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STRATEGIC OR CRITICAL MINERALS

Strategic and critical Minerals

- Strategic Minerals (also know as Critical Minerals) is a broad-based category that constitutes various minerals and elements; the majority of which are minor metals. Geography and availability of domestic supply often defines which minerals are deemed "critical" for any particular region or country.
- “Strategic and critical minerals are vital to our everyday lives. They are essential components of renewable energy, national defense equipment, medical devices, electronics, agricultural production and common household items. It is imperative that we identify the roadblocks to meeting our national minerals needs so that we can become less dependent on foreign supplies, increase our national security, and create more Indian jobs by securing our manufacturing industry and revitalizing our economy.”

Strategic and critical Minerals

- From the list of around 4000 minerals, it is challenging to exactly isolate strategic minerals. Also, as mentioned above a mineral which is strategic for one state may not be strategic for another.
- Still, in literature there are references made to some minerals which could be broadly considered as strategic minerals universally.
- No specific methodology has been followed for this identification, which is broadly based on observation and factoring the mineral requirements of the strategic industries.
- Vital Strategic Minerals include Antimony, Molybdenum, Borates, Nickel, Chromium, Cobalt, Silver, Copper, Titanium, Diamond, Tungsten, Germanium, Vanadium, Lithium, Zinc and Rare earths.

Strategic and critical minerals

- Minerals needed for military, industrial or commercial purposes that are essential to renewable energy, national defense equipment, medical devices, electronics, agricultural production and common household items
- Minerals that are essential for use but subject to potential supply disruptions
- Minerals that perform an essential function for which few or no satisfactory substitutes exist
- The absence of which would cause economic or social consequences
- 33-50% minerals are classified as such

- Demand
  - Material composition increasingly complex
  - Potential rapid growth in demand for some minerals
- Supply
  - Seemingly increasingly fragile
  - More fragmented supply chains, US import dependence, export restrictions on primary raw materials, resource nationalism, increased industry concentration

Differences between critical and strategic

- Minerals for military uses are strategic
- Minerals for which a threat to supply could involve harm to the economy are critical
- A critical mineral may or may not be strategic, while a strategic mineral will always be critical

Strategic and critical Minerals

- Strategic minerals and critical minerals. Strategic minerals were distinguished by their essentiality to the national defence, their high degree of salience in wartime and the need for strict conservation and control over distribution. While, Critical minerals were considered less essential and more available domestically, requiring some degree of conservation.
- Ten minerals, namely Sulphur, Lead, Petroleum, Zinc, Mercury, Platinum, Nickel, Graphite, 'Tin and Ferro-tungsten were identified as strategic minerals which are available in short supply in India.
- Indian policy makers are keen to identify the strategic minerals exclusively. An effort in that direction is visible in a report published by the Planning Commission in 2011. This report specifically identifies strategic minerals and metals. They include Tin, Cobalt, Lithium, Germanium, Gallium, Indium, Niobium, Beryllium, Tantalum, Tungsten, Bismuth and Selenium and Rare Earths.

Important Cultural Eras

- Stone Age (prior to 4000 B.C.)
- Bronze Age (4000 to 5000 B.C.)
- Iron Age (1500 B.C. to 1780 C.E.)
- Steel Age (1780 to 1945)
- Nuclear Age (1945 to the present)

- **Early civilisations**: fundamental importance of nonfuel minerals, metals, and materials technology and applications.
  - Stone Age, Copper Age, Bronze Age, Iron Age
  - Discovery of metals: **innovations and applications**
    - Gold (6000 BC), copper (4200 BC), silver (4000 BC), lead (3500 BC), tin (1750 BC), iron (1500 BC), mercury (750 BC)
- **Information Age**: developments in materials science and engineering, mineral exploration, and processing continue to enable and support the development of new technologies

History of strategic and critical minerals

- 1918: end of WW1 Harbord List developed
- 1938: Naval Appropriations Act
- 1939: Strategic Minerals Act
- 1940 Reconstruction Finance Corp formed to acquire and transport materials
- 1944: Surplus Property Act authorized strategic materials stockpile
- Became the Defense National Stockpile Center (DNSC)
- 1992: Congress ordered DNSC to sell the bulk of the stockpiles

Mining and Minerals In India

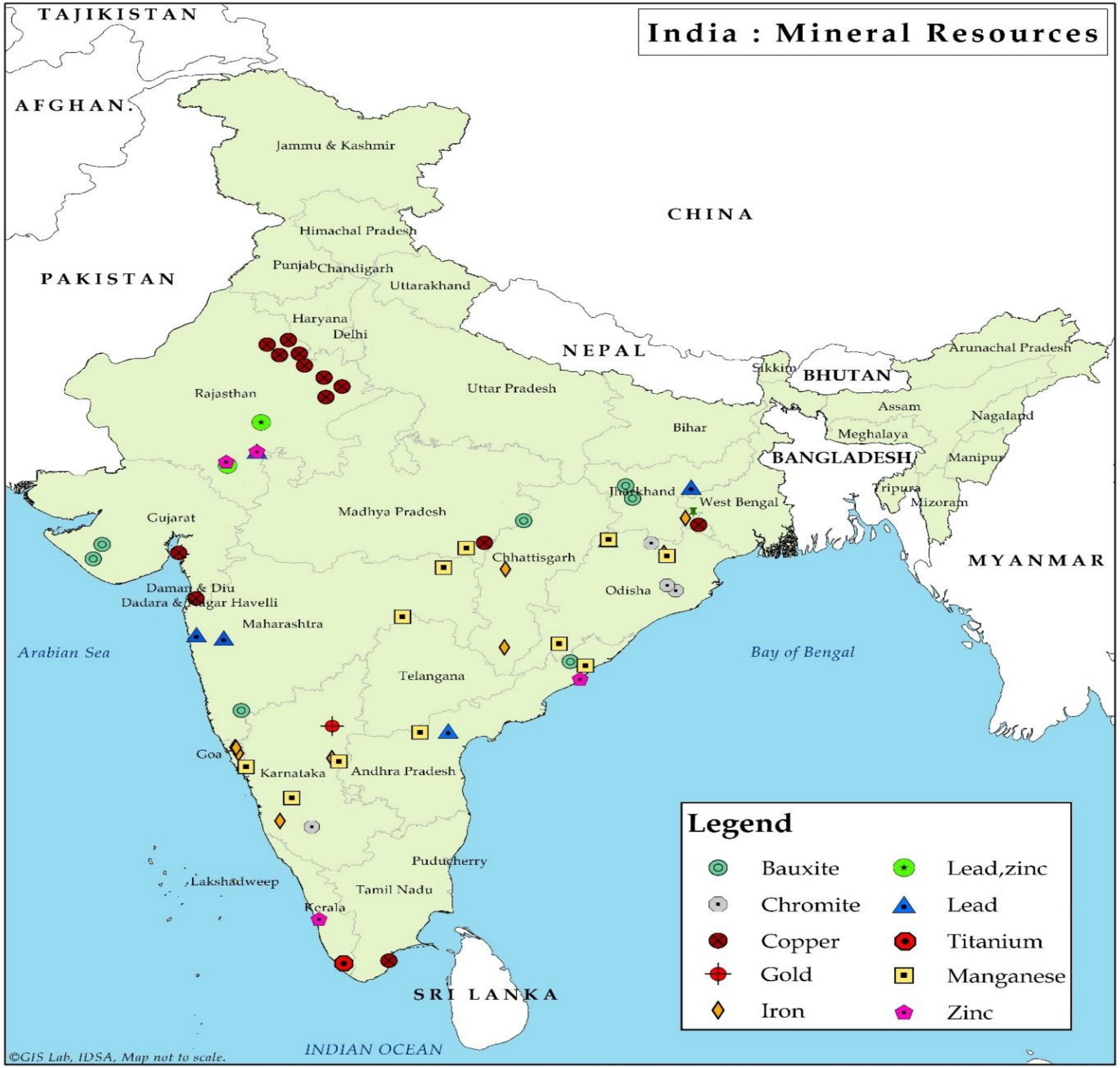
- Sir T. H. Holland, a former Director of the Geological Survey of India during the colonial period and D.N Wadia stated their study that the mineral industry and mining activities in India went through many ups and downs from the late 1800s to early 1900s. Around this period, the key minerals in use were iron, lead, copper, tin, zinc and antimony.
- Broadly, there are two categories of minerals: Major minerals and Minor minerals. The Mines and Minerals (Development and Regulation) Act, 1957 (MMDR Act 1957) defines “Minor minerals” as the minerals like building stones, gravel, ordinary clay, ordinary sand other than sand used for prescribed purposes, and any other mineral which the Central Government may, by notification in the Official Gazette, declare to be a minor mineral. Interestingly, there is no definition of major mineral in this act.

