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Tomographic constraints on Mesozoic Paleogeography of the western Arctic

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Paleogeographic reconstruction of the western Arctic is hampered by ambiguous magnetic anomalies and lack of ocean drilling north of the Beaufort Shelf. Spreading of the Canada Basin by counter-clockwise rotation of Arctic Alaska (AA) after rifting away from the Arctic Islands (AI) is currently the most widely supported hypothesis. Previous workers show that the rotation hypothesis is inconsistent with: 1) detrital zircon datasets showing different Paleozoic to Cretaceous sources for AA and AI, 2) no change in deformation style with distance from the rotation pole, 3) incompatible structural and metamorphic styles across the proposed rift and 4) opposing AA and AI paleoflow directions. To these we add tomographic constraints that permit only a single slab in the region of AA, suggesting a probable AA - Koyukuk arc linkage and a ∼170 Ma AA location ∼4500km W of that predicted by the rotation hypothesis.

One of the most massive mantle fast domains imaged by seismic body-wave tomography is a wall that extends from northwest Canada along the eastern U.S. seaboard, to the Caribbean. Classically referred to as the "Farallon slab", it has been interpreted as relict ocean lithosphere subducted eastward beneath North America since the early Mesozoic. However, its geometry and location within a hybrid hot spot reference frame are more consistent with a composite slab complex originating as oceanic crust at the leading edge of North America that was subducted westward in pace with opening of the Atlantic, to form intraoceanic arcs. High resolution, multi-frequency P-wave tomography using 10 years of North American waveform data, including USArray, permits us to resolve at least three constituent slabs in the lower mantle. From north to south they are: Angayucham (ANG), Mezcalera (MEZ) and Southern Farallon (SF). Based on an empirically calculated slab sinking velocity of 10 $\pm$2 mm/a, we calibrate time since subduction for the slabs. Assuming that their lower limits are fully imaged, they initiated ∼195 Ma, ∼185 Ma and ∼185 Ma. However, global tomographic datasets show detached segments of ANG and MEZ extending even deeper, corresponding to ∼210Ma.

Volcanic arcs formed mainly by westward subduction of the ANG are the Togiak-Koyukuk-Nyak (∼205 – 100 Ma) arcs of western Alaska, and above MEZ slab are the Bonanza-Talkeetna (∼205 – 165 Ma), Chitina-Chisana-Gravina (∼155-105Ma) arcs of southwest Alaska and western British Columbia. Collision of the ANG arc with AA continental crust caused the diachronous ∼170 Ma to ∼125 Ma Brookian orogeny that corresponds with west-to-east extinction of the western 900 km of the ANG subduction zone (and length of Brooks Range blueschist belt), followed by a thermal pulse attributed to slab detachment. West-to-east extinction of subduction is consistent with AA originating at the Siberian margin, and not at the conjugate AI rift margin, which still lay ∼2500km to the ENE at 120 Ma.