Age and origin of Mars

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Mars may have formed via runaway growth within ~1 Myr or its accretion may have been more protracted and involved large impacts. Hf-W chronometry ought in principle to be able to distinguish between these two scenarios but reported Hf-W ages for Mars range from <1 Myr to ~12 Myr [1-4]. This range in ages is mainly due to different assump-tions regarding the Hf/W ratio of the Martian mantle [5]. Th/W ratios of Martian meteorites are relatively constant and hence can be used to constrain the Hf/W ratio of the Martian mantle [5]. This approach requires knowlegde of the Hf/Th ratio of the Martian mantle, which is generally assumed to be chondritic. The chondritic Hf/Th ratio however is not well constrained and potential variations in Hf/Th ratios among different chondrite groups have not been investigated. We developed analytical techniques for the precise determination of Hf/Th ratios by isotope dilution and present an improved determination of Hf/Th ratios in chondrites. This is used to better constrain the Hf/W ratio of the Martian mantle and the age of Mars. Our new Hf and Th concentration data reveal that carbonaceous chondrites have lower Hf/Th ratios than ordinary chondrites. The calculated Hf/W ratio of the Martian mantle therefore depends on assumptions regarding the bulk composition of Mars. For instance, using our new estimate for the Hf/W ratio of the Martian mantle, two-stage W model ages of ~7 Myr and ~4 Myr are calculated for an ordinary and carbonaceous chondrite-like composition of Mars, respectively. These ages change to ~15 Myr and ~13 Myr if one assumes that Mars accreted at an exponentially decreasing accretion rate and complete metal-silicate equilibration was always achieved. These ages would further increase if metal-silicate equilibration was incomplete. In spite of this model-dependence, Hf-W chronometry provides important constraints on the age and origin of Mars because the two-stage model age corresponds to the earliest time when core formation could have been completed [6]. Hence, based on our new estimate for the Hf/W ratio of the Martian mantle, it seems unlikely that Mars had entirely been accreted in less than ~1 Myr. This suggests that Mars is probably not a stranded planetary embryo and that its formation history was similar to that of the larger terrestrial planets.

[1] Kleine T. *et al*. (2002), *Nature* **418**: 952-955.
[2] Kleine T. *et al*. (2004), *GCA* **68**: 2935-2946.
[3] Foley C.N. *et al*. (2005), *GCA* **69**: 4557-4571.
[4] Halliday A.N. and Kleine T., in: *MESS II*, D.S. Lauretta and H.Y. McSween, Editors. 2006.
[5] Nimmo F. and Kleine T. (2007), *Icarus* submitted. [6] Kleine T. *et al*. (2004), *EPSL* **228**: 109-123.

Re-Os depth profile of the upper mantle beneath Central Europe

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Variations in Re and Os concentrations in upper mantle rocks from various geotectonic environments raise the question of whether they reflect primary or secondary processes. Recent studies have shown that Re can be metasomatically imported from subducting oceanic crust or by basaltic melt metasomatism. Osmium is a compatible element and its concentration mostly remains close to PUM estimates during various mantle processes, although addition of Os from subducting slabs can introduce radiogenic Os.

Rhenium and Os concentrations, and Os isotopic data were determined for a well-characterized suite of upper mantle xenoliths sampled from beneath the Kozákov volcano (5 Ma), of the Bohemian Massif (Czech Republic). This suite of mantle xenoliths represents the upper mantle profile composed of 3 different layers, from 33 to 70 km. The xenoliths underwent 7-15% partial melting and subsequent LILE enrichment by percolation of volatile-rich melt, which was not associated with recent volcanism. These processes were more intensive with increasing depth.

The samples have highly variable, but generally low Re and Os concentrations of 6–28 ppt and 0.2–2.1 ppb, respectively, and relatively uniform $^{187}Os/^{188}Os$ (0.1219–0.1276). Thus, they have Os isotopic compositions within the range of estimates of the modern convecting upper mantle. The Os concentrations and $^{187}Re/^{188}Os$ significantly vary with depth with the lowest Os and highest (but subchondritic) $^{187}Re/^{188}Os$ at the greatest depths (~70 km). Precise age of partial melting could not be determined because of evident perturbation of the Re-Os system. However, Lu-Os “ages” point to ~1.0 Ga depletion event, if the samples affected by perturbation are excluded.

The low Os concentrations and strongly subchondritic Re/Os ratios in some samples imply that Os was removed from the system at some stage of mantle evolution. We suggest that Os was removed during percolation of high-temperature sulphur-undersaturated melt causing sulfide breakdown and Os (and Re) removal. Our data suggest that such processes may affect large proportions of the upper mantle and could significantly modify the Os composition of the Earth`s subcontinental lithospheric mantle.