



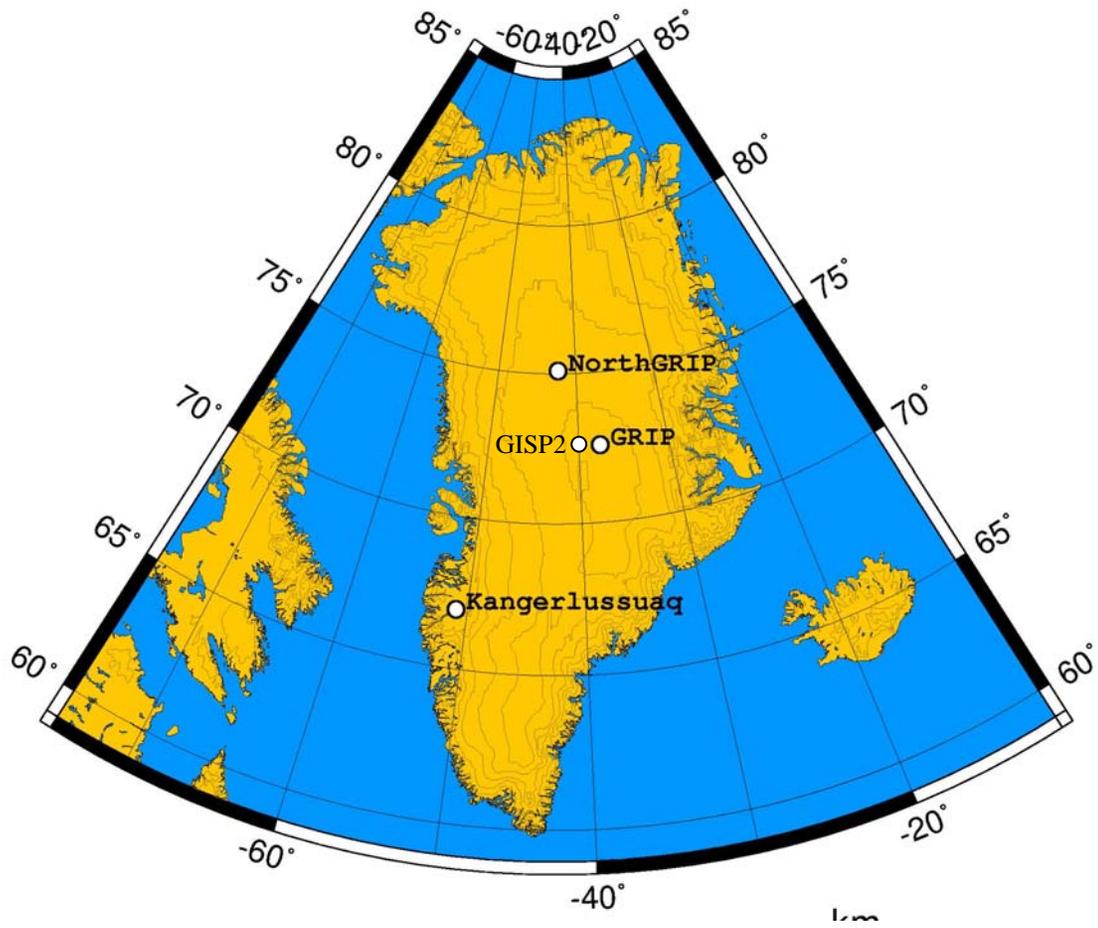
# ABRUPT CLIMATIC CHANGES AND DEEP WATER CIRCULATION IN THE NORTH ATLANTIC

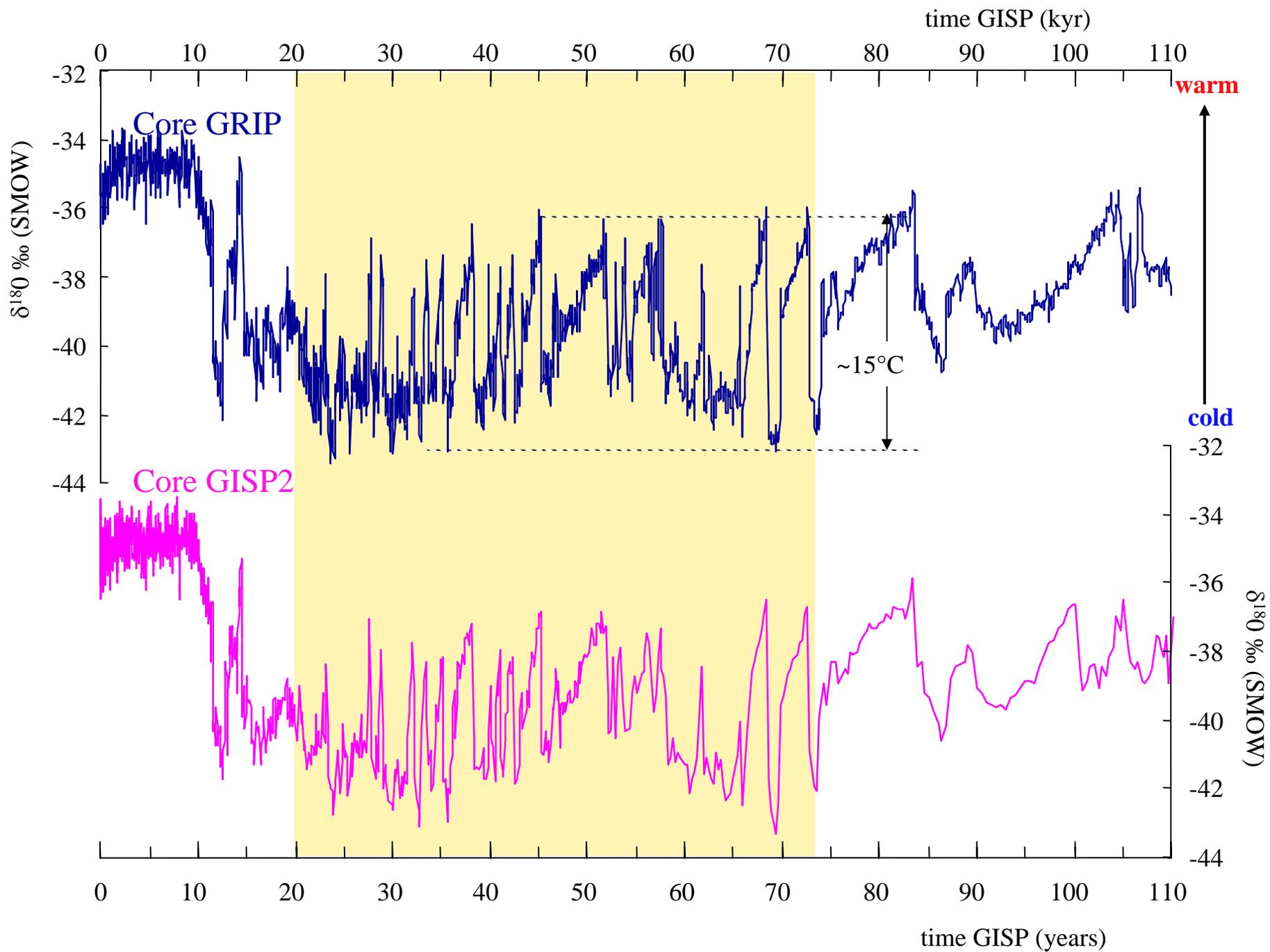
Carlo Laj and Catherine Kissel

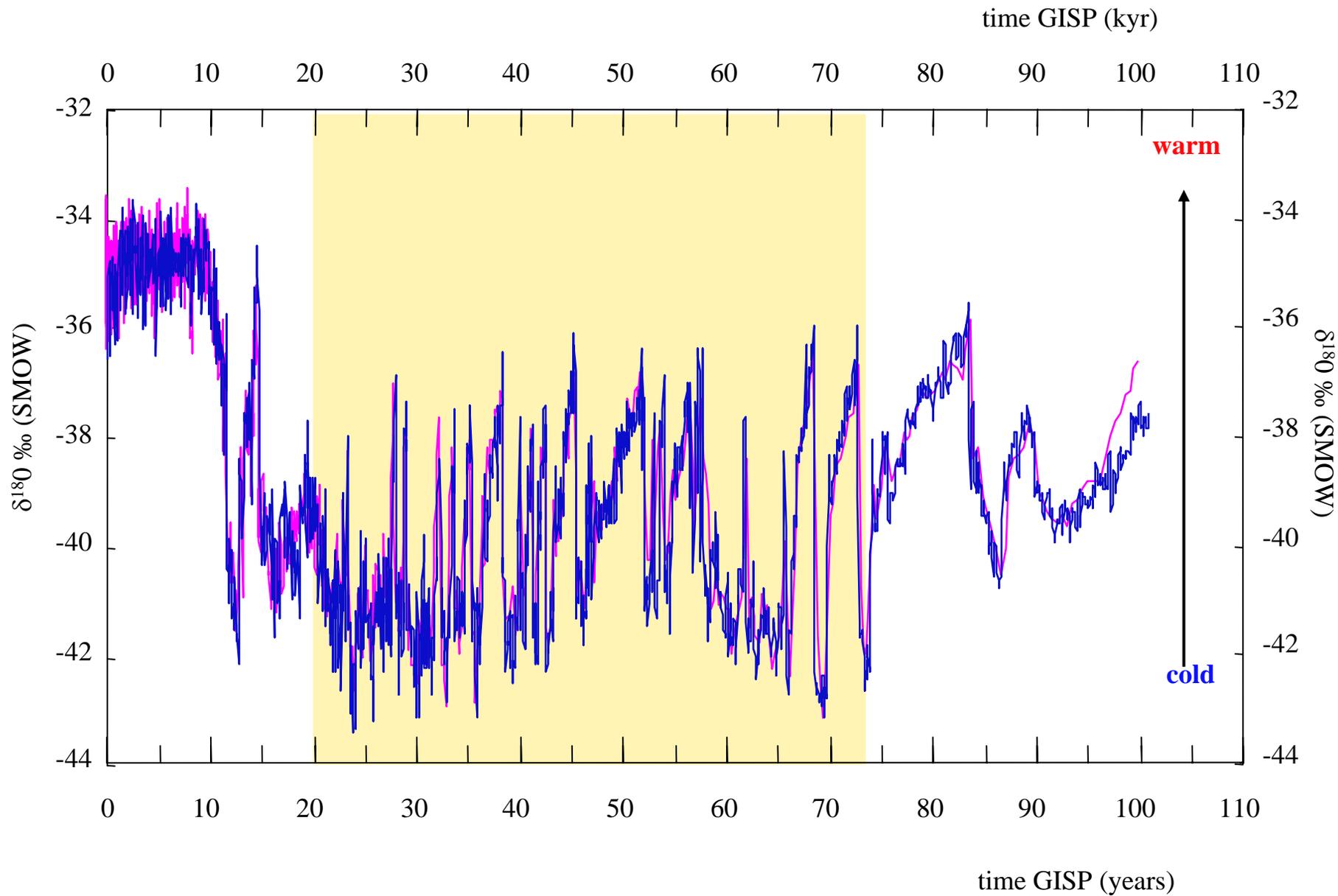
Laboratoire des Sciences du Climat et de l'Environnement  
Gif-sur-Yvette, France

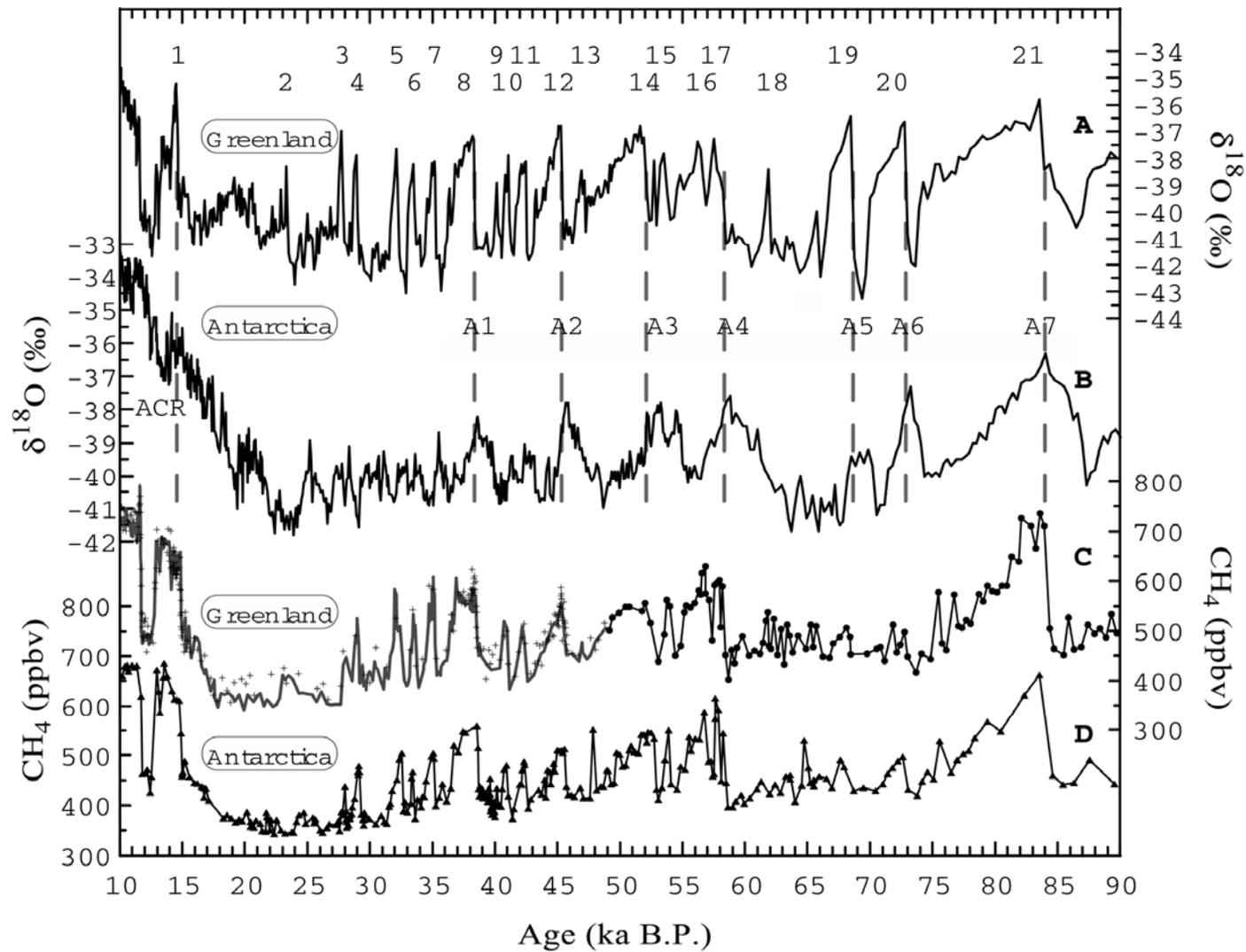
How fast did scientists realize that  
climate can change abruptly?

