New UHP eclogite in between UHP areas, WGR, Norway

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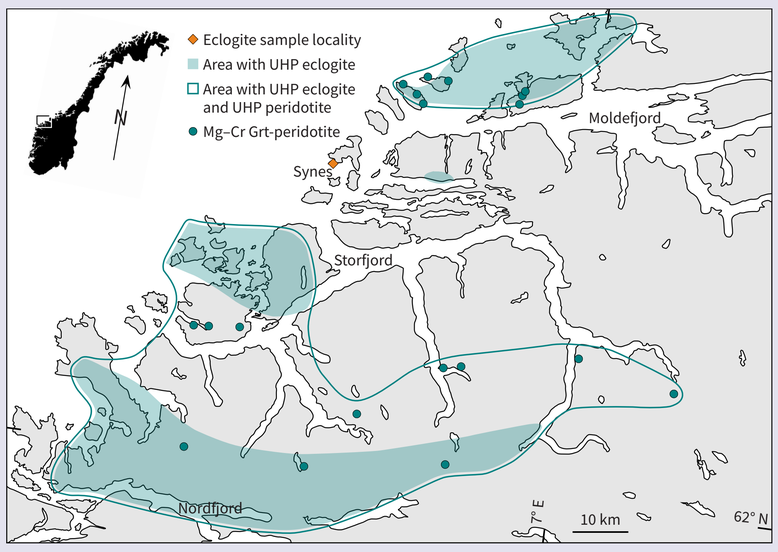
Contribution

The Western Gneiss Region (WGR) in W Norway is known for three major domains of high grade gneisses that host isolated eclogites with UHP metamorphic conditions [1]. Each domain has coastal occurrences that contain evidence for metamorphism to have occurred within the diamond stability field, either by the index mineral itself or by thermobarometry or both.

A newly studied coastal eclogite from Synes (Vigra island) situated in between the two northern UHP domains adds to these occurrences.

UHP rocks in the WGR



The distribution of UHP metamorphic rocks in the WGR can be subdivided by rock type. Mafic rocks (eclogite) define three large and one small domains that spread along the coast (shaded [1]). Whereas ultramafic rocks (garnet pyroxenite enclosed in orogenic garnet peridotite [2]) define UHP exposure that partially overlaps that of eclogite and partially fills the space in between [3]. When taken together, evidence for UHP metamorphism is concentrated in two domains (outlined) that are separated by a gap. This study focuses on the gap.

References

[1] Spencer, K. J. *et al.* Campaign-style titanite U–Pb dating by laser-ablation ICP: implications for crustal flow, phase transformations and titanite closure. *Chemical Geology* **341**, 84–101 (2013).

[2] Brueckner, H. K. The great eclogite debate of the Western Gneiss Region, Norwegian Caledonides: the in situ crustal *v.* exotic mantle origin controversy. *Journal of Metamorphic Geology* **36**, 517–527 (2018).

[3] Spengler, D., Alifirova, T. A. & van Roermund, H. L. M. Subcratonic and tectonic evolution of pyroxenite and eclogite with lamellar inclusions in garnet, Western Gneiss Region, Norway. *Journal of Petrology* **62**, egab008 (2021).

[4] Brey, G. P. & Köhler, T. Geothermobarometry in four-phase lherzolites II. New thermobarometers, and practical assessment of existing thermobarometers. *Journal of Petrology* **31**, 1353–1378 (1990).

[5] Quas-Cohen, A. *Norwegian orthopyroxene eclogites: petrogenesis and implications for metasomatism and crust-mantle interactions during subduction of continental crust*. PhD thesis (2014).

[6] Spengler, D., Brueckner, H. K., van Roermund, H. L. M., Drury, M. R. & Mason, P. R. D. Long-lived, cold burial of Baltica to 200 km depth. *Earth and Planetary Science Letters* **281**, 27–35 (2009).

[7] Taylor, L. A. & Neal, C. R. Eclogites with oceanic crustal and mantle signatures from the Bellsbank kimberlite, South Africa, part I: mineralogy, petrography, and whole rock chemistry. *Journal of Geology* **97**, 551–567 (1989).

[8] Morimoto, N. *et al.* Nomenclature of pyroxenes. *American Mineralogist* **73**, 1123–1133 (1988).

[9] Coleman, R. G., Lee, D. E., Beatty, L. B. & Brannock, W. W. Eclogites and eclogites: their differences and similarities. *Geological Society of America Bulletin* **76**, 483–508 (1965).

