

CHAPTER ONE: INTRODUCTION	1
STUDY GOALS AND OBJECTIVES.....	1
REASONS FOR DOING THIS STUDY	1
REASONS FOR DOING THIS STUDY (CONTINUED).....	2
INTENDED AUDIENCE.....	3
SCOPE OF REPORT	3
SCOPE OF REPORT (CONTINUED)	4
METHODOLOGY AND INFORMATION SOURCES.....	5
RELATED BCC RESEARCH STUDIES	6
ANALYST CREDENTIALS.....	7
BCC ONLINE SERVICES.....	7
DISCLAIMER	8
 CHAPTER TWO: EXECUTIVE SUMMARY.....	9
EXECUTIVE SUMMARY.....	9
<i>SUMMARY TABLE GLOBAL MARKET FOR RARE EARTHS, THROUGH 2016 (METRIC TONS — REO EQUIVALENT)</i>	10
<i>SUMMARY FIGURE GLOBAL MARKET FOR RARE EARTHS, 2009— 2016 (METRIC TONS — REO EQUIVALENT)</i>	11
 CHAPTER THREE: OVERVIEW	12
INTRODUCTION	12
<i>FIGURE 1 RARE EARTHS IN THE PERIODIC TABLE</i>	13
<i>TABLE 1 LANTHANOIDS</i>	13
<i>TABLE 1 (CONTINUED)</i>	14
<i>TABLE 2 TYPICAL PROPERTIES OF LANTHANOIDS</i>	14
<i>TABLE 3 SCANDIUM AND YTTRIUM</i>	15
MILESTONES IN THE HISTORY OF RARE EARTHS AND RECENT EVENTS.....	15
<i>TABLE 4 RARE EARTHS — TECHNOLOGICAL AND COMMERCIAL MILESTONES</i>	15
<i>TABLE 4 (CONTINUED)</i>	16
<i>TABLE 5 RARE EARTHS DISCOVERY</i>	16
<i>FIGURE 2 RARE EARTHS — WORLDWIDE PATENT APPLICATIONS AND PATENTS ISSUED, 1951–2010</i>	17
<i>FIGURE 2 (CONTINUED)</i>	18
CURRENT AND EMERGING APPLICATIONS FOR RARE EARTHS	19
METALLURGICAL/ MECHANICAL.....	19
<i>TABLE 6 RARE EARTH APPLICATIONS IN THE METALLURGICAL AND MECHANICAL SECTOR, 2011</i>	19
<i>TABLE 6 (CONTINUED)</i>	20
GLASS/CERAMICS	20
<i>TABLE 7 RARE EARTH APPLICATIONS IN THE GLASS/CERAMIC SECTOR, 2011</i>	20

<i>TABLE 7 (CONTINUED)</i>	21
ELECTRONICS, OPTICS, AND OPTOELECTRONICS	21
<i>TABLE 8 RARE EARTH APPLICATIONS IN ELECTRONICS, OPTICS, AND OPTOELECTRONICS, 2011</i>	22
<i>TABLE 8 (CONTINUED)</i>	23
CHEMICAL	23
<i>TABLE 9 RARE EARTH APPLICATIONS IN THE CHEMICAL SECTOR, 2011</i>	23
<i>TABLE 9 (CONTINUED)</i>	24
ENERGY.....	24
<i>TABLE 10 RARE EARTH APPLICATIONS IN THE ENERGY SECTOR, 2011</i>	24
<i>TABLE 10 (CONTINUED)</i>	25
LIFE SCIENCES.....	25
<i>TABLE 11 RARE EARTH APPLICATIONS IN THE LIFE SCIENCES SECTOR, 2011</i>	25
SENSORS AND INSTRUMENTATION	26
<i>TABLE 12 RARE EARTH APPLICATIONS IN THE SENSORS AND INSTRUMENTATION SECTOR, 2011</i>	26
CONSUMER.....	26
Established Applications.....	26
<i>TABLE 13 RARE EARTH APPLICATIONS IN THE CONSUMER SECTOR, 2011</i>	27
OTHERS	27
<i>TABLE 14 OTHER RARE EARTH APPLICATIONS, 2011</i>	27
 CHAPTER FOUR: RARE EARTH PRODUCTION TECHNOLOGY	28
INTRODUCTION	28
RARE ELEMENTS PROCESSING.....	28
<i>TABLE 15 PROCESSING STEPS IN THE RARE EARTH INDUSTRY</i>	28
MINING.....	29
Crustal Abundance and Deposit Types	29
<i>TABLE 16 RARE EARTHS CRUSTAL ABUNDANCE</i>	29
Rare Earth Minerals	30
<i>TABLE 17 TYPICAL RARE EARTH CONTENT IN VARIOUS COMMON RARE EARTH MINERALS (REO %)</i>	30
<i>TABLE 17 (CONTINUED)</i>	31
<i>TABLE 18 TYPICAL ION ADSORPTION CLAY, LATERITE ORE COMPOSITIONS (% OF TOTAL REO)</i>	31
<i>TABLE 18 (CONTINUED)</i>	32
<i>TABLE 19 TYPICAL RARE EARTH CONTENT IN OTHER RARE EARTH MINERALS (REO %)</i>	32
<i>TABLE 19 (CONTINUED)</i>	33
<i>TABLE 19 (CONTINUED)</i>	34
<i>TABLE 19 (CONTINUED)</i>	35

