Seawater-derived Nd isotope records in the Chukchi Sea, western Arctic Ocean during Holocene : implications for oceanographic circulation

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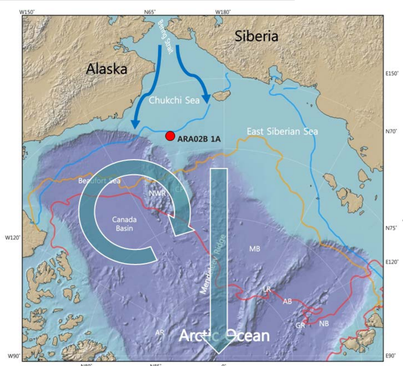
Abstract

Changes in oceanographic circulation in the Artic have a large influence on the global oceanic and climate system of the Earth through the geological times. In particular, freshwater input from the North Pacific to the western Arctic Ocean affects the Atlantic meridional overturning circulation (AMOC) after the opening of the Bering Strait. Seawater-derived neodymium isotope in marine sediments has been used as a proxy to trace the origin of water masses and oceanic circulation system. The global average residence time of Nd is shorter than the global ocean mixing time and dissolved Nd in seawater behaves quasi-conservatively. In the modern Arctic Ocean, the Nd isotope distribution is dominated by Atlantic source water, although the circum-Arctic riverine discharge and Pacific-derived waters also have noticeable impacts.

In this study, we investigated seawater-derived neodymium isotope records from a sediment core recovered from the Chukchi Sea to understand the changes in hydrograhic circulation of the western Arctic during the Holocene.

To obtain seawater-derived Nd records, we extracted Fe-Mn oxide coatings as an authigenic fraction from bulk sediments by leaching with acid-reducing solution after removing carbonate by leaching with acetic acid. Our preliminary results might show a general pattern of increasing radiogenic ε_{Nd} values through Holocene intervals. Therefore, it implies that ε_{Nd} results may be related with variations in the intensity of Bering Strait inflow during the last ~9.31 ka BP. The radiogenic trend was strongly pronounced from the late Holocene (ε_{Nd} -7.23; ca. 8.86 ka BP) to the middle Holocene (ε_{Nd} -4.78; ca. 6.20 ka BP) and vaguely during the middle Holocene. After 4.99 ka BP, ε_{Nd} values were increased again from -4.86 to -4.03 at 0.60 ka BP. $^{87}Sr/^{86}Sr$ values vary from 0.70929 to 0.70991 throughout the whole sediment core and they might be higher than the Sr isotopic value of modern seawater (0.70918). This implies that the leachates may not be preserved past seawater signal. Thus, our preliminary results indicate that further studies for assessment of leaching methods and for other reliable seawater-derived records (including authigenic carbonates, i.e., foraminiferal and bivalve shells which are found in sediment cores) are necessary.

Study Area



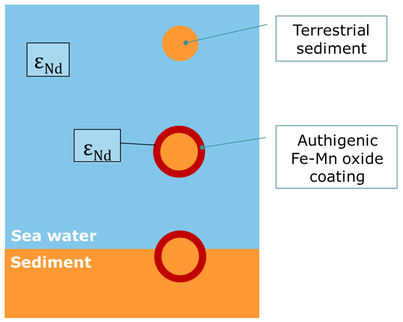
- **ARA02B 01A GC**
  - During Araon expeditoin in 2011
  - On the northern shelf of the Chukchi Sea
  - 73°37.8939'N, 166°30.9838'W
  - ca. 111 m in water depth
  - 546 cm long / ~ 9.31ka BP

- **Surface Arctic circulation**
  - The Bering Strait Inflow
  - The East Siberian Current
  - The Beaufort Gyre
  - The Transpolar Drift

Seawater-derived Nd isotope records

- **Nd isotope records as a water mass tracer**
  - Residence time of Nd in seawater < ocean mixing time

- **Seawater-derived Nd isotope records**
  - Dissolved Nd in seawater
    → incorporate to the Fe and Mn oxyhydroxides by adsorption, replacement, and co-precipitation.

