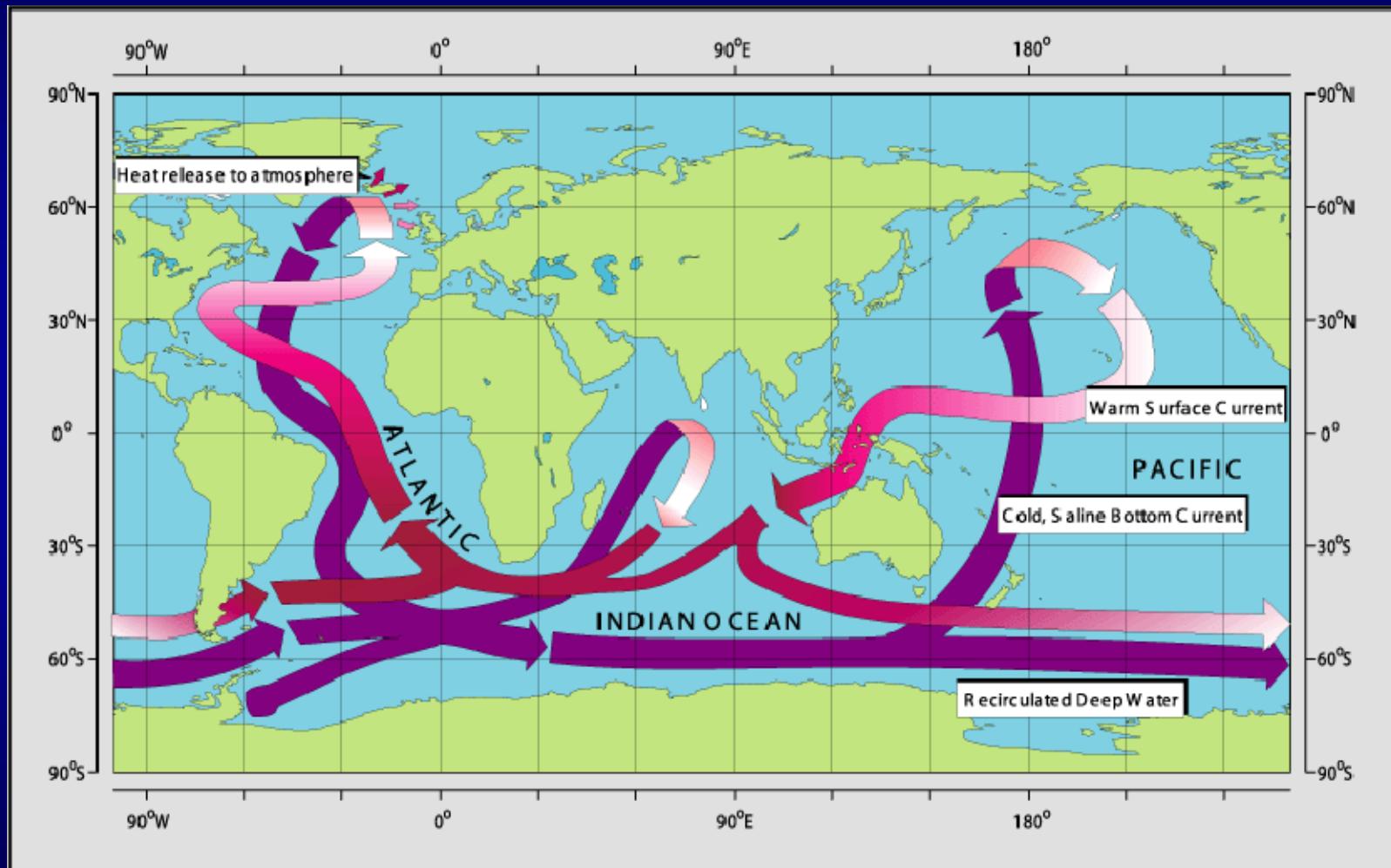


Dr. Barbara Donner  
Research Center Ocean Margins (RCOM), Bremen

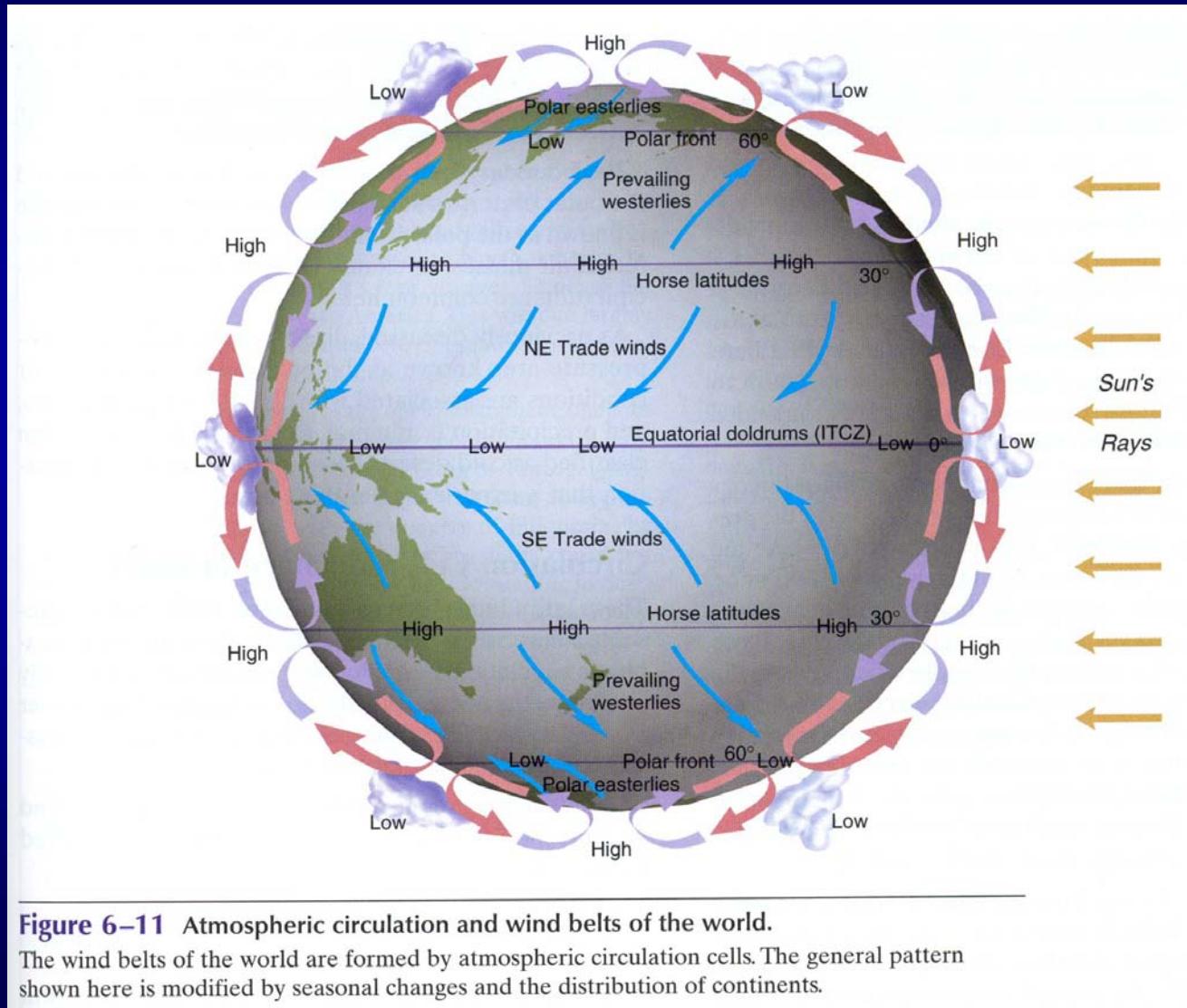
# Initiated in the North Atlantic: modern ocean circulation

