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An anhydrous model for Archean Anorthosites: Petrological and thermodynamic constraints from the ∼ 2.97 Ga Fiskenæsset Anorthosite Complex, SW Greenland.

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Archean anorthosite complexes commonly occur within cratons and their petrogenesis provide unique perspectives on the geodynamic processes that operated during the early Earth. The characteristic calcic plagioclase, aluminous chromite, and abundant amphibole found in Archean anorthosite complexes has previously been linked with hydrous Al-rich parental magmas. In combination with arc-like trace element systematics these features have been taken as evidence for their formation in a subduction zone setting and hence as for the operation of plate-tectonics. However, due to the typical high-grade metamorphism of anorthosite complexes, previous studies have mainly focused on their field characteristics, petrology, and geochemical features leaving the parental melt composition of Archean anorthosites poorly constrained.

We present new results from a combined petrological and thermodynamic study of the well preserved ∼ 2.97 Ga Fiskenæsset Anorthosite Complex (FAC) in SW Greenland. The main aims were to (1) constrain the parental magma composition and (2) to assess whether hydrous conditions were required in the petrogenesis of Archean anorthosites. Using thermodynamic modelling software (Rhyolite-MELTS), crystallization of a variety of ultramafic to mafic parental melts were tested at various H_2O-contents, redox (fO_2) and pressure conditions. The formation of predominantly feldspathic cumulate rocks, aluminous chromite, and high-An anorthosite ($An_{87\pm1}$), which resemble the features observed for the FAC, can best be explained by crystallization of an anhydrous (<< 2% H_2O) high-Al tholeiitic magma emplaced into the upper crust (≤3 kbar). The massive anorthosites formed via a combination of early plagioclase-only crystallization, combined with flotation accumulation, which are processes that are only viable within anhydrous magmas. Furthermore, the abundance of calcic amphibole can easily be explained by metamorphic hydration of primary clinopyroxene. Overall, our new results suggest that neither hydrous parental melts nor a subduction zone setting is required for the FAC, and settings like ocean-plateau, rift, or stagnant-lid should be considered viable alternatives.