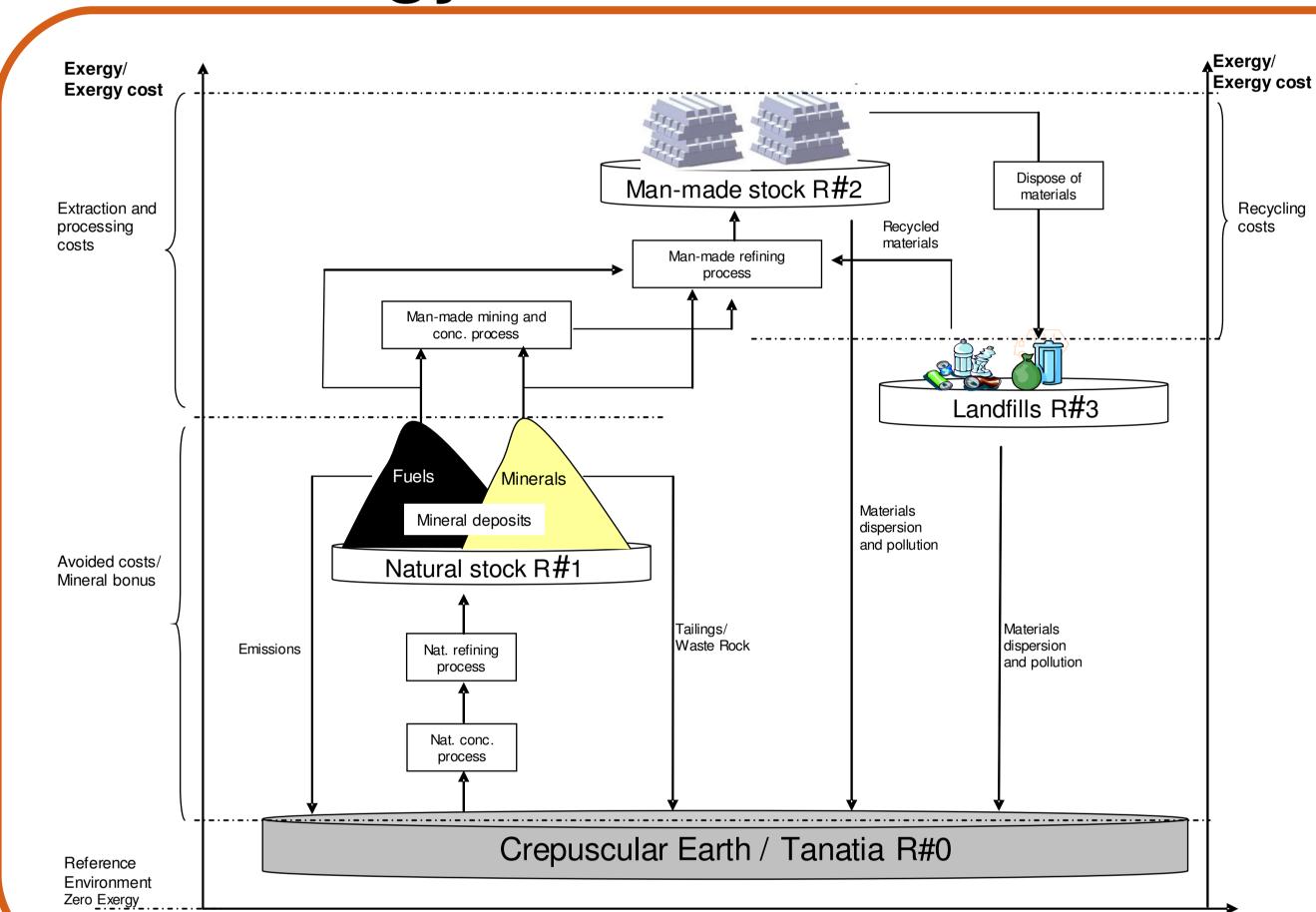
THE DEPLETION OF THE GREAT MINE EARTH

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Introduction

- The **exergy analysis** is the root of the physical cost and thus it connects Thermodynamics with Economics. It allows the assessment of **all physical properties** of natural resources, such as composition, grade or quantity, with a single unit of measure (the exergy costs) and in an objective way far removed from market distortions or currency speculation.
- In this paper the exergy degradation of the main minerals extracted in the world has been studied and their peak of production has been assessed.

