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Melt-Present Deformation across the Strike of a Collisional Orogen: P–T–t–d results from the Western Gneiss Region, Norway

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Partial melt (with a melt fraction >10–15%) dramatically decreases viscosity in orogenic systems and may change how subducted crustal material and the overriding plate deform throughout the evolution of a collisional orogen. The Western Gneiss Region (WGR), Norway, contains abundant migmatite hosting mafic inclusions that record ultrahigh- to high-pressure (UHP–HP) (eclogite-facies) conditions south of the Møre-Trøndelag strike-slip fault zone and very high temperature (granulite-facies) conditions at structurally deep levels north of the fault zone. Throughout the entire WGR, abundant evidence for partial melt is found within layer-parallel leucosomes in the host gneiss, crystallized melt in the pressure shadows of mafic pods, and as late, crosscutting pegmatites. Using combined geochronology (U-Pb) and trace-element analysis of zircon from migmatite and eclogite, we document the pressure-temperature-time-deformation conditions of eclogite and gneiss across the orogen and evaluate the role of partial melting in metamorphism and exhumation. The data was collected from a variety of textural types of leucosome as well as from the associated mafic pods. At a sample site north of the Møre-Trøndelag fault zone (Roan Peninsula) within the granulite-facies WGR, we analyzed zircon from five leucosomes within highly deformed migmatite. Results reveal U-Pb lower-intercept ages from ca. 405 to 409 Ma and upper-intercept Proterozoic dates. These zircons have distinct trace-elements patterns: all of the zircons that yield Proterozoic dates have overall much higher REE concentrations, a more significant negative Eu anomaly (-0.3 to -0.7) and steeper HREE patterns (Lu/Dy = 5–12). In comparison, the Scandian zircons reveal flatter Eu anomalies (-0.3 to 0.2) and less steep HREE patterns (Lu/Dy = 2–7), although the individual patterns do not seem to correlate with age. In addition, zircons from a garnet amphibolite from the same outcrop yield an identical age within error of ca. 407 Ma for the timing of metamorphism, and the trace-element patterns suggest crystallization at HP (garnet-stable) conditions (Lu/Dy = 1–6 and Eu* = -0.2 to 0.2). Similar age and trace-element results were obtained from zircon rims extracted from layer-parallel to crosscutting leucosomes and eclogites from the UHP domain to the south, suggesting a similar melt crystallization and metamorphic history for both domains of the WGR. The Møre-Trøndelag fault likely accommodated coeval extension that exhumed both the (U)HP and granulite domains. Results are consistent with the presence of partially molten crust in a large part of the WGR at HP or UHP conditions during the latest stages of the Caledonian orogeny. Continued, decompression-driven melting occurred during the late stages of this exhumation. The decreased viscosity and increased buoyancy and strain weakening induced by partial melting likely contributed to the switch from subduction to exhumation for the crustal rocks now exposed in the WGR.