# Modern ocean circulation

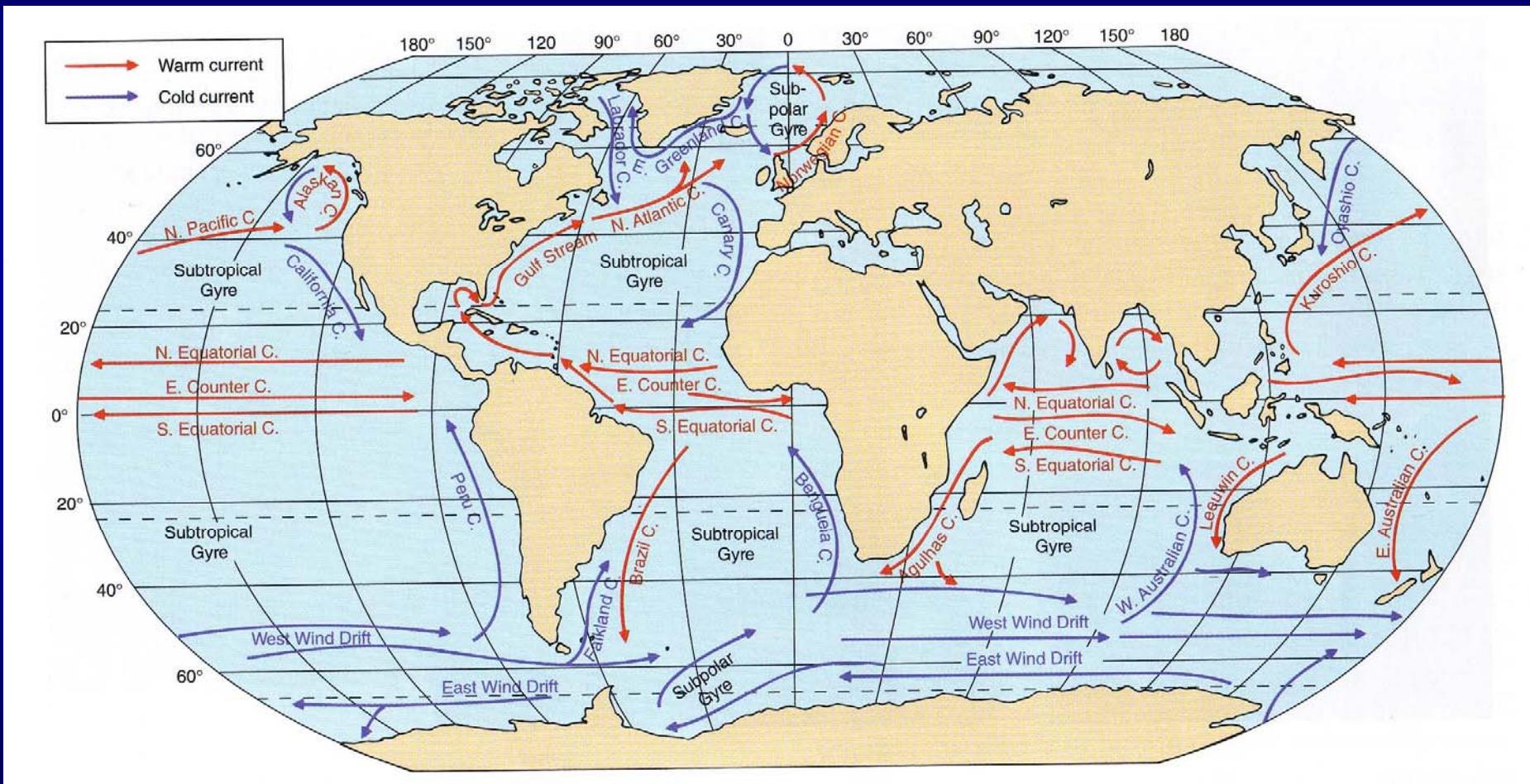


after W. Broecker

# Atmospheric circulation

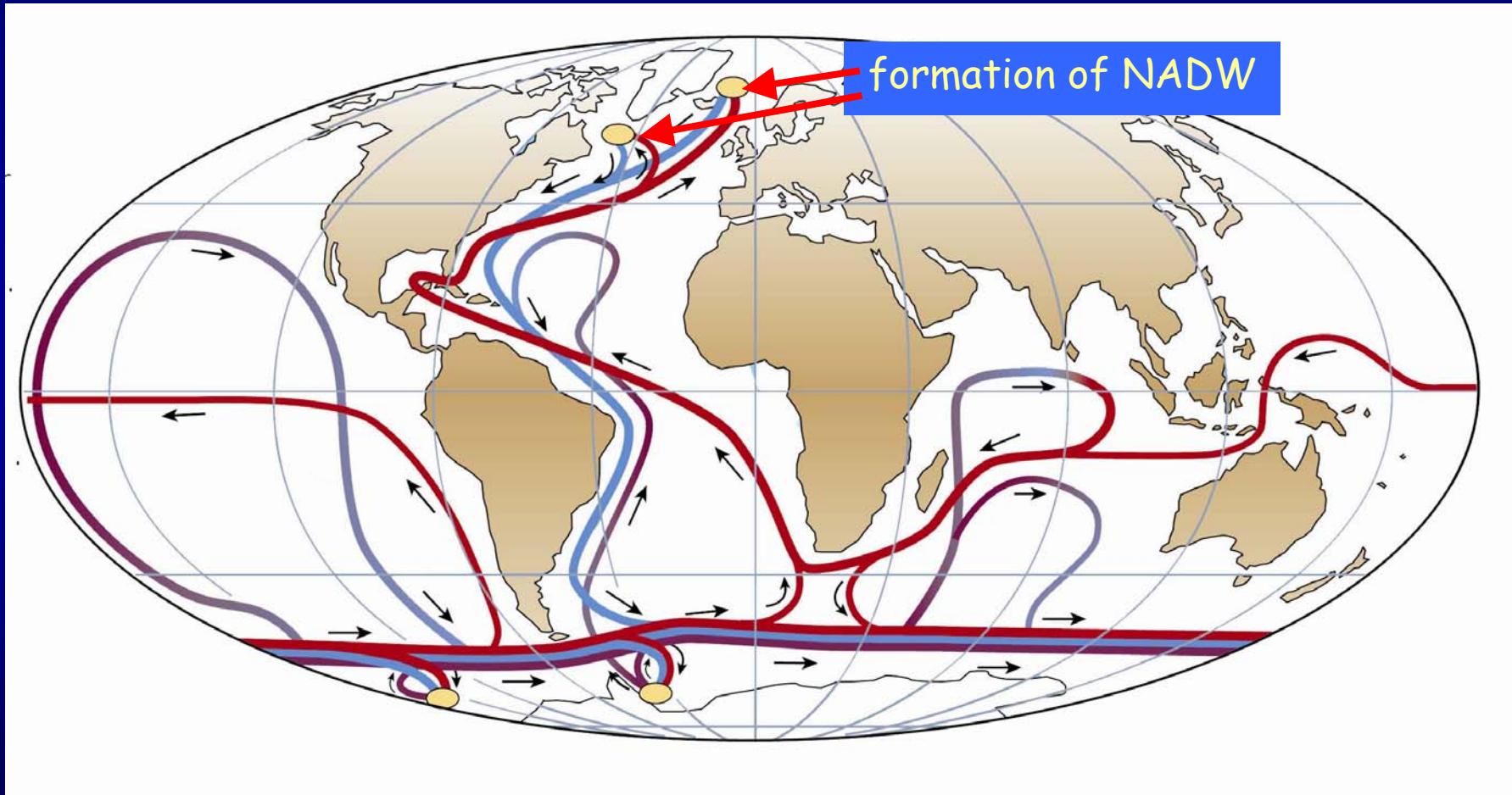


# Wind-driven surface currents



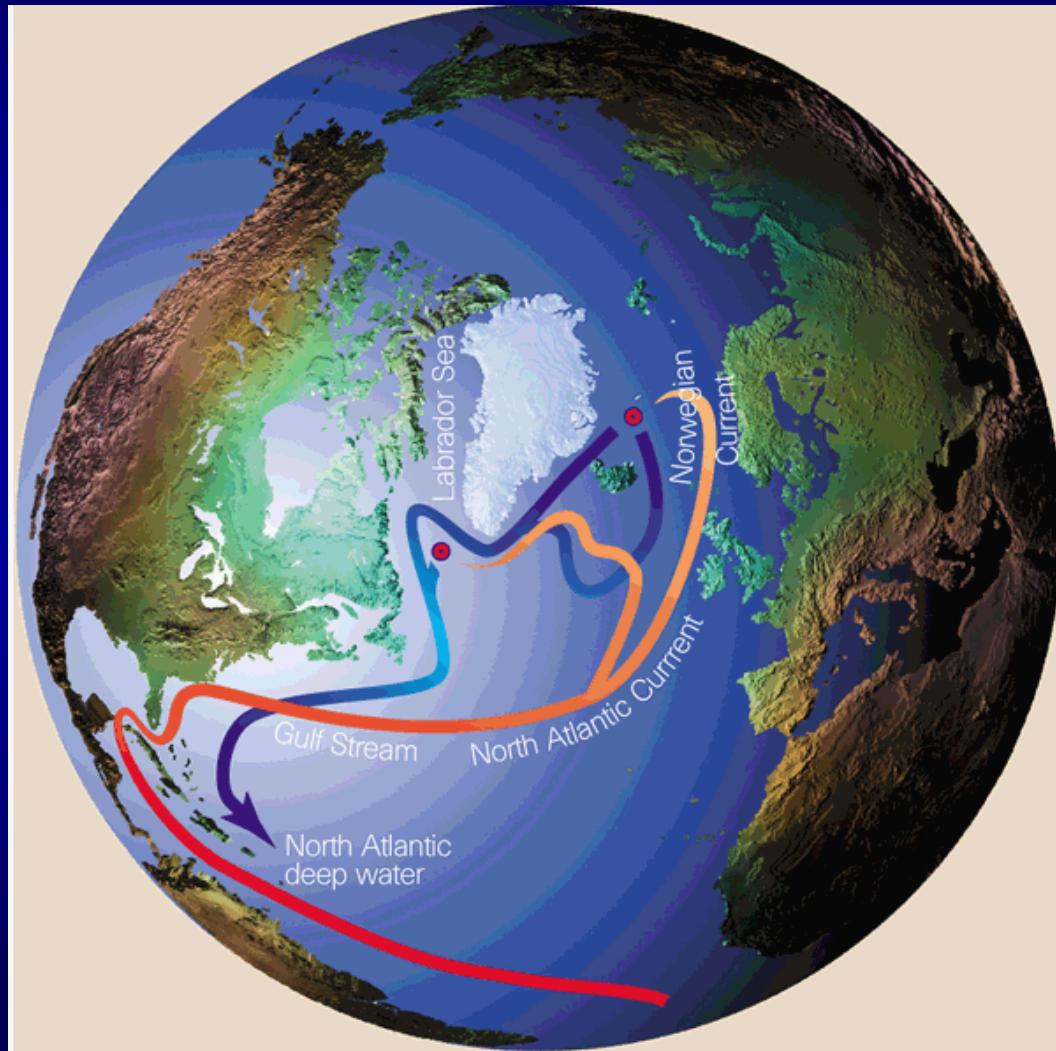
Thurman &amp; Trujillo, 1999

# Deepwater formation

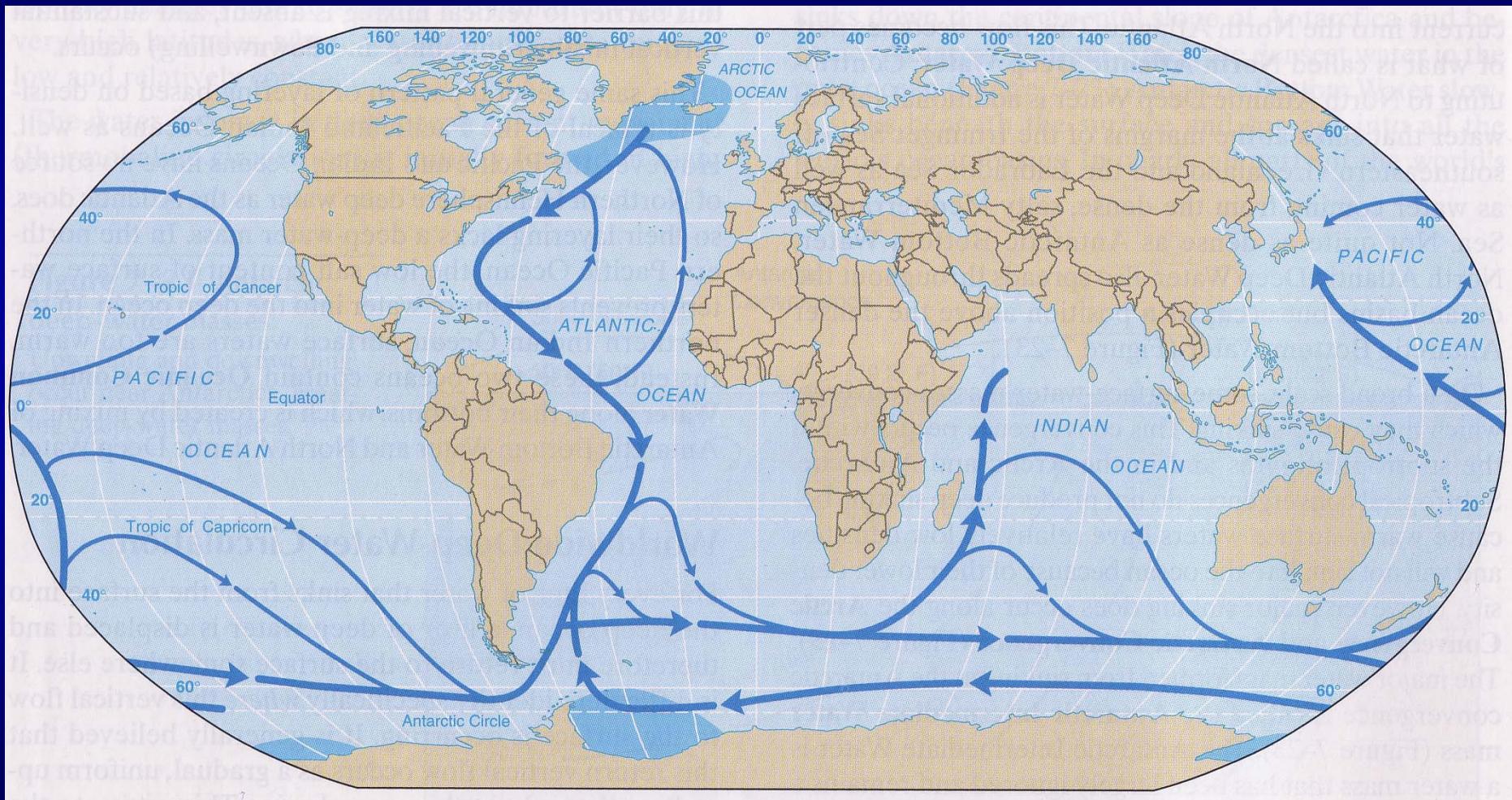


