# Lead isotopic records of palaeoceanographic change in the NW Atlantic obtained from Fe-Mn crusts

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The residence time of Pb in the oceans is considered to be shorter than the mixing time of the oceans. Various geographically dispersed sources of Pb (e.g. old continental crust, young volcanic terranes) contribute Pb with a wide range of isotopic compositions to the oceans. Therefore, unlike Sr which has a long residence time, there are Pb isotopic differences between the oceans (e.g. von Blanckenburg *et al.*, 1996). The Pb isotopic record of a Fe-Mn crust from a particular locality and ocean-depth should be sensitive both to changes in the Pb inputs to the oceans as well as changes in ocean basin-scale circulation and inter-ocean exchange (Abouchami *et al.* 1997; Ling *et al.* 1997; Burton *et al.* 1997; Christensen *et al.* 1997).

The challenge is to establish the relative effects of changes in circulation and Pb inputs in the Pb isotopic records. Progress can be made by the comparison of Pb isotopic records of crusts from different localities. For example, a comparison of the Pb isotopic records of two Central Pacific crusts separated by 3000 km, suggests that aspects of those records may reflect changes in the intensity of circulation in the Pacific (Christensen *et al.* 1997). In an Fe-Mn crust from the NW Atlantic, Burton *et al.* (1997) measured Pb and Nd isotopic records which indicated a significant shift towards more radiogenic Pb and less radiogenic Nd isotopic compositions at around 4 Ma. This was interpreted to be related to strengthening of North Atlantic Deep Water (NADW) at that time. Here we present high resolution Pb isotopic data for three Fe-Mn crusts from the NW Atlantic, including the crust analysed by Burton *et al.* (1997), which provide a profile of the history of deep water structure for the past 5 Ma.

## Samples and analysis

Three Fe-Mn crusts from along the New England seamount chain in the Northwest Atlantic were selected for analysis in order to test for the effects of water depth and distance from the continental shelf on the correlated records. Alv542 (39.4°N, 65.45°W) was dredged from a water depth of 2820 m, approximately 120 km SE from the edge of the continental shelf, BM1969.05 (39°N, 61°W) from a depth of 1850 m, 500 km SE of the shelf and Alv539 (35.6°N, 58.8°W) from a depth of 2665 m, 850 km SE from the continental shelf. Each of these samples is near or in the present path of the Deep Western Boundary Current (DWBC) which is the southern extension of NADW. The growth rates determined by $^{10}Be/^{9}Be$ measurements are $2.37 \pm 0.15$ mm/Ma for Alv539 and $1.62 \pm 0.1$ mm/Ma for BM1969.05 (O'Nions *et al.*, 1998).

Some Pb isotopic analyses were conducted *in situ* using UV laser sampling coupled with MC-ICPMS (Christensen *et al.*, 1997). Typical raster sizes were ~125 $\mu m^2$, and ~300 deep. Each of the analyses along the traverses therefore represents 50 to 70 ky.

## Results

The Pb isotopic records of Alv539 and BM 1969.05 were calibrated using the $^{10}Be/^{9}Be$ growth rates provided by O'Nions ="PS2B42">et al. (1998). Since no growth rate data are available for Alv542, its Pb isotopic record was time calibrated assuming the growth rate of Alv539 which is from a similar water depth. This results in a good match between 0 and 4 Ma in the two records.

The measured Pb isotopic record of BM1969.05 extends back to an extrapolated age of ~60 Ma, while the record of Alv539 extends to an extrapolated age of ~30 Ma. The highest $^{206}Pb/^{204}Pb$ and the lowest $^{207}Pb/^{206}Pb$ occur in the most recent portions of each crust. In Alv539 the shift to more radiogenic Pb is abrupt at $3.7 \pm 0.2$ Ma. For BM1969.05 during the interval 4–1 Ma, the change towards a more radiogenic Pb isotopic composition is more gradual. At ~0.6 Ma the rate of change in $^{207}Pb/^{206}Pb$

increases, then at ~0.2 there is an abrupt decrease in $^{207}Pb/^{206}Pb$. Consistent with these results are high resolution Nd isotopic data for Alv539 which define a shift toward less radiogenic Nd isotopic composition between 3 to 4 Ma (Burton *et al.*, this volume).

Comparing the records for the three crusts, Alv539 has similar $^{207}Pb/^{206}Pb$ to the shallower BM1969.05 until 3.7 Ma, when the $^{207}Pb/^{206}Pb$ of Alv539 drops to and follows that of the more shelfward Alv542. All three crusts come to about the same $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{206}Pb$ in their outermost layers. These observations suggest that at about 3.7 Ma DWBC (NADW) flow intensified and broadened to the east, encompassing the locality of Alv539. By approximately 0.2 Ma, DWBC (NADW) shoaled to the depth of BM1969.05 (1850 m).

## References


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