Extraction of abiotic resources

- Reserves
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    - Metals focus
        - Concentrations
        - Mineralogical wall
    - Oil focus
        - Assessing reserves
        - Caution in interpretation
- Impacts of extractive activities
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    - Environmental focus
        - Other abiotic resources: water & air quality
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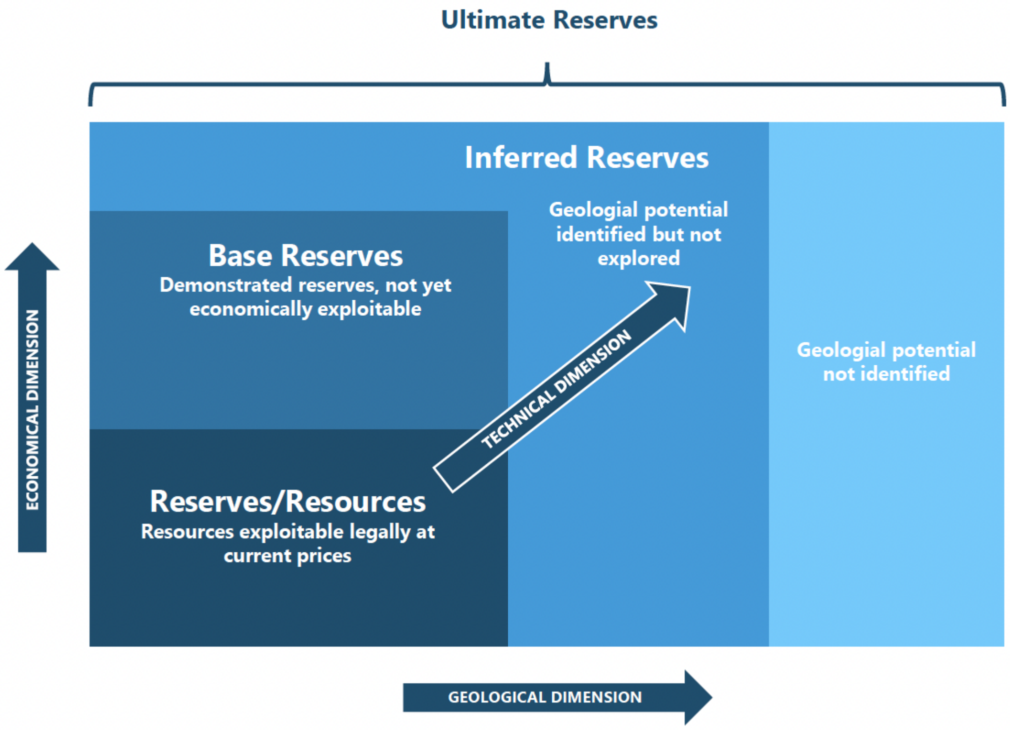
    - Socio-economical focus
        - Contrasted local realities
        - Global frictions…
        - Rootedin historical inequalities

1. Reserves

Définition



Adaptated from [3]

[3] BIHOUIX, P., GUILLEBON, B. ,2010. *Quel futur pour les métaux?*

[11] USGS, 2014. *Estimate of Undiscovered Copper Resources of the World*[online]. Fact Sheet.

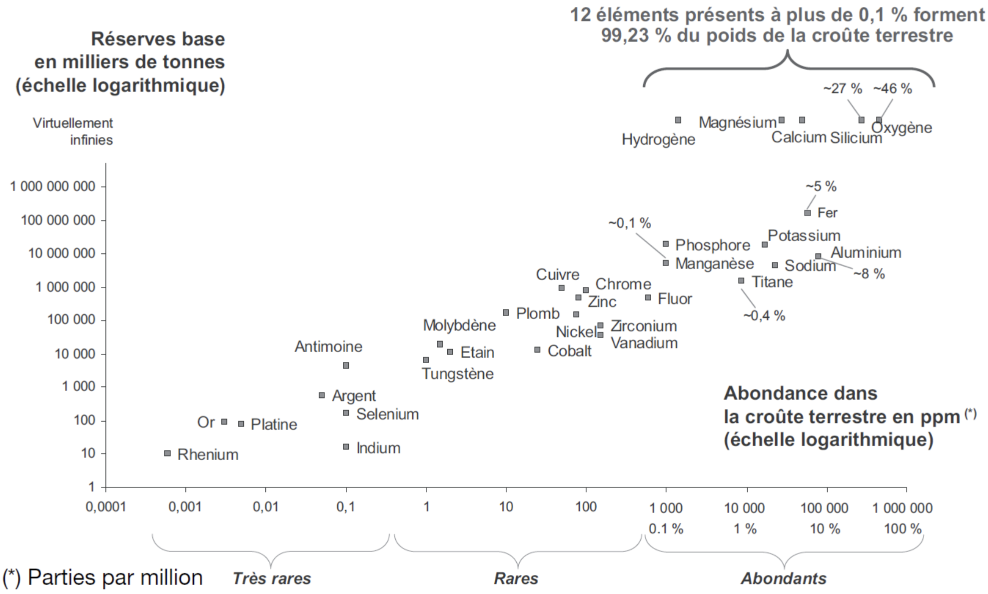
[12] USGS, 2020. *Mineral Commodity Summaries*[online].