Mining and Minerals In India

- The country produces around 87 to 89 minerals, including 4 fuel minerals, 10 metallic minerals, 49 non-metallic minerals, 3 atomic minerals and 22 minor minerals (including building and other materials).12 India's domestic mining sector contributes about 10% -11% to the industrial sector and about 2.2% - 2.5% to the economy's GDP --which is one of the lowest vis-à-vis some of the larger emerging economies such as China (20 per cent), Australia (8 per cent) and Russia (14.7 per cent)
- almost 80% is that of coal and the rest 20% constitutes of very man metals and raw materials such as gold, copper, iron, lead, bauxite, zinc and uranium. India tops the world in respect to mica. The ranks third in the production of coal, barytes and chromite. India stands 4th in iron ore production and 6th in bauxite and manganese. India is also among the top ten countries in respect of aluminium production and stands at number ten. India's mining industry constitutes a large number of small operational mines.

Mining and Minerals In India

- As per the Annual Report 2017-18 of Ministry of Mines16 there has been around 8 to 12% increase in the production of minerals every year (for financial year 2018 it was 13%).
- The number of small operational mines in the country, excluding atomic, fuel and minor minerals, was 1,531 in 2017-18. Around 200 each of these mines are in Tamil Nadu, Madhya Pradesh and Gujarat.
- However, Rajasthan is in the leading position in terms of estimated value of mineral production in the country. It had a 20.26 % share in the national output, followed by Odisha with 17.77%.
- India has identified 5.71 lakh sq. km as the obvious geological potential (OGP) area, but, only 10% of it has been explored and 1.5% is being mined. India also has potential to mine minor minerals. It is estimated that their share in the value of production is about 26%


India : Mineral Resources
TAJIKISTAN
AFGHAN.
PAKISTAN
CHINA
NEPAL
BHUTAN
BANGLADESH
MYANMAR
SRI LANKA
Jammu & Kashmir
Himachal Pradesh
Punjab
Chandigarh
Uttarakhand
Haryana
Delhi
Rajasthan
Uttar Pradesh
Bihar
Sikkim
Arunachal Pradesh
Assam
Nagaland
Meghalaya
Manipur
Tripura
Mizoram
Jharkhand
West Bengal
Gujarat
Madhya Pradesh
Chhattisgarh
Odisha
Daman & Diu
Dadara & Nagar Havelli
Maharashtra
Telangana
Goa
Karnataka
Andhra Pradesh
Puducherry
Tamil Nadu
Kerala
Lakshadweep
Arabian Sea
Bay of Bengal
INDIAN OCEAN
Legend
Bauxite
Chromite
Copper
Gold
Iron
Lead,zinc
Lead
Titanium
Manganese
Zinc
©GIS Lab, IDSA, Map not to scale.

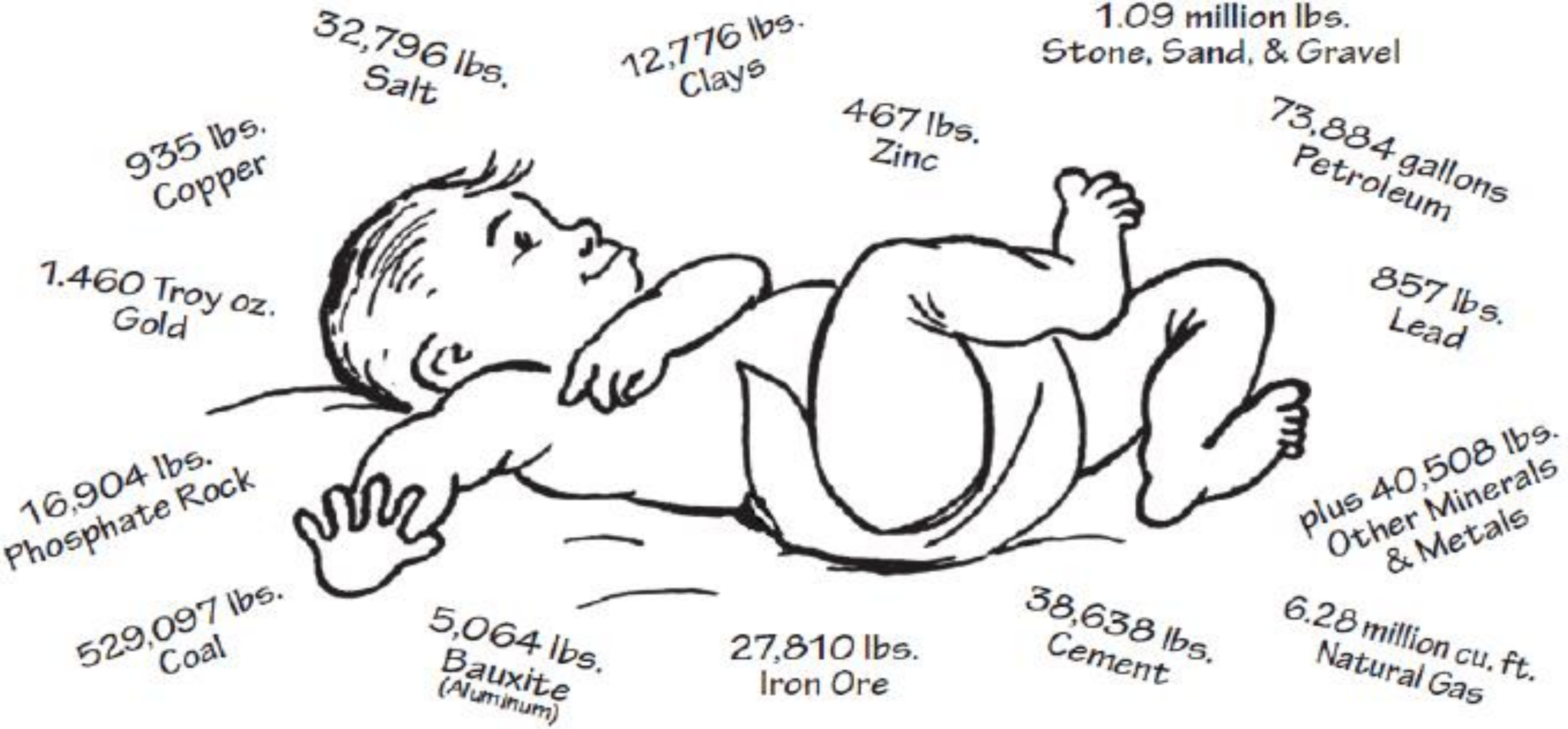
Why are minerals so important?

Your world is made of them!

The average American uses about two million pounds of industrial minerals, such as REE, potash, and aggregate, over the period of a lifetime.

