THEME 6:
THE EARLY EARTH AND PLANETS

Session 6.1:
From accretion to core formation

CONVENED BY:
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The session will cover the early history of the solar system. Topics of interest include the nature of the primordial solar system material; the chronology of the early solar system, from grain growth to planetary differentiation; the origin and distribution of short-lived isotopes; the physical and chemical conditions in the accretion disk, chondrules, opaques and matrix material in primitive chondrites; asteroidal metamorphism and metasomatism; asteroidal and planetary core formation and the earliest planetary crusts.

6.1.11

First evidence of live ^{205}Pb in the early solar system

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Extinct chronometers are among the most important tools for studies of the early evolution of the solar system and the accretion of planetary bodies. In addition, the initial abundances of the parent isotopes yield information on the stellar sources of these short-lived nuclei. The existence of the *s*-process nuclide ^{205}Pb in the early solar system has long been predicted by nucleosynthetic models. However, its detection has been hindered by analytical difficulties. ^{205}Pb decays to ^{205}Tl with a half-life of ~15 Myrs. Fractionation of Pb/Tl within the early solar system due to volatile loss or planetary differentiation should thus produce variations in ^{205}Tl/^{203}Tl.

The Tl isotopic compositions of the group IA iron meteorites Toluca and Canyon Diablo have been measured by MC-ICPMS and yield ε^{205}Tl = +16 and ε^{205}Tl = +8, respectively (where $\varepsilon^{205}\text{Tl} = 10^4 \times (^{205}\text{Tl}/^{203}\text{Tl}_{\text{sample}} - ^{205}\text{Tl}/^{203}\text{Tl}_{\text{NIST 997}})/ ^{205}\text{Tl}/^{203}\text{Tl}_{\text{NIST 997}}$). The analytical error on the measurements is less than 2 ε-units and thus the anomalies are well resolved.

The Tl isotope compositions of Toluca and Canyon Diablo are in accord with the high Pb/Tl ratios of these iron meteorites. However, thallium has only two isotopes, which precludes the distinction of anomalies produced by the decay of ^{205}Pb from effects due to mass dependent isotope fractionation of thallium. The isotope fractionation that may accompany volatile element depletion should generate "heavy" Tl isotope compositions ($\varepsilon^{205}\text{Tl} > 0$) in the residue, which is also consistent with the results.

Using Pb concentrations of 91.6 ppb and 44.2 ppb [1] for Canyon Diablo and Toluca, respectively, we calculate ^{204}Pb/^{203}Tl of 27 and 42. This yields a ^{205}Pb/^{204}Pb initial of 1×10^{-4} at the time the meteorites closed to Tl equilibration. Thus, the thallium isotope compositions of these two iron meteorites are consistent with radiogenic ingrowth of ^{205}Tl from the decay of ^{205}Pb. In order to confirm the radiogenic nature of the Tl isotope anomalies, additional iron meteorites will be analysed for Tl isotope compositions and Pb, Tl abundances.

References

[1] Göpel C., Manhés G., and Allégre, C.J. (1985) *GCA* **49,** 1681-1695.