Two-dimensional models of reactive isotope tracer dispersion in ocean gyres

F. von Blanckenburg
Isotopengeologie, Universität Bern, Erlachstr. 9a, 3012 Bern, Switzerland

H. Igel
Department of Earth Sciences, University of Cambridge, Cambridge CB2 3EQ, UK

Despite considerable differences in their source, observations in the isotope ratios of short to intermediate residence time tracers ($^{10}Be/^{9}Be$, $^{206,207,208}Pb/^{204}Pb$) show a high degree of homogenisation in oceanic basins (von Blanckenburg *et al.*, 1996*a*; von Blanckenburg *et al.*, 1996*b*). We assess the feasibility of tracer mixing by lateral advection and eddy mixing in a basin-sized oceanic gyre by solving the advection diffusion reaction equation numerically in two dimensions (similar to Richards *et al*, 1995, but incorporating reactivity, Fig. 1). For Be, strong cross-streamline diffusion is required to achieve homogenisation of the interior ^{10}Be with the margin-sourced ^{9}Be (Fig. 2a,b). This is favoured by long scavenging residence times τ, which is the case in both thermocline waters and deep waters. For Pb, all of which is margin-sourced, isotopic homogenisation is favoured by high streamline velocities (Peclet Numbers) in the gyre and τ of at least 20 y. This is the case in thermocline waters (Fig. 2c,d).

If short-residence time tracers are dispersed efficiently within an entire ocean basin important implications for the use of these isotopes in palaeoceanography are: 1) sites of tracer input (e.g. dust) might not necessarily correlate spatially with the distribution of such input in either seawater or marine sediments; 2) basin-wide responses might arise from relatively local changes in the provenance of isotopes, and need not necessarily result from global climatic changes, or variations in the deep thermohaline circulation.

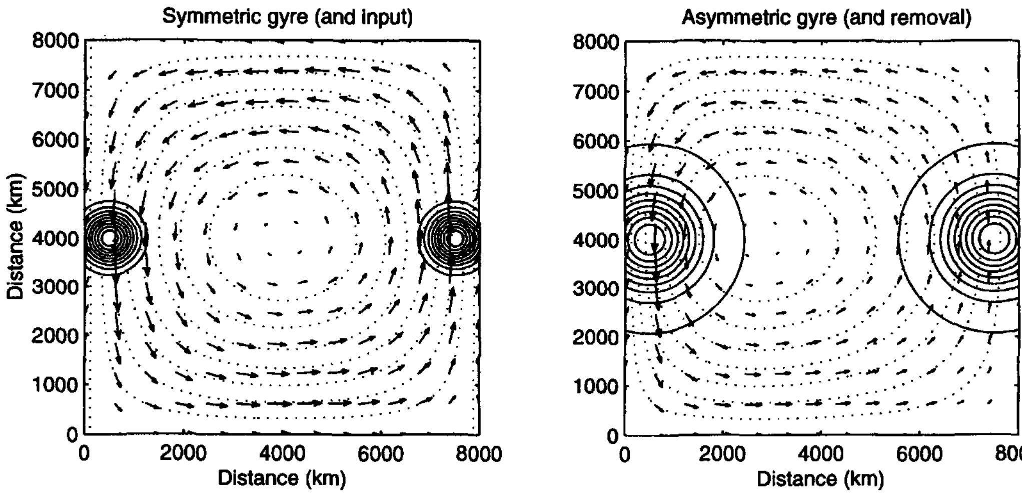

FIG. 1. Setup of model. Streamlines (dotted) and relative velocities (arrows) of symmetric gyre (left) and a gyre with strong western boundary intensification (right). Left figure also shows input of continent-sourced tracers, right figure shows zones of enhanced boundary scavenging.