- Reserves/Resources data are highly dynamic
  - May be reduced as
    - ore is mined
    - feasibility of extraction diminishes
  - May increase as
    - additionnal deposits are discovered
    - currently exploited deposits are thoroughly explored
- The Copper example : [11] & [12]
  - Reserves/Resources≃500 Mt (2014) -> 870 Mt (2020)
  - InferredReserves≃2.1 Bt(2014)
  - UltimateReserves≃3.5 Bt(2014)

2. Metals focus

[3] BIHOUIX, P., GUILLEBON, B. ,2010. *Quel futur pour les métaux?*

2.1. Concentration of minerals



Sources : BRGM, USGS 2007

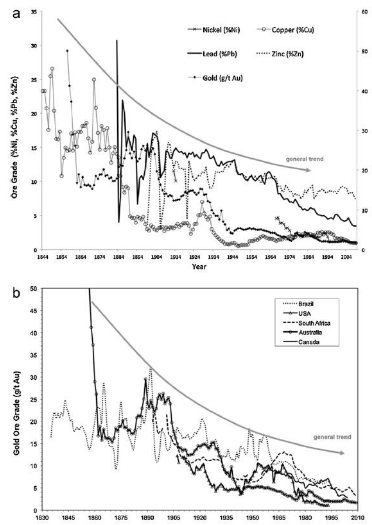
Extracted from [3]

- Average concentrations of minerals in Earth crust must be compared to typical concentrations in exploited ores
- Even for abondant elements, high ratio between economically viable concentrations and Earth crust average
  - Iron(Fe) example: 30-60 % in ores versus 5 % average in Earth crust
- Precious metals are logically the only ones where the order of magnitude is equivalent
  - Typical example: Gold (Au)

Metal	Typical concentration of exploited ores	World mean	Metal mass per ton of ore
Fe	[30-60] %		[300-600] kg
Al	[20-30] %		[200-300] kg
Zn	[3-9] %	8%	[30-90] kg
Pb	[2-7] %	5%	[20-70] kg
Ni	[1,5-3] %		[15-30] kg
Cu	[0,5-2] %	0,8 %	[5-20] kg
Au	[0,0002-0,0006] %	0,0003 %	[2-6] kg

Extracted from [3]

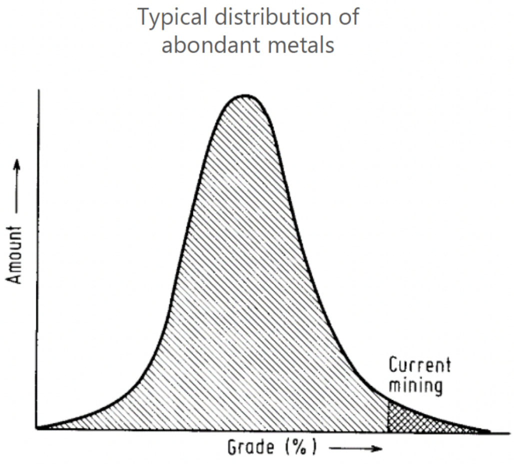
- If no major discoveries, historical tendancy is a decrease in average concentration causing an increase in cost and impacts :
  - Example of Copper (Cu): 1,8% (1930) -> 0,8% 2010
  - See opposite: (a) Concentration of varied ores in Australia(b) Concentration of Golde ores in the world



Extracted from [24]

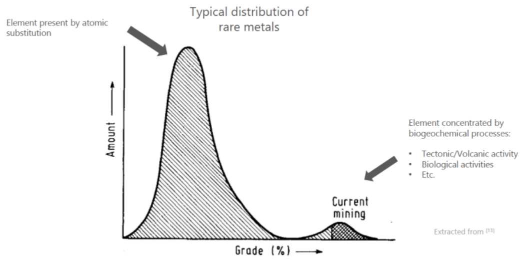
[24] PRIOR, T *et al.*, 2012. Resource depletion, peak minerals and the implications for sustainable resource management.

2.2. B. Mineralogical barrier



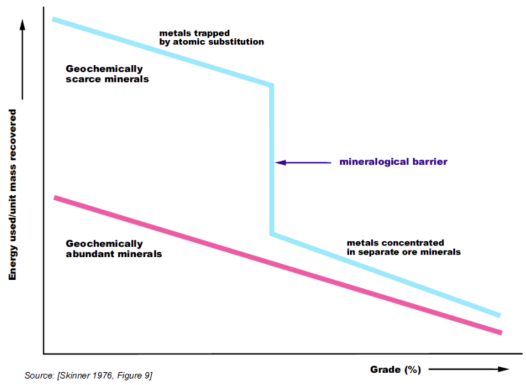
- Abondant metals mining follows a simple curve :
  - Highest-grade ores are mined first, as they're the most available ones–technically and economically
  - Like for any finite resources, mining depletes stocks, then target less high-grade ores, until a production peak happen, after what availability diminishes

Extracted from [13]



- Scarce metals are usually not found in common rocks as separate minerals but as atoms substitutions (that's makes them rare)
  - Consequently, mining activities directly seek concentrated ores (geologically rarer themselves), then must rely on more common ores, following a bimodal mining curve

Extracted from [13]

