An experimental study of minettes and associated mica-clinopyroxenite xenoliths from the Milk River area, Southern Alberta, Canada

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Because of their hydrous nature, lamprophyres provide unique insights into the cycling of water into and out of the Earth's interior. Lamprophyres from southern Alberta, Canada, were studied by Buhlmann *et al*. [1], who suggested they were derived from a mantle source containing mica, clinopyroxene, and olivine. The present experiments were conducted using a piston-cylinder apparatus at conditions appropriate for the Earth's upper mantle (~1.5 - 2.5 GPa, ~1200°C - 1400°C). A multiple saturation point of olivine and orthopyroxene was found at ~2.0 GPa and ~1350°C. This result was unexpected because partial melting of refractory harzburgite should not yield lamprophyric magmas [2]. We suggest that during ascent the minette magma chemically re-equilibrated with harzburgitic wall-rock [3]. These experiments show that these minettes are not primary.

We also conducted a set of melting experiments on three chemically distinct cognate xenoliths to determine their solidus temperatures at 1.5 - 2.5 GPa, and to characterize the glass composition. The near-solidus melts have striking similarities to madupitic lamproites studied by Barton & Hamilton [4] from the Leucite Hills, Wyoming. They hypothesized that madupitic magmas could be the product of partial melting of mica-pyroxenite. The present experiments confirm this hypothesis.

[1] Buhlmann *et al*. (2000) *Can. J. Earth Sci*. **37**, 1629-1650. [2] Parman & Grove (2004) *J. Geophys. Res*. **109**, 1-20. [3] Foley (1992) *Lithos* **28**, 435-453. [4] Barton & Hamilton (1979) *Contrib. Mineral. Petrol*. **69**, 133-142.

Origin and flux of lunar (micro-) impactors: Constraints from N-Ar analyses of single Luna 24 grains

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The $^{15}N/^{14}N$ ratio of N trapped in the lunar regolith varies by ~300 ‰, which has been attributed to either a) a secular increase of the N isotope composition of solar wind (SW) [1], or b) varying mixing proportions between solar N and non-solar N sources that are enriched in ^{15}N [2, 3]. In light of the recent Genesis findings, which revealed that modern SW N is isotopically light [4, 5], we use in this study the approach of single grain analyses to re-evaluate the provenance of N in Luna 24 soils. Our new N-Ar data, together with previous results from the Apollo sites, allow us to place limits on the proportion of solar and non-solar N trapped in lunar regolith, as well as on the recent flux of planetary material to the Moon's surface.

Single Luna 24 grains with $^{40}Ar/^{36}Ar$ ratios < 1 have $\delta^{15}N$ values between -54.5 and +123.3 ‰ relative to air. Thus, low-antiquity lunar soils record both positive and negative $\delta^{15}N$ signatures, and the secular increase of the $\delta^{15}N$ value [1] is no longer apparent when the Luna and Apollo data are combined. Instead, the N isotope signatures, corrected for cosmogenic ^{15}N, are consistent with binary mixing between SW N ($\delta^{15}N_{SW} \approx -407$ ‰ [5]) and a non-solar N component with a $\delta^{15}N$ value of +100 to +150 ‰.

Micrometeorites and interplanetary dust particles, which dominate the current flux of extraterrestrial matter on Earth, match well the required characteristics of the non-solar component present in the lunar regolith. In contrast, a possible cometary contribution to the non-solar N flux is constrained to be ≤ 8 to 15 %, assuming a $\delta^{15}N$ value of +900 ‰ for cometary material [6]. Based on the observed mixing ratio of solar to planetary N, we estimate the flux of micro-impactors to be (2.2 to 6.2) × 10^3 tons yr^{-1} at the lunar surface. Thus, assuming a water content of ~10 wt%, characterizing carbonaceous chondrites [7], micro-impactors may deliver up to ~600 tons of water per year to the Moon.

[1] Kerridge (1975) *Science* **245**, 162-164. [2] Wieler *et al*. (1999) *EPSL* **167**, 47-60. [3] Hashizume *et al*. (2002) *EPSL* **202**, 201-216. [4] Marty *et al*. (2010) *GCA* **74**, 340-355. [5] Marty *et al*. (2011), *LSPC* **XXXII**, #1870. [6] Bockelée-Morvan *et al*. (2008) *ApJ* **679**, L49-L52. [7] Kerridge (1985) *GCA* **49**, 1707-1714.