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Magnetic fingerprint of climatic changes in the Atlantic ocean

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Magnetic properties of sediments were first used to reconstruct past climatic changes mainly from continental sections (loess, lakes). The oceanic realm, known as a « slow » actor of climate changes, was largely neglected from a magnetic point of view. However, twenty years ago, the discovery of high amplitude abrupt variations of the glacial air temperature over Greenland led to wonder whether the deep ocean had participated or not to these variations. Our studies on marine sediments started at that time and indeed showed that the deep ocean actively participated to past climatic changes at different time scales.
Here I'll present a review of the results we obtained from the subpolar North Atlantic, a critical region where the different overflow deep waters formed in the Nordic seas circulate and joined to form the North Atlantic Deep Water (NADW), the major component of the thermohaline circulation. Any change in the activity of these waters may have consequences on global climate. Our magnetic investigations first focused on the reconstruction of glacial changes in the NADW intensity and were pursued on the Holocene period, climatically more stable. These studies required high sedimentation rate sediments collected thanks to the unique corers of the R.V. Marion Dufresne. In our laboratory, the co-development with 2G-Enterprises of a new generation of cryogenic magnetometers allowed us to rapidly "scan" the main magnetic properties of continuous sequences and to select strategic horizons for higher resolution analyses.
For glacial time, a continuous dynamic record of the intensity of the overturning circulation could be proposed for the first time. This "drift deposit" record is remarkably similar to that of air temperature changes over Greenland showing a close relationship between atmospheric and deep ocean changes. It indicates that the deep ocean could vary very rapidly. During the coldest events, the deep circulation was not entirely shutdown and the Nordic seas were still participating to the formation of deep/intermediate waters. Using magnetic-assisted stratigraphy for long-distance correlation, we compared our results with geochemical records of deep circulation from the southern ocean. A quantification of the time needed for an event to propagate from north to south was proposed. Finally, the compilation of results obtained from the northern and southern Hemisphere showed a glacial seesaw mechanism in the intensity of the main deep water masses during glacial time.
Holocene records were obtained from several cores distributed along one of the subpolar North Atlantic drift. I'll show how consistent they are with one another and how they document three phases of deep-water activity on which shorter term variations are superimposed. An early Holocene shutdown/shoaling of the bottom circulation at the deepest sites, most likely related to the main deglacial freshwater inputs, was followed by a progressive strengthening of the overflow water culminating around 6 kyr BP during the Holocene thermal maximum. A general decline in the overflow water was then observed until about 2 kyr B.P. when a steady state was reached.
By this review we'll emphasize the potential of magnetic studies in paleoclimatic reconstructions.