Building blocks of our way of life

Every American Born Will Need...



2.96 million pounds of minerals, metals, and fuels in their lifetime

Every Year— 38,052 pounds of new minerals must be provided for every person in the United States to make the things we use every day

8,509 lbs. **Stone** used to make roads, buildings, bridges, landscaping, and for numerous chemical and construction uses

5,599 lbs. **Sand & Gravel** used to make concrete, asphalt, roads, blocks and bricks

496 lbs. **Cement** used to make roads, sidewalks, bridges, buildings, schools and houses

357 lbs. **Iron Ore** used to make steel— buildings; cars, trucks, planes, trains; other construction; containers

421 lbs. **Salt** used in various chemicals; highway deicing; food & agriculture

217 lbs. **Phosphate Rock** used to make fertilizers to grow food; and as animal feed supplements

164 lbs. **Clays** used to make floor & wall tile; dinnerware; kitty litter; bricks and cement; paper

65 lbs. **Aluminum (Bauxite)** used to make buildings, beverage containers, autos, and airplanes

12 lbs. **Copper** used in buildings; electrical and electronic parts; plumbing; transportation

11 lbs. **Lead** 87% used for batteries for transportation; also used in electrical, communications and TV screens

6 lbs. **Zinc** used to make metals rust resistant, various metals and alloys, paint, rubber, skin creams, health care and nutrition

36 lbs. **Soda Ash** used to make all kinds of glass; in powdered detergents; medicines; as a food additive; photography; water treatment

5 lbs. **Manganese** used to make almost all steels for construction, machinery and transportation

332 lbs. **Other Nonmetals** have numerous uses: glass, chemicals, soaps, paper, computers, cell phones

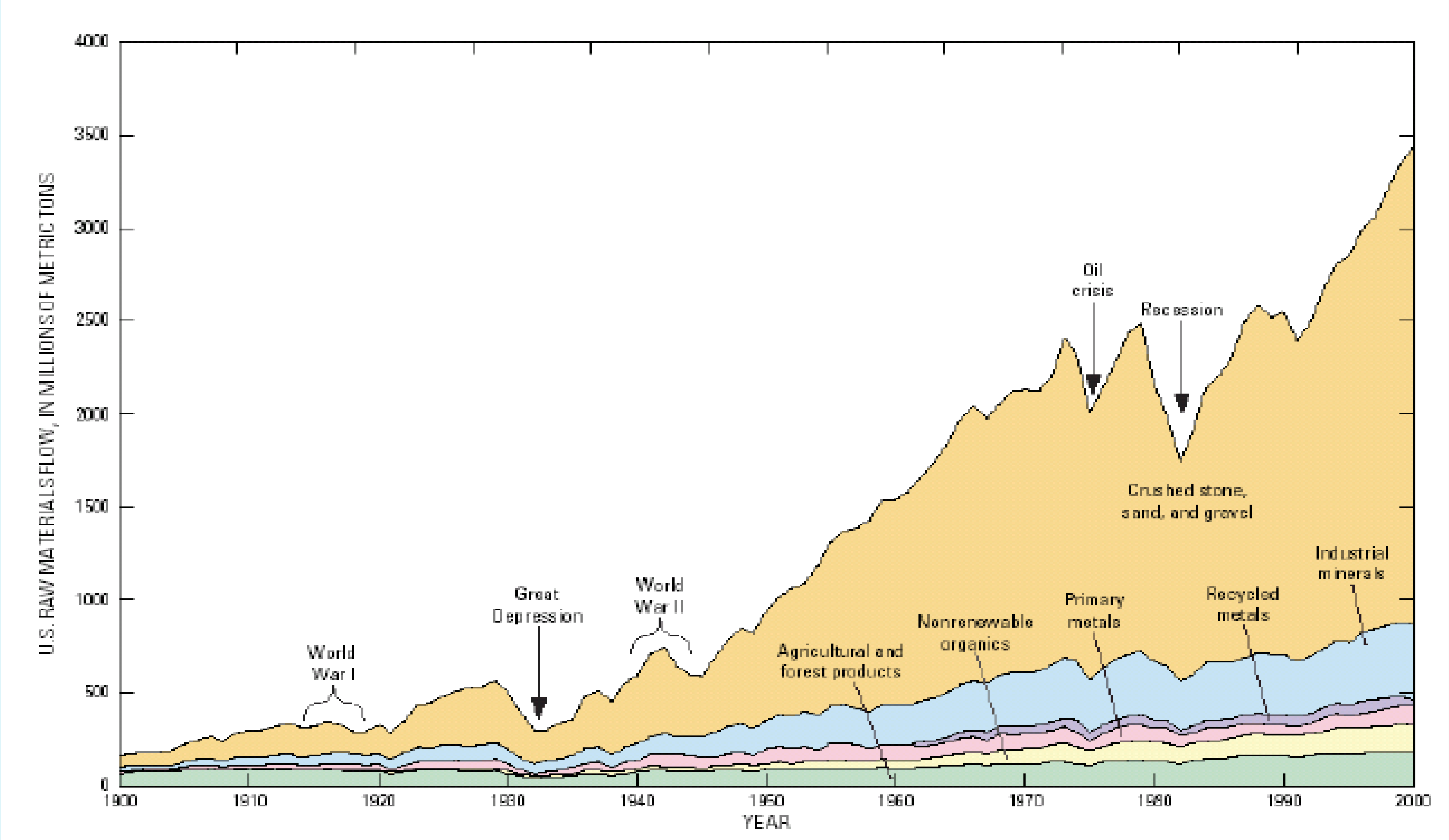
24 lbs. **Other Metals** have the same uses as nonmetals but also electronics, TV and video equipment, recreation equipment, and more

