

Where in the Amerasia Basin Should IODP Drill?*

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Abstract

The formation and evolution of the frontier Amerasia Basin and its surrounding land masses remain poorly understood. We suggest IODP drilling sites that could resolve some of these key questions: What was the pattern of continental breakup? When did the Amerasia Basin form? What is the nature of the sub-basins and structural highs of the Amerasia Basin? How are sediments and in particular source rocks spatially distributed? Chosen targets are within the IODP penetration capability of ~ 1.5 km, but ice cover could present a challenge.

Sediment-starved structural highs of the Amerasia Basin represent the most realistic drilling targets. Our primary target is the Northwind Basin, of the Chukchi Borderlands. Grantz et al. (2010) proposed that the Borderlands rotated counter-clockwise away from the Siberian margin, thereby opening the North Chukchi basin in their wake. Our goal is to determine the age of the Northwind Basin, which in turn tests whether the Borderlands have rotated. Previous interpretations date the Northwind Basin as Paleocene, post-dating both the formation of the Amerasia Basin and the proposed rotation. An alternative scenario is that the graben is a Mesozoic rift-related feature, which prior to rotation of the Chukchi Borderlands paralleled the Siberian margin. The age of the Northwind Basin, whose size is greater than the North Sea, has significant implications for its hydrocarbon potential.

A second key target is the Alpha-Mendeleev ridge, whose nature remains unclear. One possibility is that the ridge was formed by a plume during the Cretaceous. Alternatively, the ridge could be of continental affinity. The nature of the ridge has significant implications for the continental breakup pattern of the landmasses surrounding the Amerasia Basin. The most widely accepted hypothesis is that Alaska and Arctic Siberia have rotated 66° with respect to Arctic Canada. This model requires the Lomonosov ridge, which separates the Amerasia and Eurasia basins, to be a transform margin. This model would be invalidated if the Alpha-Mendeleev ridge contains continental crust.

Furthermore, it would imply that continental crust underlies at least part of the most northerly portion of the Amerasia Basin, the Makarov and Podvodnikov basins.

Another of our targets is the De Long Plateau, of the East-Siberian continental margin, whose geology remains poorly understood. Finally, we would like to revisit the Lomonosov Ridge. IODP expedition 302 drilled this ridge, but the primary objectives were climatic and cores did not penetrate into crust.

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Where in the Amerasia Basin should IODP drill?

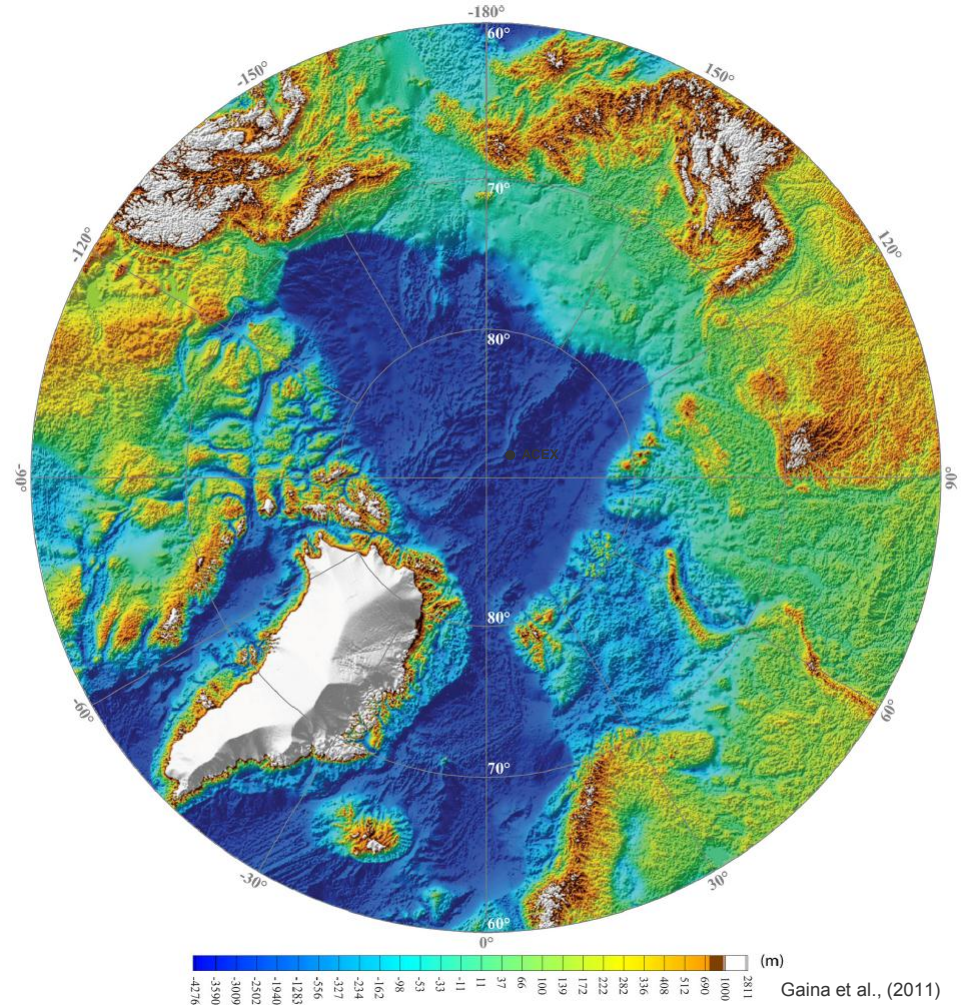
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Aims and considerations

Drilling aim: to understand the formation and evolution of the Amerasia Basin.

