277

Evidence for Meltwater Pulse 1a in the Gulf of Mexico Based on Radiogenic Isotopes

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Introduction:

- Meltwater Pulse 1a (MWP-1a) is associated with a rapid sea level rise of more than 20 m in less than 500 years during the last deglaciation.
- This event was recently dated at 14.6 to 13.9 ka based on U/Th dating of Barbados corals (Mortlock et al., 2010).
- Contributions of inferred meltwater from Southern versus Northern Hemisphere ice sheets, as well as possible paths of the meltwater are still debated.
- A foraminifera-barren interval from core MD02-2550 from the anoxic Orca Basin in the Gulf of Mexico was dated at ca. 14.54-14.35 ka based on an age model using >40 AMS ^{14}C dates on *Globigerinoides ruber*. Flower et al. (2010) infers that this interval was generated by a combination of high terrigenous influx and fresh surface water conditions from meltwater that was not conducive to foraminiferal growth. They also identified peak $\delta^{18}O$ values of -5.5 ‰ during this interval.
- This value is similar to $\delta^{18}O$ data from detrital carbonate grains recovered from Heinrich Events in the North Atlantic that are believed to represent lower Paleozoic basin sediments from northeastern Canada (Hodell and Curtis, 2008).

Method:

- Twenty-four 275 mg powdered bulk sediment samples from Orca Basin core MD02-2550 in the Gulf of Mexico (Figure 1) were leached with 10 mL of 0.1N HCl.
- The remaining residue was rinsed three times with distilled water (4x H_2O) and dissolved using standard silicate digestion procedures.
- Sr, Nd and Pb isotopes were isolated from the leachates and residue fractions using standard cation exchange column procedures.
- Nd and Pb isotopes were analyzed using a Nu Plasma Inductively Coupled Plasma Mass Spectrometer (ICP-MS) and Sr isotopes were analyzed on a Sector 54 Thermal Ionization Mass Spectrometer (TIMS).

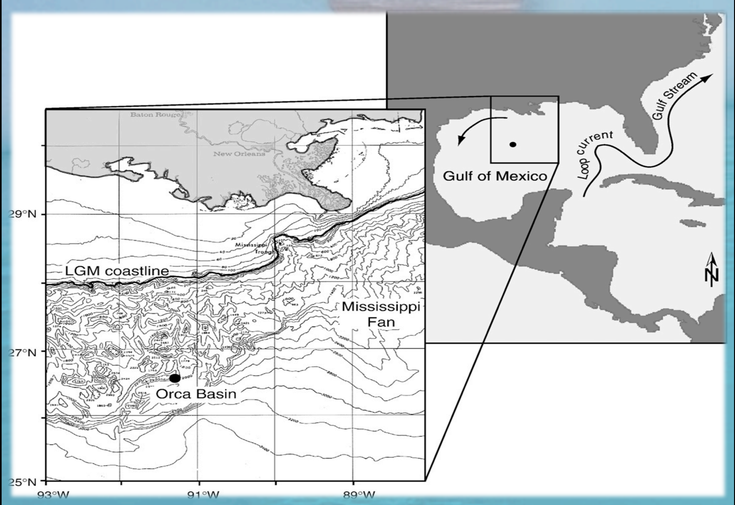

Figure 1: Map of the Gulf of Mexico showing the location of Orca Basin. Arrows indicate surface currents. Approximate location of last glacial maximum (LGM) coastline is indicated. (Taken from Meckler et al., 2008)

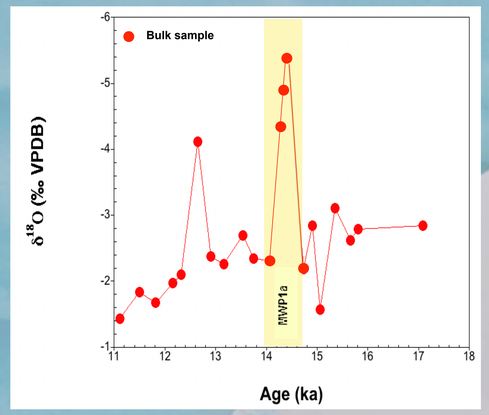

Figure 2a: Peak bulk sediment $\delta^{18}O$ values of -5.5 ‰ during the foraminifera-barren interval from core MD02-2550 (Flower et al., 2010) match $\delta^{18}O$ values reported for detrital carbonates from Heinrich Events in the North Atlantic that are believed to be sourced from the LIS (Hodell and Curtis, 2008).

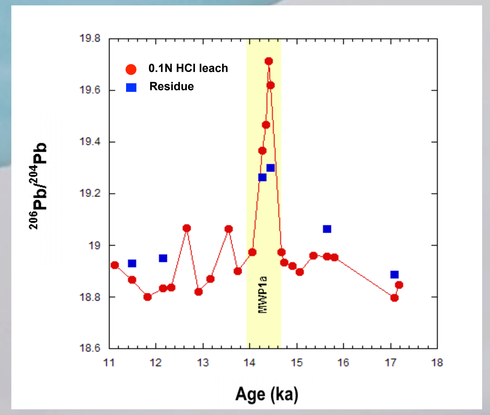

Figure 2b: $^{206}Pb/^{204}Pb$ values from 0.1N HCl leachates of bulk, powdered MD02-2550 are ~18.0 before and after the foraminifera-barren interval, and peak at values of 19.7 during this interval, coincident with the $\delta^{18}O$ minimum. There appears to be a strong seawater component as the values before and after the foraminifera-barren interval are consistent with deep water masses from Blake Ridge (Gutjahr et al, 2009), while the peak values are similar to values reported from H1 in the North Atlantic (Kurzweil et al., 2010).Detrital $^{206}Pb/^{204}Pb$ values record a similar, but smaller amplitude peak of 19.3 at the inferred MWP1a pulse.

