

Comparative planetology – What are the factors controlling the nature of terrestrial planetary crusts?

H. DOWNES

Department of Earth and Planetary Sciences, Birkbeck
University of London, Malet Street, London WC1E 7HX
United Kingdom (h.downes@ucl.ac.uk).

Size, composition, or location?

Within the Solar System, rocky bodies (planets, moons, asteroids) have a variety of sizes and crustal compositions. A common view is that “there are more variables than planets” [1], whereas others insist that the only significant factor controlling planetary evolution is the size of the body [2]. Consideration of pairs of similar sized planetary bodies (e.g., Earth/Venus; Moon/Mercury; Moon/Io, Callisto/Ganymede) suggests that two other factors are also important.

Firstly, the composition of the body controls much of its evolution, including the nature of its crust (both primary and present-day). Whether the mantle of the body is Fe-rich (e.g. Moon, Mars) or Mg-rich (Earth, Venus, Mercury) controls the compositions of erupted basalts but, more importantly, can lead to plagioclase flotation in a magma ocean under anhydrous conditions. Presence of volatiles, particularly water, to the mantle inhibits formation of an anorthositic crust [3]. Water also lowers the solidus of basalts, which can then partially melt to produce magmas of intermediate compositions which are too buoyant to subduct, leading to formation of a silicic continental-type crust. Significantly, this process does not require the operation of plate tectonics but only requires the melting of hydrated basaltic material, as is demonstrated by the Archean TTG crust of the Earth. Secondly, the location of the planetary body is an important factor, as seen in the dichotomy between Ganymede and Callisto in which the proximity to Jupiter governed the amount of impact-related heating [4] and later tidal heating, or in the contrasting magmatic histories of the Moon and Io.

Based on the three main factors, predictions can be made regarding the nature of crusts that are likely to be formed on planetary bodies of different sizes and bulk compositions, and this can then be extended to a consideration of specific locations of planets or moons (e.g. proximity to a gas giant; inside/outside the stability zone of surface liquid water etc).

[1] Taylor SR & McLennan SM (2008) *Planetary Crusts*. Cambridge. [2] Albarède F and Blichert-Toft J (2007) *Comptes Rendus Géoscience*, **339**, 917-927. [3] Brown S & Elkins-Tanton L (2009) *EPSL* **286**, 446-455. [4] Barr A & Canup R (2010) *Nature Geosciences* **3**, 164-167.

The oxidation state of Ti in synthetic and meteoritic hibonite

P.M. DOYLE^{1,2*}, A.J. BERRY^{1,2}, P.F. SCHOFIELD²,
J.F.W. MOSSELMANS³, A.D. SMITH⁴, A. SCHOLL⁵ AND
A.T. YOUNG⁵

¹Imperial College, London, UK

(*correspondence: p.doyle07@imperial.ac.uk)

²Natural History Museum, London, UK

³Diamond Light Source, Oxfordshire, UK

⁴STFC Daresbury Laboratory, Daresbury, UK

⁵Advanced Light Source, Lawrence Berkeley National Lab,
Berkeley, CA, USA

Hibonite (CaAl₂O₁₀) is a Ti-bearing mineral found in calcium aluminium inclusions (CAIs) and is thought to be the second mineral to condense from a solar composition gas [1]. As such, the crystal chemistry of hibonite could provide insight into the conditions of the early Solar System. Ti may occur as Ti³⁺ under reducing conditions, with up to 23% of the Ti in meteoritic hibonite previously reported as Ti³⁺ [2].

We have used X-ray spectromicroscopy (XANES, XPEEM) to determine Ti³⁺/Ti⁴⁺ ratios for a range of meteoritic hibonites, with spatial resolutions between 3 μm and 100 nm. We aim to use this information to investigate if hibonite grains record temporal variations in oxygen fugacity in the early Solar Nebula.

Ti-bearing hibonite samples were prepared at 1400 °C under oxidising and reducing atmospheres using a CO-CO₂ gas mixing furnace in order to produce a sample series with 0-100% Ti³⁺/ΣTi (where ΣTi = Ti³⁺+Ti⁴⁺). Neutron powder diffraction data was used to determine the site occupancy of Ti³⁺ and Ti⁴⁺ in the sample suite. Ti K- and L-edge spectra were recorded for these samples and meteoritic hibonite (c/o A. Bischoff and S. Rout). Spectral features that vary as a function of Ti³⁺/Ti⁴⁺ in the synthetic hibonite series were identified.

The resulting calibration curve was used to determine Ti³⁺/Ti⁴⁺ ratios for the meteoritic hibonite grains. The results show that blue hibonite from CAIs in the unique Acfer094 meteorite and greeny-blue hibonite from a CAI in the El Djouf001 CR meteorite have up to 10% Ti³⁺/ΣTi, and colourless hibonite grains from the Hughes030 and NWA2446 R-type meteorites have less than 3% Ti³⁺/ΣTi. Additionally, there is evidence that there may be a degree of core-to-rim variation of the Ti³⁺/ΣTi ratio within some hibonite grains.

[1] Lodders (2003) *Astrophys. J* **591**, 1220-1247; [2] Beckett *et al.* (1988) *GCA* **52**, 1479-1495.