Revisiting the Forearc Sliver Scenario Along the Southern Kurile Trench to Reconcile Interdisciplinary Observations

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Forearc sliver has been proposed as a mechanism to accommodate margin-parallel component of oblique plate convergence along the southern Kurile trench. The sliver scenario was established based mostly on the presence of the margin-perpendicular Hidaka Mountain Range (HMR), graben at Bussol Strait, en echelon Kurile Islands and high temperature metamorphic and intrusive rocks exposed at HMR. Along the volcanic front, geological faults including Kamishi-Yubetsu tectonic zone with 50 km right-lateral displacement was reported. Seismic velocity tomography and refraction/reflection experiments beneath HMR show the heterogeneous crustal structure relating to collision of the Kurile forearc and Northeast Japan arc, indicating upwelling of upper mantle, sinking of crustal material and delamination of upper mantle beneath HMR, and shortening in the foreland of HMR. Anomalous deep crustal earthquakes beneath HMR such as the 1970 M6.7 Hidaka and 1982 M7.1 Urakawa-oki earthquakes show active margin-parallel compression. However, other observations cast doubt on the forearc sliver being presently active. Although some active faults are reported along the volcanic front, they are not right-lateral faults. Interseismic GNSS velocities do not show localized right-lateral shear deformation along the volcanic front, although they show active margin-normal shortening in the foreland of HMR consistent with active collision. In this study, we propose a new scenario of forearc kinematics and strain partitioning along the southern Kurile trench to reconcile these seemingly discordant observations.

A mountain like HMR pushes sideways because of gravity and acts as a buttress of the forearc sliver to impede its migration. We compared the stress field inferred from CMT solution with that predicted from a buttressed sliver model. The comparison suggests that (1) the forearc sliver is buttressed at HMR and (2) resistance to right-lateral shear along the volcanic front is very large. Therefore, we propose a scenario as follows. The forearc sliver had been increasingly buttressed as HMR rose, so that the rate of strain partitioning diminished with time. Eventually, the forearc migration became too slow to cause recurring large earthquakes and to maintain a mature active fault zone along the volcanic front. As a result, the fault zone healed with time. At present, the forearc and backarc deform together without active faulting and localized shear along the volcanic front.

We also compared Kurile with other oblique subduction zones and found that margin (trench) curvature appears to principal control forearc kinematics. At Cascadia and Nankai where the margin is concave seaward, interseismic GNSS velocities do not show discernable localized shear to define the forearc sliver but strong margin-parallel shortening towards the area of maximum margin curvature. In contrast, in southernmost Chile where the trench is approximately straight, there is little margin-parallel shortening but significant forearc sliver migration. However, at Kamchatka, although the margin is concave off-Kamchatka Peninsula, significant margin-parallel migration of Aleutian Islands is still occurring, which we speculate is due to the extreme obliquity of plate convergence here. Even in this case, significant shortening is observed at the leading edge of the forearc sliver. The concave margin has buttressed the forearc sliver and caused shortening in the area of maximum curvature in the geological time scale as well because the tectonic setting itself, such as the margin curvature and the obliquity of plate convergence, is the controlling factor of the forearc kinematics.

Keywords: Kurile Trench, Forearc Sliver, Oblique Subduction, Hidaka Mountain Range, Strain Partitioning, Volcanic Front

