Martian Geochemistry from SNCs to Curiosity: Diversity in a complex planet

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After the Mariner 9 orbiter images, it was clear that Mars is a complex planet, with a wide diversity of landforms, underlying lithologies, and thus geochemistries. The known extent of Mars' geochemical diversity has increased with every spacecraft capability deployed, and nearly every meteorite found. In the last years, the known diversity has inflated hugely from an onslaught of data from orbiters, rovers, and Mars meteorites found on Earth.

Orbital gamma-ray geochemistry (GRS) confirmed that Mars is volatile-rich (H, K, Na), and that its 'sediments' include near-surface permafrost. Orbital sensing in 'light' wavelengths (e.g., TES, CRISM) constrains mineralogy to the meter-scale, which included discoveries of hematite (e.g., at Meridiani), serpentines and clays (e.g., Mawrth Vallis, Nili Fossae), and carbonates (e.g., Syrtis area).

Landed spacecraft have further expanded Mars' known diversitiy. *Opportunity* followed the hematite, and found acid-altered sedimentary rocks rich in jarosite, and abundant diagenetic alterations. *Spirit* aimed for lake sediments and found basalts instead (distinct from martian meteorites), carbonate rocks, alkaline basaltic rocks, and nearly pure silica. *Phoenix* confirmed Mars' permafrost, and showed that perchlorate is abundant in its soil. And *Curiosity* did find lacustrine sedimentary rocks, plus diagenetic phyllosilicates, abundant sulfate veins; it has not yet reached its target sediments (located from orbit) rich in clays and hematite.

In contrast, the meteorites from Mars are all basaltic igneous rocks, except NWA 7034 (and its pairs) which is an impact breccia of igneous materials. The absence of martian sedimentary meteorites (and the rarity of ejecta) may mean that all but the most coherent rocks are pulverized by nearby impacts and do not leave Mars. Recent meteorite finds (NWA 7034, 7635, 8159, 8649) have ballooned the known extent of martian igneous diversity. The martian basalts represent at least four distinct mantle reservoirs (plus crust), sampled over nearly the whole age of the planet (180 my to 2300 my, and even 4500 my by including ALH84001) as shown by their trace element and isotope geochemistries.

At every point, it has been easy to assume we have a representative or complete selection of Mars' geochemical diversity. I doubt this assumption is any better today that it has been before.