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In Search of Live ^{97}Tc in the Early Solar System

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Technetium (Z=43) has no stable isotope but it is observed in stars where active nucleosynthesis occurs. The p-process nuclide ^{97}Tc decays to ^{97}Mo by electron capture with a mean life of 3.7 Ma. This nuclide may have been present in the early solar system when planets, asteroids, and comets formed and differentiated. Identification of now extinct ^{97}Tc in its decay product ^{97}Mo would have profound implications for our understanding of the early solar system evolution.

As in the case of ^{182}Hf/^{182}W, metal-silicate partitioning gives rise to a large fractionation of the ^{97}Mo/^{185}Re(^{97}Tc) ratio because molybdenum is moderately siderophile while rhenium (and by inference technetium) is highly siderophile. Thus, if there was live ^{97}Tc when the terrestrial core formed, there would be a ^{97}Mo deficit in terrestrial rocks relative to iron meteorites and chondrites. Yin and Jacobsen (1998) succeeded in resolving excess ^{97}Mo in the Toluca iron meteorite ($\varepsilon^{97/96}$Mo=0.64±0.24). This finding implied that the time elapsed between the last nucleosynthetic production of ^{97}Tc in supernovae and terrestrial core formation was lower than 19-24Ma. On the contrary, Lee and Halliday (1995) estimated from tungsten isotopic measurements that, in the case of a two stage model, terrestrial core formation must have occurred at least 62±10Ma after the iron meteorites formed. Yin and Jacobsen (1998) suggested that continuous core formation might clear up the discrepancy between ^{182}Hf-^{182}W and ^{97}Tc-^{97}Mo systematics. Nevertheless, if one takes into account the dilution by interstellar medium of supernovae ejecta as well as the time elapsed between the last nucleosynthetic event and the formation of iron meteorites, then tungsten and molybdenum data appear irreconcilable. In an effort to resolve the discrepancy between ^{182}Hf-^{182}W and ^{97}Tc-^{97}Mo systematics, we have documented the molybdenum isotopic composition of terrestrial rocks and iron meteorites. The results we obtained must be seen as preliminary. Our interpretations might evolve in the future when additional data become available.

Molybdenum isotope chemistry was adapted from Qi-Lu and Masuda (1992). Molybdenum isotopic ratios were measured with the Micromass IsoProbe (MC-ICP-Hex-MS) operated at CRPG. Isotopic ratios were corrected for mass fractionation by normalization to ^{98}Mo/^{96}Mo=1.453184 (Yin and Jacobsen 1998) by use of the exponential law. The nine faraday cups allow us to measure molybdenum isotopes at masses 92, 94, 95, 96, 97, 98, and 100, and to correct for potential zirconium and ruthenium isobaric interferences at masses 91 and 99, respectively. We measured terrestrial standards (Govindaraju 1994) GSD-6, GSD-11, GSD-12 (stream sediments), GXR-4 (copper millhead), GXR-5 (soil), and VS-N (synthetic glass) as well as iron meteorites Toluca (IA) and Sikhote-Alin (IIB).

All terrestrial standards are normal within uncertainties (ε_{Mo} null), which demonstrates our ability to resolve anomalies in extraterrestrial samples if they exist. The silicate Earth shows no obvious deficit in ^{97}Mo relative to Toluca and Sikhote-Alin. This observation is consistent with the results of Birck et al. (2000) who saw no resolvable deficit in Earth at the epsilon level but is inconsistent with the conclusions of Yin and Jacobsen (1998) and Yin et al. (1999) who reported deficit of ^{97}Mo in Earth relative to Toluca and Sikhote-Alin. We conclude that ^{97}Tc had fully decayed (below detection level) before the terrestrial core formed, which clears up the discrepancy that existed between ^{182}Hf-^{182}W and ^{97}Tc-^{97}Mo systematics. Estimation of the early solar system ^{97}Tc/^{97}Mo would allow quantification of this qualitative statement, a work currently under progress in our laboratory.

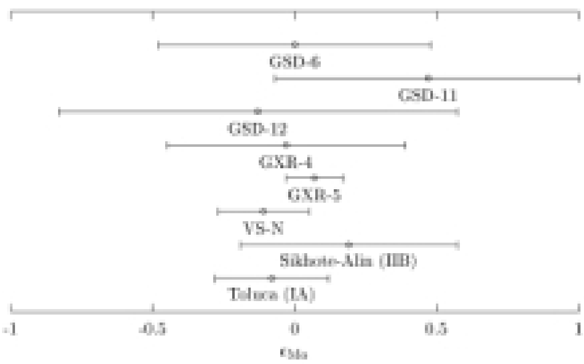

Figure 1: ε_{Mo} is defined as $[(^{97}Mo/^{96}Mo)_{SAMPLE}/(^{97}Mo/^{96}Mo)_{STANDARD}-1]x10^4$.

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