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Tomotectonic constraints on the assembly of the western Arctic region and central Alaska: progress, problems and future direction

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Alaska is made up of a mosaic of terranes that have enigmatic origins. Several plate restorations for the assembly of Alaska have been proposed, but their validity remains debated, partly due to the removal of vast volumes of oceanic plate material via subduction at the accretionary margins. The position, depth and volume of this subducted lithosphere, recognised as seismically fast anomalies in tomographic images, can be used to track the locations of subduction plate boundaries of the past, thus serving as an important constraint for plate restorations of convergent margins. Existing plate tectonic reconstructions can be assessed and developed further by integrating seismic tomographic models of the mantle with geological and palaeomagnetic bedrock datasets, a procedure which we term “tomotectonic analysis”.

Previous tomotectonic studies (e.g., Sigloch & Mihalynuk, 2017, GSA Bulletin) have highlighted various discrepancies between the most generally accepted tectonic reconstruction models of the western coast of North America and tomographic observations of slabs in the mantle. For example, the kinematic reconstruction of Laurentia, constrained by the opening of the Atlantic Ocean, places the Cordilleran margin thousands of kilometres east of the tomographically imaged Angayucham and Mezcalera slabs in the mantle during the Early to Late Jurassic. This suggests that there was extensive westward subduction beneath the Insular and Intermontane superterranes that involved multiple plates, rather than a single subduction zone. Though a recent plate reconstruction that employed tomotectonic methods (Clennett et al., 2020, G-Cubed) provided a coherent explanation of bedrock, plate kinematic and mantle observations for the Cordilleran margin, application of this model to Alaska and the Arctic was hindered by low tomographic resolution beneath that region and requires further investigation. In particular, restoration of the Arctic Alaska terrane is complicated further by its possible relationship with the proposed Arctic Alaska-Chukotka microcontinent and its involvement in the accretionary development of the Siberian peninsula and the opening of the Canada Basin, for which several working hypotheses continue to be debated.

In this study we consider the application of tomotectonic analysis to Mesozoic reconstructions of the western Arctic and central Alaska. We will compare and contrast these tectonic reconstructions with respect to the distribution of slabs in the deep mantle based on observations from the latest seismic tomographic models, such as DETOX-P1, P2 and P3 (Hosseini et al., 2020, GJI). We will also

highlight the limitations of current tomographic models and the need for targeted seismic investigations with greater resolution of the underlying mantle. This discussion provides the motivation and rationale for a new seismic tomographic model of the mantle beneath North America currently being produced by the authors using a more complete USArray dataset.