and zircon are the chief accessory minerals.

3. **Diorite.** — A coarse-grained rock, usually dark green in color. The chief minerals in it are a plagioclase feldspar with either hornblende or biotite.

4. **Gabbro.**—A coarse-grained rock in which the dark-colored silicates predominate. It is similar to a diorite in composition, having augite (an iron pyroxene) present instead of hornblende.

5. **Peridotite.**—A coarse-grained rock which is very basic in its chemical composition and contains usually only pyroxene and olivine (chrysolite) as its chief constituent minerals.

VOLCANIC, FINE-GRAINED IGNEOUS ROCK TYPES.

Volcanic rocks are found in dikes or sheets near the surface of the earth, or in flows upon its surface. They are usually too fine-grained to allow of the identification of their component minerals by the eye alone. A number of different types of volcanic rocks are recognized, based chiefly upon their microscopic study, but for the present purpose only two general types need to be described.

1. **Felsite.**—A fine-grained, light-colored rock. The feldspars, orthoclase or plagioclase, are the predominant minerals with varying amounts of quartz, amphibole, pyroxene, and biotite. Rhyolite and andesite are two members of the Felsite group, depending on the presence or absence of quartz and the kind of feldspar.

2. **Basalt.** — A fine-grained dark-colored rock. The ferromagnesian minerals, such as pyroxene and olivine, are the most common constituents, with also smaller amounts of plagioclase feldspars. Magnetite is often a prominent mineral.

Porphyries.—Igneous rocks often show considerable variation in the size of their mineral particles. When this is pronounced and certain minerals appear in distinct crystals embedded in a mass of fine-grained material, the rock is said to have a porphyritic texture, and the rock is termed a porphyry. All of the above-mentioned rocks may assume such a structure and we have such rock types as Granite-porphyry, Diorite-porphyry, Felsite-porphyry, etc.

II. ***Sedimentary Rocks*** are those which have been formed by deposition in water and the subsequent solidification of their particles into a more or less firm rock mass. Sedimentary rocks may be divided into two types according to their origin. A. *Mechanical*, in which the mineral grains that go to make up the body of the rock have been derived from some other rock mass and have been brought into the sea in the form of sand or mud, deposited at its bottom in successive layers and then later consolidated into rock. B. *Chemical*, in which the minerals of the rock have been precipitated from solution by some chemical process.

Sedimentary rocks are to be distinguished by the fact that their mineral grains are deposited in successive parallel layers, or in other words the rocks show stratification. Sedimentary rocks are composed of mineral grains which are usually rounded and are bound together by some cementing material, while igneous rocks are composed of interlocking crystals. Brief descriptions of the more important sedimentary rocks follow:

Sandstone is a sedimentary rock made up almost entirely of quartz grains cemented together by either (A) ferric oxide, in which case the rock is red or brown, or (B) by calcium carbonate, in which case the rock is light-colored. Sandstones may be fine- or coarse-grained depending upon the size of the quartz particles; very coarse-grained sandstones or compacted gravels are called *Conglomerates.*

Shale is a fine-grained sedimentary rock which has been formed by the consolidation of mud, clays, or silts.

Limestone is a sedimentary rock whose chief mineral is usually calcite, although it may be dolomite. Limestones may be mechanical in their origin and be composed of small fragments of shells, etc., cemented together, or it may be chemical in its origin, its constituent minerals having been formed by precipitation from waters carrying them in solution. Limestones are usually fine-grained; if coarse, the fragments of shells, etc., comprising them can be recognized. They are soft rocks and are usually of some light color, but may be blue, or at times almost black. Chalk is a soft very fine-grained limestone.

III. ***Metamorphic Rocks*** are rocks which have undergone considerable changes in mineralogical composition and in structure through the action of heat and pressure aided by the action of water and other chemical agents. Metamorphic rocks may have been originally either igneous or sedimentary, and it is often impossible to definitely tell which.

Schist is a common type of metamorphic rock, which is characterized by a foliated structure due to the parallel arrangement of its mineral constituents. A schist breaks readily with a wavy surface along the planes of foliation. The different types of schist are named from the most prominent mineral in them; as,

Mica Schist, which is composed chiefly of mica plates (usually muscovite) with smaller amounts of quartz, feldspar, garnet, etc.;

Hornblende Schist, with hornblende as the most prominent mineral, and smaller amounts of biotite, pyroxene, plagioclase feldspar, garnet, magnetite, etc.