<i>TABLE 19 (CONTINUED).....</i>	36
<i>TABLE 19 (CONTINUED).....</i>	37
<i>TABLE 20 OCCURRENCE OF MINERALS CONTAINING RARE EARTHS WORLDWIDE.....</i>	37
<i>TABLE 20 (CONTINUED).....</i>	38
<i>TABLE 20 (CONTINUED).....</i>	39
MINERAL PROCESSING	39
RECENT PROCESS IMPROVEMENTS, 2009 TO PRESENT	40
Highly Efficient Separation of Rare Earth Elements	40
Environmentally Friendly Methods for Rare Earths Separation	40
Rare Earth Recycling Process for Rechargeable Batteries	41
LATEST TECHNOLOGICAL DEVELOPMENTS, 2009 TO PRESENT	41
NANOPARTICLES FOR SOOT REDUCTION	41
FLUORESCENT LABELING COMPOUND	42
SINGLE CRYSTAL FOR PRODUCING A HIGH-TEMPERATURE PIEZOELECTRIC SENSOR.....	42
RARE EARTH NANORODS.....	43
RARE EARTH-ACTIVATED ALUMINUM NITRIDE POWDER FOR WHITE LEDS.....	44
PYROCATALYTIC COATINGS FOR HEATING DEVICES	44
RARE EARTH GLOBAL PRODUCTION.....	45
SUMMARY OF GLOBAL PRODUCTION	45
<i>TABLE 21 RARE EARTHS PRODUCTION BY COUNTRY, 2006–2011 (METRIC TONS).....</i>	46
INCREASING GAP BETWEEN PRODUCTION AND DEMAND	46
<i>TABLE 22 RARE EARTHS PRODUCTION AND EXPORT IN CHINA, 2007–2011 (METRIC TONS).....</i>	47
CHAPTER FIVE: GEOGRAPHICAL DISTRIBUTION OF RARE EARTH RESOURCES.....	48
INTRODUCTION	48
NORTH AMERICA	49
UNITED STATES	49
Mountain Pass	49
<i>TABLE 23 MOUNTAIN PASS, CALIFORNIA — TYPICAL ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	50
Iron Hill.....	50
<i>TABLE 24 IRON HILL, COLORADO — CARBONATITE ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	51
<i>TABLE 25 IRON HILL, COLORADO — PIROXENITE ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	52
Elk Creek	52
<i>TABLE 26 ELK CREEK, NEBRASKA — TYPICAL ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	53

Round Top Mountain.....	53
<i>TABLE 27 ROUND TOP MOUNTAIN, TEXAS — TYPICAL ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	54
Bear Lodge	54
<i>TABLE 28 BEAR LODGE, WYOMING — TYPICAL ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	55
Bokan Mountain	55
<i>TABLE 29 BOKAN MOUNTAIN, ALASKA — DOTSON ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	56
Other Resources.....	56
Summary of Rare Earths Resources in the U.S.....	57
<i>TABLE 30 U.S. RARE EARTH RESOURCES, 2011.....</i>	57
<i>TABLE 30 (CONTINUED).....</i>	58
CANADA.....	58
Thor Lake.....	58
<i>TABLE 31 THOR LAKE, CANADA — NECHALACHO ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	59
Eldor.....	59
<i>TABLE 32 ELDOR, CANADA — ASHRAM ZONE ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	60
Wicheeda	60
Strange Lake.....	61
<i>TABLE 33 STRANGE LAKE, CANADA — B-ZONE ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	62
Misery Lake	62
Oka	62
<i>TABLE 34 OKA, CANADA — TYPICAL ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	63
Hoidas Lake	64
<i>TABLE 35 HOIDAS LAKE, CANADA — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	64
Elliot Lake.....	65
<i>TABLE 36 ELLIOT LAKE, CANADA — ECO RIDGE RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)</i>	65
Other Resources.....	66
Kipawa.....	66
Eden Lake	66
Red Wine	67
Lancer.....	67
Summary of Rare Earths Resources in Canada.....	67
<i>TABLE 37 CANADA RARE EARTH RESOURCES, 2011.....</i>	67
SOUTH AMERICA	68
BRAZIL.....	68
Monazite Placers.....	68

Other Resources.....	68
Morro dos Seis Lagos	68
Araxá	68
TABLE 38 ARAXÁ, BRAZIL — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)	69
Catalão	70
TABLE 39 CATALÃO, BRAZIL — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)	70
• REE in Fertilizers.....	71
Tapira	71
TABLE 40 TAPIRA, BRAZIL — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)	72
Salitre.....	72
Pitinga	72
Morro do Ferro	73
TABLE 41 MORRO DO FERRO, BRAZIL — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)	73
Mato Preto.....	74
TABLE 42 MATO PRETO, BRAZIL — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)	74
Summary of Rare Earths Resources in Brazil	74
TABLE 43 BRAZIL RARE EARTH RESOURCES, 2011	75
ARGENTINA.....	75
Rodeo de Los Molles	75
Other Resources.....	75
EUROPE.....	75
SWEDEN	76
Norra Kärr	76
TABLE 44 NORRA KÄRR, SWEDEN — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)	76
Other Resources.....	77
FINLAND	77
Otanmäki	77
TABLE 45 KATAJAKANGAS, FINLAND — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)	78
Korsnäs	78
Kaatiala.....	79
Other Resources.....	79
NORWAY.....	79
Fen.....	79
GREENLAND.....	79
Kvanefjeld	79
TABLE 46 KVANEFJELD, GREENLAND — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)	80