Rahmstorf et al. 2002

# Deepwater formation in the North Atlantic



# Model of deep currents

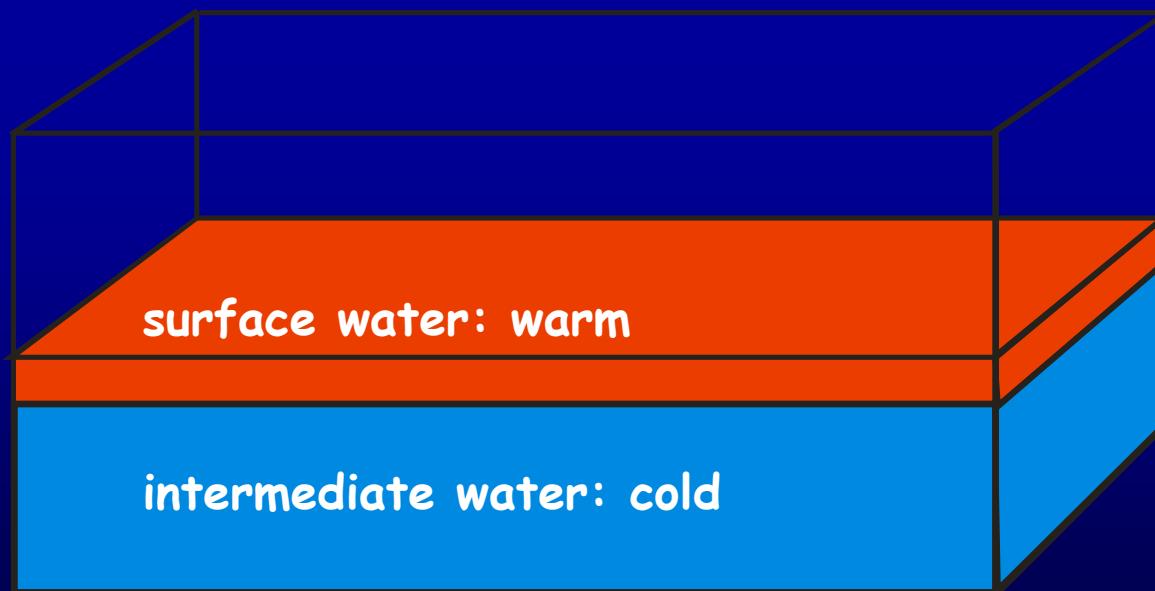


Thurman & Trujillo, 1999

# Thermohaline stratification of the ocean

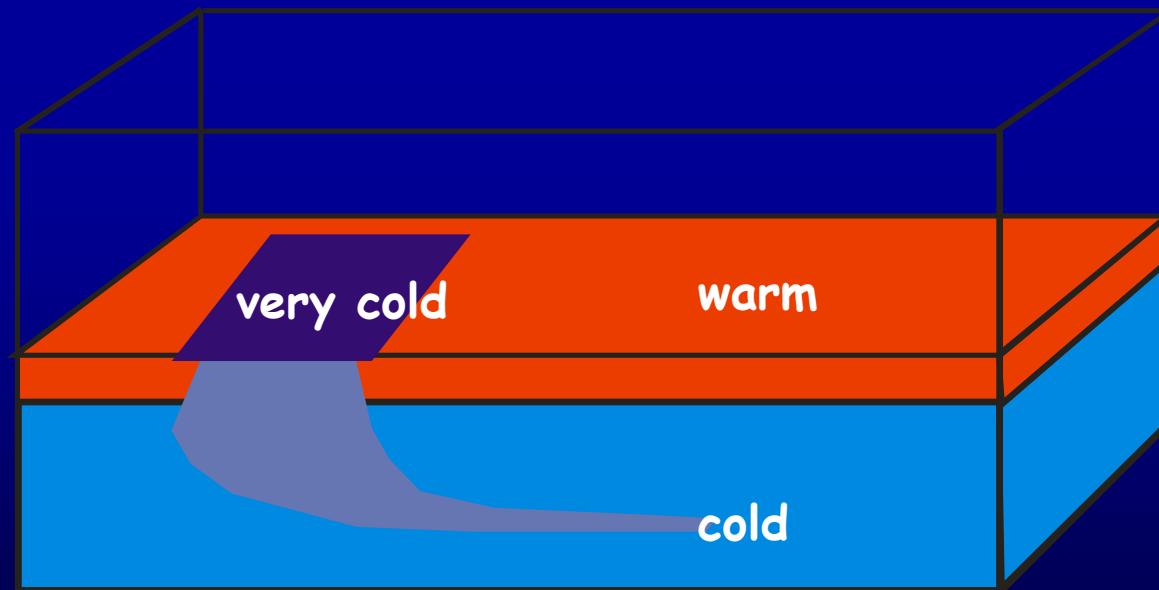
temperature and salinity specify the density of water:  
the higher the density, the heavier the water

- a warm (low saline) waterlayer rests on a cold (high saline) one
- exchange of substances between both layers is difficult



# The physical pump: formation of deepwater in the North Atlantic

- thermohaline stratification is abrogated
- substances ( $O_2$ ,  $CO_2$ ) can be transported into the deep ocean

