INTER-TRACE (FCOMP-01-0124-FEDER-007113)

Rapid changes in interglacial surface and deep-water properties in the North Atlantic: temperature, nutrient and density variability derived from trace element analyses

Principal investigator: Antje Voelker

Laboratory: Geology and Paleoceanography

Collaboration: Prof. Anne de Vernal and Prof. Claude Hillaire-Marcel, GEOTOP, UQAM, Canada; Prof. P. Martin, Dept. of the Geophysical Sciences, Univ. of Chicago, USA

Financing institution: FCT

Lab website: http://www.lneg.pt/iedt/?unidade=17764

Abstract:

This study aims to reconstruct the high-frequency variability during glacial (cold) and interglacial (warm) climate period in the interval from Marine Isotope Stage (MIS) 9 to 16, that is the period from 300 000 to 630 000 years ago. This interval includes four interglacial periods, MIS 9e, 11c, 13a, and 15e, which are being studied in high-resolution to better understand interglacial climate variability and thus to obtain insights into how our climate might change in the future (excluding human influences). On the other hand, the periods leading from the interglacials to the subsequent glacial maxima, will allow us to better understand abrupt climate change events.

At the three mid-latitude sites (IODP Site U1313; MD01-2446; MD03-2699), conditions in the surface waters are being reconstructed using trace element ratios (e.g., Mg/Ca for temperature; Cd/Ca and Ba/Ca for nutrient concentration) analyzed in the carbonate shells of planktonic foraminifer species such as *Globigerina bulloides* (Fig. 2), *Globigerinoides ruber* and *Globorotalia inflata* (Fig. 3). At the northern location of IODP Site U1305, on the other hand, we are using the percentage of the polar foraminifer species *Neogloboquadrina pachyderma* (s) as indicator for temperature changes. At all sites, the lithic fragment concentration records reveal the presence of melting icebergs and maxima were related to major ice-rafting events, similar to the Heinrich events of the last glacial cycle.

Ice-rafting events led to cooling in the surface and thermocline waters as revealed in the records of IODP Site U1313 and core MD03-2699 (Fig. 4). In general, thermocline waters cooled more in the northwestern Atlantic at IODP Site U1313, located closer to the continental ice shield in North America, than off Portugal at site MD03-2699. In addition, the Portuguese margin experienced much less variability in thermocline temperatures than the open ocean (Fig. 4) hinting to a stronger influence of subtropical North Atlantic Central Water off Portugal. During interglacial stage 11c (blue bar in Fig. 4), however, thermocline temperatures were not much

different at the two locations and at both sites thermocline temperatures started to decline prior to the end of the interglacial. Thermocline nutrient levels were generally higher in the open ocean (Fig. 4 bottom panel). Upcoming results from site MD01-2466 (Fig. 1) will show if the pattern observed at IODP Site U1313 also applies to the offshore waters off Portugal.

In addition to surface water records, we also generated benthic foraminifer trace element records at site MD03-2699. This site, retrieved from 1985 m water depth, is nowadays bathed by North Atlantic Deep Water (NADW). The bottom water temperature record of this core –based on benthic foraminifer Mg/Ca data–, however, revealed that there were times when bottom water temperatures were warmer than today and in the range of the modern Mediterranean Outflow Water (MOW). Thus this intermediate-depth site recorded changes in the depth of the NADW/ MOW interface with NADW prevailing during warm climate phases (interglacials, interstadials) with an overturning circulation similar to today while MOW –flowing deeper in the water column than today– was present during cold climate periods, namely the glacials and the stadial events, the cold periods of abrupt climate events.

