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From brittle and crystal-plastic deformation to dissolution-precipitation creep – the microfabric development in HP-metamorphic serpentinized mantle peridotites

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Exhumed HP-metamorphic and serpentinized peridotites provide a unique record of grain-scale processes in subduction zones. In this study, we examine the microfabric development in HP-metamorphic serpentinites exposed in the Erro-Tobbio Unit (Voltri massif, Italy) using light and electron microscopy (SEM/EBSD, EMP). The serpentinites are derived from mantle peridotites and underwent HP-metamorphic conditions during Alpine subduction (P = 1.8 - 2.5 GPa, T = 500-600°C). They contain large pyroxene and olivine porphyroclasts embedded in a matrix of serpentine. The pyroxene and olivine porphyroclasts record associated brittle and crystal-plastic deformation of the original peridotites, i.e. sealed microcracks, deformation bands, undulatory extinction and kink bands. Olivine porphyroclasts are partly recrystallized showing small new grains along grain boundaries and former microcracks. Subgrain rotation recrystallization is indicated by a crystallographic preferred orientation of the new grains controlled by the host crystal, and by subgrains in porphyroclasts of the same size and shape as the new grains. During recrystallization, cation exchange led to slight modification of the Mg2+ and Fe2+ content of the recrystallized grains compared to the host crystal. Only after this deformation and recrystallization of the olivine and pyroxene crystals, the peridotites became serpentinized. Deformation by dissolution precipitation creep of the serpentinites is indicated by a prevalent foliation with strain-shadows next to porphyroclasts, flattened olivine grains at phase boundaries with serpentine, and crenulation cleavage. The preceding brittle and crystal-plastic deformation of the original peridotites recorded by the olivine and pyroxene porphyroclasts might have initiated the infiltration of fluids driving serpentinization. Possibly the serpentinization took place when the peridotites were incorporated into the subduction zone.