Slates are fine-grained metamorphic rocks which possess the property of cleaving into thin layers with smooth surfaces. They are usually the metamorphic representatives of the shales.

Quartzites are metamorphosed sandstones and like them have quartz as their chief mineral. They differ from the sandstones in being harder and firmer in texture and more crystalline in appearance.

Gneisses.—These are metamorphic rocks which are characterized by a parallel arrangement of mineral particles, but which do not have as prominent cleavage planes as in the case of the schists. They are composed chiefly of quartz and feldspar with subordinate amounts of the micas, hornblende, etc.

Marbles are metamorphosed limestones. They are characterized by a crystalline structure, and if coarse the cleavage planes of the particles of calcite or dolomite are to be plainly seen.

PRINCIPAL ROCK-MAKING MINERALS.

Quartz, SiO_2.—A very common mineral found in igneous, metamorphic, and sedimentary rocks which are high in silica, such as granite, gneiss, mica schist, shale, and is practically the only mineral present in sandstone and quartzite. Determined by its hardness (7), its lack of cleavage, its conchoidal fracture and greasy luster.

The Feldspars.

Potash-feldspar, Orthoclase or Microcline, $KAlSi_3O_8$.
Soda-feldspar, Albite, $NaAlSi_3O_8$.
Lime-feldspar, Anorthite, $CaAl_2Si_2O_8$.

Isomorphous mixtures of these last two minerals are commonly known as the soda-lime, or plagioclase, feldspars. The kinds generally recognized are oligoclase, andesite, and labradorite.

The feldspars are very widely distributed and form perhaps the most common group of minerals. They are found in nearly all classes of rocks, including granites, syenites, porphyries, and felsite lavas; also in certain sandstones and conglomerates and in gneisses. Determined by the two good cleavages at right angles or nearly so, the vitreous luster, the light color, and the hardness (6).

Elæolite, or ***Nephelite***, $NaAlSiO_4$ (approximately). Found in igneous rocks (nepheline-syenite, nepheline-basalt) which are rich in soda and low in silica.

Leucite, $KAl(SiO_3)_2$.—Not a very common mineral; found only in lavas which are rich in potash and low in silica (leucite-basalt).

Sodalite, Haüynite, Noselite, Analcite.—Occasionally found in igneous rocks which are rich in soda.

The Micas.

Muscovite, common light-colored mica, $H_2KAl_3(SiO_4)_3$.
Biotite, common dark-colored mica,
$(H,K)_2(Mg,Fe)_2Al_2(SiO_4)_3$.

The micas are minerals of wide distribution in rocks. Biotite is common in rocks rich in feldspars, like granites and syenites, also in felsites and porphyries. It is found in metamorphic rocks such as gneisses and schists. Muscovite is found in granites and syenites and especially in pegmatite veins (see page 78), also very commonly in gneisses and schists. The micas are distinguished from the other rock-making minerals by their perfect cleavage, and from each other by their color.

The Pyroxenes.—**Pyroxene**, or **Augite**.—A calcium-magnesium-iron metasilicate of variable composition (see page 19), very common in dark-colored volcanic rocks (basalts, gabbros, peridotites), but rare in metamorphic rocks.

Ægirite, or **Acmite**, $NaFe(SiO_3)_2$.—A mineral related to pyroxene, of rather common occurrence in igneous rocks which are rich in soda and iron.

Enstatite, **Bronzite**, **Hypersthene**, $MgSiO_3$, with isomorphous $FeSiO_3$.—Minerals of the pyroxene group of rather rare occurrence, generally found in basic igneous rocks (peridotites).

Hornblende, or ***Amphibole.***—A calcium-magnesium-iron metasilicate of variable composition (see page 19). The amphiboles are common and widely distributed minerals, playing an important rôle in plutonic igneous rocks (such as granites, syenites, or diorites), or in metamorphic rocks (such as crystalline schists). Determined chiefly by its fine prismatic cleavage, and usually its dark-green to black color.

Chrysolite, or ***Olivine***, $(Mg,Fe)_2SiO_4$.—Generally found in volcanic rocks which are low in silica (gabbros, peridotites, and basaltic lavas). Usually granular in structure and of a yellow-green color.

Kaolin, $H_4Al_2Si_2O_9$.—Always a secondary mineral resulting chiefly from the decomposition of feldspars. It is the basis of most clays and consequently is found in great quantities in certain places.