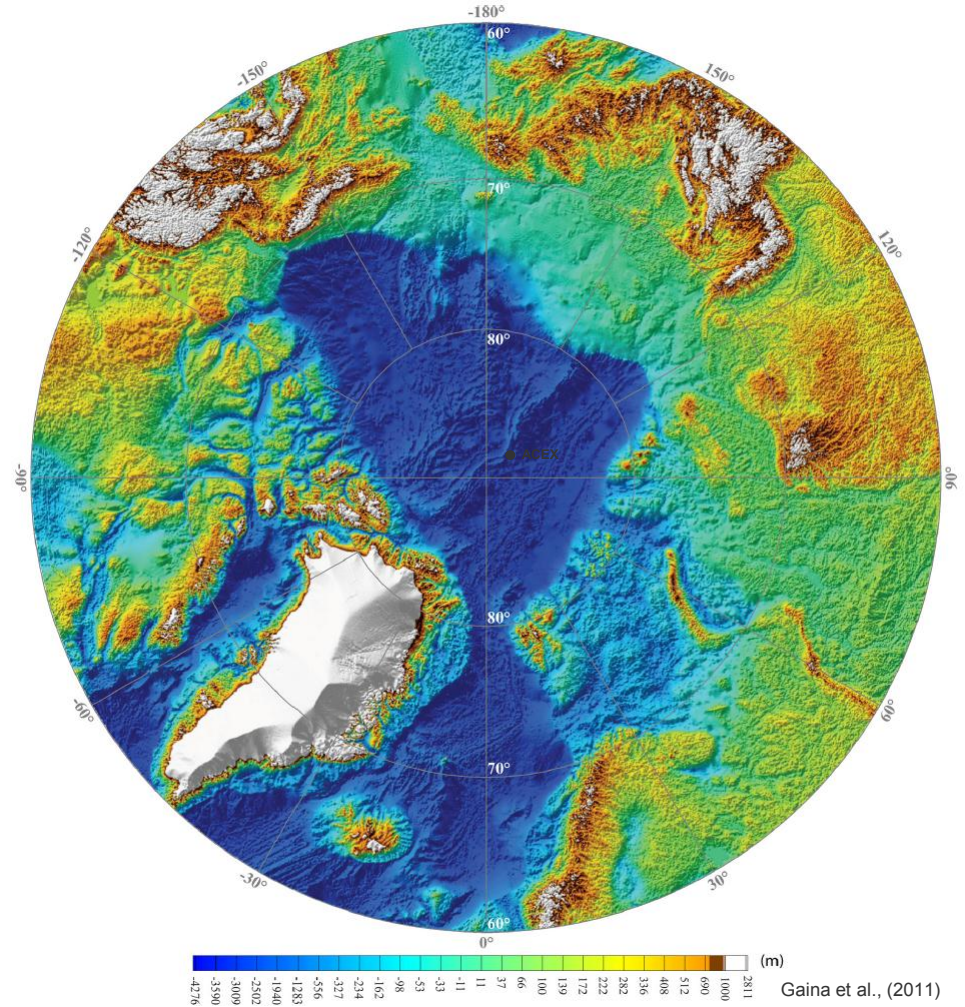
Drilling considerations:

- All targets are within the 1.5 km drilling capability of the vessels.
- Ice could provide a problem.
- Law-of-the-sea.



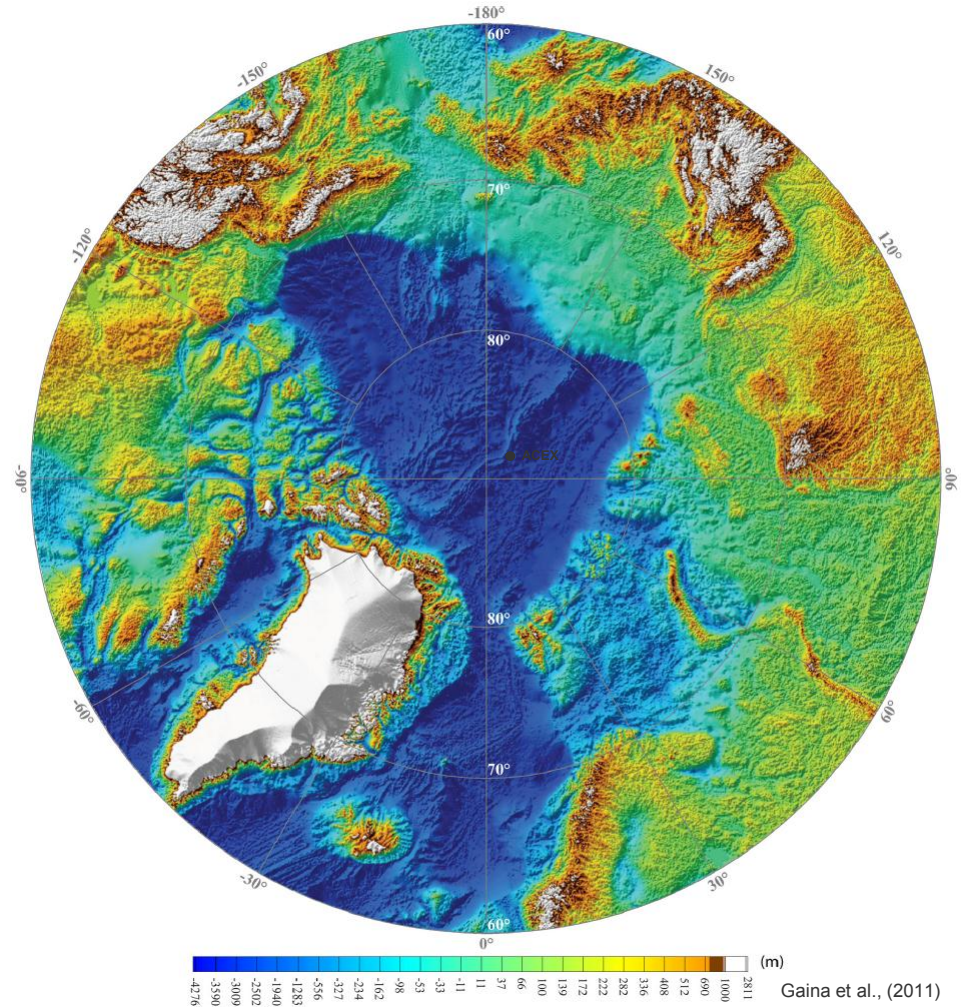
Talk overview

- Key scientific questions.
- Where should IODP drill?



