Stable isotope geochemistry of pore waters from the New Jersey shelf: fluid origin

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SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY
UNIVERSITY OF HAWAI'I AT MĀNOA

ECORD
European Consortium for Ocean Research Drilling

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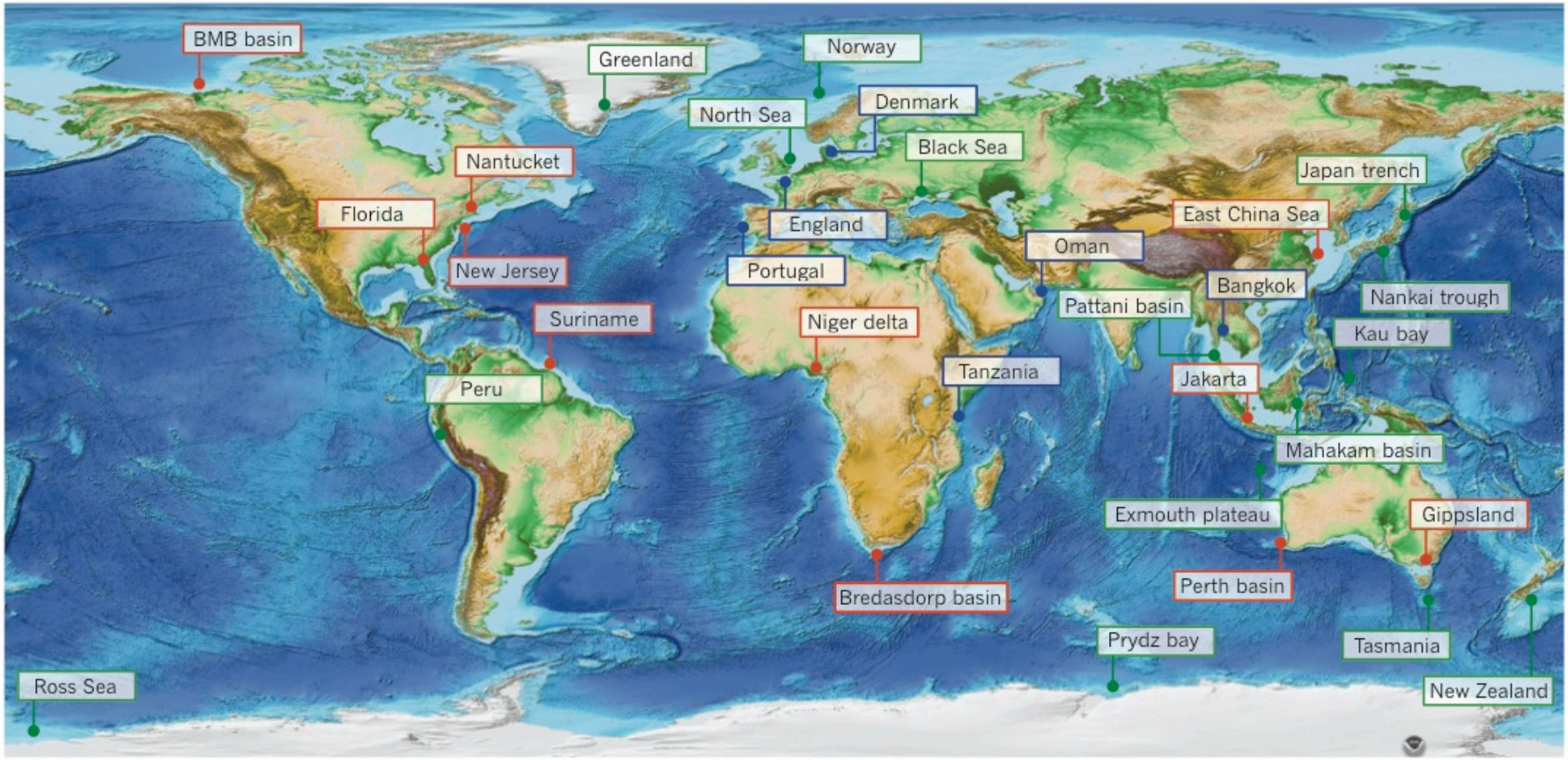
Offshore fresh groundwater



Post et al. (2013) nature

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Outline

- Stable isotopes analytical methods
- Modern or old? - Stable isotopes in hydrogeology
- The New Jersey shelf – older studies and conceptual models
- IODP Expedition 313 “New Jersey Shallow Shelf”
- Results of geochemical analyses
  - Water chemistry
  - Stable isotopes
- Fresh water - salt water stratification and fluid origin
- Implications for existing models

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ANALYTICAL METHODS

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Stable Isotopes

Standard delta notation in ‰:

$$\delta = \left(\frac{R_{sample}}{R_{reference}} - 1 \right)$$

„light values“ ➔ lower numbers, i.e. more negative
„heavy values“ ➔ higher numbers, i.e. less negative

Parameter		
Water chemistry	Onshore scientific party	Bremen
$\delta^{18}O$, $\delta^{2}H$, $\delta^{13}C_{DIC}$	Water isotope analyses	Erlangen University
$\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$	Carbonate isotopes	LIAG, Hanover
$\delta^{13}C_{org}$, $\delta^{13}C_{meth}$ and gas concentrations	Isotope analyses of C_{org} and gas isotopes	BGR, Hanover
$\delta^{34}S$	Sulfur isotopes	IOW
Mineralogy	XRD of carbonates	Erlangen University

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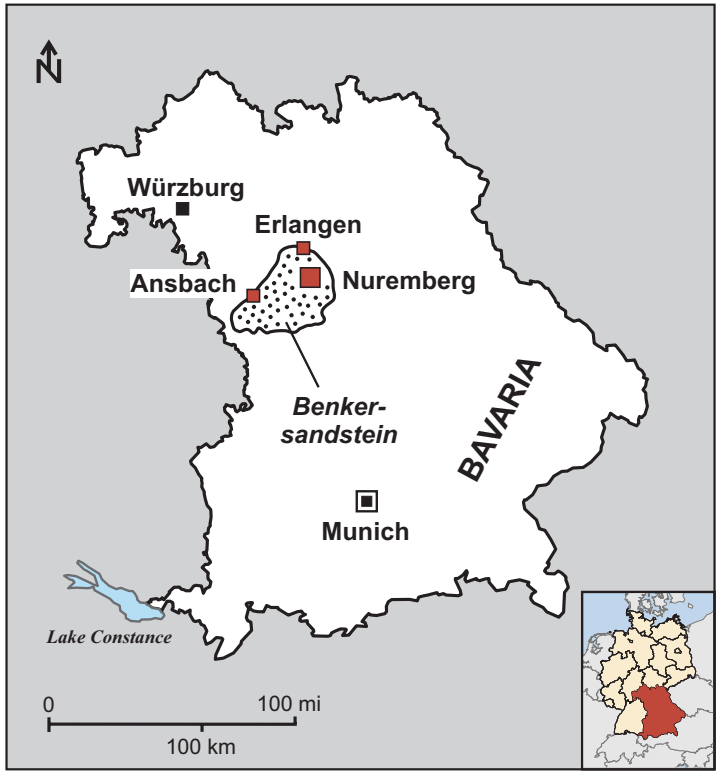

Modern water *vs* Paleowater

STABLE ISOTOPES IN HYDROGEOLOY

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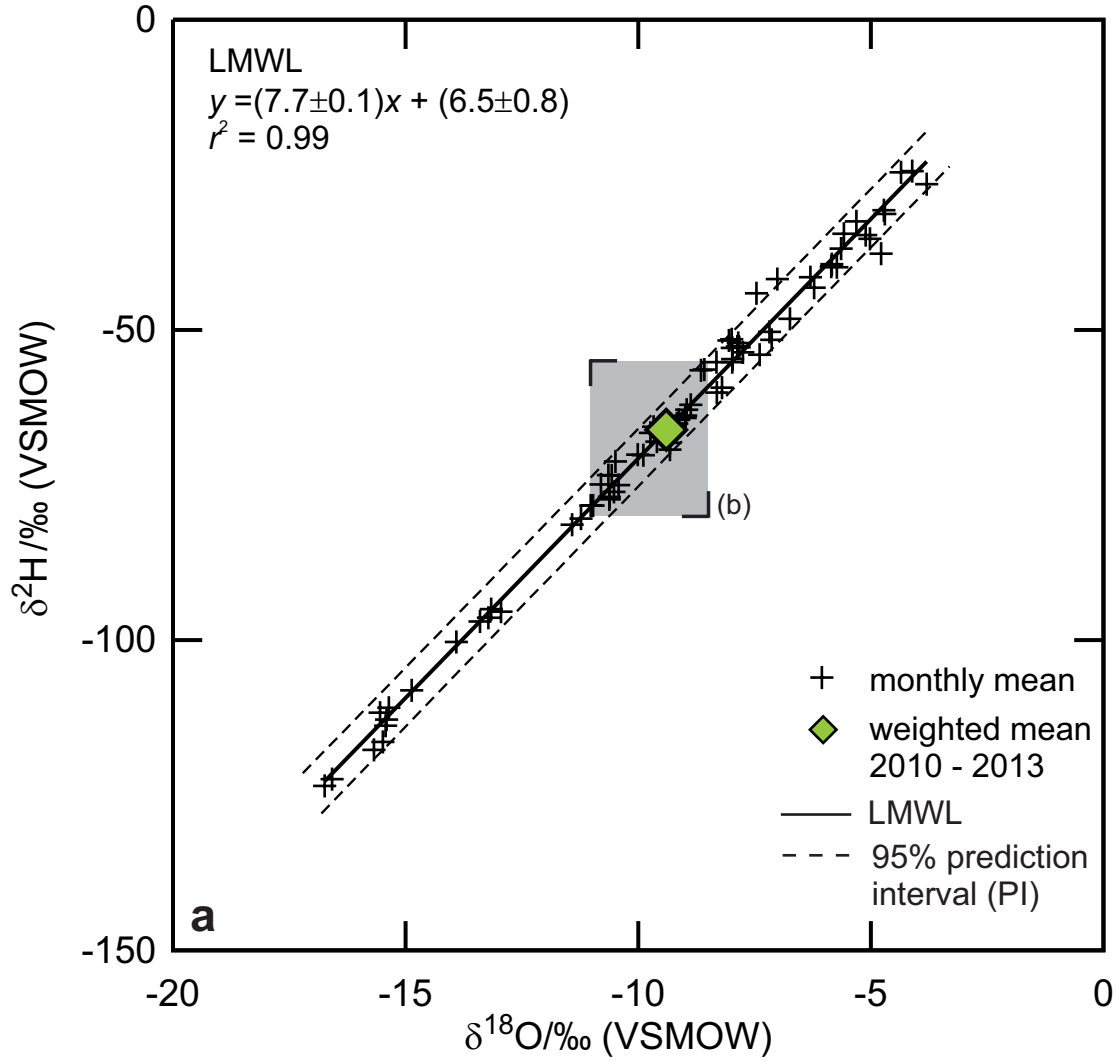
From precipitation to groundwater



