

**TELLURIUM ISOTOPE ANOMALIES IN CARBONACEOUS CHONDRITES: RESULTS FOR SEQUENTIAL ACID LEACHING EXPERIMENTS.** Y. Fukami<sup>1</sup> and T. Yokoyama<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 with petrologic types of 3 or less have been scarcely affected by thermal metamorphism on their parent bodies. These meteorites thus provide key information regarding the timing and processes of the solar system formation. Nucleosynthetic isotope anomalies found in primitive chondrites also give clues for understanding the origin of materials from which our solar system has formed. Tellurium is one of the promising 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 [1]. The  $^{126}\text{Sn}$  is generated mainly by the r-process but by spallation. If  $^{126}\text{Te}$  excesses correlating with Sn/Te ratios are observed in meteorites, it would provide a tight constraint on putative supernova injection(s) into the protoplanetary disk at the very early stage of the solar system. However, no resolvable Te isotope anomalies are reported for bulk chondrites, sulfide and metal fractions of iron meteorites, and acid leachates of carbonaceous chondrites [2, 3]. Small potential nucleosynthetic Te isotope anomalies are found in Allende CAIs, although further verification is needed to exclude the possibility of analytical artifact [4]. The largest nucleosynthetic Te isotopic anomalies hitherto obtained are in presolar nanodiamonds from the Allende meteorite [5, 6]. Most of the recent Te isotope analysis was carried out by using multi-collector inductively coupled plasma mass spectrometry (MC-ICPMS) [2-4, 7]. In contrast, we have developed precise Te isotope analysis by using a state-of-the-art thermal ionization mass spectrometry in negative ionization mode (N-TIMS). In this study, we present preliminary data of Te isotopic compositions in acid leachates of the Murchison meteorite (CM2).

**Experimental:** *Sample preparation and chemical separation.* In this study, ~1 g of powdered Murchison was subjected to the sequential acid leaching procedure (Table 1) described in [8]. Tellurium was separated using three steps anion-exchange chromatography, based on the technique used in [7]. The majority of matrix elements were removed in the first column that used 2 mL of AG1X8 (BioRad, 200-400 mesh). To further purify Te, an extraction chromatographic resin (TRU-Spec, Eichrom) was used in the second (0.2 mL)

column chemistry. This was repeated in the third step by downsizing the column volume (0.01 mL) in order to remove organic matter derived from the resin. The purified Te fraction was re-dissolved in 1 M HCl and dedicated to the subsequent Te isotope analyses.

*Mass spectrometry.* All isotope measurements were carried out by using TRITON *plus* (Thermo-Fisher Sci.) at Tokyo Institute of Technology in negative ionization mode. The separated sample was loaded on a zone-refined single Re filament, and covered by saturated  $\text{Ba}(\text{OH})_2$  solution containing NaOH. The filament was heated to 0.5 A at a rate of  $0.5 \text{ A min}^{-1}$ , then the rate was decreased to be  $0.15 \text{ A min}^{-1}$  until the current reached 0.9 A. The current was slowly increased in a stepwise fashion until the  $\text{Te}^-$  ion beam was stabilized. 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 as follows; Line 1:  $^{122}\text{Te}$  (L4),  $^{123}\text{Te}$  (L3),  $^{124}\text{Te}$  (L2),  $^{125}\text{Te}$  (L1),  $^{126}\text{Te}$  (Center),  $^{127}\text{I}$  (H1),  $^{128}\text{Te}$  (H2),  $^{130}\text{Te}$  (H3), and Line2:  $^{120}\text{Te}$  (L4),  $^{121}\text{Sb}$  (L3),  $^{122}\text{Te}$  (L2),  $^{123}\text{Te}$  (L1),  $^{124}\text{Te}$  (Center),  $^{125}\text{Te}$  (H1),  $^{126}\text{Te}$  (H2),  $^{128}\text{Te}$  (H3). 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  $^{122}\text{Te}/^{124}\text{Te}$  to be 0.53594 [9] using the exponential law.

**Results and Discussion:** To investigate the reproducibility of Te isotope measurement by N-TIMS, we repeatedly measured a terrestrial Te standard solution (Kanto kagaku, Tokyo, Japan). Fig. 1 shows the results of standard runs with 200 ng and 200 pg Te, which were performed by using multiple FCs in the two-line static mode and a single SEM in the jumping mode, respectively. All the Te isotope ratios measured by SEM are consistent with those measured by FCs within analytical uncertainties. Also, our standard data show good agreement with those of another terrestrial standard that measured in earlier reports using MC-ICPMS [7, 9].