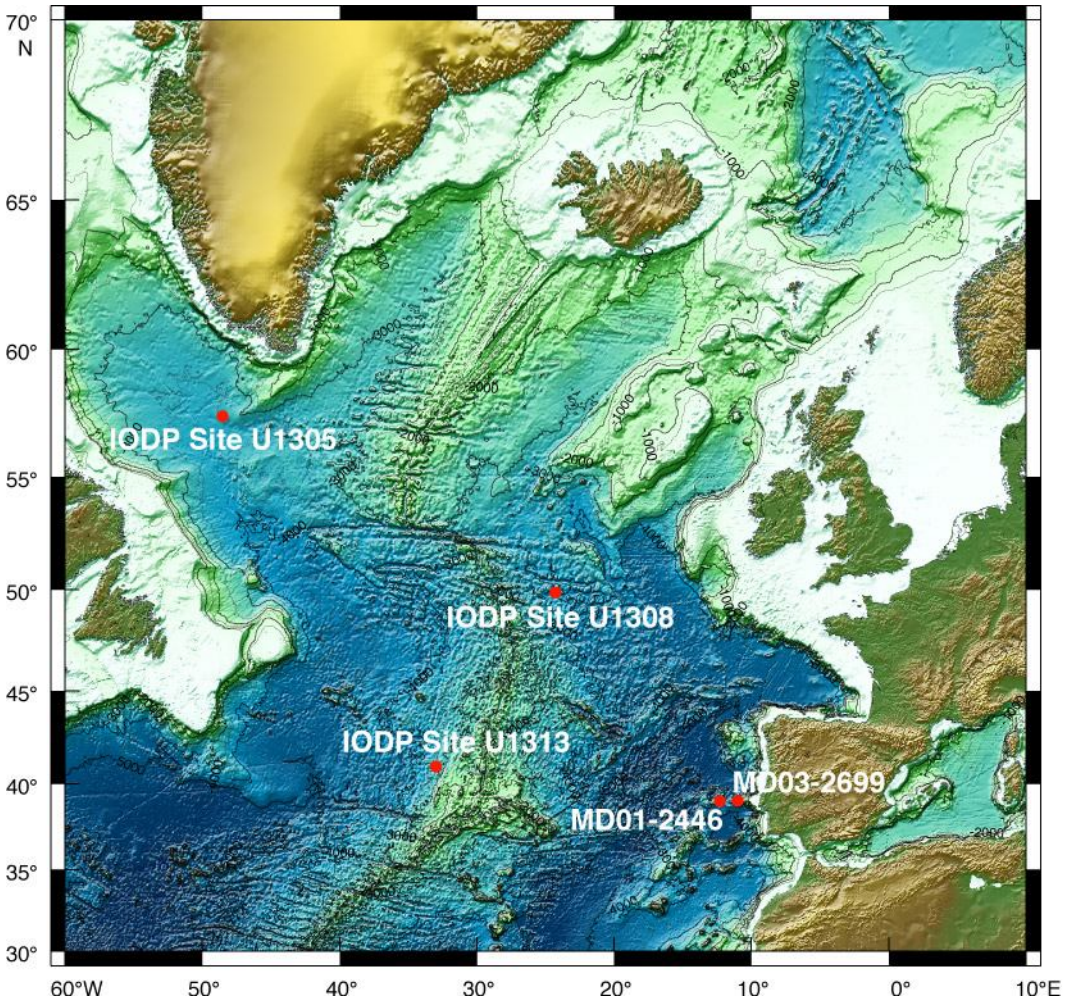

Fig. 1: Map of the North Atlantic showing the core sites being studied within the project.

Fig. 2: Photo of the surface-dwelling planktonic foraminifer species *Globigerina bulloides* that is abundant in the upwelling region of the Portuguese margin. (Courtesy of IODP Exp. 306).

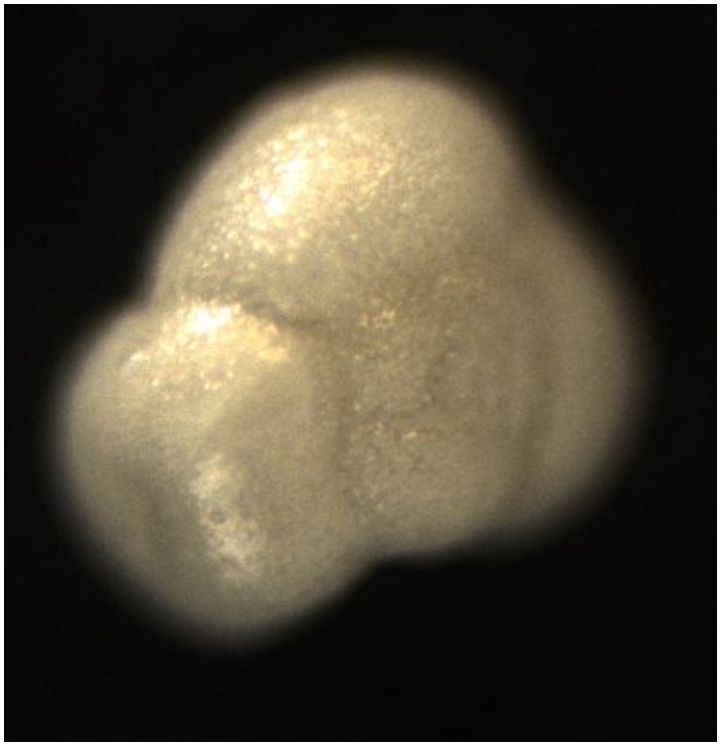

Fig. 3: Photo of the thermocline-dwelling species *Globorotalia inflata,* shells of which were used to generate the proxy records in Fig. 4. (Courtesy of IODP Exp. 306).