Motzfeldt	80
TABLE 47 MOTZFELDT, GREENLAND — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)	81
Sarfartoq	81
AFRICA	82
SOUTH AFRICA	82
Zandkopsdrift.....	82
TABLE 48 ZANDKOPSDRIFT, SOUTH AFRICA — TYPICAL RARE EARTH ORE COMPOSITIONS (PERCENT OF TOTAL REO)	82
Pilanesberg	83
TABLE 49 PILANESBERG, SOUTH AFRICA — TYPICAL RARE EARTH ORE COMPOSITIONS (PERCENT OF TOTAL REO)	83
Phalaborwa	84
Steenkampskraal.....	84
TABLE 50 STEENKAMPSKRAAL, SOUTH AFRICA — TYPICAL RARE EARTH ORE COMPOSITIONS (PERCENT OF TOTAL REO)	85
Monazite Sands	85
Summary of Rare Earths Resources in South Africa.....	86
TABLE 51 SOUTH AFRICA RARE EARTH RESOURCES, 2011	86
OTHER STATES	86
Other States (Continued)	87
COMMONWEALTH OF INDEPENDENT STATES	88
RUSSIA.....	88
Lovozero	88
TABLE 52 LOVOZERO, RUSSIA — TYPICAL RARE EARTH ORE COMPOSITIONS (PERCENT OF TOTAL REO)	88
TABLE 52 (CONTINUED).....	89
Khibina.....	89
TABLE 53 KHBIBINA, RUSSIA — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)	90
Tomtor	90
Eastern Siberia and Far East of Russia	90
Summary of Rare Earths Resources in Russia	91
TABLE 54 RUSSIA RARE EARTH RESOURCES, 2011	91
KYRGYZSTAN	91
Aktyuz	91
TABLE 55 KUTESSAI II, KYRGYZSTAN — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)	92
Other Resources.....	93
Summary of Rare Earth Resources in Kyrgyzstan	93
TABLE 56 KYRGYZSTAN RARE EARTH RESOURCES, 2011.....	93
KAZAKHSTAN	93
ASIA.....	94
INDIA	94

Monazite Placers.....	94
TABLE 57 INDIA — TYPICAL MONAZITE ORE COMPOSITION (PERCENT OF TOTAL REO)	95
CHINA	95
Bayan Obo.....	95
TABLE 58 BAYAN OBO, INNER MONGOLIA, CHINA — TYPICAL BASTNÄSITE ORE COMPOSITION (PERCENT OF TOTAL REO).....	96
Weishan.....	96
Maoniuping	96
TABLE 59 MAONIUPING, SICHUAN, CHINA — TYPICAL ORE COMPOSITION (PERCENT OF TOTAL REO)	97
Ion-adsorption Clays	97
Other Resources.....	97
TABLE 60 SOUTHERN CHINA — TYPICAL MONAZITE ORE COMPOSITION (% OF TOTAL REO)	98
Summary of Rare Earths Resources in China	98
TABLE 61 CHINA RARE EARTH RESOURCES, 2011	98
VIETNAM.....	99
Nam Xe.....	99
Dong Pao	99
Monazite Placers.....	99
Summary of Rare Earths Resources in Vietnam	99
TABLE 62 VIETNAM RARE EARTH RESOURCES, 2011	100
OTHER ASIAN RESOURCES.....	100
OCEANIA.....	101
AUSTRALIA.....	101
Olympic Dam	101
Mount Weld.....	101
TABLE 63 MT. WELD, AUSTRALIA — ORE COMPOSITION (PERCENT OF TOTAL REO).....	102
Nolans Bore.....	102
TABLE 64 NOLANS BORE, AUSTRALIA — TYPICAL RARE EARTH ORE COMPOSITIONS (PERCENT OF TOTAL REO)	103
Toongi.....	103
TABLE 65 TOONGI, AUSTRALIA — TYPICAL RARE EARTH ORE COMPOSITIONS (PERCENT OF TOTAL REO)	104
Brockman	105
TABLE 66 BROCKMAN, AUSTRALIA — TYPICAL ORE COMPOSITION (PERCENT OF TOTAL REO)	105
Yangibana	105
TABLE 67 YANGIBANA, AUSTRALIA — TYPICAL RARE EARTH ORE COMPOSITION (PERCENT OF TOTAL REO)	106
Cummins Range	106

<i>TABLE 68 CUMMINS RANGE, AUSTRALIA — TYPICAL RARE EARTH ORE COMPOSITIONS (PERCENT OF TOTAL REO)</i>	107
Other Resources.....	107
Summary of Rare Earths Resources in Australia	108
<i>TABLE 69 AUSTRALIA RARE EARTH RESOURCES, 2011</i>	108
<i>TABLE 69 (CONTINUED).....</i>	109
SUMMARY OF WORLD RESERVES OF RARE EARTHS	109
<i>TABLE 70 GLOBAL RARE EARTH RESERVES, 2011 (METRIC TONS—REO EQUIVALENT)</i>	110
<i>FIGURE 3 RARE EARTH RESERVES BY COUNTRY, 2011 (%).....</i>	111
<i>TABLE 71 HREE-RICH DEPOSITS, 2011</i>	112
STATUS REPORT OF MOST IMPORTANT PROJECTS	113
<i>TABLE 72 STATUS REPORT OF VARIOUS PROJECTS WORLDWIDE, 2011.....</i>	113
<i>TABLE 72 (CONTINUED).....</i>	114
<i>TABLE 72 (CONTINUED).....</i>	115
<i>TABLE 72 (CONTINUED).....</i>	116
GLOBAL PRODUCTION FORECAST	117
PRODUCTION FORECAST BY COUNTRY	117
<i>TABLE 73 RARE EARTHS PRODUCTION BY COUNTRY, 2011–2016 (METRIC TONS).....</i>	117
<i>FIGURE 4 RARE EARTHS: GLOBAL PRODUCTION SHARE BY COUNTRY, 2016 (%).....</i>	118
PRODUCTION FORECAST BY ELEMENT	119
<i>TABLE 74 RARE EARTH PRODUCTION BY ELEMENT, 2016 (METRIC TONS).....</i>	119
CHAPTER SIX: RARE EARTH PRICES.....	120
HISTORICAL PRICES OF BASIC RARE EARTH OXIDES	120
EARLY 1990S TO 2003.....	120
2003 TO 2009.....	120
<i>FIGURE 5 PRICES FOR THE MAJOR RARE EARTH OXIDES, 1992–2003, 99% PURITY CIF U.S. (U.S. \$)</i>	121
<i>FIGURE 6 PRICES FOR THE MAJOR RARE EARTH OXIDES, 99% PURITY FOB CHINA, 2003–2009 (\$ U.S.).....</i>	122
RECENT PRICES	122
<i>TABLE 75 RARE EARTHS AVERAGE UNIT PRICES, 99% PURITY, FOB, THROUGH 2011 (\$ US/KG)</i>	123
VALUE COMPARISON OF DIFFERENT ORES	123
<i>TABLE 76 VALUE OF ONE KILOGRAM OF REO FOR VARIOUS ORES BASED ON 2011 PRICES (\$/KG)</i>	124
<i>TABLE 76 (CONTINUED).....</i>	125
<i>TABLE 77 REO RESOURCE VALUES FOR VARIOUS ORES, 2011 (\$ BILLIONS).....</i>	125
<i>TABLE 77 (CONTINUED).....</i>	126