Methodology



- The resources are physically assessed as the energy required to replace them from a complete degraded state or reference environment to the conditions in which they are currently presented in nature: Replacement costs.
- The **minimum exergy** replacement cost of a mineral is calculated as the sum of the chemical (b_a) and concentration components (b_c) :

$$b_{ch} = \sum v_k b_{ch_{el,k}}^0 + \Delta G_{mineral} \qquad b_c = -\overline{R}T_0 + \frac{(1-x_i)}{x_i} \ln(1-x_i) + \frac{(1-x_i)}{x_i} \ln(1-x_i)$$

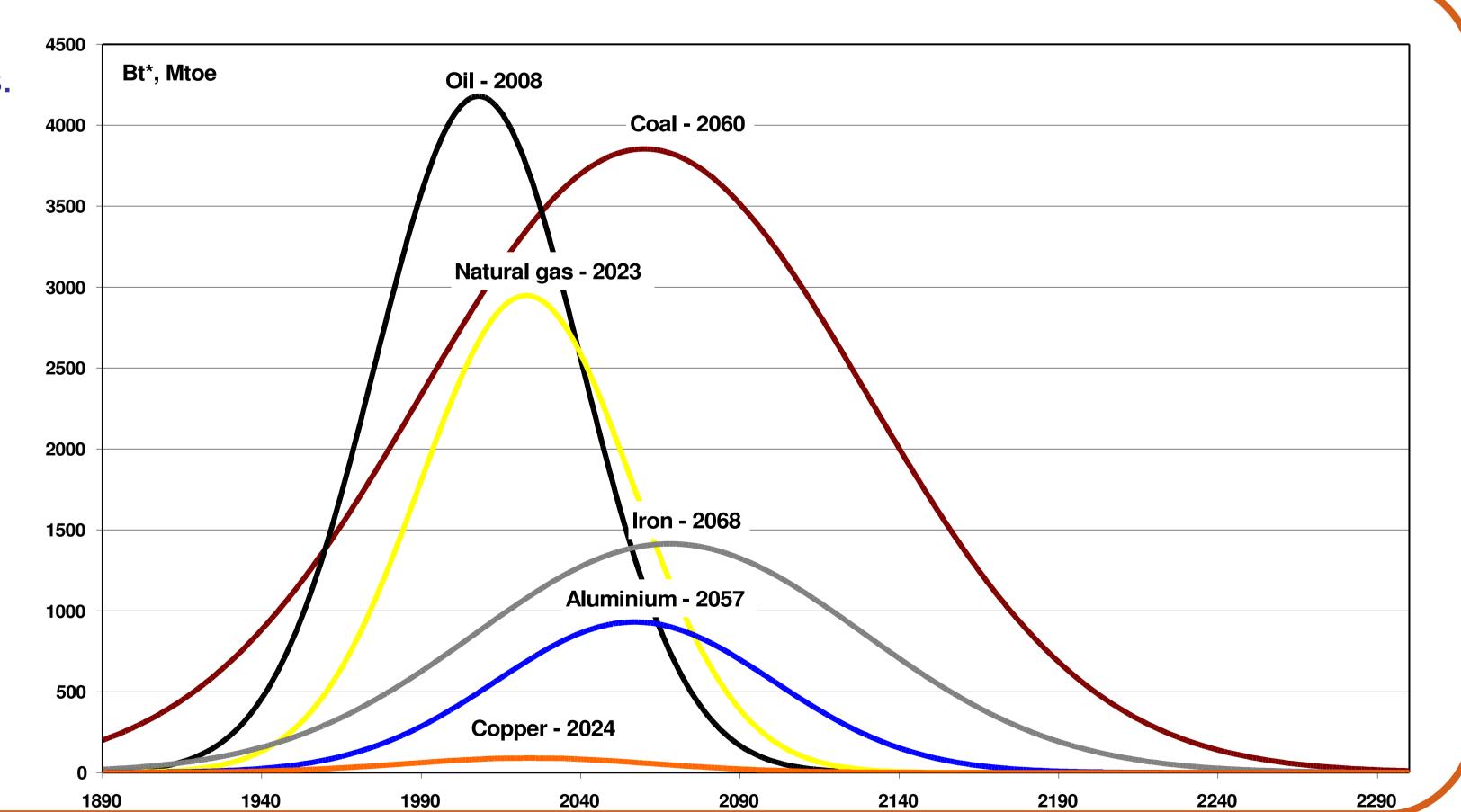
The actual exergy replacement costs consider also the state of technology:

$$b_t^* = k_{ch} \cdot b_{ch} + k_c \cdot b_c \qquad k = \frac{E_{real_process}}{\Delta b_{\min eral}}$$

Materials Evolution

Results

- Using exergy, mineral extraction behaves similar to the well known **Hubbert's peak** for fossil fuel resources.
- The exergy countdown of the planet allows visualizing and monitoring the exergy evolution of mineral resources of the Earth and estimating when each resource will reach the maximum rate of extraction.
- With historical data compiled by the USGS and BGS, and the equations presented above, we have obtained the exergy countdown of conventional fossil fuels plus iron, aluminium and copper.
- The results are striking: at the actual rates of extraction, most of the strategic metal resources will reach the peak before this century.



Conclusions

> Physical Geonomics is proposed as an accounting tool based on the exergy analysis for the management of the mineral's wealth of the crust.

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