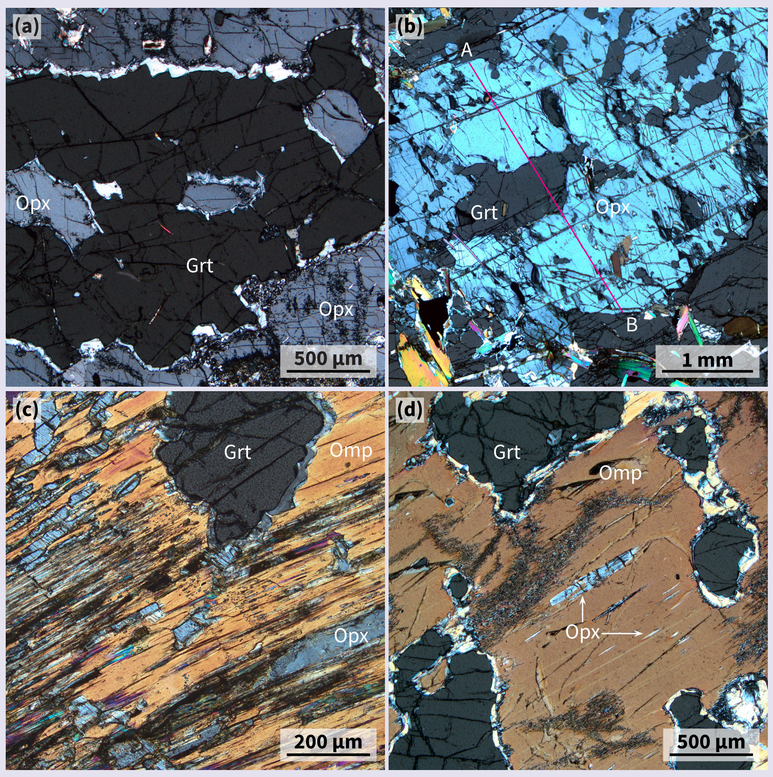
[10] Cuthbert, S. J., Carswell, D. A., Krogh-Ravna, E. J. & Wain, A. Eclogites and eclogites in the Western Gneiss Region, Norwegian Caledonides. *Lithos* **52**, 165–195 (2000).

[11] McDonald, C. S., Regis, D., Warren, C. J., Kelley, S. P. & Sherlock, S. C. Recycling argon through metamorphic reaction: the record in symplectites. *Lithos* **300–301**, 200–211 (2018).

[12] Walsh, E. O. & Hacker, B. R. The fate of subducted continental margins: two-stage exhumation of the high-pressure to ultrahigh-pressure Western Gneiss Region, Norway. *Journal of Metamorphic Geology* **22**, 671–687 (2004).

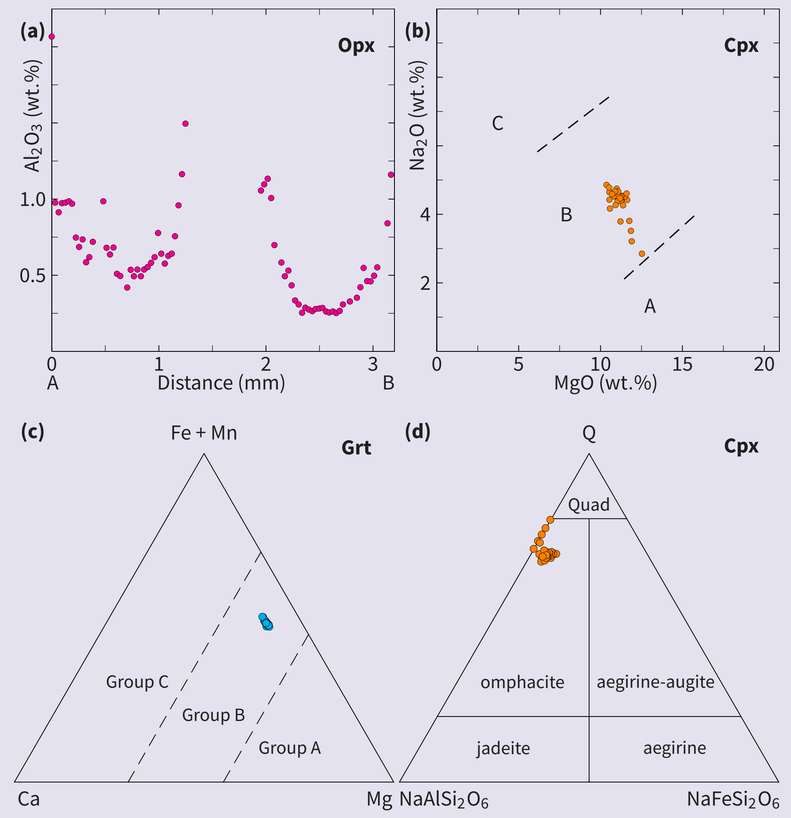
[13] Root, D. B. *et al.* Discrete ultrahigh-pressure domains in the Western Gneiss Region, Norway: implications for formation and exhumation. *Journal of Metamorphic Geology* **23**, 45–61 (2005).

Petrography



Grt + Omp + Opx are the primary minerals of the Synes eclogite, minor Rt + Ilm occur as inclusions. Secondary Amp and Bt partially replaced the primary minerals. The primary minerals are coarse grained (up to 1 cm crystal size) and show minor strain accumulation. Characteristic are poikiloblastic intergrowths of Pyx and Grt with irregular grain shapes, consistent with a magmatic co-crystallisation of these minerals (a–d, nearly cross-polarised light). Coarse and fine exsolution lamellae of Opx in coarse Omp suggest that magmatic crystallisation was followed by eclogite cooling (c–d).

