The changing oceans

Extended abstract

Eric Olausson
Department of Marine Geology
Box 7064 S-402 32 Göteborg
Sweden

If the chemical composition of sea water should remain constant for a certain time, it is necessary that the supply of most elements from weathering on land be equal to their withdrawal from sea water. The land area drained to the Atlantic is nearly twice as large as that drained into the Indian Ocean and the Pacific together. Therefore, the Atlantic, particularly the North Atlantic, receives much more weathered products from rivers than the other oceans do. However, dissolution combined with water exchanges between the oceans more or less smooth out the differences caused by the present drainage pattern, both in the chemical composition of the sea water, and in the accumulation rates of each element. A kind of equilibrium will be reached during times of stable climates. A climatic change disturbs this "equilibrium". A new "equilibrium" is approached or will be established (e.g. during a glacial age) when a new climate has been stabilized.

The *present* pattern has prevailed for about the last 8,000 years. The abyssal flow starts in the North Atlantic, a recooling occurs along the perimeter of the Antarctic continent, and the flows end by upwelling in the Indo-Pacific Oceans (see textbooks).

The author's research on Pleistocene deep-sea sediments from all oceans has led to the following conclusions (see also Olausson 1969, 1985):

The *glacial* pattern is characterized by an enlarged sink-water forming area in the North Atlantic and an intensified thermohaline circulation there due to increase in salinity and the cooling over the northernmost Atlantic-Arctic Oceans. As a consequence of these changes there was

— increased outflow from the Atlantic,
— increased upwelling in the Indo-Pacific Oceans,
— increased burial of $CaCO_3$ and organic matter there,
— decreased concentration of C and P in the sea water, and
— decreased P_{CO_2} in the atmosphere.

During the *deglacial* maximum (the transition time between the glacial and the present) the North Atlantic received large amounts of meltwater and the temperature rose. Both processes reduced the density of the surface water there. A kind of quasi-stagnation occurred resulting in

— diminished sink-water formation in the North Atlantic,
— decreased dissolution and oxidation at the floor of the North Atlantic ("preservation spike"),
— decreased concentration of Ca, Si, N, P,

etc. in the outflowing deep and bottom water,
— decreased upwelling in the Indo-Pacific Oceans,
— decreased burial of $CaCO_3$ and organic matter,
— gradually increased concentration of e.g. CO_2 in the deep water, and
— increased content of CO_2 in the atmosphere.

The excess carbonate accumulation during the last glacial epoch (25–15,000 BP) is calculated to have been about 1.5×10^{17} moles which corresponds to a reduction of ΣCO_2 by 5% and a drop in the atmospheric CO_2 pressure by some 50 ppm (Olausson, 1985). This excess precipitation was compensated for by the deglacial quasi-stagnation.

REFERENCES

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