Atlantic Meridional Overturning Circulation (AMOC) step-wise inception during the present interglacial recorded by Neodymium isotopes (εNd).

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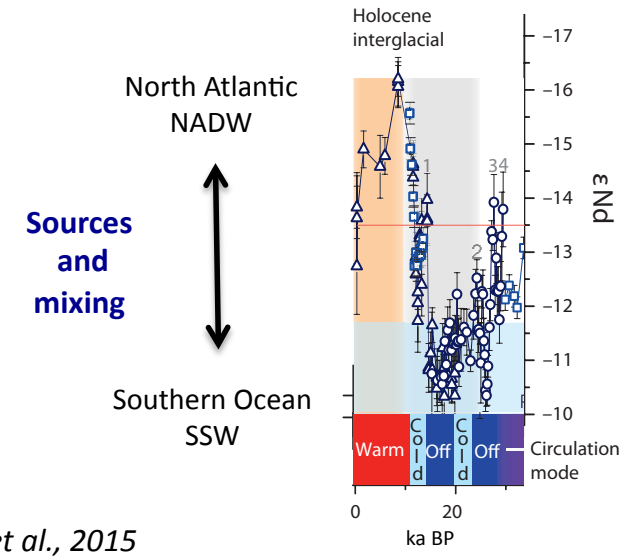
• One key uncertainty in climate projections is the response of the AMOC and deep-ocean convection processes in the Labrador Sea to high latitude warming and ice-sheet melting [1,2]. Post-glacial times are characterized by such large changes and receive much attention to decipher parameters governing AMOC changes.

• In this respect, water-mass εNd in the open ocean revealed a sensitive tracer of water-mass mixing and trajectories [3]. Distinct εNd are ultimately derived from the continents and delivered to the ocean through weathering and particle–seawater interactions.

$$\varepsilon Nd = [(^{143}Nd/^{144}Nd)_{sample}/(^{143}Nd/^{144}Nd)_{CHUR}-1]x10^4$$

• Post-glacial changes of the AMOC documented by εNd records [4] :

Bermuda Rise deep-sea sediments

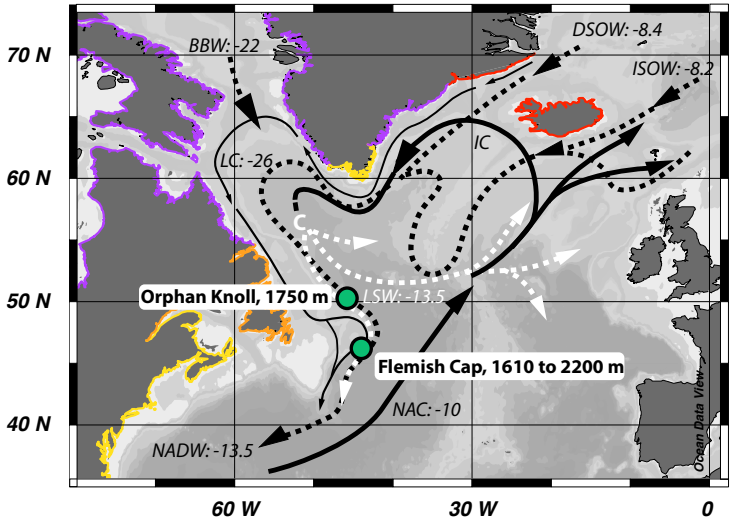


Böhm et al., 2015

They illustrate the progressive inception of the AMOC components originating from the Nordic Seas. Interpretations rely upon constant NADW signature through time

However, little is known about AMOC western and shallowest component, i.e. the Labrador Sea Water (LSW), and its Nd-isotope contribution to the NADW composition.

Locations of studied sites (green dots). Main circulating water masses are reported with their dissolved εNd signature [3,5]



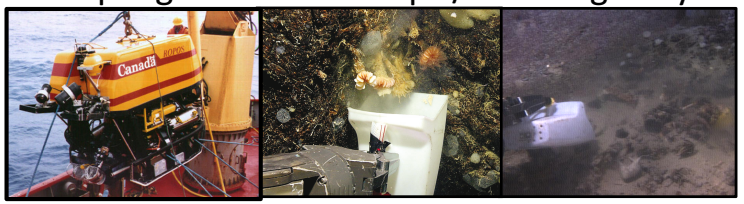
Continental εNd [6]: < -20 : ■ ; -15 to -10 : ■ ; -10 to -5 : ■ ; > -5 : ■

LSW: Labrador Sea Water ; NAC: North Atlantic Current; IC: Irminger Current; BBW: Baffin Bay Water; LC: Labrador Current; NADW: North Atlantic Deep Water; DSOW: Denmark Strait Overflow Water ; ISOW: Iceland-Scotland Overflow Water

Water masses circulating in the North Atlantic: a large array of εNd signatures stretched out between unradiogenic εNd inherited from glacial erosion of circum-Baffin Bay Precambrian basements and radiogenic εNd from young volcanic material of Iceland and the Reykjanes Ridge.

