OXYGEN-ISOTOPE ANALYSIS OF EXTRATERRESTRIAL CHROME-SPINEL GRAINS FROM JURASSIC SEDIMENTS IN CARCABUEY, SPAIN. C. E. Caplan[1,2*], G. R. Huss[2], B. Schmitz[3,2], and K. Nagashima[2], [1]Department of Geology and Geophysics, University of Hawaiʻi at Mānoa, 1680 East-West Road, Honolulu, HI 96822, [2]Hawaiʻi Institute of Geophysics and Planetology, University of Hawaiʻi at Mānoa, 1680 East-West Road, Honolulu, HI 96822, [3]Department of Physics, University of Lund, P.O. Box 118, Lund SE-22100, Sweden. *caplance@hawaii.edu.

Introduction: Reconstructing variations in the infall of extraterrestrial material throughout Earth's history may improve our understanding of various solar-system processes. Meteorites weather away quickly after arrival on Earth and thus give a very short window into this history. Fortunately, chrome-spinel grains in meteorites can survive weathering for millions of years in terrestrial sediments [1]. The extraterrestrial chrome-spinel grains found in sediment could have arrived as fragments from larger meteorites or as part of the micrometeorite flux. The parent meteorite type of the chrome-spinel grains can be determined using characteristic elemental and oxygen-isotope compositions. This has been done successfully for Ordovician samples (all L chondrites) [1-4]. The overall objective of studying sediment-dispersed chrome-spinel grains throughout the stratigraphic record is to determine how meteorite populations have changed over time. In this contribution, we present data on grains from the Callovian-Oxfordian boundary (~160 Ma) of the Ammonitico Rosso facies in southern Spain, near Carcabuey (sample TCC). In addition to opening a new window on the nature of the meteorite flux at ~160 Ma, we chose this time period because of the possibility of discovering remnants from the breakup of the Baptistina asteroid family estimated to have occurred ~160 Ma (+30, -20 Myr) [5].

Experimental: Chrome-spinel grains were recovered from ~300 kg of Spanish limestone at Lund University [see 1 for methods]. The grains were mounted in quarter-inch-diameter steel cylinders using epoxy at the University of Hawaiʼi (UH). The mounts were ground flat and polished using various diamond lapping papers. In addition three meteorite samples were chosen from the UH collection (Kernouve-H6, Bruderheim-L6, and Cherokee Springs-LL6) in order to update the chromite database against which we compare our samples. Each of the UH meteorites had already been mounted and polished prior to them being chosen for this study.

Element abundances were determined using the JEOL JXA-8500F field emission electron microprobe at UH using an accelerating voltage of 20 keV, a beam current of 20 nA, and varying beam diameters (1-5 µm). The Cameca ims 1280 ion microprobe at UH was used to measure oxygen isotopes, with Stillwater chromite as the standard. We used a ~1 nA Cs^+ primary beam with a small raster of ~3 µm. Secondary oxygen ions were measured in multi-collection mode with $^{16}O^-$ and $^{18}O^-$ on Faraday cups and $^{17}O^-$ on the mono-collector electron multiplier or Faraday cup. Each ion probe measurement consisted of 30 cycles that included 4 seconds with $^{17}O^-$ on the electron multiplier followed by 10 seconds with $^{17}O^-$ on the FC2 Faraday cup, and ended with 2 seconds on the $^{16}OH^-$ peak. The $^{18}O/^{16}O$ ratio was calculated from the 10s measurement and the $^{17}O/^{16}O$ ratio from the 4s measurement. The mass-resolving power was ~5500, which is nominally enough to resolve $^{16}OH^-$ from ^{17}O, but a low mass tail of $^{16}OH^-$ was still detected. A tail correction corresponding to 7.9 ppm of the $^{16}OH^-$ peak was applied to ^{17}O, and was typically ~0.05 – 0.50‰ (up to 1‰ in a few grains).

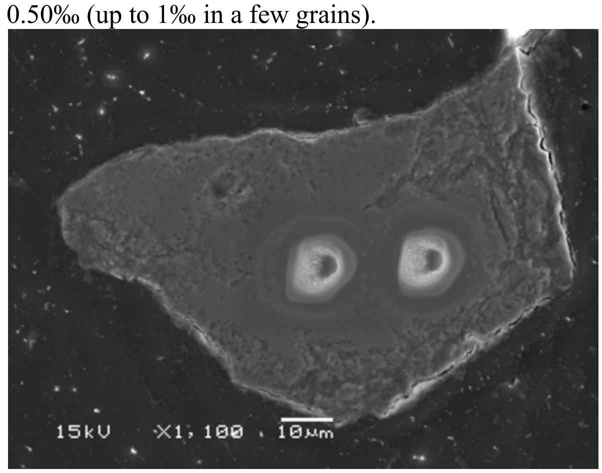

Figure 1: Secondary electron image of ion microprobe analysis pits in a representative TCC chromite grain.

Twenty-six TCC grains ranging from 63 to 220 µm were selected for electron probe and SIMS analysis. We obtained one to four spots per grain for both SIMS and electron probe analyses (Fig. 1). Measurements for each grain typically showed good reproducibility. The data were evaluated for instrumental errors and the pits were examined in detail to look for cracks using the scanning electron microscope (Fig. 1).

Results and Discussion: Al_2O_3 and FeO concentrations for the current set of TCC grains and TCC grains from earlier measurements [6] are plotted against TiO_2 concentration in Figure 2. Two sets of standards (NMNH 117075 and Stillwater chromite) and analysis of the three ordinary chondrites are also plotted for comparison. Both the FeO and Al_2O_3 figures show a wide range of abundances for the TCC chrome-spinel grains.

