Behavior of water during terrestrial planet formation

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Recent planetary formation theory suggests two stages of planetary accretion; the stage of runaway growth (e.g., Kokubo and Ida, 1998) followed by the stage of giant impacts (e.g., Chambers and Wetherill, 1998). Here, I discuss the behavior of water during terrestrial planets formation from theoretical points of view.

Usually, the solar nebula is thought to be too warm to form hydrous minerals at 1 AU from the Sun, so hydrated material is not available in planetesimals. However, recent theory suggests cool nebla, so that large amount of water can be trapped in planetesimals. Such water is lost during accretion, but substantial amount of water can be trapped in Mars-sized protoplanets formed during the stage of the runaway growth (Machida and Abe, 2007). Expected water content is size dependent; larger bodies retain water, but smaller bodies are dry. This may imply protoplanets are somewhat wetter than meteorites.

Accretion of water-bearing planetesimals results in many phenomena (Abe *et al*., 2000). Impact degassing would form a proto-atmosphere. A hydrous magma ocean can form in response to the thermal blanketing effect of an early proto-atmosphere. In addition, a large amount of hydrogen may be partitioned into metallic iron under high pressure, and delivered to the core.

In the stage of giant impacts, addition of material from large bodies beyond the orbit of Mars may transport water to the Earth region (e.g., Lunine *et al*, 2007). Giant impacts would remove some amount of water, but substantial amount survives them (Genda and Abe, 2003). Moreover, loss rate depends on the surface environment of protoplanets. On protoplanets with oceans, giant impacts result in relative enrichment of water against other gases, because gas species are efficiently blown away by the impact, while water ocean survives (Genda and Abe, 2005). Thus, planets those experienced giant impacts with oceans (Earth?) are likely enriched in water than those without oceans (Venus?) or those experienced no giant impacts (Mars?).

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Li isotopes and Li/Ca measured in foraminifera via SIMS and MC-ICP-MS

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Lithium has a residence time within Earth's oceans of ~1.5 Ma. Perturbations in the recorded Li isotope composition of seawater beyond this residence time likely reflect changes in competing fluxes of Li derived from continental silicate weathering and hydrothermal circulation. The importance of continental weathering in regulating global climate has led to great interest from several groups in ground-truthing and examining temporal records of lithium archived within foraminiferal tests.

In this study we attempt to further our understanding of Li isotopes hosted within foraminiferal carbonate using a combination of in-situ SIMS and MC-ICP-MS analysis with which to measure Li/Ca and δ^7Li. We find single specimens of *G. truncatulinoides* measured by SIMS show, in keeping with other more traditional trace metal concentrations, significant Li/Ca variation throughout the foraminiferal test that cannot be attributed to contaminant phases. Initial in situ lithium isotope ratios also allude to isotopic variation most likely reflecting depth migration during ontogenic stages of biomineralisation.

These observations can be put into context by our high precision MC-ICP-MS study of muliple specimens, sampled from five ocean basins. Deeper dwelling species record decreasing lithium isotope ratios with increasing depth of habitat. Although we document no variation in the lithium isotope composition of modern seawater we observe significant (~2 ‰) variation between surface dwelling Holocene *G. sacculifer* and *G. ruber* from several ocean basins. These lines of evidence are indicative of an environment control on the isotopic fractionation of lithium during biomineralisation, as previously proposed for Li/Ca incorporation.

This characterisation of lithium isotopes makes deconvolving variations in weathering intensity from variations in environmental forcing in Neogene records problematic. Using a mult-proxy approach however, down core variations in the lithium isotopic composition of foraminifera may yield valuble information on past weathering fluxes and climatic conditions.