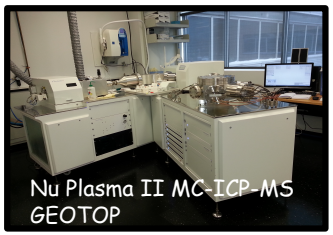
Present-day: Newly formed LSW signature results from a mixing of fresh subarctic waters (BBW, LC) with warm/saline NAC [5]

ROPOS sampling vertical outcrops / « coral graveyards »:

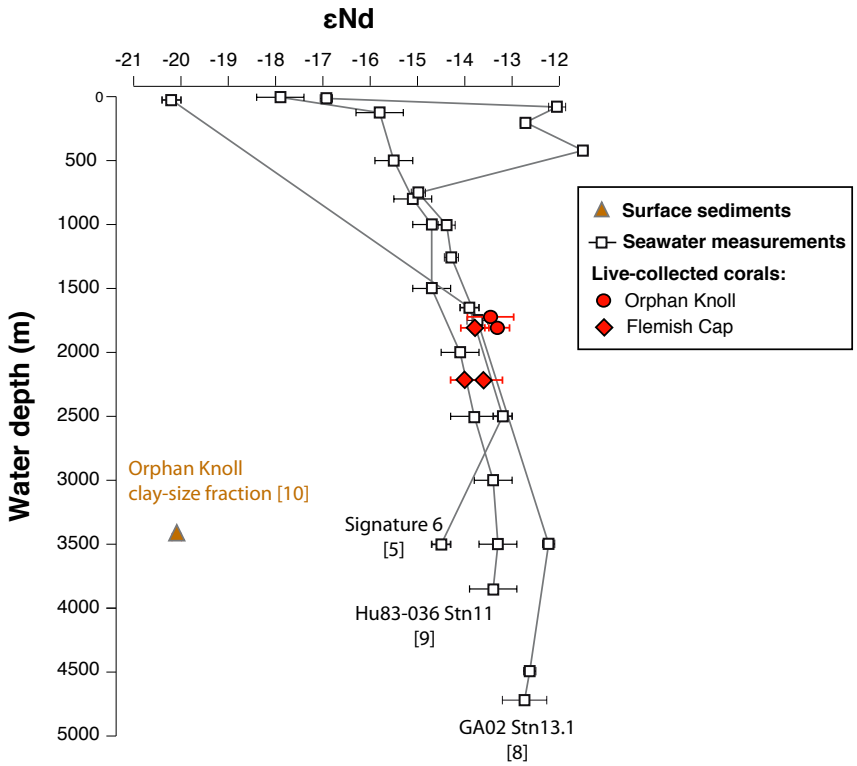


→ *Desmophyllum dianthus* collection at GEOTOP = 70 specimens

✓ Cleaning [7]
✓ U-Th
✓ Nd
21 specimens



Calibration: modern corals reflect ambient seawater



- Agreement with modern LSW signature (-13.5 to -14) [5,8]
- Strong contrast between particulate vs. dissolved Nd signatures -> sensitivity to changes in isotopic exchanges with this particulate flux

