Response of cosmogenic ^{10}Be and radiogenic isotopes to the onset of Northern Atlantic Deep Water formation

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North Atlantic Deep Water (NADW) has characteristic dissolved beryllium, neodymium, and lead isotope compositions that are distinct from those in Antarctic Bottom Water (AABW). Palaeoceanographic reconstructions and carbon isotope investigations have shown that the strength of NADW production has been constant in the past 5 Ma, with reductions only during Pleistocene glaciations (Raymo, 1997). Be, Nd, and Pb isotopes as measured in hydrogenetic ferromanganese crusts, which are known to incorporate isotopes at their respective seawater compositions, should therefore provide an alternative means to infer past variations in water mass distributions.

We have measured $^{10}Be/^{9}Be$ ratios on two NW Atlantic Fe-Mn crusts that are located within the strong western boundary current adjacent to the sites of deep water generation in the Labrador Sea. $^{10}Be/^{9}Be$-derived growth rates are constant which allows for calculation of time-corrected initial $^{10}Be/Be$ ratios. These are constant and are within the range of modern N Atlantic seawater back to 8 Ma, with the exception of some extreme value in crust Alv 539 that we consider to be a product of postgenetic alteration (Fig. 1). By comparison $^{143}Nd/^{144}Nd$ (Burton *et al.*, 1997; O'Nions *et al.*, 1998) shows a pronounced decrease in the last ~5 Ma, and $^{206}Pb/^{204}Pb$ shows a similar increase in the last ~5 Ma (Fig. 2). These changes have previously been ascribed to changes in the strength of NADW production which might be associated with the closure of the Panama Isthmus (Burton *et al.*, 1997).

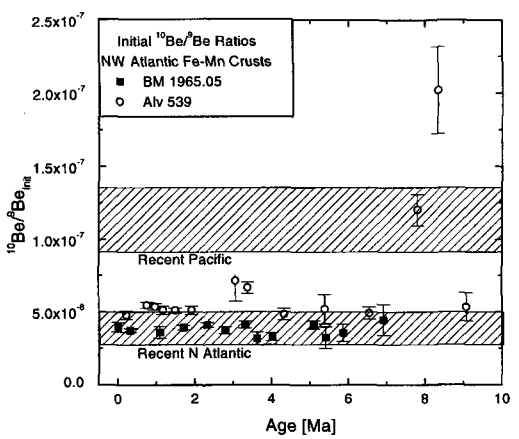

FIG. 1. Initial $^{10}Be/^{9}Be$ ratios for two North Atlantic Fe-Mn crusts.

An alternative model, that would also explain the absence of variations in the $^{10}Be/^{9}Be$ composition of seawater in the N Atlantic, is that changes in the Nd and Pb isotope composition merely reflect changes in the continental provenance of these tracers. For example, an ancient terrain would deliver Nd low in ^{143}Nd, but would leave $^{10}Be/^{9}Be$ unchanged because ^{9}Be from this terrigenous source unlike Nd bears no information about provenance - ^{10}Be is a cosmogenic isotope and is scavenged from the atmosphere and input into the oceans in rainfall. A likely possibility is that Nd sourced in the area of the Labrador Sea, where seawater $\varepsilon_{Nd} = -22$ (Stordal and Wasserburg, 1986) increased its contribution in the past 5 Ma to the blend that comprises NADW today. Such increase could come about 1) by a general increase of Labrador Seawater component in NADW; or 2) by an increase in low-radiogenic Nd delivered to the Labrador Sea by ice rafting (as proposed by Winter *et al.*, 1997, for the Arctic Sea). In this case one paradox that requires resolving is that the terrains of Greenland and Labrador are some of the least radiogenic in Pb isotope composition. One possibility is that during the strong mechanical erosion typical of ice rafting mainly radiogenic Pb hosted in accessory minerals was leached from rocks, while leaving the Feldspar Pb in the minerals (Erel *et al.* 1994). Box models show that a five-fold increase in the delivery of radiogenic Pb and Nd unradiogenic to the N Atlantic can explain the observed variations, while a possibly associated increase in the delivery of ^{9}Be

has only a minute effect on the $^{10}Be/^{9}Be$ ratio.

Box models also show that an increase of northwards spreading AABW, at the cost of the production of NADW, has no pronounced effect on the isotopic composition of either Be, Nd, or Pb in the N Atlantic. Hence the changes that are visible in carbonate $\delta^{13}C$ records during glacials do not translate into similar changes of these cosmogenic or radiogenic isotopes.

References

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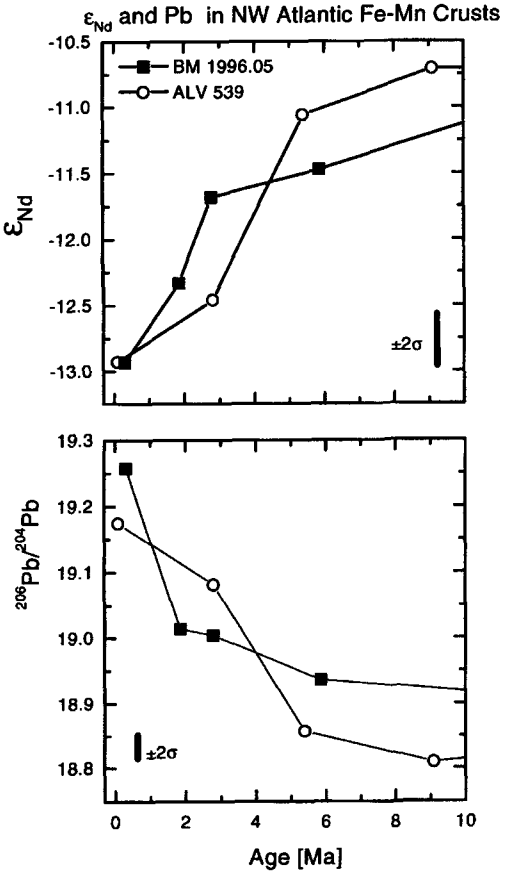

FIG. 2 ε_{Nd} (top) and $^{206}Pb/^{204}Pb$ for two North Atlantic Fe-Mn crusts.