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Mesoarchaean aluminous rocks at Storø, southern West Greenland: New age data and evidence of premetamorphic seafloor weathering of basalts

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ABSTRACT

Metamorphosed Meso- to Neoarchaean supracrustal rocks in the central part of the island of Storø (Nuuk region, southern West Greenland), show field- and geochemical evidence of premetamorphic chemical alteration. This alteration changed basaltic precursors into aluminous lithologies, and following amphibolite grade metamorphism and penetrative ductile deformation, these garnet–biotite schists now resemble adjacent metapelitic schists of sedimentary origin. Mass balance calculations (isocon method), suggests that most major elements (Si, Fe, Mg, Ca, Na and P) were leached during alteration. The calculated overall net mass changes are between −18% and −45%, consistent with breakdown of olivine, pyroxenes, plagioclase and apatite in the basaltic precursor rocks. Major and trace elements such as, K, Cs, Rb, Ba, Pb, Zn, La and Ce were added during this alteration process, whereas high field strength elements (Ti, Al, Zr, Hf and Nb) remained essentially immobile and were thus residually enriched. Interestingly, Th which is generally assumed to be immobile in fluids, was also added during this process. These chemical changes reflect interaction between a basaltic protolith and hydrous fluids that established a new equilibrium and thus a different mineral assemblage. It is proposed that the premetamorphic alteration at Storø was due to low-temperature interaction between seawater and oceanic crust, and thus essentially represents in situ submarine seafloor weathering. This interpretation is consistent with the mass balances reported from well-documented examples in younger settings.

New U–Pb zircon geochronology from the arc-related mafic sequences at Storø shows that they comprise at least two distinct age groups: an older anorthosite complex dated at 3051.3 ± 2.6 Ma and a younger supracrustal sequence with age brackets between 2840 and 2710 Ma. The allochthonous nature of these two mafic igneous to sedimentary stacks is consistent with accretionary processes in island arc complexes and a compressional Archaean tectonic setting.

1. Introduction

Metavolcanic belts in Archaean cratons constitute a major source of Au and other metals worldwide (Goldfarb et al., 2001). The origin of the supracrustal host rocks and their common Au deposits have been much debated, especially in polymetamorphosed and deformed rocks where the protoliths are not easily recognisable (e.g. Groves et al., 2003). For instance, the metavolcanic rocks are commonly associated with garnet-rich aluminous schists that superficially appear to be of sedimentary origin, but which lack lithological layering akin to transposed bedding.

Both epithermal, orogenic and volcanogenic-massive-sulphide mineralisation processes are well understood and closely associated with specific types of hydrothermal alteration and controlled by host rock compositions and fabrics including porosity and permeability, as well as heat and fluid sources, ambient temperature and hydrostatic pressure gradients (Hedenquist and Lowenstein, 1994; Eilu and Groves, 2001; Herrington et al., 2005). Various low-temperature subaqueous and subaerial weathering processes can also lead to significant chemical alteration (e.g. Alt and Teagle, 2003; Polat et al., 2012). Due to this difficulty in identifying different alteration processes through metamorphic overprint, several orogenic deposits have for example now been reinterpreted as metamorphosed epithermal (and in a few cases volcanogenic-massive-sulphide) deposits (Hallberg, 1993; Penczak and Mason, 1999; Bonnet et al., 2005; McFarlane et al., 2007; Owens and Pasek, 2007; Garde et al., 2012). Such distinctions are important not least for future Au exploration.

Identifying different types of alteration in highly deformed and metamorphosed rocks can be challenging, because the bulk composition of leached rocks may be similar to that of rocks derived by sedimentary processes. Archaean aluminous schists and gneisses within supracrustal belts in the North Atlantic craton of southern West Greenland have

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therefore been interpreted as metasedimentary rocks (e.g. Rivalenti and Rossi, 1972), as various kinds of chemically altered (meta)volcanic rocks (e.g. Beech and Chadwick, 1980; Dymek and Smith, 1990; Garde et al., 2007, 2012), or as a combination of both (Smith et al., 1992; Bolhar et al., 2005).

In this paper we describe and discuss the nature of chemical alteration of Archaean arc-related mafic metavolcanic rocks on the island of Storø in Godthåbsfjord, in the central North Atlantic craton of southern West Greenland. It is shown that a conspicuous component of aluminous rocks, which superficially resembles adjacent metasedimentary rocks, likely formed during the interaction between mafic rocks and cold seawater, implying that the combined sequence of mafic metavolcanic and aluminous lithologies are likely to represent a section through Archaean oceanic crust.

We also present new geochronological data, which corroborate that the central part of Storø comprises at least three different tectonic slices of Eoarchaean to Neoarchaean crust including at least two different age groups of mafic rock sequences that were juxtaposed during Neoarchaean tectonic amalgamation of older magmatic arcs (e.g. Nutman and Friend, 2007).