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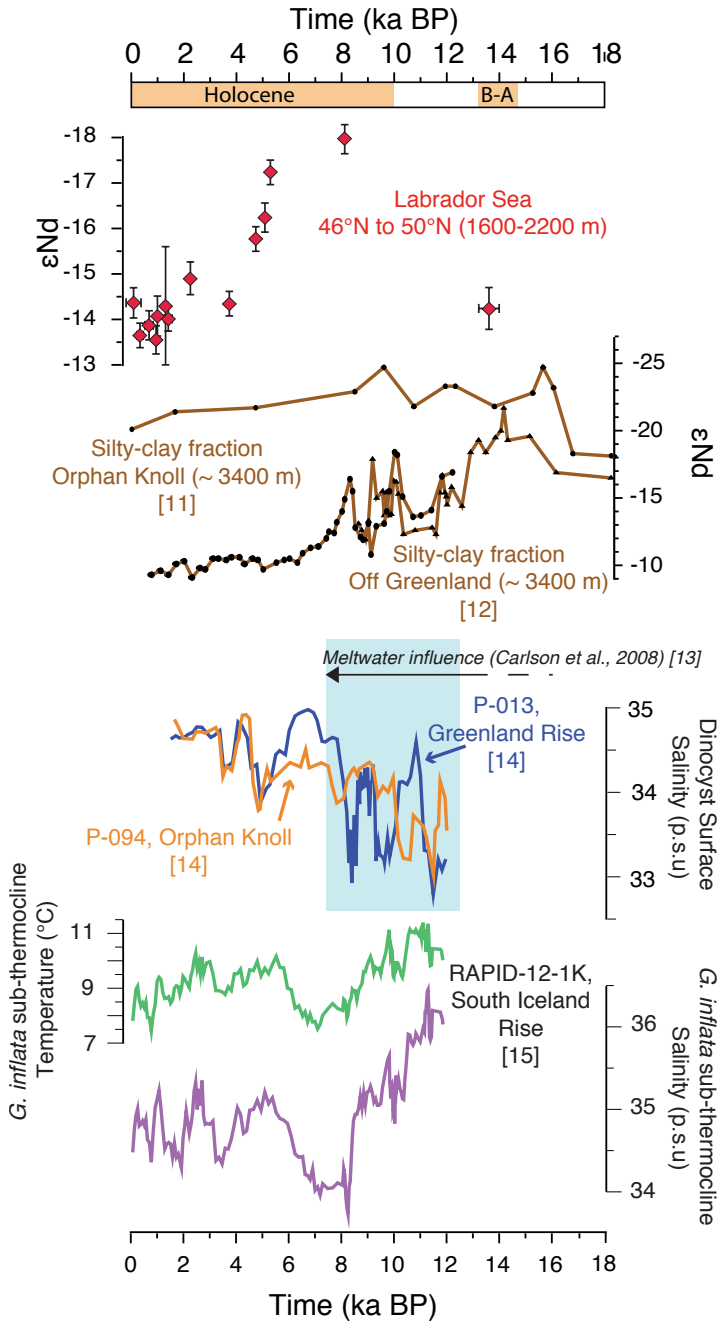

Early Holocene: influence of terrigeneous inputs

Deglacial fluxes enhanced unradiogenic Nd contributions into the Labrador Sea and that are predominant in intermediate to deep waters (εNd ~ -18 at about 8 ka BP)

What are the drivers of the mid-Holocene εNd shift?

- Lags the latest significant meltwater supplies from Laurentide Ice-Sheet (LIS) at ~ 7ka BP [13]

- Likely relates to **increased radiogenic supplies from the southern Irminger basin area**, following the inception of a strong post-glacial Irminger Current between ~ 7 and ~ 5 ka BP [16] in connection with Sub-polar Gyre dynamics

- Coincides with a **maximum influence of tropical warm/saline water masses** from near surface to the sub-thermocline, and routing to the Irminger Basin South of Iceland [15]