The initial subdivision of the grains was made based on their oxygen isotope (Fig. 3) and Fe_2O_3 abundances.

We believed that all iron oxide in extraterrestrial chromite grains is FeO with little to no Fe_2O_3, but soon found that this is not the case. In this data set, grains with positive $\Delta^{17}O$ values and no Fe_2O_3 are mostly from ordinary chondrites. TCC grains with ~0‰ $\Delta^{17}O$ and measurable Fe_2O_3 were classified as terrestrial. The grains that plotted below the TFL were classified into two groups, those with Fe_2O_3 and those without. These two categories may contain primitive or ungrouped achondrites. The remaining grains could not be classified using these parameters.

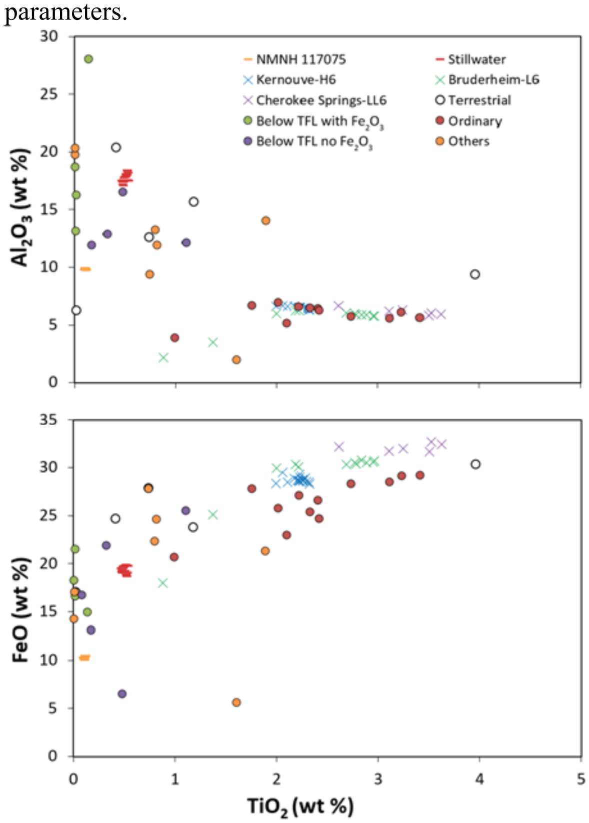

Figure 2: Elemental oxide abundances of TCC chrome-spinel grains. Abundances for three type 6 ordinary chondrites are also plotted for comparison. One grain plots outside of the Al_2O_3-TiO_2 plot, ~44 Al_2O_3 wt%. FeO values are after calculating Fe_2O_3.

In the Al_2O_3 plot, the ordinary-chondrite TCC grains cluster quite close to the type 6 ordinary chondrite data, whereas the same TCC grains in the FeO plot appear to lie just below the type 6 ordinary chondrite clusters. The FeO offset between the type 6 ordinary chondrites (which have no Fe_2O_3) and the TCC data may be due to terrestrial alteration of the sediment-dispersed grains, where Fe is replaced by Zn and Mn.

The ordinary-chondrite TCC grains show characteristic abundances in other elements as well. Compared to all other grains in this study, the ordinary-chondrite grains tend to have higher V_2O_3 and Cr_2O_3, as well as lower TiO_2 and MgO.

A thorough chrome-spinel database is needed in order to best classify sediment-dispersed grains. We need to analyze chrome-spinel grains from various meteorite types in order to update and broaden the known oxygen-isotope and elemental abundance data for such grains. Thus far, we have new elemental data for H, L, and LL type 6 chondrites (Fig. 2).

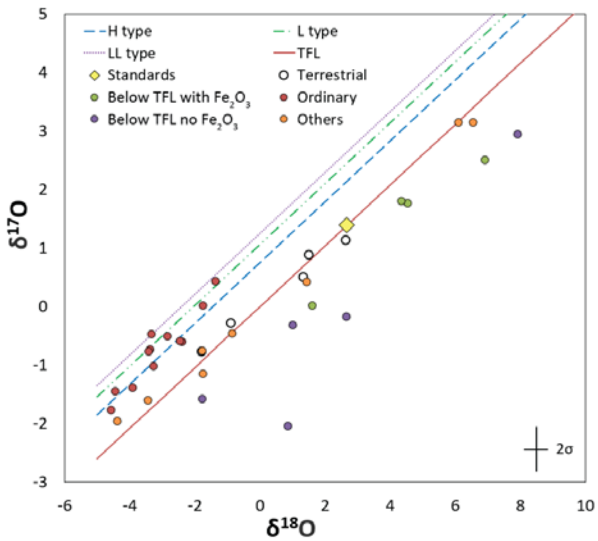

Figure 3: $\delta^{17}O$ and $\delta^{18}O$ values for TCC grains and the average for the standards. Assigned errors are 2 standard deviations of the standard measurements. Also plotted are the Terrestrial Fractionation Line (TFL) and lines of constant $\Delta^{17}O$ passing through the means for H, L, and LL chondrites [7].

Conclusions: Our study shows that it is possible to obtain information about ancient meteorite fluxes by elemental and oxygen isotopic analyses of sediment-dispersed chrome-spinel. Overall, the spread of data in this study shows that the meteorite population from the Jurassic time period is different than the population from the Ordovician (all L chondritic type) [1]. The continuation of grain collection will provide improved statistics in order to understand the significance of the data spread for the Jurassic time period.

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