Gondwana Research 23 (2013) 436–451

Contents lists available at SciVerse ScienceDirect

Gondwana Research

journal homepage: www.elsevier.com/locate/gr

Remnants of arc-related Mesoarchaean oceanic crust in the Tartoq Group of SW Greenland

Kristoffer Szilas [a,b,c,*], Vincent J. Van Hinsberg [d], Alex F.M. Kisters [e], J. Elis Hoffmann [f,g], Brian F. Windley [h], Thomas F. Kokfelt [a], Anders Scherstén [i], Robert Frei [b,j], Minik T. Rosing [c,j], Carsten Münker [g]

[a] Geological Survey of Denmark and Greenland - GEUS, Øster Voldgade 10, 1350 Copenhagen K, Denmark
[b] Department of Geography and Geology, University of Copenhagen, Øster Voldgade 10, 1350 Copenhagen K, Denmark
[c] Natural History Museum of Denmark, Øster Voldgade 5-7, 1350 Copenhagen K, Denmark
[d] Department of Earth Sciences, University of Oxford, South Parks Road, Oxford, United Kingdom
[e] Department of Earth Sciences, Stellenbosch University, Matieland 7602, South Africa
[f] Steinmann Institut für Geologie, Universität Bonn, Poppelsdorfer Schloss, 53115 Bonn, Germany
[g] Geologisch-Mineralogisches Institut, Universität zu Köln, Zülpicher Str. 49b, 50674 Köln, Germany
[h] Department of Geology, University of Leicester, University Road, Leicester, LE1 7RH, United Kingdom
[i] Department of Earth and Ecosystem Sciences Division of Geology, Lund University, Sölvegatan 12, 223 62 Lund, Sweden
[j] Nordic Center for Earth Evolution, NordCEE, Denmark

ARTICLE INFO

Article history:
Received 11 July 2011
Received in revised form 12 November 2011
Accepted 13 November 2011
Available online 2 December 2011

Keywords:
Archaean
Greenland
Tartoq Group
Geochronology
Supracrustal belt
Oceanic crust

ABSTRACT

The Tartoq Group, located in SW Greenland, consists of supracrustal rocks of mainly tholeiitic basaltic composition, including pillow lavas, sills/dykes and gabbros, as well as ultramafic rocks. Metamorphic grade ranges from greenschist facies to granulite facies. The Tartoq Group crops out as a series of blocks and slivers that are imbricated with originally intrusive Mesoarchaean TTG orthogneisses. The supracrustal rocks form part of a SE vergent fold and thrust belt consistent with the imbrication of TTG gneisses and supracrustal rocks along a convergent margin. LA-ICP-MS U–Pb zircon dating of an intrusive TTG sheet yields a minimum age of 2986 ± 4 Ma for the Tartoq Group. This age is consistent with MC-ICP-MS Lu–Hf and Sm–Nd isotopic whole-rock data for mafic samples from different blocks of the Tartoq Group, which yield errorchron ages of 3189 ± 65 Ma and 3068 ± 220 Ma, respectively. The mafic supracrustal rocks of the Tartoq Group have chondrite-normalized REE patterns with La_{CN}/Sm_{CN} of 0.67–1.96 and rather flat primitive mantle-normalized multi-element patterns, except for scattered LILE contents, and generally negative Nb-anomalies with Nb/Nb* of 0.26–1.31. Th/Yb varies between 0.06 and 0.47 and Nb/Yb between 0.45 and 4.4 indicative of an arc affinity when compared to rocks from modern settings. The similar geochemistry of the different lithological units, together with their coeval formation, as evident from trace element geochemical trends, supports a co-magmatic origin for the rock assemblage and their formation as imbricated relics of oceanic crust. Accordingly, we propose that the Tartoq Group represents remnants of Mesoarchaean oceanic crust, which formed in a suprasubduction zone geodynamic environment.

© 2011 International Association for Gondwana Research. Published by Elsevier B.V. All rights reserved.