Thermocline Temperature and Nutrient Concentration Changes

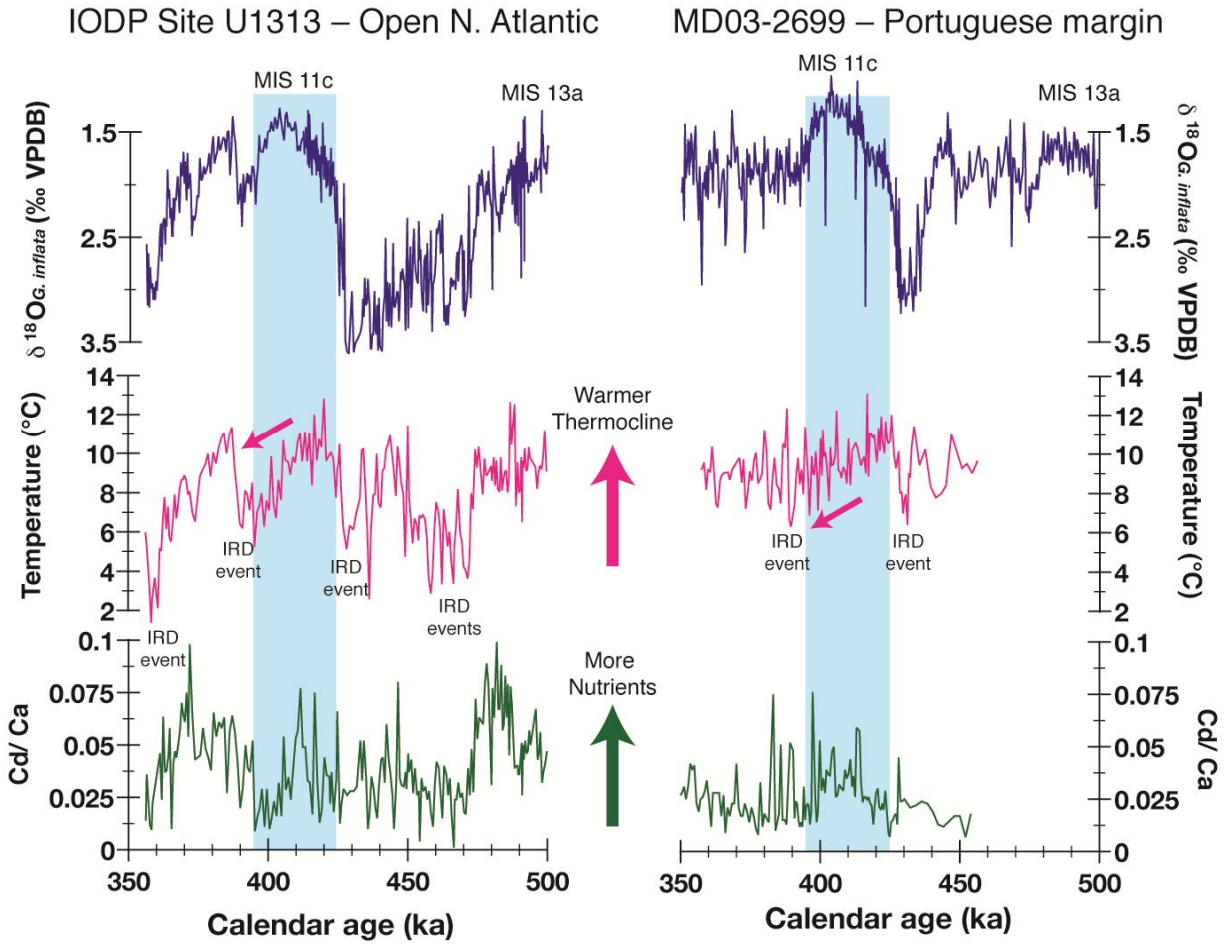

Fig. 4: Proxy records for thermocline conditions at open ocean IODP Site U1313 (Voelker et al., in prep.; Fig. 1) and at site MD03-2699 (Salgueiro et al., in prep.) from the Estremadura promontory in the Portuguese eastern boundary upwelling system. The blue bar highlights interglacial stage 11c that is seen as being comparable to the Holocene, the climate period we are living in.