Local meteoric water line (LMWL) – Erlangen city

(GNIP station 1076301)

van Geldern et al. (2014)

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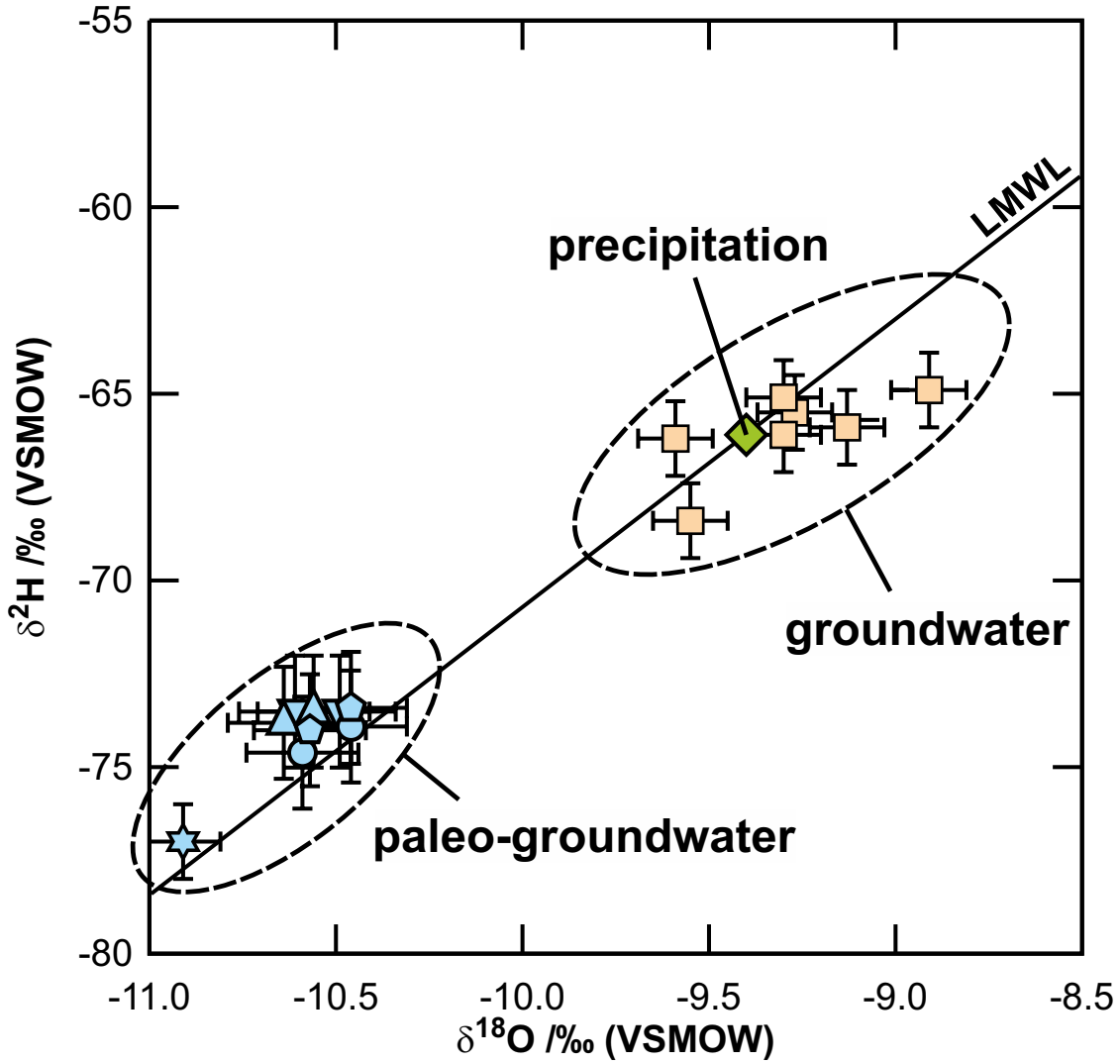
From precipitation to groundwater



van Geldern et al. (2014)

Precipitation

Groundwater
- shallow
- deep aquifer

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2 November 1979, Volume 206, Number 4418

SCIENCE

U.S. Geological Survey Core Drilling on the Atlantic Shelf

Geologic data were obtained at drill-core sites along the eastern U.S. continental shelf and slope.

John C. Hathaway, C. Wylie Poag, Page C. Valentine
Robert E. Miller, David M. Schultz, Frank T. Manheim
Francis A. Kohout, Michael H. Bothner, Dwight A. Sangrey

Older Studies and Conceptual Models

NEW JERSEY SHELF

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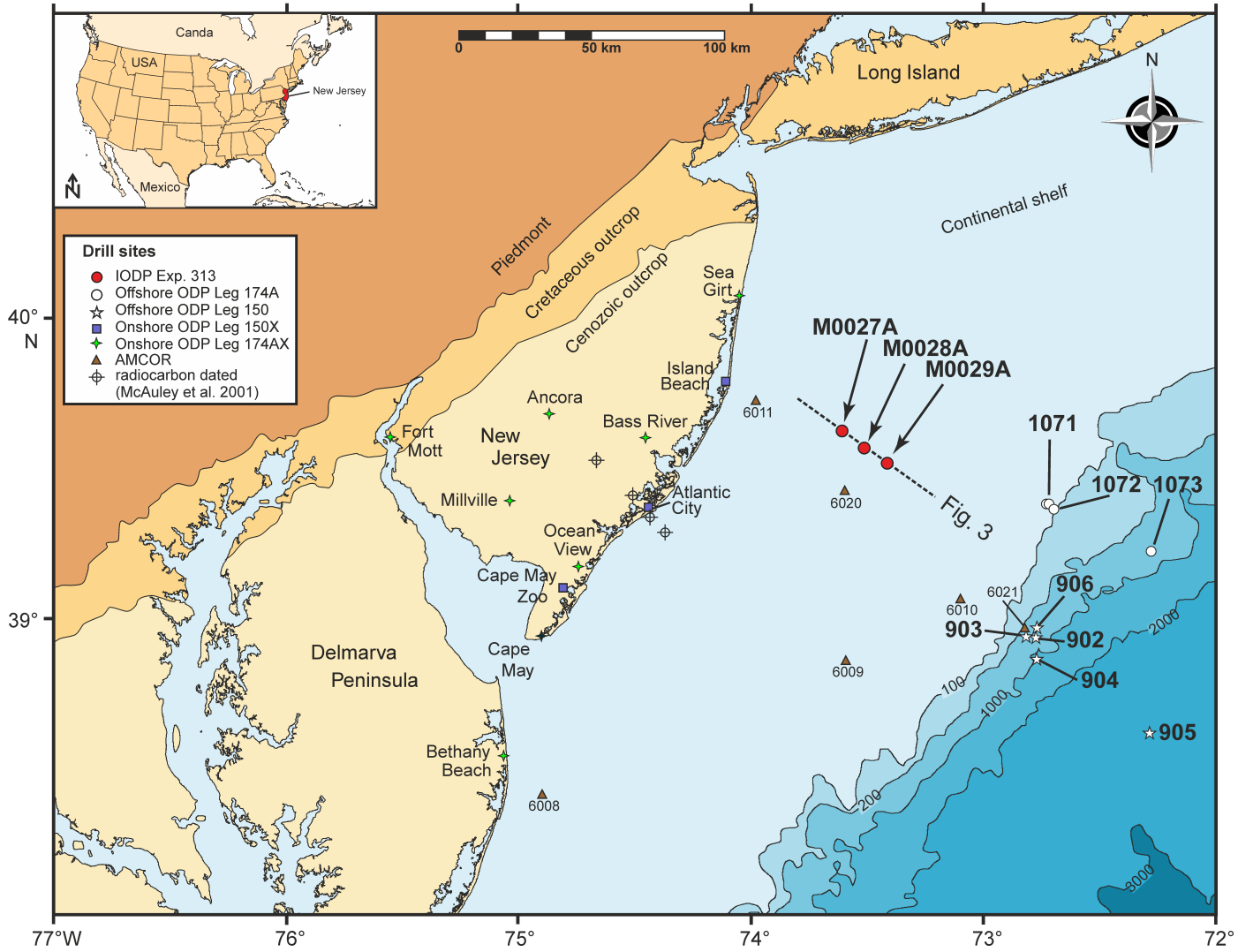
Drilling Site