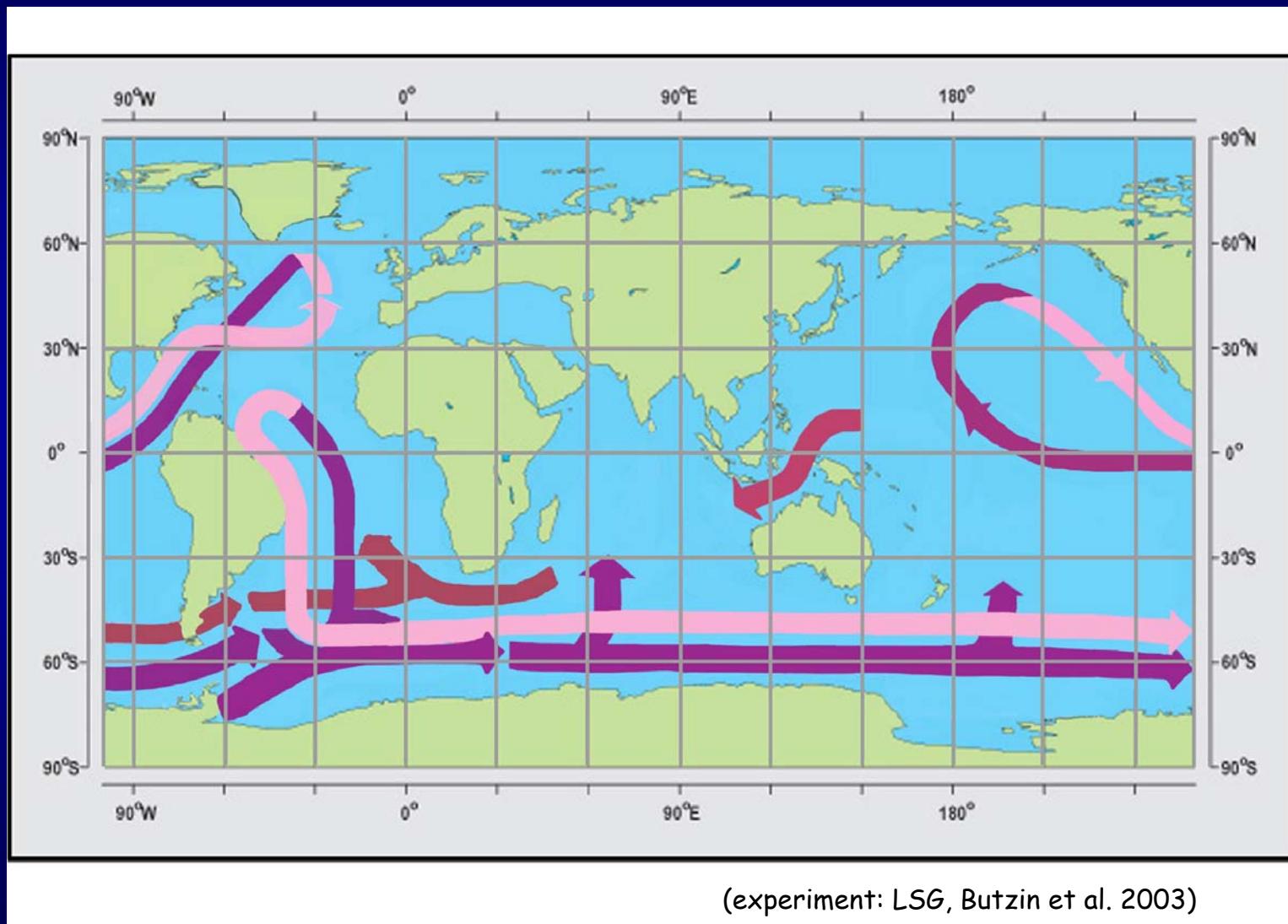


# Main currents in the North Atlantic



McCartney et al., 1996

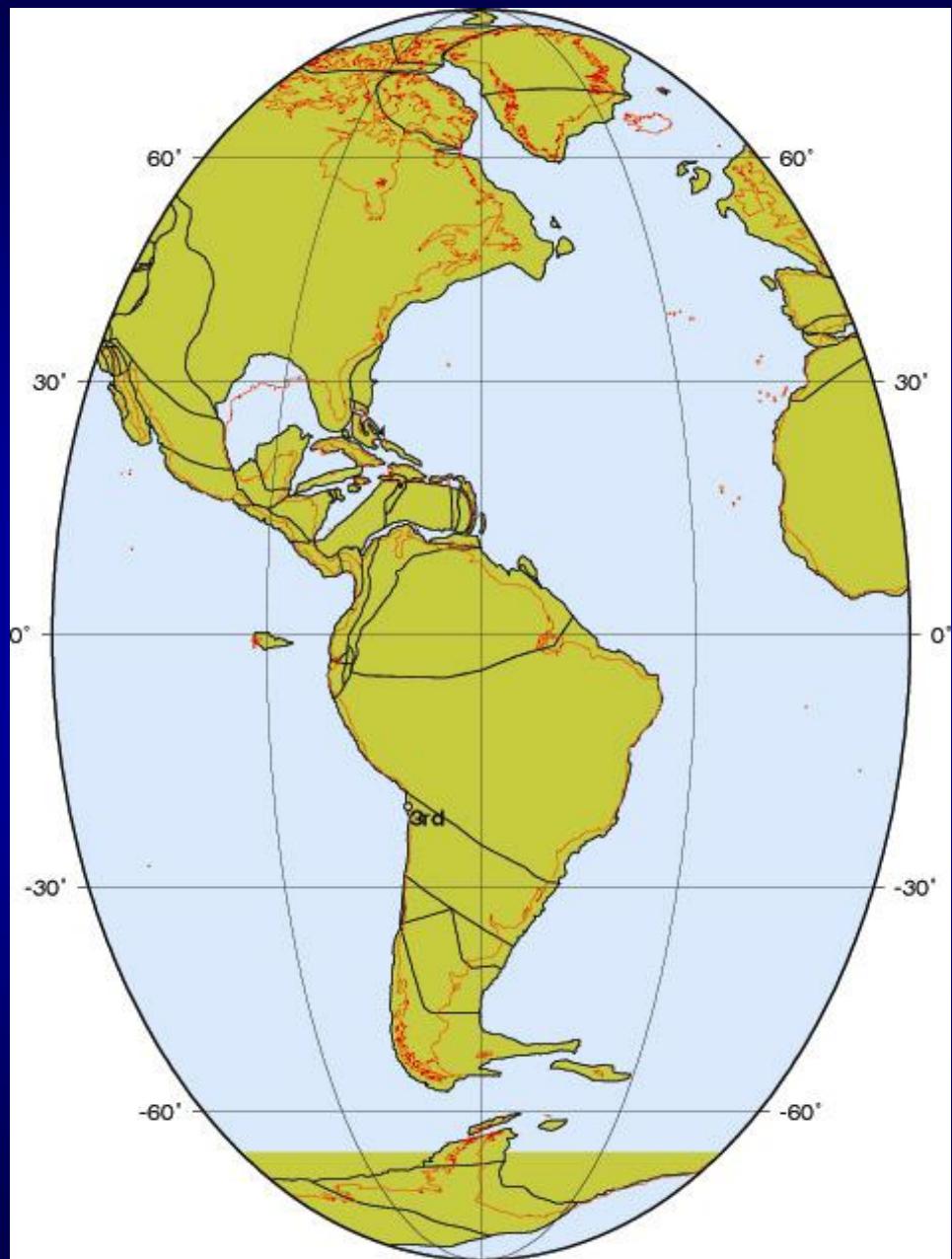
# Circulation in tertiary: 20 Ma b.p.



# Plates' constellation: **today**

red: shore lines

[www.odsn.de](http://www.odsn.de)

