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Research paper

Geochemistry of the Mesoarchean Fiskenæsset Complex at Majorqap qâva, SW Greenland: Evidence for two different magma compositions

Hua Huang [a], Ali Polat [a,*], Brian J. Fryer [a,b], Peter W.U. Appel [c], Brian F. Windley [d]

[a] Department of Earth and Environmental Sciences, University of Windsor, Windsor, ON, Canada N9B 3P4
[b] Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada N9B 3P4
[c] Geological Survey of Denmark and Greenland, 1350-Copenhagen, Denmark
[d] Department of Geology, University of Leicester, Leicester, LE17RH, UK

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ABSTRACT

The Mesoarchean Fiskenæsset Complex was emplaced as multiple sills and dykes of magma and crystal mush into oceanic crust, forming an association of ca. 550-meter-thick layered anorthosites, leucogabbros, gabbros, hornblendites, pyroxenites, dunites, and peridotites. The complex was intruded by tonalites, trondhjemites and granodiorites (TTG), and underwent multiple phases of deformation. The Fiskenæsset Complex and bordering TTG intrusions were variably affected by granulite facies metamorphism and retrogressed under amphibolite facies conditions.

This study presents new field, petrographic, and major and trace element geochemical data for the six major stratigraphic units of the Fiskenæsset Complex at Majorqap qâva, SW Greenland. In addition, new high-precision trace element data are reported for hornblendes from three stratigraphic units. The sampled major lithological units from bottom to top are: Lower Gabbro, Ultramafic, Lower Leucogabbro, Middle Gabbro, Upper Leucogabbro, and Anorthosite. Both whole-rock and hornblende trace element data are consistent with crystallization of the complex from two different parental magmas, originating from different mantle sources. Subsequent differentiation of these parental magmas in the oceanic arc crust resulted in two evolved geochemical rock suites (Suite A and Suite B), which are both characterized by depletions of HFSE (Nb, Ta, Zr and Hf) relative to Th, U, LREE and LILE (Rb, Ba), and enrichments of Sr and Pb relative to MREE; these data are consistent with a magmatic arc geodynamic setting.

1. Introduction

Archean layered intrusions in high-grade gneissic terranes are predominantly composed of anorthosites, leucogabbros, gabbros, and peridotites; anorthosites are the major component (Windley and Smith, 1976; Myers, 1988; Phinney et al., 1988; Ashwal, 1993; Ashwal et al., 1994). Although subsequent tonalite–trondhjemite–granodiorite (TTG) intrusions have removed most of their stratigraphy, and deformation and metamorphism have modified many original structures, the primary igneous mineralogy, textures, structures, and contact relationships are still surprisingly well preserved in several complexes. Anorthosites are best known from the Archean high-grade gneiss complexes in SW Greenland, Canada, Australia, India, and South Africa (Hor et al., 1975; Myers, 1985, 1988; Barton, 1986; Kinny et al., 1988; Phinney et al., 1988; Ashwal, 1993; Ashwal et al., 1994; Sajeev et al., 2009; Hoffmann et al., 2012). Modern equivalents of Archean anorthosites are found in xenoliths brought up from the magma chambers of extant island arcs as in the Lesser Antilles (e.g. Kiddle et al., 2010), and in Paleozoic analogs in New Zealand (Gibson and Ireland, 1999).

Calcic anorthosite layered complexes are particularly widespread in the Archean craton of SW Greenland (Fig. 1), where they provide important constraints on petrogenetic and geodynamic processes that operated in the early Earth (Windley and Smith, 1974; Myers, 1985; Ashwal, 1993; Polat et al., 2009, 2010; Hoffmann et al., 2012). Despite their abundance, only the Fiskenæsset and Naajat Kuuat complexes have been intensively investigated (e.g., Windley et al. 1973; Windley and Smith 1974; Henderson et al. 1976; Myers and Platt 1977; Weaver et al. 1981; Myers 1985; Ashwal et al. 1989; Polat et al., 2009, 2010, 2011a,b; Hoffmann et al., 2012).

The best-preserved stratigraphic section of the Fiskenæsset Complex is at Majorqap qâva (Myers, 1985) (Fig. 1), where primary magmatic and structural features are remarkably well developed (Figs. 2 and 3). Although some early studies of the mineral chemistry were conducted on rocks from Majorqap qâva (Myers and Platt, 1977), today we are able to undertake much higher precision analyses of several petrogenetically important elements (e.g., Nb, Ta, U, Th, V, Co, Sc, Pr, Er, Ho), which enable us to distinguish between different magma

* Corresponding author.
E-mail address: polat@uwindsor.ca (A. Polat).