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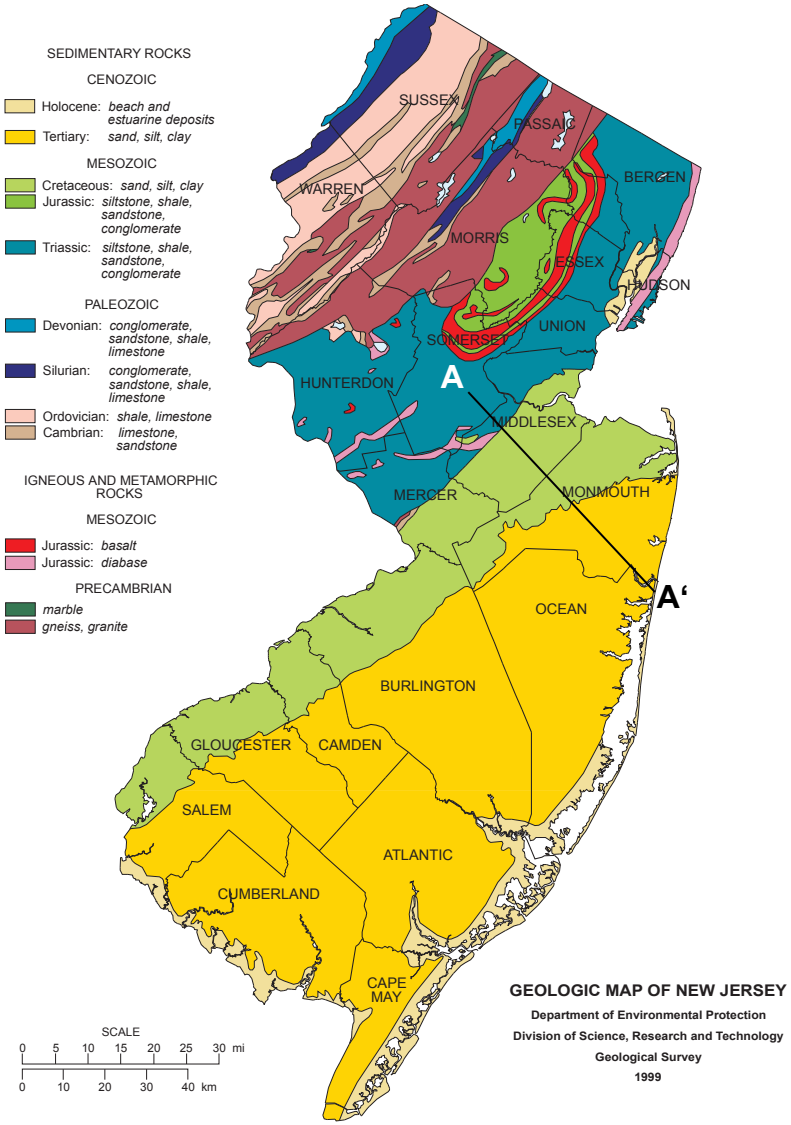
New Jersey – Onshore Geology



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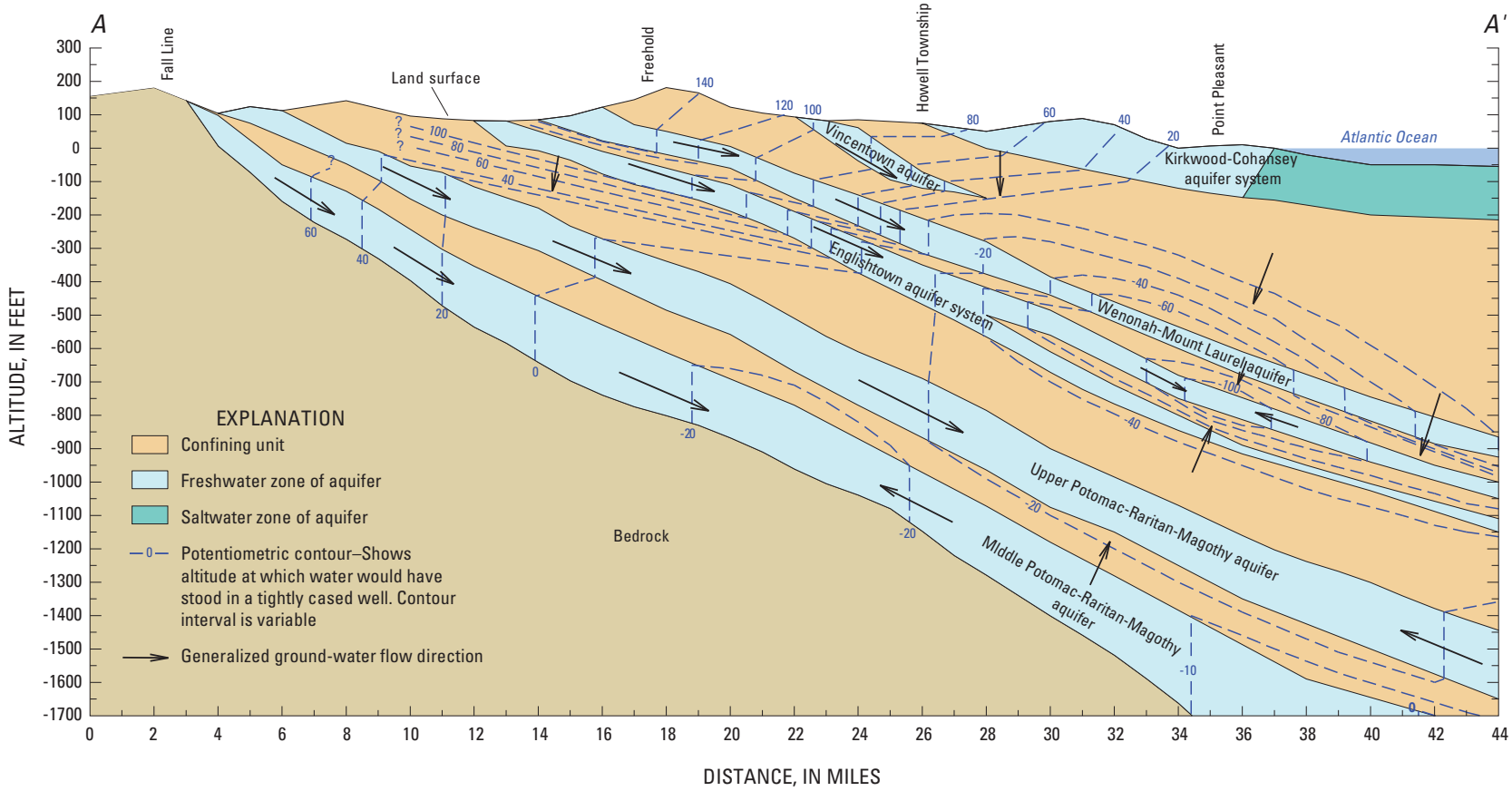
New Jersey - Aquifers



dePaul et al. (2003)

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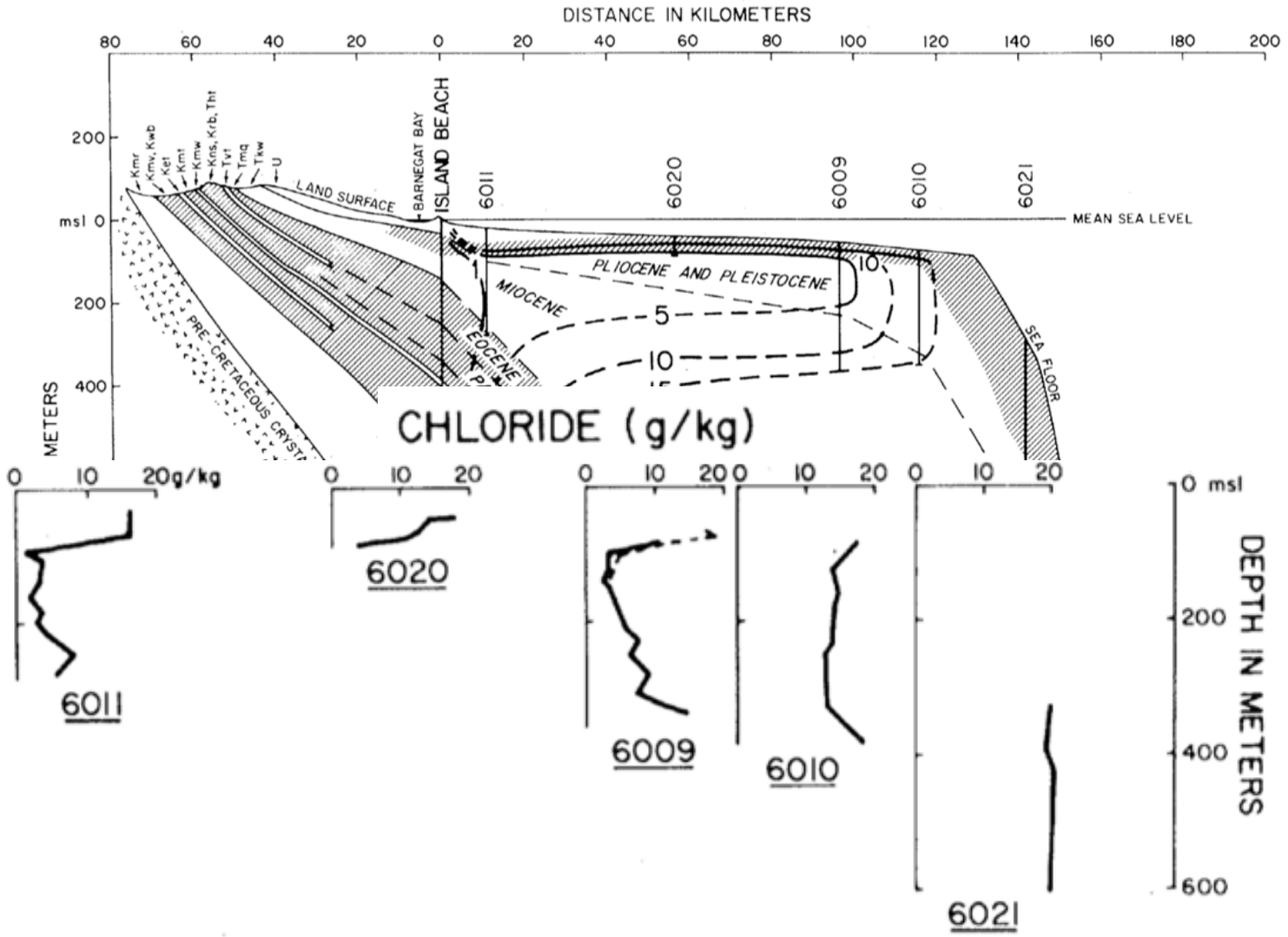
New Jersey Shelf Fresh Water Lens