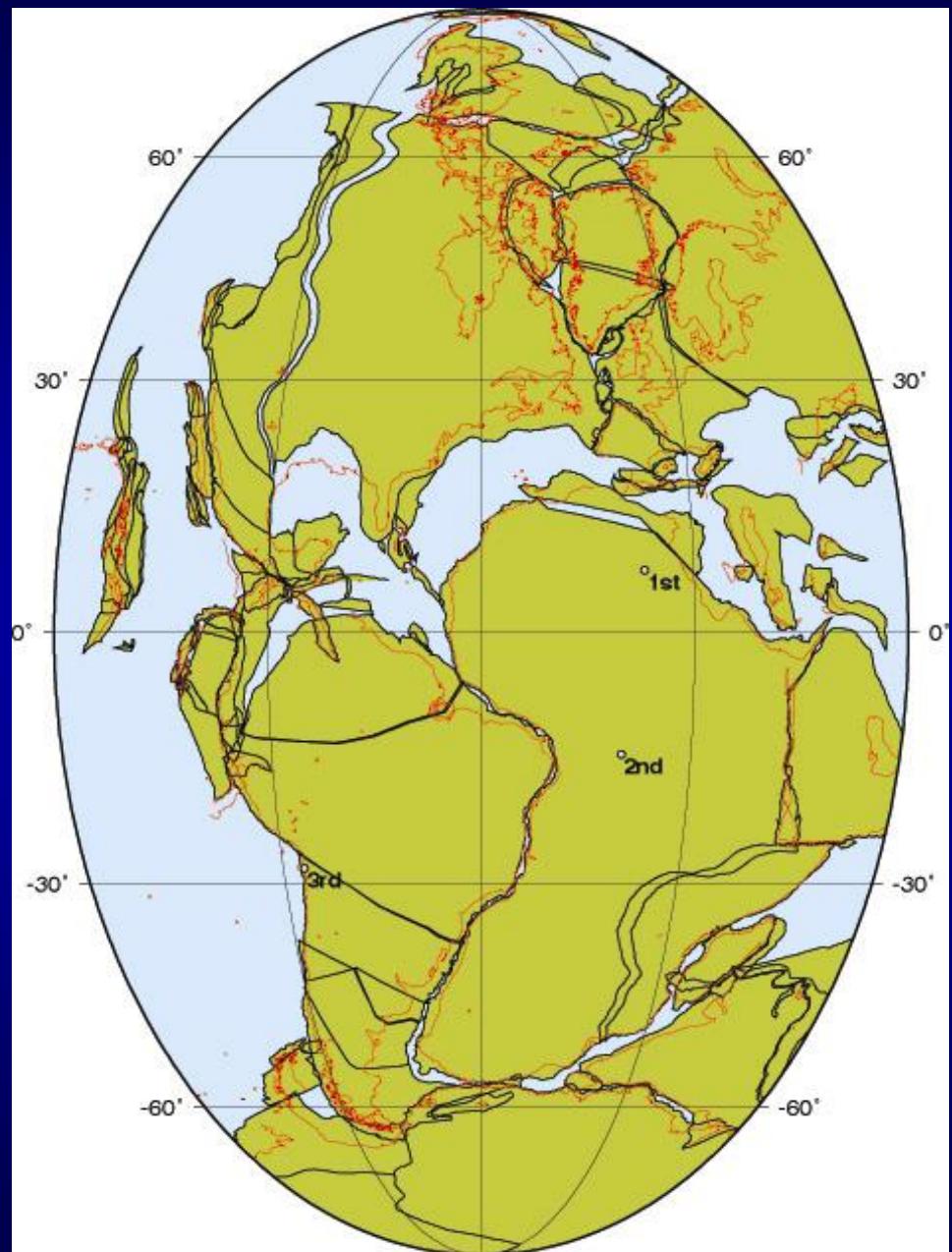


Plates'  
constellation:

150 Ma b.p.

red: shore lines

[www.odsn.de](http://www.odsn.de)

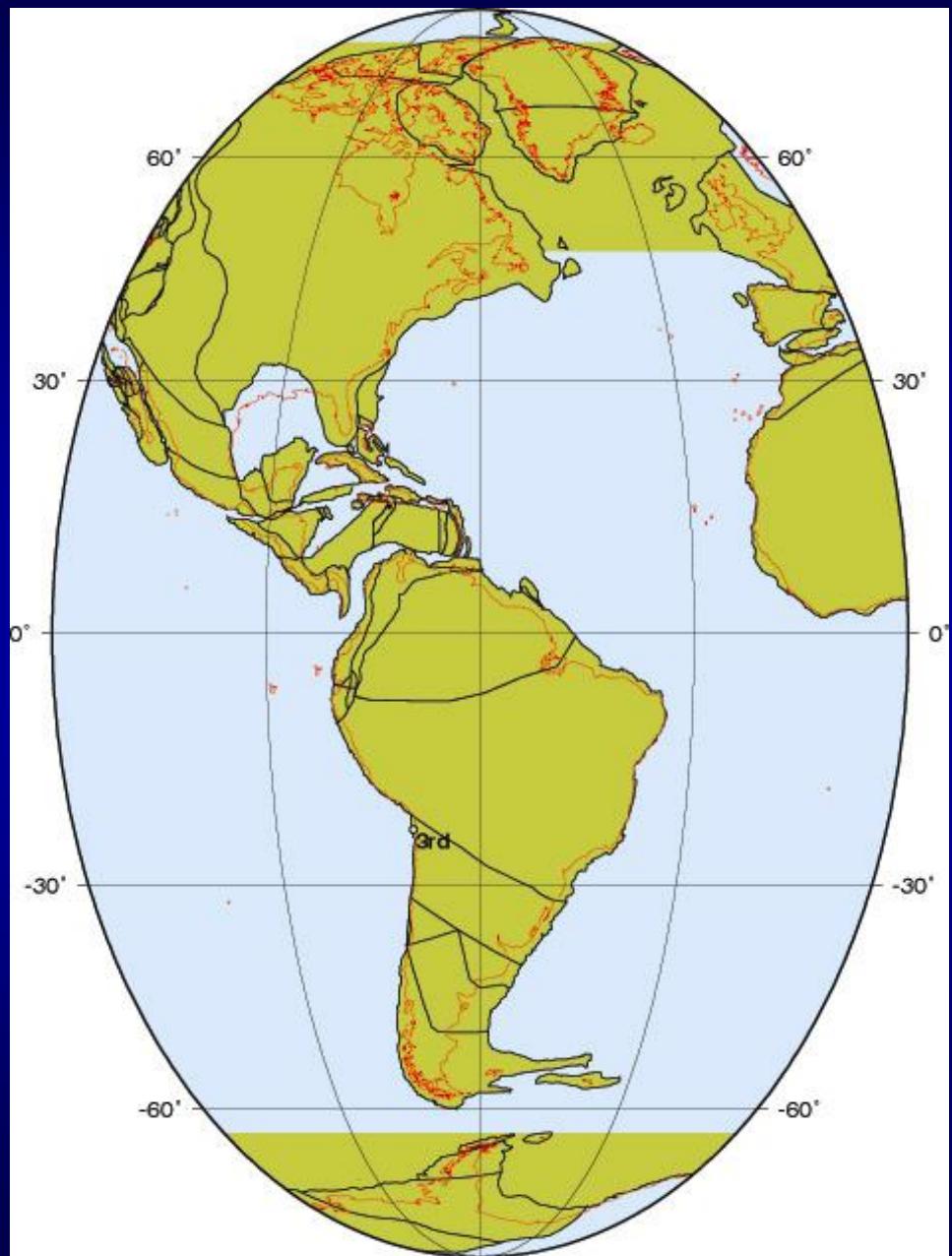


Plates'  
constellation:

13 Ma b.p.

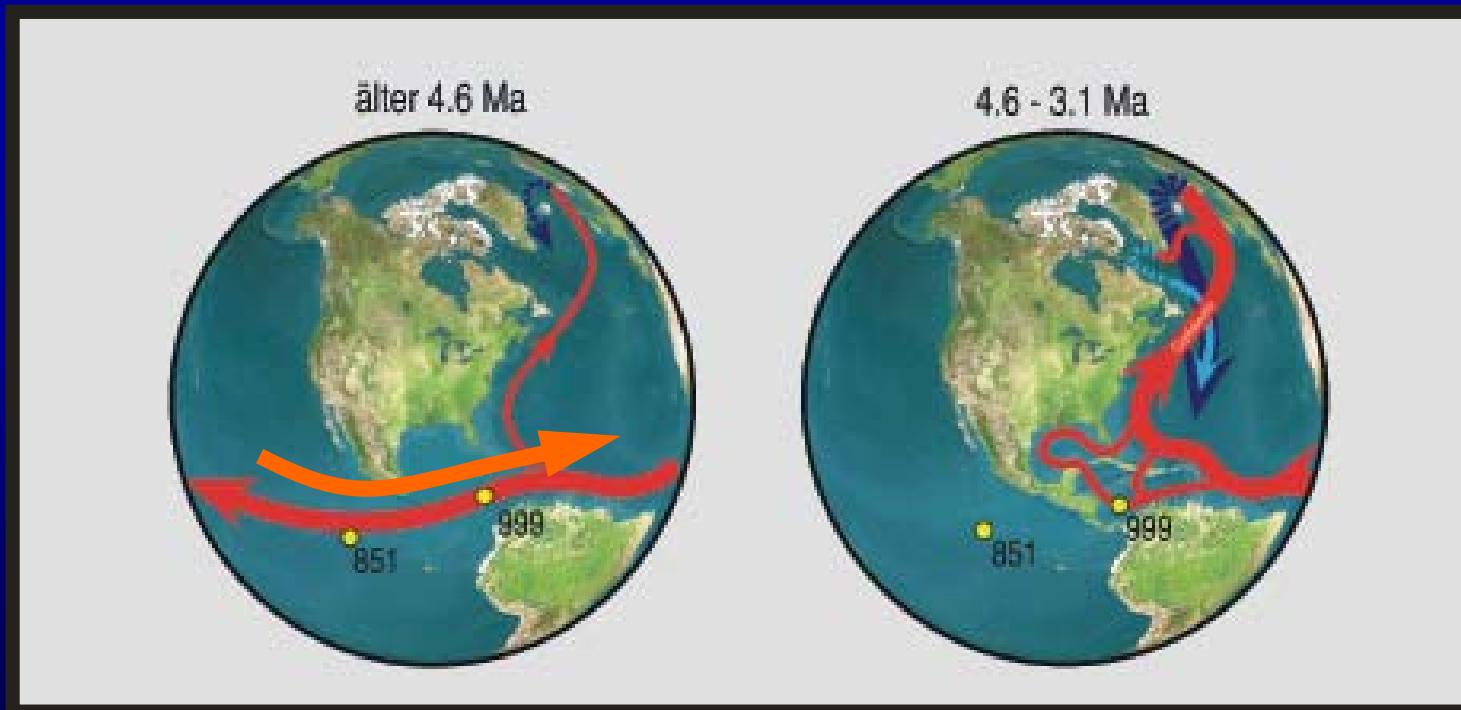
red: shore lines

[www.odsn.de](http://www.odsn.de)



## Severe changes, 4.6 Ma b.p.

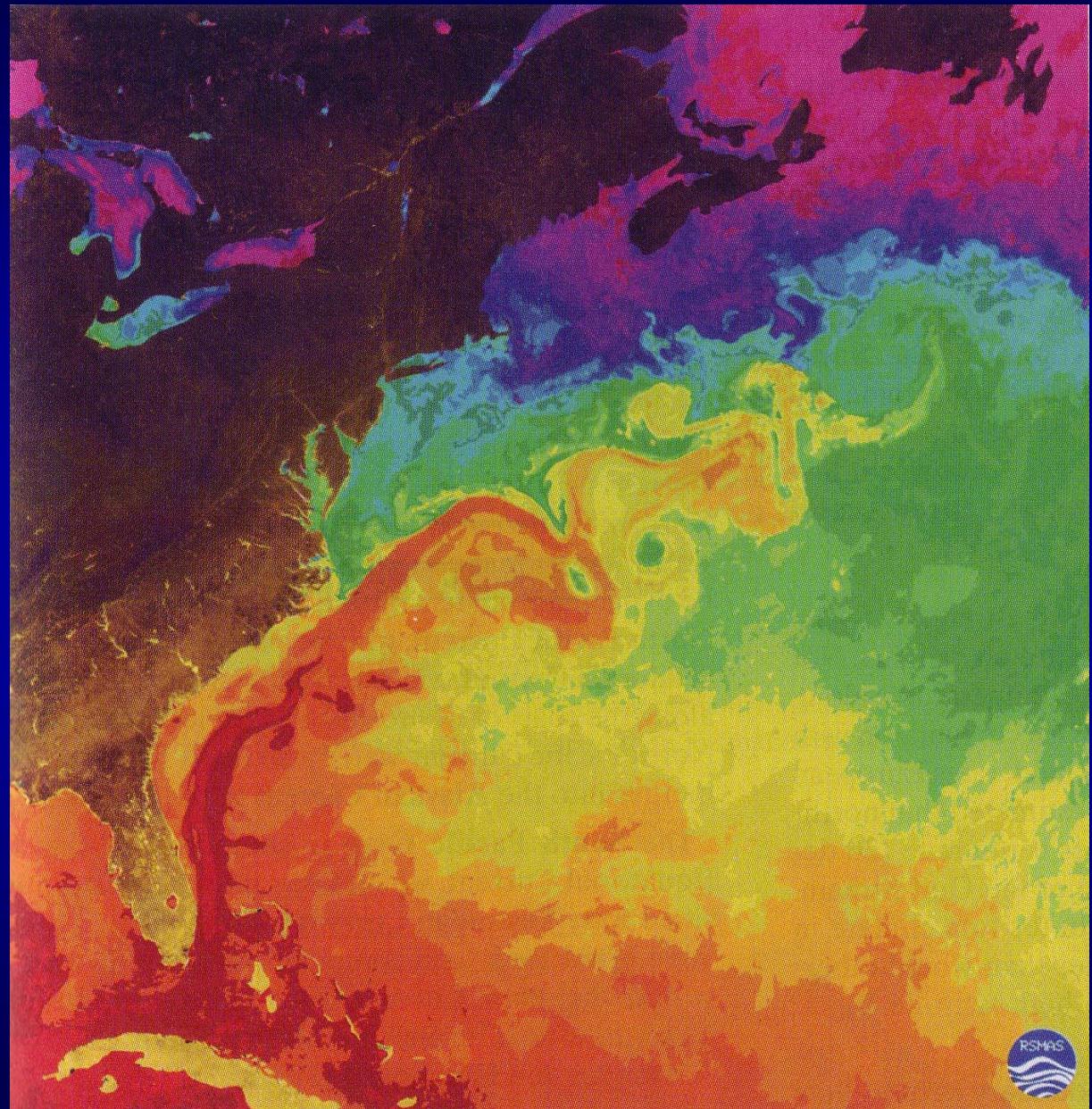
- shallow gateway (depth < 100 m)
- **complete reorganisation of the circulation pattern in the Atlantic ocean**