Key scientific questions

1. Mode of opening.
2. Timing.
3. Nature.
4. Distribution of sediments.



Key question 1 – mode of opening

1) Arctic Islands strike-slip model

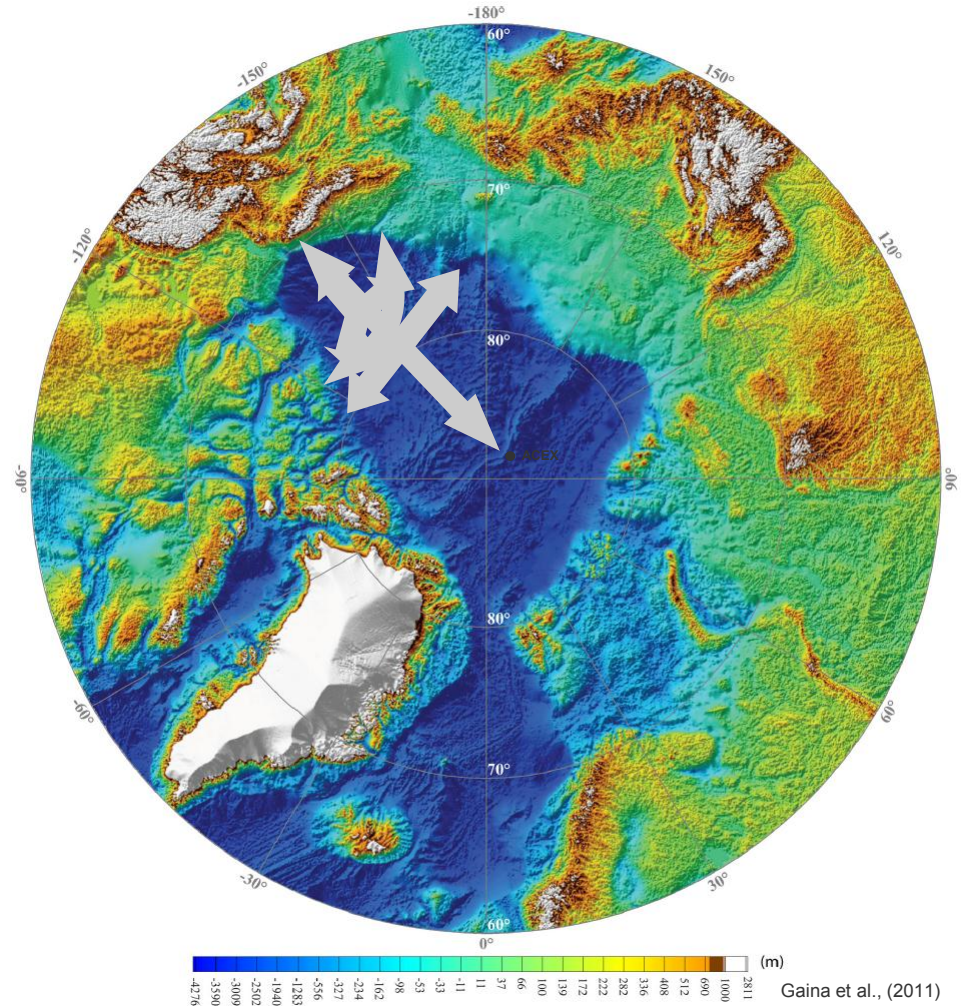
– Alaska rifts off the Lomonosov Ridge or the Alpha and Mendeleev ridges.

2) Arctic Alaska strike-slip model

- Siberia and Chuckchi rift from the Canadian Arctic islands.

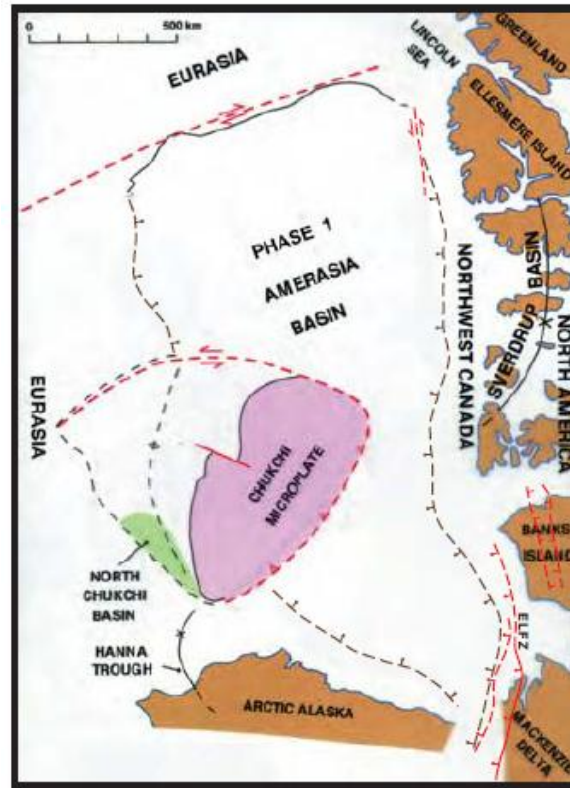
3) Three stage model – Amerasia Basin opens in 3 stages.

4) Rotational model – counter-clockwise rotation of Alaska away from Canada.