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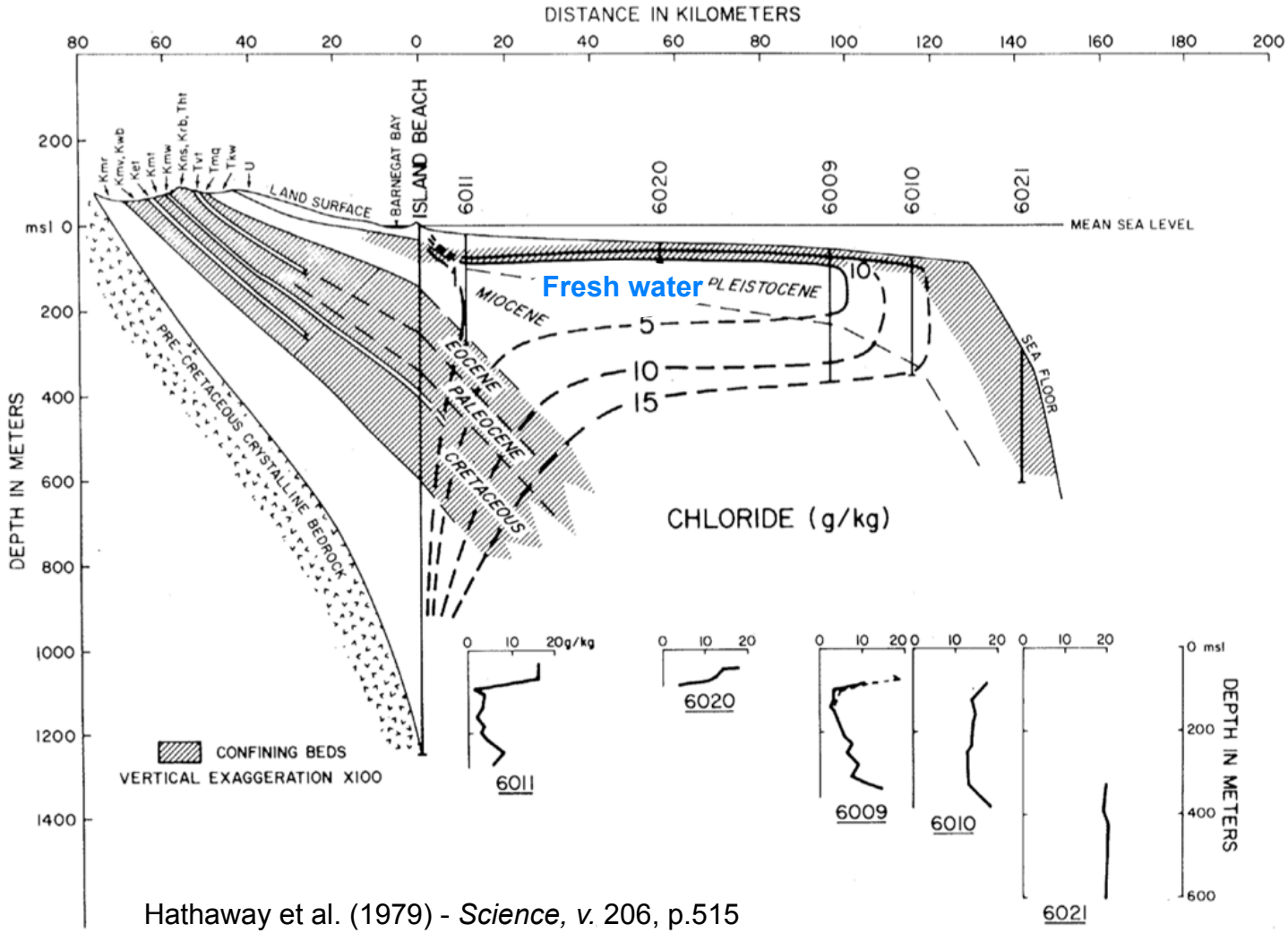
New Jersey Shelf Fresh Water Lens



Hathaway et al. (1979) - *Science, v.* 206, p.515

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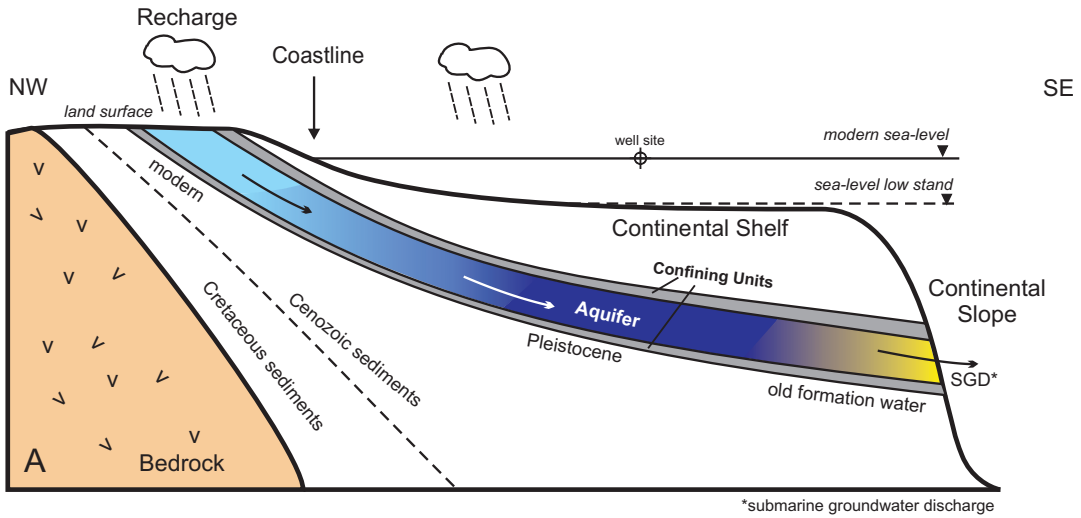
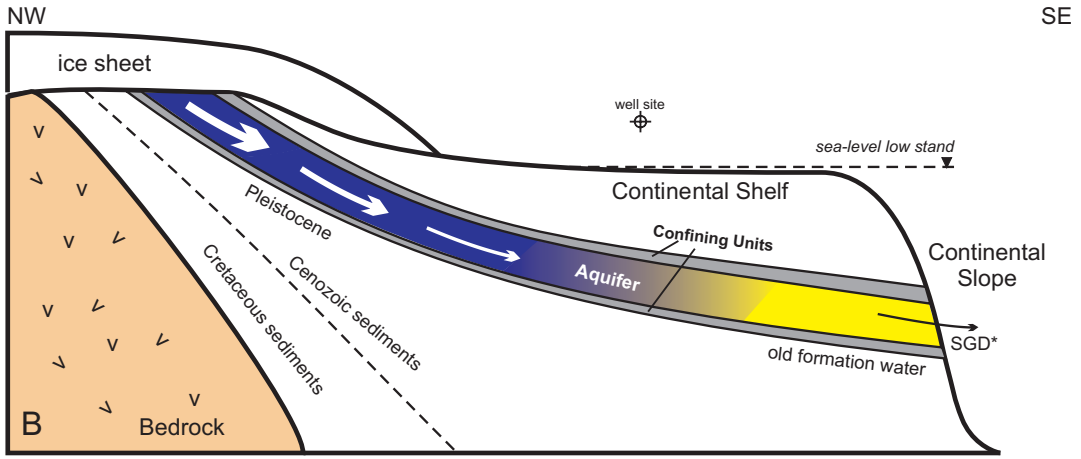
Fresh Water Origin – Conceptual Models





van Geldern et al. (2013) - *Geosphere*

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Water Origin – Before IODP Expedition 313