1950s	~	tens of thousands of years
1970s	~	thousands of years
1980s	~	hundreds of years









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climate can change abruptly?

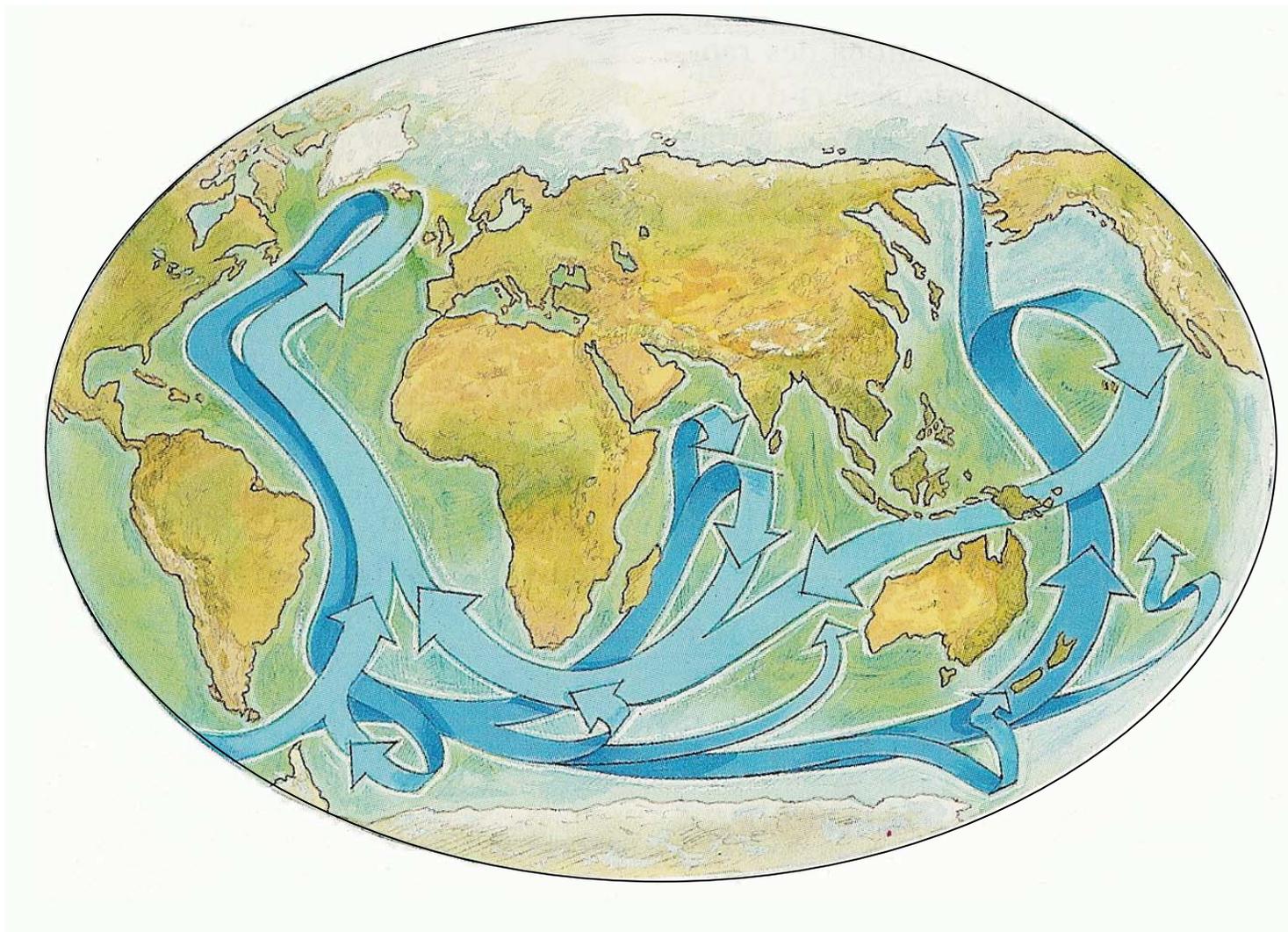
1950s ~ tens of thousands of years

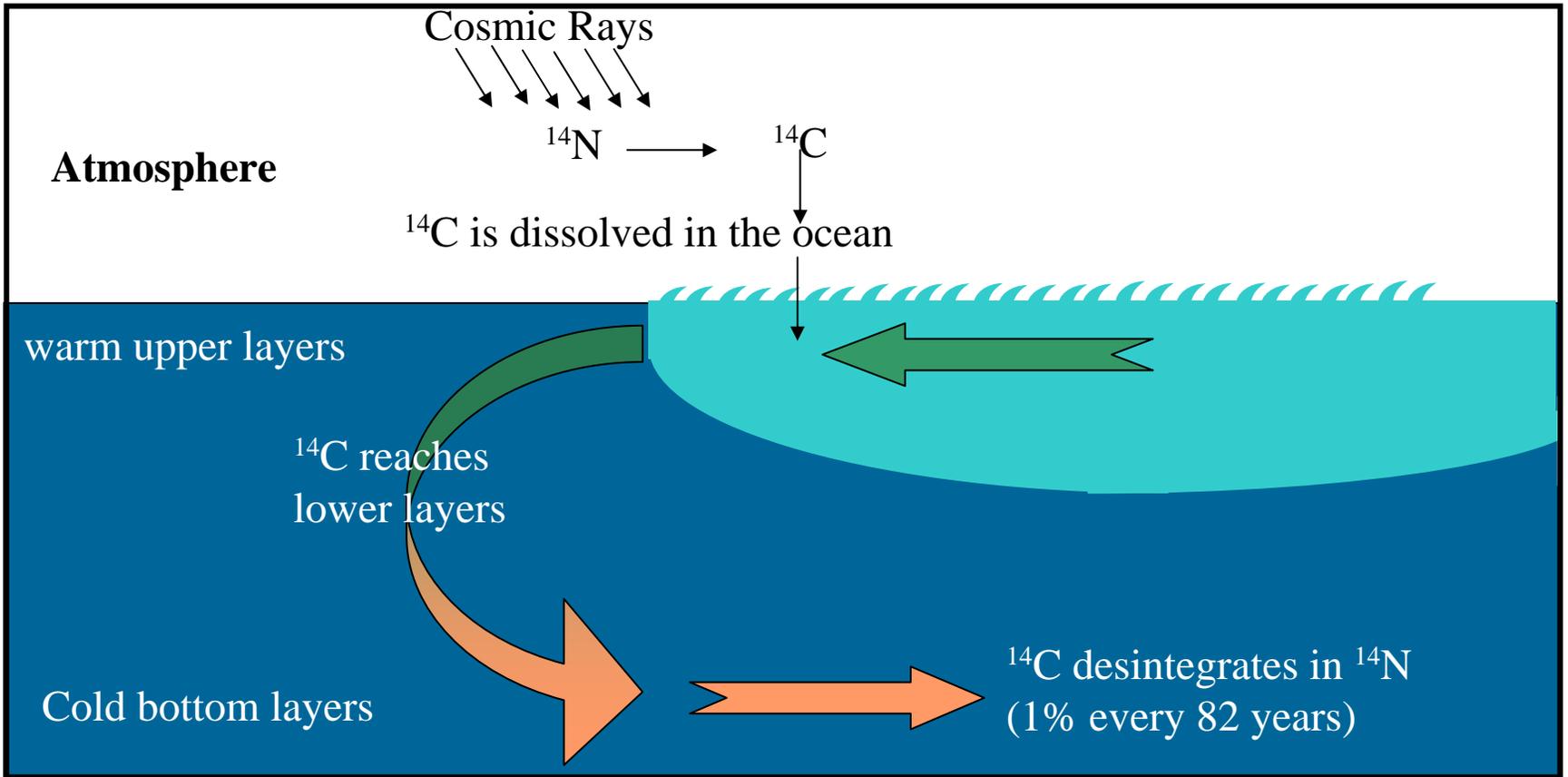
1970s ~ thousands of years

1980s ~ hundreds of years

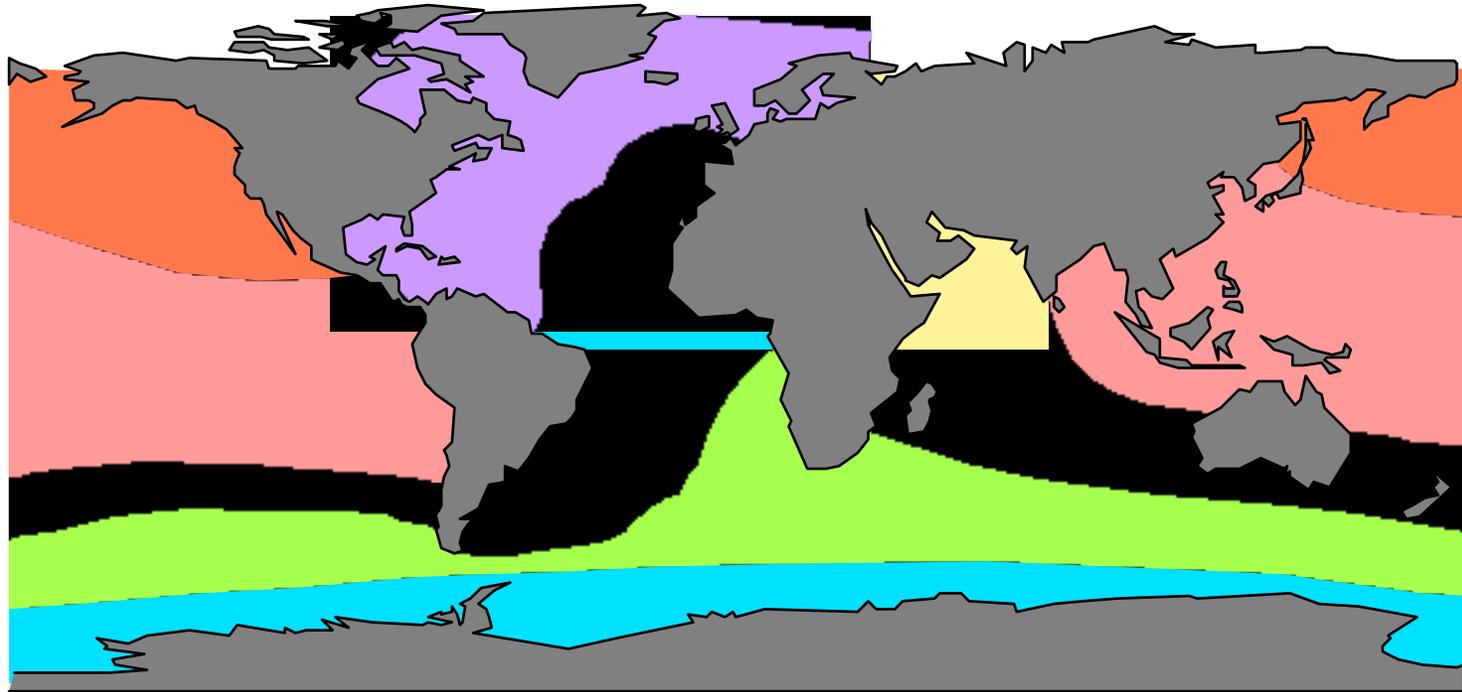
After Greenland ~ decades!!!!

# Thermohaline circulation





Age (years) of bottom waters obtained from  $^{14}\text{C}$  determinations



<250



250 to 500



500 to 1000



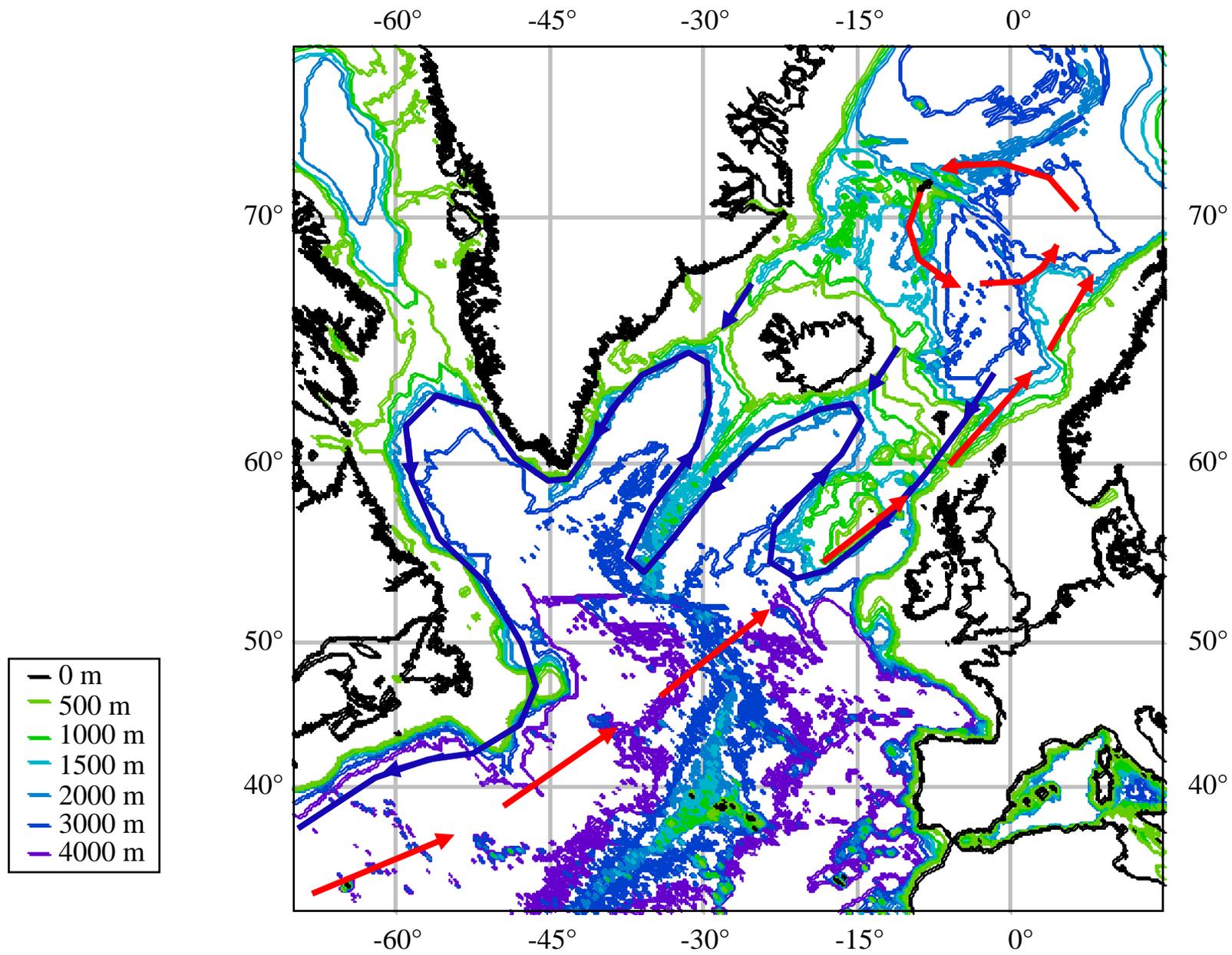
1000 to 1250



1250 to 1500



>1500



Some facts about the thermohaline circulation:

Carries twenty times more water than the combined world rivers.