<i>TABLE 78 REO RESOURCE VALUES BY REGION, 2011 (\$ BILLIONS).....</i>	127
<i>TABLE 78 (CONTINUED).....</i>	128
<i>FIGURE 7 VALUE OF RARE EARTH RESOURCES BY REGION, 2011 (%).....</i>	129
FUTURE PRICE TRENDS.....	129
CHINA'S PRODUCTION AND EXPORT POLICIES	130
RARE EARTH RECYCLING	130
MANUFACTURING RELOCATION	130
DEVELOPMENT OF ALTERNATIVE PRODUCTS.....	131
REE DEPOSIT DEVELOPMENT	131
SUPPLY VERSUS DEMAND.....	132
<i>TABLE 79 FORECAST — RARE EARTHS AVERAGE UNIT PRICES, 99% PURITY, FOB, THROUGH 2016 (US\$/KG).....</i>	133
CHAPTER SEVEN: GLOBAL MARKET	134
ANALYSIS OUTLINE	134
GLOBAL MARKET SUMMARY	134
MARKET SEGMENTATION BY INDUSTRY.....	134
Market Segmentation ... (Continued).....	135
<i>TABLE 80 GLOBAL DEMAND FOR RARE EARTHS BY INDUSTRY, THROUGH 2016 (METRIC TONS)</i>	136
<i>FIGURE 8 GLOBAL DEMAND FOR RARE EARTHS BY INDUSTRY, 2009–2016 (METRIC TONS).....</i>	137
<i>FIGURE 9 RARE EARTHS CONSUMPTION SHARE BY INDUSTRY, 2011 AND 2016 (%).....</i>	138
<i>FIGURE 9 (CONTINUED)</i>	139
<i>TABLE 81 GLOBAL MARKET FOR RARE EARTHS BY INDUSTRY, THROUGH 2016 (\$ MILLIONS).....</i>	140
MARKET SEGMENTATION BY ELEMENT.....	140
<i>TABLE 82 GLOBAL RARE EARTH CONSUMPTION BY ELEMENT, THROUGH 2016 (METRIC TONS REO).....</i>	141
<i>FIGURE 10 RARE EARTHS: MARKET SHARE BY ELEMENT, 2011 AND 2016 (%).....</i>	141
<i>FIGURE 10 (CONTINUED)</i>	142
METALLURGICAL/MECHANICAL SECTOR	142
PERMANENT MAGNETS.....	143
Types	143
<i>TABLE 83 MAIN TYPES OF PERMANENT MAGNETS, 2011.....</i>	143
Applications	143
<i>TABLE 84 CURRENT APPLICATIONS OF PERMANENT MAGNETS, 2011.....</i>	144
<i>TABLE 85 CURRENT RARE EARTH MAGNET APPLICATIONS, 2011.....</i>	145
Current Market Summary	145
<i>TABLE 86 PERMANENT MAGNETS: GLOBAL PRODUCTION BY TYPE, THROUGH 2011 (METRIC TONS).....</i>	146

FIGURE 11 PERMANENT MAGNETS: PRODUCTION SHARE BY TYPE, 2011 (%)	146
FIGURE 11 (CONTINUED).....	147
Consumption and Revenues of Rare Earths by Magnet Type	147
TABLE 87 RARE EARTHS FOR PERMANENT MAGNETS: GLOBAL CONSUMPTION BY MAGNET TYPE, THROUGH 2011 (METRIC TONS REO).....	147
TABLE 88 RARE EARTHS FOR PERMANENT MAGNETS: GLOBAL REVENUES BY MAGNET TYPE, THROUGH 2011 (\$ MILLIONS)	148
Consumption of Rare Earths by Element	148
TABLE 89 RARE EARTHS FOR PERMANENT MAGNETS: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2011 (METRIC TONS REO)	148
FIGURE 12 RARE EARTHS FOR PERMANENT MAGNETS: CONSUMPTION SHARE BY ELEMENT, 2011 (%).....	149
Market Growth Trends.....	149
Electric and Hybrid Vehicles.....	149
TABLE 90 FORECAST — ELECTRIC AND HYBRID VEHICLES: GLOBAL REVENUES, THROUGH 2016 (\$ BILLIONS).....	150
Wind Turbines	150
Electronics	150
Market Forecast.....	151
TABLE 91 FORECAST — PERMANENT MAGNETS: GLOBAL PRODUCTION BY TYPE, THROUGH 2016 (METRIC TONS).....	151
FIGURE 13 FORECAST — PERMANENT MAGNETS: PRODUCTION SHARE BY TYPE, 2016 (%)	152
Consumption and Revenues of Rare Earths by Magnet Type	152
TABLE 92 FORECAST — RARE EARTHS FOR PERMANENT MAGNETS: GLOBAL CONSUMPTION BY MAGNET TYPE, THROUGH 2016 (METRIC TONS REO).....	153
TABLE 93 FORECAST — RARE EARTHS FOR PERMANENT MAGNETS: GLOBAL REVENUES BY MAGNET TYPE, 2011 THROUGH 2016 (\$ MILLIONS).....	153
Consumption of Rare Earths by Element	153
TABLE 94 FORECAST — RARE EARTHS FOR PERMANENT MAGNETS: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2016 (METRIC TONS REO).....	154
FIGURE 14 FORECAST — RARE EARTHS FOR PERMANENT MAGNETS: CONSUMPTION SHARE BY ELEMENT, 2016 (%).	154
FIGURE 14 (CONTINUED).....	155
METALLURGICAL ALLOYS.....	155
Rare Earth Elements for Metallurgy.....	155

