WHAT HEATED H/L CHONDRITE LAP 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 (10Be, 26Al, 36Cl) and light noble gases (He, Ne, Ar).

Results: The concentrations of 10Be (17.3 dpm/kg) and 26Al (50 dpm/kg) and 36Cl (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 10Be concentration of 1.3 dpm/kg in the metal phase, combined with the high 36Cl/10Be 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 (4He), 4.5 Ma (4Ne) and 2.5 Ma (38Ar). The inconsistent CRE ages can be explained by loss of cosmogenic gases from the metal phase, as well as 4He from the silicates during the recent heating event. Since most of the cosmogenic 21Ne is in the silicates, 21Ne is least affected, while complete loss of cosmogenic 38Ar from the metal phase accounts for ~50% loss of total 38Ar.

The measured 4He/3He ratio of 5.4 in LAP is consistent with the spallogenic ratio [2], indicating radiogenic 4He is <0.4 x 10^-8 cm^-2 s^-1. The lack of radiogenic 4He indicates a very recent heating event, probably the same event that initiated the recent CRE recorded by cosmogenic helium. The measured 40Ar concentration of (56 ± 17) x 10^-8 cm^-2 s^-1 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 4He was lost, (2) most (~99%) of the radiogenic 40Ar was lost, (3) part of the cosmogenic 38Ar 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.