Mineral ecology of carbon: Predictions of "missing" minerals

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Mineral ecology, the study of the diversity and distribution of minerals on Earth and other terrestrial planets and moons, exploits large mineralogical databases to identify deterministic versus stochastic aspects of mineral evolution [1] [2]. Of the ~5000 species approved by the International Mineralogical Association (rruff.info/ima), a few minerals dominate Earth's crustal volume and are very common (i.e., 101 species are reported from more than 1000 localities in the crowd-sourced database mindat.org). However, most mineral species are rare: 22% of species are known from only one locality, and more than half of all minerals are reported from 5 or fewer localities (mindat.org). This type of frequency distribution, which is also characteristic of the words in a book or the biomass in an ecosystem, conforms to a Large Number of Rare Event (LNRE) distribution [2] [3].

When applied to mineral statistics, LNRE distribution functions can be exploited to estimate the number and nature of as yet undiscovered species. Here we apply a Generalized Inverse Gauss-Poisson (GIGP) function to the 403 known minerals of carbon, using the 82,922 mineral species-locality pairs tabulated in mindat.org (as of January 2015). We find that carbon-bearing minerals, for which more than 25% of approved C species are known at only one locality, conform to a LNRE distribution.

Our model predicts that 548 C minerals exist on Earth today, indicating that ~145 species have yet to be discovered. Furthermore, by analyzing subsets of the most common additional elements in (i.e., C + O = 378 species; C + H = 282 species; C + Ca = 133 species; C + Na = 100 species), we predict that the majority of missing carbon-bearing species are hydrous carbonates, including ~50 missing calcium-bearing carbonates and ~80 missing sodium-bearing carbonates. We predict more than 20 missing species in the system C-Na-O-H±Ca±Y. We suggest, therefore, that previously overlooked mineral species (possibly white, poorly-crystalized phases) await discovery in alkali lakes, their associated evaporites, and in alkalic pegmatites.

[1] Hazen et al. (2015) *Canadian Mineralogist*, in press. [2] Hystad et al. (2015) *Mathematical Geosciences*, in press. [3] Baayen (2001) *Word Frequency Distributions*. Kluwer, Dordrecht.