Circulation of Eocene to Pliocene intermediate water masses in the Indian Ocean: Evidence from fossil fish teeth Nd isotopes

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We have evaluated Nd and Sr isotopic compositions of fossil fish teeth from ODP site 757 (17°S, 88°E, 1650 m) on the Ninetyeast Ridge in the Indian Ocean. The calcareous nannofossil stratigraphy was enhanced with Sr age estimates from Oligocene forams. ε_{Nd} values of teeth increase from ~-7.5 at 36 Ma to ~-6 at 28.5 Ma. After 28.5 Ma values begin to decrease, falling to ~-7.5 at 11.5 Ma before rising to a mid-Pleistocene value of -5.8.

Variations in ε_{Nd} are believed to reflect changes in circulation of intermediate water masses in the Indian Ocean. The structure of the curve does not provide evidence of a Himalayan weathering input which is consistent with data from deeper sites in the Indian Ocean [3]. Today, site 757 is influenced by the Indonesian throughflow jet (ε_{Nd} ~ -5), which injects Pacific waters into intermediate depths of the Indian Ocean. The low salinity core of AAIW (ε_{Nd} ~ -8) is currently well developed south of 18°S in the Indian Ocean [1].

During the middle Eocene, $\delta^{18}O$ values at site 757 were higher than in the southern Indian Ocean, possibly reflecting a warm water mass overlying the [2]. The Tethys sea was a potential source for such a water mass (modern Mediterranean ε_{Nd} ~-9). Plate reconstructions for the Eocene show progressive constriction of the eastern Tethys connection with the Indian ocean. The shift toward radiogenic ε_{Nd} values from 35-28.5 Ma may reflect a decreased contribution of nonradiogenic Tethyan seawater, which was replaced by Indonesian throughflow water.

Crustal subsidence of site 757 into an AAIW-type water mass is one possible explanation for decreasing values from 28.5-11.5 Ma. Additionally, data from site 1090 (43°S, 20°W) suggest that waters sourced from the Southern Ocean were influenced by a nonradiogenic water mass during this interval, related to changes in circulation associated with the opening of the Drake Passage [4].

Values increase again after 11.5 Ma to -5.8 near the top of the core, approaching modern throughflow values.

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Lu-Hf ages of high pressure metamorphism in the Variscan fold belt of southern Germany

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The closure temperature of Lu-Hf in a particular garnet is ca. 50-150°C higher than that of Sm-Nd ([1], using the revised ^{176}Lu decay constant from [2]). Lu-Hf geochronology, in conjunction with Sm-Nd ages, is therefore a valuable tool for dating eclogite formation (i.e., garnet growth), or estimating exhumation rates. We have dated four Münchberg Massif (MM) eclogites with Lu-Hf on Grt-Omph pairs: two light eclogites from Oberkotzau (north-east MM), and two dark eclogites from Weissenstein (south-west MM). The dark variety (Cpx + Grt + Qtz +Rt ± Hbl ± Pheng has a MORB-like bulk composition, whereas the light variety (Cpx + Grt + Qtz + Rt + Ky ± Pheng ± Zo ± Hbl) has a high-Al basaltic composition [3, 4]. The light eclogites gave ages of 405 ±7 Ma and 384 ±6 Ma (2_), and both have $\varepsilon_{Hf}(t)$ values of +6.5. The dark eclogites yielded ages similar to those of the light variety, 397 ±7 Ma and 398 ±6 Ma, but have distinctively higher $\varepsilon_{Hf}(t)$ of +12.2 and +11.9. Lu-Hf ages for both types overlap with published Sm-Nd and Rb-Sr internal isochron ages (380-395 Ma, [4]) for dark eclogites. The close agreement among all three isotope systems suggests extremely rapid exhumation soon after eclogitization. The high initial ε_{Nd} (ca. +8, [4]) and ε_{Hf} of the dark eclogites confirms that their mantle source was characterized by long-term depletion (e.g., MORB). In contrast, the lower initial ε_{Hf} and high Al-contents of the light eclogites may point to a subduction-related origin for their basaltic protoliths.

A suite of garnet metabasites from the Böllsteiner Odenwald (Mid-German Crystalline Rise) were once eclogites before being retrogressed to garnet amphibolites [5]. Our first attempt at dating the high pressure stage yielded Lu-Hf Grt-WR ages of 357 ±7 Ma and 353 ±11 Ma. Grt and wr from both samples plot on a single isochron (357 ±6 Ma; MSWD = 1.09) and give an initial ε_{Hf} of +11.3, which is indicative of long term depletion in their mantle source. Some resetting may have occurred during retrograde metamorphism; the Lu-Hf ages are thus minimum ages for the eclogite facies event in the Odenwald.

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