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Thermal fragmentation of garnet during deep-seated co-seismic frictional heating.

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The amphibolite-facies mylonite-pseudotachylyte association of the Austroalpine Mont Mary unit (Western Alps) provides an outstanding example of interplay between frictional and viscous deformation in the ductile realm. Pseudotachylytes overprint ultramylonitic bands and are then affected by ductile shearing during which the host-rock high grade minerals (sillimanite and garnet) are stable, suggesting pseudotachylyte formation and ductile shearing are coeval. Despite garnet being stable (as recorded by thin overgrowths surrounding rare clasts), the pseudotachylytes are commonly free or poor of garnet. In the host-rock, garnet grains close to the pseudotachylyte veins are intensely fragmented and locally comminuted down to a sub-micrometric grain size. We suggest a general process for garnet disappearance, during co-seismic frictional heating, due to thermal shock fragmentation. We show that garnet has the lowest thermal shock resistance of the different host-rock minerals (garnet, plagioclase, quartz, and sillimanite in an increasing sequence of resistance), and thus underwent the most extreme comminution leading to total melting within frictional melt, which was therefore deprived of nuclei for growth of garnet microlite and neoblasts. Low thermal shock resistance of garnet is due to its peculiar thermo-elastic and mechanical properties. Garnet builds up the highest thermal pressure as result of shock heating at constant volume because of high bulk modulus. This, combined with its relatively low fracture toughness and low thermal conductivity, may account for its behaviour. Our analysis highlights the critical role of thermal shock as a general process in mineral comminution during the initial stages of co-seismic slip preceding (and promoting) extensive production of frictional melts. Our finding has general implications for establishing the coeval development of pseudotachylytes and mylonites and, therefore, for recognising the evidence of deep earthquakes in exhumed rocks.