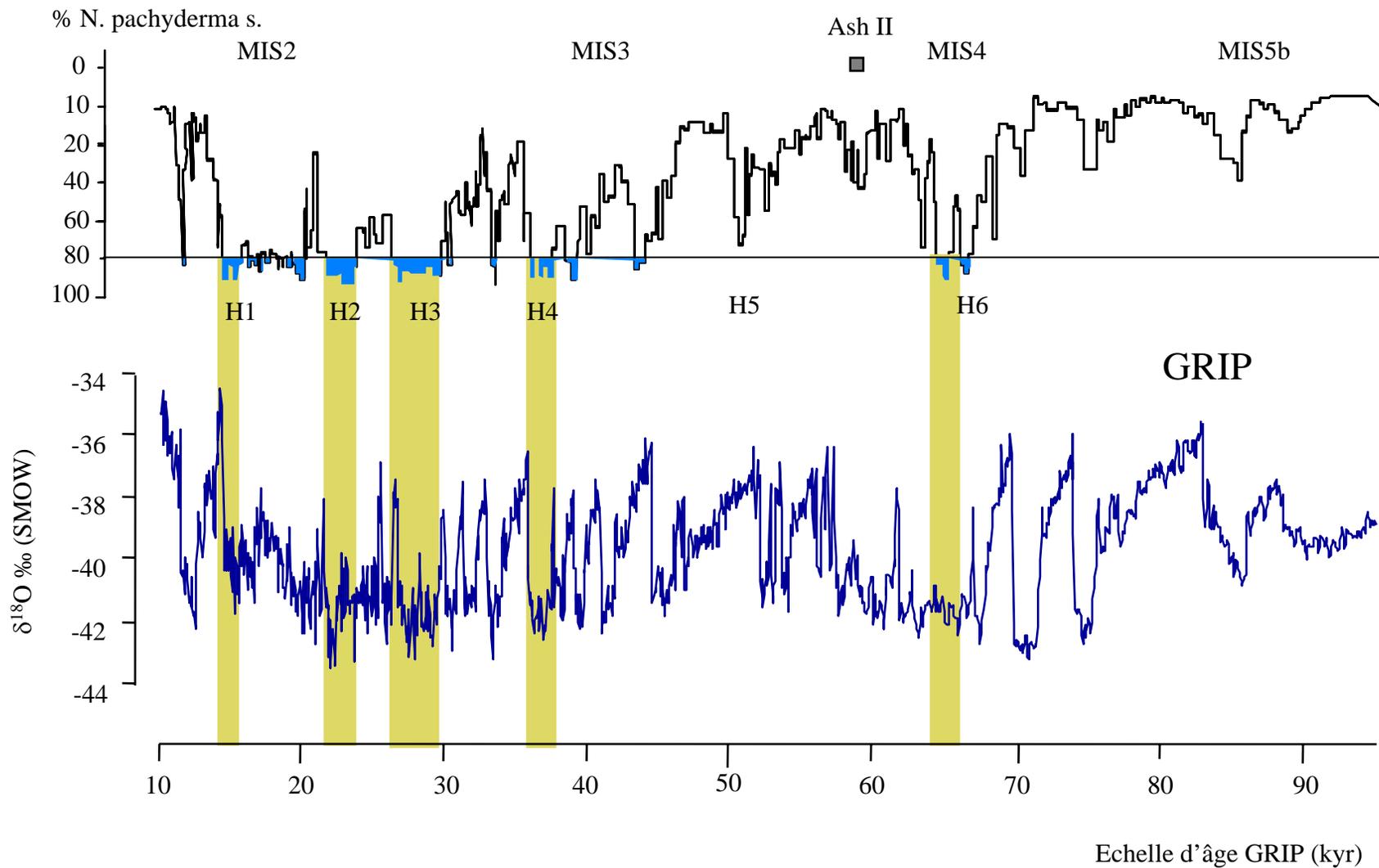
The amount of heat transferred from sea to air is about 30% of that received by the entire North Atlantic from the Sun.

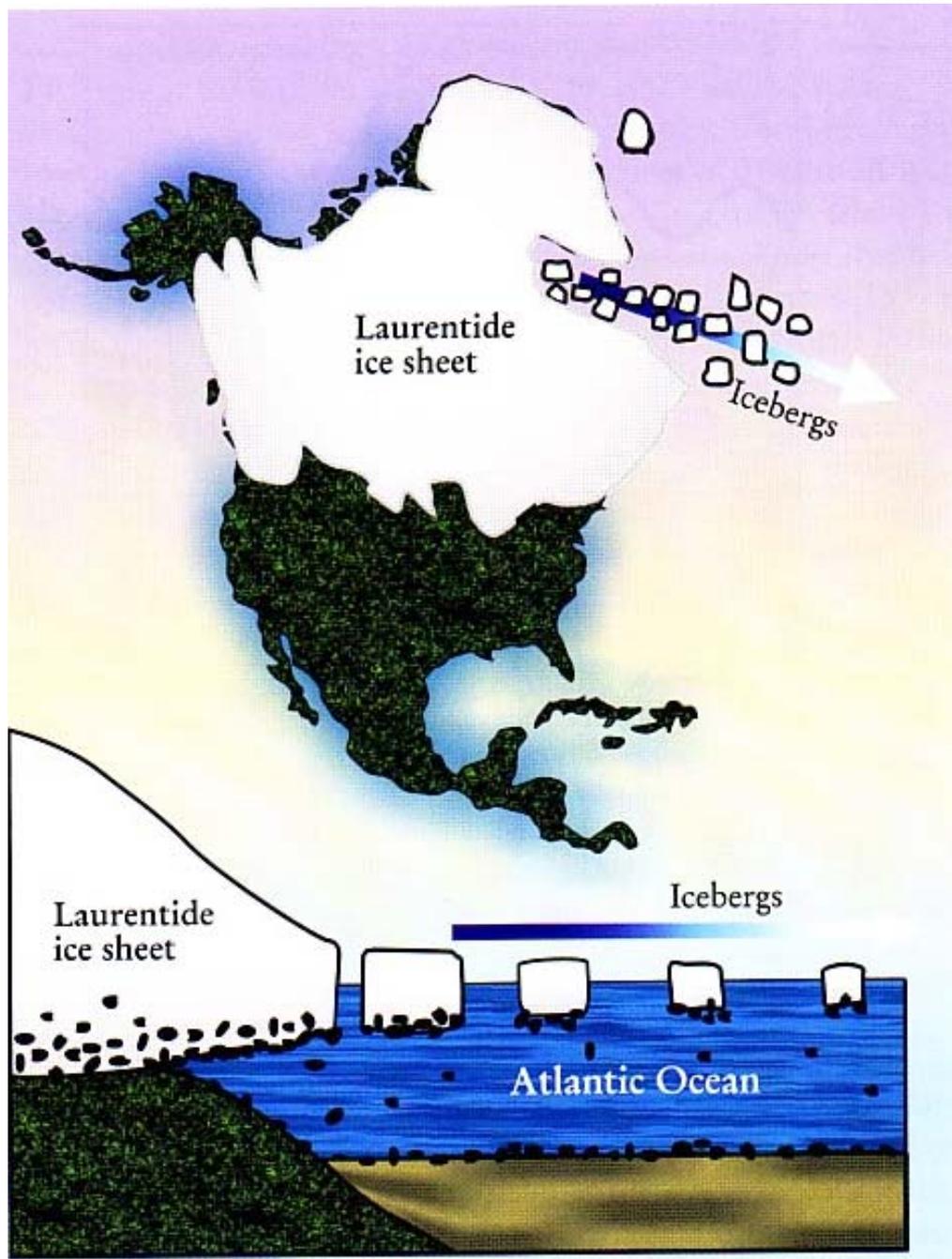
**Major climatic factor!!!!**

Question:

Did the conveyor belt change during abrupt climatic events?

