# 資源問題の課題と展望



2008. 1. 25

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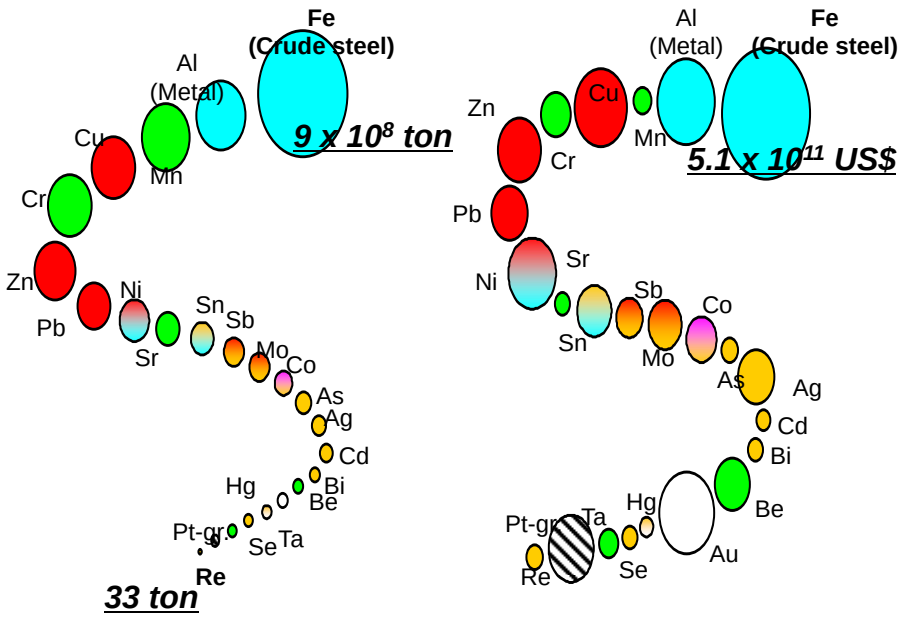
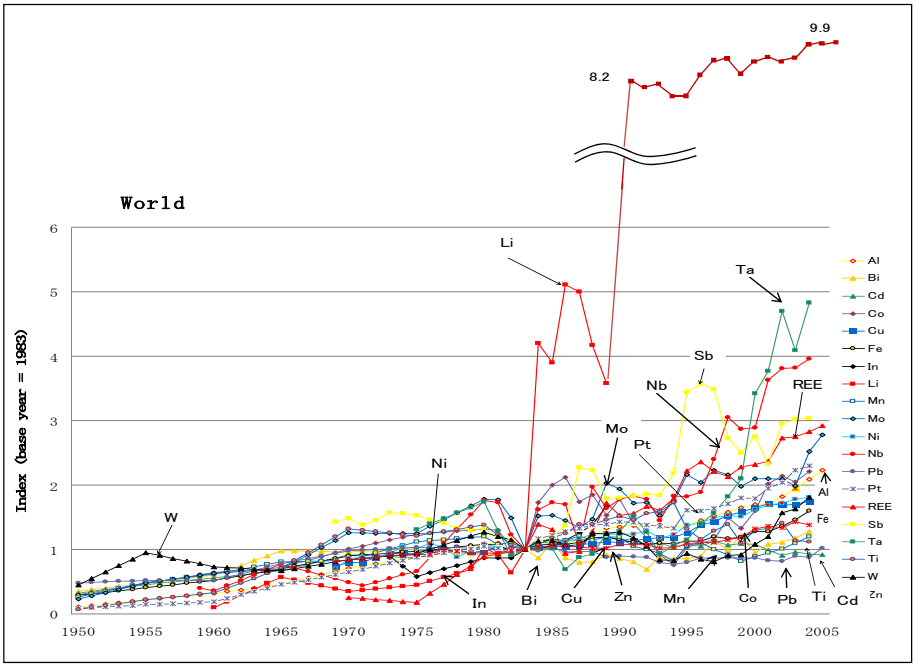
## I. 多種、多様になった鉱物資源

