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Multiple fluid sources accompany step-wise brittle deformation at 80 km depth (Monviso eclogitic breccias, W. Alps)

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The Monviso meta-ophiolite complex (NW-Italy, W-Alps) represents a unique fragment of oceanic lithosphere metamorphosed to eclogite-facies peak conditions during Alpine subduction (2.6 GPa-550°C, Lago Superiore Unit). We focus our study on two major shear zones cutting across the complex at low angle, the Lower Shear Zone (LSZ) and the Intermediate Shear Zone (ISZ), where abundant blocks of brecciated Fe-Ti-metagabbros are scattered in the intermediate to upper levels of the LSZ and ISZ. Complex compositional variations in meter-sized blocks and decameter-scale slivers of brecciated metagabbros are found in the LSZ but not in the ISZ. Here, the foliation of intact Fe-Ti (composed of omphacite + garnet + rutile ± quartz ± glaucophane) and Mg-Al-rich metagabbros (composed of omphacite + rutile ± quartz ± glaucophane and locally garnet) are cut by unfoliated breccia planes (cemented by omphacite + garnet ± lawsonite), demonstrating pristine brecciation at eclogite-facies conditions. The existence of (at least) three generations of HP-veins (omphacite + garnet) and a first omphacite-rich matrix M1 cut by a secondary matrix M2 rich in garnet ± lawsonite pseudomorphs reveals multiple brittle rupture events (possibly shortly spaced in time) prior to a stage of massive eclogite-facies fluid ingression (lawsonite-rich matrix M3). Trace element compositions (bulk and in-situ) of the three successive matrices allow to track the progressive change in the fluids involved in the brecciation, reflecting a progressive opening up of the system. In detail, M1 matrix crystallized during percolation of fluids buffered by the Grt-bearing Mg-Al metagabbros, M2 matrix formed upon mixing of fluids derived from the surrounding Grt-bearing Mg-Al metagabbros and from serpentinites and M3 matrix records involvement of external fluids buffered by serpentinites. Similarly to the matrices, the three generations of HP-veins from LSZ and ISZ reflect a progressive transition from "closed" geochemical system (with trace element composition similar to that of the host Fe-Ti metagabbros) to "open" system (syn-brecciation veins, progressively enriched in serpentinite-buffered trace elements). The sharp increase in fluid-content observed from M1-matrix (omphacite-rich) to the lawsonite-rich M3-matrix thus points to local embrittlement prior to external fluids ingress via successive brecciation events. Structural and geochemical evidence suggests that eclogite-facies brecciation (preferentially within Fe-Ti gabbros embedded in Mg-Al metagabbros) controlled the initial stages of strain localization within the LSZ and ISZ. Strain localization into the LSZ occurred towards the end of the M2 stage, after which fluid flow was restricted to the LSZ only, leading to shear zone network widening and incorporation of brecciated mafic and ultramafic blocks. Thus the LSZ metagabbros record successive stages of deformation and fluid infiltration in a large-scale shear zone, exemplifying the chemical changes that can be provoked by reactive fluid flow through the plate interface.