The effect of the volume fraction of garnet on the deformation behaviour of eclogite

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Owing to the formation and presence of potentially large amounts of eclogite this metamorphic rock's deformation behaviour is of great importance for the rheology of the lithosphere in continental collision and subduction zones. The rheological behaviour of poly-mineralic rocks depends on the relative amount, the distribution and the strength of their components. We constrained the rheological behaviour and microstructural evolution of synthetic eclogite aggregates, composed of garnet and omphacite in varying fractions, by deformation experiments. Aggregates, synthesized in a piston cylinder apparatus to control the relative proportions of garnet and omphacite, were deformed in a modified Griggs apparatus at temperatures and pressures characteristic for in-situ conditions at plate boundaries. A series of aggregates containing volume fractions of 0, 25, 50, 75 and 100 % garnet were deformed at 1000 °C, 2.5 GPa and a strain rate of 3*10-6 s-1. The deformed two-phase aggregates are characterized by a distinct foliation defined by a strong shape preferred orientation of garnet and omphacite. In aggregates containing a volume fraction of 75 % garnet, strain is accommodated by a combination of crystal plastic deformation of garnet and omphacite as well as conjugate sets of cracks with respect to the maximum compressive stress direction. Misorientation deviation angle maps reveal intracrystalline misorientations up to 5° and 10° for garnet and omphacite respectively. Aggregates containing equal volume fractions of garnet and omphacite show similar intracrystalline misorientation of both phases but less cracking. Elongate omphacite crystals are aligned perpendicular to the shortening direction. In aggregates containing a volume fraction of 25 % garnet, omphacite forms interconnected weak layers presumably accommodating most of the strain. Low angle grain boundaries and recrystallized grains are common indicating the onset of dislocation climb and associated recovery mechanisms. Some large (40-70 µm) garnet crystals embedded in the omphacite matrix exhibit fine-grained tails perpendicular to the shortening direction. The tails are formed by small (<10 µm) neocrystallized grains nucleated from fragments of the initial garnet as indicated by chemical zoning observed in back scattered electron images. In contrast to two-phase aggregates mono-mineralic aggregates, do not show a distinct foliation, but large (40-70 µm) omphacite crystals are embedded in a fine-grained (<20 µm) matrix of equally-sized, polygonal omphacite grains indicating recrystallization. Garnetite exhibits mostly brittle deformation in the form of conjugate stets of microcracks with respect to the maximum compressive stress. The microstructures resulting from the deformation experiments show a switch from a load bearing framework (≥75 % volume fraction garnet) towards the development of interconnected weak omphacite layers (≤50 % volume fraction garnet) accompanied by a switch from overall brittle to crystal plastic dominated deformation behaviour.