Including These Energy Fuels

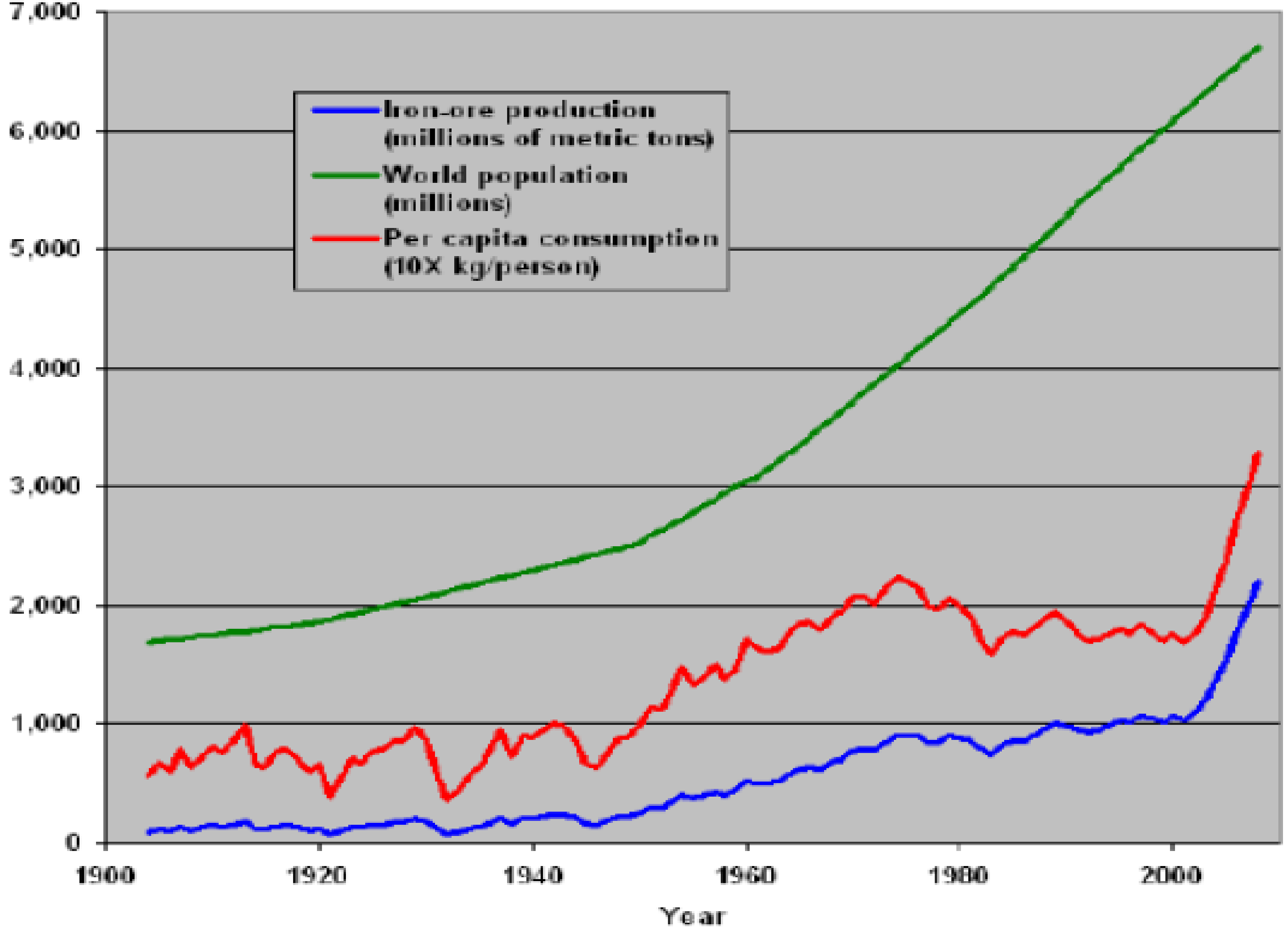
- 951 gallons of **Petroleum**
- 6,792 lbs. of **Coal**
- 80,905 cu. ft. of **Natural Gas**
- 1/4 lb. of **Uranium**

To generate the energy each person uses in one year—

U.S. flow of raw materials by weight 1900-2000. The use of raw materials in the U.S. increased dramatically during the last 100 years (from Wagner, 2002).



Demand is growing partly because world population is increasing, and partly because standards of living (measured by per capita consumption) are increasing.



Iron

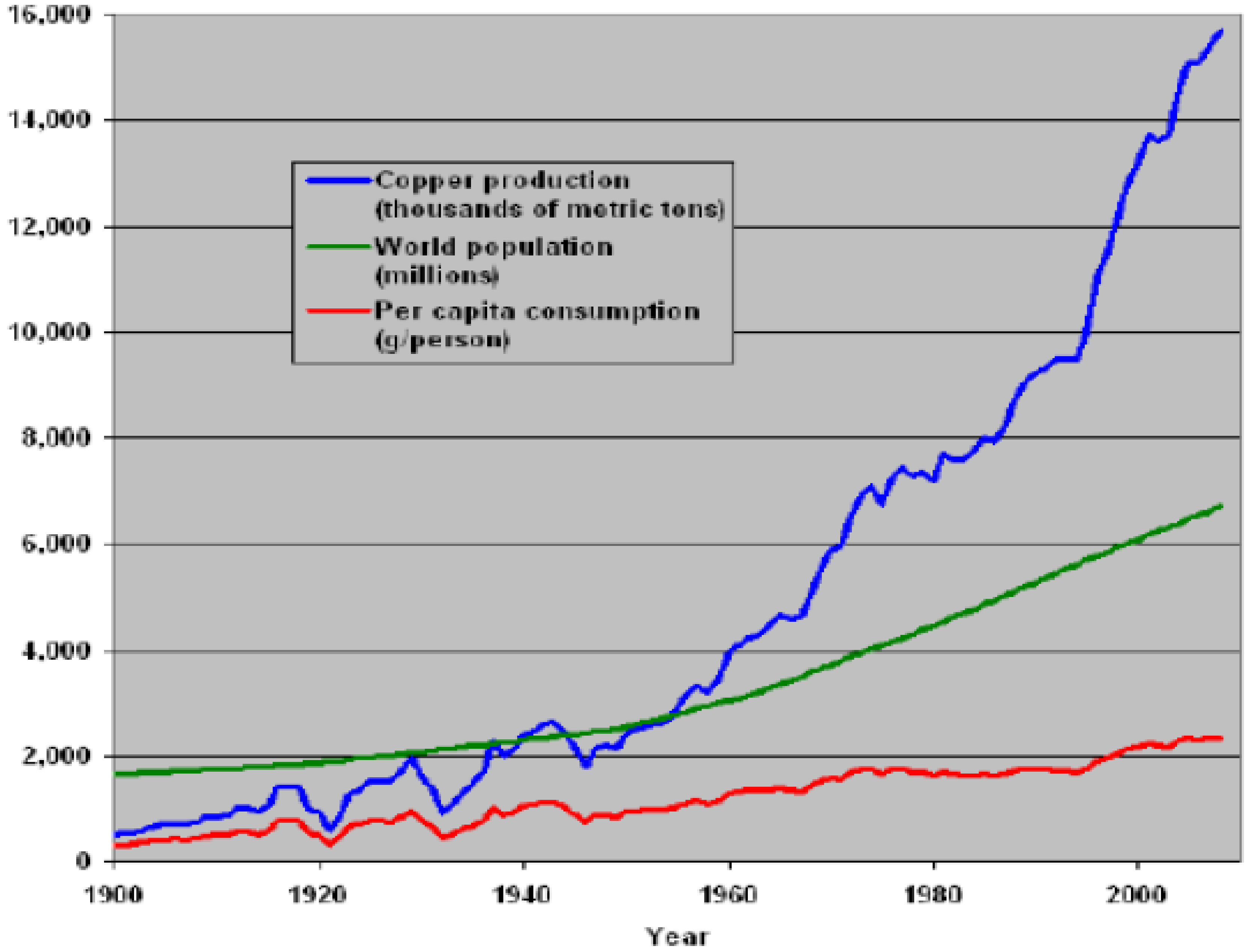
~4X more population than 100 years ago

~14X more production than 100 years ago

~4X more per capita consumption than 100 years ago

Production statistics mostly from USGS/USBM

Demand for nearly every mineral (and energy) commodity is high.