after Haug & Tiedemann, 1998

# Gulf Stream, sea-surface temperatures

Thurman & Trujillo,  
1999



## Marine sediments

time interval:  
several million years

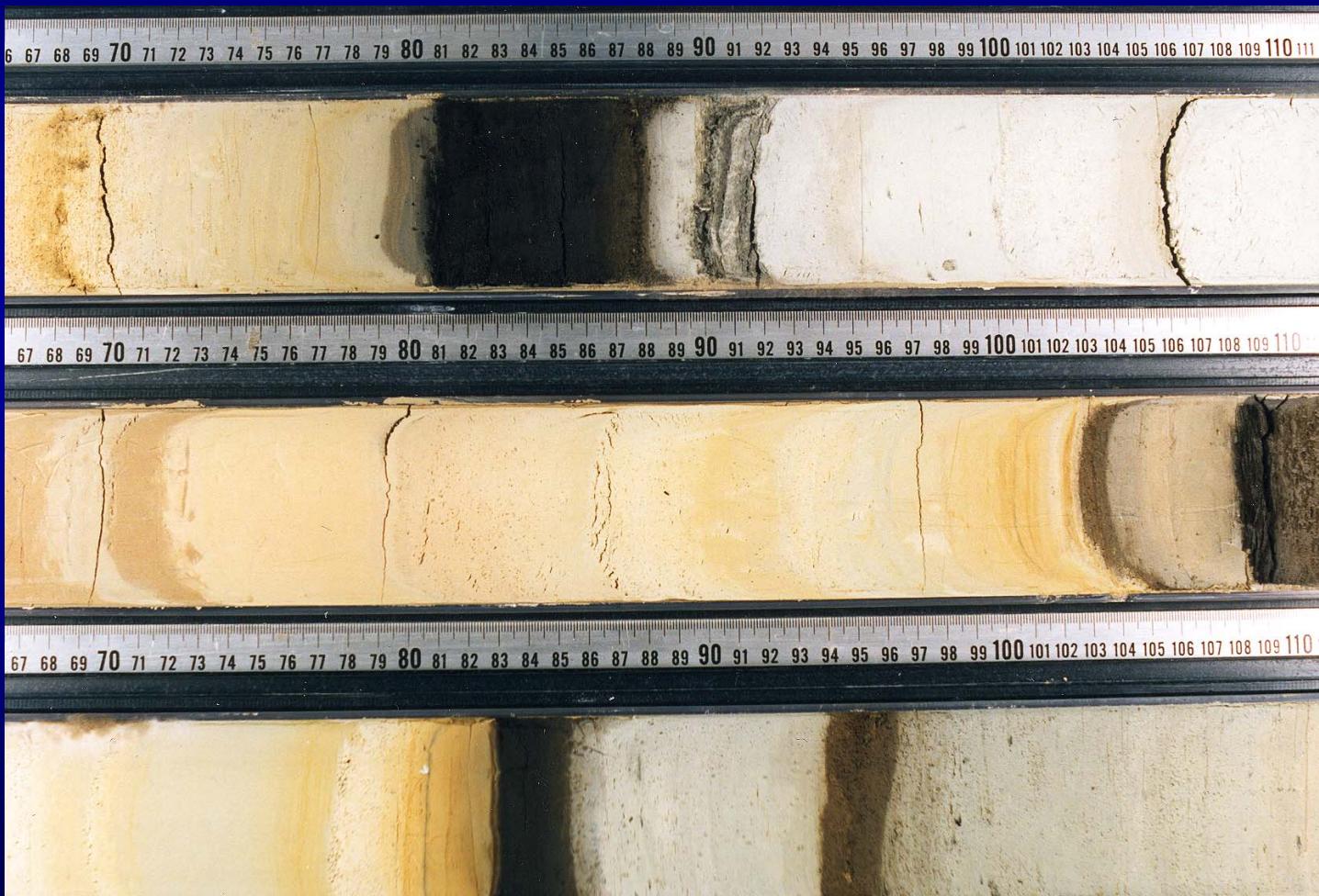
resolution:  
about 1000 years

parameter:  
SST, salinity, ice  
volume, nutrients,  
productivity, ocean  
circulation



Bremen core repository, IODP, 2004

# Marine sediments

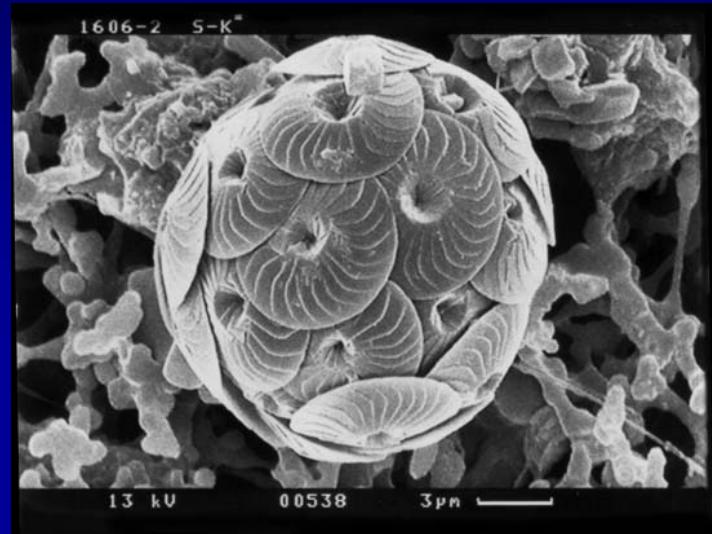


marum

# Marine sediments: archives of the past



foraminifers



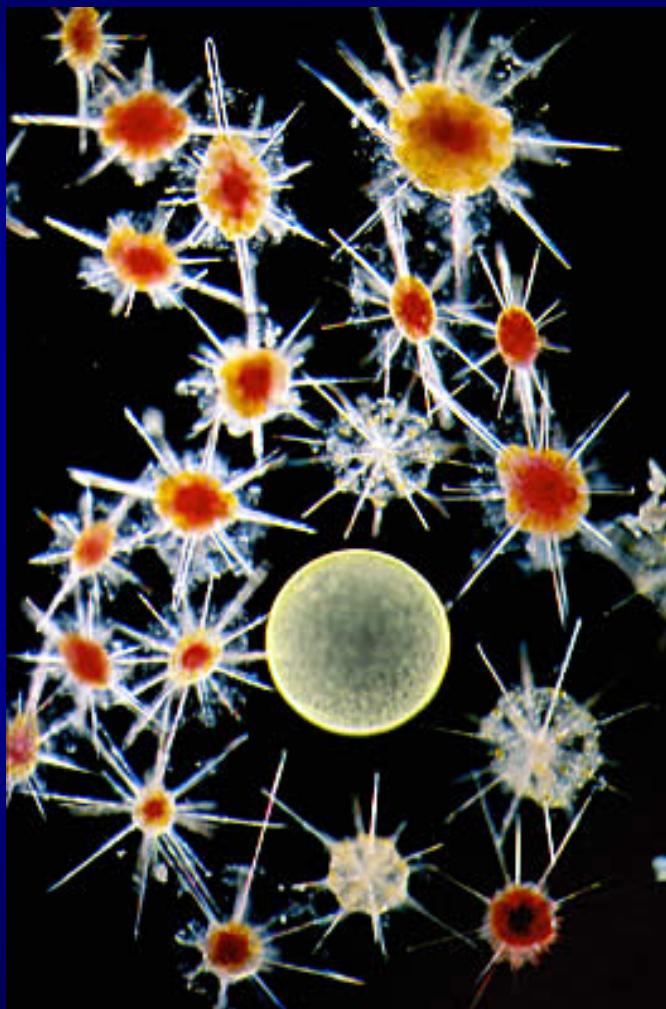
coccolithophorides

calcareous  
microfossils



pteropods

# Marine sediments: archives of the past

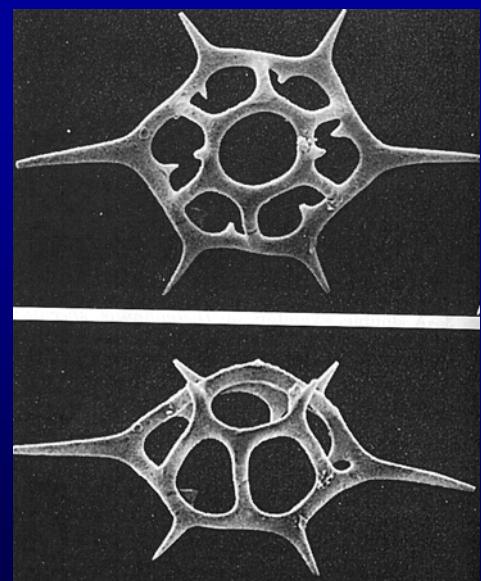


radiolaria, alive



diatoms,  
alive

siliceous  
microfossils



silicoflagellates