Hf-Nd isotopic variations of authigenic and silicate components in north Pacific sediments

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Recent studies of hydrogeneous Fe-Mn crusts have shown that Hf and Nd isotope time series in seawater are decoupled despite the similar geochemistry of these elements in the mantle and similar residence times in seawater. It is considered that the decoupling is either caused by a slight difference of oceanic residence time of Hf and Nd or a different behavior of these elements during weathering of continental crust. We determined Hf and Nd isotope compositions of both silicate and authigenic fractions in north Pacific surface sediments in order to understand the behavior of Hf and Nd in seawater at the present time. Weathering products in the Asian continent (loess, river deposit and desert sand) were also examined. After carbonates in these samples had been dissolved in weak hydrochloric acid (0.25M), Fe-Mn components were leached with oxalic acid (0.1M). The residues were defined as silicate components.

For the silicate fractions, ε_{Nd} of deep sea sediment in the north central Pacific (-10 to -7) and ε_{Hf} and ε_{Nd} of continental shelf sediments in the Yellow Sea and the East China Sea (-24 to -7 and -14 to -10, respectively) are similar to those of the Asian continental material (ACM) (ε_{Hf} = -17 to -14, ε_{Nd} = -12 to -10). ε_{Hf} in the north central Pacific (-4 to 0) is obviously higher than that of ACM. ε_{Hf} in grain size fractions of ACM shows large variations from -16 to -4 and that in <2 µm fraction of the Asian loess is -4. This confirms previous evidence that the fine particles of the weathering products in the Asian continent are transported into the north central Pacific by wind and dominate the pelagic sediments.

The regional variations in Hf and Nd isotopic compositions in the oxalic acid leachates of deep sea sediments are consistent with published data for Fe-Mn crusts. This suggests that Hf and Nd in the leachates of these sediments have seawater origin.

The Nd isotopic composition of the oxalic acid leachate of ACM is similar to that in silicate fraction of ACM (ε_{Nd} = -12 to -10), while the Hf isotope composition of the leachate (ε_{Hf} = -1 to +11) is significantly higher than that of the silicate fraction. This suggests the different behavior of these elements during weathering process. Furthermore, the Hf isotope composition of the ACM leachate is quite similar to that in seawater. The easily dissolved fraction in eolian dust from the Asian continent is a possible significant source of Hf to seawater.

Was ^{26}Al a chronometer or heat source in the early solar system?

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Chondritic meteorites are often considered to be representative of materials which accreted to form planets. ^{26}Al (half life 730000yrs) is commonly used as a high resolution chronometer for comparing events early in the solar system, as recorded by these chondrites; it is also appealed to as a heat source for planetessimal thermal processing. It is also considered a viable heat source for the early melting of terrestrial planets. Some of these characteristics appear mutually exclusive, particularly when considered in the light of chondrite evolutionary pathways.

Calcium-Aluminium-rich Inclusions (CAIs) are probably the earliest extant solids formed in the solar system and contain the highest initial ^{26}Al abundances. Studying the systematics of ^{26}Al within CAIs should help us understand the evolution of ^{26}Al in other chondritic materials and, ultimately, its role in the early solar system.

We have used laser ablation MC-ICP-MS (ArF excimer UV laser coupled to a Nu Instruments ICP-MS) to measure low Al/Mg minerals in a Type B Leoville (CV3) CAI. The CAI exhibits typical igneous texture with a melilite-spinel-fassaite-anorthite core surrounded by a melilite mantle containing minor spinel. For ion microprobe analysis only anorthite would be suitable for high precision Al-Mg chronology due to its high Al/Mg. By the application of high precision ICPMS we can determine Al-Mg ages on spinel, fassaite and melilite (though not anorthite due to low Mg abundances).

Results demonstrate that the outermost part of this inclusion underwent isotopic exchange and re-equilibration, probably in a nebula resetting after the complete decay of ^{26}Al. In the classical interpretation of variations in ^{26}Al/Al, CAI evolution and the vision of chondrites as planetary precursors would imply that ^{26}Al had entirely decomposed prior to the final accretion of chondritic parent bodies hence would not be available for the heating of planetessimals and planets.

These results suggest that the early evolution of chondritic materials occurring sequentially as: CAI formation, chondrule formation, accretion, lithification, planetessimal melting did not occur prior to the complete decay of ^{26}Al, there was still nebula processing after the complete decay.