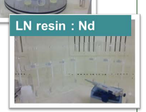


$$\varepsilon_{Nd} = \left[\frac{\left(\frac{^{143}Nd}{^{144}Nd}\right)_{sample} - \left(\frac{^{143}Nd}{^{144}Nd}\right)_{CHUR}}{\left(\frac{^{143}Nd}{^{144}Nd}\right)_{CHUR}}\right] \times 10^4$$

Methods

Grinding bulk sediment → Weighing (~1000mg) → Remove carbonate → Fe-Mn coating extraction → Column purification

Aliquoting for trace element analysis (ICP-MS)

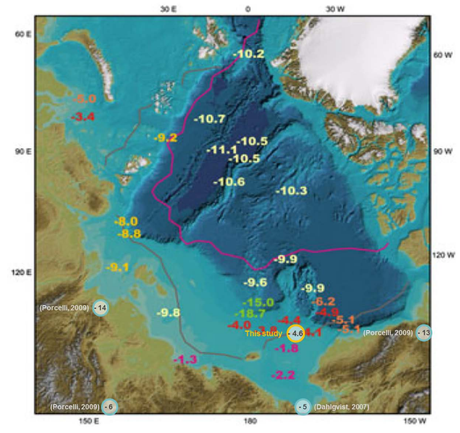


Sequential extraction method used for obtainng the authigenic Fe-Mn oxide leachates

	Bayon et al. (2002)			Gutjahr et al. (2007)			Haley & Polyak (2013)			this study		
Fraction	Reagent	Temp [°C]	Time [h]	Reagent	Temp [°C]	Time [h]	Reagent	Temp [°C]	Time [h]	Reagent	Temp [°C]	Time [h]
Carbonate	10 % AA[1)]	25	3	1 M Buffered AA	25	3)	7M Buffered AA	25	0.5	1 M Buffered AA	25	3)
Fe-Mn Oxide	1 M HH[2)] in 25 % A A	80	3	0.05 M HH (pH 4) in 15 % AA	25	3	3.5M Buffered AA ⇒"a" leachate	25	> 12	0.02 M HH (pH 4.5) in 25 % AA	25	3
							0.025 M HH (pH 4) in 1.25 M AA ⇒ "b" leachate	25	1			

1) AA : Acetic Acid
2) HH : Hydroxylamine Hydrochloride
3) Until reactoin is complete

ε_{Nd} distribution in the modern Arctic



(Haley & Polyak, 2013)

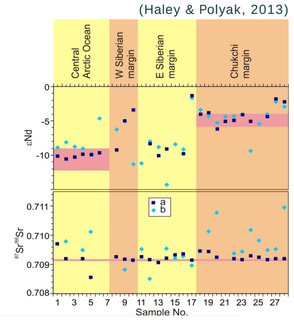
- **ε_{Nd} of surface sediments in Arctic (Haley & Polyak, 2013)**
  End-members
  – Atlantic (~ 11 ε_{Nd})
  – Pacific (~ 5 ε_{Nd})

  Deviations of Chukchi samples
  - Sediment redistribution
  - Deep water cascades downslope

- **ARA02B 01A : ~ 4.6 ε_{Nd}**
  Comparable with Haley & Polyak (2013), despite of different leaching methods

ε_{Nd} records during Holocene

(Haley & Polyak, 2013)



- **ε_{Nd} records trend :**
  Increasing Pacific inflow during Holocene
  1) 9.31 ~ 8.86 ka : decrease from – 6.6 to -7.2
  2) 8.86 ~ 6.20 ka : increase from -7.2 to -4.8
  3) 6.20 ~ 0.60 ka : increase slightly to -4.0
  4) core top : -4.6 (0~1cm), -4.9 (1~2cm)

- Comparable $^{87}Sr/^{86}Sr$ values with “a” leachate (Haley & Polyak, 2013) except 2 samples of core top (0 ~ 2cm)

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