

**TELLURIUM ISOTOPE COMPOSITIONS IN SEQUENTIAL ACID LEACHING SAMPLES OF CARBONACEOUS CHONDRITES.** Y. Fukami<sup>1</sup>, T. Yokoyama<sup>1</sup> and Wataru Okui<sup>1</sup>, <sup>1</sup> Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro, Tokyo 152-8551, Japan, [fukami.y.aa@m.titech.ac.jp](mailto:fukami.y.aa@m.titech.ac.jp)

**Introduction:** Primitive chondrites have key information regarding the timing and processes of the solar system formation. Nucleosynthetic isotope anomalies found in primitive chondrites give clues for understanding the origin of materials formed in the early stage of the Solar System. Precise determination of isotopic compositions for various trace elements in meteorites suggests heterogeneous isotopic distribution in the protosolar nebula (e.g. Cr, Ti, Mo, Ru, Sm [1-3]). In contrast, some limited elements support isotopic homogeneity in the early solar system (e.g. Zr, Te, Os [4-6]). The inconsistency would be caused by incomplete mixing and/or destruction of some selected presolar materials in the solar nebula. However, the reason for such distinct isotopic signatures is not well understood. To understand this, it is important to identify presolar phases for individual elements as isotopically anomalous carriers that contributed to the Solar System. For detecting internal isotope anomalies in meteorites, sequential acid leaching method, a chemical mineral separation, is quite useful especially for trace elements.

Tellurium is one of the intriguing elements for the study of nucleosynthetic isotope anomalies in meteorites. Tellurium has eight stable isotopes produced by stellar nucleosynthesis of the p-process ( $^{120}\text{Te}$ ), s-process ( $^{122}, ^{123}, ^{124}, ^{125}, ^{126}\text{Te}$ ) and r-process ( $^{125}, ^{126}, ^{128}, ^{130}\text{Te}$ ). The isotopic composition of Te is also affected by the extinct nuclide of  $^{126}\text{Sn}$  that decays to  $^{126}\text{Te}$  with a half-life of 234.5 kyr [7]. However, no resolvable Te isotope anomalies are reported for bulk chondrites, sulfide and metal fractions of iron meteorites, and acid leachates of carbonaceous chondrites [5]. Small potential nucleosynthetic Te isotope anomalies are found in Allende CAIs, although further verification is needed to exclude the possibility of analytical artifact [8]. The largest nucleosynthetic Te isotopic anomalies hitherto obtained are in presolar nanodiamonds from the Allende meteorite [9, 10].

In our preliminary study, we have reported the Te isotope compositions in acid leachates from the Murchison meteorite (CM2) [11]. In this study, we present additional Te isotope data in sequential acid leachates of two carbonaceous chondrites, Allende (CV3) and Tagish Lake (C2-ung). In addition, we measured the Te isotope compositions in the residue that survived in the acid leaching procedure.

**Experimental:** *Sample preparation and chemical separation.* We conducted the 6-step sequential acid

leaching experiments on ~1 g powdered samples of Allende (CV3) and Tagish Lake (C2-ung.), following the technique of [11]. The remaining acid residues for these meteorites and that from Murchison [12] were completely decomposed by combustion in a quartz Carius tube at 1000 °C over 40 hours (step 7). After the combustion, the tube was opened while chilling the tube bottom with liquid N<sub>2</sub>, followed by the addition of 1:2 mixture of conc. HCl and conc. HNO<sub>3</sub>. Then, the tube was sealed and heated at 200 °C over 40 hours. Finally, the solution was dried in a Teflon beaker and dissolved in a pressure digestion system, DAB-2 (Berghof, Germany) using HF-HNO<sub>3</sub> mixed acid at 220 °C over 40 hours.

Tellurium was separated using three steps column chemistry used in [12], which was modified after [13]. The purified Te fraction was re-dissolved in 1 M HCl and dedicated to the subsequent Te isotope analyses.

*Mass spectrometry.* Tellurium isotope measurements were carried out by using a thermal ionization mass spectrometry in negative mode (TRITON *plus* at Tokyo Institute of Technology, Thermo-Fisher Sci.). The separated sample was loaded on a zone-refined single Re filament, and covered by saturated Ba(OH)<sub>2</sub> solution containing NaOH. Isotope ratios were acquired by using nine Faraday cups (FCs) when the beam intensity of  $^{126}\text{Te}$  exceeded ~0.3 V. Our instrument has nine Faraday Cup collectors, however, all eight Te isotopes cannot be simultaneously collected because of the limitation of the collector geometry. Therefore, we used the zoom optics option, and the isotope measurements were performed by a two-line analytical setting. When the  $^{126}\text{Te}$  beam intensity was lower than 0.3 V, all isotopes were measured by a single secondary electron multiplier (SEM) in jumping mode. The Te isotope ratios obtained were corrected for mass fractionation by normalizing the measured  $^{128}\text{Te}/^{130}\text{Te}$  ratio to be 0.92941 [14] using the exponential law.

**Results and Discussion:** Tellurium isotope ratios in leachate samples from Tagish Lake and Murchison are indistinguishable from those of the terrestrial standard within analytical uncertainties (Fig. 1). For Allende, step 1-6 are also indistinguishable from those of the terrestrial standard. The only exception is the leaching step 7 of Allende, which presented negative isotope anomalies in  $\delta^{122}\text{Te}$  and  $\delta^{124}\text{Te}$  (Fig. 2). Because  $^{122}\text{Te}$  and  $^{124}\text{Te}$  are pure s-process isotopes while

$^{128}\text{Te}$  and  $^{130}\text{Te}$  are pure r-process nuclide, the negative isotope anomalies observed in the Allende step-7 are either due to the deficit of s-process (or excess of r-process) component in the sample, or to that the sample has a  $^{128}\text{Te}/^{130}\text{Te}$  ratio different from the terrestrial value. Fig. 2 shows some mixing trends between terrestrial composition and previously reported Te isotope compositions in nanodiamonds from Allende, and those estimated by nucleosynthesis theories, respectively [9, 10, 15]. Interestingly, the Allende step-7 is plotted on the mixing line of the terrestrial component and the r-process compositions calculated by Meyer [10].

