Available online at www.sciencedirect.com
ScienceDirect
Precambrian Research 158 (2007) 93–118
Precambrian Research
www.elsevier.com/locate/precamres

Geochemistry and geochronology of high-grade rocks from the Grove Mountains, East Antarctica: Evidence for an Early Neoproterozoic basement metamorphosed during a single Late Neoproterozoic/Cambrian tectonic cycle

Xiaochun Liu [a,*], Bor-Ming Jahn [b,c], Yue Zhao [a], Guochun Zhao [d], Xiaohan Liu [e]

[a] *Institute of Geomechanics, Chinese Academy of Geological Sciences, 11 Minzudaxue Nanlu, Beijing 100081, China*
[b] *Institute of Earth Sciences, Academia Sinica, Taipei 11529, Taiwan*
[c] *Department of Geological Sciences, National Taiwan University, Taipei 106, Taiwan*
[d] *Department of Earth Sciences, The University of Hong Kong, Pokfulam Road, Hong Kong*
[e] *Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China*

Received 30 May 2006; received in revised form 8 April 2007; accepted 24 April 2007

Abstract

The Grove Mountains of East Antarctica are an inland continuation of the Prydz Belt. The high-grade metamorphic complex in this area is composed of felsic orthogneisses and mafic granulites, with minor paragneisses and calc-silicate rocks. U–Pb zircon analyses using SHRIMP and LA-ICP-MS techniques reveal that the protoliths of mafic granulites and felsic orthogneisses were emplaced during a short time interval of ca. 920–910 Ma. Mafic granulites can be divided into low- and high-Ti groups. They have initial ε_{Nd} values [$\varepsilon_{Nd}(T)$] ranging from +0.8 to −1.9. TiO_2 is positively correlated with FeO^t/MgO and La/Nb ratios, whereas it shows a negative correlation with $\varepsilon_{Nd}(T)$ values, indicating that the petrogenesis of their protoliths involved partial melting of a weakly enriched subcontinental lithospheric mantle and fractional crystallization of the magma accompanied by minor crustal contamination. Felsic orthogneisses have an affinity of A_2-type granites, characterized by enrichment in REE, Y, Zr, Th and Ga and high Ga/Al and Y/Nb ratios. Most of them have $\varepsilon_{Nd}(T)$ values of −0.7 to −3.5 and Nd depleted mantle model ages (T_{DM}) of 1.76–1.65 Ga, and a few have low $\varepsilon_{Nd}(T)$ values of −10.4 to −10.6 and old T_{DM} of 2.46–2.27 Ga, reflecting a heterogeneity in their source region. Their protoliths were probably produced by high-temperature partial melting of tonalitic–granodioritic rocks triggered by the underplating of mantle-derived mafic magma during post-orogenic extension. U–Pb analyses also reveal a metamorphic age of ca. 2050 Ma from detrital zircons in a paragneiss, suggesting that the sedimentary materials of the paragneiss may have come from an as yet undiscovered Early Paleoproterozoic orogen of unknown provenance. Voluminous mafic–felsic intrusives and a small amount of sedimentary rocks constitute an Early Neoproterozoic basement of the Grove Mountains. Subsequently, this basement experienced only a single Late Neoproterozoic/Cambrian metamorphic cycle at ca. 550–535 Ma. The available data indicate that the Prydz Belt is a collage of multiple basement terranes and each of them has a distinct tectonic evolution. This supports the suggestion that the Prydz Belt may represent a Late Neoproterozoic/Cambrian collisional orogen that resulted in the final phase of the Gondwana assembly.

Keywords: Early Neoproterozoic; Mafic–felsic intrusion; Late Neoproterozoic/Cambrian; Single metamorphic cycle; Grove Mountains; Prydz Belt; East Antarctica

* Corresponding author. Tel.: +86 10 68486756; fax: +86 10 68422326.
E-mail address: liuxchqw@yahoo.com.cn (X. Liu).