Table 1 Production and reserves of 35 minerals and 4 energies

| Element | Unit | Production (P)[a] | Reserves (R) | Lifetime (R/P) | Price (U.S.$/kg) | Major countries of reserves | | |
|---|---|---|---|---|---|---|---|---|
| Al(bauxite) | 1000t | 154,166 | 23,000,000 | 149 | *** | Guinea(32%) | Australia(19%) | Jamaica(9%) |
| Al(metal) | 1000t | 28,005 | - | - | 1.48 | - | | |
| Sb | t | 154,537 | 1,800,000 | 12 | 2.43 | China(44%) | Russia(19%) | Bolivia(17%) |
| As | 1000t | 35.1 | 702-1,053 | 20-30 | 0.7 | - | | |
| Be | t | 3,300 | - | - | 745 | - | | |
| Bi | t | 3,810 | 330,000 | 87 | 6.39 | China(73%) | Peru(3%) | |
| B | 1000t | 4,350 | 170,000 | 39 | 0.4-0.425 | Turkey(35%) | U.S.A.(24%) | Russia(24%) |
| Cd | t | 16,873 | 600,000 | 36 | 0.66 | Australia(18%) | China(15%) | U.S.A.(15%) |
| Cr | 1000t | 13,500 | 810,000 | 60 | 0.063 | Kazakhstan(36%) | South Africa(12% | India(3%) |
| Co | t | 47,600 | 7,000,000 | 147 | 20.7 | Congo(49%) | Australia(21%) | Cuba(14%) |
| Cu | 1000t | 13,670 | 470,000 | 34 | 1.72 | Chile(32%) | U.S.A.(7%) | Indonesia(7%) |
| Au | kg | 2,550,000 | 43,000,000 | 17 | 12,346 | South Africa(19% | U.S.A.(13%) | Australia(12%) |
| In | t | N.A. | 2,500 | - | 175 | Canada(28%) | U.S.A.(12%) | China(11%) |
| Fe(ore) | 1000t | 1,120,000 | 70,000,000 | 63 | 0.0250 | Russia(20%) | Australia(16%) | Ukraine(13%) |
| Fe(crude steel) | 1000t | 900,000 | - | - | 0.563 | - | - | |
| Pb | 1000t | 2,851 | 67,000 | 23 | 0.970 | Australia(23%) | China(17%) | U.S.A.(12%) |
| Li | t | N.A. | 4,100,000 | - | N.A. | Chile(73%) | China(13%) | Brazil(5%) |
| Mn | 1000t | 21,900 | 300,000 | 14 | 0.00235 | Ukraine(47%) | China(13%) | Australia(11%) |
| Hg | t | 1,530 | 120,000 | 78 | 4.93 | Spain(63%) | Kyrgyzstan(6%) | |
| Mo | 1000t | 128 | 8,600 | 67 | 11.6 | China(38%) | U.S.A.(31%) | Chile(13%) |
| Ni | 1000t | 1,286 | 62,000 | 48 | 9.45 | Australia(36%) | Russia(11%) | Cuba(9%) |
| Nb | t | 32,800 | 4,400,000 | 134 | 14.5 | Brazil(98%) | | |
| Pt-gr. | kg | 453,000 | 71,000,000 | 157 | 18,970 | South Africa(89% | Russia(9%) | U.S.A.(1%) |
| REE | t | 95,000 | 88,000,000 | 926 | - | China(31%) | Russia(22%) | U.S.A.(15%) |
| Re | kg | 33,000 | 2,400,000 | 73 | 840.0 | Chile(54%) | U.S.A.(16%) | Russia(13%) |
| Se | t | 1,430 | 82,000 | 57 | 11.0 | Chile(19%) | U.S.A.(12%) | Canada(8%) |
| Si | 1000t | 4,000 | N.A. | - | 1.35 | - | - | |
| Ag | t | 18,243 | 270,000 | 15 | 150 | Porland(19%) | Mexico(14%) | Peru(13%) |
| Sr | t | 370,000 | 6,800,000 | 18 | 0.1 | N.A. | | |
| Ta | t | 1,210 | 43,000 | 36 | 60.6 | Australia(93%) | | |
| Th | t | 5,650 | 1,200,000 | 212 | 107 | Australia(25%) | India(24%) | Norway(14%) |
| Sn | 1000t | 255 | 6,100 | 24 | 7.87 | China(28%) | Malaysia(16%) | Indonesia(13%) |
| Ti | 1000t | 4,950 | 420,000 | 85 | 6.50 | Australia(48%) | South Africa(15% | Norway(10%) |
| W | t | 59,100 | 2,900,000 | 49 | 50.0 | China(62%) | Canada(9%) | Russia(9%) |
| V | t | 60,000 | 13,000,000 | 217 | 3.31 | China(38%) | Russia(38%) | South Africa(23% |
| Zn | 1000t | 9,184 | 220,000 | 24 | 0.86 | Australia(15%) | China(15%) | U.S.A.(14%) |
| Zr | 1000t | 864 | 38,000 | 44 | 20-31 | South Africa(37% | Australia(24%) | Ukrine(11%) |
| Crude Oil | 1000toe | 3,702,900 | 161,900,000 | 44 | 0.211 | Saudi Arabia(22.1 | Iran(11.2%) | Iraq(9.7%) |
| Natural Gas | 1000toe | 2,355,400 | 161,286,572 | 68 | 0.110 | Russia(26.8%) | Iran(15.4%) | Qatar(14.4%) |
| Coal | 1000t | 5,185,200 | 909,064,000 | 175 | 0.043 | U.S.A.(27.1%) | Russia(17.3%) | China(12.6%) |
| Uranium | t | 36,042 | 2,458,200 | 68 | 32.0 | Australia(23.2%) | Kazakhstan(16.8% | U.S.A.(10.9%) |




Metal production. Market size.




## II. 歯止めのかからない資源の需要増加

1. ベースメタル
2. レアメタル

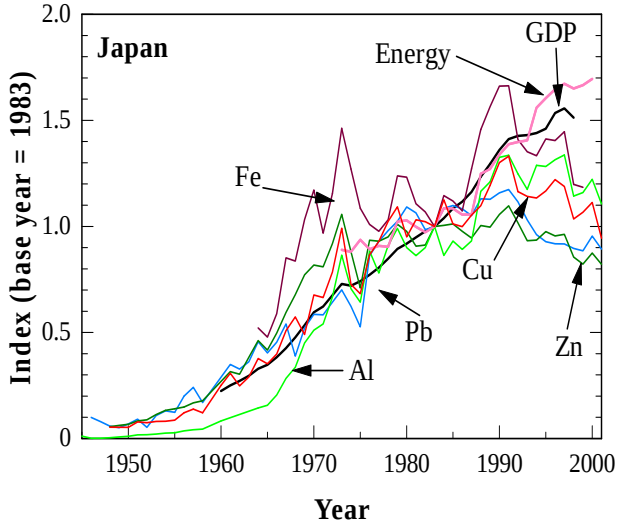



**図1-4　わが国の1983年を基準にした主要金属消費量とエネルギー消費量、GDPの成長**
（出典：IEA, OECD, WBMS）

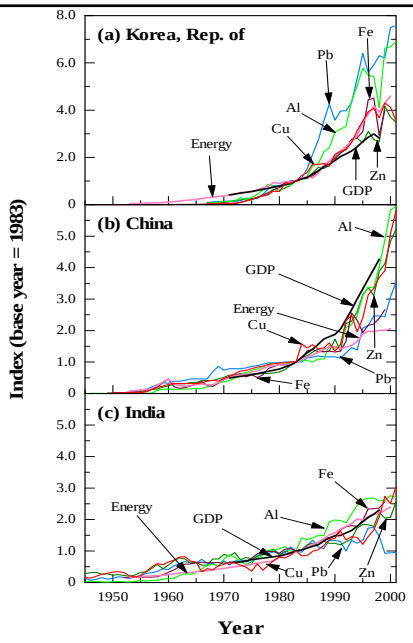
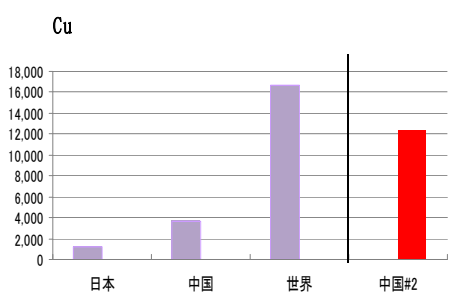
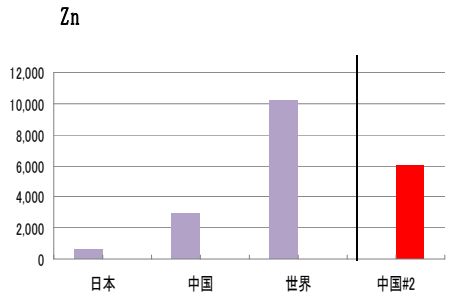