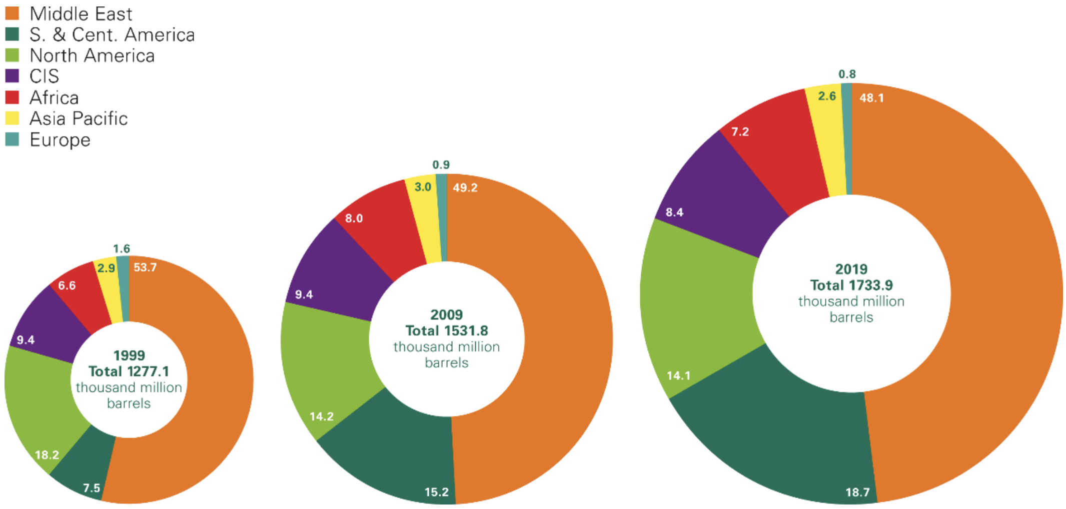


- The shift to these more common rocks can be a turning point in processes needed, and generate a mineralogical barrier

[13] SKINNER, B.J., 1979. Chapter 10 A Second Iron Age Ahead? In: *Studies in Environmental Science*. [14] AYRES, Robert U, 2001. Resources, Scarcity, Growth and the Environment. . 2001. P.35.

3. Oil focus

3.1. Assessing reserves [15]

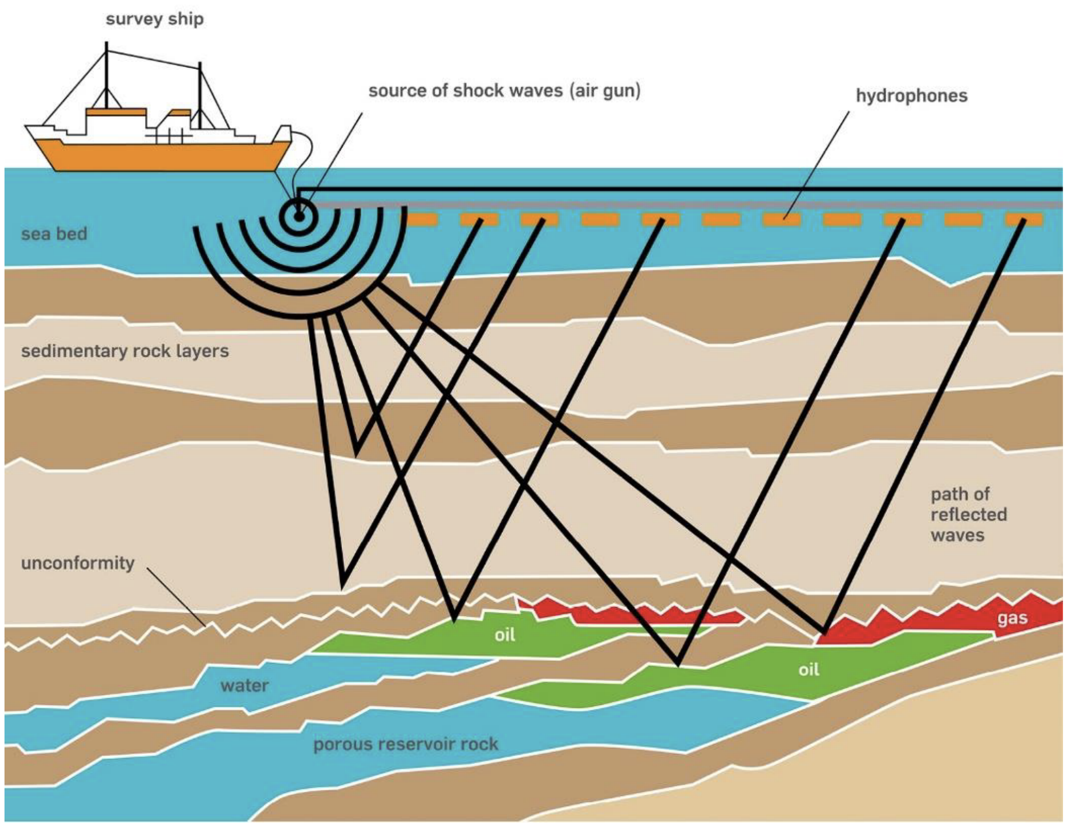


Extracted from [6]

[6] BP, 2020. BP Statistical Review of World Energy. [online].

[15] JANCOVICI, Jean-Marc, 2019. Les Energies fossiles. *Ecole des Mines* [online].

