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TRANSMISSION ELECTRON MICROSCOPY ON ECLOGITES FROM THE LOWER SCHIST COVER AND THE ECLOGITE ZONE (TAUERN WINDOW, AUSTRIA)

by

E. B. Barnert[1], W. F. Müller[1], E. Schmädicke[1,2] & G. Franz[3]

[1]Institut für Mineralogie
Technische Universität Darmstadt, Schnittspahnstrasse 9, D-64287 Darmstadt
[2]Institut für Geologie und Mineralogie
Universität Erlangen, Schloßgarten 5a, D-91054 Erlangen
[3]Institut für Angewandte Geowissenschaften
Technische Universität Berlin, Strasse des 17. Juni, D-10623 Berlin

We are studying the microstructure of the mineral constituents of eclogites from the Tauern Window, Austria, by transmission electron microscopy (TEM). The eclogites occur in two different units: the Lower Schist Cover and the Eclogite Zone, where they experienced a different thermal and mechanical history.

a) Lower Schist Cover: Most of our studies have been made on TEM specimens of sample LT 26c-87, locality Frosnitztal, Keespöllach [1]. Mineral chemistry, phase relations and geothermometry point to low formation temperatures (400 - 500°C) at 8 - 12 kbar [1]. The eclogites formed from rocks of basaltic composition during the Silurian subduction about 420 Ma ago [2]. Omphacite (Omp), barroisite (Bst), glaucophane (Gln), albite, muscovite, paragonite, garnet, epidote, rutile, and titanite were seen in the TEM. The rock was heavily deformed as revealed by high densities of dislocations in Omp and amphibole; dislocations in the other minerals were rarely encountered.
Omphacite: Structurally, it is almost always characterized by a primitive Bravais lattice. Most grains contain rather small (around 50 nm in size) equiaxed roundish antiphase domains (APDs) with the displacement vector 1/2[110] (for literature on omphacite, see [3], [4]). Their small size is well in agreement with their formation at low temperatures. Occasionally, within the same grain, areas a few μm in width occur which are free or nearly free of antiphase domain boundaries (APBs). Faults parallel to (010) up to 1 μm in length are probably chain multiplicity faults (CMFs). The partial dislocations at their ends have the Burgers vector b parallel to [101] or [-101]. The CMFs may have been formed by the dissociation reaction [001] = 1/2[101] + 1/2[-101] (cf. [5]). Recovery processes are evident from frequent low angle grain boundaries (LAGB). Rather conspicuous are dynamically recrystallized Omp grains, ca. 5 μm in size, free of dislocations, which grow into the heavily deformed Omp matrix with a dislocation density up to 10^{14} m^{-2}. The size of the APDs in the recrystallized grains was also around 50 nm. Lamellar Bst precipitates near (010), 0.5 μm in width and a few μm long, were seen in a grain with frequent CMFs and LAGBs subparallel to (010); the lattices of Bst and Omp share (010) and (10^{-1}).

Wavy exsolution lamellae on (100) occurred in Omp of more Fe-rich composition in a specimen of the same thin section, but in another layer of the banded eclogite (see [1]).

Amphibole: Bst is characterized by the occurrence of CMFs parallel to (010). Densities up to about 45 μm^{-1} (measured along a line of about 1 µm length perpendicular to (010)) have been noted. Gln does not show CMFs.

Epidote: The only one epidote studied so far contained a wedge-shaped twin lamella, from about 0.1 µm to 0.2 µm, according to the twin law m parallel to (100).

Titanite: Titanite was encountered as sub-idiomorphic inclusions of a few to several µm in size in Omp. Electron diffraction patterns showed the absence of reflections of the type k + l odd and streaks parallel to b*. According to [6], the space group A2/a is attained when > 4 mole percent of Ti is substituted by Al and Fe, as is the case in our titanite.

