



Howard Flack crystallographic lecture series 2025



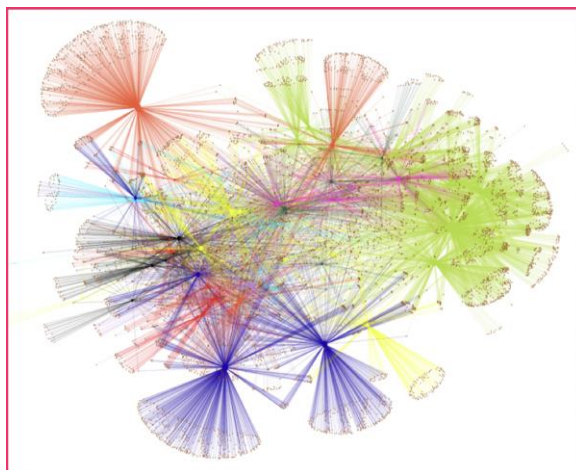
Prof. Robert M. Hazen

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***Mineral evolution and the search for critical resources,
life's origins, and time's second arrow***

Uni Geneva, Nov 14th, 12:15, Auditorium Stueckelberg, Ecole de Physique

Minerals, which display dramatic increases in diversity and complexity through more than 4.5 billion years of Earth's evolution, provide a quintessential example of an abiotic evolving system. Quantitative studies of mineral evolution rely on large and robust mineralogical data resources, including crystal structures, compositions, and physical properties. These data, coupled with advanced analytical and visualization methods, enable us to search for new deposits of critical resources, to probe near-surface environments thought to have influenced the origins of life, and to suggest a framework that unifies behaviors of both biotic and abiotic evolving systems. We posit that all such systems are characterized by combinatorial richness subject to selection—characteristics that hint at a second arrow of time.



A network graph of more than 5700 mineral species connected to 57 modes of formation embeds the evolution of Earth's mineral diversity through more than 4.5 billion years. Colors link groups of minerals formed in similar ways. Of special note, green indicates minerals formed exclusively through biological processes.

