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UHT granulite-facies metamorphism in Rogaland, S Norway, is polyphase in nature

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Propensity of metamorphic assemblages to remain metastable after melt extraction complicates singularly the petrologist's task to discriminate between a single granulite-facies P-T path and a polyphase one. Using an integrated petrological and in-situ geochronological approach in key rock-samples, we reconstruct the pressure-temperature-time path of Sveconorwegian metamorphism across a 30 km-wide metamorphic gradient ranging from upper amphibolite facies to ultra-high temperature (UHT) granulite-facies in Rogaland, S. Norway. Thermodynamic modelling of phase equilibria in the Na2O-CaO-K2O-FeO-MgO-Al2O_3-SiO_2-H_2O-Ti2O-O_2 chemical system (Perple_X code) are carried out with an emphasis on moderately oxidized, spinel-bearing assemblages resulting from either garnet or sapphirine breakdown. Geochronological U-(Th)-Pb data acquired on both monazite (LA-ICP-MS) and zircon (SIMS) are complemented by minor- and trace-elements signatures of both minerals, to monitor REE distribution through time and to evaluate garnet apparition or demise. Coupling field, petrological and geochronological data lead to a polyphase metamorphic history, lasting about 100 My. The onset of regional granulite facies metamorphism at 1035 Ma is associated with the emplacement of large volumes of granitic magmas in the amphibolite to granulite facies transition zone. In the deeper part of the crustal section, localized sapphirine-bearing restitic lithologies testify to UHT temperatures (900−920 °C). These conditions were reached at ca. 1010 Ma following a tight clockwise P-T path associated with minor exhumation (7 to 5.5 kbar) and subsequent cooling to 700 °C. A distinct thermal episode, initiated at ca. 950 Ma, reached UHT granulite-facies conditions with the intrusion of massif-type anorthosite plutons at ca. 930 Ma producing a 5-km wide aureole. The aureole is delimited by the presence of osumilite in high Fe-Al rocks yielding quantitative estimates of 900-950 °C at a maximum pressure of 5 kbar. We conclude that preconditioning of the crust was a condition necessary to develop such a UHT metamorphic aureole around the anorthosite complex.