# DSDP site 609

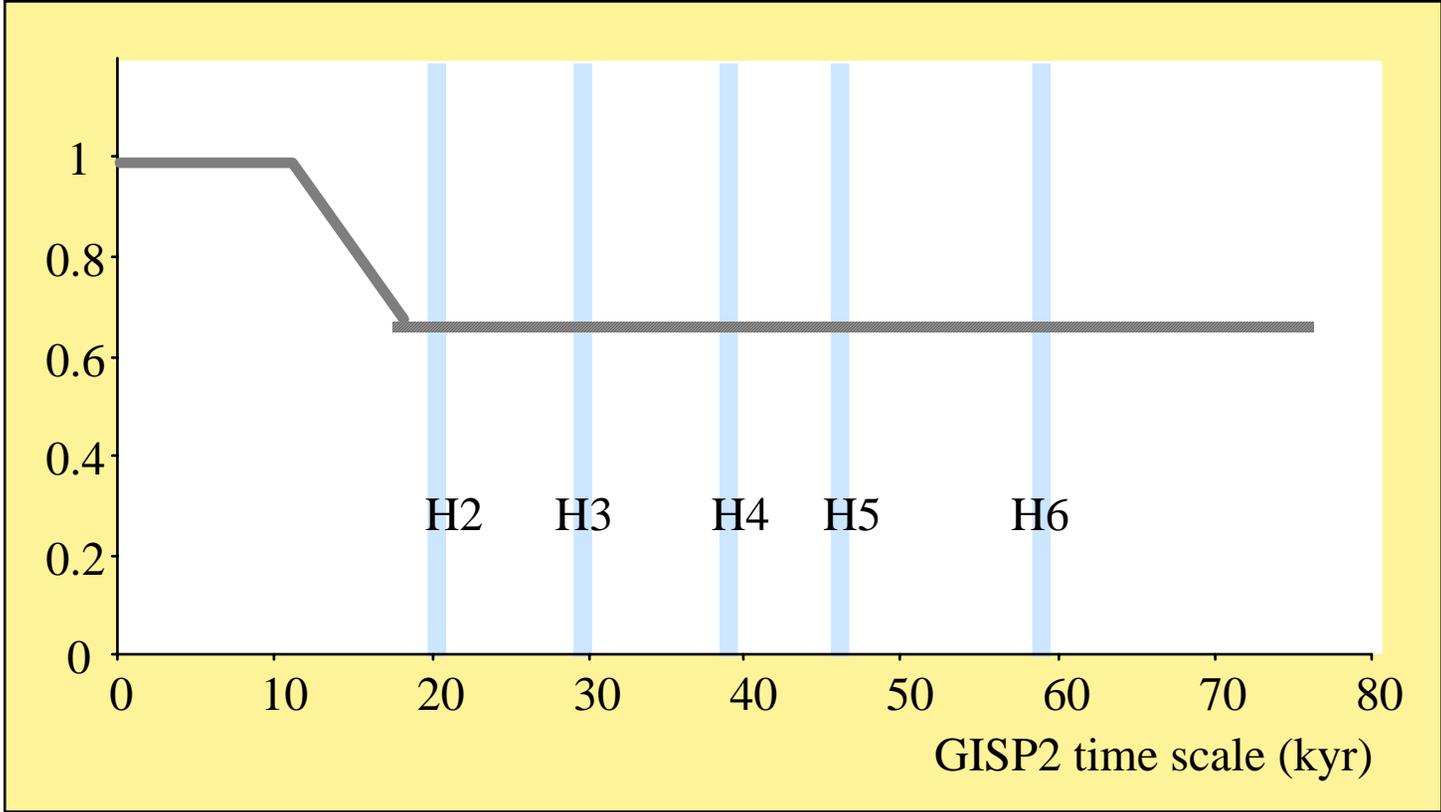




*Edouard Bard*  
*Physics Today (Dec. 2002)*

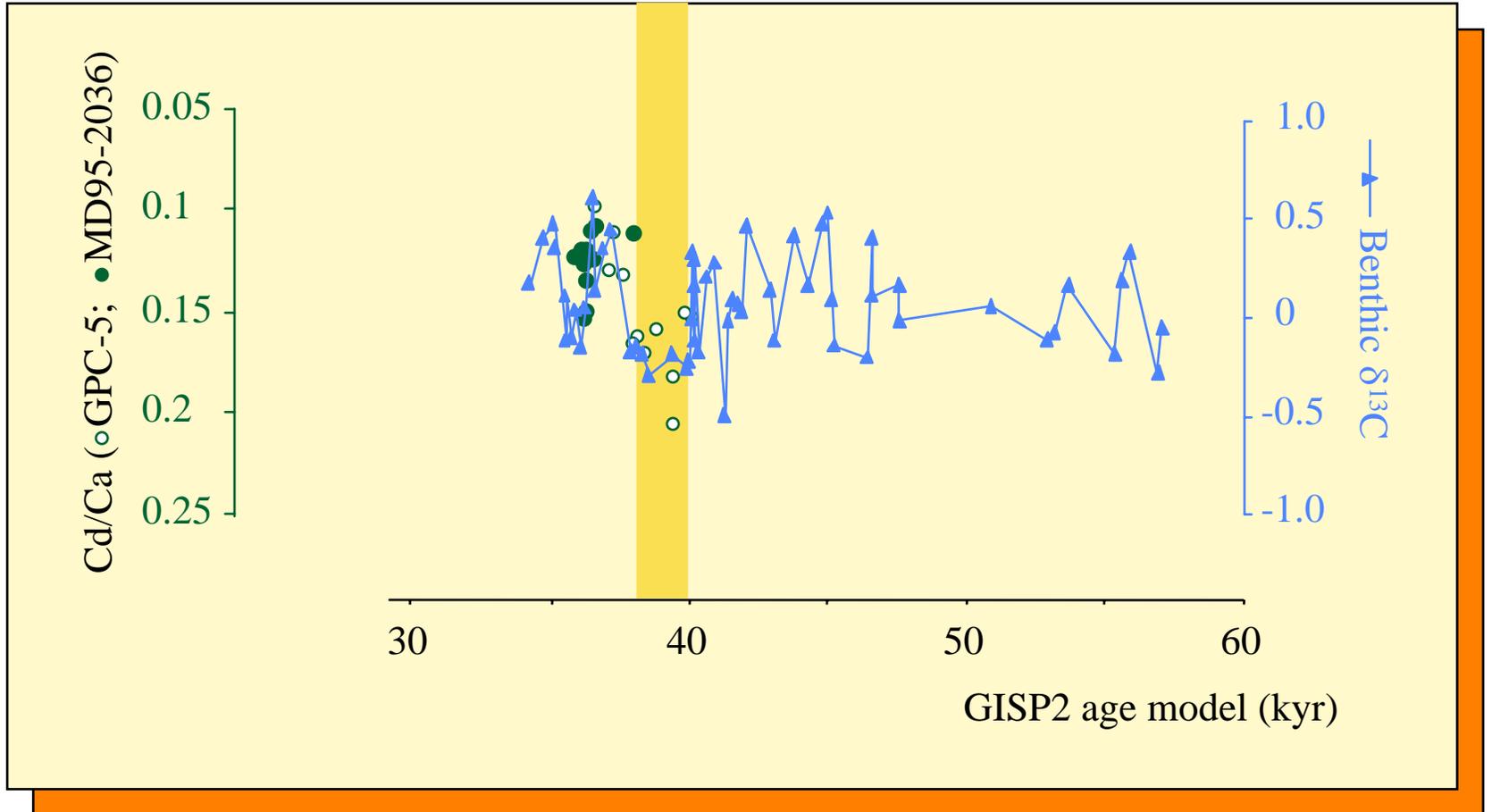


*Photo:  
Elsa Cortijo  
(LSCE)*



NADW normalised to its present value

H4



Benthic  $\delta^{13}\text{C}$  + Cd/Ca

from Keigwin and Boyle, 1999

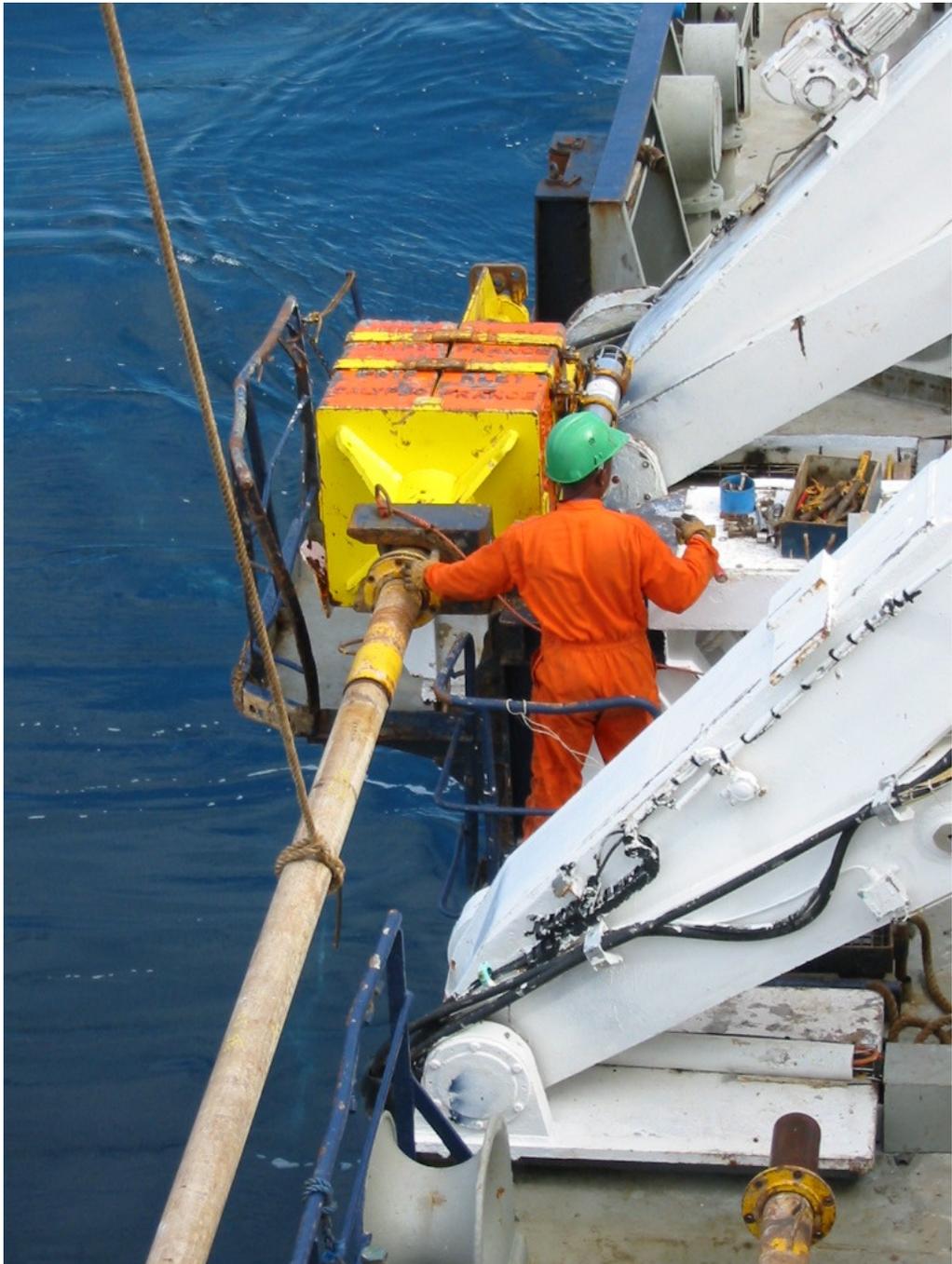








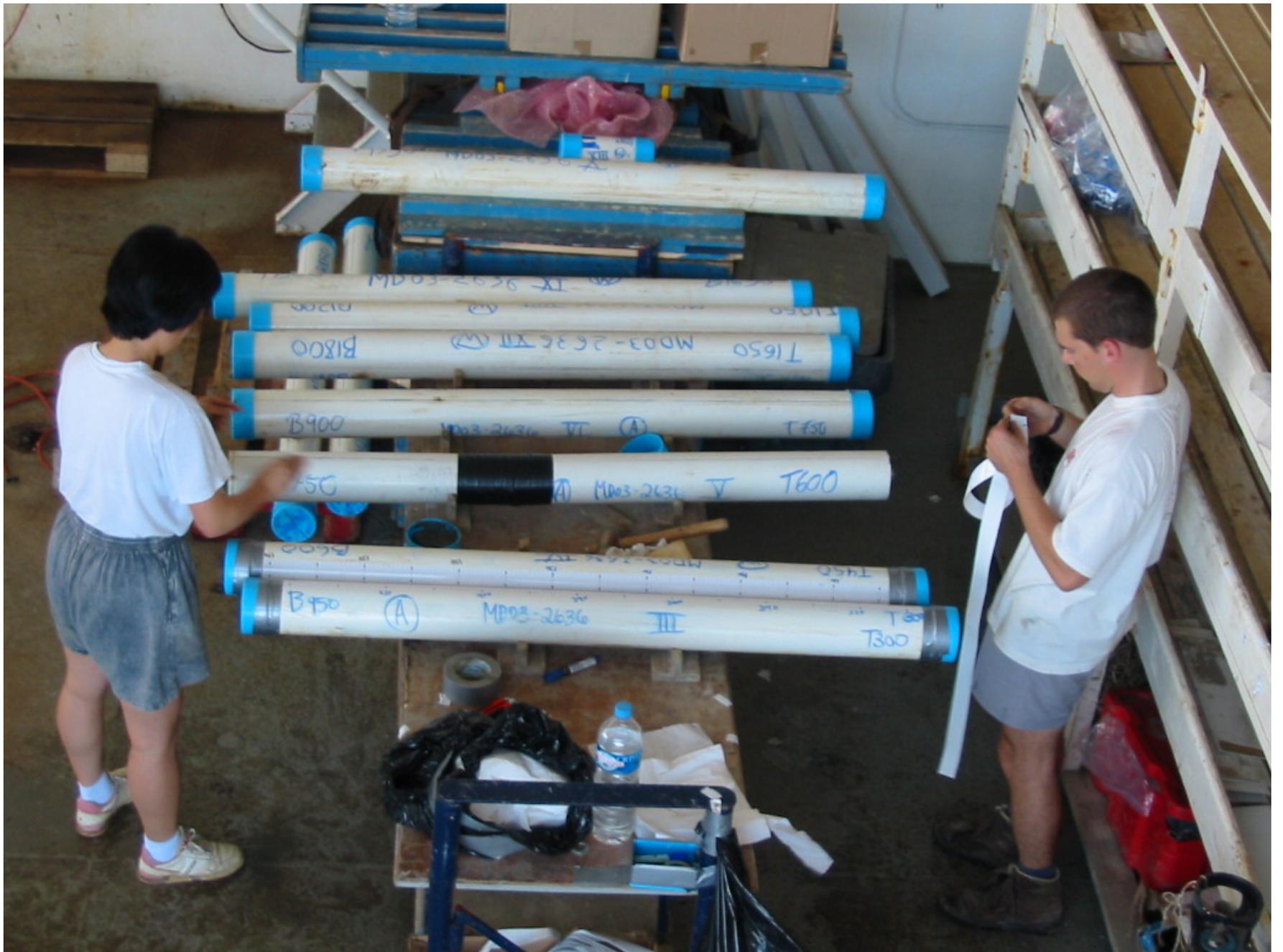














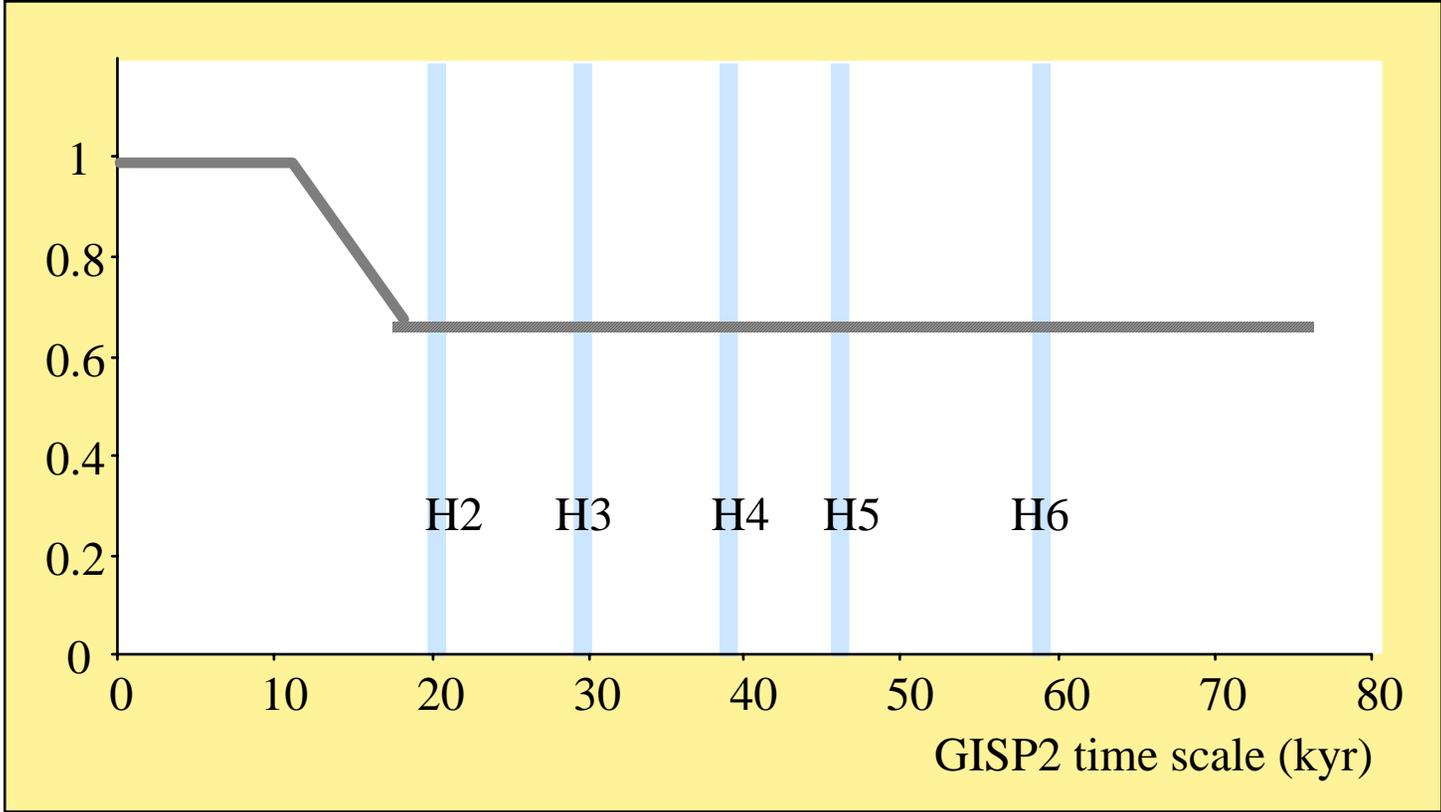
QuickTime™ et un décompresseur  
Photo - JPEG sont requis pour visualiser  
cette image.



