

# Contents

<b>1</b>	<b>Introduction and History</b> .....	1
1.1	Prologue .....	1
1.2	Organization of the Book .....	2
1.3	The Ancient Authors.....	4
1.3.1	Classical Authors .....	6
1.3.2	Medieval Authors .....	10
1.3.3	Arab Authors .....	14
1.3.4	Chinese and Indian Authors .....	15
<b>2</b>	<b>Properties of Minerals</b> .....	17
2.1	Mineral Chemistry.....	17
2.2	Mineral Structure.....	17
2.3	Mineral Identification Methods .....	21
2.3.1	Element Analyses.....	21
2.3.2	Petrographic Analyses.....	23
2.3.3	Physical Methods of Identification.....	25
2.4	Color of Minerals.....	27
<b>3</b>	<b>Exploitation of Mineral and Rock Raw Materials</b> .....	45
3.1	Introduction .....	45
3.2	Rock Classification and Properties .....	46
3.3	Igneous Rocks.....	46
3.3.1	Extrusive Igneous Rocks .....	48
3.3.2	Intrusive Igneous Rocks.....	51
3.4	Sedimentary Rocks .....	53
3.4.1	Carbonate Sedimentary Rocks.....	55
3.4.2	Terrigenous Sedimentary Rocks .....	56
3.4.3	Pyroclastic Sedimentary Rocks.....	58
3.5	Metamorphic Rocks .....	58
3.6	Unconsolidated Deposits.....	62
3.6.1	Surface Deposits.....	62

3.6.2	Placer Deposits .....	63
3.6.3	Residual Deposits.....	64
3.7	Outcrops, Mining, and Quarrying .....	65
<b>4</b>	<b>Lithic Materials .....</b>	<b>69</b>
4.1	Introduction .....	69
4.2	Microcrystalline Quartz.....	76
4.3	Other Siliceous Rocks .....	82
4.3.1	Quartzite .....	82
4.3.2	Opal.....	83
4.3.3	Felsite.....	84
4.3.4	Rhyolite/Andesite.....	84
4.3.5	Siliceous Shale/Slate/Schist .....	84
4.4	Obsidian .....	85
4.5	Other Minerals and Rocks .....	88
<b>5</b>	<b>Gemstones, Seal Stones, and Ceremonial Stones .....</b>	<b>91</b>
5.1	Introduction .....	91
5.2	Quartz Minerals (SiO <sub>2</sub> ) .....	94
5.2.1	Crystalline Varieties.....	94
5.2.2	Cryptocrystalline Varieties .....	96
5.3	Non-Quartz Silicates and Minerals .....	100
5.3.1	Coarse-Grained .....	100
5.3.2	Fine-Grained .....	106
5.3.3	Glassy.....	111
5.4	Carbonate and Sulfate Minerals .....	111
5.4.1	Coarse-Grained .....	111
5.4.2	Fine-Grained .....	112
5.5	Oxide Minerals.....	113
5.6	Organic Gems .....	116
5.7	Other Gem Minerals.....	119
5.7.1	Sulfide Minerals .....	120
<b>6</b>	<b>Soft Stones and Other Carvable Materials .....</b>	<b>121</b>
6.1	Introduction .....	121
6.2	Serpentinite .....	122
6.3	Steatite and Soapstone .....	125
6.3.1	Asbestos.....	128
6.4	Alabaster and Gypsum.....	128
6.5	Limestone and Marble .....	132
6.6	Catlinite.....	135
6.7	Other Carved Stone.....	136
6.8	Sedimentary Rocks .....	137
6.9	Volcanic Rocks.....	140
6.10	Miscellaneous Rocks .....	141

- 7 Metals and Related Minerals and Ores** ..... 143
  - 7.1 Introduction ..... 143
  - 7.2 Gold (Au) ..... 146
  - 7.3 Silver (Ag) ..... 152
  - 7.4 Native Copper (Cu) ..... 154
  - 7.5 Other Copper Minerals ..... 158
    - 7.5.1 The Copper Ore Minerals ..... 164
  - 7.6 Iron (Fe) ..... 166
  - 7.7 Iron Minerals ..... 169
  - 7.8 Tin (Sn) Minerals ..... 171
  - 7.9 Lead (Pb) Minerals ..... 176
  - 7.10 Zinc (Zn) Minerals ..... 178
  - 7.11 Other Ore Minerals and Metals ..... 180
  - 7.12 Oxidation of Metallic Ores ..... 181
  