2. Geological setting

The island of Storø is located in the central part of the largely Mesoarchaean North Atlantic craton that forms most of southern Greenland and continues as the Nain Province in eastern Labrador (Fig. 1; Schiøtte et al., 1989; Schiøtte and Bridgwater, 1990; St.-Onge et al., 2009). In southern West Greenland the craton has recently been divided into six tilted crustal blocks that expose the root zones of several convergent andesitic island arc–continental arc systems and oceanic supra-subduction zones (Garde, 2007; Polat et al., 2007; Windley and Garde, 2009; Szilas et al., 2012, 2013, in press). Storø itself is located at the south-eastern margin of the >3000 Ma Fiskefjord block of Windley and Garde (2009), previously referred to as the Akia terrane (e.g. Friend et al., 1996). The complex, collisional Godthåbsfjord–Ameralik belt to its south-east, which also comprises the eastern part of Storø, consists of several smaller terranes of different origins and ages that were tectonically assembled and folded at around 2720 Ma (Friend et al., 1996). Following the assembly of the Fiskefjord block and the terranes to the south-east, Storø and adjacent parts of the Godthåbsfjord–Ameralik belt were intruded by c. 2650–2550 Ma granitoid crustal melts including the 2550 Ma Qôrqut granite complex (Brown et al., 1981; Friend et al., 1996; Nutman and Friend, 2007; Nutman et al., 2007, 2010). This resulted in an extensive network of granitic pegmatites throughout the supracrustal rocks in central Storø.

The central part of Storø consists of a stack of supracrustal rocks of different ages and compositions that have been referred to as the 'Storø supracrustal belt' or 'Storø greenstone belt' in the literature, most recently by Scherstén et al. (2012). Existing age data quoted below are from Scherstén et al. (2012) and stem from GEUS reports

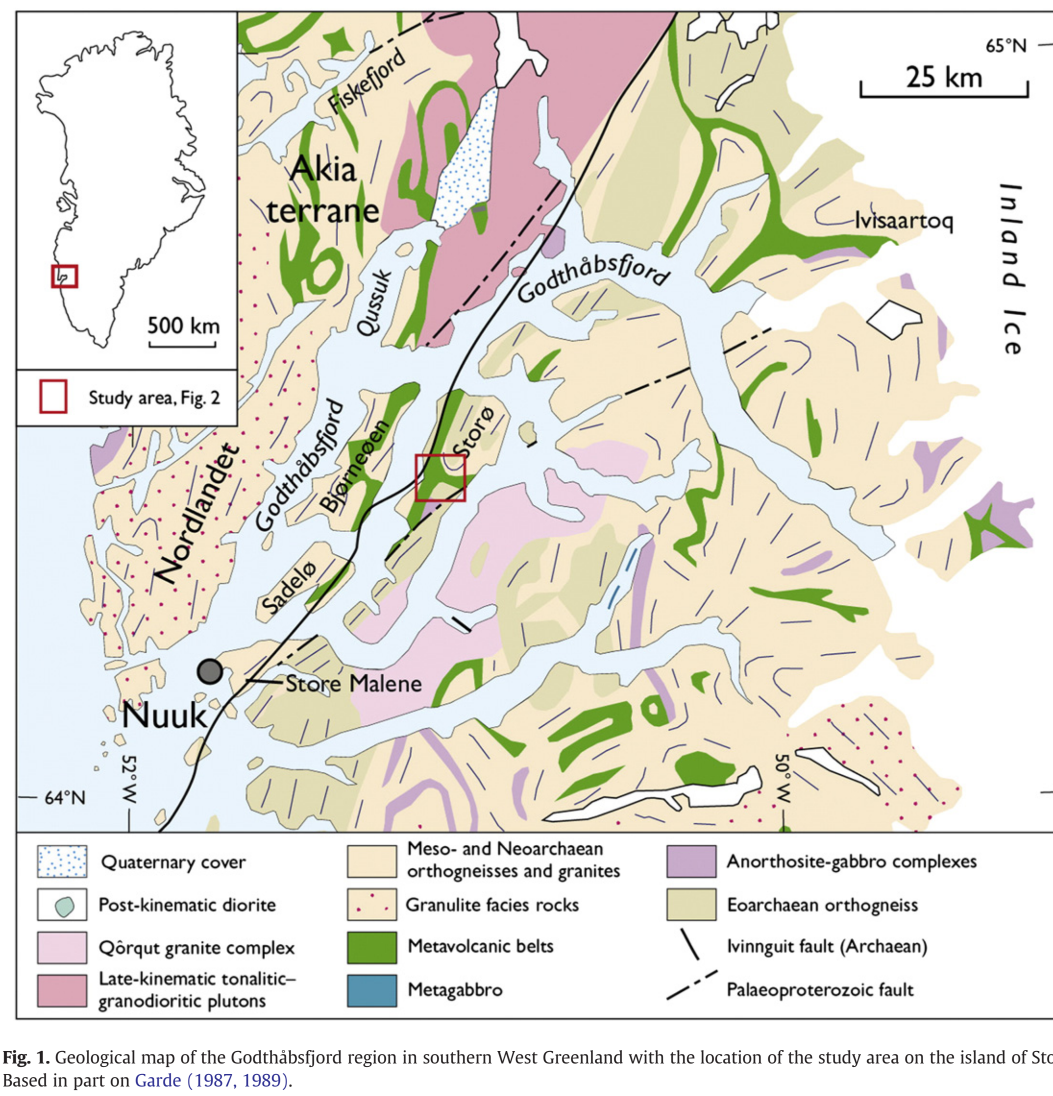

Fig. 1. Geological map of the Godthåbsfjord region in southern West Greenland with the location of the study area on the island of Storø. Based in part on Garde (1987, 1989).