Southern Hemisphere influences on the stability of the global thermocline: The radiocarbon record of abrupt change in the ocean's interior

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***Abstract*- The stability of the ocean's global thermohaline circulation looms as one of the most prominent sources of uncertainty in any projection of future climate change: The deep sea sedimentary record of the Pleistocene demonstrates that the ocean had the capacity to undergo dramatic and abrupt changes in state. The use of radiocarbon may allow the reconstruction of ocean ventilation processes over the periods of abrupt change in the late Pleistocene.**

I. INTRODUCTION

Among the most prominent sources of uncertainty regarding the future development of climate is the stability of the ocean's global thermohaline circulation. The deep sea sedimentary record provides many examples of dramatic and abrupt changes in conditions, and a variety of evidence shows that the ocean was somehow involved in the global climate changes that punctuated the late Pleistocene epoch. Yet resolution of the actual mechanisms that promoted an unstable thermohaline circulation during the Pleistocene is prerequisite for assessing whether past "catastrophies" are at all relevant for explaining present climate change and for predicting the future. Thus far, attempts to constrain these mechanisms have been fraught with many uncertainties, and competing theories remain untested. Here we describe the initial results of a project to use radiocarbon as a highly diagnostic tracer of ocean ventilation processes over the "abrupt changes" of the late Pleistocene.

II. SOUTHERN VS. NORTHERN SOURCES

Basic theoretical considerations suggest that to understand why the global thermohaline circulation may have become unstable in the past – and, indirectly whether the system is close to a threshold of stability today – it is necessary to document the dynamics of the mid-depth ocean. In particular, it is essential to resolve changes in the density contrast between water sinking from opposite hemispheres. Radiocarbon offers the potential for resolving (southern vs. northern hemisphere) water mass origin and for understanding ventilation rates. In principle, it should be possible to map the distribution of radiocarbon in the mid-depth and deep ocean at various times in the past using benthic foraminifers (protists that lock in their carbonate shells a snapshot of deep ocean chemistry). In practice, the South Atlantic is perhaps the only region to describe the varying influence of southern hemisphere water masses, because it is the only place in the world's ocean where a distinct layer of Southern Ocean water (Antarctic Intermediate Water) is sandwiched between waters of North Atlantic origin.

III. FIELD WORK

In the period between March and May 2003, we conducted a sediment coring cruise on the R/V Melville with the primary purpose of collecting a suite of sediment cores from the Southwest African margin--a region where, within a limited area, the seafloor intersects all the principal watermasses involved in the thermohaline circulation of the Atlantic. We collected a detailed depth transect of cores off Namibia, intended to monitor the full dynamic range and stratal geometry of the mid-depth watermasses in the Southern Hemisphere. Using material from these cores, we will eventually be able to map changes in the distribution of radiocarbon in benthic foraminifers over specific abrupt events, to deduce the ventilation history of mid-depth water and to help delineate northern vs. southern sources. We will also be able to map changes in the benthic foraminiferal tracers for water density ($\delta^{18}O$) and temperature (Mg/Ca). The first results from this unique set of cores will be presented, with emphasis given to the records from sediments presently bathed in Antarctic Intermediate Water (700 - 1000 meters water depth).

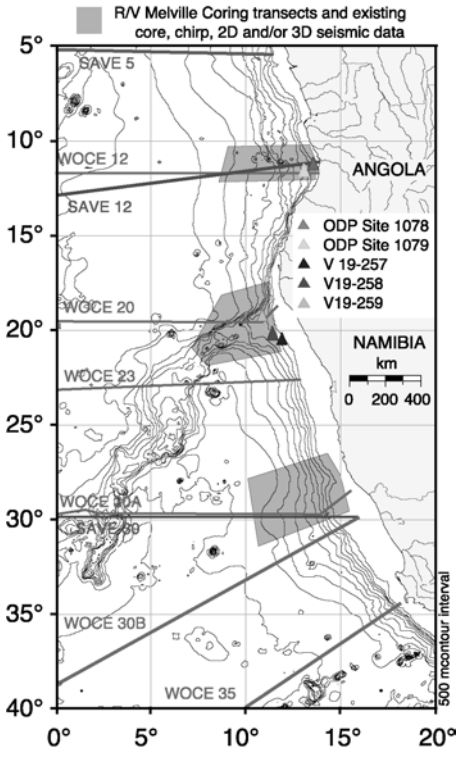

Fig. 1. Geographic setting of study area.