Reply to “A comment on ‘An evolutionary system of mineralogy: Proposal for a classification of planetary materials based on natural kind clustering’”

ROBERT M. HAZEN¹,*

¹Earth and Planets Laboratory, Carnegie Institution for Science, 5251 Broad Branch Road NW, Washington, D.C. 20015, U.S.A.

ABSTRACT

I welcome the “Comment” from Hatert et al. (2021) related to the proposal for an “Evolutionary system of mineralogy” (Hazen 2019) and thank them for their historically informed, conceptually nuanced, and consistently constructive contribution. They offer corrections related to two facets of my paper that seemed unfairly to criticize aspects of the International Mineralogical Association’s Commission on New Minerals, Nomenclature and Classification (IMA-CNMNC) protocols for classifying minerals.

First, they note an unfortunate inferred ambivalence with respect to the relationship between the IMA system and the new evolutionary system. If I was once ambivalent, that view has changed. Having spent the past two years in an ongoing effort to develop this new historical approach, I am struck every day by the power of the IMA-CNMNC system of species classification and nomenclature, which is fundamental and indispensable to the science of mineralogy. As Hatert et al. suggest, any new approach to organizing natural solids, including one focused on planetary evolution, must rest on the foundation provided by the IMA-CNMNC and its many volunteers who selflessly bring order to the mineral kingdom. In the best scenario, the evolutionary system may one day emerge as one of several useful approaches that complement and amplify but in no way replace this core IMA-CNMNC foundation, as clearly stated in the abstract of Hazen (2019).

Second, Hatert et al. (2021) offer corrections regarding the IMA-CNMNC approach to classification, in particular a mischaracterization of the formal process to incorporate amorphous phases, poorly crystalline materials, and loosely defined “mineraloids.” I am grateful for the clarifications, as well as the implication that IMA protocols may facilitate the embrace of additional such phases in the future.

Finally, I welcome the chance to explore further the emerging concept of “natural kinds” as applied to the mineral kingdom. Here, our thoughts differ. I suggest that minerals, considered in their information-rich, idiosyncratic, paragenetic contexts (in contrast to IMA-CNMNC species), have the potential to represent quintessential examples of “natural kinds.” Furthermore, when viewed in their evolutionary context, minerals offer an intriguing opportunity to expand the concept of “historical natural kinds” beyond its present limited and, at times, controversial use in biology, into the realm of the co-evolving geosphere and biosphere.

Keywords: Philosophy of mineralogy, classification, mineral evolution, natural kinds, cluster analysis, nomenclature, mineral species, IMA-CNMNC

INTRODUCTION

In mid-2018, I began to confront a knotty problem that had been with me for more than a decade: Is there a coherent, internally consistent way to place the qualitative narrative of “mineral evolution” (e.g., Zhabin 1979, 1981; Hazen et al. 2008) into a more quantitative and rigorous framework? Since the pioneering conceptual studies of the twentieth century (Bowen 1928; Gastil 1960; Laznicka 1973; Zhabin 1979, 1981; Meyer 1981), the idea of an evolving mineral realm has had intrinsic appeal. Geoscientists realize that minerals provide the most robust and information-rich testimony for billions of years of cosmic history. From the oldest presolar moissanite grains, now dated at a remarkable ~7 billion years (Heck et al. 2020), to the biominerals of our teeth and bones forming in real time, the mineral kingdom holds the key to unlocking secrets of planetary evolution through deep time.

For more than 60 years, from the time I would spend hours every month as a rapt middle-school student studying the fabled “Dana Collection” housed in row upon row of slant-topped glass displays at the American Museum of Natural History, I embraced the framework that would become the IMA classification system. I proudly displayed a growing collection on groaning bedroom shelves, with handwritten labels citing name, formula, crystal structure, and locality. I learned early on that nothing in mineralogy is more fundamental than chemical composition and crystal structure; each species is defined by virtue of its unique combination of those two attributes.

But in 2018, I was faced with a dilemma. The emerging historical narrative of mineralogy in which new kinds of minerals