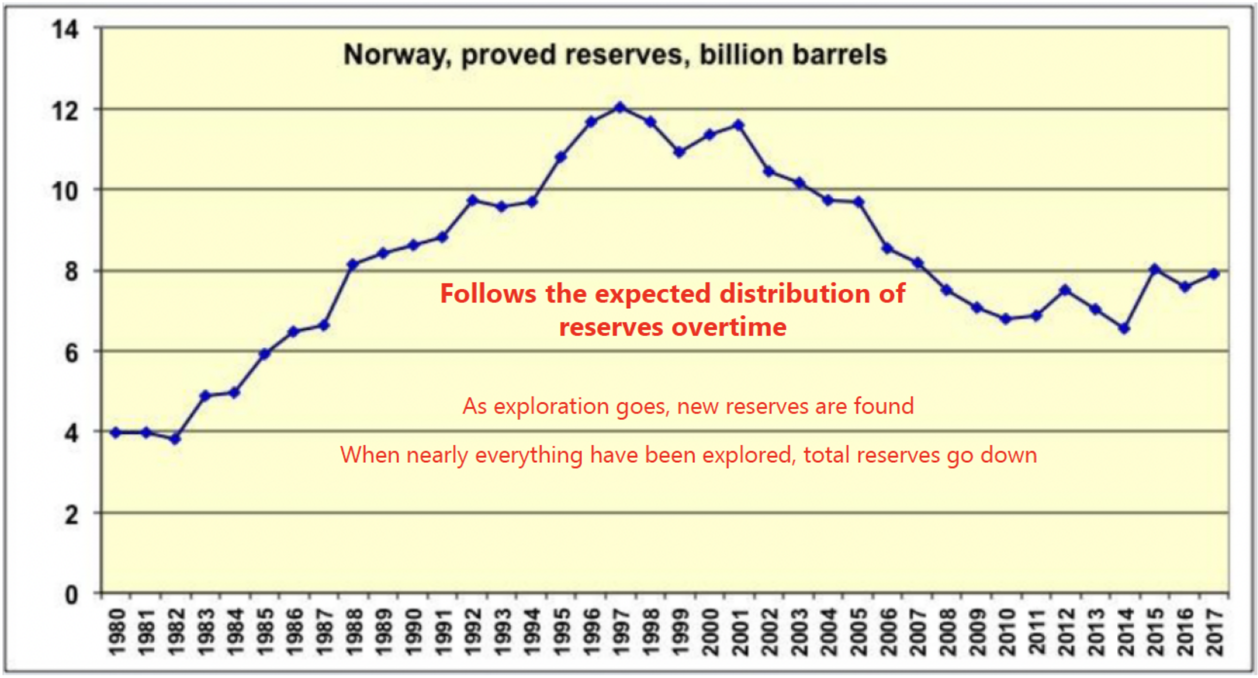
- When a potential reserve of oil is suspected, sismography combined with exploratory drilling is used to estimate :
  - Quantities of oil
  - Probable recovery rate of the oil