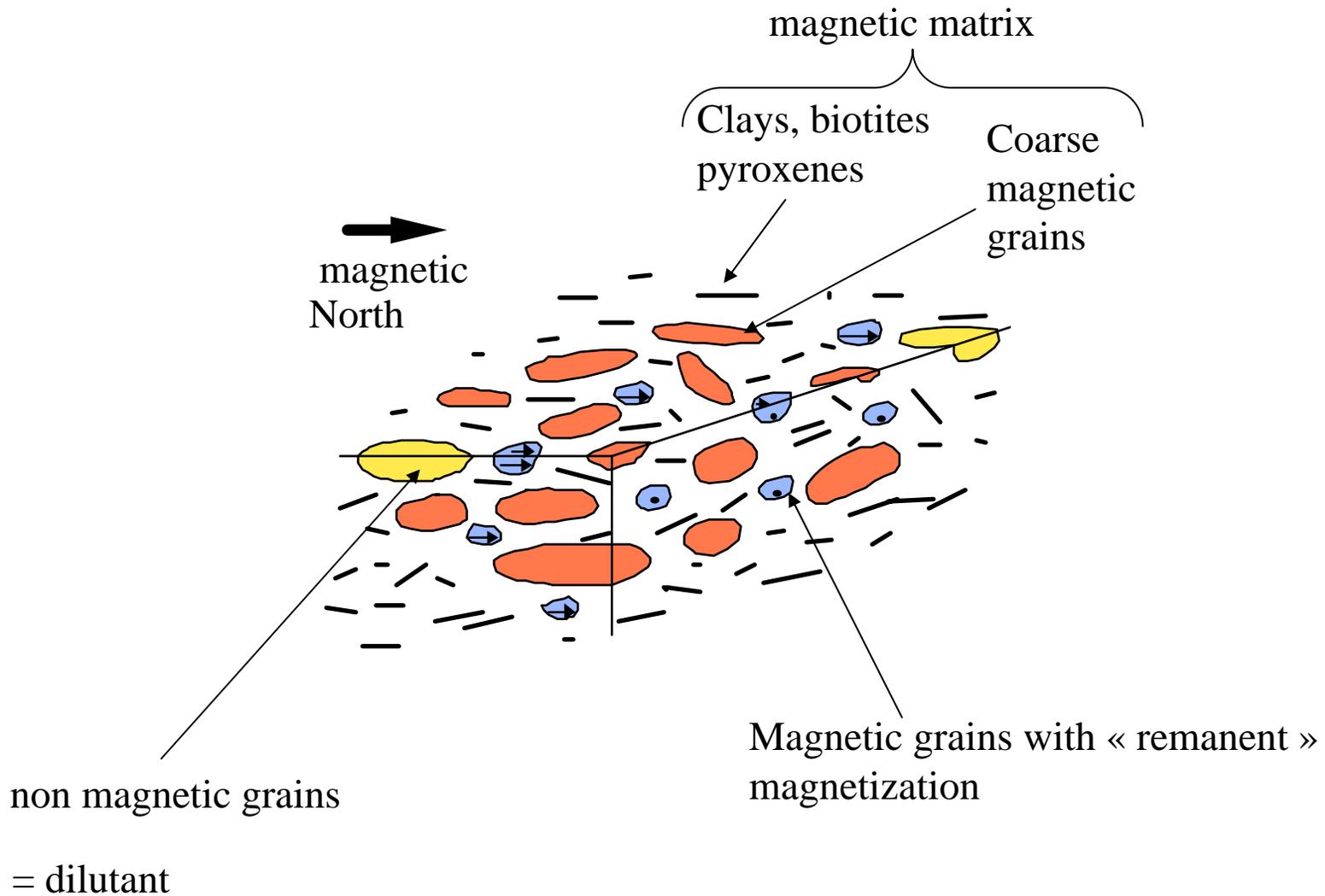








NADW normalised to its present value



Paleomagnetic signal from sediments

Earth magnetic field

Environmental setting

Declination  
Inclination  
Intensity

of the natural  
magnetic  
vector

Nature  
Grain size  
Concentration  
Preferential alignment

of the  
magnetic  
grains

History of the  
earth magnetic  
field

Stratigraphic  
correlations

Correlations  
within the  
same basin

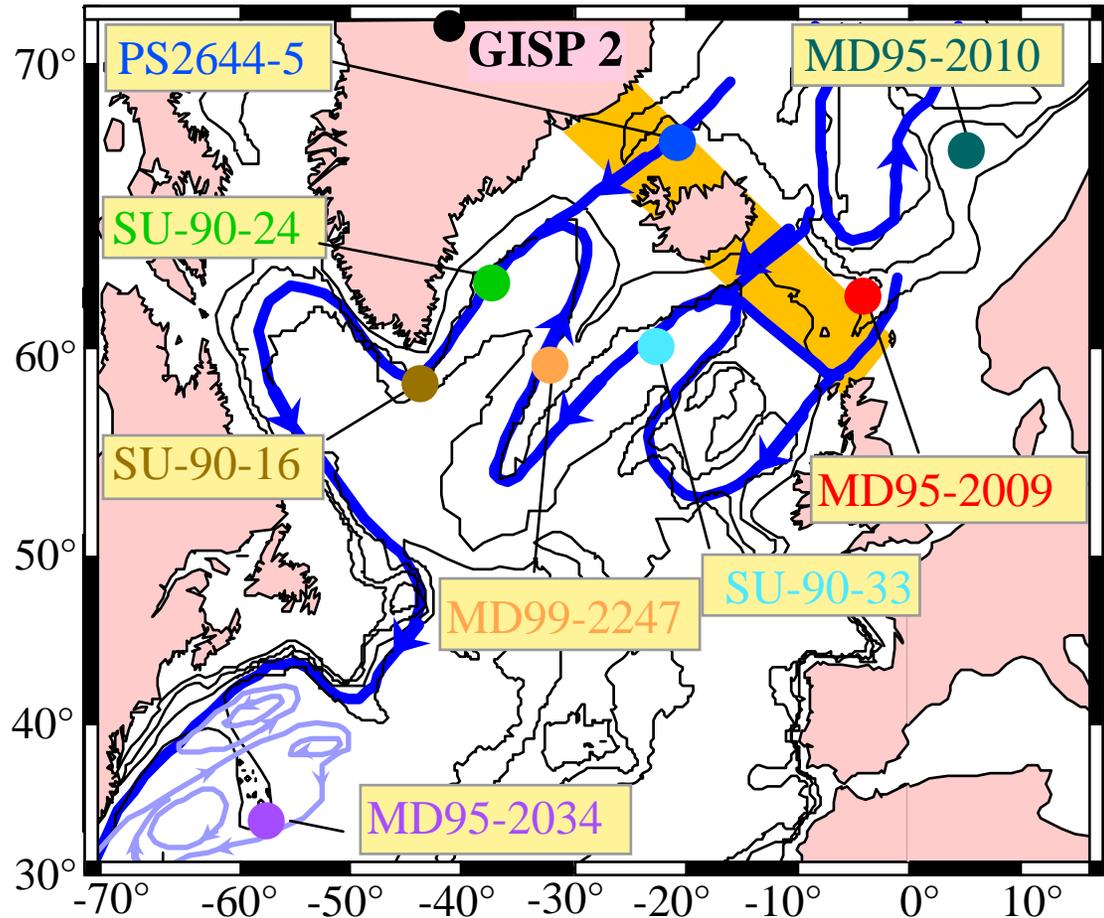
Environmental  
changes

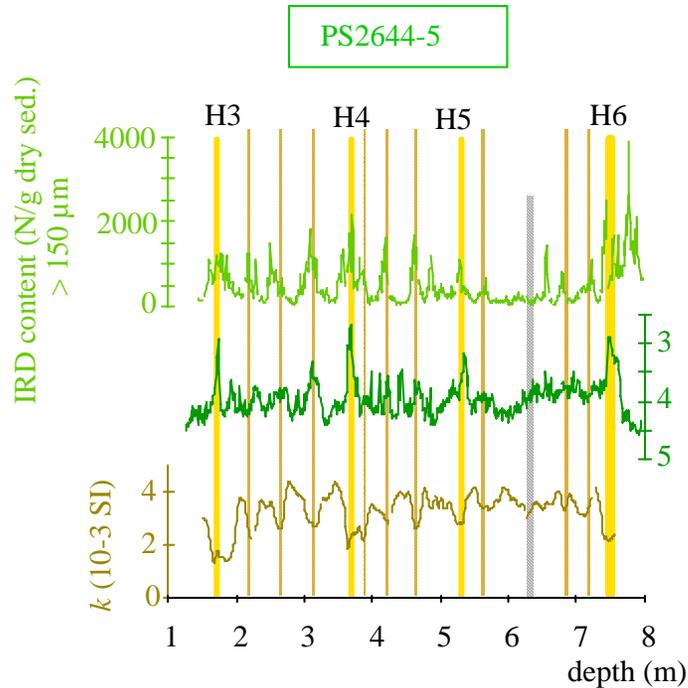
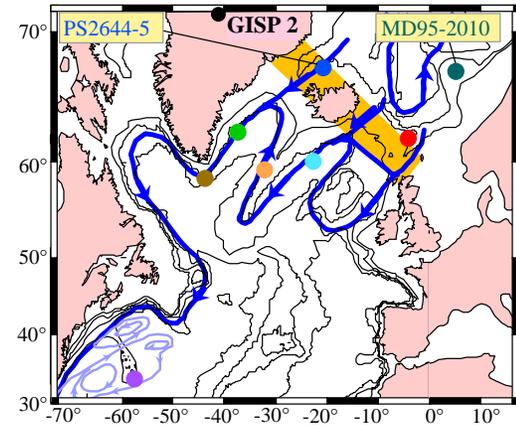
Source  
Transport  
Deposition

→ NADW

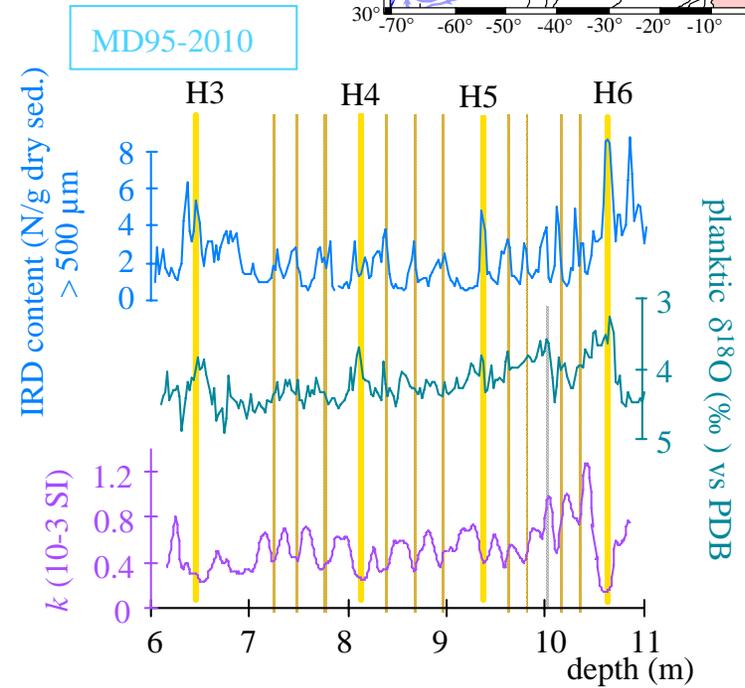
📁 ① the cores are all located on the present path of the NADW

📖 ① the cores are all characterized by high sedimentation rates (10 to 30 cm/kyr) during last glacial period.





*A. Voelker*



*T. Dokken*

Some minima in the magnetic record coincide with light planktic  $\delta^{18}\text{O}$  peaks and with IRD peaks. They are identified as Heinrich events.

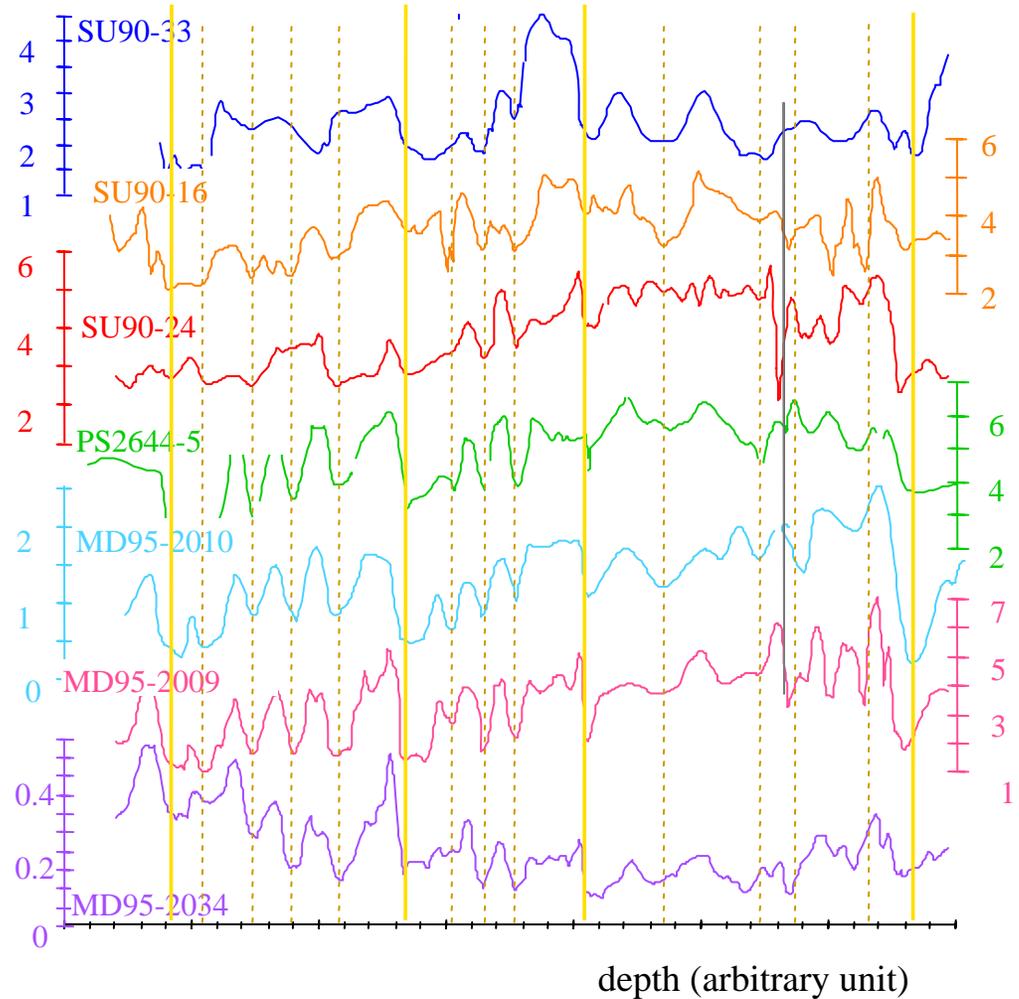
# Intercorrelation of cores

**ARM ( $10^{-1}$  A/m) =  
concentration in fine  
grained magnetites**

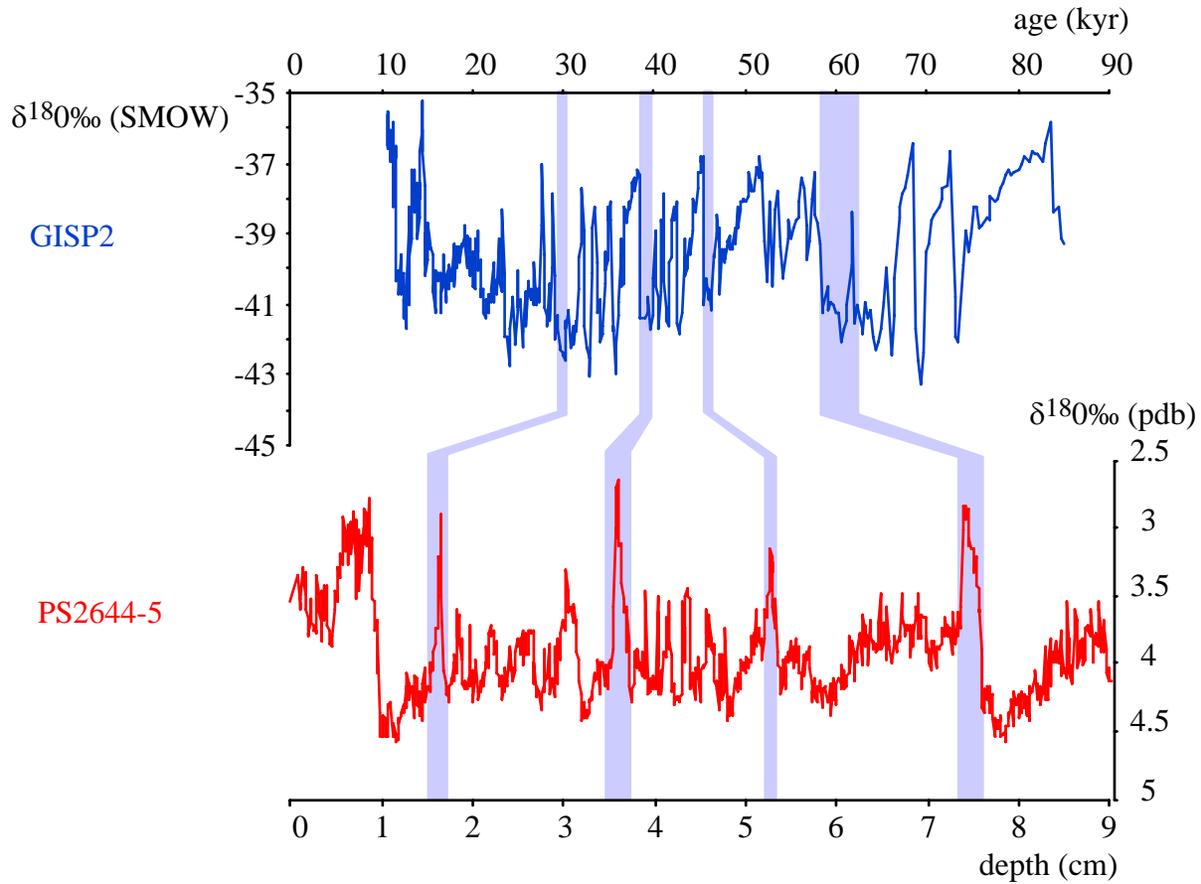
The high frequency  
variations in  
concentration can be  
inter-correlated using:

