Sm-Nd isotopic changes in sediments from the upper continental slope off southeastern Canada vs Laurentide Ice Sheet meltwater routing

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The influx rate and routing of Laurentide Ice Sheet (LIS) meltwaters exerted a tight control over North Atlantic thermohaline circulation during the last ice age and deglaciation. Sm-Nd isotopic analyses along NW North Atlantic margins can provide important information about the source of sediment supplies, thus about meltwater routes. Recent studies have shown that isotopic changes in sediments from the upper rise primarily record changes in the intensity of the deep Western Boundary UnderCurrent (WBUC). The present study show that on the upper slope, off SE Canada, they vary as a function of sedimentary fluxes from the continent and thus reflect changes in the routing and influx of glacial meltwater. The study core was raised from a depth of 1400 m, near the outlet of the Laurentian Trough into the North Atlantic, in an area influenced by the Labrador Current. The upper 1600 cm span the Last Glacial Maximum (LGM)-present interval. AMS-^{14}C measurements, benchmark layers and oxygen isotope stratigraphy indicate a major change in sedimentation rates during the early Holocene, from a late glacial rate of ~100 cm/yr to a post-glacial rate of ~38 cm/ka. εNd values range from about –10 to –20. The least radiogenic signatures (-10 to –11) characterize the LGM sediment. The overlying layer spanning the deglaciation (from ca. 16 until 9-8 ka BP) yield εNd values between –12 and –13, whereas in the upper ~ 350 cm of sediment (9-8 ka BP-Present), they range from –15 to –20. A thin layer rich in detrital carbonates and lithic fragments, assigned to Heinrich-event 1, separates the LGM vs. deglacial units. It shows a very low εNd value (-18.2). We attribute the major changes in sedimentation rates and εNd values at ca. 9-8 ka BP to a drastic reduction in meltwater flux and sedimentary supply from the SE margin of the LIS through the St. Lawrence Gulf. This is consistent with the opening of Hudson Bay, dated at 8.2 ka BP. The rerouting of meltwaters, from the Gulf of St. Lawrence to the Hudson Strait, resulted in a relative increase of low εNd sediments from Precambrian shield rocks carried by the Labrador Current to the study site, and a reduction in sedimentary supplies from the Paleozoic-dominated SE sector of the LIS margin. The upper rise and the upper slope sequences depict virtually opposite isotopic trends during the late deglacial period. This reflects the increased transport of younger sediment supplies from the mid-ocean ridge to the rise by the WBUC as a result of higher production of North Atlantic Deep Water.

The role of capillary pressure on the atmospheric noble-gas “excess air”

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Non-saturated zone (NSZ) of soils is defined by the coexistence of water and air above the water table. Such “suspended” water does not follow gravity and persists over air by decreasing its internal pressure below the atmospheric one, including the negative pressure domain. Mercury and Tardy (2001) have recently calculated thermodynamic properties of water in the stretched domain, to assess the consequences of the stretched water state upon the geochemical equilibria, within NSZ (Mercury et al., 2003). Particularly, it is predicted an increasing capability of the capillary water to dissolve noble gases.

Noble gases can be used as paleoclimatic proxies. It is assumed that atmospheric noble gases (ANG) are dissolved at the water table within the recharge area of aquifers, and their concentration is dependent of the air temperature during recharge. For waters of known age, we can obtain temperatures at the time of recharge from their measured concentrations. Often, noble gas concentrations in groundwater exceed those predicted by solubility equilibrium with the atmosphere, producing an “excess air” (Aeschbach-Hertig et al., 2000). One potential cause of the “excess air”, often ignored or oversimplified in previous ANG studies, is the capillary pressure of water. The role of the capillary pressure of the solvent is here assessed using the dataset obtained by Stute et al. (1995) on the San Juan Basin groundwater, New Mexico. Paleocapillary pressures, paleotemperatures and “excess air” are simultaneously regressed to adjust the calculated dissolved ANG (using thermodynamic data from Shock et al, 1989) to the measured ones. Results fit well the measured dataset, and show that capillary pressure is generally close to, but not equal, 1 bar. This means that recharge of noble gases does not take place at the water table but at the top (or close to the top) of the capillary fringe, well-known to be very irregular and variable in some extent with the water level. Dissolution of noble gases may be a NSZ process, where simultaneous air entrapment can occur, facilitating the formation of “high” amount of excess air.

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