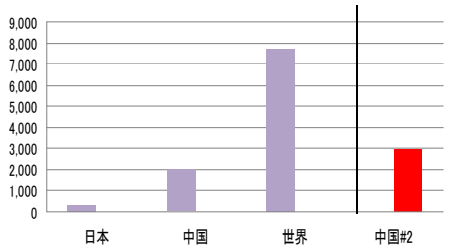

**図1-6 韓国(a)、中国(b)、インド(c)における1983年を基準にした主要金属消費量とエネルギー消費量、GDPの成長（出典：IEA, OECD, WBMS）**



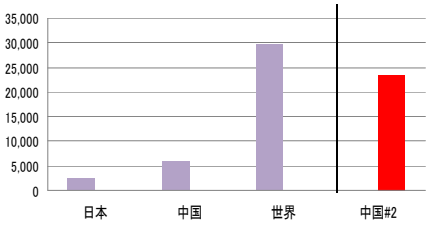

中国の消費の増加（現在の世界消費の75%）




中国の消費の増加（現在の世界消費の60%）




中国の消費の増加（現在の世界消費の39%）




中国の消費の増加（現在の世界消費の79%）

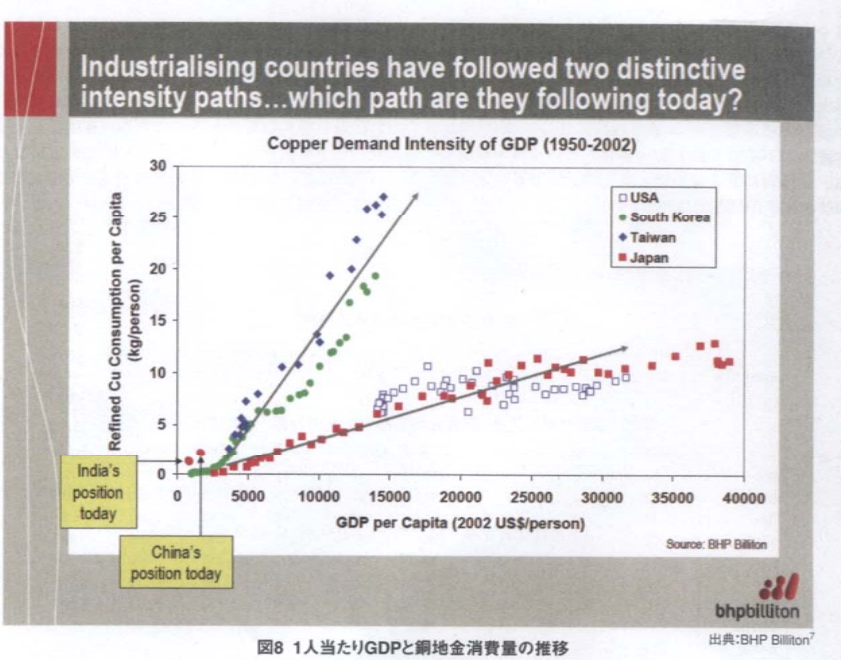
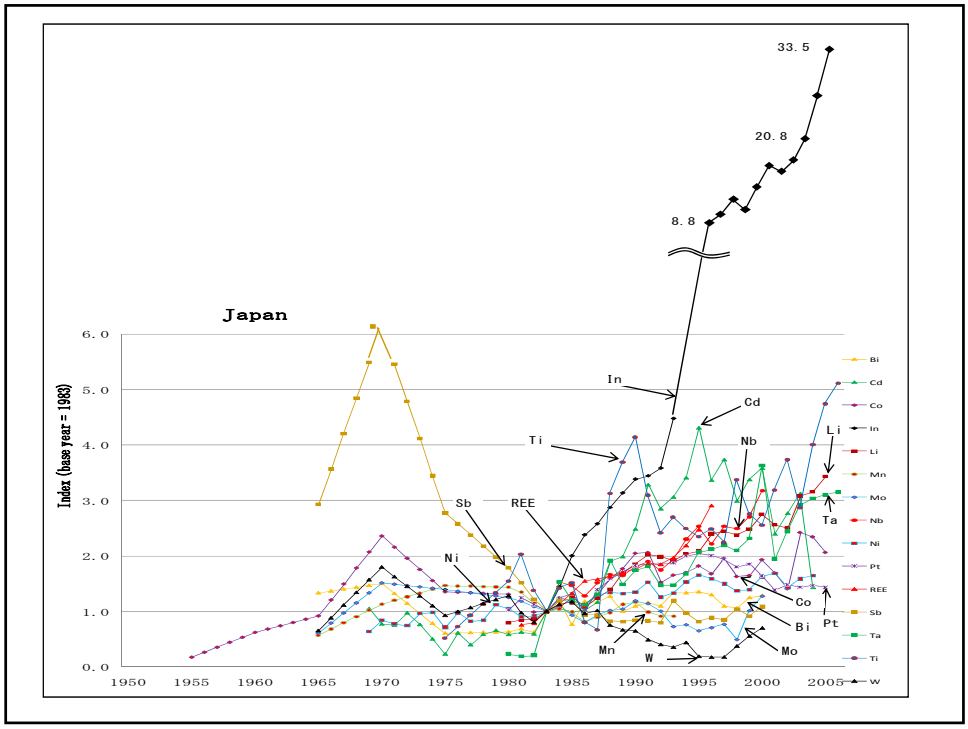
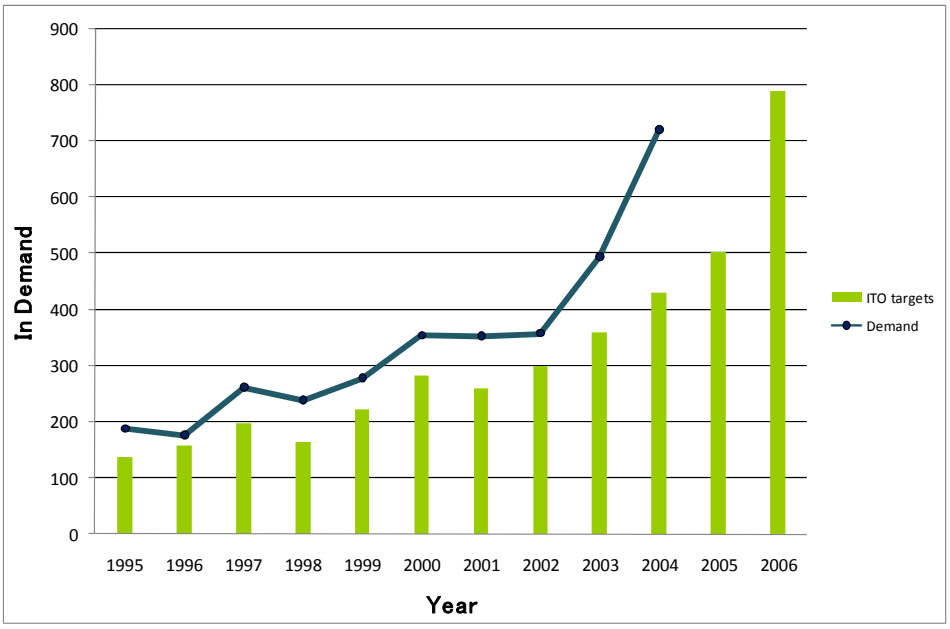