The Heinrich events (HE)  
and the ash layer I

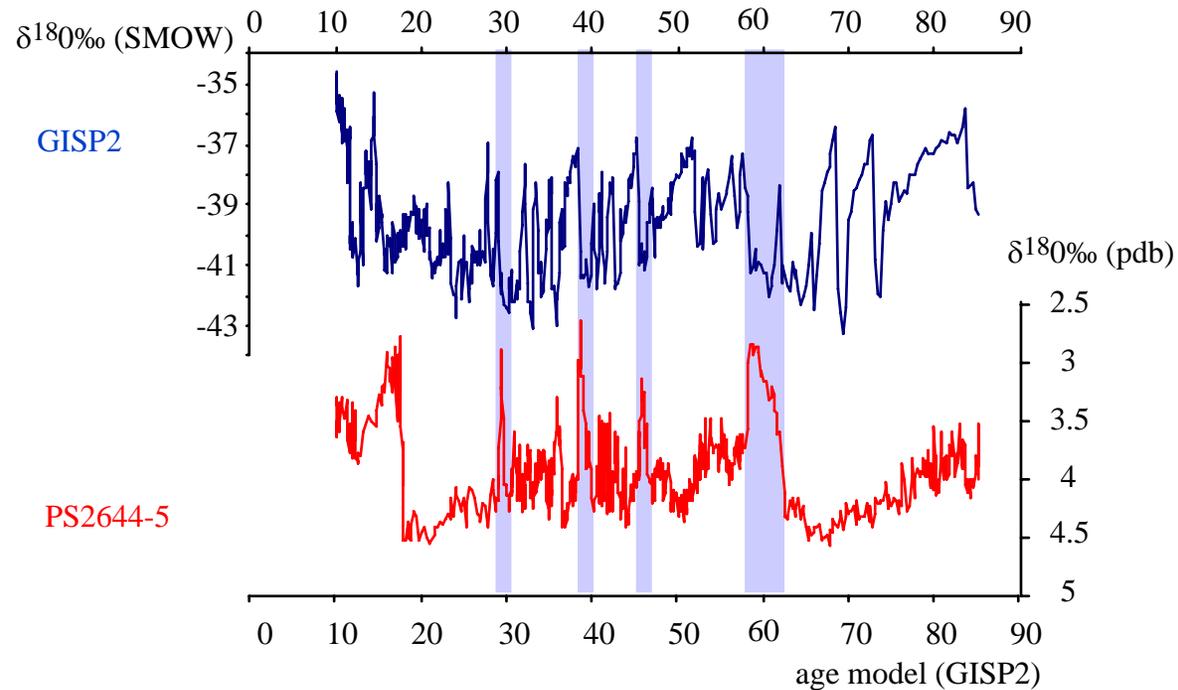
2) The oscillations between HE



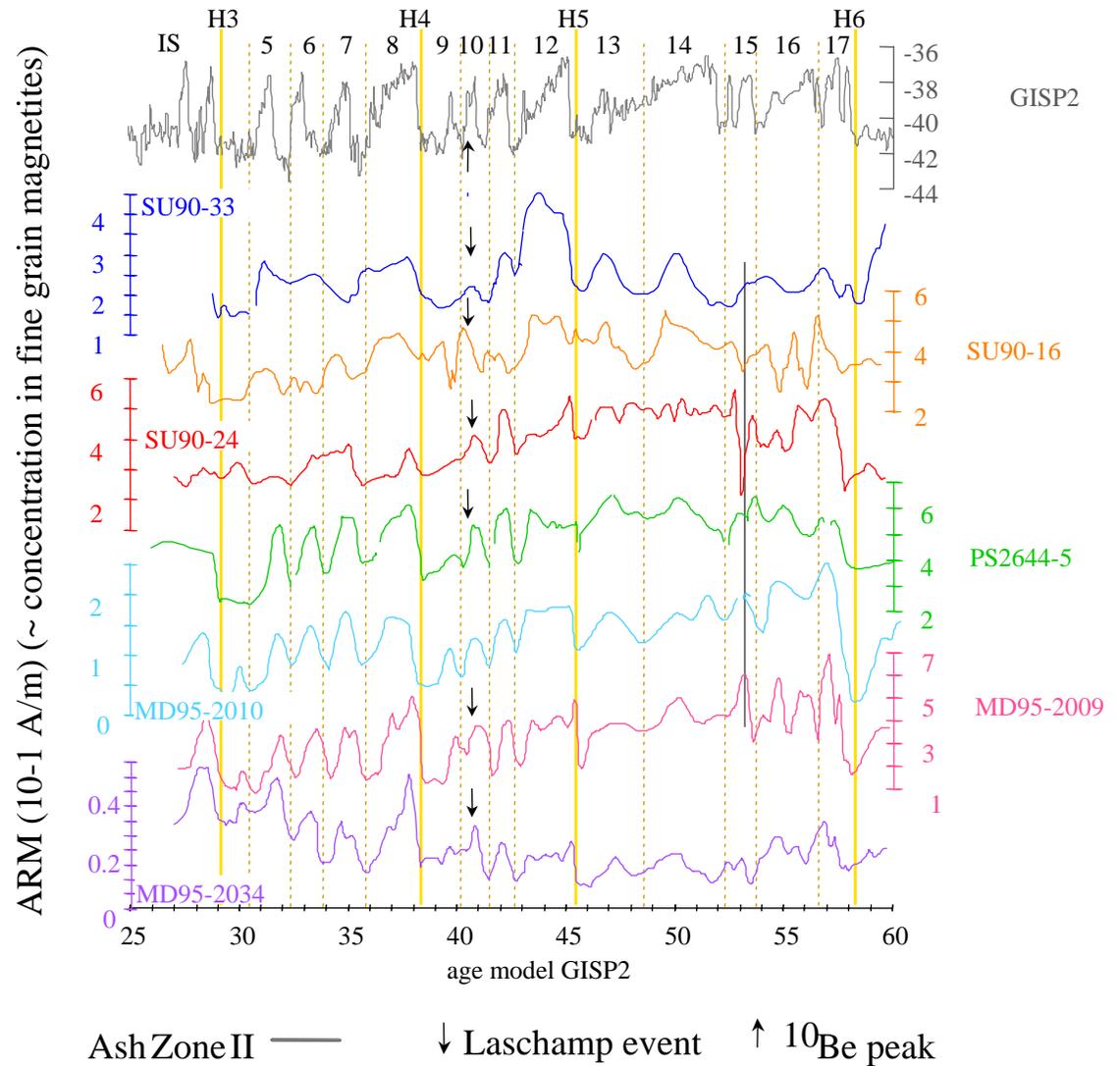
# Correlation with the record from Greenland ice



# Transfer of ice age model to marine sediments

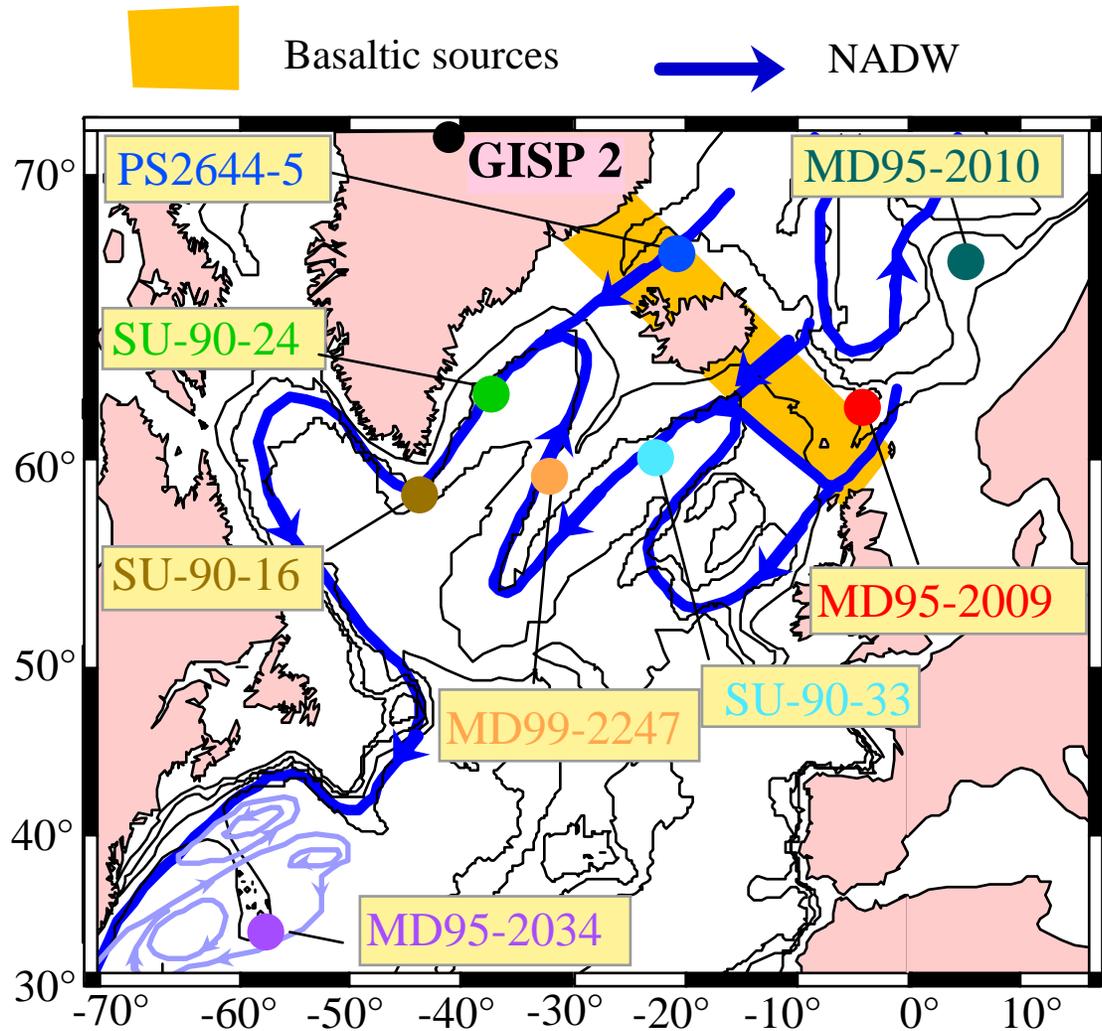


Using the correlation proposed by Voelker et al., the magnetic records can be transferred on the GISP2 age model



The main source for magnetites in the studied sediments is the basaltic Iceland-Faeroe province.

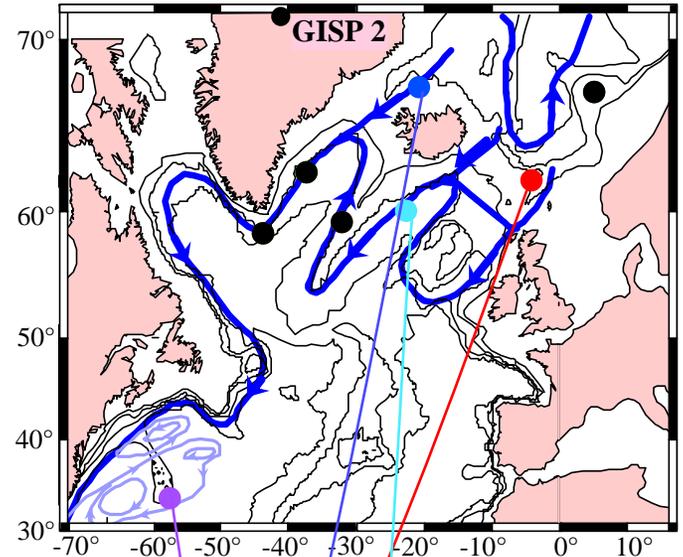
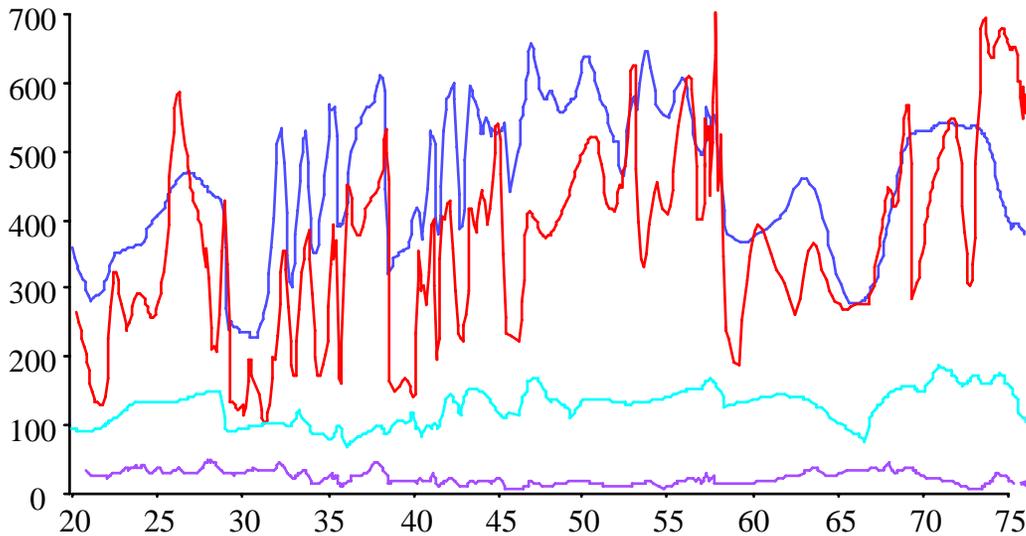
All the cores are distributed along the NADW path, downstream with respect to the source