- 8 Ceramic Raw Materials** ..... 183
  - 8.1 Introduction ..... 183
  - 8.2 Clays ..... 184
  - 8.3 Pottery ..... 188
  - 8.4 Tempers ..... 189
  - 8.5 Glazes ..... 191
  - 8.6 Porcelain ..... 193
  - 8.7 Glass ..... 194
  - 8.8 Faience ..... 197
  - 8.9 Fired-Brick, Tile, and Terracotta ..... 198
  - 8.10 Refractory Ceramics ..... 200
  
- 9 Pigments and Colorants** ..... 201
  - 9.1 The Nature of Pigments and Colorants ..... 201
  - 9.2 Historical Background ..... 203
  - 9.3 Iron Oxide Compounds ..... 207
  - 9.4 Manganese Compounds ..... 212
  - 9.5 Copper Compounds ..... 212
  - 9.6 Lead Compounds ..... 213
  - 9.7 Carbon Compounds ..... 215
  - 9.8 Sulfide Compounds ..... 215
  - 9.9 Carbonates ..... 216
  - 9.10 Silicates ..... 217
  - 9.11 Gold and Silver ..... 220
  - 9.12 Tin Compounds ..... 220
  - 9.13 Cobalt ..... 221
  
- 10 Abrasives, Salt, Shells, and Miscellaneous Geologic Raw Materials** ..... 223
  - 10.1 Introduction ..... 223
  - 10.2 Abrasives ..... 223
  - 10.3 Salt (Halite) ..... 224

10.4	Natron .....	228
10.5	Alum .....	230
10.6	Shells, Coral, Fossils, and Fossil Bone.....	232
10.7	Other Geologic Raw Materials .....	238
10.7.1	Mica .....	238
10.7.2	Petroleum Products – Asphalt, Bitumen, and Pitch .....	239
10.7.3	Sulfur (S).....	241
10.7.4	Mercury (Hg).....	242
10.7.5	Salt peter, Niter.....	243
10.7.6	Epsomite ( $MgSO_4 \cdot 7H_2O$ , Epsom Salt) .....	244
10.7.7	Nitric Acid .....	245
10.7.8	Tutty/Cadmea.....	245
10.7.9	Fuller’s Earth .....	245
10.7.10	Stone Money .....	246
<b>11</b>	<b>Building, Monumental, and Statuary Materials.....</b>	<b>247</b>
11.1	Introduction .....	247
11.2	Building Stone .....	247
11.2.1	Granite/Diorite.....	251
11.2.2	Porphyry .....	253
11.2.3	Basalt/Andesite/Dolerite .....	253
11.2.4	Limestone/Sandstone .....	255
11.2.5	Marble .....	257
11.2.6	Slate/Schist/Quartzite .....	259
11.2.7	Gypsum .....	260
11.3	Cements and Mortars .....	261
11.3.1	Lime .....	261
11.3.2	Gypsum .....	263
11.3.3	Aggregates .....	264
11.3.4	Hydraulic Reactions .....	265
11.3.5	Natural Pozzolana .....	266
11.3.6	Artificial “Pozzolana”.....	267
11.3.7	Modern Portland Cement.....	268
11.4	Masonry .....	268
11.5	Mud Brick, Terracotta, and Other Earthen Architectural Materials ..	269
11.6	Weathering and Decomposition .....	273
	<b>References .....</b>	<b>281</b>
	<b>Glossary .....</b>	<b>319</b>
	<b>Appendix A: Pigments Used in Antiquity .....</b>	<b>327</b>
	<b>Mineral, Rock, and Metal Index.....</b>	<b>333</b>
	<b>Geographic Index .....</b>	<b>339</b>
	<b>General Index .....</b>	<b>345</b>