<i>TABLE 95 RARE EARTH ELEMENTS FOR METALLURGY, 2011</i>	155
<i>TABLE 95 (CONTINUED)</i>	156
Current Market Summary	156
<i>TABLE 96 HIGH-PERFORMANCE ALLOYS: GLOBAL CONSUMPTION, THROUGH 2011 (METRIC TONS)</i>	157
<i>TABLE 97 RARE EARTHS FOR METALLURGY: GLOBAL CONSUMPTION, THROUGH 2011 (METRIC TONS)</i>	157
Consumption and Revenues of Rare Earths by Element.....	157
<i>TABLE 98 RARE EARTHS FOR METALLURGY: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2011 (METRIC TONS REO)</i>	158
<i>FIGURE 15 RARE EARTHS FOR METALLURGY: CONSUMPTION SHARE BY ELEMENT, 2011 (%)</i>	158
<i>FIGURE 15 (CONTINUED)</i>	159
<i>TABLE 99 RARE EARTHS FOR METALLURGY: GLOBAL REVENUES BY ELEMENT, THROUGH 2011 (\$ MILLIONS)</i>	159
Market Growth Trends.....	159
<i>TABLE 100 FORECAST — HIGH-PERFORMANCE ALLOYS: GLOBAL CONSUMPTION, THROUGH 2016 (METRIC TONS)</i>	160
Market Forecast.....	160
<i>TABLE 101 FORECAST — RARE EARTHS FOR METALLURGY: GLOBAL CONSUMPTION, THROUGH 2016 (METRIC TONS)</i>	160
Consumption and Revenues of Rare Earths by Element.....	160
<i>TABLE 102 FORECAST — RARE EARTHS FOR METALLURGY: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2016 (METRIC TONS REO)</i>	161
<i>FIGURE 16 FORECAST — RARE EARTHS FOR METALLURGY: CONSUMPTION SHARE BY ELEMENT, 2016 (%)</i>	161
<i>FIGURE 16 (CONTINUED)</i>	162
<i>TABLE 103 FORECAST — RARE EARTHS FOR METALLURGY: GLOBAL REVENUES BY ELEMENT, THROUGH 2016 (\$ MILLIONS)</i>	162
GLASS/CERAMICS SECTOR	162
<i>TABLE 104 RARE EARTH ELEMENTS FOR GLASS AND CERAMICS, 2011</i>	163
CURRENT MARKET SUMMARY	164
<i>TABLE 105 RARE EARTHS FOR GLASS AND CERAMICS: GLOBAL CONSUMPTION, THROUGH 2011 (METRIC TONS)</i>	164
Consumption and Revenues of Rare Earths by Element.....	164
<i>TABLE 106 RARE EARTHS FOR GLASS AND CERAMICS: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2011 (METRIC TONS REO)</i>	165

FIGURE 17 RARE EARTHS FOR GLASS AND CERAMICS:	
CONSUMPTION SHARE BY ELEMENT, 2011 (%).....	165
FIGURE 17 (CONTINUED).....	166
TABLE 107 RARE EARTHS FOR GLASS AND CERAMICS: GLOBAL REVENUES BY ELEMENT, THROUGH 2011 (\$ MILLIONS).....	166
Market Growth Trends	166
Polishing Compounds	166
TABLE 108 FORECAST — CMP SLURRIES: GLOBAL REVENUES BY MATERIAL TYPE, THROUGH 2016 (\$ MILLIONS).....	167
TABLE 109 FORECAST — ADVANCED DISPLAYS: GLOBAL REVENUES BY TYPE, THROUGH 2016 (\$ BILLIONS).....	168
Advanced Ceramics	168
TABLE 110 GLOBAL MARKET FOR ADVANCED CERAMICS, THROUGH 2016 (\$ BILLIONS).....	168
Glass.....	169
TABLE 111 FORECAST — GLASS MARKETS FOR RARE EARTHS: GLOBAL REVENUES BY SECTOR, THROUGH 2016 (\$ BILLIONS).....	169
Market Forecast	169
TABLE 112 FORECAST — RARE EARTHS FOR GLASS AND CERAMICS: GLOBAL CONSUMPTION, THROUGH 2016 (METRIC TONS).....	170
Consumption and Revenues of Rare Earths by Element.....	170
TABLE 113 FORECAST — RARE EARTHS FOR GLASS AND CERAMICS: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2016 (METRIC TONS REO).....	170
FIGURE 18 FORECAST — RARE EARTHS FOR GLASS AND CERAMICS: CONSUMPTION SHARE BY ELEMENT, 2016 (%).....	171
TABLE 114 FORECAST — RARE EARTHS FOR GLASS AND CERAMICS: GLOBAL REVENUES BY ELEMENT, THROUGH 2016 (\$ MILLIONS).....	172
Electronics, Optics, and Optoelectronics	172
TABLE 115 RARE EARTH ELEMENTS FOR ELECTRONICS, OPTICS, AND OTOELECTRONICS, 2011.....	173
TABLE 115 (CONTINUED).....	174
Current Market Summary	174
TABLE 116 RARE EARTHS FOR ELECTRONICS, OPTICS, AND OTOELECTRONICS: GLOBAL CONSUMPTION, THROUGH 2011 (METRIC TONS).....	175
Consumption and Revenues of Rare Earths by Element.....	175
TABLE 117 RARE EARTHS FOR ELECTRONICS, OPTICS, AND OTOELECTRONICS: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2011 (METRIC TONS REO).....	176

