Nd and Hf model ages in the Western Gneiss Region, Norway: A new way to better understand mantle-crust evolution

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The signification of Hf model ages is revisited through the study of metabasites and their gneissic host-rock of Vårdalsneset (Western Gneiss Region, Norway), with the comparison of Nd and Hf model ages, that are assumed to be similar for a given sample.

Three different mantle-crust differentiation models currently exist on the basis of Nd and Hf isotope systematics: (i) the canonical model with chondritic Earth and an unique early step of differentiation, (ii) a model with chondritic Earth and a continual growing crust since 3 Ga and (iii) a model with sub-chondritic Earth and a continual growing crust since 4.56 Ga, and they remain to debate. It is therefore expected that Nd and Hf model ages calculations could allow the validation of one of these models.

Rock protoliths as well as trace-element mobility are characterized by a petrological and geochemical study. Metabasic samples likely came from cumulates and MORB-type basalt whereas gneiss could represent paragneiss and not orthogneiss as usually accepted in the WGR of Norway.

As the trace elements appear slightly mobile, the Nd and Hf isotopic data enable to calculate model ages.

Interestingly, whatever the crust-mantle differentiation model used, Nd model ages are equal within error contrarily to Hf model ages (Table 1).

	Nd (i)	Hf (i)	Nd (ii)	Hf (ii)	Nd (iii)	Hf (iii)
min	1.44±0.35	2.18±0.39	1.16±0.30	1.44±0.38	1.09±0.34	1.22±0.39
max	1.87±0.02	3.21±0.52	1.44±0.06	1.97±0.78	1.31±0.04	1.56±0.38

Table 1: Nd and Hf model ages in Ga calculated on metabasites for the three mantle-crust differentiation model.

We assume that both Nd and Hf model ages should be in agreement with metabasites zircon U-Pb age (1.15 ± 0.20 Ga). Thus, we show that only the third model with sub-chondritic Earth and a continual growing crust since 4.56 Ga allows to obtain significant model ages with both Nd and Hf isotopic systems ranging from 1.09 ± 0.34 to 1.56 ± 0.38 Ga.

Pb isotopic history of weathering on Antarctica during the Eocene-Oligocene transition

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The initiation of Antarctic continental glaciation at the end of the Eocene is one of the most dramatic climate events in the Cenozoic. Drawdown of atmospheric CO_2 below a threshold value is considered one of the prerequisites for this glacial transition, suggesting a possible role for silicate weathering. In this study we compare Pb isotopes recorded in Hydroxylamine Hydrochloride extractions (seawater) and residual terrigenous material from two intermediate water, circum-Antarctic sites (ODP Sites 689 and 738) to evaluate the extent of chemical weathering and the composition of weathered material during the Eocene/Oligocene transition (EOT). Prior to the EOT, seawater and residues record similar $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ values. At the EOT, both sites record increasing seawater and residue $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ values, with some structure apparent in the higher resolution record of Site 738 that matches the two-step glacial transition defined by $\delta^{18}O$. In contrast, $^{206}Pb/^{204}Pb$ values for seawater become more radiogenic at both sites, while values for residues become less radiogenic.

The similarity between seawater and residue values for all three Pb isotopic systems suggest extensive, congruent chemical weathering that may have started during the warm Eocene, an interpretation supported by other proxies. Variations in residue Pb isotopes starting at the EOT imply intensified mechanical weathering that incorporated multiple silicate source rocks with different chemical compositions. This interpretation is consistent with the idea that the glaciers weathered rocks from a broader region as they grew. The fact that seawater Pb isotopic values track residue values argues that the silicate mechanical weathering products from the glaciers were exposed to active chemical weathering and controlled the local seawater Pb isotopic signal. This silicate weathering could have contributed to the drawdown of atmospheric CO_2. The correlation with the $\delta^{18}O$ two-step also implies that intervals of cooling and ice growth were associated with weathering pulses. The pattern for $^{206}Pb/^{204}Pb$ values is distinct from the other two isotopic systems after the EOT and is interpreted to represent weathering of Phanerozoic carbonates that contribute uranogenic, but not thorogenic, Pb. Weathering inputs from these carbonate source rocks may have contributed to deepening of the carbonate compensation depth.