- Based on the results of the 1970s drillings different models have been proposed:
  - Fresh water is “old” (last glacial maximum (LGM) or older)
- The most recent (Cohen et al., 2010):
  Fresh water lens below the New Jersey Shelf emplaced during the LGM (older than ~20.000 years)
- by a combination of:
  - Sub-glacial recharge from the continental ice shield
  - Meteoric recharge during sea-level low stands
- Nonrenewable resource

photo: ECORD

30 April to 17 July 2009

IODP EXPEDITION 313

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IODP 313 - New Jersey Shallow Shelf (NJSS)

- Main objectives of NJSS:
  - **Investigate global sea-level changes in the early and middle Miocene**
  - **Relation of sea-level changes to the architecture of sedimentary sequences**
- "Mission Specific Platform" (MSP)
- 45 to 67 km offshore New Jersey
- Three drilling sites
- Depths from 631 to 755 mbsf
- Extensive petrophysical and logging data with good geo-chronology for correlation of seismic boundaries with lithology
- Detailed study of interstitial **water chemistry**

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photo: ECORD

… 45 km offshore Atlantic City…

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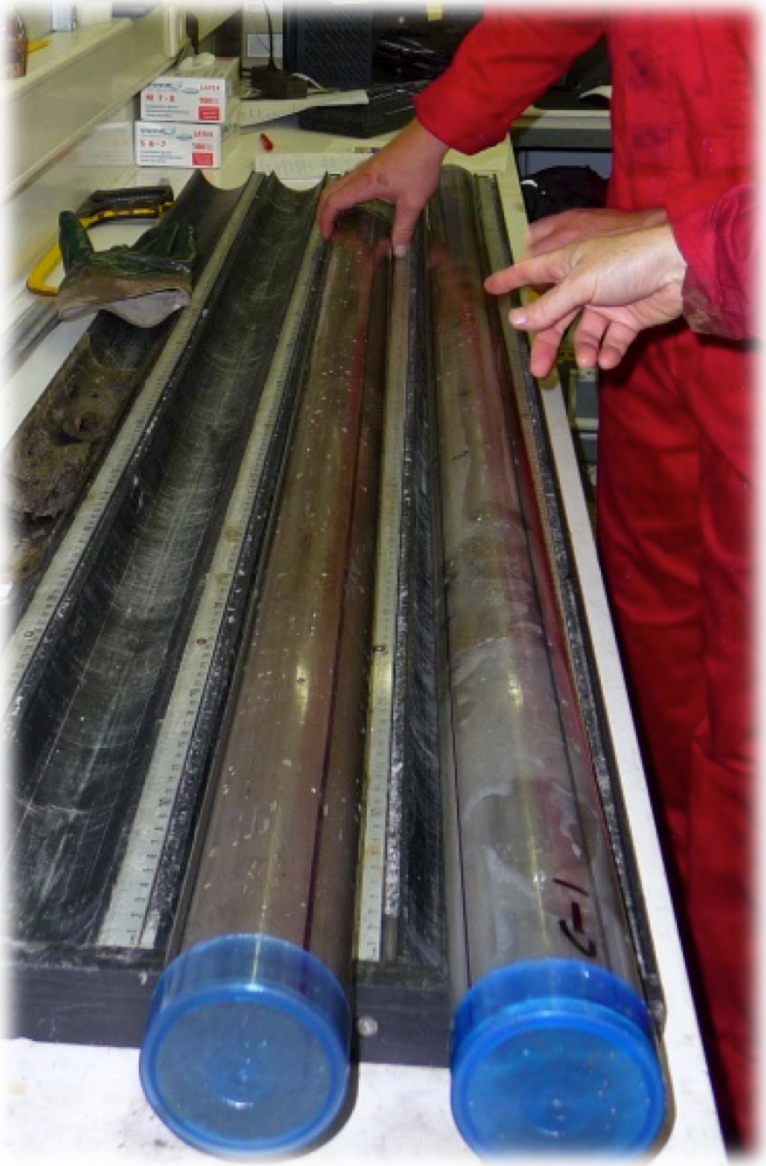

Core recovery and curation

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Core analysis

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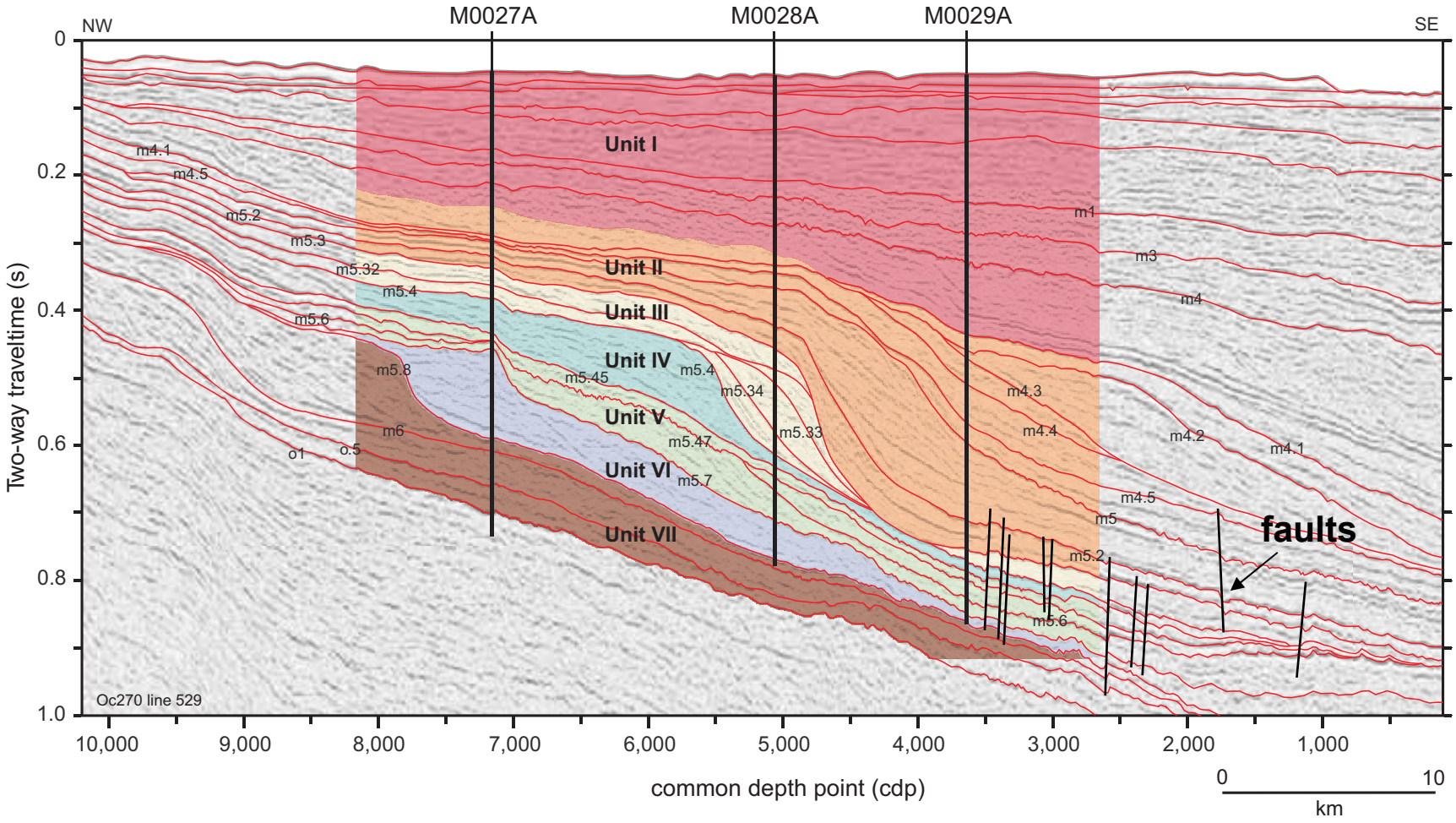
Offshore Seismic Profile



Lofi et al. (2013) Geosphere

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Results – Pore Water Chemistry