The Te isotopic compositions in acid leachates of Murchison are shown in Fig. 2. The Te isotope ratios

are reported as delta-notations relative to the standard solution. Tellurium isotopic compositions in the leachates 1, 5 and 6 are not resolvable from the terrestrial standard within analytical uncertainties. Although the errors are relatively large, the isotopic pattern of leachate 3 may indicate the enrichment of heavier Te isotopes relative to the terrestrial, which can be created by the depletion of s-process isotopes [10] or excess of r-process Te. Because the Te beam intensity of leachates from step 2 and 4 were extremely low ( $^{126}\text{Te} < 1 \times 10^3$  cps), we cannot neglect potential Sn isobaric interferences, which must be further verified. In contrast to our result, large nucleosynthetic Os isotope anomalies are observed in acid leachates of the same meteorite that were prepared by the same sequential leaching procedure [8]. The inconsistency might indicate that the main presolar phases that carry Te were thermally unstable compared to those containing Os, which have led to homogeneous Te isotope distribution in the early solar system. Otherwise moderately volatile Te has been somehow selectively lost from presolar phases while remaining refractory Os in their hosts.

**References:** [1] Oberli F. et al. (1999) *Int. J. Mass Spectrom.*, 184, 145–152. [2] Fehr M. et al. (2005) *GCA*, 69, 5099–5112. [3] Fehr M. et al. (2006) *GCA*, 70, 3436–3448. [4] Fehr M. et al. (2009) *Meteorit. Planet. Sci.*, 44, 971–984. [5] Richter S. et al. (1998) *Nature.*, 391, 261–263. [6] Maas R. et al. (2001) *Meteorit. Planet. Sci.*, 36, 846–858. [7] Fehr M. et al. (2004) *Int. J. Mass Spectrom.*, 232, 83–94. [8] Reisberg L. et al. (2009) *EPSL.*, 277, 334–344. [9] Lee D-C. & Halliday A. N. (1995) *Int. J. Mass Spectrom. Ion Process.*, 146/147, 35–46. [10] Arlandini C. et al. (1999) *The Astrophys. J.*, 525, 886–900.

Table 1. Sequential acid leaching procedure used in this study.

Step	Reagent	Time	Temp.
1	5ml acetic acid + 5ml H <sub>2</sub> O	1 day	20°C
2	2.5ml HNO <sub>3</sub> + 5 ml H <sub>2</sub> O	5 days	20°C
3	3 ml HCl + 3.5 ml H <sub>2</sub> O	1 day	75°C
4	3 ml HF + 1.5 ml HCl + 1.5 ml H <sub>2</sub> O	1 day	75°C
5	1 ml HF + 1 ml HCl	3 days	150°C
6	2 ml HNO <sub>3</sub> + 2 ml HF	15 hours	120°C

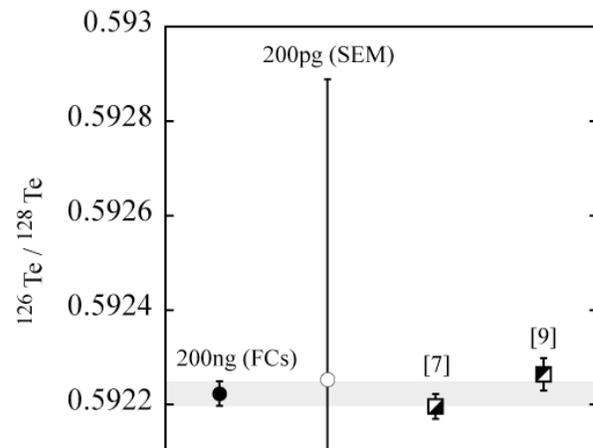


Fig. 1.  $^{126}\text{Te}/^{128}\text{Te}$  ratios of our terrestrial standard (Kanto Kagaku) measured by N-TIMS in this study. Also presented are those of another terrestrial standard measured by MC-ICPMS in earlier reports [7, 9]. Error bars are 2 sigma. All isotope ratios were normalized to  $^{124}\text{Te}/^{128}\text{Te} = 0.14853$  [9]

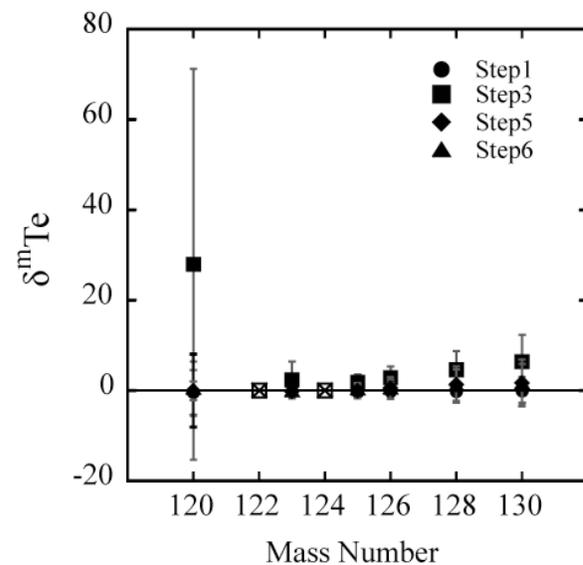


Fig. 2. Te isotopic compositions in acid leachates of Murchison meteorite.