July 16-21, 2017 at UC San Diego, CA, USA

Adsorption of RNA on Mineral Surfaces and Mineral Precipitates.

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A widely held "RNA first" model proposes that RNA gave organic matter in Earth its first access to Darwinism. Such a model, which requires a mechanism to generate RNA from a prebiotic "soup", must also manage the intrinsic instability of any RNA so formed. Association of RNA with mineral surfaces has been suggested as a possible solution to this problem. However, the prebiotic significance of laboratory experiments that study the interactions between oligomeric RNA and mineral species is difficult to discern. While laboratory-generated samples of synthetic minerals can have controlled compositions, they are often viewed as "unnatural". On the other hand, natural mineral specimens can differ widely depending on their provenance and impurities.

Here, we manage this problem by finding trends in the interaction of RNA with natural mineral specimens, synthetic mineral specimens, and co-precipitated pairs of synthetic minerals. If these trends run in parallel, a persuasive case can be made that those interactions are mineral-specific, rather than simply being examples of large molecules associating with large surfaces of precipitated synthetic minerals, or the consequence of mineral impurities that vary from sample to sample.

Using this approach, we have discovered Periodic Table trends in the binding of oligomeric RNA to alkaline earth carbonate minerals and alkaline earth sulfate minerals. These trends are seen in both natural and synthetic minerals, and are validated by comparison of co-precipitated synthetic minerals.

We also found differential binding of RNA to polymorphic forms of calcium carbonate, and the stabilization of bound RNA on aragonite. Similarly, we found that silicon dioxide (silica, SiO_2), in the form of synthetic opal, adsorbs and stabilizes RNA from aqueous solution more than fully amorphous silica, which in turn adsorbs RNA more than crystalline quartz. Moreover, RNA adsorbed on opal is considerably more stable than the same RNA free in aqueous solution at basic pH.

These results have relevance to the prebiotic concentration and stabilization of RNA in the "Discontinuous Synthesis Model" for the origin of life via an RNA World. Remarkably, the mineral ensemble that we would ideally like for this model is close to that being discovered today by NASA missions to Gale Crater on Mars.