WATER ORIGIN

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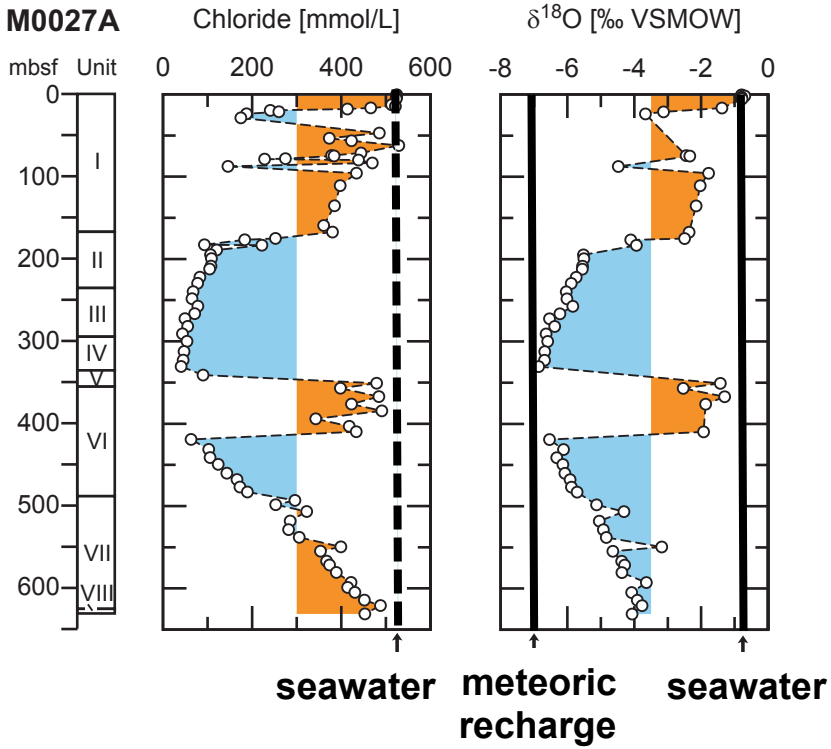
Water Stable Isotopes



van Geldern et al. (2013) - *Geosphere*

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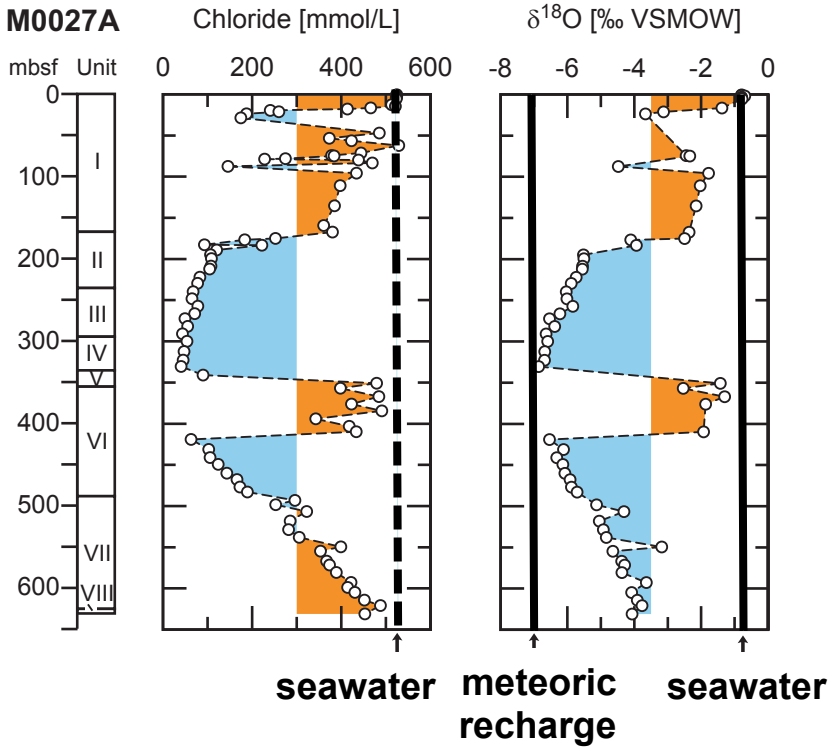
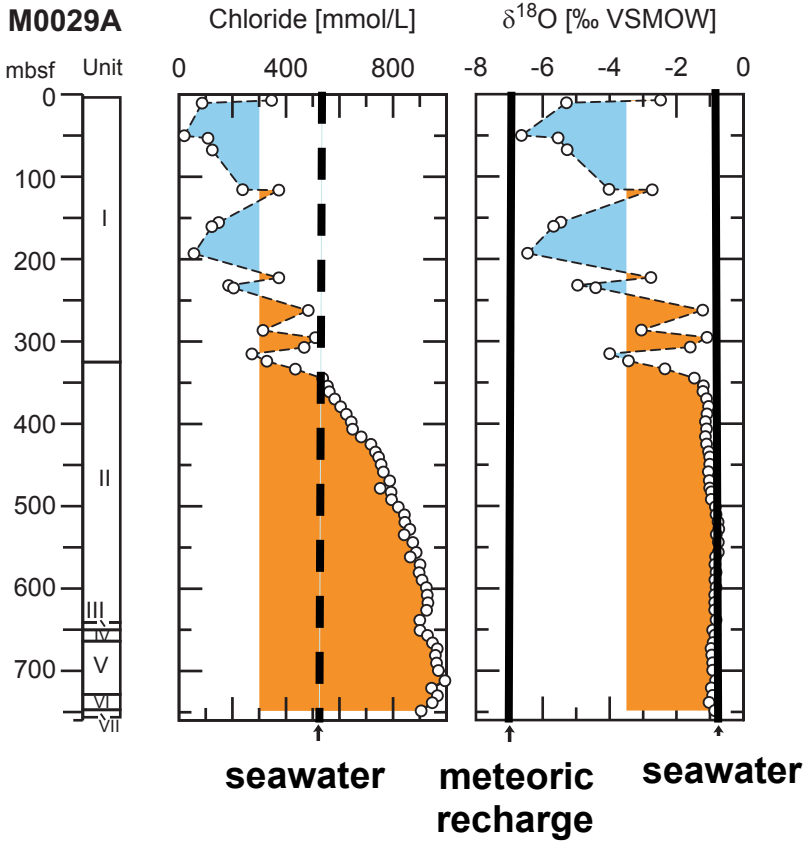
Water Stable Isotopes





van Geldern et al. (2013) - *Geosphere*

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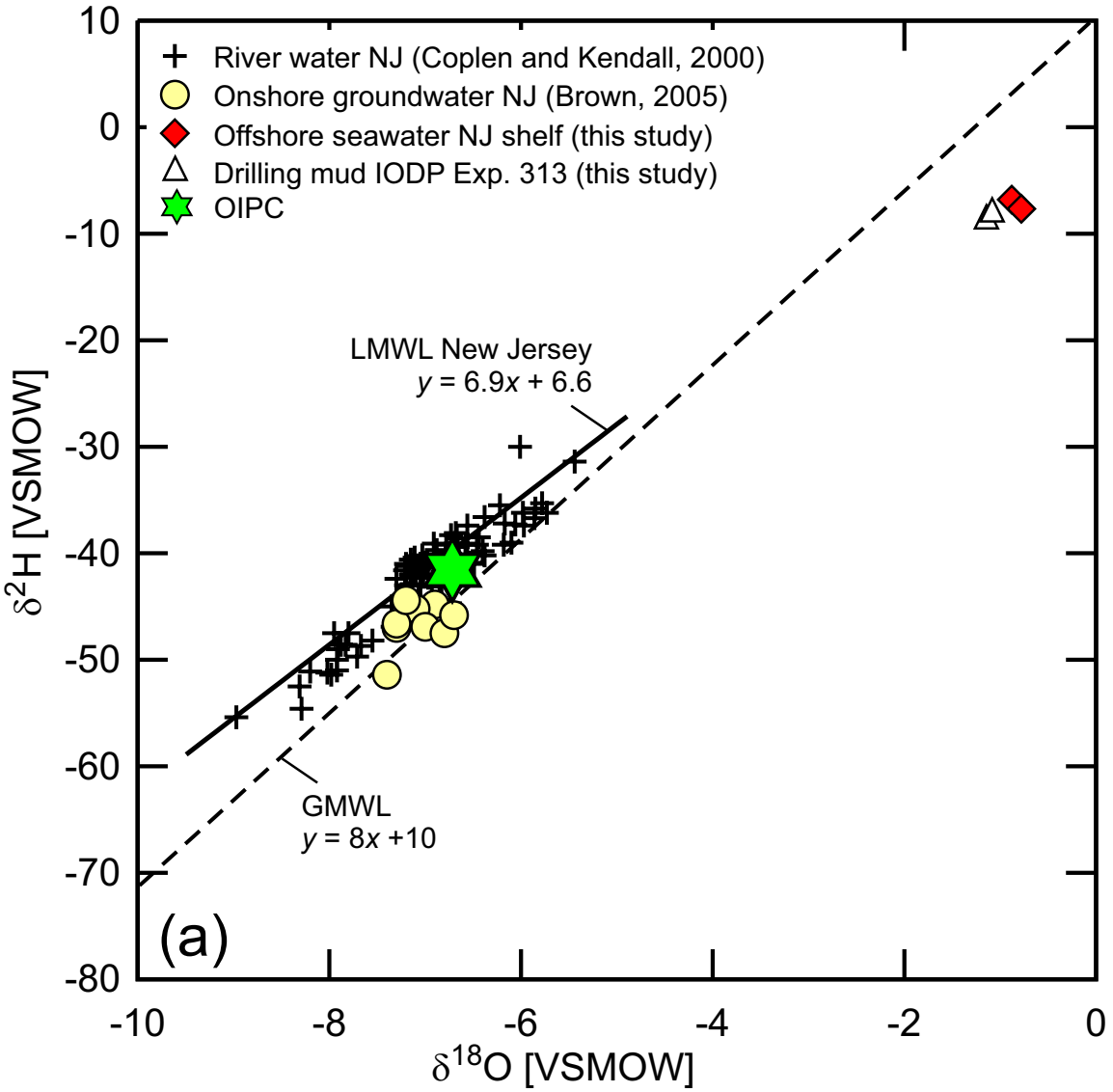
Meteoric recharge onshore NJ