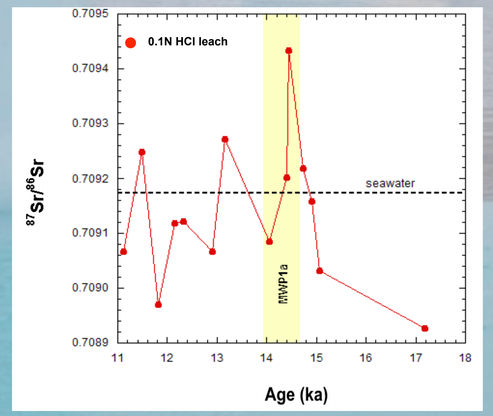

Figure 2c: Sr isotopes from the bulk sediment leachate at MD02-2550 reveal variable background values with a peak value of .70943 that coincides with the $\delta^{18}O$and $^{206}Pb/^{204}Pb$ peaks in the foraminifera-barren unit. Although there appears to be a strong seawater component, these peak values plot well above seawater values, suggesting a contribution from silicates or a change in the composition of the silicate material. Specifically, the direction of this change could reflect a shift from silicates transported down the Mississippi River to silicates derived from the LIS. Values that plot below the seawater curve suggest addition of older detrital carbonate material.

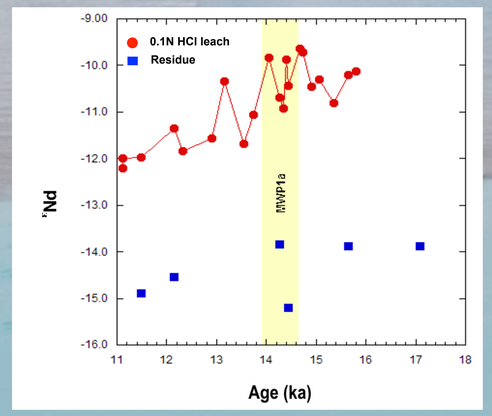

Figure 2d: Nd isotopes of the leachates do not show distinct values during the foraminifera-barren interval as observed in the Sr and Pb isotopic data. This may suggest the Sr and Pb isotopic data are strongly influenced by carbonate material that is attacked by the dilute leach, but Nd concentrations are very low in carbonates (ppb levels). However, the concentrations of Nd in our leachates suggest that the dilute acid may also be attacking oxides coatings and/or silicates. Detrital ε_{Nd} values also lack distinct values during the foraminifera-barren interval, supporting the idea that the data is strongly influenced by carbonate material. There is no apparent pattern in the data to support the idea of a shift from one source to another during MWP1a.

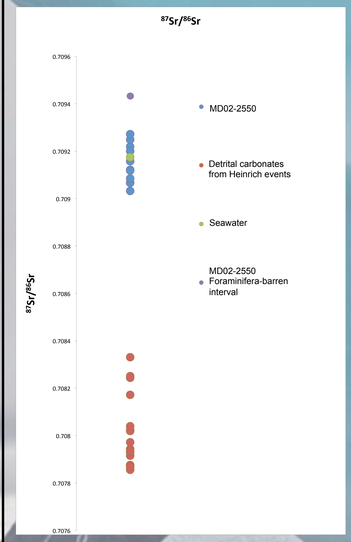

Figure 3: $^{87}Sr/^{86}Sr$ values for background and foraminifera-barren intervals from core MD02-2550, Heinrich Event detrital carbonate (Nielsen and Hodell, pers. comm.), and modern seawater. Error bars are smaller than symbols.

The MD02-2550 data plot well above Heinrich Event detrital carbonate values and close to the seawater values, suggesting the Sr leached from these samples predominately reflects local seawater carbonates that dissolved during leaching. Values slightly higher than seawater suggest the acid also attacked some of the silicates, while lower values may indicate the presence of Phanerozoic detrital carbonates that could have been transported down the Mississippi River.

Conclusions:

- Background isotopic values before and after the peak presumably represent the values typical of leachates of combined carbonate and silicate material typical of the Orca Basin, much of which presumably represents biogenic carbonates formed in local seawater and silicates derived from Mississippi River outflow.
- The peak values may be dominated by local and detrital carbonate sources as well as a component derived from leaching silicate material.
- Nd isotopic values do not record a pattern consistent with a source change. The data most likely represents oxide coatings and/or silicate values.
- Peak Pb and Sr isotopic values, which coincide with the $\delta^{18}O$ minimum values during this foraminifera-barren interval, are consistent with a LIS source.
- This study supports a contribution from the LIS to the Orca Basin during MWP-1a, suggesting that at least a portion of MWP-1a can be attributed to a Northern Hemisphere source that was transported down the Mississippi River Valley to the Gulf of Mexico.

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