

Ureilite meteorites: Our only extensive sample suite from the mantle of a dwarf planet

ANDREW TOMKINS¹ AND LAUREN JENNINGS²

¹Monash University

²Universitat Munster

Presenting Author: andy.tomkins@monash.edu

We have generated thermometry data for numerous ureilite meteorites and developed a thermal model for the ureilite parent body (UPB), which we use to examine the effects of size, composition, and formation time on the thermal evolution of the UPB. We find that MgO-rich ureilites sampled mantle at 1200–1250°C, whereas FeO-rich ureilites were subject to a far broader range of temperatures ranging between 1050 and 1280°C. When combined with the thermal models, our results imply that, (1) the UPB formed within 1 m.y. of initial condensation of the Solar System, (2) ureilites are metamorphic residues of core and crust extraction, with pyroxene chemistries and textures reflecting moderate to extensive melt loss, and in some samples, melt re-addition, and (3) ureilites sample a broad range of depths in the UPB mantle with sparse MgO-rich samples possibly coming from a deeper mantle and numerous FeO-rich samples coming from shallower levels. The broad temperature range for the FeO-rich ureilites might be explained by variation over a small depth range in proximity to a hotter shallow magma ocean that was heated by concentrated ²⁶Al, the Al having been preferentially extracted from the mantle during partial melting. Only rare samples might come from an igneous crust that formed from the shallow magma ocean. Pyroxene chemistry suggests that the UPB may have been large enough to achieve pressures >2 kbar in the lower mantle, and coupled with the thermal models, this implies that the parent body had a diameter on the order of 1000 km. Acknowledging the strong evidence of a catastrophic impact in ureilite meteorites, we propose that the UPB was not totally destroyed as commonly supposed, but rather, a giant impact entirely removed the crust and the majority of the mantle. This would leave a dense M-type asteroid equivalent in size to some present in the solar system today; Psyche is possibly the remnant of the UPB, but may be slightly too low in FeO. There are several other good candidates amongst the M-type asteroids, such as 22 Kalliope at 150 km diameter and density of 4.8–5.9 g cm⁻³.