0301-9268/$ – see front matter
doi:10.1016/j.precamres.2007.04.005

1. Introduction

Unravelling the nature of tectonothermal events in a complex orogenic belt is a difficult issue. This is particularly true for the case of the Prydz Belt [also termed Pinjarra Orogen (Fitzsimons, 2003) or Kuunga Orogen (Boger et al., 2002)] in East Antarctica. In this belt, Archaean, Late Mesoproterozoic/Early Neoproterozoic (ca. 1000 Ma) and Late Neoproterozoic/Cambrian (ca. 550 Ma) events have been identified in different localities, but the polyphase deformation, metamorphism and magmatism have provoked a debate on the extent, process and role of each event and therefore on the formation models of the supercontinents Rodinia and Gondwana (Fitzsimons, 2003; Harley, 2003; Yoshida et al., 2003; Zhao et al., 2003). Since the Prydz Belt is situated in the interior of the previously proclaimed unified East Gondwana, some important questions about its evolution emerge: (1) How did the earlier crust in the belt and adjacent areas evolve? (2) What was the nature of the Late Mesoproterozoic/Early Neoproterozoic precursor of the belt and its relationship to other terranes of similar age in the East Antarctic Shield? (3) Were there any geological events recorded in the belt during the time interval of 1000–550 Ma? And most importantly, (4) Whether the Late Neoproterozoic/Cambrian orogeny represented a suture resulted from the collision between two continental blocks, or an intraplate reworking belt in response to the collision in the East African Orogen?

The Grove Mountains are situated about 200 km east of the southern Prince Charles Mountains (SPCM) (Fig. 1). They are considered as an inland continuation of the Prydz Belt based on a few published Cambrian age data (Zhao et al., 2000, 2003; Mikhalsky et al., 2001a). However, the Precambrian crustal history of this area remains poorly constrained. Lithologically, the Grove Mountains mainly comprise high-grade metamorphic rocks and abundant intrusive charnockites and granites. The metamorphic rocks are dominated by orthopyroxene-bearing felsic orthogneisses and mafic granulites, with minor garnet-bearing paragneisses and calc-silicate rocks (Liu et al., 2002; X.H. Liu et al., 2003; X.C. Liu et al., 2003). In this paper we report the result of geochemical and geochronological study on these rocks. We demonstrate that the protoliths of both mafic granulites and felsic orthogneisses are the Early Neoproterozoic post-orogenic intrusives, but not the Late Mesoproterozoic igneous complexes as revealed in the Prydz Bay and eastern Amery Ice Shelf (EAIS) (Y. Wang et al., 2003; Liu et al., 2007). In conjunction with an Early Paleoproterozoic detrital zircon age obtained from a paragneiss, we interpret that the Grove Mountains represent a distinct basement terrane, which was metamorphosed during a single Late Neoproterozoic/Cambrian tectonic cycle. This interpretation may help us to better understand the tectonic evolution of the Prydz Belt in the context of the Gondwana assembly.

2. Geological setting

The Prince Charles Mountains–Prydz Bay area comprises three Archaean cratonic blocks, a Late Mesoproterozoic Fisher Terrane, an Early Neoproterozoic Rayner Complex and a Late Neoproterozoic/Cambrian Prydz Belt (Fig. 1). The three Archaean blocks are exposed in the SPCM, Vestfold Hills and Rauer Group. Each of them preserves distinct crustal histories and therefore is unlikely to represent remnants of a single unified craton (Harley, 2003). The Fisher Terrane crops out in the southern sector of the northern Prince Charles Mountains (NPCM), where mafic–felsic volcanism and intrusion occurred at 1300–1020 Ma, followed by amphibolite facies metamorphism at 1020–940 Ma (Beliatsky et al., 1994; Kinny et al., 1997; Mikhalsky et al., 1999). The Rayner Complex occurs in the NPCM and adjacent Mawson Coast. It is characterized by regional granulite facies metamorphism accompanied by widespread charnockitic and granitic magmatism at ca. 990–980 Ma (Manton et al., 1992; Kinny et al., 1997; Young et al., 1997; Zhao et al., 1997; Boger et al., 2000; Carson et al., 2000). A limited magmatic activity also took place in the area at ca. 940–900 Ma, which was considered as a protraction of the Early Neoproterozoic orogenic event (Boger et al., 2000; Carson et al., 2000). In addition, intraplate deformation and emplacement of minor planar pegmatites at ca. 550–500 Ma were observed in some places (Carson et al., 2000; Boger et al., 2002). This may be a response to the intense Late Neoproterozoic/Cambrian tectonism occurred in the Prydz Belt.

The Prydz Belt crops out along the Prydz Bay coastline, and extends southward through the EAIS to the Grove Mountains (Fitzsimons, 2003; Zhao et al., 2003). The high-grade metamorphic rocks in the Prydz Bay–EAIS area comprise two lithological associations, mafic–felsic composite orthogneisses and migmatitic paragneisses that were termed Søstrene Orthogneiss and Brattstrand Paragneiss and were referred to the basement and cover sequences, respectively (Fitzsimons and Harley, 1991; Carson et al., 1995; Fitzsimons, 1997). Geochronological studies in the Larsemann Hills and the McKaskle Hills suggest that the Søstrene Orthogneiss was emplaced during 1170–1020 Ma (Y. Wang et al., 2003; Liu et al., 2007), while the Brattstrand Paragneiss