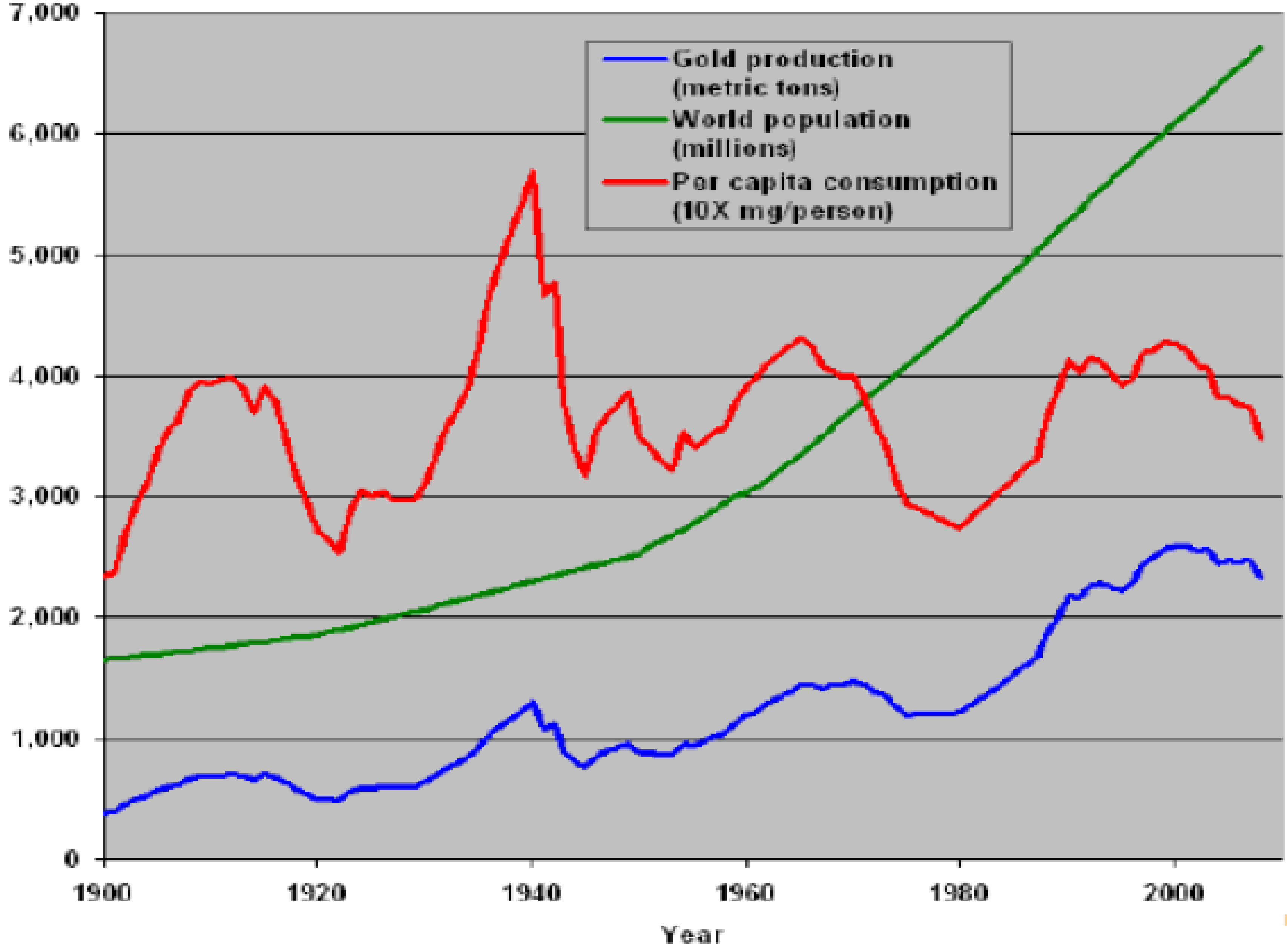
Copper

~22X more production than 100 years ago

~6X more per capita consumption than 100 years ago

Production statistics mostly from USGS/USBM

Demand for nearly every mineral (and energy) commodity is high.



