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Evidence for partial melting in the central region of the Lewisian complex, Scotland

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The Lewisian complex of NW Scotland is among the most studied fragments of Precambrian crust on Earth, yet fundamental questions regarding its evolution remain unanswered. Although partial melting and melt loss have commonly been proposed as a mechanism to explain aspects of the geochemistry of the granulites in the central region, unambiguous outcrop evidence for anatexis of the volumetrically dominant meta-igneous rocks has not been demonstrated. Mineral equilibria modelling of ultramafic and mafic rocks from Scourie support temperatures in excess of 900 °C for the peak of granulite-facies (Badcallian) metamorphism, conditions under which most hydrate-bearing crustal rocks should begin to melt.

Using detailed field observations that emphasize the recognition of features diagnostic of anatectic migmatites, we show that metabasic rocks throughout the central region partially melted, evolving from subsolidus amphibolites to suprasolidus clinopyroxene-rich migmatites via fluid-absent melt-producing reactions consuming hornblende. Within large mafic–ultramafic bodies, melt derived from metagabbro segregated into felsic sheets, which record mass transfer to higher crustal levels. Although evidence for melting and melt loss from the volumetrically dominant pyroxene-bearing felsic gneisses is commonly ambiguous, melting is inevitable at the inferred temperatures if the protoliths contained hydrous phases (hornblende and/or biotite).

The interpretation of widespread anatexis based on field data is examined using the abundant geochemical data that exist for rocks of the central region. We suggest that the geochemical data may be reconciled with partial melting and melt loss. The combined evidence suggests that these processes were important within the central region of the Lewisian complex, which would have had profound consequences for the compositional, thermal and rheological evolution of the Archaean crust in this part of the North Atlantic craton. Our results provide insight into the process of intracrustal differentiation during the Archaean.