<i>FIGURE 19 RARE EARTHS FOR ELECTRONICS, OPTICS, AND OPTOELECTRONICS: CONSUMPTION SHARE BY ELEMENT, 2011 (%)</i>	176
<i>FIGURE 19 (CONTINUED)</i>	177
<i>TABLE 118 RARE EARTHS FOR ELECTRONICS, OPTICS, AND OPTOELECTRONICS: GLOBAL REVENUES BY ELEMENT, THROUGH 2011 (\$ MILLIONS)</i>	177
MARKET GROWTH TRENDS	177
Advanced Displays.....	177
Light-Emitting Diodes.....	178
Lasers	178
Optical Fibers	178
<i>TABLE 119 FORECAST — OPTICAL FIBERS: GLOBAL MARKET, THROUGH 2016 (\$ MILLIONS/MILLIONS OF KILOMETERS)</i>	179
Microelectronics	179
<i>TABLE 120 SEMICONDUCTORS: REVENUES BY REGION, THROUGH 2016 (\$BILLIONS)</i>	179
MARKET FORECAST	180
<i>TABLE 121 FORECAST — RARE EARTHS FOR ELECTRONICS, OPTICS, AND OPTOELECTRONICS: GLOBAL CONSUMPTION, THROUGH 2016 (METRIC TONS)</i>	180
Consumption and Revenues of Rare Earths by Element.....	180
<i>TABLE 122 FORECAST — RARE EARTHS FOR ELECTRONICS, OPTICS, AND OPTOELECTRONICS: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2016 (METRIC TONS REO)</i>	181
<i>FIGURE 20 FORECAST — RARE EARTHS FOR ELECTRONICS, OPTICS, AND OPTOELECTRONICS: CONSUMPTION SHARE BY ELEMENT, 2016 (%)</i>	181
<i>FIGURE 20 (CONTINUED)</i>	182
<i>TABLE 123 FORECAST — RARE EARTHS FOR ELECTRONICS, OPTICS, AND OPTOELECTRONICS: GLOBAL REVENUES BY ELEMENT, THROUGH 2016 (\$ MILLIONS)</i>	182
CHEMICAL SECTOR.....	182
<i>TABLE 124 RARE EARTH ELEMENTS FOR THE CHEMICAL INDUSTRY, 2011</i>	183
<i>TABLE 124 (CONTINUED)</i>	184
CURRENT MARKET SUMMARY	184
<i>TABLE 125 RARE EARTHS FOR THE CHEMICAL INDUSTRY: GLOBAL CONSUMPTION, THROUGH 2011 (METRIC TONS)</i>	185
Consumption and Revenues of Rare Earths by Element.....	185
<i>TABLE 126 RARE EARTHS FOR THE CHEMICAL INDUSTRY: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2011 (METRIC TONS REO)</i>	185

FIGURE 21 RARE EARTHS FOR THE CHEMICAL INDUSTRY:	
CONSUMPTION SHARE BY ELEMENT, 2011 (%).....	186
TABLE 127 RARE EARTHS FOR THE CHEMICAL INDUSTRY:	
GLOBAL REVENUES BY ELEMENT, THROUGH 2011 (\$ MILLIONS).....	187
Market Growth Trends	187
TABLE 128 FORECAST — CATALYSTS AND PHOTOCATALYSTS:	
GLOBAL REVENUES, THROUGH 2016 (\$ MILLIONS)	188
Market Forecast	188
TABLE 129 FORECAST — RARE EARTHS FOR THE CHEMICAL INDUSTRY: GLOBAL CONSUMPTION, THROUGH 2016 (METRIC TONS).....	188
Consumption and Revenues of Rare Earths by Element.....	189
TABLE 130 FORECAST — RARE EARTHS FOR THE CHEMICAL INDUSTRY: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2016 (METRIC TONS REO).....	189
FIGURE 22 FORECAST — RARE EARTHS FOR THE CHEMICAL INDUSTRY: CONSUMPTION SHARE BY ELEMENT, 2016 (%).....	190
TABLE 131 FORECAST — RARE EARTHS FOR THE CHEMICAL INDUSTRY: GLOBAL REVENUES BY ELEMENT, THROUGH 2016 (\$ MILLIONS)	191
Energy Sector	191
TABLE 132 RARE EARTH ELEMENTS FOR THE ENERGY SECTOR, 2011.....	192
Current Market Summary	192
TABLE 133 RARE EARTHS FOR THE ENERGY SECTOR: GLOBAL CONSUMPTION, THROUGH 2011 (METRIC TONS).....	193
Consumption and Revenues of Rare Earths by Element.....	193
TABLE 134 RARE EARTHS FOR THE ENERGY SECTOR: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2011 (METRIC TONS REO)	193
FIGURE 23 RARE EARTHS FOR THE ENERGY SECTOR:	
CONSUMPTION SHARE BY ELEMENT, 2011 (%).....	194
TABLE 135 RARE EARTHS FOR THE ENERGY SECTOR: GLOBAL REVENUES BY ELEMENT, THROUGH 2011 (\$ MILLIONS)	195
Market Growth Trends	195
Batteries.....	195
High-Temperature Superconductors	196
TABLE 136 FORECAST — SUPERCONDUCTORS: GLOBAL REVENUES BY TYPE, THROUGH 2016 (\$ MILLIONS).....	196
Fuel Cells	196
TABLE 137 FORECAST — FUEL CELLS: GLOBAL REVENUES BY TYPE, THROUGH 2016 (\$ MILLIONS).....	197
Solar Cells and Other Applications	197