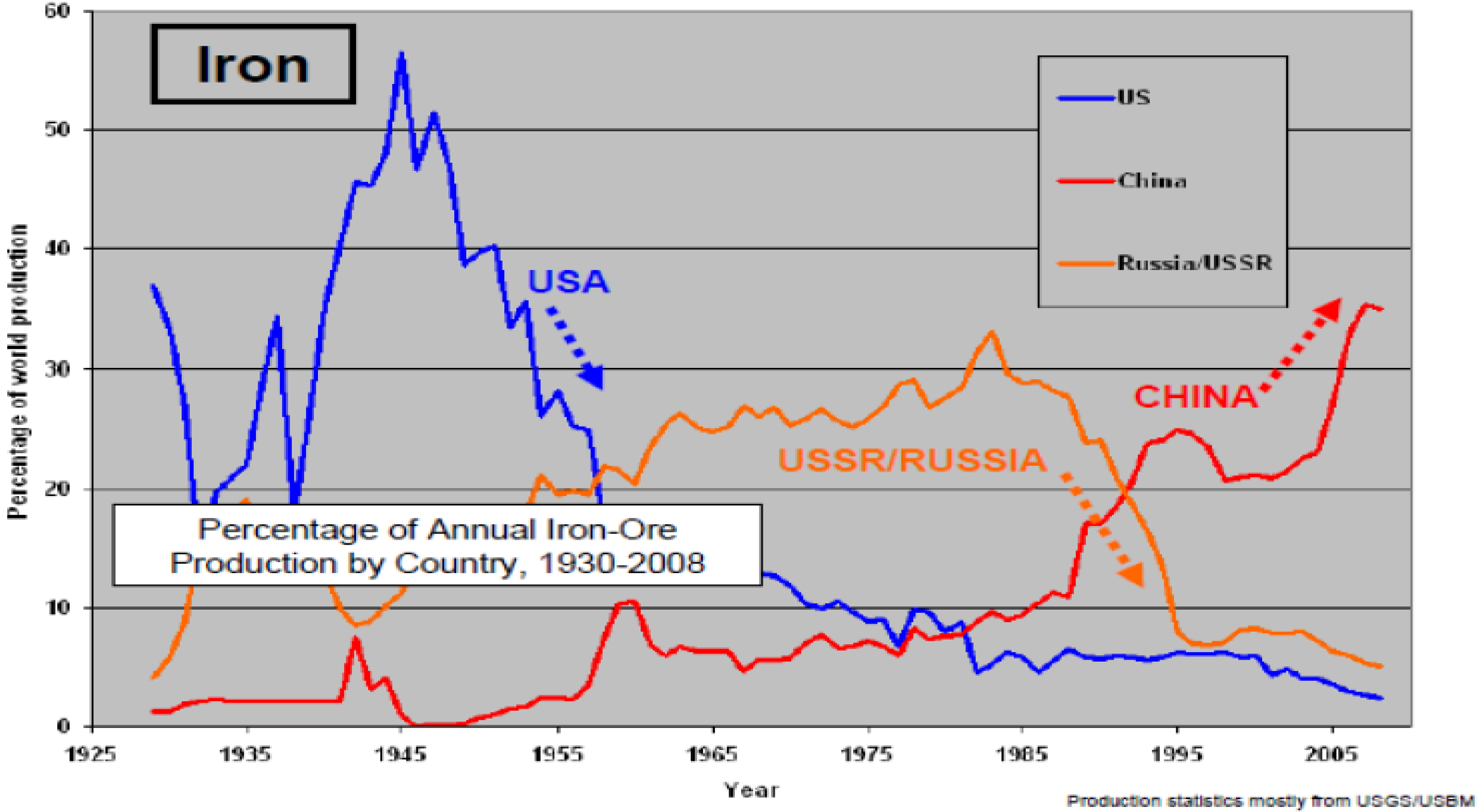
Gold

~same per capita consumption as 100 years ago

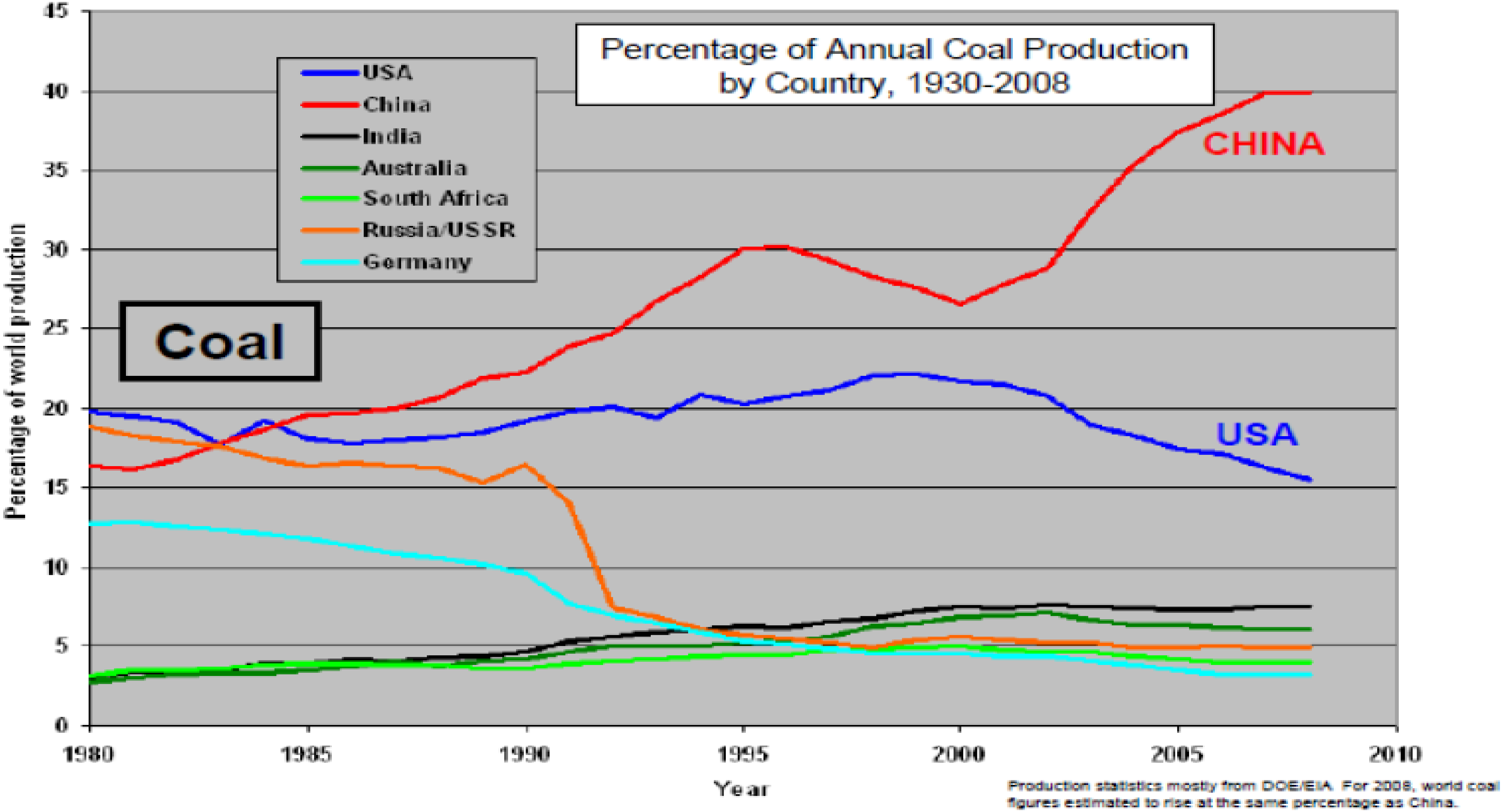
~4X more production than 100 years ago

Production statistics mostly from USGS/USBM

China has been #1 in iron-ore production since 1992.



China has been #1 in coal production since 1985.



	Elements	Top three supply countries and share (%)			Top three share (%)	Metal life (years)
China	REE	China 95%	USA 3%	CIS 2%	100%	709
	Mo (Re)	USA 32%	China 25%	Chile 22%	78%	46
	Sb	China 88%	Guatemala 3%	Bolivia 2%	95%	13
	Ga	China 43%	Germany 20%	Kazakhstan17%	80%	365
	W	China 75%	CIS 6%	Canada 5%	86%	55
	In	China 58%	Japan11%	Canada, Korea 9%	78%	22
	Bi	China 52%	Mexico 21%	Peru17%	90%	55
South Africa	PGE	South Africa 80%	CIS 12%	Canada 4%	96%	154
	Cr	South Africa 38%	India 18%	Kazakhstan 18%	74%	>24
	V	South Africa 39%	China 32%	CIS 27%	98%	221
	Mn	South Africa 20%	Australia 19%	China 14%	53%	40
Others	Ni	CIS 19%	Canada 16%	Australia 11%	46%	40
	Li	Chile 38%	Australia 22%	Argentina, China 12%	84%	164
	Co	Congo 36%	Canada 13%	Australia 12%	61%	22

The World Has Changed

For industry, the changes in the world are creating opportunities for:

exploration (domestically and worldwide, particularly in areas with potential for large deposits),

development and production (including new technologies for extracting metals from known deposits), and

sustainability (including the future of the environment, local and national economies, social and governmental stability, recycling, and substitutions of other minerals and products).

Round Mountain, NV (2007)

Some of the challenges in producing critical and strategic minerals

Policy Structures: Mining/Mineral Sector in India

- Indian Bureau of Mines regularly publishes the Indian Minerals Yearbook providing all requisite details about the global scenario, India's production cycle, exports, imports and details about the substitutes.
- Two of the key regulations in the sector are:
- 1. Mines and Minerals (Development and Regulation) Amendment Act, 2015 The MMDR Amendment Act, 2015 specifies that the mineral concessions for major minerals will be granted through auction or competitive bidding. It also states that the mines will be granted for a fixed tenure and will be made easily transferable; strict penalty provisions will be introduced to stop illegal mining; and a National Mineral Exploration Trust (NMET) will be established to conduct detailed exploration on a regional basis.

Policy Structures: Mining/Mineral Sector in India

- 2. Atomic Minerals Concession Rules, 2016 The Ministry of Mines, Power, Coal, and New & Renewable Energy have decided that the State Governments will now grant mineral concessions, where atomic mines are less than the prescribed threshold values, to the private sector by auction or competitive bidding.
- The first National Mineral Policy was enunciated by the Government in 1993 for liberalization of the mining sector. The National Mineral Policy, 1993 aimed at encouraging the flow of private investment and introduction of state-of-the-art technology in exploration and mining. This policy was replaced with a new National Mineral Policy during 2008. In 2018 a new draft policy has been circulated to cater for the present day requirements. Currently, in the mining sector, there are various government supported autonomous agencies and private industries making significant contributions

Policy Structures: Mining/Mineral Sector in India

- The 2018 draft policy document mentions that the mineral exploration would be incentivized to attract private investments. However, the policy still lacks clarity on the actual fiscal incentives for potential investors. Since, mineral exploration is a risky business, no big investor is likely to make investments without clear assurances in regards to finances and technological assistance. Also, the policy has no provisions for transfers of mineral concessions as is the normal practice in other mineral rich nations. The mining sector also suffers from several shortcomings in the licensing regime such as the separation of auction for prospecting licenses from provision of mining licenses that need to be overcome.
- A new report called the 'Critical Non-Fuel Mineral Resources for India's Manufacturing Sector: A Vision for 2030' offers a first-of-its-kind framework for India to identify the 12 critical minerals (including beryllium, germanium, rare earths (heavy and light), rhenium, tantalum, etc.) that can play an important role in the Make in India programme, and assesses the impact of these critical minerals on the manufacturing sector.