Mineral chemistry



Opx grains in contact with Grt have Al_2O_3 concentration gradients with 'U-shape' patterns that are consistent with diffusion to have partially overprinted an initial mineral-chemical equilibration (a). Cores of large Opx grains have compositional flat plateaus of ~0.25 wt.% Al_2O_3. Omp is classified as Group B eclogite [7] (b). The Jd component in crystal cores is ~26 % and lowers to ~20 % toward crystal rims [8] (d). The Ae component was estimated assuming Fe^{3+}=Na–Cr–Al. Grt grains are chemically uniform and are classified as Group B [9] (c).

Thermobarometry

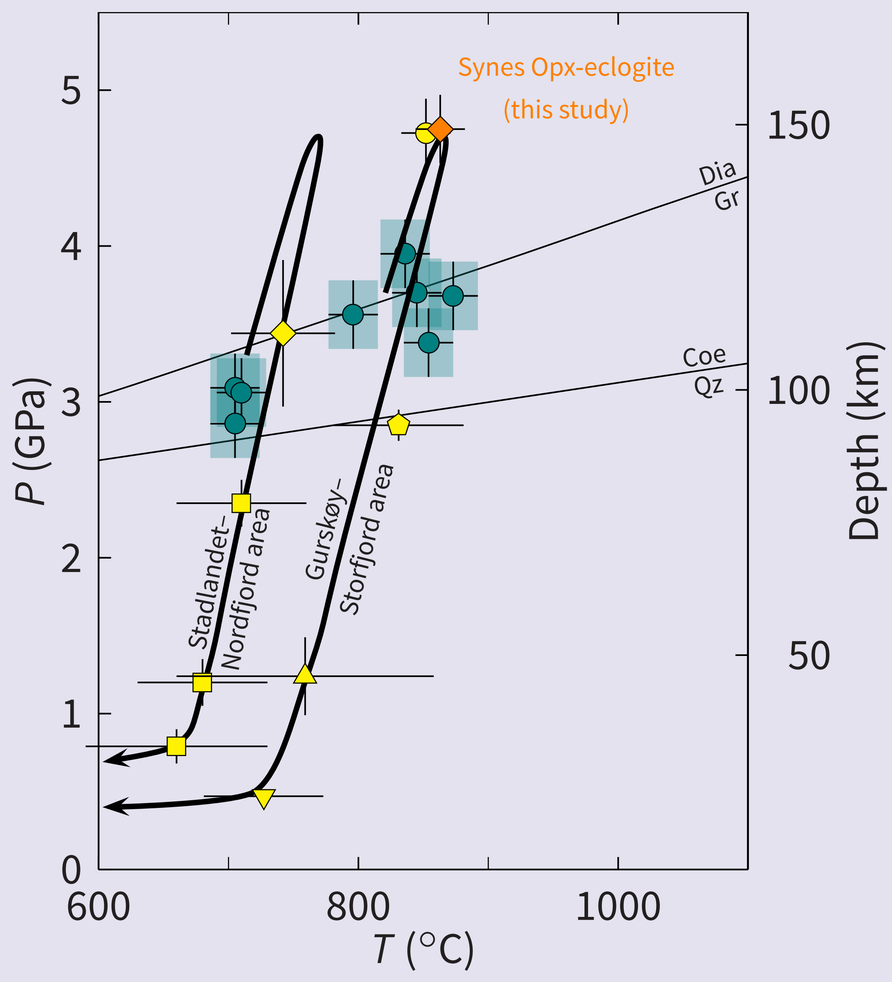
Iterative application of the compositions of low-Al Opx and Grt to the Ca-in-Opx thermometer and Al-in Opx/Grt barometer calibrations of [4] suggests that the Synes Opx-eclogite was exposed to 863 °C and 4.75 GPa. Thus the magmatic mineral texture equilibrated chemically deep in the diamond stability field. Similar metamorphic conditions have been reported from nearby UHP metamorphic areas [3, 5, 6].

Literature data (from [3]):

Pre-tectonic *PT* data:
- Grt-pyroxenite in orogenic peridotite [3]

Syn-tectonic *PT* data: Stadlandet–Nordfjord area
- Average (n=16) UHP Opx-eclogite [10]
- Gneiss NF42, Krokkenakken [11]

Syn-tectonic *PT* data: Gurskøy–Storfjord area
- Average (n=2) Grt-websterite QC29A, N Remøy [5], recalculated using Ca- and Al-in-Opx calibrations of [4]
- Opx-eclogite 9814i4, N of Stranda [12]
- Average (n=4) metapelite [13]
- Metapelite R9828C30, Sandsøya [13]



The arrows connect metamorphic conditions preserved in ultramafic, mafic and felsic lithologies that are exposed in two areas. The similarity in path shape argues for a shared evolution of these different lithologies.

Conclusion

The new sample shows that coastal rock exposure in between Storfjord and Moldefjord records metamorphic conditions within the diamond stability field.

Because the metamorphic conditions are similar to those in adjacent UHP domains, we argue that all UHP domains in the WGR are connected at the current erosion level.

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