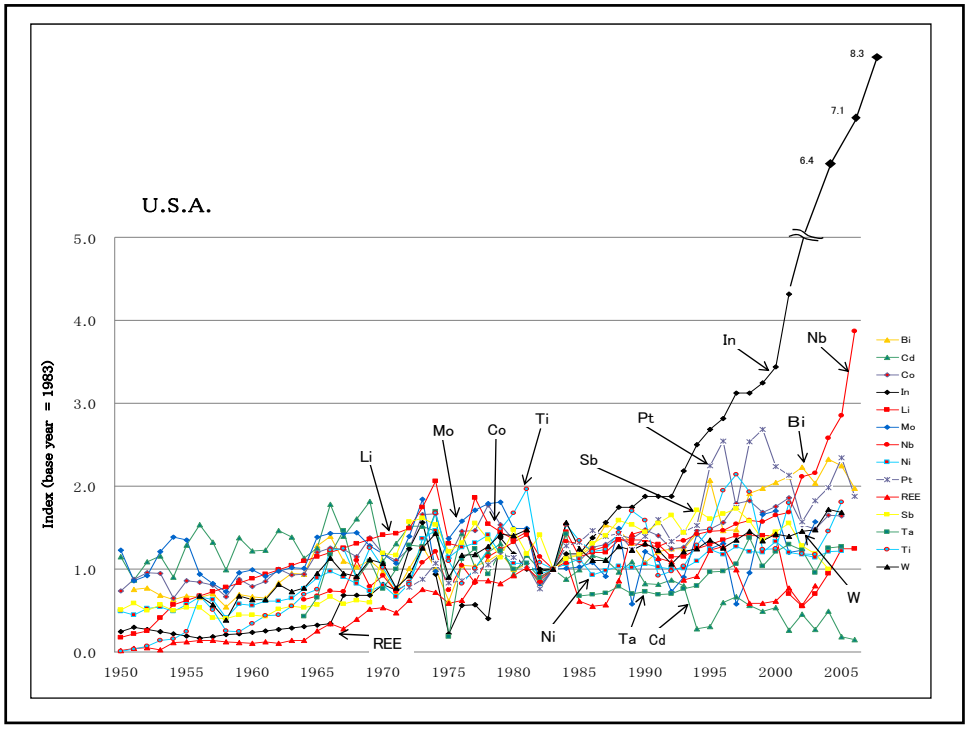

図8 1人当たりGDPと銅地金消費量の推移

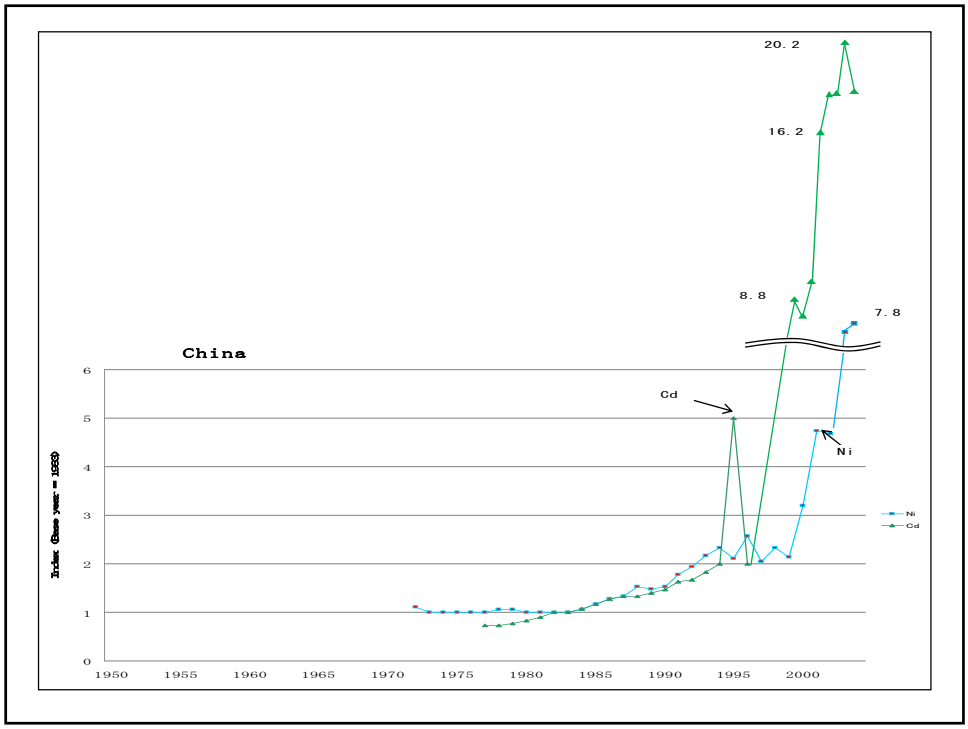
出典:BHP Billiton[7]




日本のインジウム金属と透明電極の消費量


U.S.A.
Index (base year = 1983)
8.3
7.1
6.4
5.0
4.0
3.0
2.0
1.0
0.0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
In
Nb
Bi
Li
Mo
Co
Ti
Pt
Sb
REE
Ni
Ta
Cd
W
Bi
Cd
Co
In
Li
Mo
Nb
Ni
Pt
REE
Sb
Ta
Ti
W


China
20.2
16.2
8.8
7.8
Cd
Ni
6
5
4
3
2
1
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Ni
Cd