Some of the challenges in producing critical and strategic minerals

- How much of the minerals do we need?
- Are there enough materials in the pipeline to meet the demand for these technologies and other uses?
- Can any of these be recycled?
- Are there substitutions that can be used?
- Are these minerals environmental friendly—what are the reclamation challenges?
  - REE and Be are nearly always associated with U and Th and the wastes from mining REE and Be will have to accommodate radioactivity and radon

- Many critical elements are produced entirely as by-products of the refining of major metals
    - Tellurium (copper)
    - Indium & germanium (zinc)
    - Gallium (aluminum)
    - Rhenium (molybdenum)
    - Cobalt (copper, nickel)
- Prices are artificially low (economy of scope) until the co-production saturates
- By-product does not drive production of main product, even at high prices
- Price demand inelasticity

Long term mineral availability (>10 Yr)

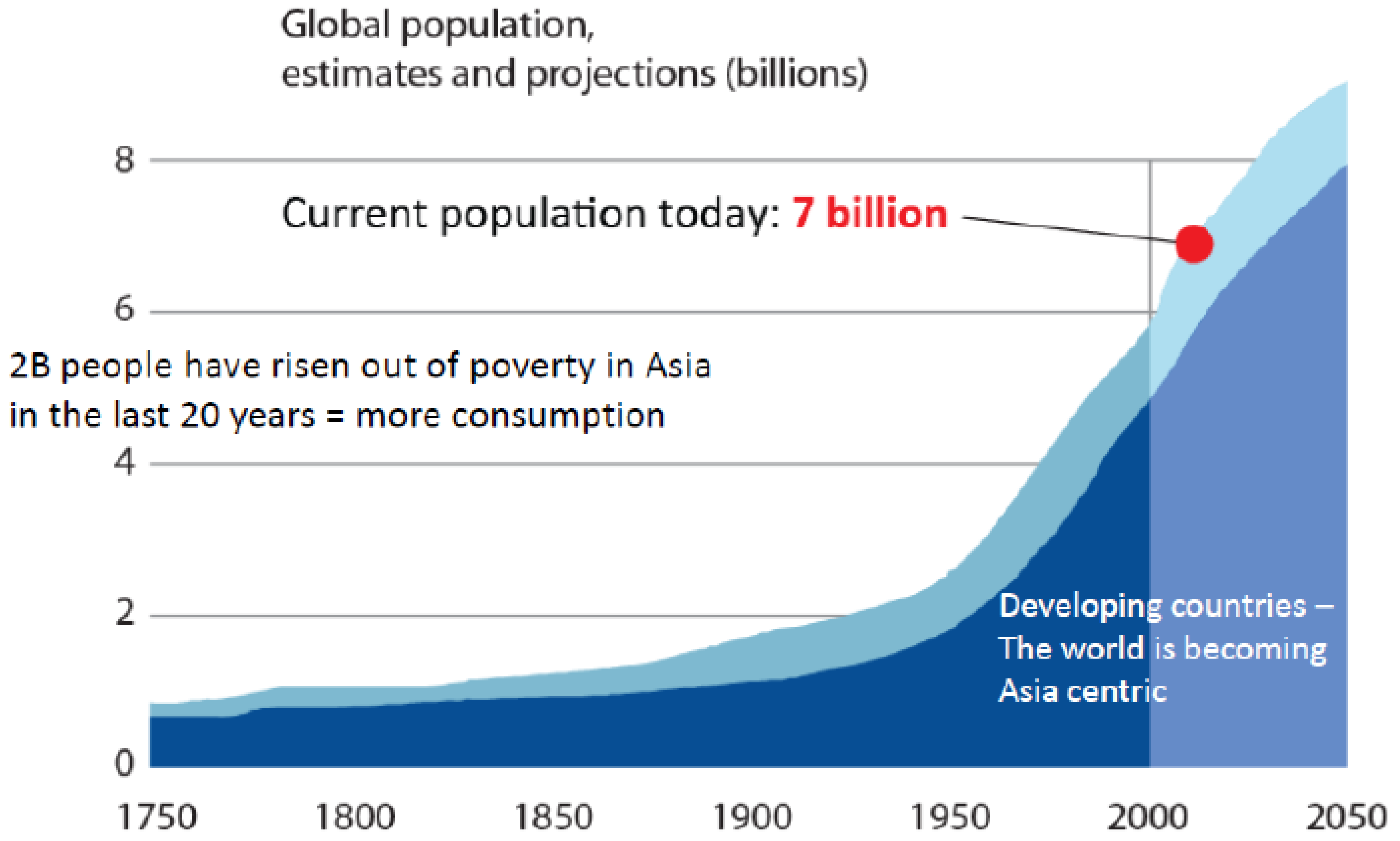
- Geologic (does the mineral resource exist)
- Technical (can we extract and process it)
- Environmental and social (can we mine and process it in environmentally and socially acceptable ways)
- Political (how does politics influence)
- Economic (can we mine and produce it at a cost the markets will pay)

Short- and medium-term availability

- Significant or unexpected increase in demand
- Small markets
- Production from a small number of mines, companies, or markets
- Minerals whose supply consist significant of byproduct production (i.e. Ga byproduct of bauxite mining)
- Markets for which there is no significant recovery from old scrap

Global challenges

- The small volumes of strategic/critical minerals utilized makes them price sensitive
- New producers need a reliable, long-term buyer
- Long-term buyers require a fixed price, but operating costs are variable
- Monopolies/oligopolies can drive out marginal producers by over-supplying the market until the competition is eliminated


Global population,
estimates and projections (billions)
8
6
4
2
0
Current population today: 7 billion
2B people have risen out of poverty in Asia
in the last 20 years = more consumption
Developing countries –
The world is becoming
Asia centric
1750
1800
1850
1900
1950
2000
2050

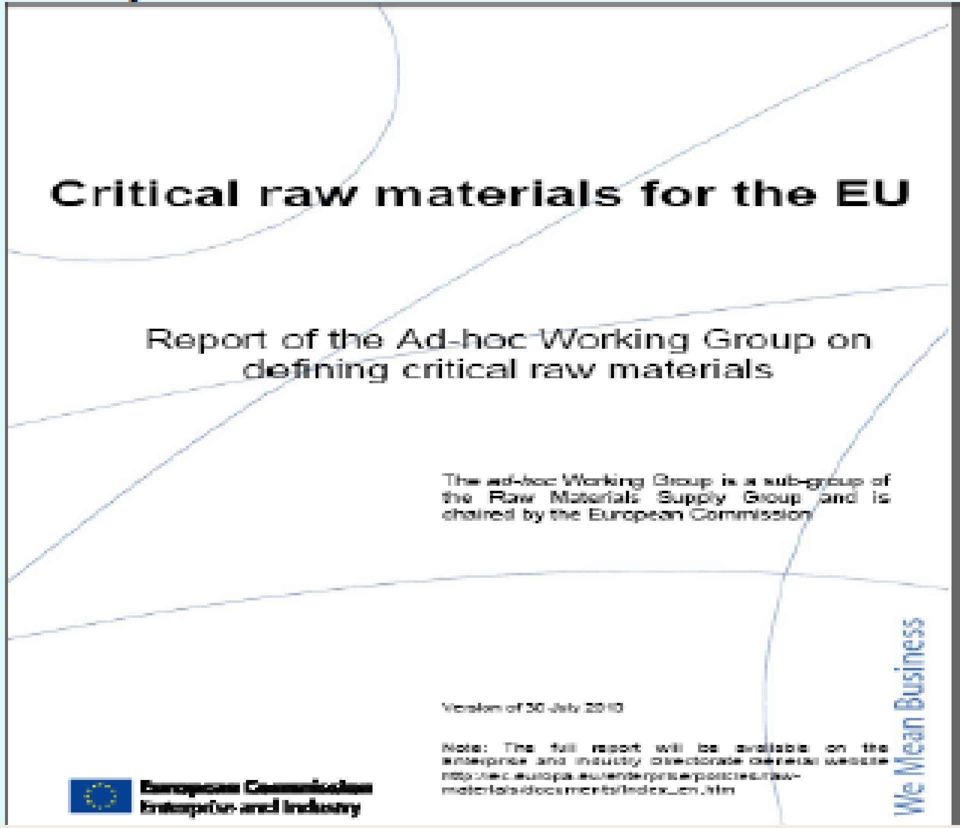
UNEP

Strategic and critical minerals for the U.S. (Long, 2009; Long et al., 2010)

