

Water storage and amphibole control in arc magma differentiation

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Arc magmas are distinguished from those of other tectonic settings by several first order characteristics; 1) they tend to be relatively differentiated with even the most mafic rocks in a suite typically $\geq 50\%$ SiO₂, 2) they typically contain high H₂O contents and 3) they have distinctive trace element signatures. The “standard” model for arc petrogenesis involves melting of a mantle wedge, preconditioned by the ingress of fluids \pm melts from the subducted slab (oceanic crust \pm sediments). This produces primitive hydrous basalts with a distinct trace element signature reflecting a combination of process and inheritance from source components. The subsequent differentiation path is critical in defining the compositions of rocks ultimately formed through eruption or emplacement, and also for dictating practical criteria such as eruptive behavior. A petrographic survey of volcanic arc rocks show that they are typically in equilibrium with a shallow pressure gabbroic assemblage. On the other hand, indications of open system processes along with thermal modeling argue for processing in the deep crust.

We have collated data from single volcanic suites from a representative global sample of arcs, and found compelling evidence for the involvement of amphibole during differentiation. Preferential sequestration of middle REE (e.g. Dy) over heavy and light REE can only reasonably be explained by the involvement of amphibole, which has middle REE partition coefficients higher than both light and heavy. Amphibole also, by virtue of its low SiO₂, has the capacity to leverage liquid SiO₂ towards higher values, and may also lower TiO₂ as seen in arc magmas. The amphibole could be directly fractionated from liquids in which it is stable, or residual in partial melts of amphibolite. In either case differentiation is dominantly in the mid-deep crust.

The signature of amphibole indicates that a significant H₂O-bearing reservoir exists in the arc crust, which may be tapped to produce silicic, explosive magmas or ore-forming fluids. Furthermore, amphibole has the capability of rotating REE patterns to obtain the characteristic light REE enrichment of the continental crust.

Construction of the ion nanoprobe: A progress report

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We report on progress towards construction of the ion nanoprobe, a new instrument designed for isotopic and chemical analysis at the few-nm scale [1]. The new instrument will combine a recently developed high resolution liquid metal ion gun (LMIG), tunable solid state lasers for laser resonant ionization, a molecular fluorine excimer laser for UV ionization, and an improved time-of-flight mass spectrometer. The instrument is intended to provide a significant decrease in spot size and increase in sensitivity compared to the current state-of-the-art SIMS instrument, the Cameca NanoSIMS-50: the LMIG can be focused to 10 nm; the most advanced previous generation of this type of instrument, SARISA, has recently demonstrated a useful yield (atoms detected per atom removed) of greater than 20% [2], and our goal is 35%. Isotopic precision is currently at the few permil level, as a result of a number of recent advances in laser position and wavelength stabilization [3]. Compared to SARISA, the ion nanoprobe will operate at significantly higher accelerating voltage, improving mass resolution and sensitivity, and will have a finer-focused primary ion beam. The physical layout will also be different, with the flight tube of the ion nanoprobe mounted vertically above the sample chamber; this assembly will be mounted in the center of an H-shaped laser table equipped with active vibration cancellation devices. A thermally stabilized, low-vibration, draft-free room to house the ion nanoprobe is now under construction.

Much of the cometary dust returned by the Stardust mission from Comet Wild 2 has been processed at high temperature and presolar grains like those found in meteorites and interplanetary dust particles are very rare. Contemporary interstellar grains collected by Stardust are just now being extracted and will be a high priority for the ion nanoprobe, as will be small presolar SiC and subgrains in presolar graphite that are beyond current analytical technology.

[1] Davis *et al.* (2007) *Geochim. Cosmochim. Acta* **71**, A205.

[2] Veryovkin *et al.* (2008) *Lunar Planet. Sci.* **39**, #2396.

[3] Levine *et al.* (2008) *Lunar Planet. Sci.* **39**, #1661.