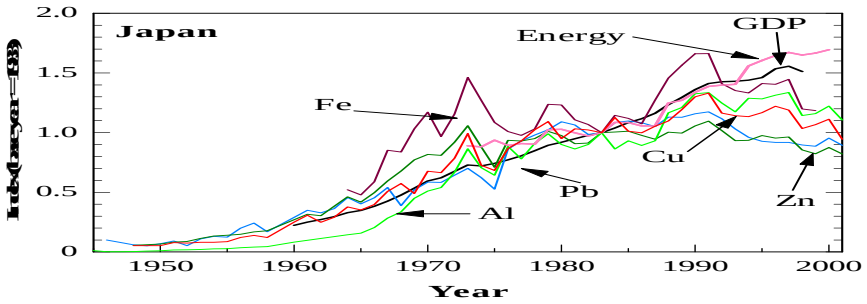
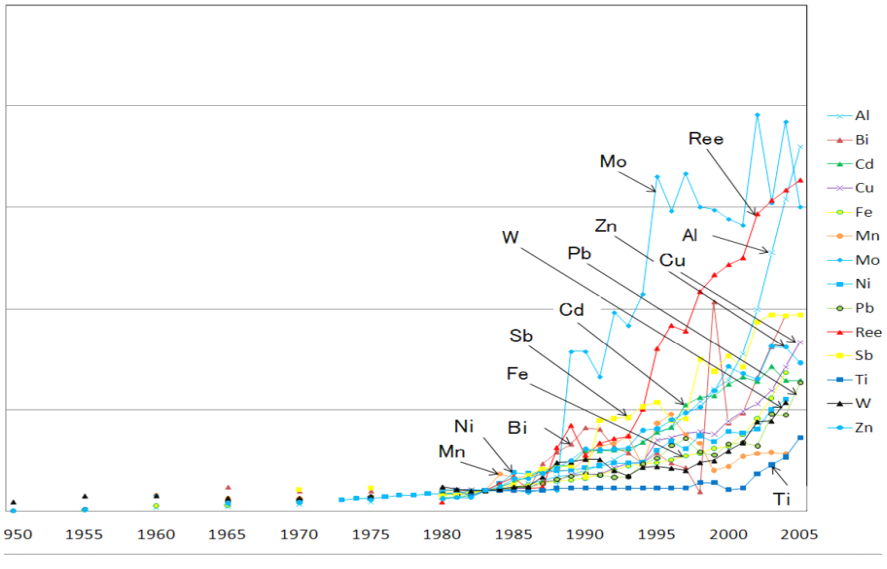
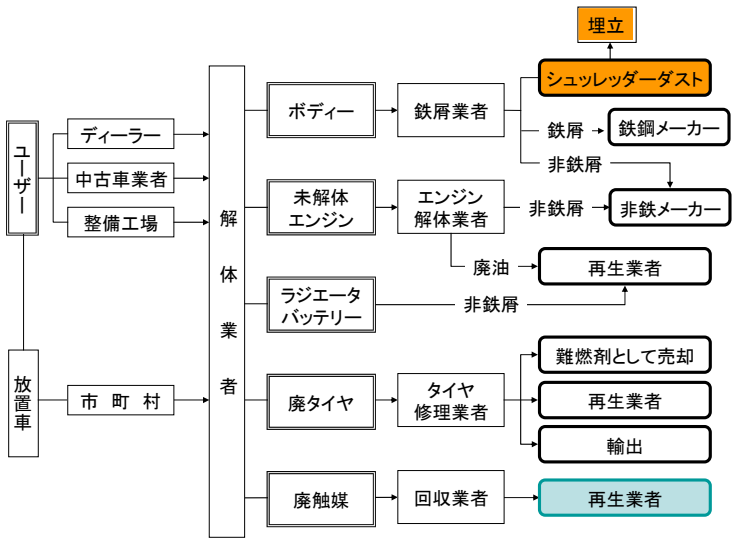



**図1-4　わが国の1983年を基準にした主要金属消費量とエネルギー消費量、GDPの成長**
（出典：IEA, OECD, WBMS）

# 中国鉱物資源生産推移

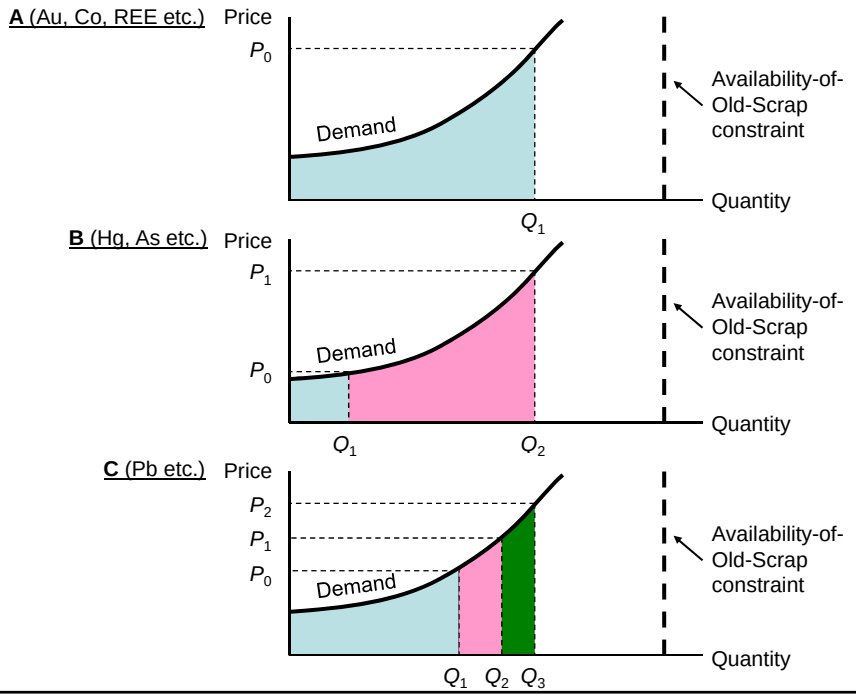


## III. リサイクルを過信することはできない



# リサイクルを促進させている要素

- 金属の市場価格(a)
- 環境保全
  - 環境保全(狭義)(b)
  - 健康管理(c)
- 資源の枯渇(d)



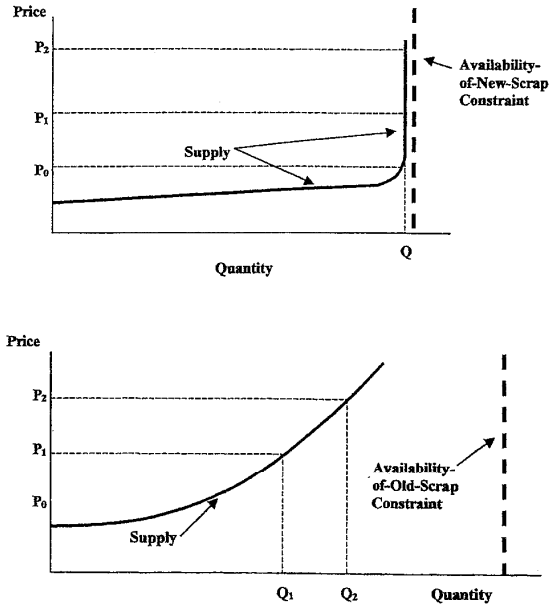
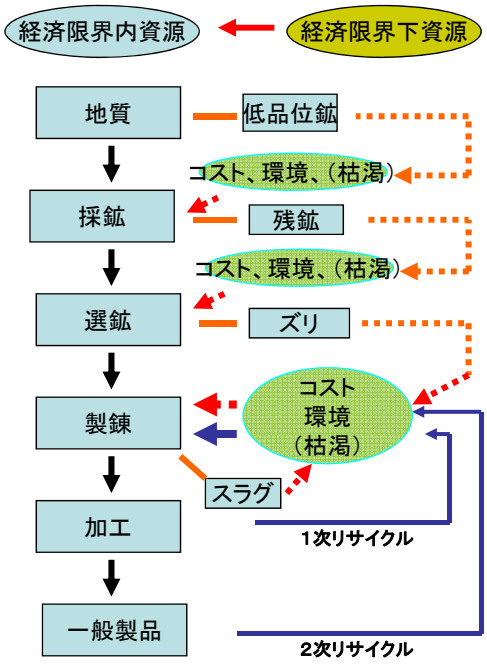
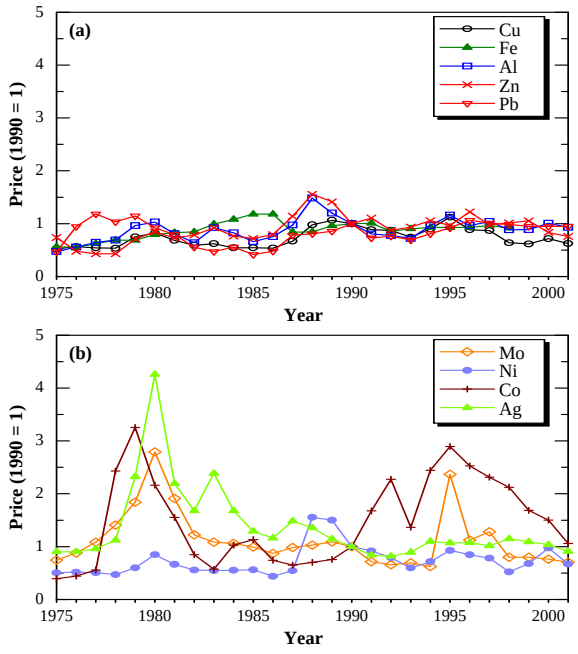
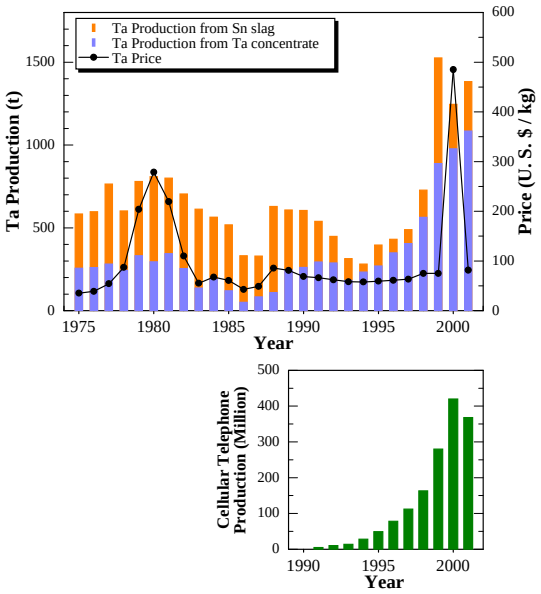



