# U-isotope fractionation during chemical weathering

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Our ability to use uranium isotopes as a tool for determining rates and timescales of weathering critically depends on the processes that produce fractionation between $^{234}U$ and $^{238}U$. First, during water rock interaction, $^{234}Th$ can be directly recoiled into the water phase and subsequently decays to $^{234}U$. Second, mineral dissolution can lead to an enhancement of $^{234}U$ in the water. We have used both a theoretical and experimental approach to better model both processes.

We used continuous leaching experiments of a ground granite reported in Andersen *et al.* [1] combined with major element analyses to constrain the preferential leaching rates $^{234}U$ relative to $^{238}U$ for each mineral. To model these experiments, we have considered that $^{234}U$ consist of two pools one that is easily leachage and one that has annealed at a slow rate and becomes indistinguishable from $^{238}U$. This model provides a good fit to the experiments but can also be extended to longer timescales.

In order to better describe the recoil efficiency we have used surface area measurements based on the BET method and used this data to determine the fractal dimension of the surface. This fractal dimension is then used to correct the recoil efficiency for surface roughness at the length scale of recoil (~30 nm). DePaolo *et al.* [2] had underlined that BET measurements overestimate the surface area to calculate recoil efficiency. Our methodology now provides a refined estimate of recoil efficiency that is more consistent with observations.

The combination of these approaches provides a predictive framework with which one can estimate more reliably weathering rates based on U isotopes. This will be done using examples from the literature as well our study of carbonate weathering in Eastern France. Notably, an improper estimate of preferential leaching leads to an incorrect estimate of weathering rates.

[1] Andersen *et al.* (2007) *Geochim. Cosmochim. Acta* 71, A25. [2] DePaolo *et al.* (2006) *Earth Planet. Sci. Lett.* **248**, 394-410.

# The age of the hidden reservoir

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Recent evidence based on W isotopes [1] has shown that the age of the Moon has to be younger than 60 Ma after the beginnning of the solar system. In contrast, it has been inferred that the formation of a putative hidden reservoir to explain the difference in $^{142}Nd$ between chondrites and terrestrial material had to be earlier than 30 Ma. As the Moon-forming giant impact probably entirely melted the Earth, it is unclear how this event could have preserved a hidden reservoir at the base of the mantle.

Here we reexamine the age of the formation of the hidden reservoir based on a mass balance of $^{142}Nd$ and $^{143}Nd$ isotopes in the Earth. Boyet and Carlson [2] have used the $\varepsilon^{143}Nd$ in MORBs to estimate the maximum degree of Sm/Nd fractionation in the early Earth and thus obtained that their hidden reservoir must have formed prior to 30 Ma. This is clearly an upper limit because the subsequent continental crust extraction must have further depleted the Earth's mantle following the formation of an enriched reservoir. We have recalculated this age based on a complete mass balance including the formation of a hidden reservoir and of the continental crust as well as the corresponding Nd isotope evolution. The corresponding system of seven equations can be solved iteratively and yields the age of formation of the "hidden reservoir". Surprisingly, the age of formation of the hidden reservoir using conservative parameters for the concentrations of Nd in the continental crust and depleted mantle has to be less than 5-10 Ma. Essentially the hidden reservoir must have formed before the Earth has completed its accretion. We consider this unlikely and suggest that Sm/Nd in terrestrial material must have fractionated at an early stage in the history of the solar system: a possibility is that the missing component was lost during or prior to accretion.

[1] Touboul M. *et al.* (2007) *Nature* **450**, 1206-1209. [2] Boyet, M. & Carlson, R. W. (2005) *Science* **214**, 427-442.