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Intermediate-depth Fracturing of Oceanic Lithosphere in Subduction Zones: Memories from Exhumed High-Pressure Ophiolites

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Understanding processes acting along the subduction interface is crucial to assess lithospheric scale coupling between tectonic plates and mechanisms causing intermediate-depth seismicity. Despite a wealth of geophysical studies aimed at better characterizing/localizing this seismicity, we still critically lack constrains on processes triggering fracturing in regions (40-100km depths; T > 400°C) where deformation is expected to be achieved by plastic flow. We herein attempt to bridge this gap by providing a review of available evidence from brittle deformation patterns in exhumed High Pressure (HP) ophiolites, together with some new, critical observations.

Field examples from various ophiolitic terranes (New-Caledonia, W. Alps, Tian Shan…) indicate that brittle deformation under HP conditions generally implies vein filling and precipitation of HP minerals, probably under very high pore fluid pressure conditions. Coalescence of such vein networks could explain some of the seismic events recorded along the fluid-rich subduction interface region. By contrast, HP pseudotachylites (though reported in only few localities so far) are apparently restricted to somehow deeper slab regions where fluid-deficient conditions are prevalent (Corsica, Zambia, Voltri?).

The recent discovery of eclogite breccias, found as m-sized dismembered fragments within an eclogite-facies shear zone from the Monviso area (W. Alps), provides a new opportunity to study the genesis of intermediate-depth earthquakes. We herein argue that these eclogite breccias constitute unique remnants from an ancient fault zone associated with intraslab, intermediate-depth seismicity at ca. 80 km depth. The breccia is internally made of 1-10 cm-sized rotated fragments of eclogite mylonite cemented by an eclogite-facies matrix attesting of fracturing and fault sealing under lawsonite-eclogite facies conditions (550°C, 2.5 GPa) during subduction of the Tethyan seafloor. Textural observations and polyphased fracturing-healing events frozen in garnet zoning patterns indicate that brecciation was most likely seismic and was accompanied by the input of externally-derived fluids, thereby highlighting again the role of fluids.

Although dehydration embrittlement or hydrofracturing are generally amongst the most preferred candidates for explaining intermediate-depth seismicity, this contribution stresses the need for even more detailed studies to better understand the formation of such events.