Petrology of sub-cratonic pyroxenite and eclogite containing lamellae-bearing garnet, Western Gneiss Region, Norway

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Garnet from the lithospheric mantle underneath cratons can contain oriented lamellar inclusions of pyroxene and oxides like rutile as a result of exsolution of majoritic and titaniferous components due to cooling and/or decreasing pressure. We investigated ten new such microstructure-bearing samples of pyroxenite and eclogite from six peridotite bodies in SW Norway, which were once located in the E Greenland mantle lithosphere. The lamellar inclusions occur in porphyroclastic garnet and vary – dependent on their size - systematically in shape, (acicular to short-prismatic), width (~50 μm to sub-micron size), spacing (several 100 to ~10 μm), and phase (pyroxene to pyroxene + Ti-oxides to Ti-oxides). Smaller lamellae can fill the space between larger lamellae, which support consecutive generations. The larger (early formed) lamellae are more poorly preserved and more difficult to locate in the suite of samples than the smaller (lately formed) exsultes. A younger generation of lamellar and other inclusions occur lined-up along healed cracks cutting across cores but not rims of garnet. These inclusions comprise oxides, silicates, carbonates (aragonite, calcite, magnesite) and fluid inclusions (N₂, CO₂, H₂O). Their origin either relates to the Precambrian rock history and/or to a hydrous environment as typical for mantle wedge metasomatism prior to Scandian recrystallisation. Mineral chemistry suggests that the lamellae-bearing garnet grains equilibrated at two discrete depth levels, corresponding to ~3.7 GPa (850 °C) and ~3.0 GPa (710 °C), at a cratonic geotherm corresponding to 38 mW/m² surface heat flow. Five samples contain porphyroclastic orthopyroxenes with Al₂O₃ concentration showing W-shaped profiles and/or very low Al₂O₃ content (0.18–0.23 wt%) in cores of large (>200 µm) recrystallised grains. Both characteristics typify short intracrystalline diffusion lengths and are consistent with an early prograde metamorphic evolution into the diamond stability field. This evolution is related to subduction during the Scandian orogeny. Porphyroclastic orthopyroxenes in other samples show U-shaped Al₂O₃ concentration profiles and long diffusion lengths of several 100 μm, i.e. longer than the grain radius of the recrystallised grains. Their cores contain high Al₂O₃ contents (0.65–1.16 wt%) consistent with a diffusional overprint that followed partial rock recrystallisation and obliterated pro- and peak metamorphic records. The presence of systematic exsolution microstructures in all samples demonstrates a similar early evolution of pyroxenite and eclogite in all six peridotite bodies. The wide distribution of our samples across the Western Gneiss Region indicates that (1) majoritic and titaniferous garnet occurred widespread in the E Greenland lithospheric mantle and (2) rock bodies of Scandian ultra-high pressure
metamorphism can be found in nearly the entire area between Nordfjord and Storfjord and from the coast towards ~100 km in the hinterland, i.e. in a region much larger than previously anticipated.