- Antimony
- Barite
- Chromite
- Cobalt
- Fluorite
- Gallium
- Graphite
- Indium
- PGE (platinum group elements)
- REE (rare earth elements)
- Rhenium
- Tantalum
- Titanium
- Tungsten
- Yttrium
- Niobium

Strategic minerals for the European Union

- Antimony
- Beryllium
- Cobalt
- Fluorspar
- Gallium
- Germanium
- Graphite
- Indium
- Magnesium
- Niobium
- PGM (platinum group metals)
- REE (rare earth elements)
- Tantalum
- Tungsten



Critical raw materials for the EU

Report of the Ad-hoc Working Group on defining critical raw materials

The ad-hoc Working Group is a sub-group of the Raw Materials Supply Group and is chaired by the European Commission

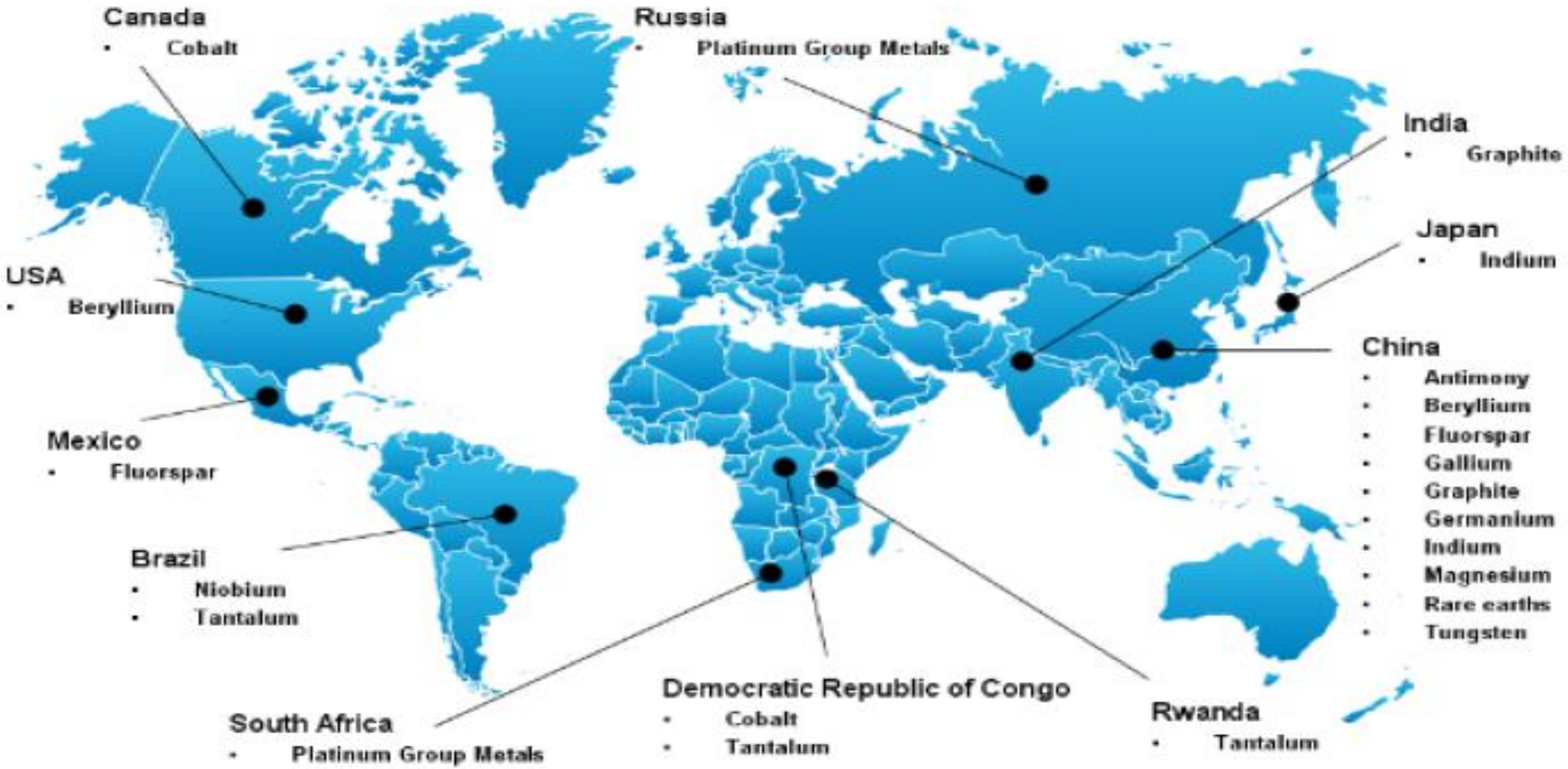
Version of 30 July 2010

Note: The full report will be available on the enterprise and industry directorate general website http://ec.europa.eu/enterprise/policies/raw-materials/documents/index_en.htm

European Commission
Enterprise and Industry

We Mean Business

Production concentration of critical raw mineral materials



Challenges for India’s Mining/Mineral Sector

- Broadly, the strategic mineral sector is expected to face similar difficulties as that of the entire mining sector. Import dependency is one of the most obvious challenges. Normally, such dependence materializes either because the minerals are physically not available within the physical geography of the country or the excavation of the minerals is not possible/feasible.
- It is important to note that on occasions, in spite of having minerals available in the backyard, the import of mineral becomes more cost-effective than creating an industry-structure for its extraction within the country.
- Also, India faces various challenges such as the high cost of acquiring land and on occasion local resistance for land acquisition. In addition, there are major challenges such as Naxalism. There apparently is an interrelationship between the Naxalite conflict and India’s mineral production and mining policies. Following table gives a broad idea about locations where some strategic minerals are available, but excavation is a difficulty

Challenges for India’s Mining/Mineral Sector

- At present, India’s import dependency is mainly on states such as China, Brazil, Democratic Republic of Congo (DRC), Russia, Australia and the US. Geopolitical factors could impact such bilateral arrangements from time to time. India has considerable dependence on DRC for mineral imports. Unfortunately, DRC is one country with maximum political turbulence. Hence, the internal situation in that country could have an impact on India’s import needs.
- Internally too there are new challenges. India has a very high percentage of open pit mining. Opencast or open pit mining is a method in which extraction of a mineral is done near the surface of the earth, creating large open pits. Being cost-effective, this is a very popular method. This activity presents enormous social and environmental challenges that need to be addressed.

Summary

- It is difficult to have a universal definition of strategic minerals. India would be required to have its own conceptualization of its strategic minerals. Strategic industry is growing in India and the need for strategic minerals is expected to increase. India has already identified a few minerals, which it feels are strategic in nature.
- There is also a need to develop a practice of risk assessment and devising management strategies for key strategic materials for the present and future. The entire domain of undertaking assessments, factoring strategic needs, managing domestic production and deciding on export/import policies would be a complex and multidisciplinary task.
- Hence, it is important to evolve a separate structure within the government apparatus (along with the members from industry) for undertaking this task.

Summary

- India is a mineral-rich country and generally, availability is not an issue. However, the real challenge is that of excavation and processing. For this purpose, some major investments need to be made. Since returns on such investments would take time to materialize there is a need for the government to device a specific industry policy for this sector. Unfortunately, policies like the one for Beach Sand Minerals (BSM), which was announced in August 2018, lack industry focus.
- The role of the private sector in mining and the minerals sector will increase in the years to come. There is a need to increase the research focus in all relevant areas of technology and to undertake research on recycling of minerals and finding the correct substitutes (device material substitution strategies).Effort should be made to reduce the import dependency of technologies too. Unfortunately, geological and material sciences are not popular areas of research in India.