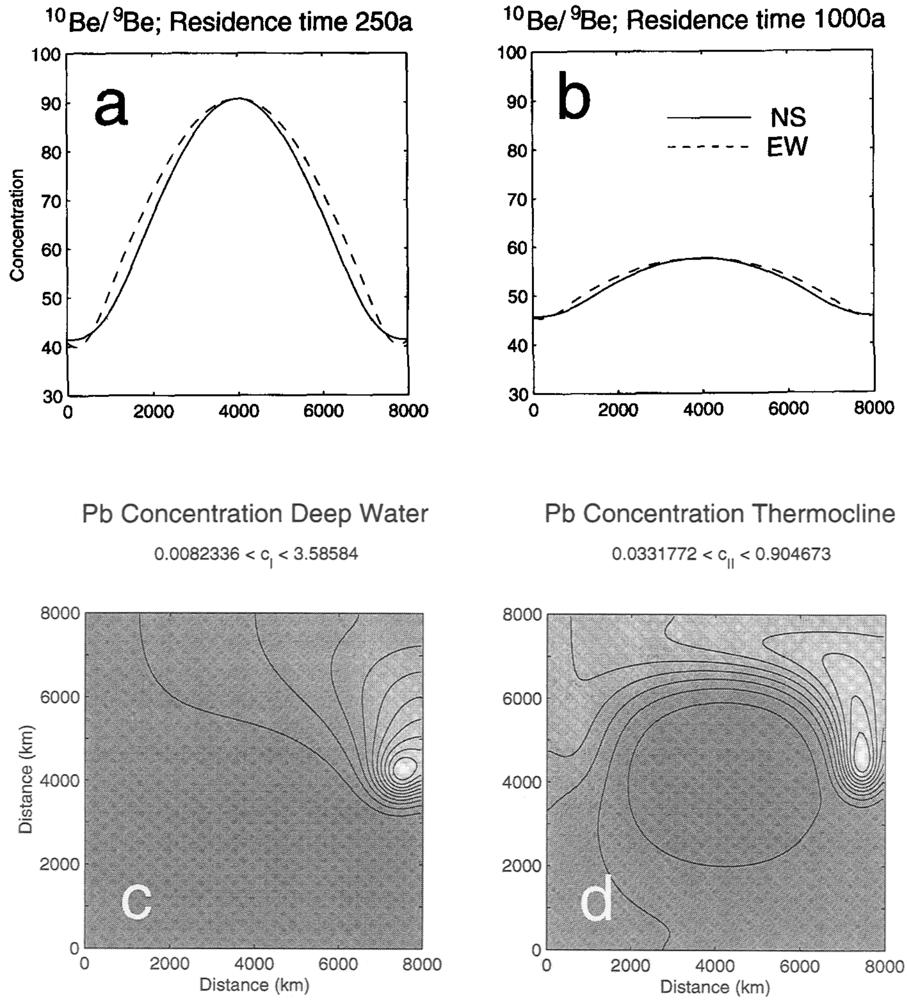

FIG. 2. (a) NS and EW cross sections through gyre showing steady state $^{10}Be/^{9}Be$ ratios. The open ocean residence time is 250 a. (b) Same conditions, but the longer residence time of 1000 y results in strong smoothing of $^{10}Be/^{9}Be$ ratios. The mean water velocity is 3.2cm/sec, the eddy mixing coefficient is 5×10^6 cm^2s^{-1}. c) Dispersion of Pb from a continental source by deep water (Mean velocity is 0.15 $cm.sec^{-1}$, the open ocean residence time is 80 a, numbers give conc ranges. d) Dispersion of Pb from a continental source by deep water (Mean velocity is 3.2 $cm.sec^{-1}$, the open ocean residence time is 20 a).

References

Richards, K.J., Jia, Y. and Rogers, C.F. (1995) *J. Phys. Oceanogr.*, **25**, 873–87.

von Blanckenburg, F. *et al.* (1996*a*) *Earth Planet. Sci. Lett.*, **141**, 213–26.

von Blanckenburg, F., O'Nions, R.K. and Hein, J.R. (1996*b*) *Geochim. Cosmochim. Acta*, **60**, 4957–64.