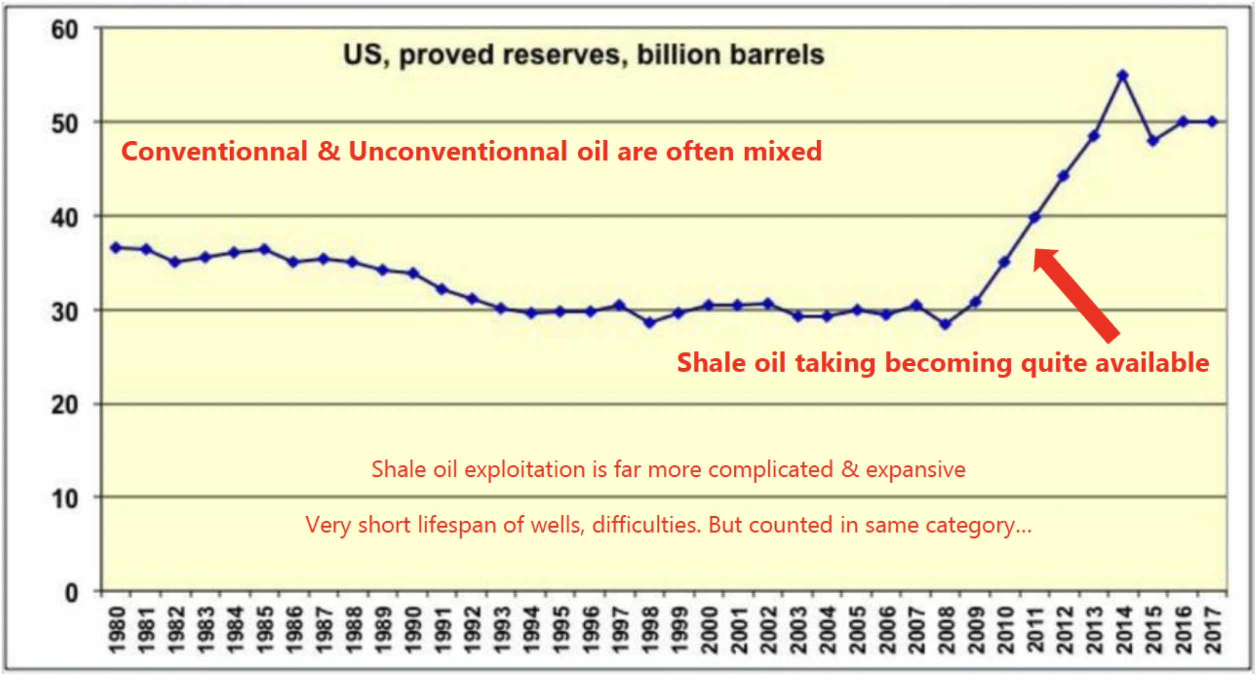


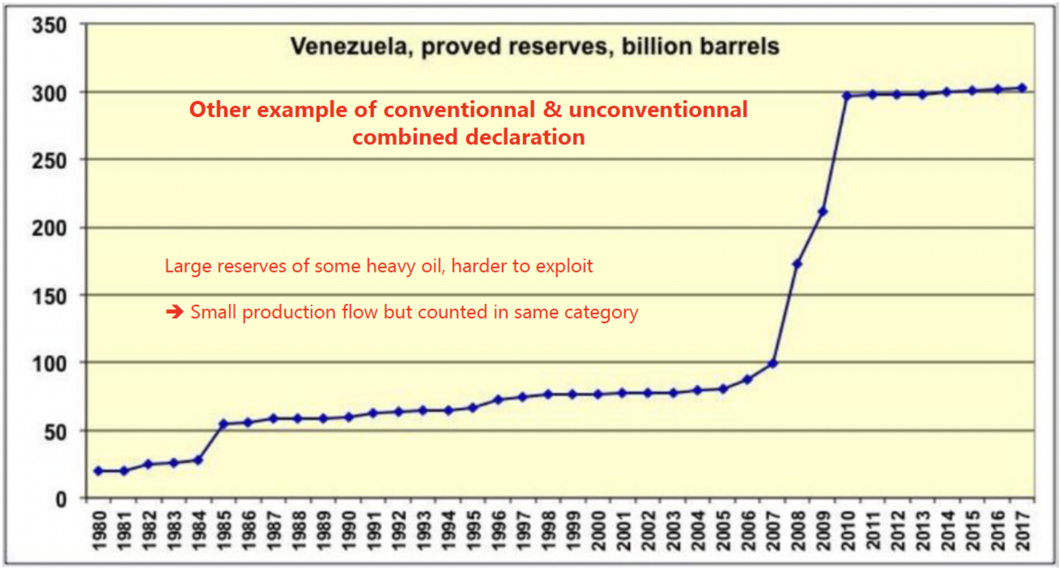
- As any oil extraction needs heavy infrastructure -> CAPEX>>OPEX.

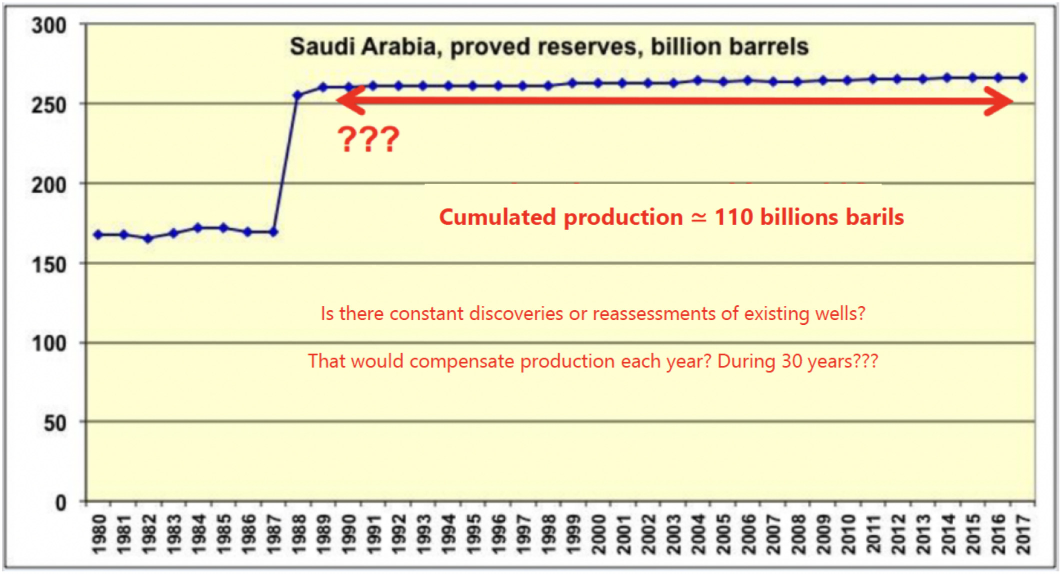
  Which means the dynamics of a specific reserve are :
  - Strongly dependent on quantities& recovery rates estimations accuracy
  - Weakly dependent of variations in oil price (infrastructure already there)
- Who evaluate & declare the reserves?
  - A lot of oil companies are state-owned. Around 10% of oil compagnies are listed on the stock exchange -> legally binded to communicate the estimations
  - Large part of data comes from countries but :
    - Geopolitical strategies due to production international agreements
    - Different conventions on what to count and in which category
    - No independent verifications

3.2. Caution in interpretation









Adapted from [15]