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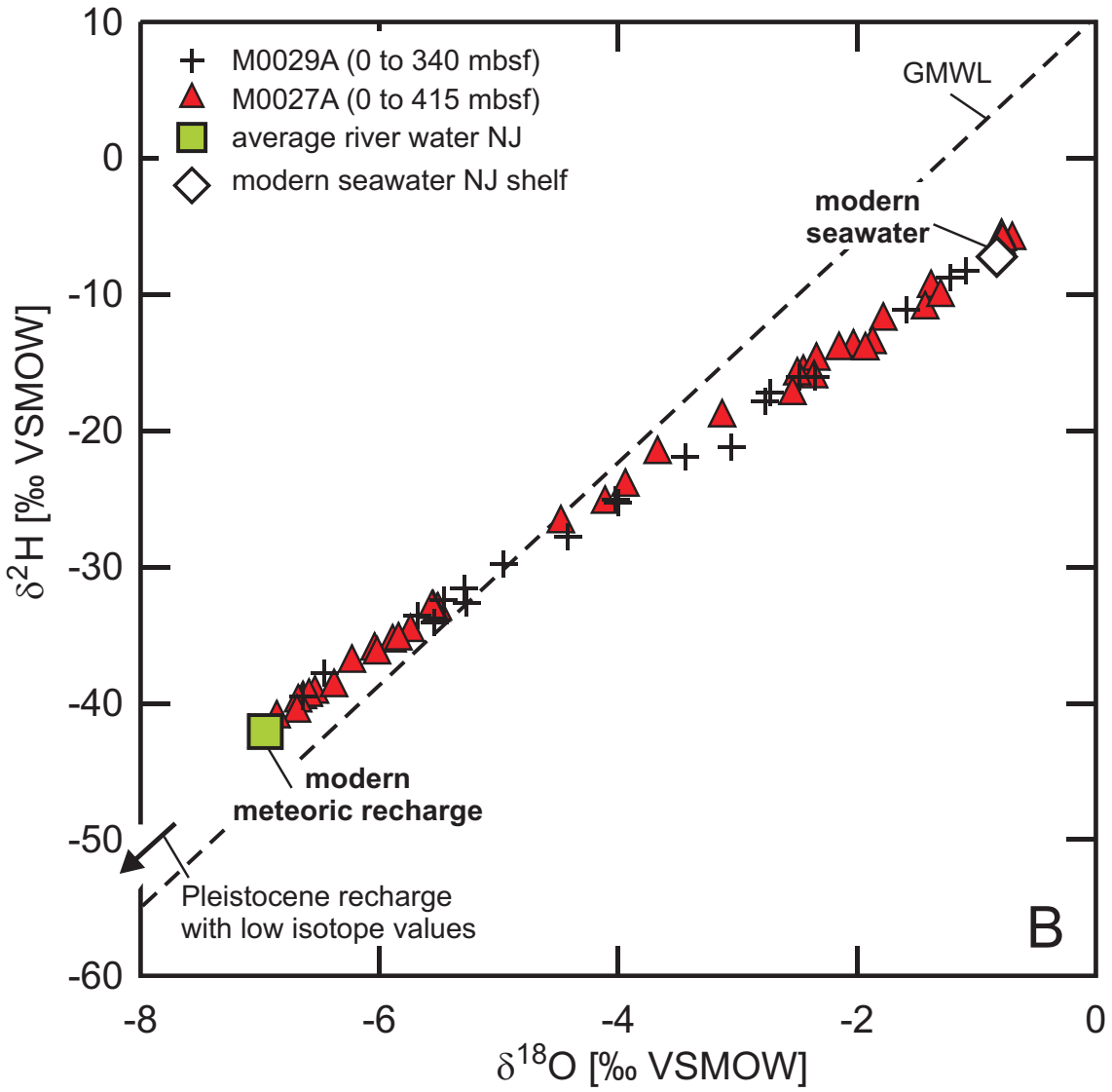
Water Origin



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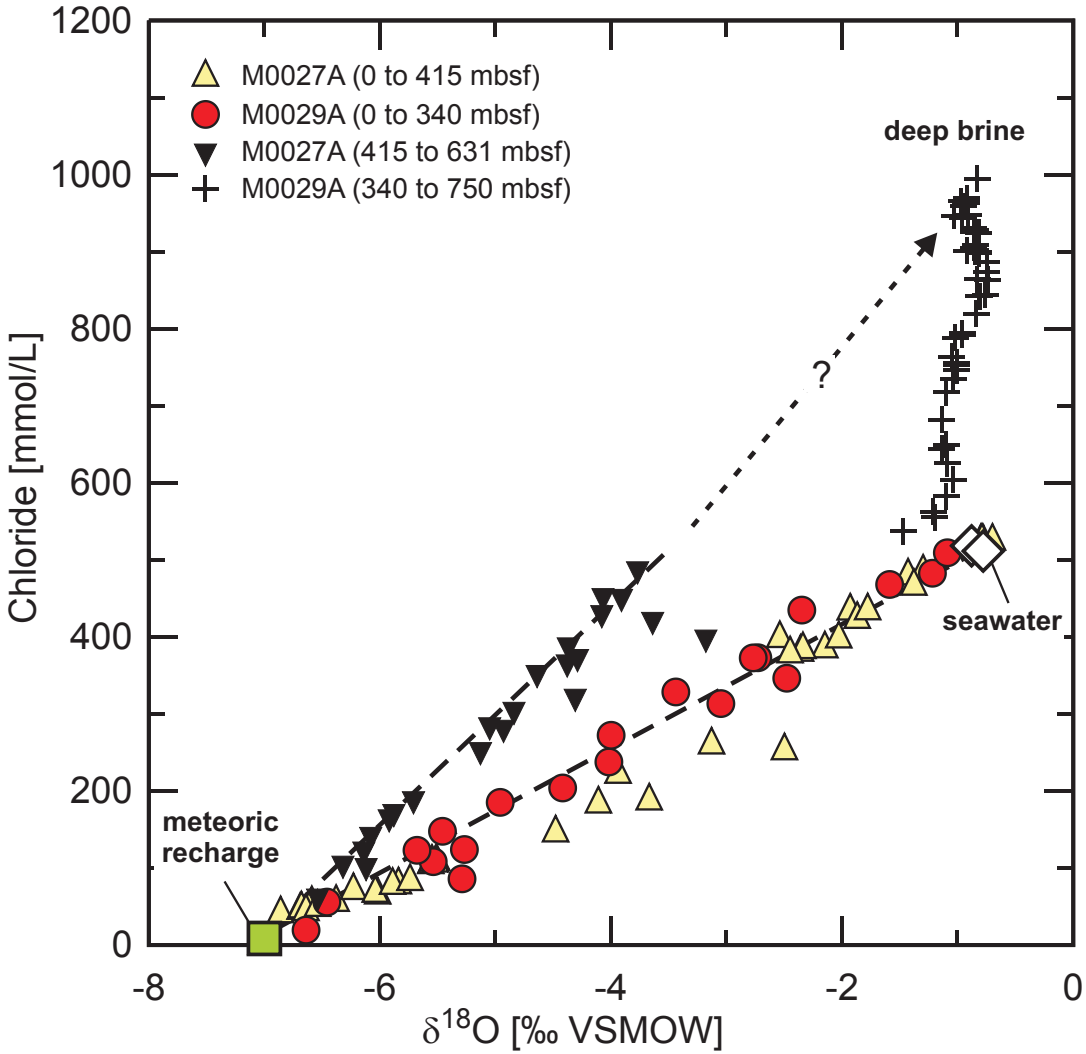
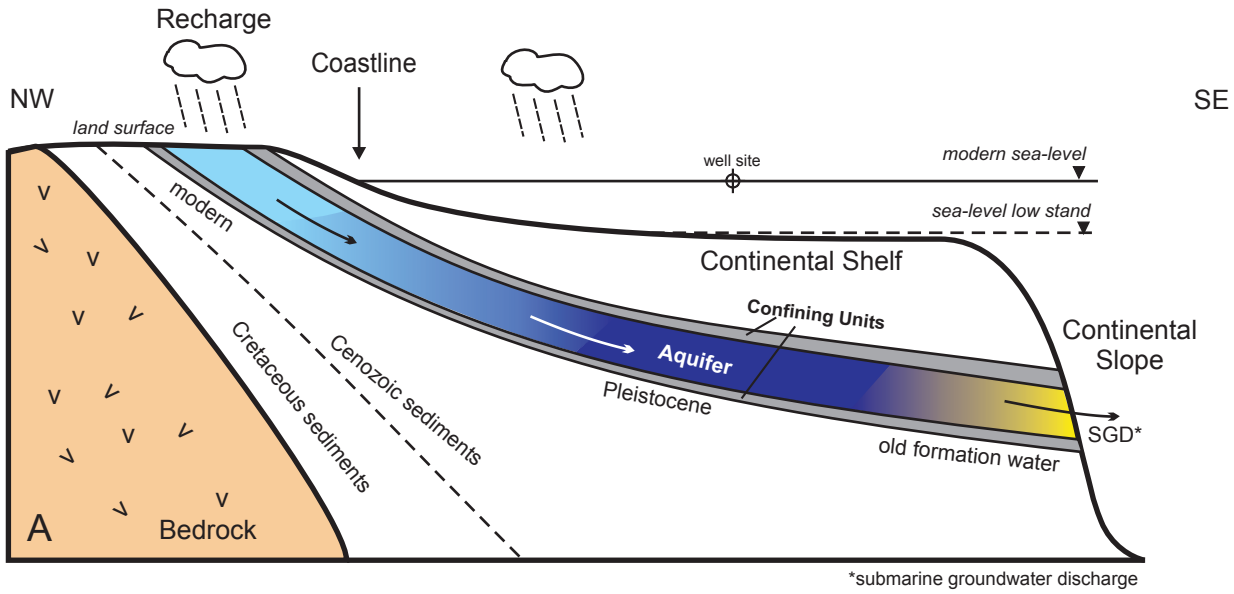
Water Origin



