‘It from bit’ in mineralogy: how information emerges, evolve and disappear in the world of mineral structures

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The ‘it from bit’ idea is due to the American physicist John Wheeler as the hypothesis that information sits at the core of Nature: the world is a totality of informational objects interacting with each other (Floridi 2004). Minerals are specific (very specific, indeed!) natural objects, the composition, structure, formation and evolution of which constitute the subject of mineralogy. Can minerals be considered as informational objects? Where information is stored in minerals? There can be different views on this subject and one of them is to look at the complexity of minerals as consisting of atoms arranged in periodically repeating three-dimensional arrangements. Then the complexity of minerals can be estimated in quantitative terms through the application of the Shannon information theory (Krivovichev 2012, 2013). Each mineral can be viewed as a finite reservoir of information, since unit cells are finite portions of space containing finite amounts of atoms. Structural complexity calculated in bits is related to the configurational entropy: complex configurations possess lower entropies (Krivovichev 2016).

The introduction of complexity analysis into the mineralogical discourse allows for many interesting insights with regard to the fate of information in natural processes involving minerals. First, the emergence of complexity (and diversity) is governed by various specific mechanisms, also valid for other complex natural systems (modularity is one of them). The relations between energy and complexity are the second specific point of interest: the rise of complex structures and diverse mineral parageneses is impossible without essential energy input. In fact, many complex minerals appear as dissipative structures forming as the energy flows through a geochemical system. The increasing temperature results in the dissipation of structural information through the increasing disorder, seen for both individual mineral species (Avdontceva et al. 2015) and mineral associations (Krivovichev 2015). Metastable crystallization under far-from-equilibrium conditions favors formation of simple structures, which is especially clear in the Ostwald cascades of phases (Krivovichev et al. 2017) and processes of metastable nucleation (Lupi et al. 2017). Mineral complexity evolves with geological history, at least at the overall scale (Krivovichev et al. 2018). Finally, the information capacity of minerals can be compared with those of other natural objects such as DNA and human brain. The use of information science in mineralogy thus allows for the unified view on the information storage and processing in natural systems, including non-living nature, life and mind, indirectly supporting the theory of ‘Three Big Bangs’ (Rolston III, 2010).

Avdontceva et al. (2015) Phys Chem Miner 42:671-676
Floridi L (2004) in Weckert J, Al-Saggaf Y, eds. Computing and Philosophy Conference, vol. 37.
Rolston III, H (2010) Three Big Bangs – Matter-Energy, Life, Mind. Columbia Univ Press.
Krivovichev SV (2012) Acta Crystallogr A68:393-398
Krivovichev SV (2013) Mineral Mag 77:275-326
Krivovichev SV (2015) in Danisi R, Armbuster T, eds. Highlights in Mineralogical Crystallography. De Gruyter, pp 31-74
Krivovichev SV (2016) Acta Crystallogr B72:274-276
Krivovichev SV, Hawthorne FC, Williams PA (2017) Struct Chem 28:153-159
Lupi et al. (2017) Nature 551:218-222