図 2.7　一次および二次スクラップの回収量と価格

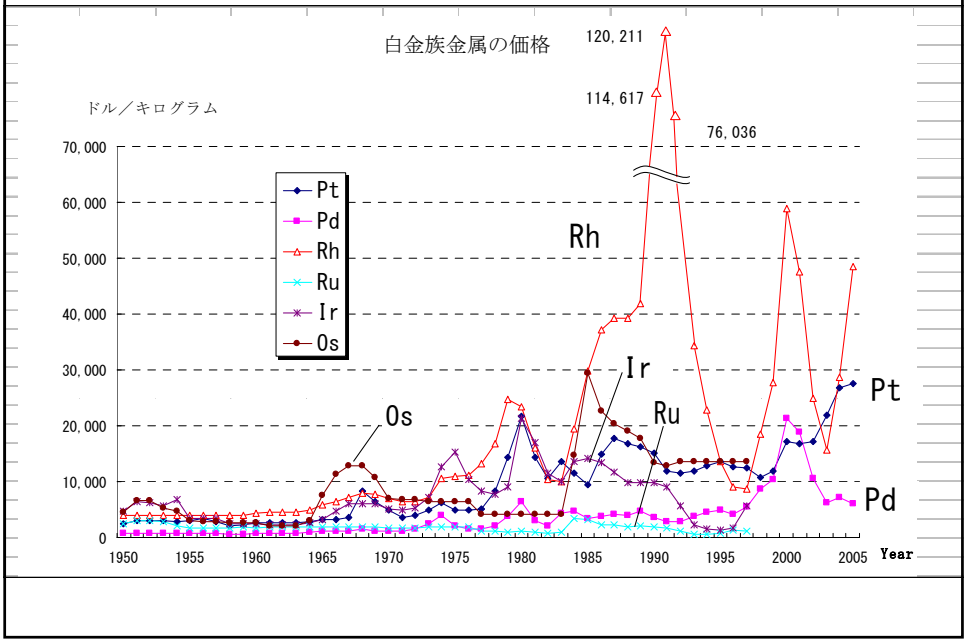


# Ⅳ金属資源の需給バランスの崩れと価格の高騰

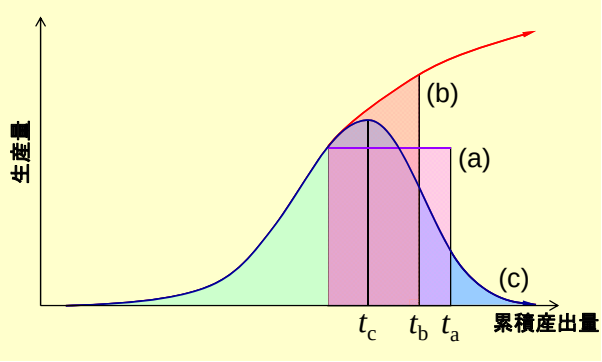





- **図3-1** タンタルの世界生産量と価格および日本の携帯電話生産台数



## Ⅴ.想定される枯渇パターン




(a) 静態的累積産出曲線　(b) 動態的累積産出曲線

(c) ベル型累積産出曲線

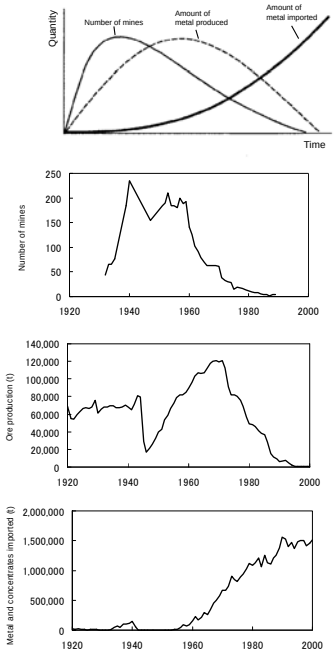
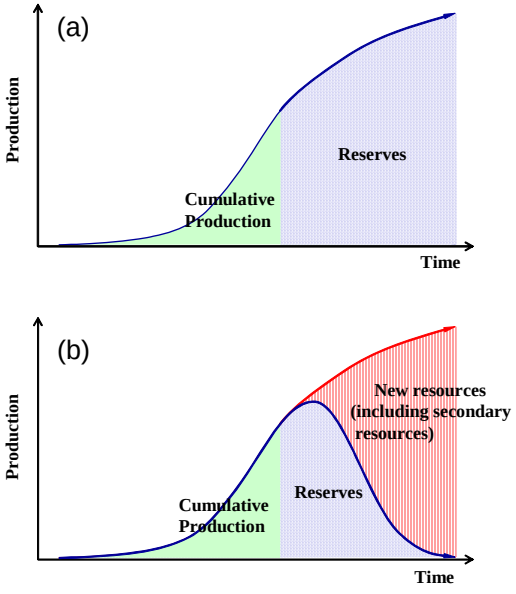
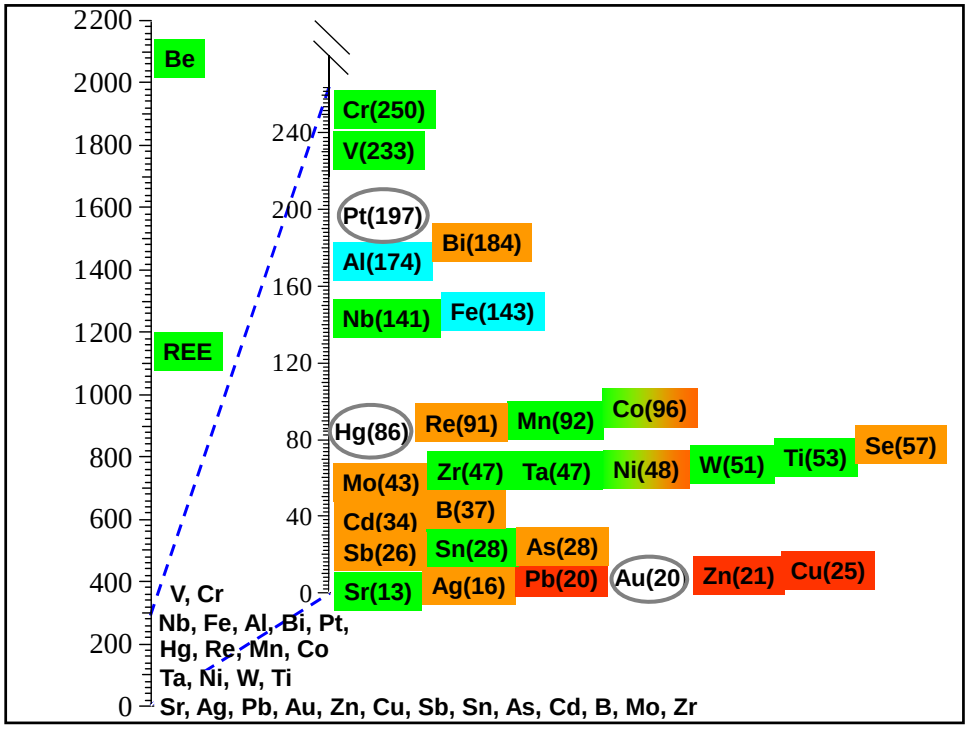



Fig.6 Hewett curves for number of mines, ore production, mental and concentrates imported in Japan (Source: Skinner(1976), MITI)




- Fig.9 Production path for resources: (a) adequate resources (b) scare resources