4. Medias

https://pod.utt.fr/video/3946-ev14-abiotic-resources-4-extraction-reserves/

5. Impacts of extractive activities

5.1. Growing interdependancies

a) Energy footprint of minerals

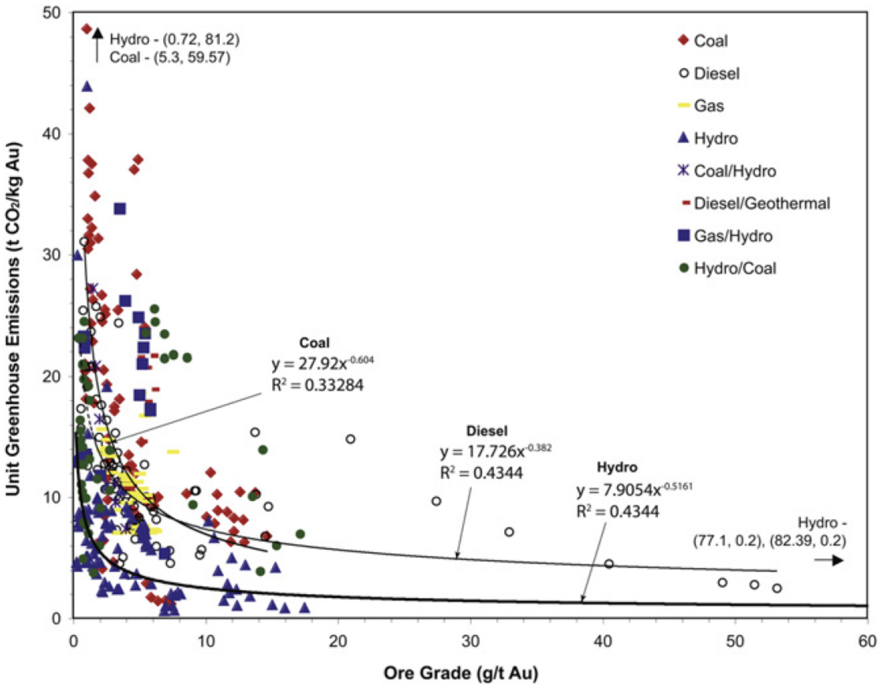
- A lot of operations involved
  - Extraction, mineral processing, metal working
  - 1st order transformation: smelting and refining
  - Transport between steps
  - This raw metal undergo varied 2nd order transformations to become raw products with diverging final energetical footprint
  - Copper example: tubes 20-30% higher footprint than foils

- Uncertainties in data
    - Diversity of production sites (mineral concentration, efficiency of processes)
    - Varied studies perimeter (no standard approach, weigh of hypothesis)
    - Disparities in sources of information available

Metal	Production energy (tep/t)	Mining production (Mt)	Total energy (Mtep)
Steel	0,4-0,5	1360	544-680
Al	3,8-7,4	39,7	147-288
Cu	0,8-3,6	3,6	12-56
Cr	?	21,5	?
Zn	0,9-1,9	11,3	10-21
Mn	?	14	?
Si	?	5,7	?
Ni	2,7-4,6	1,6	4-7
Mg	8,6-10,2	0,8	7-8
Pb	0,5-1,1	3,8	2-4
Sn	4,6	0,3	1-2
Total (2010)	In Mtep		730-1070
Total (2010)	For World	Primary energy	7-10%

Extracted from [3]

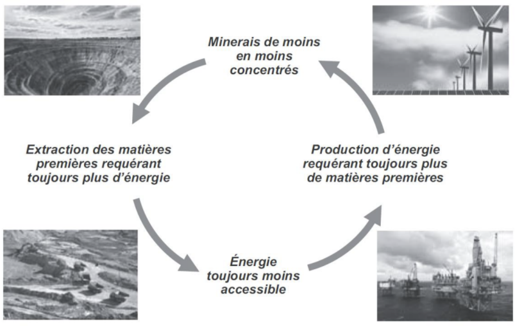
- Extraction & Refining of metals
    - Less & less concentrated mineral resources -> more & more energy



Extracted from [24]

[24] PRIOR, T *et al.*, 2012. Resource depletion, peak minerals and the implications for sustainable resource management.

b) Material footprint of energy



- Extraction & Refining of oil
  - ≃5% of world Steel use for gas/oil exploration & production
  - 'Offshore', 'Depp offshore', or

    Unconventionnal oil -> rise in the use of platforms, ships, complex tools, etc.
- Even « Renewable energies » are quite materially dependent:
  - A 1MW windmill contains ≃ 3t of Cu, and needs 10x more steel & concrete per kWh than a classical plant
  - A classical PV installation (Si) needs ≃ 4kg of Cu per kW capacity.
  - Most these technologies also need rare metals like In, Ga, Se, Ne, etc.

5.2. Environmental focus

a) Other abiotic resources: water & air quality

Impacts on abiotic resources: water & air quality [16] & [17]

[16] ELAW, 2010. 1st Edition: *Guide pour l'évaluationde EIE de projetsminiers* [online].

[17] Hydraulic Fracturing 101. *Earthworks* [online].

