GEOLOGIC ENTROPY WITH ECONOMIC CONSTRAINTS PREDICTS MINERAL PRICES

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We propose a geologic entropy for describing the price of an element from its abundance. Maximizing a geologic entropy function under economic constraints using the Lagrange multiplier method yields specific predictions verifiable by data.

By now sustainability theory has established the existential need for managing consumption and closing recycling loops for materials. In 2019, society experienced a serious shortage in helium that substantially impacted the research community. A similar crisis for rare earth materials occurred in 2010. In both cases market factors were important to the supply risk, and new insights into the relation between market price and mineral element availability will presumably be helpful in understanding shortages.

Upon maximizing entropy subject to constraints, our method reproduced the empirical power-law behavior observed between price and abundance. We also investigated models that assume an exponential "activated process" for mining an element and for a highly regulated economy with fixed prices. Results indicate that the most likely abundance distribution under economic constraints yields a price-availability relation that is, within the spread of the data, identical to conventional supply and demand conditions in mineral economics.

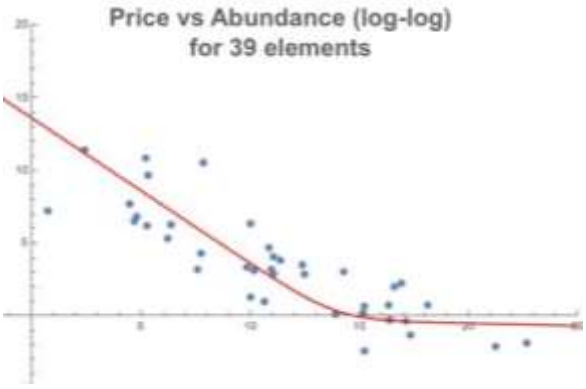

Figure 1 – Analytic theory predicts price-abundance relation for chemical elements based on proposed geologic entropy with economic constraints.

This work opens a window into a useful entropy function for geology and a way to apply economic constraints in a simple way that could help us better understand the parallels between statistical physics and economics. The underlying principle is that there is a most likely distribution of elemental abundances in a large ensemble of inhabitable planets as a way to define a useful entropy function. (This distribution is NOT claimed to be spatial distribution, which is well beyond our present capability and need, but rather a global average available to inhabitants to run a society.) We apply constraints—such as total expense cap and highly regulated prices—by maximizing the geologic entropy using Lagrange multipliers, thereby providing specific predictions verifiable by data. Surprisingly, results indicate that supply and demand aspects emerge with only statistical predicate. This work opens a window into a useful entropy function for geo-economics and a way to apply economic constraints using statistical physics.