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Integrating surface and mantle constraints for palaeo-ocean evolution: a tour of the Arctic and adjacent regions (Arne Richter Award for Outstanding Young Scientists Lecture)

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Plate tectonic reconstructions heavily rely on absolute motions derived from hotspot trails or palaeomagnetic data and ocean-floor magnetic anomaies and fracture-zone geometries to constrain the detailed history of ocean basins. However, as oceanic lithosphere is progressively recycled into the mantle, kinematic data regarding the history of these now extinct-oceans is lost. In order to better understand their evolution, novel workflows, which integrate a wide range of complementary yet independent geological and geophysical datasets from both the surface and deep mantle, must be utilised. In particular, the emergence of time-dependent, semi or self-consistent geodynamic models of ever-increasing temporal and spatial resolution are revealing some critical constraints on the evolution and fate of oceanic slabs. The tectonic evolution of the circum-Arctic is no exception; since the breakup of Pangea, this enigmatic region has seen major plate reorganizations and the opening and closure of several ocean basins. At the surface, a myriad of potential kinematic scenarios including polarity, timing, geometry and location of subduction have emerged, including for systems along continental margins and intra-oceanic settings. Furthermore, recent work has reignited a debate about the origins of 'anchor' slabs, such as the Farallon and Mongol-Okhotsk slabs, which have been used to refine absolute plate motions. Moving to the mantle, seismic tomography models reveal a region peppered with inferred slabs, however assumptions about their affinities and subduction location, timing, geometry and polarity are often made in isolation. Here, by integrating regional plate reconstructions with insights from seismic tomography, satellite derived gravity gradients, slab sinking rates and geochemistry, I explore some Mesozoic examples from the palaeo-Arctic, northern Panthalassa and western margin of North America, including evidence for a discrete and previously undescribed slab under present-day Greenland. While regional in focus, the methods and insights described have global applications and illustrate the power of an integrated approach.