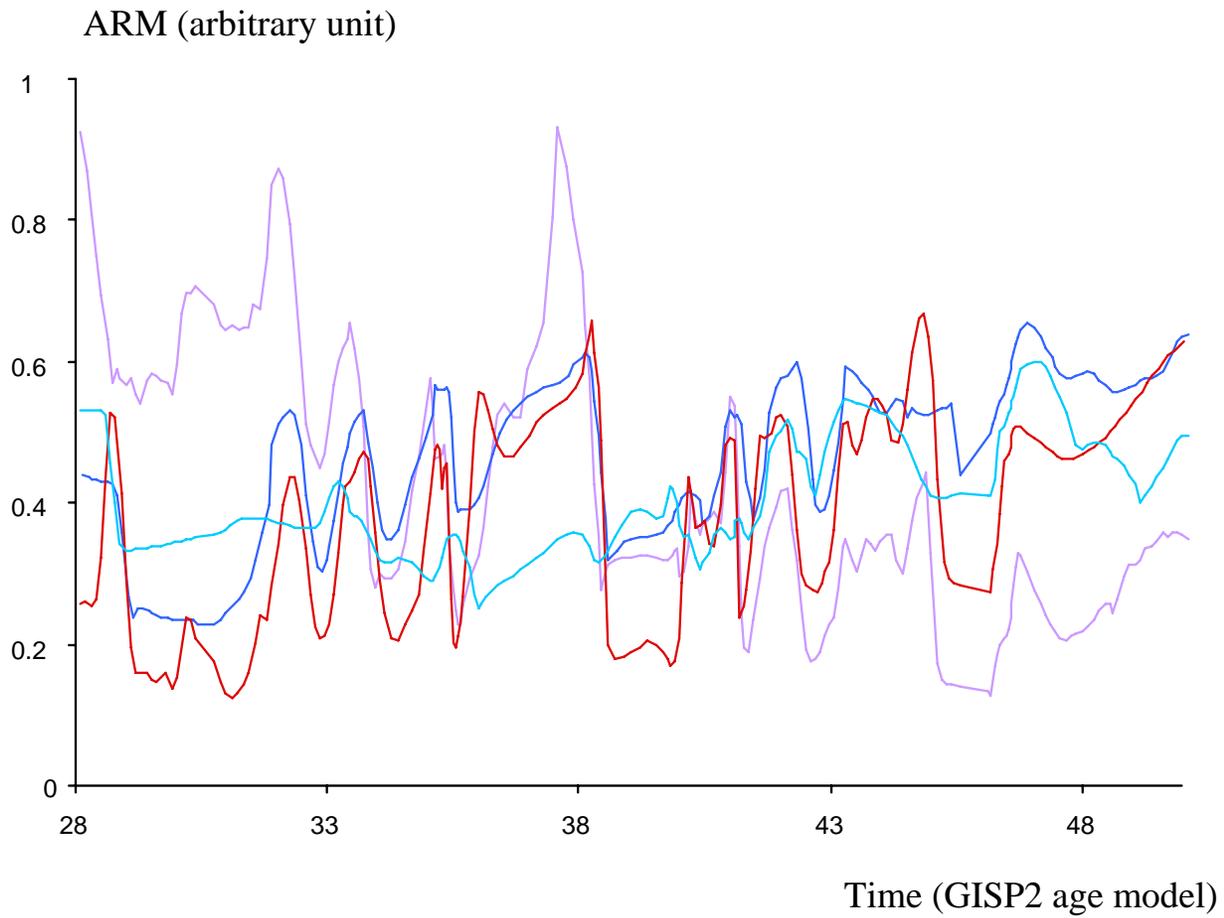
ARM illustrates the amount of fine grained magnetites.

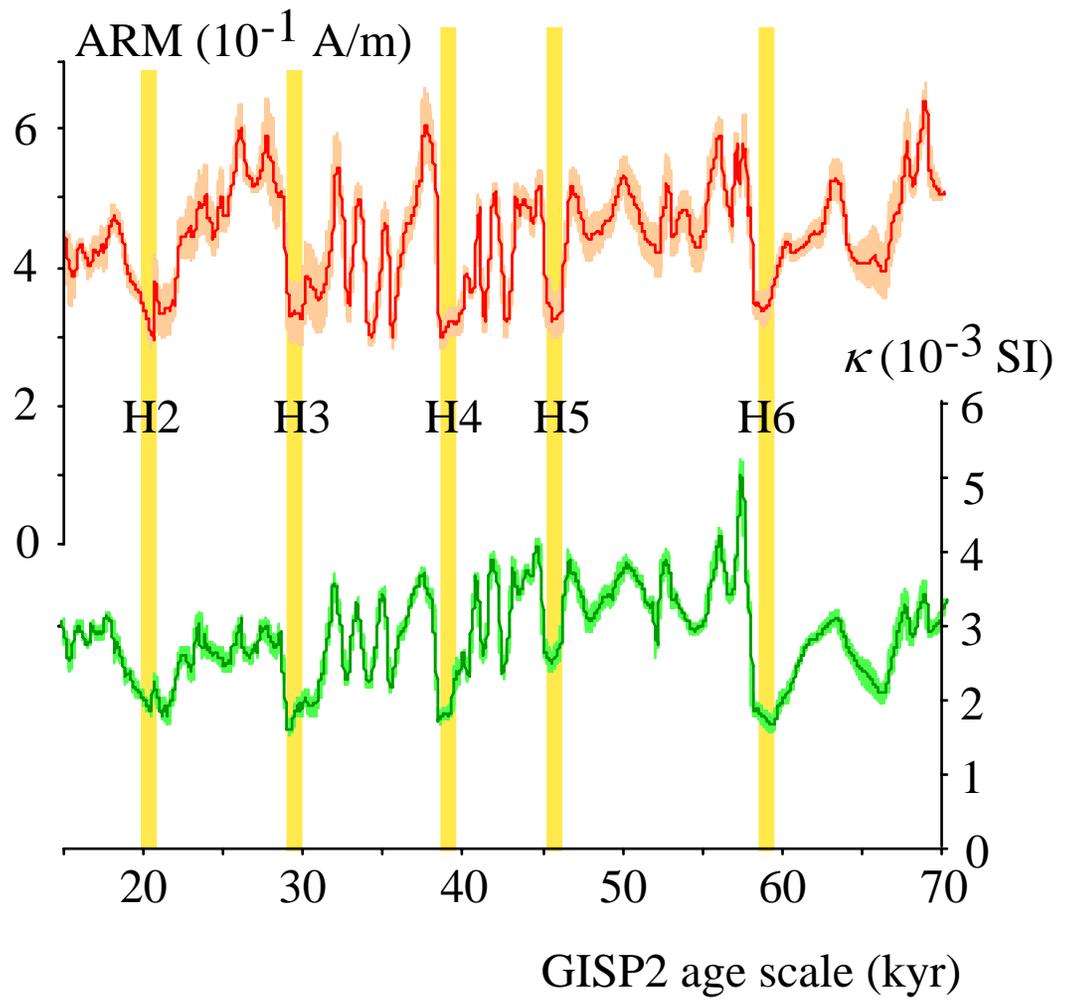
This parameter is better adapted than susceptibility because it is not sensitive to the variations of clay mineralogy.

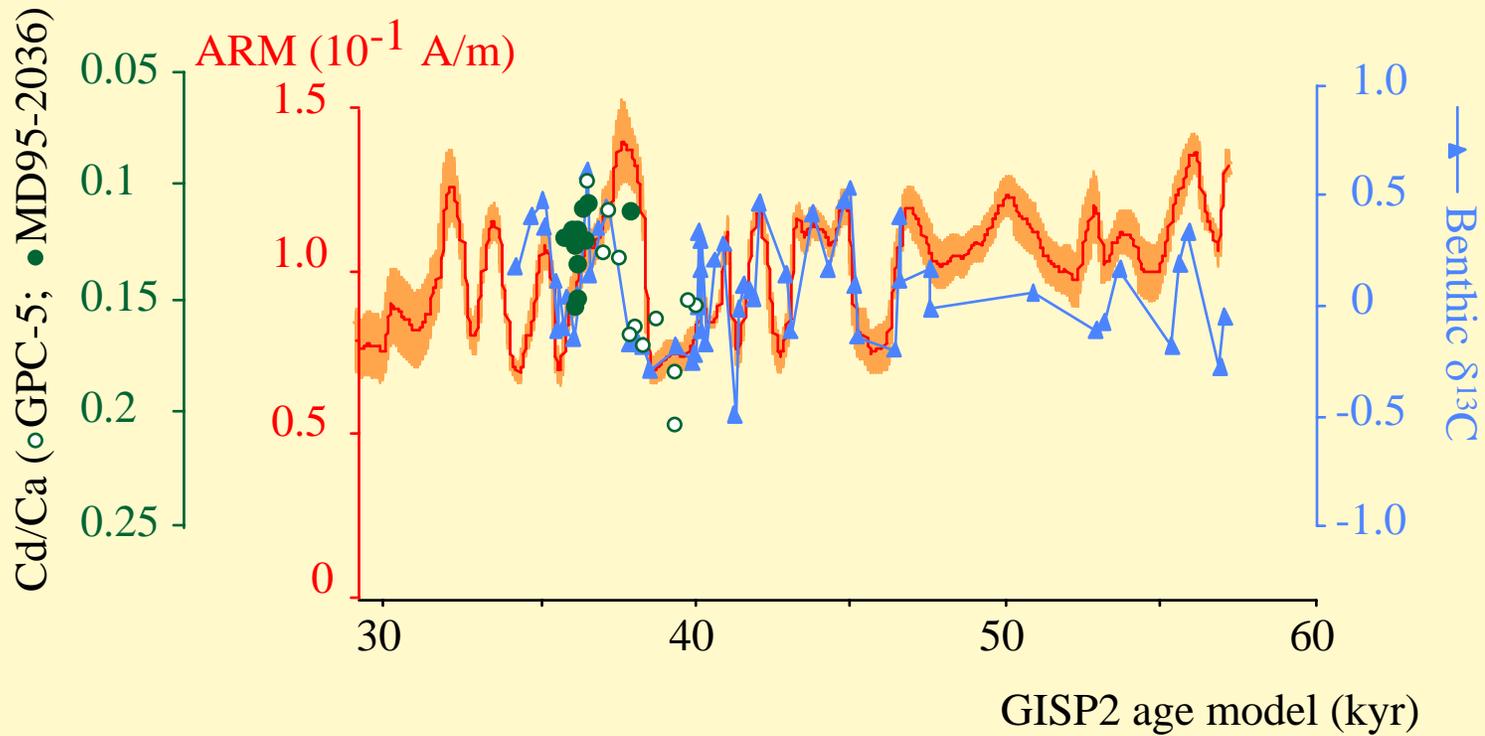
ARM ( $10^{-6}$  A/m)



Time (GISP2 age model)

