

Contents

1. General Issues about this Book	21
I. Basics and Principles	27
1. What are Non-Ferrous Metals?	29
1.1. Why Differentiation between Non-Ferrous and Iron (Steel)? . . .	30
1.2. Classification of Non-Ferrous Metals	32
1.2.1. Groups of Non-Ferrous Metals	33
2. Minerals and Mining	35
2.1. Minerals	35
2.2. Mining	38
3. Production by Extractive Metallurgy	43
3.1. Preparation of the Ores and Concentrates	44
3.2. Pyrometallurgy	45
3.3. Hydrometallurgy	51
4. Alloys	55
5. Processing of Metals	57
5.1. Melting and Casting	57
5.2. Metal forming: Extrusion, Rolling, Drawing and Forging	59
5.2.1. Powder Metallurgy (PM)	62
6. Applications	65
II. The Individual Non-Ferrous Metals	67
1. Actinium	69
2. Actinides (Actinoides)	71
2.1. Properties	71

2.2. Production	72
2.3. Use	73
2.4. History	74
3. Aluminium	75
3.1. Properties	75
3.2. Minerals and Mining	77
3.3. Production	79
3.3.1. Primary Production	79
3.3.2. Recycling	86
3.4. Alloys	90
3.5. Processing of Aluminium and Aluminium Alloys	92
3.6. Use	93
3.6.1. Aluminium Metal	93
3.6.2. Chemicals	95
3.7. History	97
3.8. Bibliography	98
4. Antimony	101
4.1. Properties	101
4.2. Minerals and Mining	102
4.3. Production	104
4.4. Use	107
4.5. History	109
4.6. Bibliography	109
5. Arsenic	111
5.1. Properties	111
5.2. Minerals and Mining	112
5.3. Production	113
5.4. Use	115
5.5. History	117
5.6. Bibliography	118
6. Barium	119
6.1. Properties	119
6.2. Minerals and Mining	120
6.3. Production	121
6.4. Use	122
6.5. History	125
6.6. Bibliography	126

7. Beryllium	127
7.1. Properties	127
7.2. Minerals and Mining	128
7.3. Production	129
7.4. Use	130
7.5. History	133
7.6. Bibliography	134
8. Bismuth	135
8.1. Properties	135
8.2. Minerals and Mining	136
8.3. Production	137
8.4. Use	139
8.5. History	141
8.6. Bibliography	141
9. Boron	143
9.1. Properties	143
9.2. Minerals and Mining	144
9.3. Production	146
9.4. Use	147
9.5. History	152
9.6. Bibliography	153
10. Cadmium	155
10.1. Properties	155
10.2. Minerals and Mining	156
10.3. Production	157
10.4. Use	159
10.5. History	162
10.6. Bibliography	162
11. Calcium	163
11.1. Properties	163
11.2. Minerals and Mining	164
11.3. Production	166
11.4. Use	167
11.5. History	171
Similar Outline for All Meals until Zirconium	173
	173
	174

71.2. Minerals and Mining	653
71.3. Production	654
71.4. Use	658
71.5. History	661
71.6. Bibliography	661
72. Vanadium	663
72.1. Properties	663
72.2. Minerals and Mining	665
72.3. Production	666
72.4. Use	668
72.5. History	670
72.6. Bibliography	671
73. Ytterbium	673
74. Yttrium	677
75. Zinc	681
75.1. Properties	681
75.2. Minerals and Mining	683
75.3. Production	684
75.4. Use	689
75.5. History	695
75.6. Bibliography	695
76. Zirconium	697
76.1. Properties	697
76.2. Minerals and Mining	698
76.3. Production	699
76.4. Use	702
76.5. History	704
76.6. Bibliography	704
III. Non-Ferrous Metals are Essential for	705
1. Batteries - Energy Storage Systems	709
1.1. Basics - How batteries work	709
1.2. Zinc Carbon Batteries	713
1.3. Alkaline (Zinc) Batteries	715
1.4. Zinc Air Battery	717

1.5. Nickel-Cadmium Battery	720
1.6. Nickel–Metal Hydride Batteries	722
1.7. Lithium Ion Battery	724
1.8. Lead Acid Battery	726
1.9. Redox Flow Batteries (RFB)	729
1.10. Sodium Sulfur Battery (Solid State Batteries)	731
1.11. Fuel Cells and Water Electrolysis	733
1.11.1. Fuel Cells	734
1.11.2. Water Electrolysis	737
1.12. Bibliography	739
2. Non-Ferrous Metals for Renewable Electrical Energy	741
2.1. Solar Energy (Photovoltaics)	741
2.1.1. Silicon Based Photovoltaic Cells	742
2.1.2. Non Silicon Thin Layer Photovoltaic Cells	745
2.1.2.1. Bibliography	748
2.2. Wind Power	748
2.2.1. Bibliography	751
3. Non-Ferrous Metals in Renewable Thermal Energy	753
3.1. Low Temperature Systems	753
3.2. Concentrated Solar Power Plants (CSP-Systems)	755
4. Non-Ferrous Metals in Saving Energy	757
4.1. Non-Ferrous Metals in Saving Thermal Energy	757
4.2. Non-Ferrous Metals in Saving Electrical Energy	759
5. Non-Ferrous Metals in Saving Resources	763
5.1. Non-Ferrous Metals against Corrosion and Wear	763
5.1.1. Alloying Base Metals against Corrosion	763
5.1.2. Coating Base Metals against Corrosion and Wear	765
5.2. Non-Ferrous Metals in Saving Material	766
5.2.1. Iron and Steel	766
5.3. Recycling of Non-Ferrous Metals	767
5.3.1. Bibliography	771
IV. Appendix (Glossary, Tables, Index)	773
1. Glossary	775

2. Tables	791
2.1. Densities and Melting Points of Non-Ferrous Metals	791
2.2. Redox Potentials of Non-Ferrous Metals and some Ions	793
2.3. Production Figures of Mined Non-Ferrous Metals	795
3. Keyword Index	799