High Velocity Collisions Recorded in Asteroidal Meteorites: New Ways to Constrain Planet Formation

W.F. BOTTKE[12] AND S. MARCHI[1,2]

[1] Southwest Research Institute, Boulder, CO, USA
[2] Center for Lunar Origin and Evolution, NLSI

It was recently shown that 40Ar–39Ar ages in meteorites reflect unusually high impact velocities exceeding 10 km/s [1]. Compared with typical impact velocities for main-belt asteroids of about 5 km/s, these collisions produce 100–1,000 times more highly-heated material by volume. It was proposed that the 40Ar–39Ar ages between 3.4 and 4.1 Gyr ago from Vesta, the H-chondrite parent body and the Moon record impacts from numerous main-belt asteroids that were driven onto high velocity and highly eccentric orbits by the effects of the late migration of the giant planets. The timing of these asteroidal and lunar impact signatures help define the so-called Late Heavy Bombardment.

An intriguing implication of this work concerns the 40Ar–39Ar events seen between ~4.4–4.53 Gyr ago among many stony meteorite groups. Although some of those ages may reflect cooling through the blocking temperature after igneous crystallization, others are unambiguously related to early impact events on primordial asteroids during the planet formation era [e.g., 2]. More recent impacts in the main asteroid belt ejected this material off the parent body, allowing it to reach Earth through dynamical processes. We postulate that these early high-velocity impacts likely came from leftover planetesimals residing in the terrestrial planet region, many of which had highly eccentric and inclined orbits. If true, these ~4.5 Gyr ago events constrain the nature and decay rate of this putative population, as well as early planet formation processes. Using numerical simulations, we will explore the implications of these results in our talk. We will also probe how these same methods and data allow us to glean insights into the timing of the giant impact that formed the Moon.

[1] Marchi, Bottke *et al.* (2013) *Nature Geosci.*, **6**, 303-307.
[2] Bogard, D. D. (2011) *Chem. Erde Geochem.* **71**, 207-226.

Hypersaline volatiles in a palladium-enriched mafic pegmatoid from the 2.48 Ga East Bull Lake intrusion, Sudbury District, Ontario, Canada

BRANDON BOUCHER[1], JACOB HANLEY[1] AND RICHARD JAMES[2]

[1]Saint Mary's University, Halifax, NS, Canada. B3H 3C3 (boucher.brandon.m@gmail.com; jake.hanley@gmail.com)
[2]MERC, Laurentian University, Sudbury, ON, Canada (rjames@laurentian.ca)

The East Bull Lake intrusion (EBLI) is a Paleoproterozoic mafic-ultramafic (low-Ti, high-Al tholeiitic) intrusion located roughly 90 km west of Sudbury, ON. The intrusion itself consists primarily of massive- and layered leucogabbro and leucogabbronorite and is interpreted to be the product of crystallization of partial melts from sublithospheric depleted mantle, a remnant of a ~2.48 Ga large igneous/metallogenic province. The heavily contaminated lower zones of the intrusion host disseminated-blebby PGE-Cu-Ni sulfide mineralization (up to ~10s ppm PGE locally in massive sulfide pods).

Microthermometry was conducted on fluid inclusion assemblages containing late-stage magmatic-hydrothermal fluids in interstitial quartz from a mineralized pegmatitic leucogabbro from the central portion of the intrusion. The FIAs contain three-phase liquid-rich inclusions with halite daughter phases. Final homogenization occurred by halite dissolution at temperatures significantly higher than vapour bubble disappearance. Using a method for calculating minimum trapping pressures at the T of homogenization [1,2], FIAs not influenced by post-entrapment modification show minimum trapping pressures from 1.6-3.0 kbars, with final homogenization temperatures ranging from 291° to 367°C (bulk salinities of 38-44 wt% NaCl equiv.) For comparison, Ti-in-quartz thermometry for fluid inclusion-rich domains in the quartz indicate crystallization from 650-750°C. The data suggest that if the inclusions are primary then actual trapping pressures are significantly higher than the minimum values estimated above, constraining the depth of emplacement of the mineralized intrusion to at least 18km.

The study provides first constraints on the nature of late-stage magmatic-derived fluids associated with the EBLI and provides a means for comparison to other mineralized intrusions that show involvement of magmatic fluids in the redistribution of chalcophile/highly siderophile ore metals.

[1] Lecumberri-Sanchez *et al.* (2012) Geochim et Cosmochim acta **92**, 14-22. [2] Becker *et al.* (2008) Econ. Geol. **103**, 539-554

DOI:10.1180/minmag.2013.077.5.2
www.minersoc.org