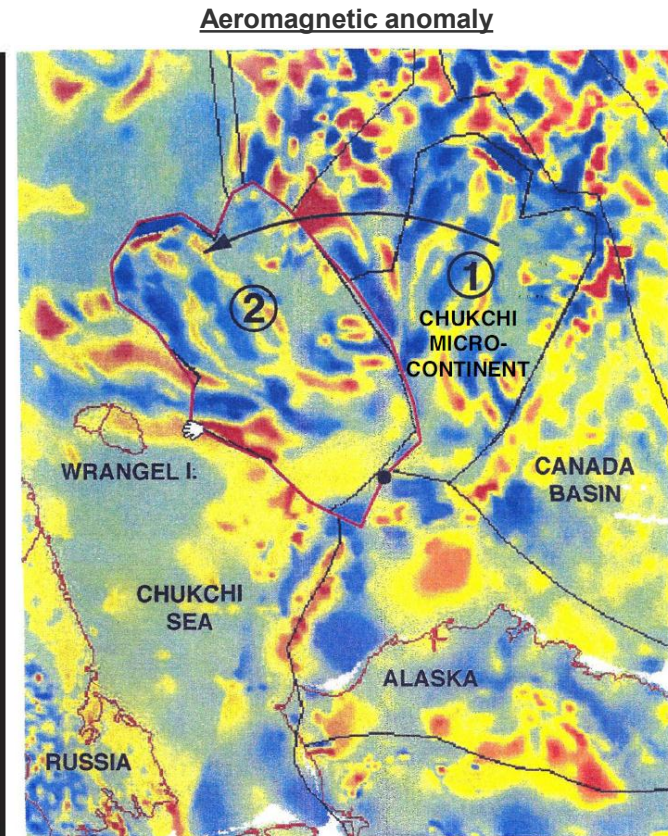


Key question 1 – mode of opening

Has the Chukchi Borderlands rotated into its present day position?



Grantz et al., (2011)

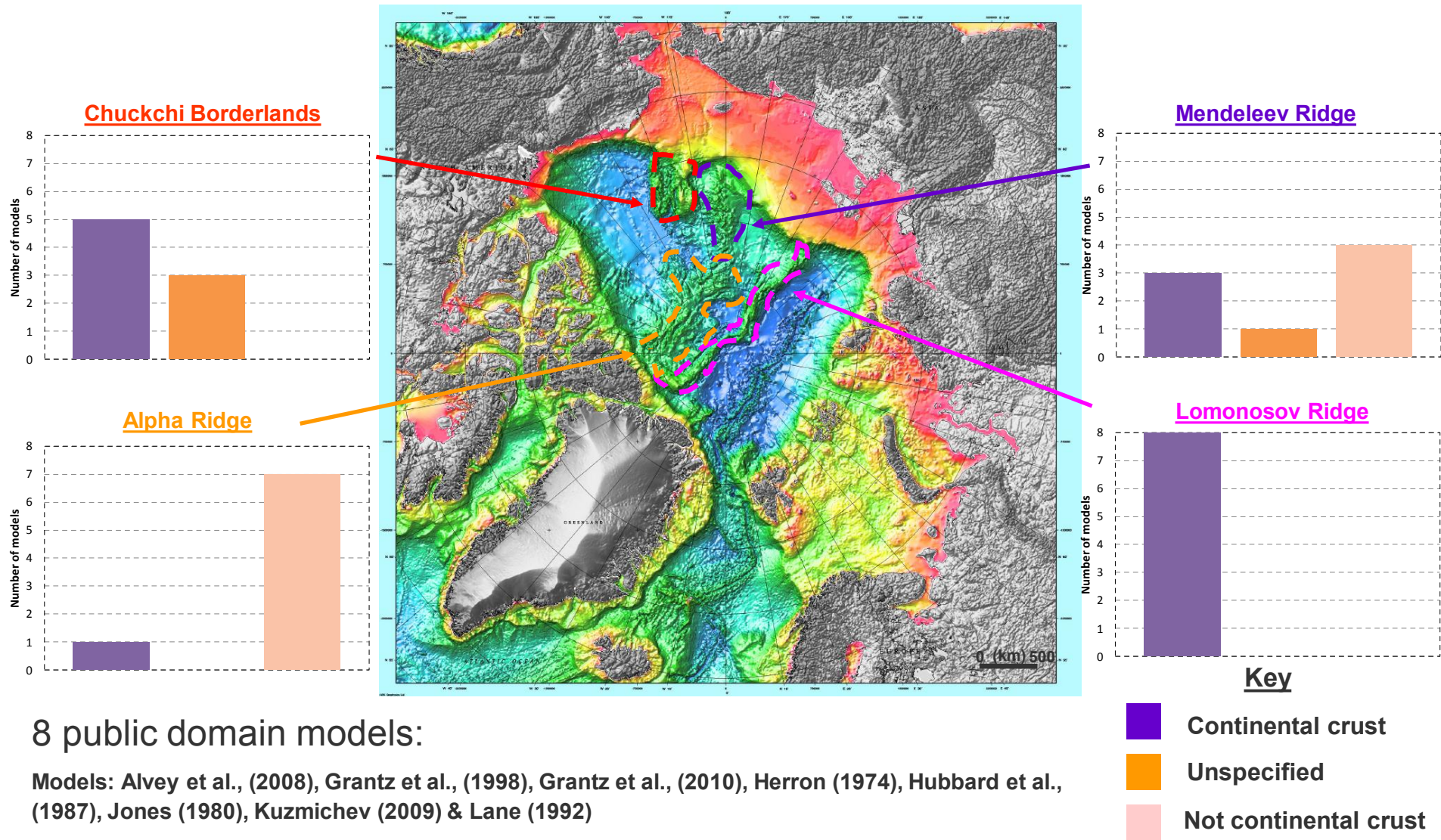


Grantz (2011)

Key question 2 - Timing

When did the Amerasia Basin form?

