WHAT HEATED H/L CHONDRITE LAPAZ ICEFIELD 031047 ~0.5 MILLION YEARS AGO ?

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Introduction: LaPaz Icefield 031047 (LAP) is a 16.5 g chondrite with properties intermediate between H and L [1], and – most notably – petrographic evidence for a transient heating event with temperatures above 700 °C, followed by rapid cooling. Despite evidence for recrystallization of the metal, it has a low shock stage (S2) and high porosity (27 vol%). Based on Ar-Ar dating, this event was dated at ~100 Myr, while the CRE age was estimated at <0.5 Ma [1]. To better constrain the cosmic-ray exposure (CRE) and thermal history of this meteorite, we measured cosmogenic radionuclides (^{10}Be, ^{26}Al, ^{36}Cl) and light noble gases (He, Ne, Ar).

Results: The concentrations of ^{10}Be (17.3 dpm/kg) and ^{26}Al (50 dpm/kg) and ^{36}Cl (4.6 dpm/kg) in the stone fraction are very close to saturation levels in a small object (R~10 cm) [4], suggesting a CRE age ≥5 Ma. However, the low ^{10}Be concentration of 1.3 dpm/kg in the metal phase, combined with the high ^{36}Cl/^{10}Be ratio (11.1), suggest a short CRE age of 0.5-1 Ma. Although such a large discrepancy between the CRE age of the stone and metal phase has not been observed in any other chondrite, it suggests that a recent heating event may have reset the cosmogenic radionuclide inventory of the metal phase, while radionuclides in the silicates were unaffected.

The cosmogenic noble gas concentrations yield CRE ages of 0.5 Ma (^{3}He), 4.5 Ma (^{21}Ne) and 2.5 Ma (^{38}Ar). The inconsistent CRE ages can be explained by loss of cosmogenic gases from the metal phase, as well as ^{3}He from the silicates during the recent heating event. Since most of the cosmogenic ^{21}Ne is in the silicates, ^{21}Ne is least affected, while complete loss of cosmogenic ^{38}Ar from the metal phase accounts for ~50% loss of total ^{38}Ar.

The measured ^{4}He/^{3}He ratio of 5.4 in LAP is consistent with the spallogenic ratio [2], indicating radiogenic ^{4}He is $<0.4 \times 10^{-8}$ cm^{3} STP/g. The lack of radiogenic ^{4}He indicates a very recent heating event, probably the same event that initiated the recent CRE recorded by cosmogenic helium. The measured ^{40}Ar concentration of $(56 \pm 17) \times 10^{-8}$ cm^{3} STP/g yields an apparent K-Ar age of ~400 Ma (for K=270 ppm), but probably reflects incomplete degassing (~99%) during a recent heating event.

Conclusion. The combined noble gas and cosmogenic radionuclide data can be explained by a single heating event ~0.5 Ma ago, in which: (1) all cosmogenic He and radiogenic ^{4}He was lost, (2) most (>99%) of the radiogenic ^{40}Ar was lost, (3) part of the cosmogenic ^{38}Ar was lost, probably mostly from the metal fraction, and (4) all (or most) of the cosmogenic radionuclides from the metal fraction were lost. Explanations for this heating event include impact heating or solar heating. Since an impact on a meter-sized object would break up the meteoroid before reaching temperatures >700 °C, our results favor solar heating as proposed by [1], but in the meteoroid during one or more close passages to the Sun rather than on the asteroid parent body.

References: [1] Wittmann A. et al. 2011. *GCA* 75, 6140-6159. [2] Leya I. and Masarik J. (2009) *MAPS* 44, 1061-1087.