

INTERROGATING LEACHING PROCEDURES OF METEORITES FOR TRIPLE OXYGEN ISOTOPE ANALYSES. R. M. Havel¹, D. E. Ibarra¹, R. Bartoschewitz², G. Budde¹; ¹Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, USA; Bartoschewitz Meteorite Laboratory, Gifhorn, Germany; riley_havel@brown.edu.

Introduction: Triple oxygen isotope analyses of meteorites are a fundamental tool for the classification and investigation of meteorite samples [1, 2]. However, upon landing on Earth's surface, meteorites are subject to weathering and contamination by terrestrial oxygen that can alter their original oxygen isotopic composition. Notably, the isotopic composition of the contaminating oxygen will vary depending on fall/find location (*e.g.*, meteoric water: $\delta^{18}\text{O} = -60$ to 0% , Standard Light Antarctic Precipitation (SLAP): $\delta^{18}\text{O} = -55.5\%$, atmospheric O_2 : $\delta^{18}\text{O} = 24\%$) and the degree of contamination will vary depending on the weathering grade and sample characteristics.

Leaching treatments can be used to remove terrestrial weathering products from altered sample material. Ethanolamine thioglycolate (EATG) leaching is an alternative to the standard leaching with dilute HCl. Although HCl leaching is easier to perform, it may remove indigenous phases (*e.g.*, glassy mesostasis) in addition to weathering products, disturbing the original oxygen isotopic composition of a sample [3]. EATG leaching aims to remove only oxygen-bearing compounds formed due to terrestrial weathering (iron hydroxides, iron oxides) and metallic iron without disturbing silicate-bound oxygen [4]. EATG leaching has been shown to be capable of effectively removing terrestrial contamination, but has not yet been systematically and comprehensively evaluated across all meteorite classes [*e.g.*, 3-10]. This study aims to better constrain the effects of EATG leaching on bulk meteorite oxygen isotopic compositions and how it differs from HCl leaching. A representative set of meteorites in terms of class, weathering grade, and fall/find location were selected to broadly understand the effectiveness of EATG and HCl leaching in removing terrestrial weathering products of variable oxygen isotopic compositions and the effect it has on original bulk meteorite oxygen isotope signatures.

Materials and Methods:

Samples and leaching procedures. Sample preparation and analyses were performed at Brown University. To date, we have obtained data for samples of many classes (CO, CV, EL, EH, LL, R, Ureilite, Brachinite, Aubrite, Eucrite, Diogenite, Shergottite), weathering grades (High, W1, W2), and fall/find locations (Northwest Africa, Azerbaijan, Czech

Republic, Russia, China). Cleaned sample chips were crushed to produce homogeneous powders, 10-20 mg aliquots of which were leached largely following established procedures [3, 4, 11, 12]. HCl leaching: Samples were leached in 2-4 mL of 1 M HCl solution while vortex mixing for 5 minutes. After leaching, residues were rinsed 2x in Milli-Q and 1x in isopropyl alcohol (IPA). EATG leaching: Samples were leached in 2-4 mL of 1:1 EATG:IPA solution for a total reaction time of 2 hours while sonicating and vortex mixing every 15 minutes. If the color of the reacted solution indicated a significant reaction with weathering products, the solution was replaced after 1 hour. After leaching, residues were rinsed 3x in 1:1 Milli-Q:IPA and 1x in IPA, and then dried at room temperature.

Oxygen isotope measurements. Laser fluorination was performed using an Elemental Scientific Inc. MIR10² heating and fusion system. The triple oxygen isotope measurements of the liberated O_2 were made on a Thermo Scientific 253 Plus. Sample aliquots and standard reference materials of 2-5 mg were weighed into a nickel sample holder and heated under vacuum in a fully assembled sample chamber overnight at 80 °C to remove adsorbed moisture. Oxygen was extracted from the sample via laser fluorination in a BrF_3 atmosphere and purified using a series of cold traps and molecular sieves, closely following previously detailed procedures [13]. Triple oxygen isotope compositions of all samples are normalized to an average composition of San Carlos Olivine (SCO) standard reference material run in-chamber across all analytical sessions. Compositions are reported using the δ -notation, $\delta^x\text{O} = [({}^x\text{O}/{}^{16}\text{O})_{\text{sample}}/({}^x\text{O}/{}^{16}\text{O})_{\text{standard}}] - 1 \times 1000$ (‰), relative to the VSMOW-SLAP2 scale [14]. Analytical precision for this method based on replicate analyses of SCO ($n = 20$) is about 0.2‰ for $\delta^{17}\text{O}$, 0.4‰ for $\delta^{18}\text{O}$, and 0.01‰ for $\Delta^{17}\text{O}$ (2 s.d.).