Chlorite, or ***Clinochlore***. — The chlorites form an ill-defined group of hydrous silicates of aluminium with ferrous iron and magnesium. They are green in color and micaceous in structure, but their foliæ are inelastic, which serves to distinguish them from the true micas. They are secondary minerals resulting from the alteration of magnesium silicates. Many igneous rocks owe their green color to the formation of secondary chlorite. The mineral is also common in metamorphic rocks.

Serpentine, $H_4Mg_3Si_2O_9$. — Always a secondary mineral resulting from the alteration of magnesium silicates like pyroxene, amphibole, and especially chrysolite. It is a common mineral found in both igneous and metamorphic rocks which have been more or less altered.

Calcite, $CaCO_3$. — A very common and widely diffused mineral. Found to some extent in igneous rocks as a secondary mineral, but chiefly in the sedimentary and metamorphic series. Such rocks as chalks, limestones, and marbles are composed almost entirely of the mineral. It can be determined by its softness (3), its cleavage, and its ready effervescence in acids.

Dolomite, $CaMg(SiO_3)_2$.—A mineral occurring in the same way as calcite. It forms dolomite marbles and, associated with varying amounts of calcite, is found in the dolomitic limestones.

ACCESSORY MINERALS, COMMONLY FOUND IN ROCKS.

In addition to the principal rock-making minerals, a descriptive list of which has just been given, there are a number of minerals which are found occurring persistently in rocks, but only in small amounts, and generally in minute crystals. They are called *Accessory Rock Minerals*, and the more important of them are listed below.

Magnetite, Fe_3O_4.	These iron minerals are commonly found in disseminated crystals or segregated masses in plutonic, volcanic, and metamorphic rocks.
Ilmenite, $FeTiO_3$.	
Hematite, Fe_2O_3.	
Pyrite, FeS_2.	
Pyrrhotite, $Fe_{11}S_{12}$.	

Apatite, $Ca_4[Ca(F,Cl)][PO_4]_3$.	Found in almost all plutonic and volcanic rocks, though generally in small quantities and usually only in microscopic crystals.
Rutile, $Ti\,O_2$.	
Titanite, $Ca\,Ti\,Si\,O_5$.	
Zircon, $Zr\,Si\,O_4$.	

Garnet (almandite), $Fe_3\,Al_2[Si\,O_4]_3$.	Found in metamorphic rocks (gneisses and schists).
Epidote, $Ca_2\,[Al\,.\,OH]\,(Al, Fe)_2\,[Si\,O_4]_3$.	
Staurolite, $(Mg, Fe)\,[Al\,.\,OH]\,[Al\,O]_4[Si\,O_4]_2$.	
Cyanite, $Al_2\,Si\,O_5$.	

Iolite, Zoisite, Piedmontite, Scapolite or Wernerite, Andalusite and Sillimanite are minerals occasionally found in metamorphic rocks.

VEINS AND VEIN MINERALS.

The rocks of the earth's crust are everywhere crossed by cracks or fissures. These openings may be narrow and short, or they may be large and persist for considerable distances. Often these fissures have been filled by mineral materials which have been deposited in them from solutions that have circulated through the openings. Such a filled fissure is called a vein. Veins vary greatly in shape and size, according to the type of fissure which they occupy, and this in turn is largely determined by the character of the rock through which it passes. Veins also vary in their mineral contents, according to the chemical character of the solutions which formed them. A great many different minerals with many different associations may be found in veins, but there are certain minerals and associations that are more frequent in their occurrence, as is pointed out in the succeeding lists.

1. In gold-bearing quartz veins.

Quartz, $Si\,O_2$.
Pyrite, $Fe\,S_2$.
Chalcopyrite, $Cu\,Fe\,S_2$.
Arsenopyrite, $Fe\,As\,S$.

2. In veins carrying sulphide ores of silver, lead, and zinc. The silver minerals are noted on page 49. The sulphides of lead and zinc are generally galena, $Pb\,S$, and sphalerite, $Zn\,S$ or $(Zn, Fe)\,S$.

Quartz, $Si\,O_2$.
Pyrite, $Fe\,S_2$.
Marcasite, $Fe\,S_2$.
Arsenopyrite, $Fe\,As\,S$.
Calcite, $Ca\,CO_3$.
Dolomite, $Ca\,Mg\,[CO_3]_2$.
Siderite, $Fe\,CO_3$.
Rhodochrosite, $Mn\,CO_3$.

Chalcopyrite, Cu Fe S_2.
Tetrahedrite, $Cu_8 (Sb, As)_2 S_7$.
Barite, Ba SO_4.
Fluorite, Ca F_2.

