# The influence of erosion and palaeogeography on seawater neodymium during the past 20 million years

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## Introduction

The residence time of neodymium (Nd) in seawater is similar to or less than the mixing time of the oceans. Consequently, the major oceans possess distinctive Nd isotopic compositions which reflect the erosional sources of rare earth elements and their distribution through water mass circulation. In contrast, the residence time of strontium (Sr) is orders of magnitude greater than the mixing time of the oceans, and the Sr isotopic composition of seawater is spatially uniform on a global scale. However, there are significant variations in the Sr isotopic composition of seawater over time, which permits the use of this system for high-resolution stratigraphic dating. Thus, in principle, the combined use of Sr and Nd isotopes provides both temporal and spatial information on water mass evolution. Hydrogenous ferromanganese (Fe-Mn) crusts are considered to grow directly from seawater, and potentially preserve a record of the chemistry of the seawater from which they grow. This study presents the Nd isotopic record preserved by Fe-Mn crusts from the Pacific and Atlantic oceans, where complementary Sr data are used to document the timescale of growth.

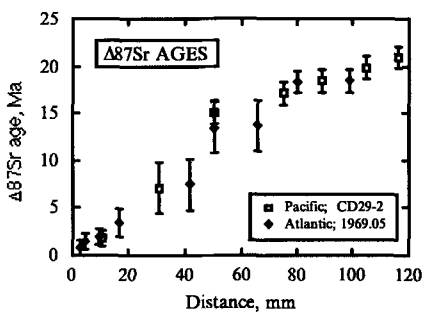


FIG. 1.

## Sample and analytical details

Two Fe-Mn crusts were selected for analysis; (1) CD29-2, from the South Karin ridge (16.42 N; 168.14 W) in the central Pacific ocean from a water depth of ~2400 metres. (2) BM 1969.05 from the San Pablo seamount (39.0 N; 60.57 W) in the west North Atlantic from a water depth of ~1850 metres. The crusts were sampled on a $\geqslant 1$ mm scale perpendicular to the growth layers. Each sample was leached in 10% HoAc to remove carbonate bound Sr, prior to dissolution in 5M HCl (after Futa *et al.* 1988). Sr and Nd were separated using standard ion exchange procedures, and analysed by dynamic multi-collection on a VG 354 mass spectrometer. Repeat measurement of the Sr standard NBS 987 and JM Nd over the period of analysis gives an average of $0.710233 \pm 9$ ($\pm 13$ ppm) and $0.511122 \pm 9$ ($\pm 18$ ppm), respectively.

## Results

*Central Pacific, South Karin ridge.* Sr isotopic compositions indicate that growth of the crust started some 20 Ma ago, with an average growth rate of ~ 5 mm/Ma (Fig. 1). The Nd isotopic composition of the crust 10 mm from the outer growth surface gives an $\varepsilon_{Nd}$ value of $-3.12 \pm 0.19$ (Fig. 2) in good agreement with the present day seawater (SW) composition at similar water depths (Piepgras & Jacobsen, 1988). However, the Nd isotopic compositions show a significant variation over the 20 Ma growth period. Nd shows a decrease to a less radiogenic value of $-5.79 \pm 0.19$ at the base of the crust, and a marked shift occurring during the period between 15 and 20 Ma ago.

*North Atlantic, San Pablo seamount.* Sr isotope data indicate that this crust, like that from the Pacific, grew over an interval of about 20 Ma, with a similar average growth rate (Fig. 1). The Nd

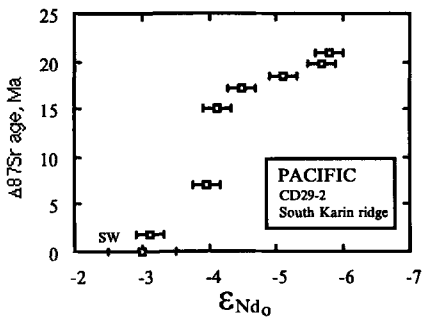


FIG. 2.

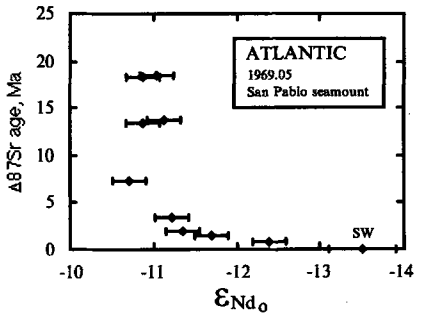


FIG. 3.

isotopic composition of the crust 3mm from the outer surface yields an $\varepsilon_{Nd}$ value of $-12.4\pm0.19$ (Fig. 3). Present day seawater (SW) at similar depths gives a value of $-13.5\pm0.4$ (Piepgras & Wasserburg, 1987). Nd isotopic compositions, like those in the Pacific crust, show a significant variation with time. However, in this case $\varepsilon_{Nd}$ values shift towards more radiogenic values and these changes occur over the time interval from the present day to 7–10 Ma ago (Fig. 3) with no resolvable change over the time interval from 10 to 20 Ma.

*Conclusions* These results indicate that there have been significant changes in the Nd isotopic composition of seawater supplying the crusts over the past 20 Ma. In the Pacific Nd was less radiogenic than present day, with a marked change occurring between 15 and 20 Ma ago. In contrast, in the Atlantic Nd shifted towards more radiogenic values than present day, and this change occurred over the past 7–10 Ma. At present it is not clear to what extent these patterns are related. Erosional sources of Nd are likely to have been broadly similar to the present day. For the Pacific the supply of less radiogenic Nd some 20 Ma ago may reflect direct access of Atlantic water via an open central American isthmus. For the North Atlantic, the marked shift towards unradiogenic values from 10–7 Ma to the present day may reflect the onset of consistent North Atlantic deep water production or may simply document plate movement into the path of deep water. These results highlight the potential for hydrogeneous Fe-Mn crusts to preserve information on the sources of erosional input, palaeogeography and its effect on palaeocirculation patterns in the oceans.

## References

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