Pb-Tl chronology of IIAB and IIIAB iron meteorites

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The short-lived ^{205}Pb-^{205}Tl system ($t_{½}$= 15.1 My) is the only decay system in which the parent nuclide is an s-process only nuclide, and thus the Solar System initial abundance of ^{205}Pb provides unique constraints on the amount of AGB star material injected into the Solar Nebula shortly before its collapse. The Pb-Tl system is furthermore one of few that can be used to date metal crystallization and hence provide independent age constraints on the core crystallization and thermal history of planetary bodies.

Measured Pb concentrations vary widely—from 0.5 ppb to more than 1 ppm due to terrestrial Pb contamination, which was not removed despite repeated leaching. The fraction of primordial Pb is calculated assuming deviation in the Pb isotope composition of the iron meteorites from primordial Pb is due to terrestrial Pb contamination. The concentration range of primordial Pb is very limited—from 0.1 ppb to 1.7 ppb. Concentrations of Tl range from 2 ppt to 485 ppt, with most samples below 20 ppt. This gives ^{204}Pb/^{203}Tl ratios for the IIABs from 0.05 to 5.8, and from 1.6 to 14 for the IIIABs, close to the chondritic ratio of 1.4. Values of ε^{205}Tl range from -18 to +23 and correlate with ^{204}Pb/^{203}Tl ratios, suggesting that the ε^{205}Tl variations are from the decay of ^{205}Pb at different Pb/Tl ratios. The IIAB isochron has an intercept, $\varepsilon^{205}Tl_0$ = -12±1 that is more negative than that of the carbonaceous chondrites, $\varepsilon^{205}Tl_0$ = -7.6±2.1.

This may imply that metal/silicate separation of the IIAB parent body was associated with mass-dependent Tl isotope fractionation of ~7 ε-units. However, experimental data suggest that a fractionation of this magnitude is not likely. Alternatively, if the carbonaceous chondrite isochron is recalculated rejecting samples suffering from large terrestrial Pb contamination, the slope of ε^{205}Tl vs. ^{204}Pb/^{203}Tl is steeper, with $\varepsilon^{205}Tl_0$ = -13±6. This gives Pb-Tl ages for the IIAB and IIIABs of around 15 Ma after carbonaceous chondrites.

The IIAB isochron intersects the carbonaceous chondrite isochron at ^{204}Pb/^{203}Tl = 0.15. This indicates that metal-silicate segregation took place around 2 Ma after carbonaceous chondrites, and that the metal portion of the IIAB parent body had a low Pb/Tl ratio. The latter conclusion is in agreement with previous work that inferred that IIAB irons had sulphur-rich metal compositions, and with existing experimental partitioning data suggesting that a sulphur-rich metal phase should be significantly enriched in Tl compared to Pb. The reinterpreted carbonaceous chondrite isochron gives a Solar System initial ^{205}Pb/^{204}Pb ratio of 2±1 x 10^{-3}.

Laboratory mesocosm experiments to quantify effects of elevated CO_2, plant evolution, and mycorrhizal status on carbon flux and weathering.

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The evolution of vascular land plants in the Paleozoic is hypothesized to have enhanced weathering of Ca and Mg bearing silicate minerals (e.g. [1]). However, this plant-centric view neglects the co-evolution of plants and their associated mycorrhizal fungi. Indeed, many weathering processes usually ascribed to plants may actually be driven by the combined activities of roots and mycorrhizal fungi [2]. Here we present results from a novel mesocosm-scale laboratory experiment designed to allow investigation of plant-driven carbon flux and mineral weathering at different soil depths, and under ambient (400 ppm) and elevated (1500 ppm) atmospheric CO_2.

We selected plant species to quantify the effects of mycorrhizal type (arbuscular, AM, vs. ectomycorrhizal, EM), rooting depth, and angiosperms vs. gymnosperms on carbon flux and biological weathering. These species included the AM *Sequoia sempervirens*, *Osmunda regalia*, *Magnolia grandiflora*, and *Ginkgo biloba*, as well as two EM species, *Pinus sylvestris* and *Betula pendula*. Two long-term (7-13 months) experiments were conducted under similar environmental conditions with one exception: Experiment 1, focused on rooting depth, used a low nutrient substrate and Experiment 2, studying angiosperms vs. gymnosperms, used an organic-rich substrate.

Only under low nutrient conditions did we observe increased biomass in plants and bulk fungus grown under elevated CO_2. For the two species grown in both experiments, mineral core fungal biomass and the magnitude and timing of carbon flux from plant to belowground biomass seemed to be more correlated to soil organic content than CO_2. Fungal activity was related to plant carbon flux and was not proportional to fungal biomass, which may be important for biological weathering. Bulk and mineral core solution chemistries differ between plant-free controls, plant species, minerals, and CO_2 levels, potentially giving insight into mechanisms and degree of mineral weathering. Ongoing measurements will further assess mineral weathering and quantify biomass element uptake in these systems.

[1] Berner (1997) *Science*, **276**, 544-546. [2] Taylor et al. (2009) *Geobiology* **7**, 171-191