Circum-Arctic mantle structure from global tomography – consistent with plate reconstructions?

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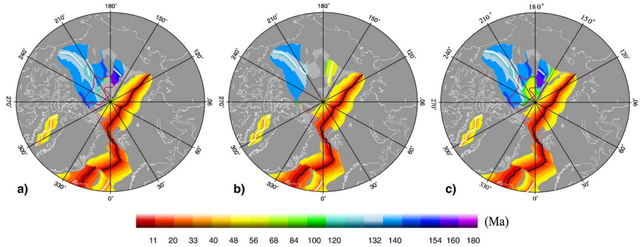
Abstract. I attempt a slab inventory for the circum-Arctic region, north of ~ 50˚N. Comparing four recent global body-wave tomography models, I identify robustly resolved, fast seismic anomalies in the transition zone and lower mantle. Reliably imaged slabs are mostly located between 900 and 1800 km depth, implying Cretaceous and early Tertiary times of subduction.

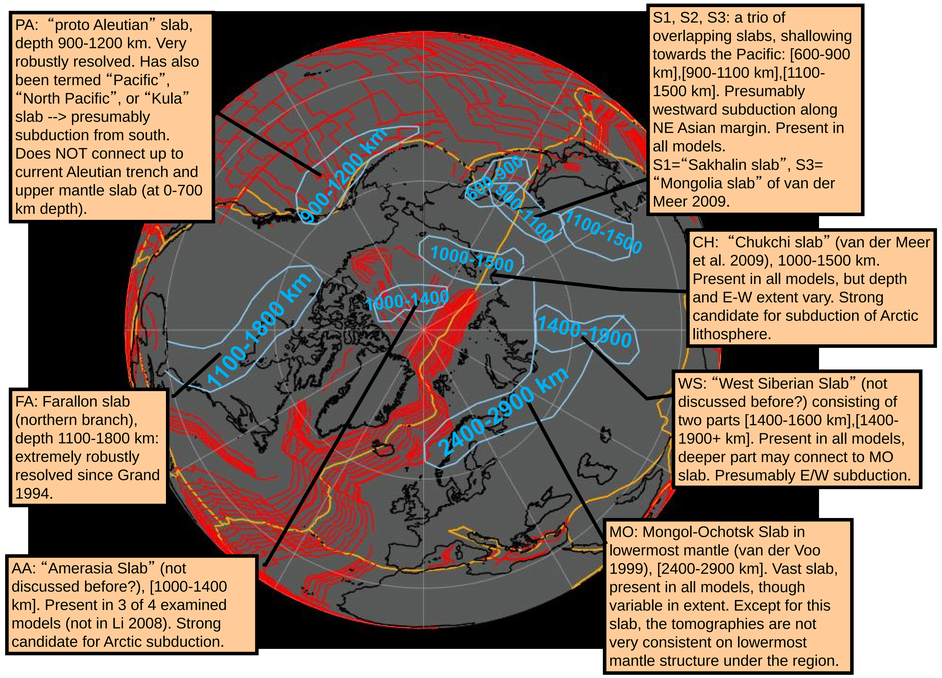
This is broadly consistent with plate reconstructions, which infer Cretaceous spreading in the High Arctic, but with considerable uncertainties as to timing and locations. Reconciling the two data sets, by matching infered paleo-trenches to subducted slabs, may allow to discriminate between scenarios and to conclusively constrain absolute locations.

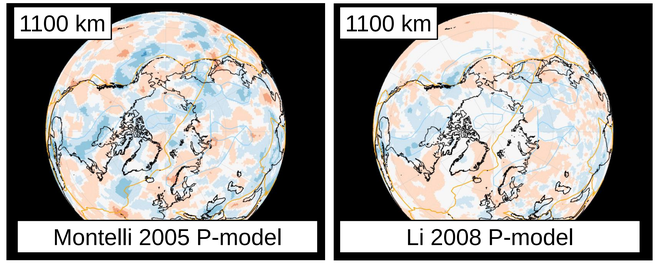
I. Tectonic motivation



Above figure from Alvey 2008 illustrates three alternative spreading scenarios consistent with the incomplete magnetic seafloor data from the High Arctic. In the Eurasia Basin, spreading started ~55 Ma and is ongoing (red-yellow colors). The older Amerasia Basin opened during the Cretaceous (140+ Ma to ~80 Ma?). The scenarios differ in the speculated extent, timing, and rift location(s) for the basin. Spreading in the Cretaceous Arctic should have been accompanied by subduction in the circum-Arctic. Are these slabs still tomographically visible? If so, they can potentially distinguish between scenarios.

II. Circum-Arctic slab inventory





Slab identification. Comparison of two tomographies (at 1100 km depth). The other two models examined were Amaru 2007 (P) and Montelli 2005 S-model.

III. Plate reconstructions

Evolution of tectonic plates over time, according to two different reconstructions. Left: ONeill et al. 2005, right: Alvey et al. 2008 (their Model 3). Note the significant differences in absolute plate locations, e.g. positions of Greenland or North America w.r.t. the slabs. Such uncertainties might be overcome by a tight and consistent linking of slabs to paleo-trenches, as indicated by the slabs (if they sank vertically).

Depth of slab	Time of subduction if the average sinking rate was…		
	1.0 cm/yr	1.5 cm/yr	2.0 cm/yr
1000 km	100 Ma	66 Ma	50 Ma
1500 km	150 Ma	100 Ma	75 Ma
2000 km	200 Ma	133 Ma	100 Ma

Thank you to Carmen Gaina for providing the Arctic reconstruction models of Alvey et al. 2008.

References:
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