1. Introduction

The identification of the geodynamic environments in which Archaean supracrustal belts have formed is highly controversial. Many of the uncertainties relate to later overprints of the rock record in form of deformation, metamorphism and alteration processes. The majority of Archaean supracrustal belts are strongly deformed and tectonically dismembered, and thus, individual belts may comprise a composite of rocks with several different origins. Before any definite conclusions about the possible tectonic setting can be drawn, it is critical to establish whether or not a suite of rocks are co-magmatic and to what extent tectonic processes have disrupted the original sequence. Moreover, geochemical fingerprinting of igneous rock suites (e.g., Condie and Kröner, 2011) relies on the assumption of uniformitarian principles, but it is uncertain to what extent processes on the modern Earth can be extrapolated to the Archaean rock record. Many geoscientists maintain that modern tectonic environments such as subduction zones were responsible for the formation of even the earliest recorded supracrustal rocks (e.g. Isua supracrustal belt at c. 3800 Ma; Polat et al., 2002, 2011; Dilek and Polat, 2008; Friend and Nutman, 2010; Hoffmann et al., 2011). At the same time, there is a strong school of thought proposing that subduction zone processes only started to operate much later in the Meso- or even Neoproterozoic (e.g. Hamilton, 1998, 2011; Davies, 1999; McCall, 2003; Stern, 2005, 2008).

* Corresponding author at: Geological Survey of Denmark and Greenland - GEUS, Øster Voldgade 10, 1350 Copenhagen K, Denmark.
E-mail address: ksz@geus.dk (K. Szilas).

1342-937X/$ – see front matter © 2011 International Association for Gondwana Research. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.gr.2011.11.006

Previous controversies regarding the co-magmatic origin of Archaean rock suites such as the Isua supracrustal belt (e.g. Furnes et al., 2007; Nutman and Friend, 2007; Hamilton, 2007; Furnes et al., 2009: Friend and Nutman, 2010), the Jamestown "ophiolite" (De Wit et al., 1987; Lowe and Byerly, 2007; Van Kranendonk et al., 2009) and the Dongwanzi complex (Kusky et al., 2001, 2011; Zhai et al., 2002; Zhao et al., 2007) highlight the difficulties in establishing whether or not the rock assemblages in such supracrustal belts are co-magmatic and how to interpret their geodynamic environment of formation. The problems outlined above demonstrate that more work on Archaean supracrustal belts is needed and that careful studies of such rocks may provide answers as to when and how the Earth arrived at its present style of plate tectonics.

In this paper we aim to contribute to the knowledge of the Archaean supracrustal rock record by presenting the first comprehensive modern major-, trace-, and isotope-geochemical data set, together with new field observations, for the Mesoarchaean Tartoq Group in SW Greenland. We interpret this assemblage of mafic to ultramafic rocks, ranging from pillow lavas through sills/dykes to gabbros and ultramafic cumulate/mantle restite, as lithological units which collectively represent a section through oceanic crust. The majority of samples yield a well-defined Lu–Hf errorchron and we take this as evidence of them being co-magmatic, although there is room for some parts of the Tartoq Group to be slightly younger or older than the age of c. 3190 Ma that we present here as the likely formation age. The similarity in geochemistry of the various lithological units supports the rocks as having formed in the same tectonic environment, which we propose was an arc to backarc setting according to classifications based on modern suites of rocks. Additionally, we find structural evidence of horizontal deformation in support of a convergent margin setting.

2. Geological background

The Tartoq Group is located adjacent to Sermiligaarsuk fjord in SW Greenland and crops out within an area of approximately 1000 km^2 (Fig. 1). It consists of several fault-bound supracrustal blocks that are imbricated with originally intrusive, Archaean orthogneisses of tonalite–trondhjemite–granodiorite (TTG) composition. A U–Pb zircon age of 2944 ± 7 Ma from an intrusive TTG sheet confirms the Archaean age of the Tartoq Group (Nutman and Kalsbeek, 1994).