[3] BIHOUIX, P., GUILLEBON, B. ,2010. *Quel futur pour les métaux?*

- Acid drainage :
  - Most ores contains sulfure -> exposition to the surface through mining -> formation of sulfuric acid -> dissolves other metals and spills out in surrounding rivers or groundwater Ex: Summitville (1992-1995) [3]

- Settling tanks
  - Containment of mining wastes -> infiltration into ground water or over flowsi n case of rain(one of the worst possible industrial accidents in terms of environmental impact) *Ex: Aznacollar 1998 in Spain*

- Mines dewatering
  - Mining sometimes directly meet the groundwater table -> pursuit of mining need pumping of water -> reduction or elimination of water circulation in surrounding zones, varied degradations on soils and wildlife

    Ex: Sadiola Gold mine pumped 5,6 Mm3 of water in a year (≃ consommation of 800 000 Malians) [3]
- Mobile or non-mobile sources of air pollutants
  - Fuel combustion & exhaust gases of machines or vehicules -> CO_2, CO, organic compounds -> climate change
  - Waste particles dispersed by wind
  - Precious metals are often melted onsite before sent to rafineries -> high levels of Hg, As, SO_2
- Uncontrolled mercury (Hg) rejections
  - [Hg] in ores can rach 10 mg/kg -> 1 Mt of ores produced means 10t of Hg potentially emitted
  - Vaporization of Hg in gold metling is a major cause of Hg mission in atmosphere

Specifics to oil :

- *Hydraulic fracturing & Oil spills contaminations*
- *Details in* [17]

b) Biotic resources: wildlife and land

[16] ELAW, 2010. 1st Edition: *Guide pour l'évaluationde EIE de projetsminiers* [online].

[17] Hydraulic Fracturing 101. *Earthworks* [online].

- Loss of habitat
  - Excavation or accumulation of waste -> mobile species (birds and some mammals)are hunted out + sedentary species (little mammals, reptiles, invertebrates) are killed
  - Acid drainage or dewatering -> severes impacts on surrounding aquatic life
  - These 2 points -> perturbation of trophic chains (diminution of food for the higher- level predators)
  - Disparition of vegetation
- Fracture of habitat
  - Large portions of land occupied

    -> perturbation of migrations or local isolation of species

Specifics to oil (again):

- *Hydraulic fracturing & Oil spills contaminations*
- *Details in* [17]

5.3. Socio-economical focus

[16] ELAW, 2010. 1st Edition: *Guide pour l'évaluationde EIE de projetsminiers* [online].

[17] Hydraulic Fracturing 101. *Earthworks* [online].

[3] BIHOUIX, P., GUILLEBON, B. ,2010. *Quel futur pour les métaux?*

a) Contrasted local realities

[16] ELAW, 2010. 1st Edition: Guide pour l'évaluation de EIE de projets miniers [online].

[17] Hydraulic Fracturing 101. Earthworks [online].

[3] BIHOUIX, P., GUILLEBON, B. ,2010. Quel futur pour les métaux?

- Human migrations
    - Displacement & reinstallation of communities (expropriated or not) -> resentment + power perturbations -> local conflicts
    - New high economic activity -> arrival of new populations -> new pressures on land, water or waste management -> tensions & potential conflicts with original inhabitants

      Ex of Grasberg Mines in Indonesia: From <1000 (1973) to 110 000 (1999) ; violent conflicts during 1970-1990
    - New needs of infrastructures -> urbanization -> wide-ranging effects
- Loss of drinkable water access
    - Due to uncontrolled exploitations & industrial pollutions
- Pressures on means of existence
    - Mining activities not correctly managed -> economic cost on other sectors (agriculture & fishing in particular)
- Public health consequences
    - Potential sanitary risks are often seglected

      -> example of improvised mining towns are been shown to threaten food security and availability
    - Indirect effects of exposition to mining activities are higher incidences of tuberculosis, asthma, chronic bronchitis, etc.
    - A review of metals direct toxicity impacts can be found in a dedicated chapter of [3]
- Cultural & Esthetics
    - Destruction of cultural resource by surface perturbation or excavation
    - To pographical or hydrological changes
    - Higher access to previously inacessible locations

      -> theft or vandalism of cultural artifacts
    - Visual impacts due to deforestation& presence of infrastructures

b) Global frictions...

[25] HUISMAN, J., PAVEL, C., *et al*. 2020. *Critical Raw Materials in Technologies and Sectors -Foresight* [online].

[3] BIHOUIX, P., GUILLEBON, B. ,2010. *Quel futur pour les métaux?*

- Emerging geopolitical stakes for metals
    - As for oil, the main consumer countries are also the ones with the smallest reserves
    - Understanding of these problematics is more recent for metals and is parallel to the recent rise of metals prices in the 2000s
    - The EU Commission now regurlaly pubish reports on the matter[25]
    - Strategical stocks of metals constituted during Cold War, dismantled after the 90s, are back since15-20 years
- Capitalistic concentration of compagnies :
    - in 2008, 4173 compagnies in mining but 149 majors (3,6%) were controlling 83% of the market[3]
    - Power to initiate struggles with states over natural resources and their exploitation, in order to maximize private profits and mutualize losses or environmental externalities
    - Complex conflicts with explicit and implicit actors

[3] BIHOUIX, P., GUILLEBON, B. ,2010. *Quel futur pour les métaux?*

- Armed conflicts already existing
    - Not as visible as oil conflicts yet
    - DRC (Democratic Republic of the Congo) being the richer african country in metals, its history since mid-XXth is a paradigmatic example
- Crossings with colonization & neocolonization
    - 1961 Defense agreements between France, Niger, Dahomey & Ivory Coast garantee limitation of exportations to other countries than France in case of needs
    - 2007 contract of China & RDC: heavy construction work (6 billions $) in in exchange of metal mining authorizations (10 Mt of Cu, 200 000 t of Co, 372 t of Au)
        - With explicit intention of asking land if the metal provisionning does not meet expectations
        - Direct implication in local economy