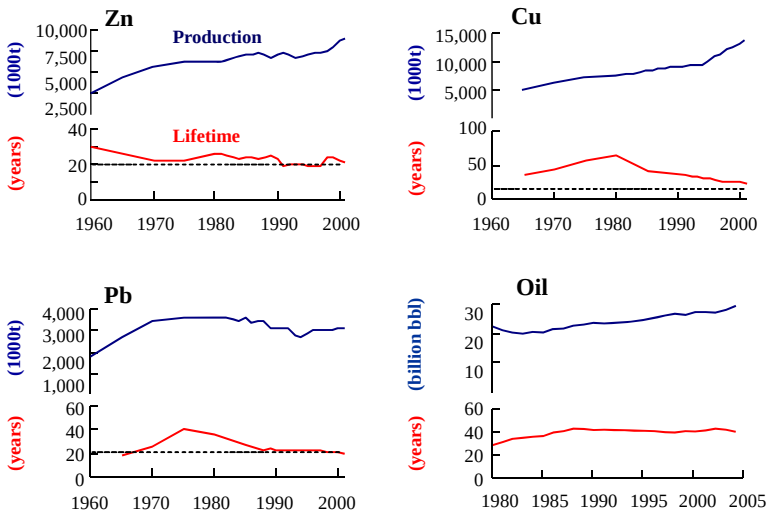
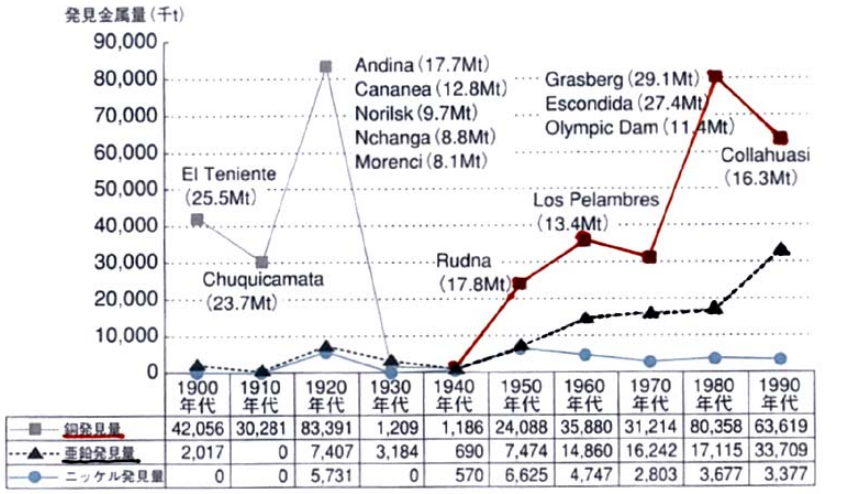




Figure 3.2. Production and lifetime of zinc, lead, copper, and oil. (Source: USBM, WBMS.)




| | 1900年代 | 1910年代 | 1920年代 | 1930年代 | 1940年代 | 1950年代 | 1960年代 | 1970年代 | 1980年代 | 1990年代 |
|---|---|---|---|---|---|---|---|---|---|---|
| 銅発見量 | 42,056 | 30,281 | 83,391 | 1,209 | 1,186 | 24,088 | 35,880 | 31,214 | 80,358 | 63,619 |
| 亜鉛発見量 | 2,017 | 0 | 7,407 | 3,184 | 690 | 7,474 | 14,860 | 16,242 | 17,115 | 33,709 |
| ニッケル発見量 | 0 | 0 | 5,731 | 0 | 570 | 6,625 | 4,747 | 2,803 | 3,677 | 3,377 |