The metavolcanic rocks are characterised by the lowest degree of metamorphism found anywhere in the North Atlantic craton of Greenland, but they also have the largest range in metamorphic grade found within a single supracrustal sequence in this region. The metamorphic conditions range from greenschist to granulite facies conditions (Van Hinsberg et al., 2010), thus meta- is taken as being an implicit prefix for all lithological units throughout this paper. Lithological units of the Tartoq Group include greenschists, amphibolites and minor ultramafic rocks and their field relations are well described from 1:20,000-scale mapping in an almost totally exposed terrain (e.g. Higgins and Bondesen, 1966; Higgins, 1968; Berthelsen and Henriksen, 1975; Higgins, 1990; Petersen, 1992; Van Hinsberg et al., 2010). Most rocks have undergone variable degrees of retrogression and hydrothermal overprint, and hydrothermal fluid flow has extensively affected rocks in high strain zones, giving rise to gold mineralisation in strongly carbonated rocks (Appel and Secher, 1984; King, 1985; Petersen, 1992; Evans and King, 1993).

Berthelsen and Henriksen (1975) and Kisters et al. (2011) describe the Tartoq Group as allochthonous slivers of supracrustal rocks in a TTG-dominated terrain with, for the most part, originally intrusive contacts that have almost invariably been subsequently tectonized. Both internal contacts within the supracrustal belts as well as the TTG-supracrustal contacts are characterized by early mylonitic and late cataclastic fabrics resulting from the final structural assembly of the TTG-supracrustal terrain. Internal thrust zones are commonly delineated by felsic schists. The abundant carbonate-rich mylonites and felsic schists were previously described as metasediments, but are here interpreted as sheared TTG sheets and strongly carbonated deformation zones, respectively, and thus they are not primary lithological units of the Tartoq Group (see Sections 5.1 and 6.1). The

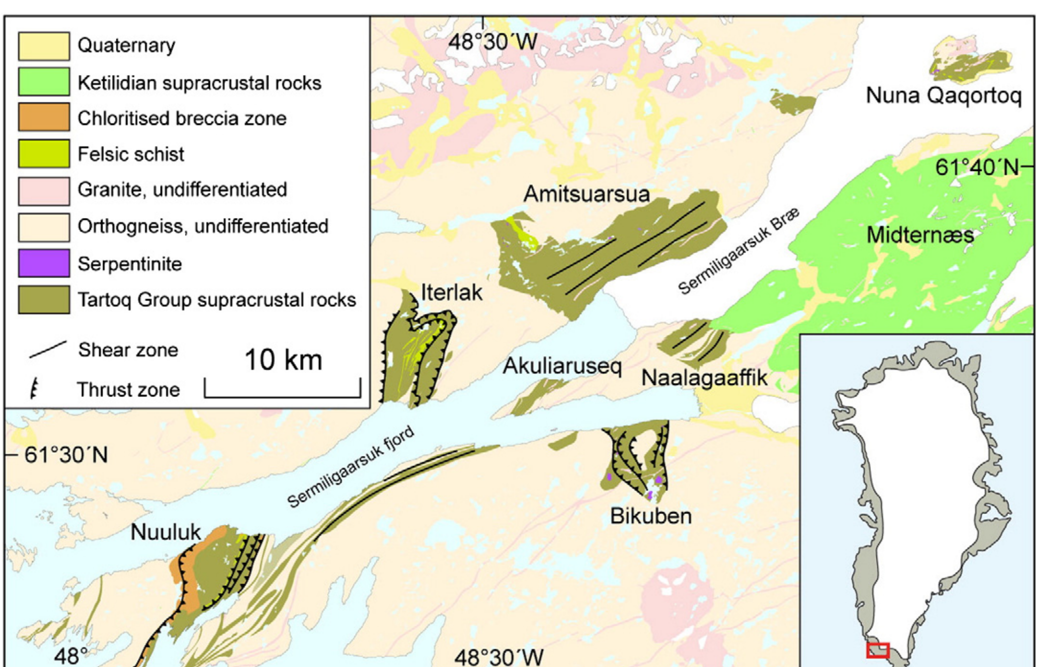

Fig. 1. Map of Sermiligaarsuk fjord showing the supracrustal blocks, which comprise the Tartoq Group and are situated within Archaean TTG orthogneisses. Younger supracrustal rocks of the Ketilidian orogen crop out to the east and are unconformable on top of the Tartoq Group. Several large thrust- and shear zones have been identified, which are often associated with felsic schists and TTG mylonites.

Download English Version:

https://daneshyari.com/en/article/4727447

Download Persian Version:

https://daneshyari.com/article/4727447

Daneshyari.com