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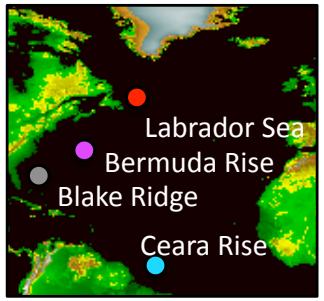
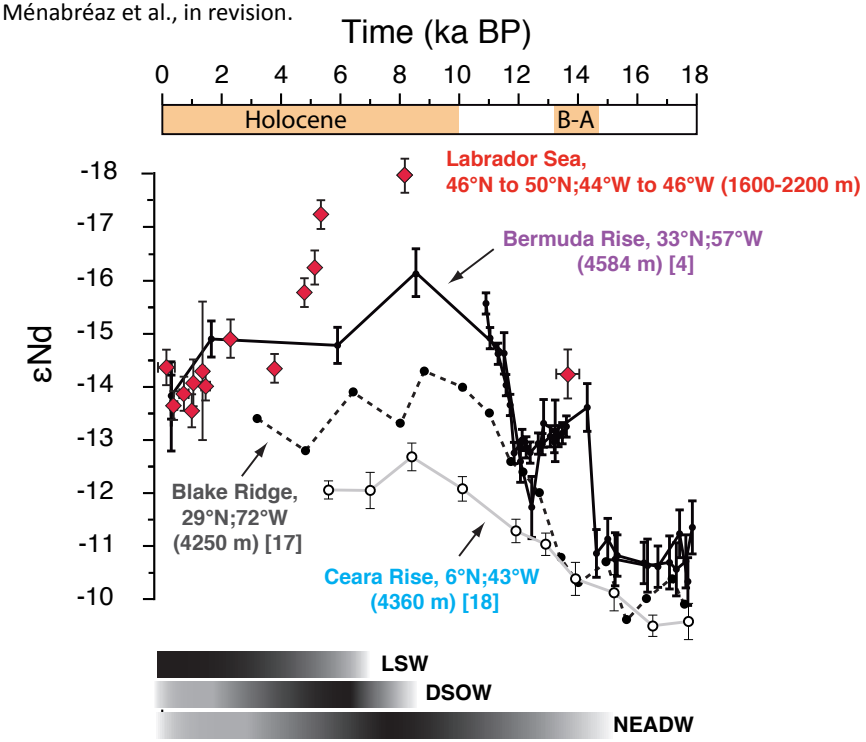
Step-wise inception of the AMOC: Late Holocene modern-like LSW production



Ménabréaz et al., in revision.

• Early Holocene: decoupling of Labrador Sea vs. mature NADW
• **After 4 ka BP: « full » LSW contribution to NADW i.e. modern-like AMOC conditions**



→ **Unradiogenic imprint** on **Early Holocene** NADW εNd-signature linked to intense isotopic exchange within Labrador Sea (role of frequent and large scale turbidity currents triggered by LIS instabilities)

→ **LSW production: a more radiogenic labelling** of LSW and thus NADW, as it implies a more important contribution from radiogenic saline NE Atlantic sources.

→ modern-like εNd signature in intermediate waters of the Labrador Sea does not necessarily mean that convection occurs in the basin, as illustrated by the Bølling-Allerød interval

→**A critical factor** for modern-like LSW = **salt addition** from open North Atlantic via Irminger-type current.
+ Possible effect of Neoglacial ?

Pattern of a progressive westward shift in the assemblage of a modern-like NADW: combined effect of the sequential late-glacial reduction in meltwater supplies from east to west (i.e., from Fennoscandian to Inuitian/Laurentide ice-sheets) with a concomitant partial westward deflexion of North Atlantic waters driving salty waters towards the Labrador Sea

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Related Article: Ménabréaz L., Hillaire-Marcel C., Maccali J., Poirier A., Ghaleb B. & Edinger E. In revision. Impact of fresh- vs. Salt-water fluxes in the Labrador Sea on the full inception of the modern AMOC from deep-sea coral Nd-record.

References:

[1] Stocker et al., 2013. IPCC, 2013 : Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2013).

[2] Sgubin et al., 2017. https://doi.org/10.1038/ncomms14375

[3] Tachikawa et al., 2017. https://doi.org/10.1016/j.chemgeo.2017.03.018

[4] Böhm et al., 2015. https://doi.org/10.1038/nature14059

[5] Lacan & Jeandel, 2005. https://doi.org/10.1029/2005GC000956

[6] Georoc Database http://georoc.mpch-mainz.gwdg.de/georoc/

[7] van de Flierdt et al., 2010. https://doi.org/10.1016/j.gca.2010.08.001

[8] Lambelet et al., 2016. https://doi.org/10.1016/j.gca.2015.12.019

[9] Piepgras & Wasserburg, 1980. https://doi.org/10.1016/0012-821X(80)90124-7

[10] Innocent et al., 1997. https://doi.org/10.1016/S0012-821X(96)00251-8

[11] Fagel et al., 1999. https://doi.org/10.1029/1999PA900041

[12] Fagel et al., 2004. https://doi.org/10.1029/2003PA000993

[13] Carslon et al., 2008. https://doi.org/10.1038/ngeo285

[14] Solignac et al., 2004. https://doi.org/10.1016/j.quascirev.2003.06.003

[15] Thornalley et al., 2009. https://doi.org/10.1038/nature07717

[16] Andersen et al., 2004. https://doi.org/10.1016/j.quascirev.2004.08.004

[17] Gutjahr et al., 2008. https://doi.org/10.1016/j.epsl.2007.10.037

[16] Howe et al., 2016. https://doi.org/10.1130/G38155.1