Mica: In one case, a mica with about the same amount of Na und K was found, which is perhaps a paragonite/muscovite intergrowth in the unit cell range.

b) Eclogite Zone: Samples "Gatter" and "Knappenhaus" (Frosnitztal, [7]), geothermo-barometry: 550 - 630°C, ~ 20 kbar [8]. Omp-1, Omp-2, Grt, Gln, Tr, Ab, Tlc, Qtz, Ms, Pg, Ky, Ep, Czo, Dol, Mgs, Rt and Zr were identified by polarising microscopy, electron microprobe analysis and analytical TEM, in terms of selected area electron diffraction (SAED) and energy dispersive x-ray microanalysis (EDX). Omp shows APDs which are partially coarsened. The average diameter of the domains is 80 - 200 nm in both specimens which is in agreement with eclogites taken from the neighbouring Dorfer- and Timmeltal (50 - 200 nm, samples from T.J.B. Holland) described by CARPENTER [3]. Most APDs are equiaxed, their APBs smoothly curved. Occasionally, APBs parallel to (010) occur which are surrounded by a zone without APBs (Fig. 1).

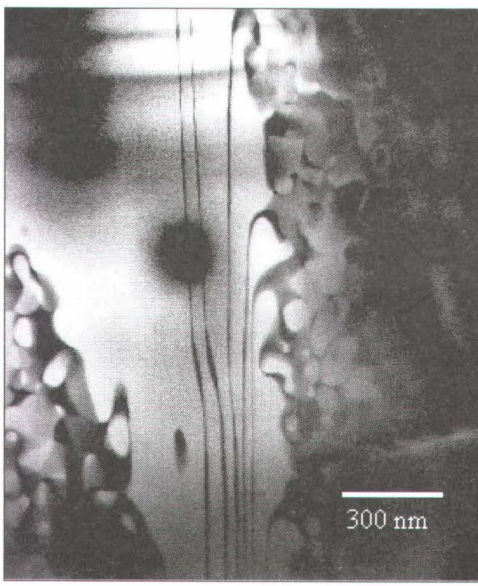

Fig. 1
Dark field image of omphacite-2 with APB's parallel (010) (Eclogite Zone).

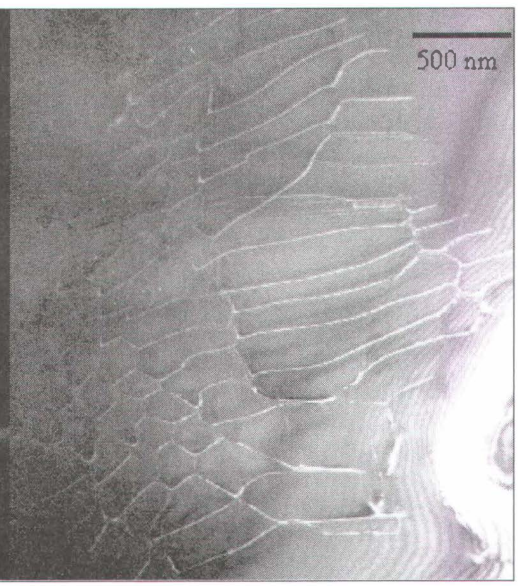

Fig. 2
Weak beam dark field image of a dislocation network in omphacite-2 (Eclogite Zone).

We found the (010) APBs in contact with and as a continuation of the equiaxed APBs. The area with the oriented APBs does not exhibit chemical differences to the other APDs as verified by EDX. The (010) APBs in Fig. 1 seem to be induced by a sinistral shear deformation of the crystal. Perhaps these APBs can be used as an intracrystalline "micro-shear sense indicator"
The SAED patterns of lamellae parallel to (100), where maximum splitting of reflections in a*-direction occurs, can be interpreted as twin or exsolution lamellae. The lamellae show pressure shadows due to deformation twinning. In case of exsolution, omp should decompose into jadeite and augite. We observed, however, APBs in and around the lamellae, crossing the lamellae without being influenced by them. Hence, these are twin lamellae which seem to have been formed by a deformation process before the APD-building phase transition C2/c to P2/n took place. The dislocation network (Fig. 2, note split dislocations!) is a result of dynamic recovery processes, probably during lasting deformation (dynamic recovery). We did not observe any interaction between the dislocations and the APBs. Epitaxial intergrowth parallel (001) between omp and tremolite is determined by SAED patterns. Epitaxial overgrowth of clinopyroxene with tremolite is a typical retrograde phenomenon. This is another argument for tremolite as a post eclogitic amphibole and not being part of the primary assemblage.

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