Key question 3 - nature

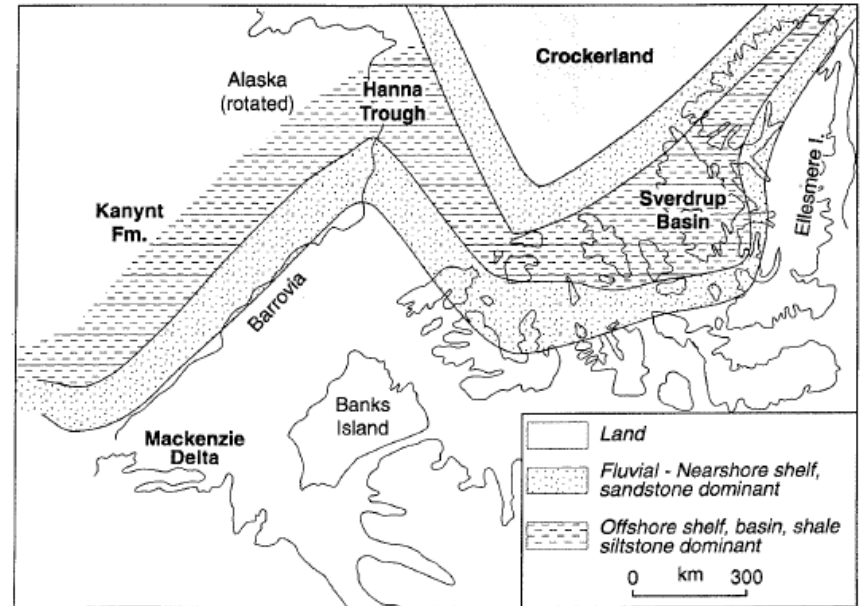


Key question 3 - nature

**What is the nature of the sub-basins
and structural highs of the Amerasia Basin?**

Key question 4 – distribution of sediments

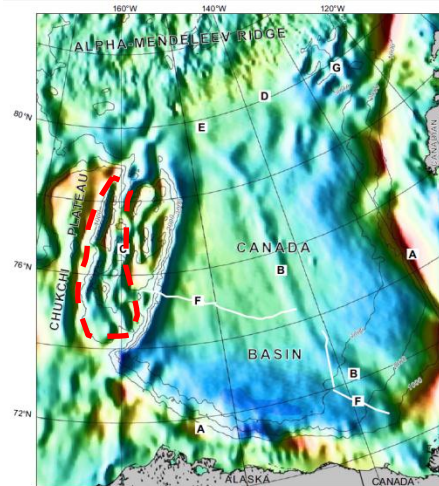
- How are sediments distributed throughout the basin?
- What does this tell us about the evolution of the basin?
- How widespread are source and reservoir rocks?



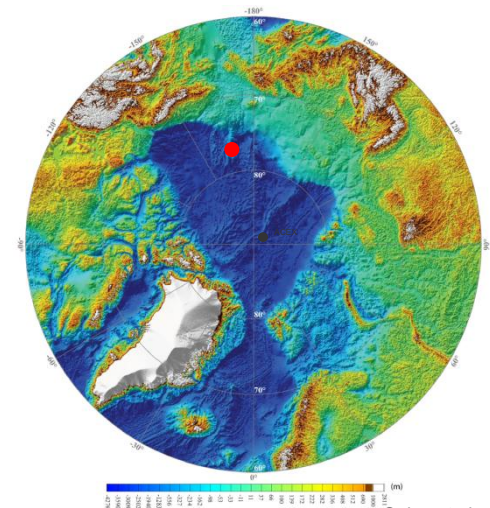
Embry (1998)

Where should IODP drill? – Northwind Basin

- Chukchi Borderlands – offshore Siberia.
- 1.5 to 2 km ocean-depth.
- 0.25 to 2.5 km sediment thickness.



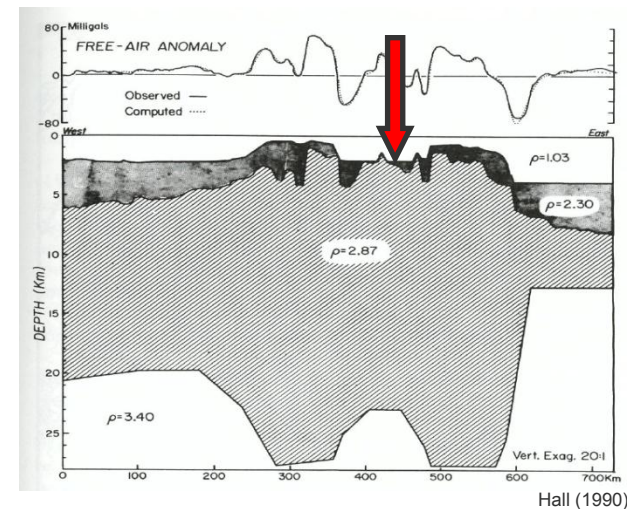
Grantz et al., (2011)



Gaina et al., (2011)

Questions addressed:

- Mode of opening.
- Distribution of sediments.
- Nature.



Where should IODP drill? – Northwind Basin

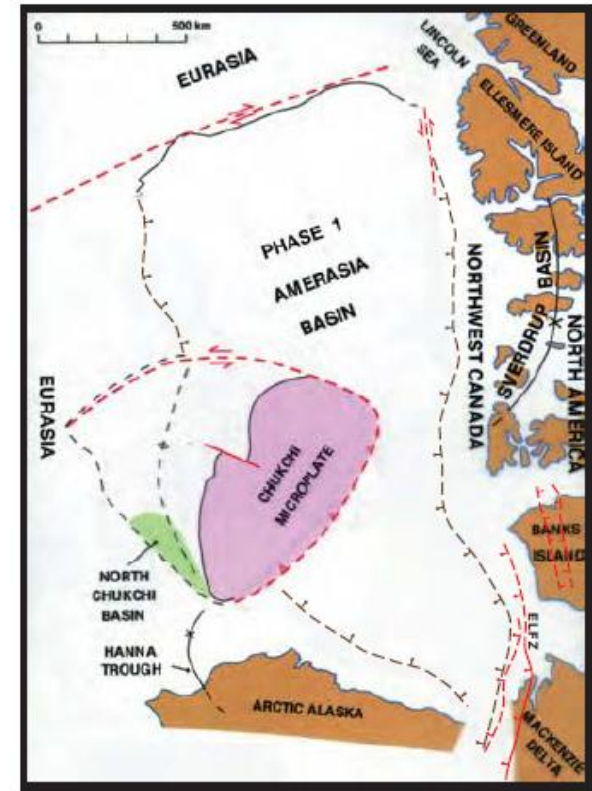
Reasoning:

Mode of opening:

- The Northwind basin may be late Paleocene in age (e.g., Grantz et al., 1990).
- Alternatively, the Borderlands may have rotated and the basin could have formed margin parallel.
- The age of the Northwind basin would be much older in this scenario.

Nature:

- If the Borderlands has rotated, then the North Chukchi Basin must have a continental affinity.