（原図;澤田賢治）

図 3 銅・亜鉛・ニッケル鉱床の発見金属量推移（1900～1990年代）

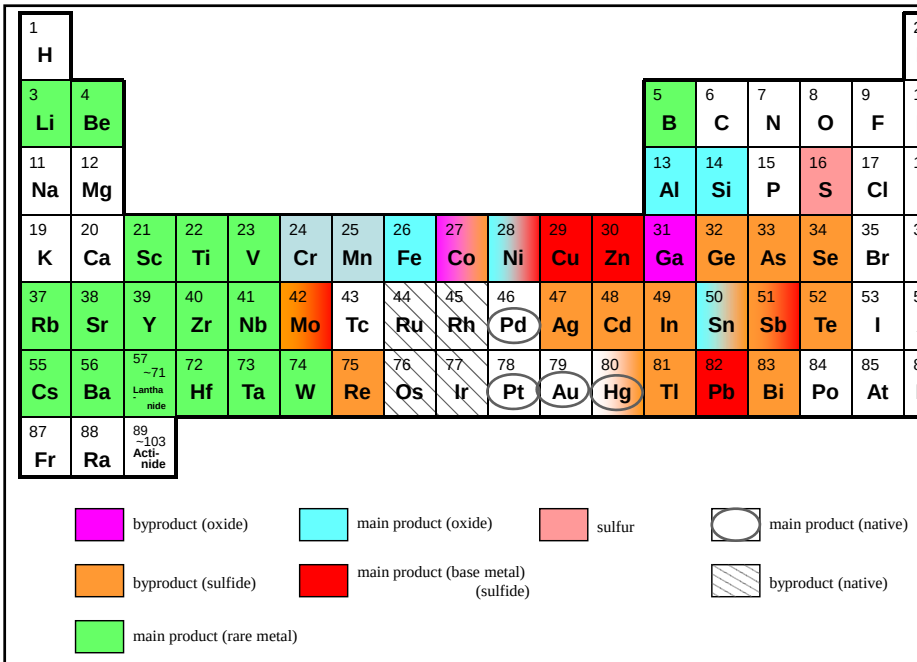
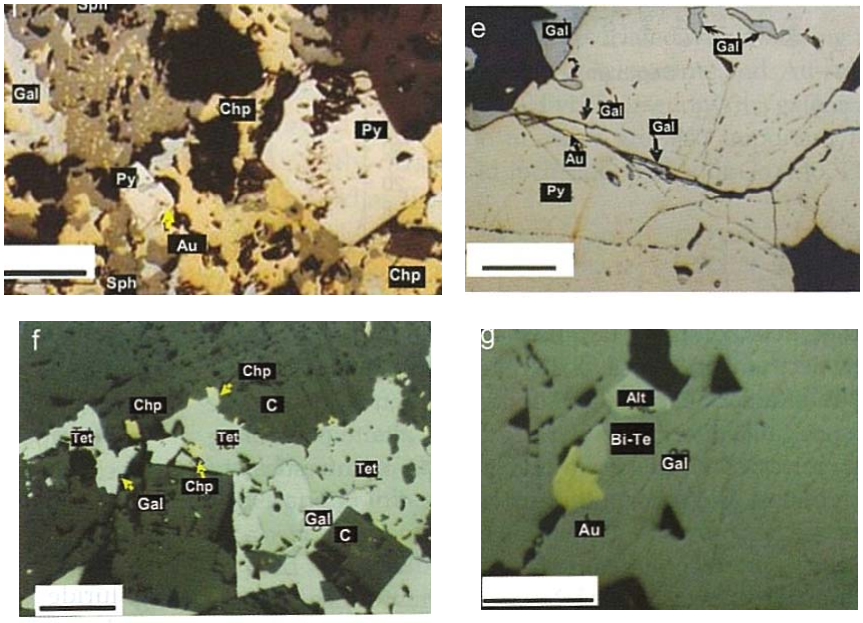
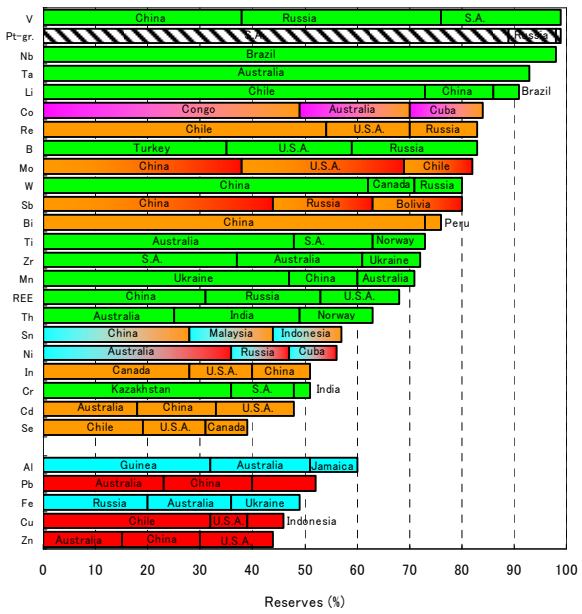
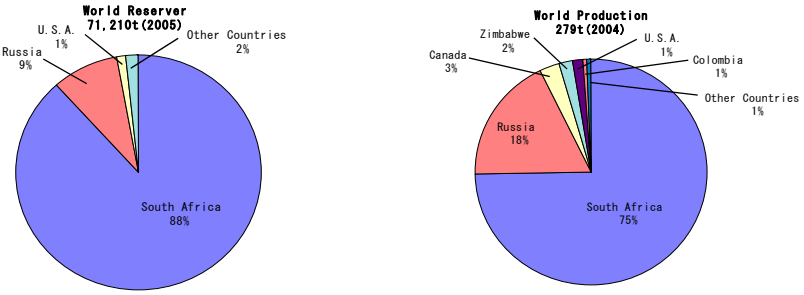



Figure 3. 7 Main product and byproduct on the periodic table of elements.

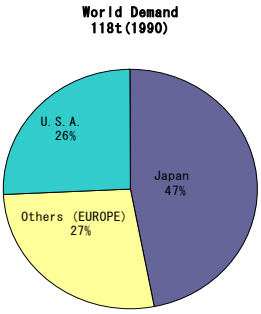

Gal
Chp
Py
Py
Au
Sph
Chp
e
Gal
Gal
Gal
Gal
Au
Py
f
Chp
Chp
C
Tet
Tet
Tet
Chp
Gal
Gal
C
g
Alt
Bi-Te
Gal
Au


V
Pt-gr.
Nb
Ta
Li
Co
Re
B
Mo
W
Sb
Bi
Ti
Zr
Mn
REE
Th
Sn
Ni
In
Cr
Cd
Se
Al
Pb
Fe
Cu
Zn
China
Russia
S.A.
S.A.
Russia
Brazil
Australia
Chile
China
Brazil
Congo
Australia
Cuba
Chile
U.S.A.
Russia
Turkey
U.S.A.
Russia
China
U.S.A.
Chile
China
Canada
Russia
China
Russia
Bolivia
China
Peru
Australia
S.A.
Norway
S.A.
Australia
Ukraine
Ukraine
China
Australia
China
Russia
U.S.A.
Australia
India
Norway
China
Malaysia
Indonesia
Australia
Russia
Cuba
Canada
U.S.A.
China
Kazakhstan
S.A.
India
Australia
China
U.S.A.
Chile
U.S.A.
Canada
Guinea
Australia
Jamaica
Australia
China
Russia
Australia
Ukraine
Chile
U.S.A.
Indonesia
Australia
China
U.S.A.
0
10
20
30
40
50
60
70
80
90
100
Reserves (%)










（Platinum Group）