<i>TABLE 138 FORECAST — PHOTOVOLTAIC MODULES: GLOBAL PRODUCTION BY TYPE, THROUGH 2016 (MW)</i>	198
MARKET FORECAST	198
<i>TABLE 139 FORECAST — RARE EARTHS FOR THE ENERGY SECTOR: GLOBAL CONSUMPTION, THROUGH 2016 (METRIC TONS).....</i>	199
Consumption and Revenues of Rare Earths by Element.....	199
<i>TABLE 140 FORECAST — RARE EARTHS FOR THE ENERGY SECTOR: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2016 (METRIC TONS REO).....</i>	199
<i>FIGURE 24 FORECAST — RARE EARTHS FOR THE ENERGY SECTOR: CONSUMPTION SHARE BY ELEMENT, 2016 (%)</i>	200
<i>TABLE 141 FORECAST — RARE EARTHS FOR THE ENERGY SECTOR: GLOBAL REVENUES BY ELEMENT, THROUGH 2016 (\$ MILLIONS)</i>	201
OTHER SECTORS.....	201
<i>TABLE 142 RARE EARTH ELEMENTS FOR OTHER SECTORS, 2011.....</i>	202
<i>TABLE 142 (CONTINUED).....</i>	203
CURRENT MARKET SUMMARY	203
<i>TABLE 143 RARE EARTHS FOR OTHER SECTORS: GLOBAL CONSUMPTION, THROUGH 2011 (METRIC TONS).....</i>	204
Consumption and Revenues of Rare Earths by Element.....	204
<i>TABLE 144 RARE EARTHS FOR THE OTHER SECTORS: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2011 (METRIC TONS REO)</i>	204
<i>FIGURE 25 RARE EARTHS FOR OTHER SECTORS: CONSUMPTION SHARE BY ELEMENT, 2011 (%)</i>	205
<i>TABLE 145 RARE EARTHS FOR OTHER SECTORS: GLOBAL REVENUES BY ELEMENT, THROUGH 2011 (\$ MILLIONS)</i>	206
MARKET GROWTH TRENDS	206
<i>TABLE 146 FORECAST — VARIOUS APPLICATIONS OF RARE EARTHS IN THE LIFE SCIENCES, SENSORS AND INSTRUMENTATION, AND CONSUMER SECTORS: GLOBAL REVENUES, THROUGH 2016 (\$ BILLIONS)</i>	206
MARKET FORECAST	207
<i>TABLE 147 FORECAST — RARE EARTHS FOR OTHER SECTORS: GLOBAL CONSUMPTION, THROUGH 2016 (METRIC TONS)</i>	207
Consumption and Revenues of Rare Earths by Element.....	207
<i>TABLE 148 FORECAST — RARE EARTHS FOR OTHER SECTORS: GLOBAL CONSUMPTION BY ELEMENT, THROUGH 2016 (METRIC TONS REO).....</i>	208
<i>FIGURE 26 FORECAST — RARE EARTHS FOR OTHER SECTORS: CONSUMPTION SHARE BY ELEMENT, 2016 (%)</i>	208
<i>FIGURE 26 (CONTINUED).....</i>	209

<i>TABLE 149 FORECAST — RARE EARTHS FOR OTHER SECTORS: GLOBAL REVENUES BY ELEMENT, THROUGH 2016 (\$ MILLIONS)</i>	209
CHAPTER EIGHT: GLOBAL INDUSTRY STRUCTURE.....	210
MINERS AND SUPPLIERS OF RARE EARTHS	210
<i>TABLE 150 MINERS AND SUPPLIERS OF RARE EARTHS, 2011</i>	211
<i>TABLE 150 (CONTINUED).....</i>	212
<i>TABLE 150 (CONTINUED).....</i>	213
<i>TABLE 150 (CONTINUED).....</i>	214
<i>TABLE 150 (CONTINUED).....</i>	215
<i>TABLE 150 (CONTINUED).....</i>	216
<i>TABLE 150 (CONTINUED).....</i>	217
<i>TABLE 151 GEOGRAPHICAL DISTRIBUTION OF KEY PLAYERS, 2011 (NUMBER OF COMPANIES)</i>	218
OTHER KEY PLAYERS IN THE RARE EARTH INDUSTRY	218
<i>TABLE 152 OTHER RELEVANT INDUSTRY PLAYERS, 2011.....</i>	218
<i>TABLE 152 (CONTINUED).....</i>	219
NOTABLE RECENT INDUSTRY CHANGES	219
<i>TABLE 153 NOTABLE INDUSTRY CHANGES SINCE 2009.....</i>	219
<i>TABLE 153 (CONTINUED).....</i>	220
RARE EARTHS PRODUCTION BY REGION	220
<i>TABLE 154 RARE EARTHS PRODUCTION BY REGION, THROUGH 2016 (METRIC TONS).....</i>	221
RARE EARTHS CONSUMPTION BY REGION.....	221
<i>TABLE 155 RARE EARTHS CONSUMPTION BY REGION, THROUGH 2016 (METRIC TONS).....</i>	222
COMPANY PROFILES	222
AGC SEIMI CHEMICAL	222
ARAFURA RESOURCES	223
BAOTOU STEEL RARE EARTH HIGH-TECH	224
Baotou Rare Earth.....	224
Baotou Research Institute of Rare Earths	225
CHINA MINMETALS	226
CHINA RARE EARTH HOLDINGS	227
DANDONG JINLONG RARE EARTH.....	228
FERRO CORPORATION	229
GANSU RARE EARTH GROUP	230
INDIAN RARE EARTHS	231
Indian Rare Earths (Continued)	232
IRTYSH RARE EARTHS	233
LYNAS CORPORATION	233
Lynas Corporation (Continued)	234
MITSUI MINING AND SMELTING.....	235
Nippon Yttrium	236