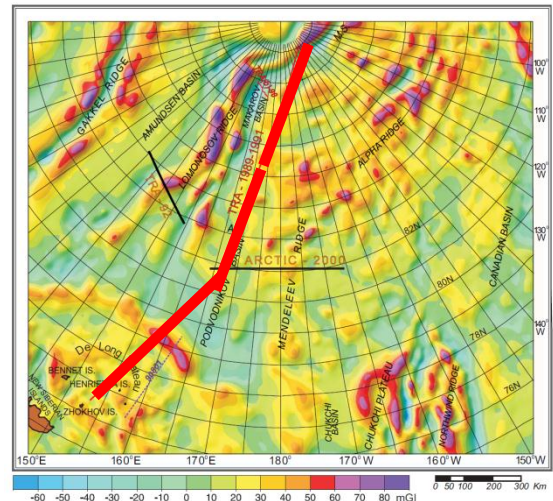
Grantz et al., (2011)

Where should IODP drill? – Alpha-Mendeleev ridge

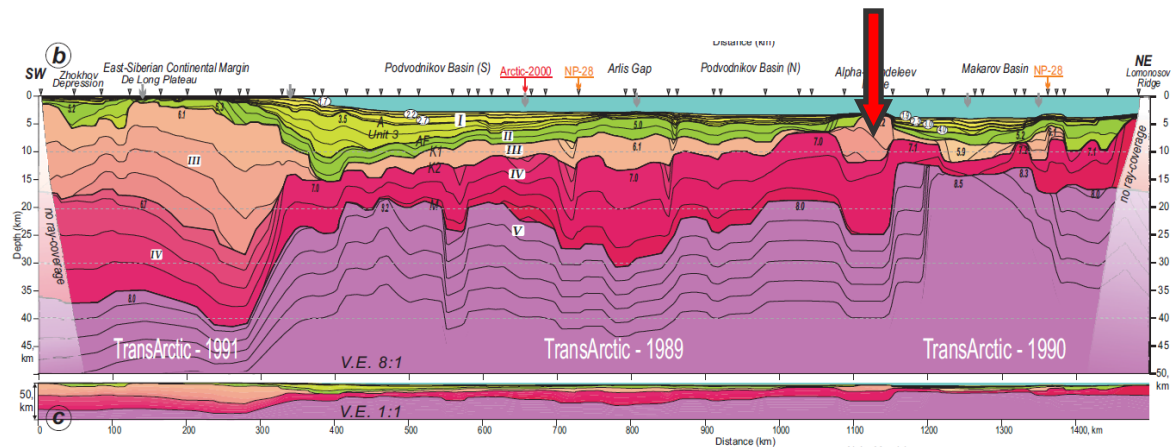
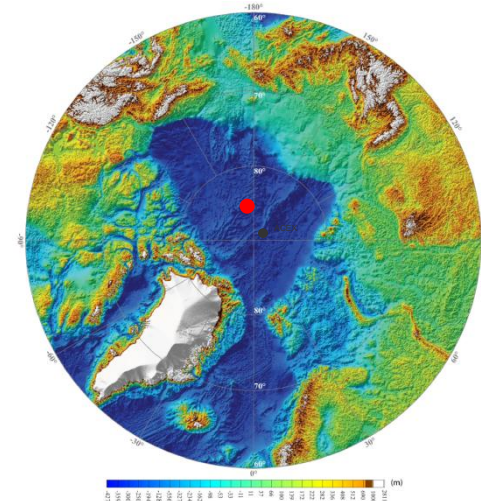
- High-standing ridges in the centre of the Amerasia Basin.
- 3 km ocean depth.
- 500 m + sediment thickness.

Questions addressed:

- Mode of opening.
- Distribution of sediments.
- Nature.
- Age.



Labedeva et al., (2011)

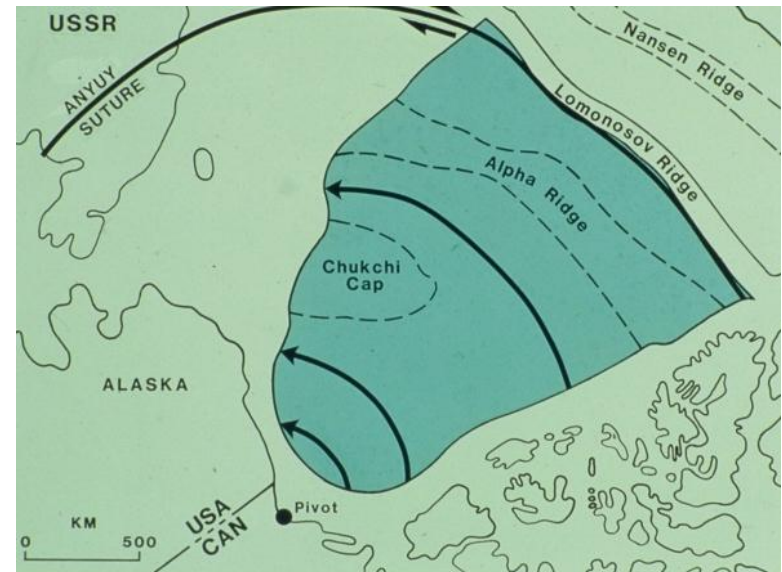


Labedeva et al., (2011)

Where should IODP drill? – Alpha-Mendelev ridge

Reasoning:

- Nature: the nature of both the Alpha and Mendeleev ridges is debated.
- Mode of opening: a continental affinity invalidates the rotational model.
- Age: the age of the formation of the ridges is debated.



