PETROLOGY, GEOCHEMISTRY AND PB-PB AGE OF A LARGE IGNEOUS INCLUSION FROM THE ORDINARY CHONDRITE PAPOSO 004

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Introduction: Large igneous inclusions are relatively rare and enigmatic components of ordinary chondrites, as they are only found in about 4% of this class of meteorites [1]. They can range up to several cm in diameter and are generally low in metal and sulfides. It has been suggested that individual large igneous inclusions could have formed by a range of mechanisms: some may have formed as unusually large chondrules [e.g. 1], others as impact melts [e.g. 1,2], igneous differentiates, or nebular melts formed at high-temperature via evaporation or condensation [e.g. 1,3]. Recently, O isotope analysis has demonstrated that some inclusions formed in distinct reservoirs before being incorporated into their host chondrites. This indicates that nebular or collisional mixing occurred prior to complete accretion of ordinary chondrite parent bodies [4].

Here, we report the petrology, geochemistry, triple O isotopic composition, and Pb-Pb whole-rock age of a large igneous inclusion found in the L3.1 ordinary chondrite Paposo 004. This inclusion may provide further insights into the origin and accretion mechanisms of planetary bodies.

Sample and Methods: The melt inclusion, named Pap-I1, was ca. 16 mm by 8 mm at the surface of the slab of its host chondrite Paposo 004 (L3.1). A section of the inclusion was prepared for SEM imaging and electron microprobe analysis at UNM and Western. One whole-rock (WR) fraction (~30 mg) was crushed and dissolved for major and trace element analysis by quadrupole ICP-MS iCAP *Q* at Western, while another WR fraction (~220 mg) was taken for an 8-step dissolution procedure for Pb isotopic analysis. This procedure follows the protocol of [5] where terrestrial and common Pb-rich components are first removed before radiogenic Pb is progressively leached out. Lead separation from the leachate and residue matrices was achieved using ion-exchange chromatography [5]. Total procedural blanks were 1.4±1.0 pg, while sample-to-blank ratios for the leachates and residues range from 180 to 5348. Lead isotopic analyses were carried out using a Neptune Plus MC-ICP-MS at UCA. Instrumental mass fractionation was corrected using the Tl-doping and NBS 981 standard-bracketing method, and NBS 983 was used as a secondary isotopic standard. The Pb-Pb age was calculated using $^{238}U/^{235}U = 137.786 \pm 0.011$ [6]. For O isotopes, an approximately 10 mg whole-rock chip was crushed and homogenised and ~2 mg aliquots of this powder were then loaded for O isotope analysis by infrared laser-assisted fluorination at the OU [7].

Results: *Petrography*. The inclusion is dominated by microporphyritic olivine grains (<100 µm) with some larger phenocrysts (>250 µm), a barred olivine relict chondrule with low-Ca pyroxene ($Fs_{22.1\pm4.9}$, $Wo_{1.5\pm1.3}$), glass (sodic plagioclase: Na_2O = 8.8±3.0 wt%) and troilite, kamacite and taenite. The smaller olivine grains are more Fe-rich than the phenocrysts, with $Fa_{29.4\pm6.8}$ and $Fa_{14.5\pm2.3}$, respectively. The Fe/Mn ratios in olivine (46.2±9.4) resemble those of L chondrites (43.0±5.8 [4]). *Geochemistry*. The bulk chemistry of Pap-I1 indicates that it did not experience any fractionation process, based on lithophile elements, with only Ca being significantly depleted compared to CI chondrites. Bulk REE abundances are slightly enriched by 30 to 50% compared to CI chondrites, but show no significant signs of fractionation between REE. *Pb-Pb age.* Blank-corrected $^{206}Pb/^{204}Pb$ ratios range from 12.3 to 37.4. Plotting the last 5 leachates and residue fractions in an "inverse" $^{204}Pb/^{206}Pb$ vs. $^{207}Pb/^{206}Pb$ diagram results in a Pb-Pb errorchron age of 4534±11 Ma (MSWD = 103). *O isotopes*. The mean of the two replicates of Pap-I1 gave the following composition: $\delta^{17}O = 3.492 \pm 0.238‰$, $\delta^{18}O = 4.595 \pm 0.219‰$, $\Delta^{17}O = 1.103 \pm 0.124‰$ and plots in the L chondrite field [8].

Discussion: The Pb-Pb age of Pap-I1, while imprecise due to its unradiogenic composition, is nonetheless within the range of formation ages obtained for other inclusions in ordinary chondrites, with I-Xe and Hf-W model ages found between 0.5 to 50 Ma after CAI formation [9,10,11]. These relatively young ages of inclusions, along with their unfractionated chemistry and texture, are best explained as products of impact melting. The presence of Pap-I1 within an unbrecciated ordinary chondrite indicates a protracted accretion history for the L ordinary chondrite parent body.

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