Tellurium isotope anomalies in nanodiamonds from Allende meteorite are reported in [9] and [10]. Those anomalies point to the excess of r-process nuclei ( $^{128}\text{Te}$  and  $^{130}\text{Te}$ ) in nanodiamonds. Our results also indicate the excess of r-process component of Te in the step 7 of Allende. It is likely that nanodiamonds exist in the Allende residue that survived in the six leaching steps performed in this study. Therefore, isotope signature of step 7 of Allende is a mixture of nanodiamonds and other acid resistant component. Allende meteorite underwent intensive thermal metamorphism on the parent body and thus rarely contains presolar grains except for nanodiamonds. Therefore, the negative isotope anomalies obtained in this study can be caused solely by nanodiamonds, which are the source of excess r-process Te. This result is consistent with previous studies [9, 10]. The absence of isotope anomalies in the step 7 of Murchison and Tagish Lake would be the results of the low abundance of nanodiamonds, which are carrier of Te isotope anomalies.

**References:** [1] Trinquier A. et al. (2009) *Science*, 324, 374–376. [2] Burkhardt C. et al. (2011) *EPSL*, 312, 390–400. [3] Chen J. H. et al. (2010) *GCA*, 74, 3851–3862. [4] Schönbachler M. et al. (2003) *EPSL*, 216, 467–481. [5] Fehr M. et al. (2006) *GCA*, 70, 3436–3448. [6] Yokoyama T. et al. (2010) *EPSL*, 291, 48–59. [7] Oberli F. et al. (1999) *Int. J. Mass Spectrom.*, 184, 145–152. [8] Fehr M. et al. (2009) *Meteorit. Planet. Sci.*, 44, 971–984. [9] Richter S. et al. (1998) *Nature.*, 391, 261–263. [10] Maas R. et al. (2001) *Meteorit. Planet. Sci.*, 36, 846–858. [11] Reisberg L. et al. (2009) *EPSL.*, 277, 334–344. [12] Fukami Y. and Yokoyama T. (2012) *LPSC.*, XXXIII, 1861. [13] Fehr M. et al. (2004) *Int. J. Mass Spectrom.*, 232, 83–94. [14] Lee D-C. & Halliday A. N. (1995) *Int. J. Mass Spectrom. Ion Process.*, 146/147, 35–46. [15] Arlandini C. et al. (1999) *The Astrophys. J.*, 525, 886–900.

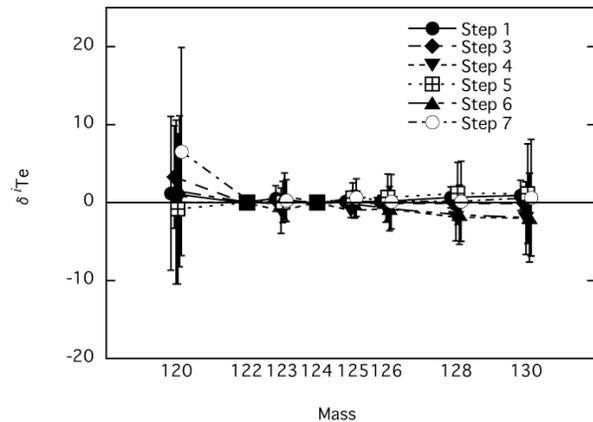


Fig. 1. Tellurium isotope ratios in sample solutions from Tagish Lake measured by N-TIMS in this study. All isotope ratios were normalized to  $^{122}\text{Te}/^{124}\text{Te} = 0.53594$  [14].

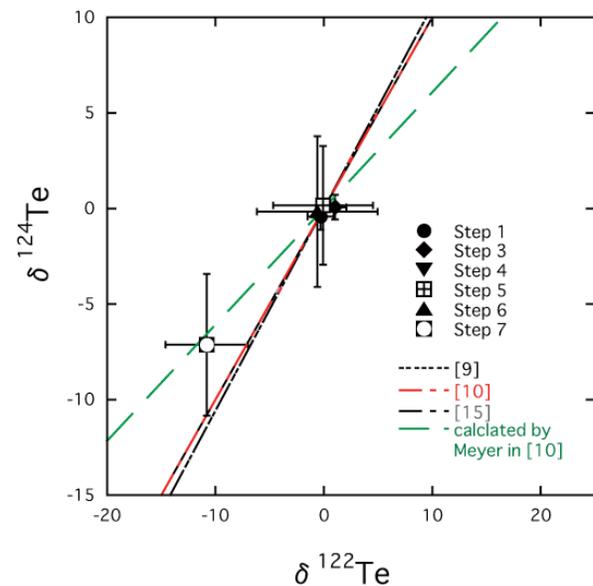


Fig. 2. Tellurium isotope ratios in sample solutions from Allende measured by N-TIMS in this study. The Te ratios are reported in delta-notations relative to terrestrial standard solution (Kanto Chemical, Japan). All isotope ratios were normalized to  $^{128}\text{Te}/^{130}\text{Te} = 0.92941$  [14].