MOLYCORP	236
Molycorp (Continued)	237
NEO MATERIAL TECHNOLOGIES	238
Neo Material Technologies (Continued)	239
RHODIA.....	240
Rhodia (Continued).....	241
SANTOKU CORPORATION	242
Santoku Corporation (Continued).....	243
SHIN-ETSU CHEMICAL CO., LTD.	244
Shin-Etsu Chemical Co., Ltd. (Continued).....	245
SHOWA DENKO.....	246
SUMMIT ATOM RARE EARTH COMPANY	247
TREIBACHER INDUSTRIE	248
Treibacher Industrie (Continued)	249
Treibacher Industrie (Continued)	250
 CHAPTER NINE: U.S. PATENT ANALYSIS	251
INTRODUCTION	251
SUMMARY OF PATENTS AWARDED DURING THE PERIOD 2009 THROUGH 2011.....	251
<i>TABLE 156 RARE EARTHS — U.S. PATENTS, 2011</i>	252
<i>TABLE 156 (CONTINUED)</i>	253
<i>TABLE 156 (CONTINUED)</i>	254
<i>TABLE 156 (CONTINUED)</i>	255
<i>TABLE 156 (CONTINUED)</i>	256
<i>TABLE 156 (CONTINUED)</i>	257
<i>TABLE 156 (CONTINUED)</i>	258
<i>TABLE 156 (CONTINUED)</i>	259
<i>TABLE 156 (CONTINUED)</i>	260
<i>TABLE 156 (CONTINUED)</i>	261
<i>TABLE 156 (CONTINUED)</i>	262
<i>TABLE 157 RARE EARTHS — U.S. PATENTS, 2010</i>	263
<i>TABLE 157 (CONTINUED)</i>	264
<i>TABLE 157 (CONTINUED)</i>	265
<i>TABLE 157 (CONTINUED)</i>	266
<i>TABLE 157 (CONTINUED)</i>	267
<i>TABLE 157 (CONTINUED)</i>	268
<i>TABLE 157 (CONTINUED)</i>	269
<i>TABLE 157 (CONTINUED)</i>	270
<i>TABLE 157 (CONTINUED)</i>	271
<i>TABLE 157 (CONTINUED)</i>	272
<i>TABLE 157 (CONTINUED)</i>	273
<i>TABLE 157 (CONTINUED)</i>	274
<i>TABLE 157 (CONTINUED)</i>	275
<i>TABLE 158 RARE EARTHS — U.S. PATENTS, 2009</i>	276

<i>TABLE 158 (CONTINUED).....</i>	277
<i>TABLE 158 (CONTINUED).....</i>	278
<i>TABLE 158 (CONTINUED).....</i>	279
<i>TABLE 158 (CONTINUED).....</i>	280
<i>TABLE 158 (CONTINUED).....</i>	281
<i>TABLE 158 (CONTINUED).....</i>	282
<i>TABLE 158 (CONTINUED).....</i>	283
GENERAL TRENDS.....	284
<i>TABLE 159 RARE EARTHS: U.S. PATENT TRENDS, 2009–2011</i>	284
<i>FIGURE 27 RARE EARTHS: U.S. PATENT TRENDS, 2009–2011</i>	
(<i>NUMBER OF PATENTS).....</i>	285
TRENDS BY COUNTRY AND REGION.....	285
<i>FIGURE 28 SHARES OF U.S. PATENTS RELATED TO RARE</i>	
<i>EARTHS BY REGION, 2009–2011 (%).....</i>	286
<i>FIGURE 29 RARE EARTHS: PATENTS BY COUNTRY, 2009–2011 (%).....</i>	287
<i>FIGURE 29 (CONTINUED).....</i>	288
TRENDS BY ASSIGNEE	288
TRENDS BY ASSIGNEE (CONTINUED)	289
<i>TABLE 160 ASSIGNEES OF U.S. PATENTS RELATED TO RARE</i>	
<i>EARTHS, 2009–2011</i>	289
<i>TABLE 160 (CONTINUED).....</i>	290
<i>TABLE 160 (CONTINUED).....</i>	291
<i>TABLE 160 (CONTINUED).....</i>	292
<i>TABLE 160 (CONTINUED).....</i>	293
<i>TABLE 160 (CONTINUED).....</i>	294
<i>TABLE 160 (CONTINUED).....</i>	295
TRENDS BY PATENT CATEGORY	295
<i>FIGURE 30 RARE EARTHS: SHARES OF U.S. PATENTS BY</i>	
<i>CATEGORY, 2009–2011 (%)</i>	296
TRENDS BY APPLICATION	296
TRENDS BY APPLICATION (CONTINUED)	297
<i>FIGURE 31 RARE EARTHS: SHARES OF U.S. PATENTS BY</i>	
<i>APPLICATION, 2009–2011 (%)</i>	298
TRENDS BY RARE EARTH TYPE.....	299
<i>FIGURE 32 RARE EARTHS: SHARES OF U.S. PATENTS BY</i>	
<i>MATERIAL TYPE, 2009–2011 (%)</i>	300