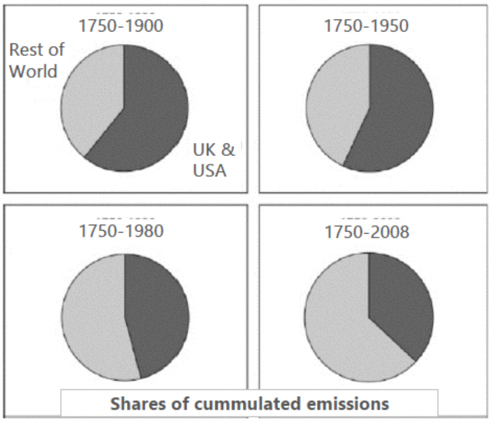
No need to developp on the well known history of oil geopolitical conflicts since mid-XXth!

c) Rooted in historical inequalities

[3] BIHOUIX, P., GUILLEBON, B. ,2010. *Quel futur pour les métaux?*

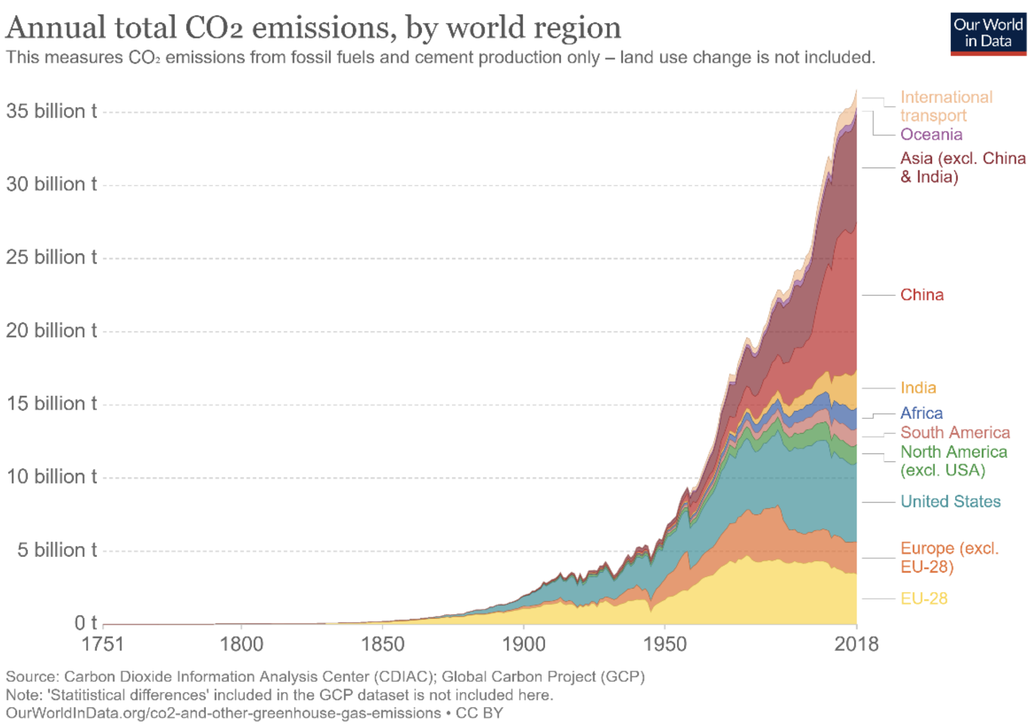
[18] RITCHIE, Hannah and ROSER, Max, 2017. CO_2 and Greenhouse Gas Emissions. *Our World in Data*[online].

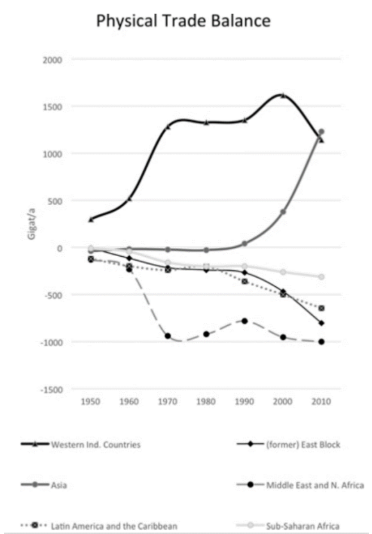
[19] BONNEUIL, C., FRESSOZ, J-B., 2016. *L'événement anthropocène: la Terre, l'histoire et nous*.



Adapted from [19]

- Developed countries did develop themselves on the exploitation of countries now productors & consumers
  - Between 1815-1880, 5/6 of British investments were outside their empire, chiefly to develop mining (coal, in particular) and transport of ores by rail in dominated countries [19]





- 20th century have mainly reorganized exploitation, but it continued on
  - USA based its economic rise on intensive use of its own resources during 1870-1940
  - Supported decolonization mainly to gain access to material resources of newly independant countries
  - Conversely, East block exploited its own environnment above all
- Emerging trend ->
  - Reappropriations of national resources & path of developpmen
  - Setting of export restrictions [3]

5.4. Medias

https://pod.utt.fr/video/3947-ev14-abiotic-resources-5-extraction-impacts/