Architected geomaterial development for geochemical research

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Geological materials are typically non-uniform on multiple length and time scales. Although there is extensive research done on "representative" materials, any given rock core or sample provides either a limited view of the structural complexity observed in the field or non-repeatable compositional heterogeneity. This makes accurate delineation of the properties of such materials difficult to analyze. Synthetic materials, on the other hand, such as controlled pore glasses, aerogels, etc. provide much more quantifiable matrices, but their very simplicity makes them less representative of real rocks. It is, therefore, beneficial to study systems that are as simple as possible, and where the physical state of the reacting constituents is well characterized, but that are more representative of earth materials as an intermediate step. This requires: 1) synthesis of suitable nano- or microscale mineralogical components, and 2) methods for arranging them (i.e. deposition by centrifugation, ultrasonic treatment, etc.) and sintering or cementing them into a synthetic rock ("synrock") of sufficient size. These "architected geomaterials" can then be used for both post-synthesis analysis of the formation of pore structures (i.e. how are poer structures in sedimentary or metamorphic rocks affected by settling, compaction and/or reaction) and utilized in other experimental venues. The goal is to develop materials with controllable, repeatable heterogeneity and structure that can be tested under a range of thermal, hydraulic, chemical and mechanical conditions, such as samples with architected nanoporous structures, fractured systems, crystal face interfaces, known wettability and reactivity etc., as well as upscaled, "core-scale" properties such as quantifying the relationship of permeability and elastic constants to porosity and pore structure.