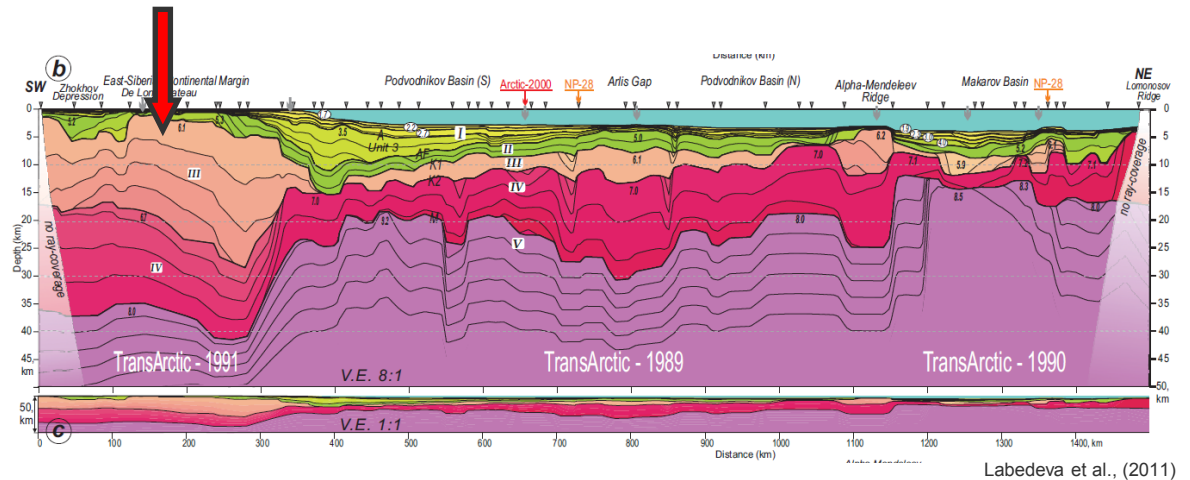
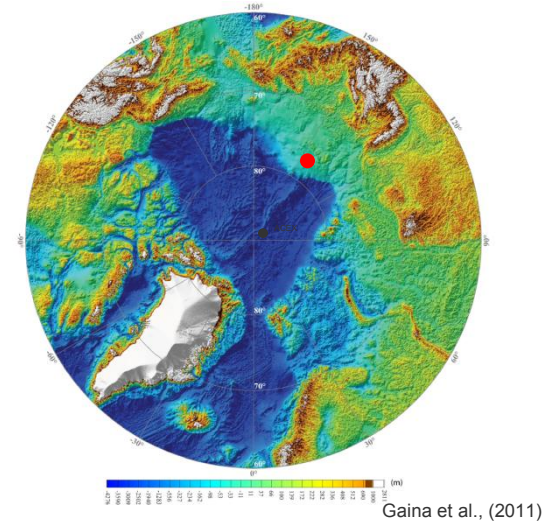
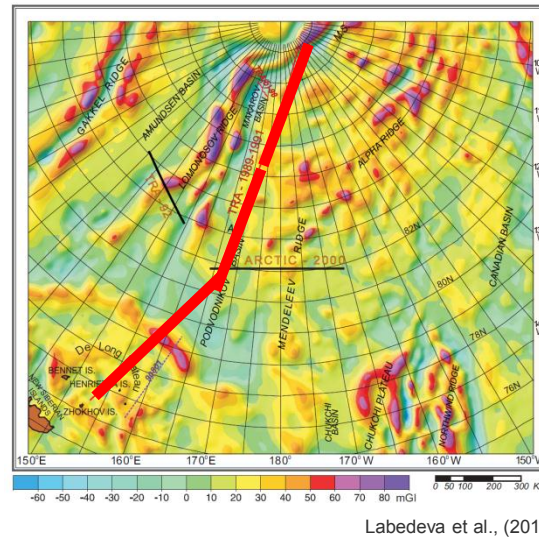
Embry (2009)

Where should IODP drill? – De Long Plateau

- Siberian continental shelf.
- < 1 km ocean depth.
- 1 km + sediment thickness.

Questions addressed:

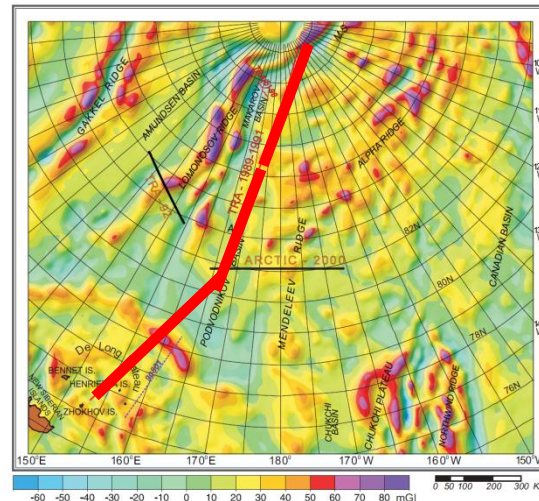
- Distribution of sediments.



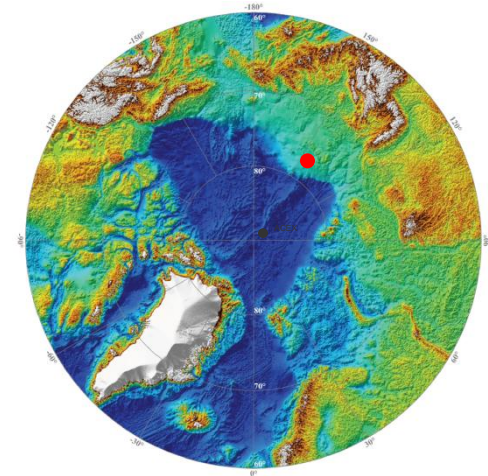
Where should IODP drill? – De Long Plateau

Reasoning:

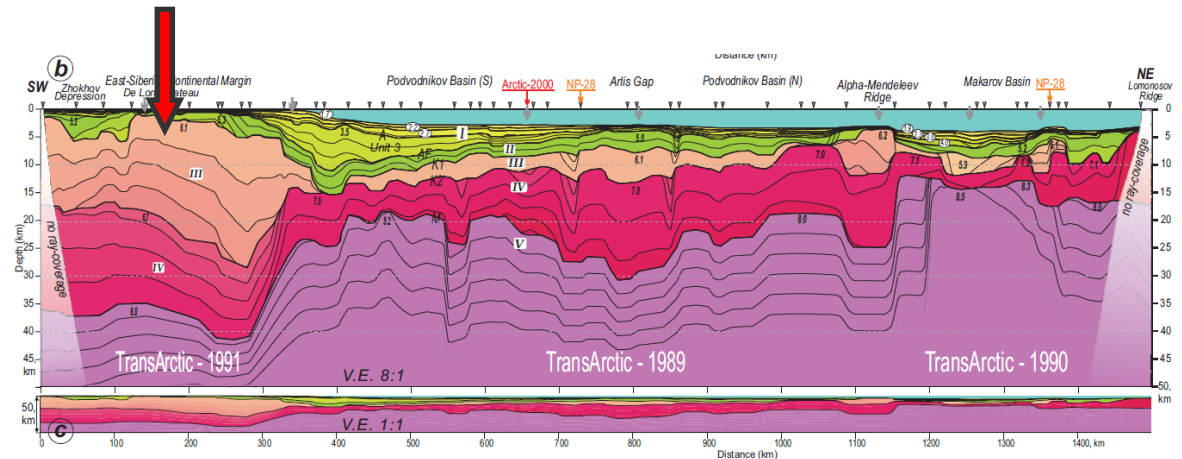
The geology of the Russian continental shelf is relatively poorly understood.



Labedeva et al., (2011)



Gaina et al., (2011)



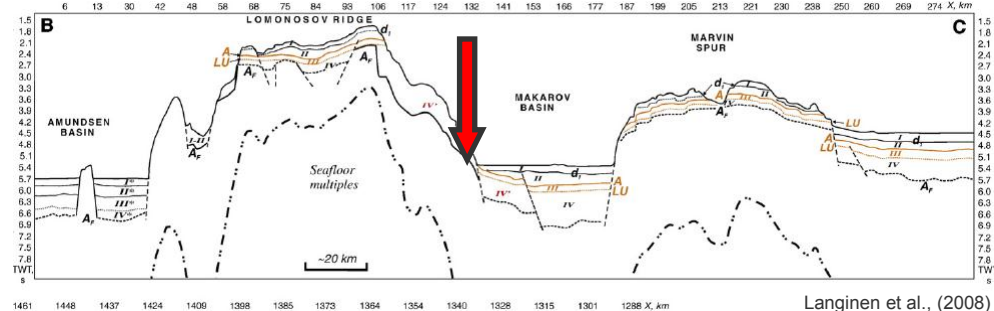
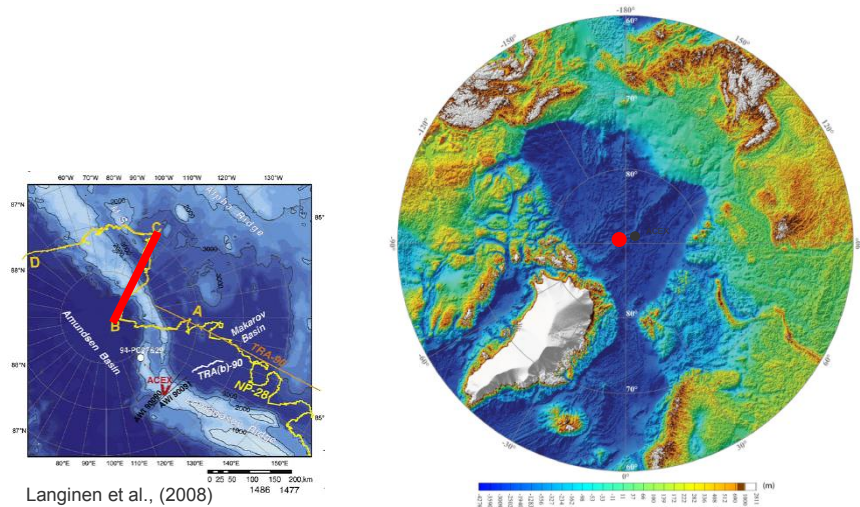
Labedeva et al., (2011)

Where should IODP drill? – Lomonosov Ridge

- Between the Amerasia and Eurasia basins.
- 3 to 4 km ocean depth.
- <1.5 km sediment thickness.

Questions addressed:

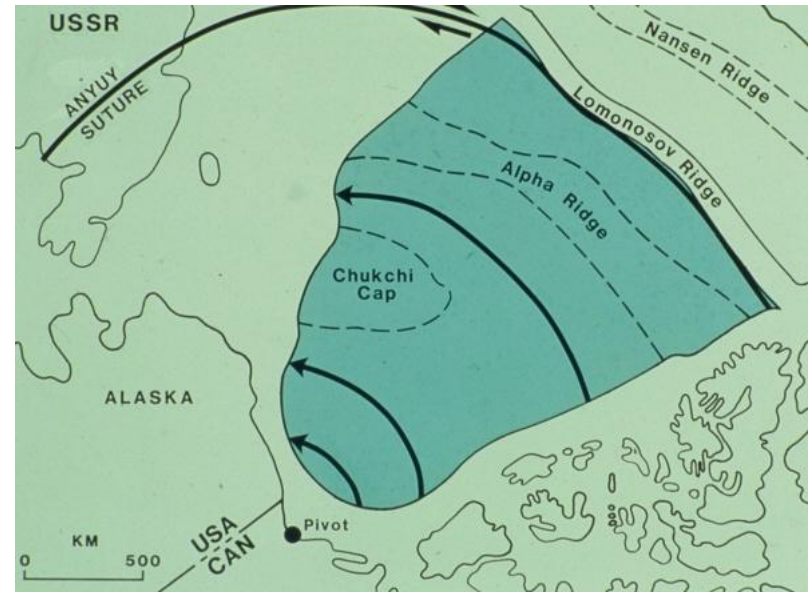
- Distribution of sediments.
- Mode of opening.
- Nature.



Where should IODP drill? – Lomonosov Ridge

Reasoning:

- Nature: some debate still exists relating to the nature of the Lomonosov ridge.
- Mode of opening: compare the geology of the Lomonosov Ridge with that of the other margins of the Amerasia Basin.



Embry (2009)

Summary

- Numerous fundamental questions relating to the Amerasia Basin exist: mode of opening, timing, nature, distribution of sediments.
- We propose 4 drilling targets which could help to answer these questions:
 - Northwind Basin (Chukchi Borderlands).
 - Alpha-Mendeleev ridge.
 - De Long Plateau.
 - Lomonosov ridge.

