Hot/cold, wet/dry, big/small, erupt/stall, juvenile/anatectic? – Multiple personalities of felsic magmatism

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Felsic magmas are linked by qtz-feldspar-melt equilibria that limit their range of major element compositions. Crustal processing is thus clearly a common factor in production of all such magmas, but this does little to resolve – and in fact obscures – longstanding and recent controversies concerning sources, generation and emplacement processes, evolution, and relationships between felsic plutonism and volcanism.

Field, geochemical, and geochronological characteristics of similarly silicic rocks from a variety of environments we have investigated* reveal remarkable diversity:

- Scales: small (~10^{-3} km^3 - increments in some plutons, small eruptions) to giant (10^3 km^3 supereruptions)
- Initial temperatures: ~700 C to near 1000 C
- Zircon inheritance: negligible to dominant
- Entrained crystal fractions: negligible to near lock-up
- Initial water contents: ~dry to wet (≤3 to near 10 wt%)
- Clear volcano-pluton connections, as well as plutons unlikely to have erupted counterparts and eruptions unlikely to have left appreciable plutonic residue
- Isotopically juvenile to ancient crust-dominated
- Involvement of mafic magma: obvious in some, apparently limited in others, absent or occult in yet others

Characteristics generally correlate and suggest that (1) cool, wet, crystal-rich magmas, largely anatectic, are doomed to stall without eruption; (2) very large magma volumes ('big tanks') may reflect unusual thermal input, either initially producing huge volumes or mobilizing stagnant mushes. Intriguing departures from simple relationships warrant further consideration – e.g. large variations in T and magma volumes in closely associated magma systems, isotopically primitive granitoids with abundant ancient zircon inheritance, very hot felsic magmas with no obvious mafic input.

[*Deep-seated to very shallow plutons, convergent and extensional settings, southern Appalachians, SW USA, Iceland; small to supereruption volcanic deposits, subduction, extension, hot spot settings, Cascades & SW USA, Iceland]

Chalcopyrite in the R chondrite PRE 95411

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The R chondrites record petrologic grades from 3 to 6, suggesting parent-body histories from unaltered to nearly equilibrated. However, a growing body of evidence suggests the group may have experienced hydrothermal alteration. Reports of amphibole, biotite, and chalcopyrite in the R chondrites all support aqueous processes [1-3]. Recent observations of hydrous minerals in a second R chondrite and other indications of aqueous alteration appear to corroborate the earlier results [4, 5]. Here we expand on these efforts and report an investigation of chalcopyrite in a sulfide assemblage in the R3 chondrite PRE 95411.

Electron microprobe analysis indicates the assemblage is primarily composed of pyrrhotite with minor pentlandite, troilite, and chalcopyrite. Based on previously described methods [6], we used focused ion beam scanning electron microscopy (FIB-SEM) to prepare an electron-transparent cross section of the assemblage for transmission electron microscope (TEM) analysis [7]. Selected-area electron-diffraction confirms the presence of chalcopyrite and troilite. Energy-dispersive X-ray spectrometry shows that the chalcopyrite and troilite grains are bifurcated by an Fe-Ni-O-rich vein. The vein center contains a linear domain of Fe-rich, Ni-poor nanocrystalline material. In comparison, the material around the domain is amorphous and relatively Ni-rich and Fe-poor. Chemical mapping also reveals that the grain boundary between troilite and the chalcopyrite is enriched in Cu. These microstructural features are reminiscent of those associated with a cubanite grain in the Orgueil CI chondrite [8], suggesting hydrothermal alteration.

These results indicate that the R chondrites experienced volatile-rich conditions. Improved understanding of the distribution of volatiles provides important constraints on the formation and evolution of the solar system.

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