Vein minerals may be divided into two classes, namely, *Primary Minerals*, or those which were originally deposited in the fissure by the mineral waters, and *Secondary Minerals*, or those which have resulted from an alteration of the primary minerals. Primary minerals are usually unoxidized compounds (chiefly sulphides) and have in general been deposited by ascending waters. Secondary minerals, on the other hand, are usually oxidized compounds (chiefly oxides, carbonates, sulphates, and silicates) and have been formed from the primary minerals by the action of oxidizing waters descending from the surface along the vein. In the following table the chief primary minerals are given in one column, and opposite them the various secondary minerals which may be formed from them under different conditions.

3. Primary and secondary minerals of veins.

Primary Minerals.	*Secondary Minerals.*
Pyrite, Fe S_2. Marcasite, Fe S_2.	Limonite, $Fe_4 O_3 [OH]_6$. Melanterite, Fe $SO_4 \cdot 7 H_2O$.
Chalcopyrite, Cu Fe S_2.	Native Copper. Chalcocite, Cu_2 S. Bornite, $Cu_5 Fe S_4$. Malachite, $[Cu . OH]_2 CO_3$. Azurite, Cu $[Cu . OH]_2 [CO_3]_2$. Chrysocolla, Cu Si $O_3 \cdot 2 H_3O$? Cuprite, Cu_2 O. Chalcanthite, Cu $SO_4 \cdot 5 H_2O$.
Galena, Pb S.	Cerussite, Pb CO_3. Anglesite, Pb SO_4. Pyromorphite, $Pb_4 [Pb Cl] [PO_4]_3$. Wulfenite, Pb Mo O_4.
Sphalerite, Zn S.	Smithsonite, Zn CO_3. Calamine, $H_2 [Zn_2 O] Si O_4$. Goslarite, Zn $SO_4 . 7 H_2O$.
Argentite, Ag_2 S, or other sulphide compounds of silver.	Native Silver. Cerargyrite, Ag Cl. Embolite, Ag (Cl, Br). Bromyrite, Ag Br.

Tellurides of gold.
Feldspars.

Native Gold.
Kaolin.

In connection with masses of granite rocks there are often found veins or dikes which consist chiefly of the characteristic minerals of the granite (quartz, feldspar, and mica) and usually in very large crystals. Other minerals are commonly present also, frequently in large crystals, but which are to be found in only very small amounts, if at all, in the neighboring granite, and which, because they contain hydroxyl, boron, or fluorine, show that .vapors of these substances existing under great pressure were active in the formation of the veins. Because of the presence of these minerals and also from the evidence of the structure of the veins it is considered that, usually at least, they have been deposited from solutions or vapors at high temperatures and pressures, and have not resulted from the simple cooling of a molten mass, like a true igneous rock. Such veins are known as *Pegmatite Veins*, and a list of their characteristic minerals follows.

4. In pegmatite veins.

Of common occurrence.

- Quartz.
- Feldspar,
  - Orthoclase.
  - Microcline.
  - Albite.
- Mica,
  - Muscovite.
  - Biotite.
- Garnet,
  - Almandite.
  - Spessartite.
- Beryl.
- Tourmaline.
- Apatite.
- Fluorite.

Of somewhat rare occurrence.

- Pyrite.
- Molybdenite.
- Lepidolite.
- Spodumene.
- Triphylite.
- Columbite.
- Cassiterite.
- Monazite.

MINERALS RESULTING FROM CONTACT METAMORPHISM.

When limestone rocks are subjected to heat and pressure through the intrusion into them of masses of hot igneous rocks they are metamorphosed and changed into crystalline limestones or marbles. If the limestone was impure, other minerals are frequently formed at the same time in the limestone in the zone near the plane of contact between the two rocks. These minerals are spoken of as *Contact Metamorphic Minerals*, and a list of the more important of them is given below.

Graphite.
Spinel.
Corundum.
Wollastonite.
Tremolite.
Pyroxene.
Phlogopite.
Garnet, { Grossularite.
 Andradite.

Igneous rocks when cooling give off large amounts of water and various elements (especially boron and fluorine) in the form of vapors, under the influence of which various minerals, commonly called *Pneumatolytic Minerals*, are developed in limestones in the zone near the contact plane between that rock and the igneous intrusion. The following minerals are often formed in this way:

Chondrodite.
Vesuvianite.
Scapolite.
Tourmaline.
Fluorite.

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