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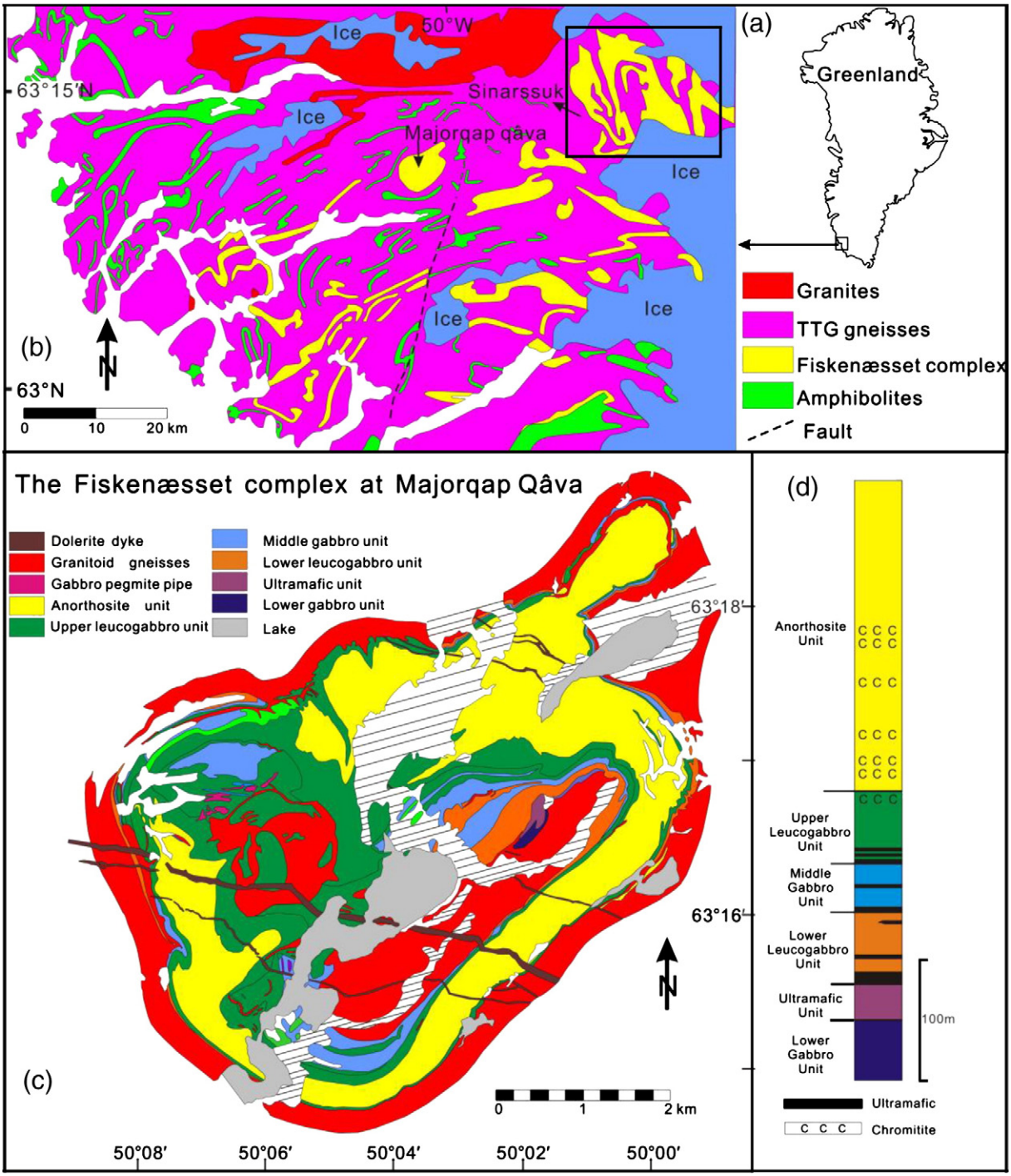

Fig. 1. (a) General location of the study area in Greenland. (b) Simplified geological map of the Fiskenæsset region (after Myers, 1976). (c) Simplified geological map of the Majorqap qâva outcrop of the Fiskenæsset Complex (after Myers, 1985). (d) Simplified stratigraphic succession of the Fiskenæsset Complex compiled from a number of outcrops (after Myers, 1985). The diagonal lines represent the Quaternary deposits.

types that are diagnostic of specific geodynamic environments such as mid-ocean ridges, ocean islands and subduction zones.

This paper presents new whole-rock geochemical data from all major stratigraphic units of the Mesoarchean Fiskenæsset Complex at Majorqap qâva, as a result of our extensive new field work on the complex in this region (Fig. 1; Supplementary Fig. 1). In addition, we report new high precision trace element data for hornblendes from three units: Lower Gabbro, Ultramafic, and Middle Gabbro. New geochemical data reveal the presence of two distinct suites derived from differentiation of primary magmas that originated from a Mesoarchean sub-arc mantle wedge.

2. Regional geology, field characteristics, metamorphism, and geochronology

The Fiskenæsset region consists of ~80% granitoid orthogneiss, ~15% amphibolite, and ~5% anorthosite, leucogabbro, gabbro and ultramafic rocks including peridotite, dunite, pyroxenite, and hornblendite (Kalsbeek and Myers, 1973; Windley and Smith, 1974; Myers, 1985; Windley and Garde, 2009; Polat et al., 2011a). Most of the Fiskenæsset region underwent granulite facies metamorphism and subsequent amphibolite facies retrogression (Pidgeon and Kalsbeek, 1978; Riciputi et al., 1990; McGregor and Friend, 1992). However, for descriptive