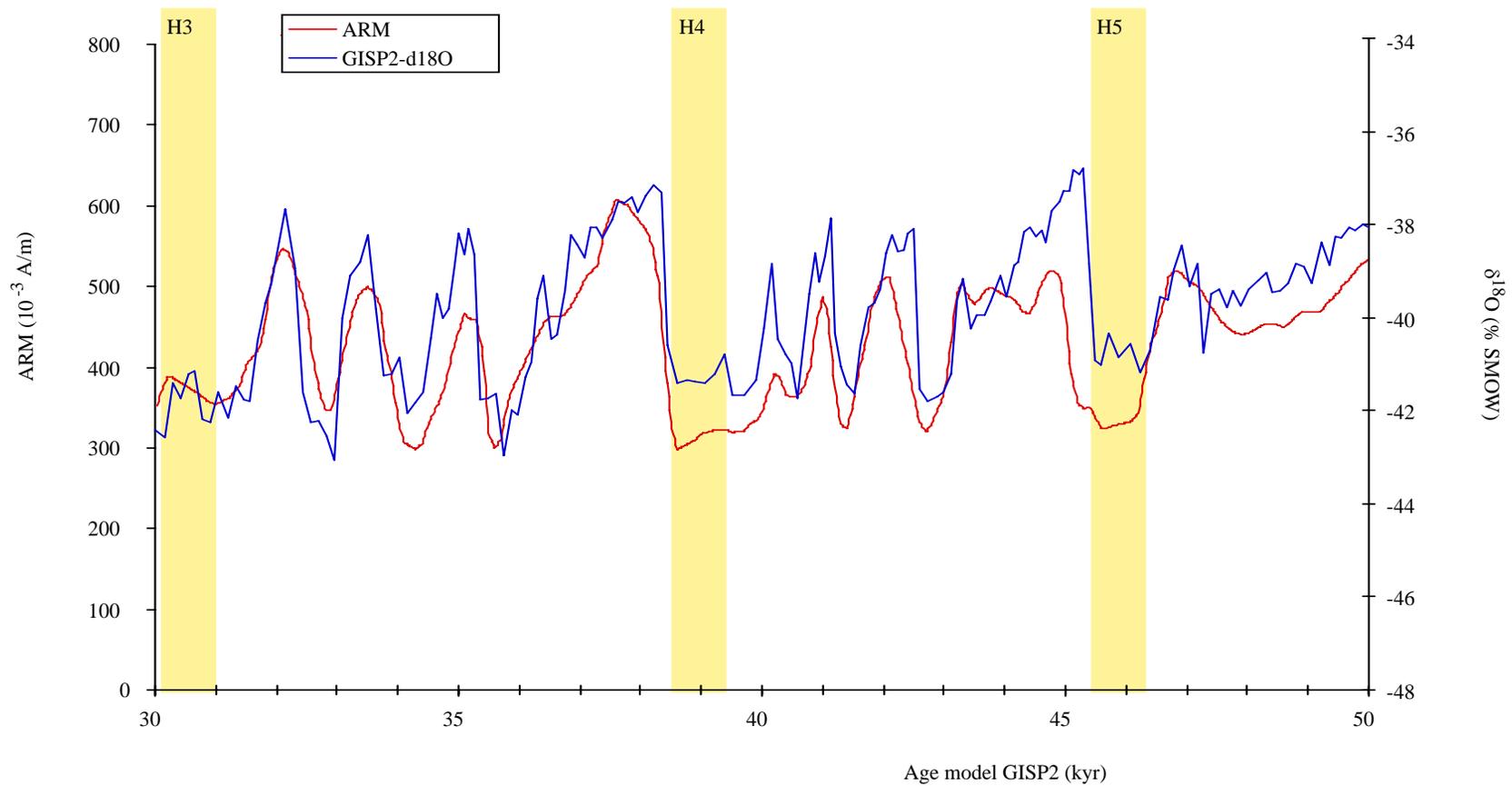






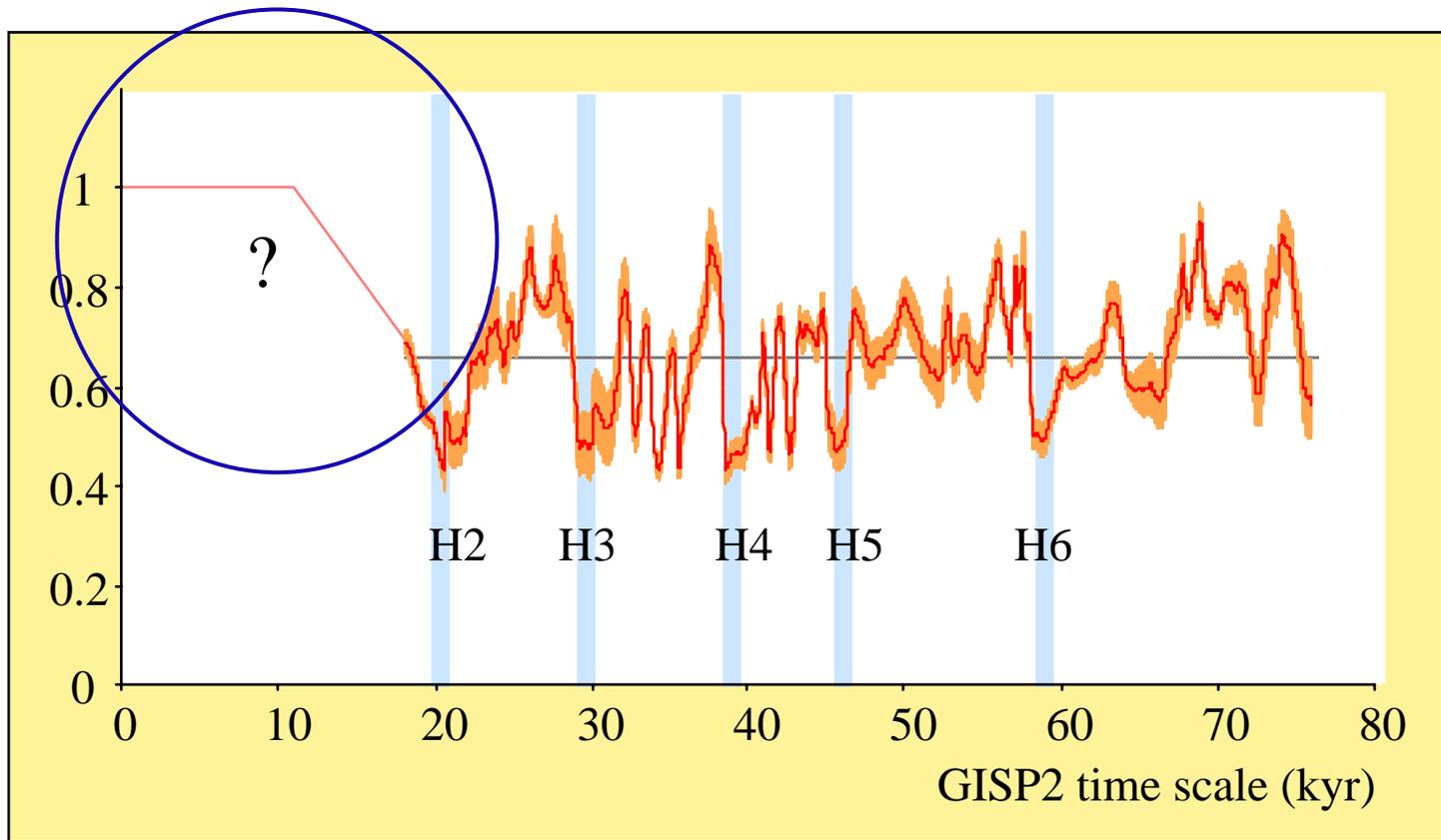
Benthic  $\delta^{13}\text{C}$  + Cd/Ca

from Keigwin and Boyle, 1999



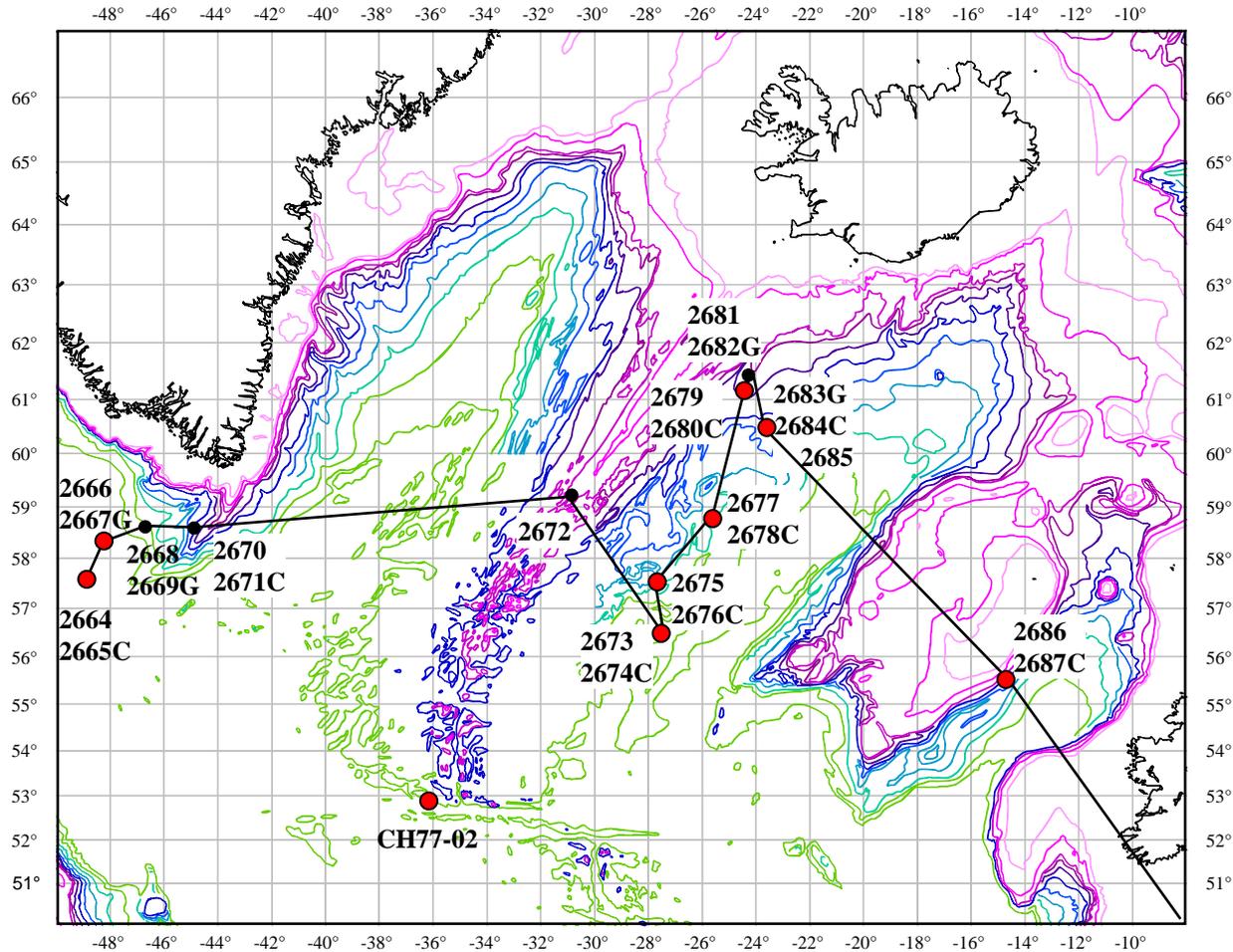
The normalized ARM stack illustrates the relative changes in the NADW strength during the last glacial period

*Laj et al., 2002*

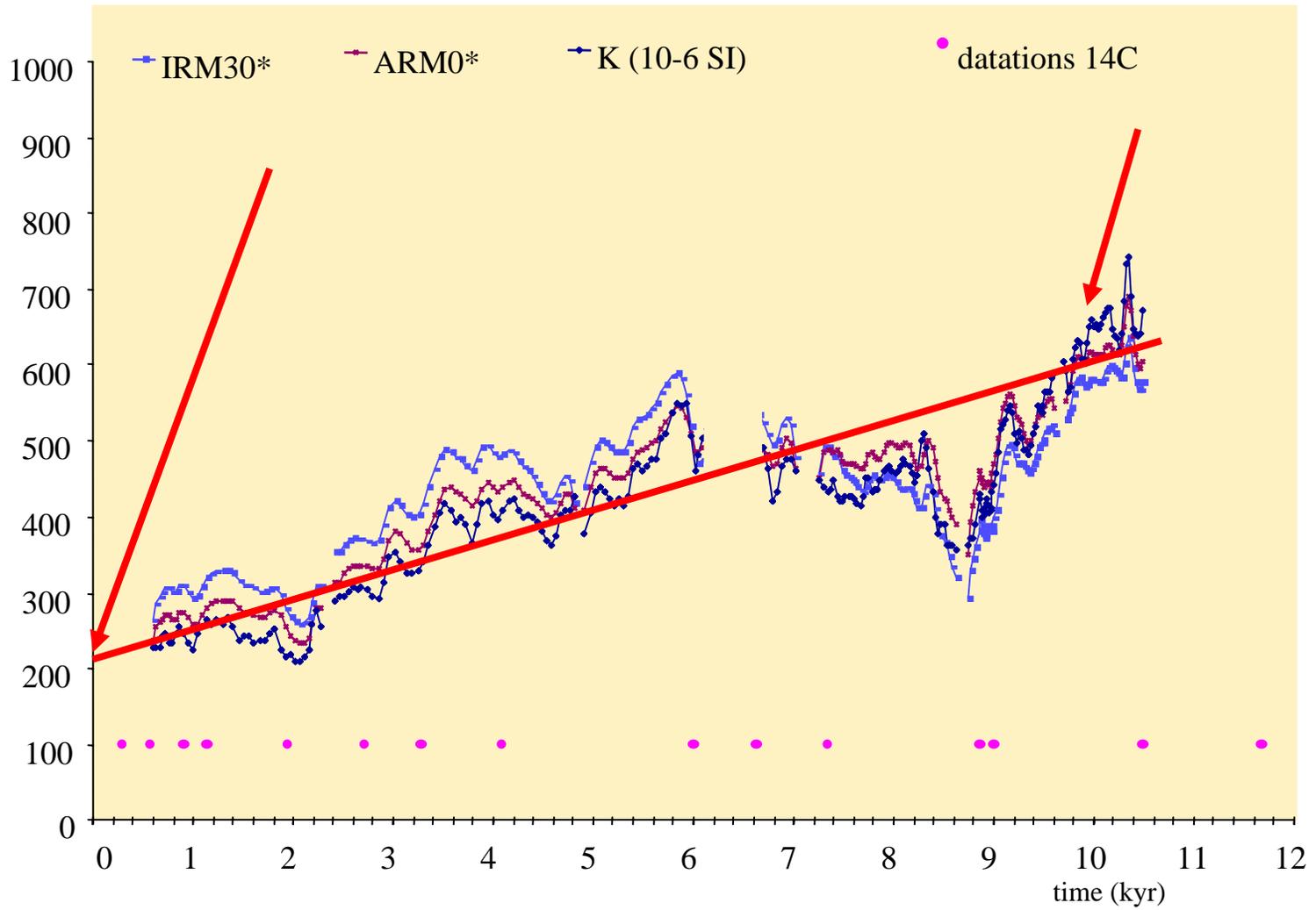


NADW normalised to its present value

# P.I.C.A.S.S.O cruise (2003) R. V. Marion Dufresne (IPEV)

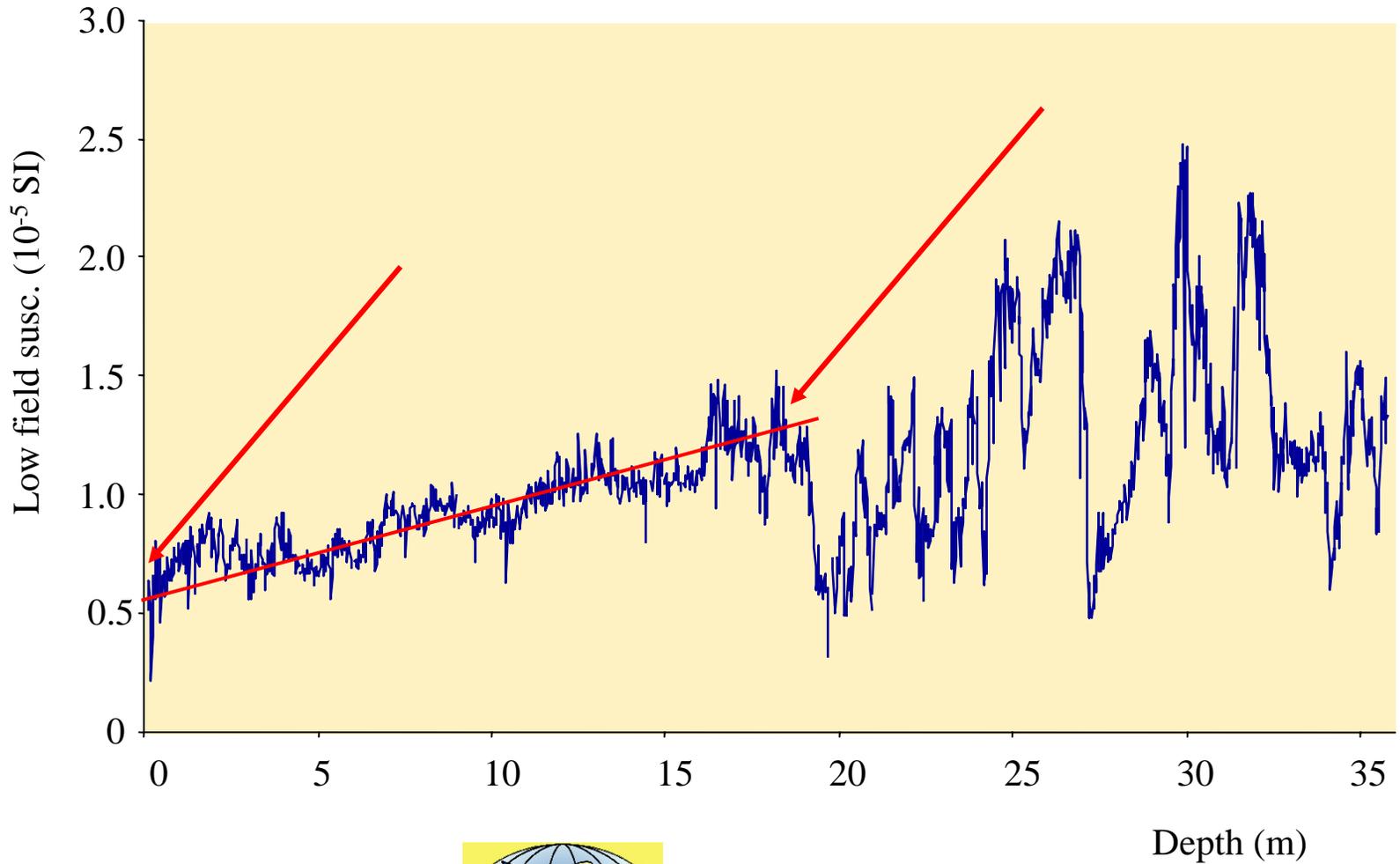


# CH77-02



Study underway at 

MD03-2675 (Calypso)



Study underway at 

First step towards a quantitative evaluation of changes  
in the strength of the NADW.

The story continues... Solution hopefully at GIFT-2005!