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Seismicity, metamorphism and rheology of the lower continental crust

Håkon Austrheim
University of Oslo, Norway (h.o.austrheim@geo.uio.no)

Seismological data document that both normal earthquakes and tremors occur in the lower continental crust. Pseudotachylytes (frictional melts and ultracommunited rocks) have been described from several high grade metamorphic terrains and may be the geological manifestation of this seismicity. The Grenville (c. 930Ma) granulite facies complex (T: 800 ^{0}C; P: $\leq$10kbar) of the Lindås Nappe in the Bergen Arcs, W-Norway underwent a fluid induced partial eclogite (T: 600-650 ^{0}C; P: 15-20 kbar) and amphibolite facies metamorphism during the Caledonian (c.400-430 Ma) continent collision. Pseudotachylyte fault and injection veins formed in the dry granulites at or close to the reaction fronts both in the eclogitized (western parts) and the amphibolitized (eastern parts) of the Nappe. They are locally recrystalized with the development of amphibolite and eclogite facies assemblages demonstrating that they formed pre or syn the Caledonian metamorphism. The pseudotachylytes transect lithologies ranging from peridotite to anorthosite and consequently the influence of the seismic energy release on a range of granulite facies minerals including garnet, pyroxenes, olivine, plagioclase, hornblende and scapolite can be observed.
The seismic energy released promotes the Caledonian metamorphism and change the petrophysical properties of the lower crust in the following ways: The melting and the ultracommunition of the granulite facies minerals increased the reactive surface area and produce local pathways for fluid. S-rich scapolite, a common mineral in granulities play a key role in this process by releasing S and C to form sulfides and carbonates. Small sulfide grains impregnate the pseudotachylyte veins which may lead to an increased electrical conductivity of the deep crust. The pseudotachylyte veins impose inhomogeneities in the massive rocks through grain size reduction and lead to strain localization with development of amphibolite and eclogite facies shear zones. Formation of eclogite facies breccias where meter size blocks of rotated granulites are enclosed in eclogite may have initiated by the seismic events as indicated by fractures in the relict granulite facies garnet. The seismic events may have been important in large scale transport of fluid required to bring about the metamorphism of the dry granulite facies complex.