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New constraints from forward thermodynamic modelling and monazite dating on a kyanite-garnet gneiss and a calc-silicate rock from the ultrahigh pressure terrain of the island of Fjørtoft, Western Gneiss Region, Norway

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A kyanite-garnet gneiss and a diopside-rich calc-silicate rock from the northeastern island of Fjørtoft, Western Gneiss Region (WGR), Norway, were studied to determine their pressure (P) - temperature (T) evolution mainly on the basis of the chemical zonation of mm-sized garnet and contoured P-T pseudosections calculated with PERPLE_X. In addition, monazite in the graphite-bearing gneiss was dated with the electron microprobe. Garnet in the gneiss shows a homogeneous Ca-poor and Mg-rich core that yielded P-T conditions around 1.2 GPa and 880 °C. Zr-in-rutile thermometry on tiny rutile inclusions in such garnet cores confirmed the high temperatures (T = 790-884 °C at P = 1.2 GPa). Compared to the garnet core, the garnet rim is characterized by gradual increase and decrease of the Ca and Mg contents, respectively. This compositional change points to an anticlockwise P-T loop, i.e. P-T conditions changed from 1.5 GPa and 840 °C to 1.6 GPa and 760 °C and then both pressure and temperature decreased simultaneously. Zr-in-rutile thermometry applied to rutile grains in the matrix and enclosed in the garnet rim yielded cooling temperatures of 720-803 °C at P = 1.6 GPa. Garnet cores and rims in the gneiss are proposed to witness a polymetamorphic evolution. Garnet in the calc-silicate rock records a prograde P-T path, as the Ca content decreases whereas the Mg content increases from the core to the rim of large garnet grains. Core and rim compositions yielded P-T conditions of ca. 1.3 GPa and 700-740 °C and 1.5-1.6 GPa and 780-860 °C, respectively. Zirconium contents in rutile enclosed in garnet cores point to temperatures between 668 and 763 °C at P = 1.3 GPa. Three textural types of monazite were identified in the gneiss: old cores, neoblasts and recrystallized domains locally replacing old cores in a single grain. The old cores yielded Grenvillian-Sveconorwegian ages around 1.0 Ga, whereas the neoblasts and the recrystallized domains showed Caledonian ages with three groups concentrating around 450, 430 and 400 Ma.

Our study has the following geodynamic implications. The studied rocks never reached P-T conditions of the diamond stability field as invoked in previous works. As ultrahigh-pressure conditions for crustal rocks from Fjørtoft could not be confirmed, continental subduction to great depths is unlikely for the surveyed part of the WGR. Nevertheless, the recovered P-T-t history suggests burial of a crustal section beneath an overriding continental plate during the Caledonian. In detail, a granulitic part (i.e. the kyanite-garnet gneiss) either of the Laurentian or Sveconorwegian crust was tectonically eroded, subducted to depths of about 50 km, and brought back via channel flows in the subduction and exhumation channel systems, in which early Palaeozoic (?) sediments (i.e. the calc-silicate rock) were also involved in.