From the Workshop Organizers

The December issue of MAPS emphasizes the martian meteorites (also called SNCs) and Mars’ geochemical and physical processes. We focus on the idea that much of the geochemistry and petrology of the martian meteorites can be explained by mixing relationships, both of physical objects and of chemical components. This idea was explored at the workshop “Unmixing the SNCs: Chemical, isotopic, and petrologic components of the martian meteorites,” held at the Lunar and Planetary Institute between October 11–13, 2002. The papers presented in this issue grew out of the workshop and represent a significant affirmation of the concepts of mixing, including ideas on early martian differentiation and the hypothesis of a martian magma ocean. Several authors also find close analogues between martian geochemical components and those of lunar basalts (like KREEP); from the perspective of planetary differentiation (at least), Mars appears less like the Earth and more like the Moon (Jones 2000).

In broad terms, the geochemistry of the martian meteorites can be represented by three mantle or crustal components, defined originally in terms of their radio-isotopic characteristics (Jones 1989; Borg et al. 1997). One source is depleted in igneous incompatible elements (like QUE 94201); the other two are relatively enriched but distinct (the sources of Shergott and of the nakhlites). These components were separated very early in Mars’ history (~4.51 Ga; Borg et al. 2003) and remixed more recently.

Our knowledge of the characteristics of these martian geochemical components is incomplete. Kringle et al. provide additional data on QUE 94201, the meteorite that defines the depleted component. Treiman shows that nearly all element abundances in the shergottites can be explained in terms of two of the components (QUE 94201 and Shergotty), plus igneous fractionations. Herd and Goodrich et al. show that the signatures of the shergottite components include their oxidation states, as monitored by oxide-silicate equilibria; depleted is reduced, enriched is oxidized. Goodrich demonstrates that these differences in oxidation state represent the original magma and not igneous fractionation. Herd shows that oxygen isotope composition varies along with oxidation state and suggests that the higher oxidation state may be accompanied by greater water content (see Lentz et al. 2001). However, silicate minerals may not be useful in evaluating oxidation states, according to Dyar; ferric iron content of silicates in martian meteorites is not correlated with oxidation state, as measured by Herd and Goodrich. This decoupling may reflect hydrogen mobility in late- and post-igneous environments. Walton and Spray look at another aspect of mixing—the physical processes of impact melting and mixing that have been suggested to control the compositions of some shergottites (Mittlefehldt 1999).

The idea of an early magma ocean on Mars has gained favor recently (e.g., Brandon et al. 2000; Kleine et al. 2002; Borg et al. 2003). Elkins-Tanton et al. modeled the crystallization and physical state of a model martian magma ocean, with particular attention to density inversions. They find that aluminum from the magma will be concentrated in garnet and can be isolated into the lowermost mantle by convective overturn. The remaining mantle will be Al-depleted, matching the sources of the martian meteorites. Borg and Draper modeled crystallization of a likely magma ocean and explored whether the compositions of martian basalts could arise as partial melts of that ocean’s cumulates. Their model is successful, for the most part, in replicating the chemical components of the shergottites, which they find similar to lunar chemical components (e.g., KREEP).

At the other end of time, one has to wonder how martian basalts can form at all in a mantle depleted in the heat-producing elements. Jones asks where these elements must reside and infers that a deep layer of nakhlite-like geochemistry could provide enough heat to produce basalts from the overlying depleted mantle (i.e., the QUE 94201 component). Jones also notes the geochemical similarities between martian and lunar basalts as evidence for a martian magma ocean. Kiefer, laudably, has constrained geophysical convection models by the geochemistry of martian meteorites. He finds that the presence of young basalts on Mars (including the shergottites) requires that >39% of Mars’ current radioactive heat production be in its mantle. At that limit, which is just consistent with Jones’ inferences, partial melting can occur sporadically at the heads of convective plumes.

We hope you find these articles interesting, useful, and perhaps provocative! Chris Herd and I, organizers of the “Unmixing the SNCs” workshop, would like to thank all the participants for sharing their ideas and research and for the efforts of writing for this volume.

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REFERENCES