van Geldern et al. (2013) - *Geosphere*

Fresh Water – Salt Water



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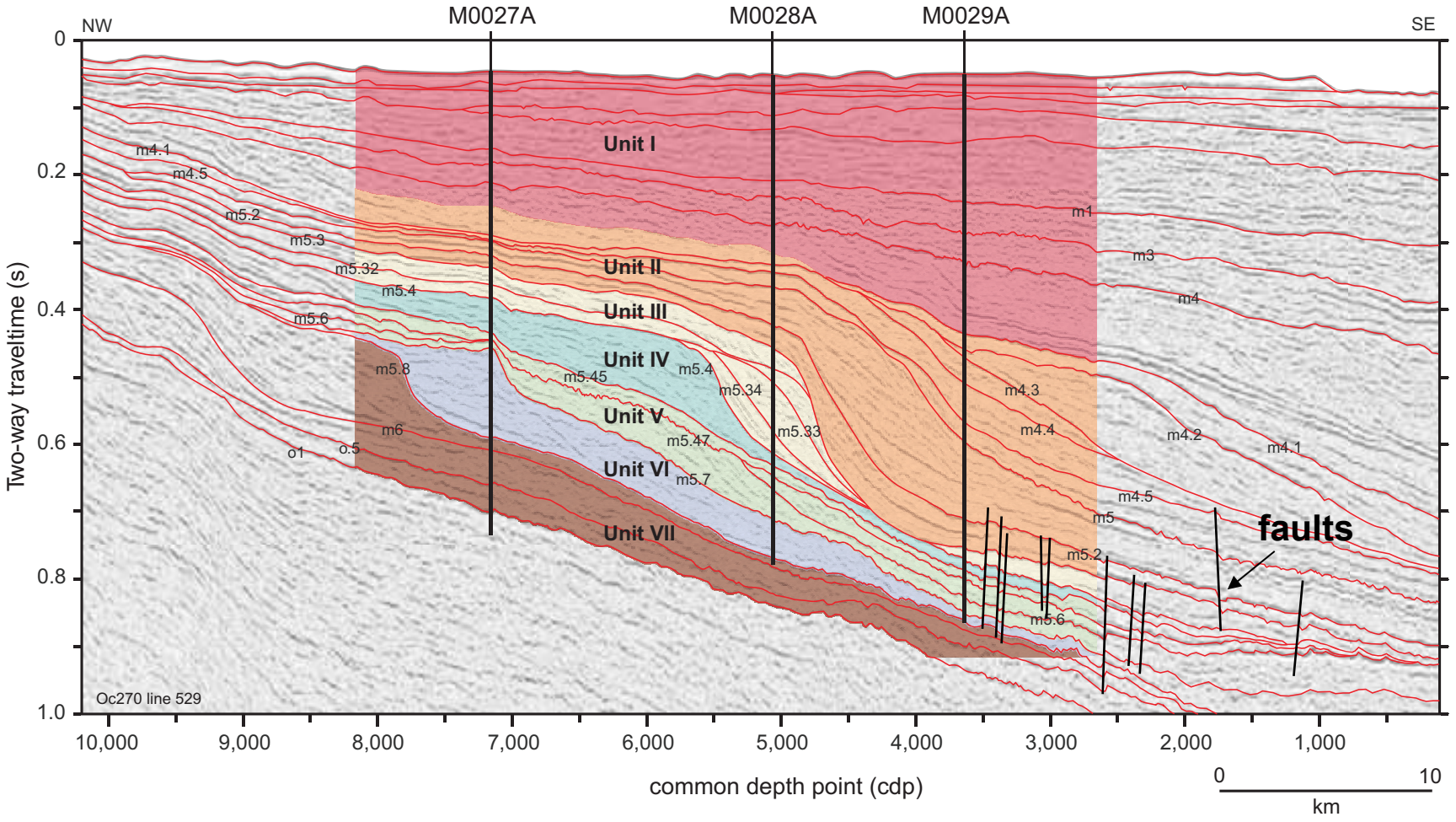
Deep Brine



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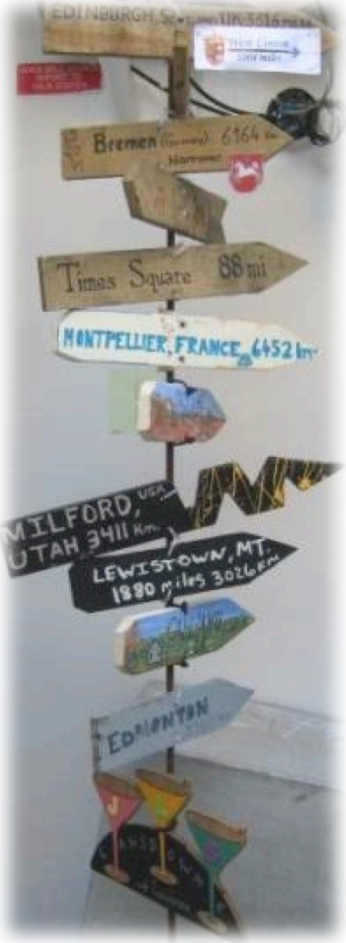
Conclusions – Fluid Origin

- More **complex geometry** than previously assumed “fresh water lens”
- Stable isotopes and water chemistry identified **three** fluid phases:
  (1) fresh water that represents meteoric water
  (2) salt water of marine origin
  (3) saline brine from evaporites in the deep underground
- **No** indication for **Pleistocene** glacial melt waters
- Stable isotopes **might** indicate a **modern origin** of the fresh water by onshore meteoric recharge
- **Fresh water** was found in the **fine grained** sediments
- **Salt water** infiltrates along **coarse-grained**, sandy units
- Existing **groundwater models** of the Atlantic shelf have to be refined

Aknowledgments

- S. Meyer, S. Konrad, S. Krumm, and C. Weinzierl (FAU Erlangen)
- A. Jäckel (LIAG, Hanover)
- M. Kölling (MARUM, Bremen)
- P. Escher (IOW, Warnemünde)
- S. Schlömer, C. Poggenburg, D. Laszinski, and U. Berner with colleagues (BGR, Hanover)
- Integrated Ocean Drilling Program (IODP)



Full reference:
van Geldern, R., T. Hayashi, M. E. Böttcher, M. J. Mottl, J. A. C. Barth, and S. Stadler. 2013. Stable isotope geochemistry of pore waters and marine sediments from the New Jersey shelf: Methane formation and fluid origin. Geosphere 9: 96-112, [doi: 10.1130/GES00859.1].

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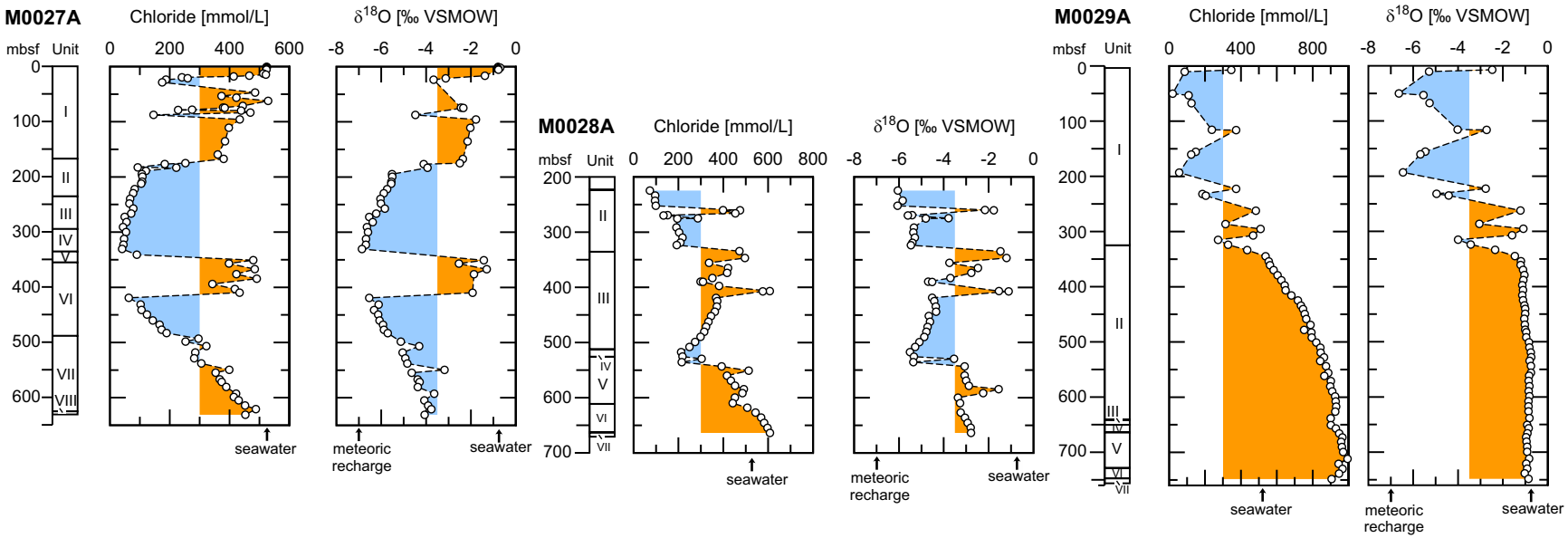
Water Stable Isotopes



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