Discussion:

Carbonaceous Chondrites (CC). Two CC samples, both Northwest Africa (NWA) finds with undetermined weathering grades were analyzed. These initial data show that EATG removes an isotopically heavy component along the carbonaceous chondrites anhydrous minerals (CCAM) line in CCs, shifting the treated isotopic composition to lower $\Delta^{17}\text{O}$ values away from the terrestrial fraction line (TFL) (Fig. 1). This component could either be a contaminant with a

specific heavy O composition or, more likely, an isotopically heavy indigenous component. Leaching in dilute HCl has the same effect, but of a different magnitude. For NWA 12895, HCl leaching shifts the treated isotopic composition less so than EATG leaching.

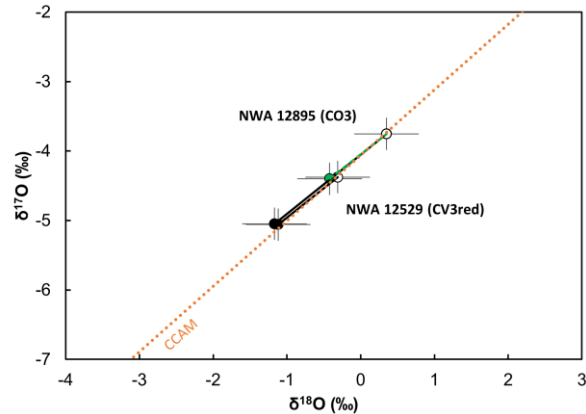


Fig. 1. $\delta^{17}\text{O}$ versus $\delta^{18}\text{O}$ for investigated carbonaceous chondrites. The orange dotted line is CCAM [15]. EATG leached data are shown as black filled circles; HCl leached data as green filled circles; untreated points as open circles. EATG leached data are connected to their untreated pair by a black solid line; HCl leached data by a green dashed line.

Non-Carbonaceous Chondrites (NCC). Five NCC samples (3 NWA finds, 1 China find, and 1 Azerbaijan fall) with variable weathering grades were analyzed. These data show that EATG and HCl leaching removes minimal amounts of either contamination or indigenous components in NCCs, shifting the treated isotopic compositions nearly parallel to the TFL in the same direction (Fig. 2).

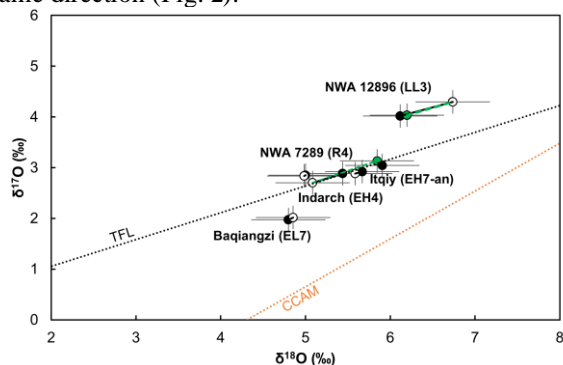


Fig. 2. $\delta^{17}\text{O}$ versus $\delta^{18}\text{O}$ for investigated non-carbonaceous chondrites. The black dotted line is the terrestrial fractionation line (TFL).

Achondrites. Six achondrite samples (3 NWA finds, 1 China find, 1 Russia fall, and 1 Czech Republic fall) with undetermined weathering grades were analyzed. Similar to the NCCs, these data show that EATG and HCl leaching has little to no effect on the isotopic compositions of these samples and when a shift is observed, it is nearly parallel to the TFL in the

same direction (Fig. 3). In the case of the ureilite Loulan Yizhi 034, a China find, it appears that EATG and HCl leaching remove different components, shifting the treated compositions away from and towards the CCAM, respectively.

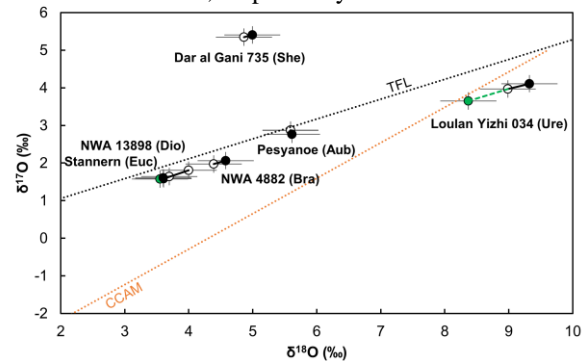


Fig. 3. $\delta^{17}\text{O}$ versus $\delta^{18}\text{O}$ for investigated achondrites.

Conclusions: While EATG and HCl leaching treatments are capable of removing terrestrial weathering products, our initial results demonstrate that both also have the potential to remove indigenous phases from the samples, which alters their true oxygen isotope compositions. The magnitude and direction of observed shifts in isotopic composition from untreated to treated samples are both method- (Fig. 3, Loulan Yizhi 034) and sample-dependent (Fig. 1), and seem most pronounced for CCs [9]. Currently, we are in the process of obtaining data for a more comprehensive set of samples, including Antarctic samples to investigate the role of isotopically anomalous Antarctic precipitation contamination.

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