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Producing high pressure pseudotachylytes: implications for the generation of intermediate-depth earthquakes

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Gabbro- and peridotite-hosted blueschist facies pseudotachylytes (PST) from Cima di Gratera, Corsica, previously determined to have formed under high pressure and temperature conditions (1.8 - 2.6 GPa, 1400 °C), have been causally linked to the generation of intermediate-depth earthquakes. Detailed petrographic and microtextural analyses of these PST indicate that their initiation is controlled by a thermally activated shear runaway process that is controlled by rheology rather than mineralogy (as with dehydration embrittlement or transformational faulting), such that the rock behaves as a viscoelastic material. This is evidenced by sheared out, prolate, kinked and twinned wallrock clasts that have been peeled off and entrained into the PST vein as sigmoids. The presence of gouge and wallrock grains that have undergone crystal plastic behaviour that increases towards PST are suggestive of a high temperature shear localization mechanism. The presence of metastable high temperature crystallisation products from the PST such as hoppers and dendrites of olivine (Mg# 84), enstatite and diopside (peridotite), and Al-rich omphacite and Fe-rich anorthite (gabbro) support the hypothesis of a short-lived high temperature event resulting from thermal runaway. Overprinting of these high temperature mineral assemblages by ones indicating lower temperatures, but still high pressures, such as glaucophane, albite and epidote (gabbro) and clinochore, fine-grained granoblastic olivine, enstatite and diopside (peridotite) are further support of this. The detailed study of two different lithologies (peridotite and gabbro) that were exposed to similarly high PST-producing P-T conditions are used to corroborate the proposed runaway process. This work provides the first detailed observations from natural samples indicating that intermediate-depth seismicity may be generated by thermal runaway.

Detailed microprobe analyses and BSE imaging of the PST vein matrix (comprising glass, the crystallisation products and entrained wallrock material) show that the PST melt ranges in water content from 0 - 14 wt%. This water is derived internally within the shear system due to the wholesale fusion of hydrous wallrock minerals (glaucophane, tremolite, clinochlore and serpentine) rather than dehydration. These observations, together with the microtextures, preclude local dehydration embrittlement, transformational faulting and purely ductile models such as self-localizing runaway (as proposed by Kelemen and Hirth, 2007 and John et al., 2009) as sources of intermediate-depth seismicity.