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Late Archaean granulite facies metamorphism in the Vestfold Hills, East Antarctica

F. Zulbati [1], S.L. Harley *

Grant Institute of Earth Science, School of Geosciences, The University of Edinburgh, West Mains Road, Edinburgh EH9 3JW, UK

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Abstract

Granulites of the Vestfold Hills record a pulsed end-Archaean to early Palaeoproterozoic M1–M2 evolution that is distinct from other Archaean areas in East Antarctica and cratonic domains placed adjacent to East Antarctica in Gondwana reconstructions. Pressure and temperature conditions of the end-Archaean to earliest Palaeoproterozoic (2501–2496 Ma) M1 granulite facies metamorphism in the Vestfold Hills have been constrained from mineral assemblages and thermobarometry of Fe-rich paragneisses. Reintegrated compositions of exsolved subcalcic clinopyroxenes and pigeonites in a metaironstone yield temperatures of 895±35 °C, whilst reintegrated compositions of perthitic feldspars in semipelitic paragneisses give minimum estimates of 860±30 °C. These results rule out the extreme ultrahigh temperature (UHT) conditions previously proposed for M1 in the Vestfold Hills. Pressures of metamorphism during M1 are estimated as 8.1±0.9 kb at 850±40 °C from hercynite+sillimanite+almandine+corundum and retrieved Fe–Mg–Al relations in orthopyroxene coexisting with garnet. A second metamorphic event, M2, occurred at 600–660 °C and 6–8 kb based on thermometry of recrystallised pyroxene neoblasts and thermobarometry applied to M2 garnet–quartz symplectites formed on orthopyroxene and garnet. The intervening emplacement of the magmatic Crooked Lake Gneiss Group precursors occurred at similar or shallower pressures prior to D2–M2, an event that caused tectonic interleaving and reactivation of the Vestfold Hills basement at mid-crustal depths in the earliest Palaeoproterozoic, prior to its unroofing to shallower levels (3–5 kb) by 2470 Ma. The lack of correlative Archaean histories in areas that were formerly adjacent in Gondwanan reconstructions is consistent with the Vestfold Hills region either being exotic to the East Antarctic Shield until the final (Neoproterozoic to Cambrian) amalgamation of Gondwana, or being accreted to part of East Antarctica in a Proterozoic event distinct from the Rayner–Eastern Ghats tectonism that united much of India with Antarctica at 1000–900 Ma.

Keywords: East Antarctica; Archaean; Granulite; Thermobarometry; Gondwana

1. Introduction

Reconstruction of East Gondwana and its Precambrian precursors, and correlation of former East Gondwanan and Rodinian crustal domains now dispersed between India, Asia, Australia and Antarctica, is dependent upon a thorough knowledge of the tectonothermal histories of those fragments that remain preserved in the present-day continents (Tingey, 1991; Fitzsimons, 2003). The Vestfold Hills form the only exposed portion of a late Archaean to Palaeoproterozoic (2520–2475 Ma) craton fragment that occurs in the East Antarctic Shield (Fig. 1) within the region that formerly was sited opposite east and

* Corresponding author. Fax: +44 131 6683184.
E-mail addresses: fabiozulbati@yahoo.com (F. Zulbati), Simon.Harley@ed.ac.uk (S.L. Harley).
[1] Present address: Via Camasio 19, 20157 Milan, Italy.

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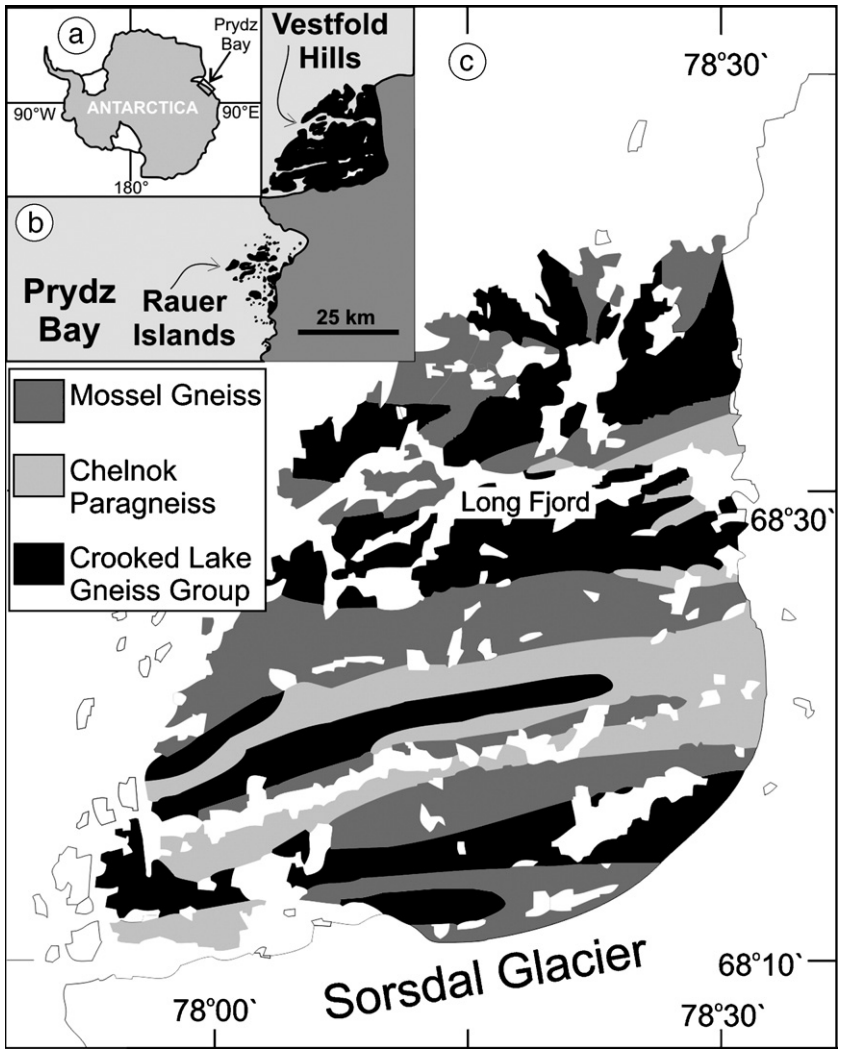

Fig. 1. a) Position of the Vestfold Hills in Antarctica. b) Position of the Vestfold Hills and Rauer Islands in the Prydz Bay. c) Simplified geology of the Vestfold Hills.

northeastern India according to recent Gondwana reconstructions (e.g. Dasgupta and Sengupta, 2003). Given this, and the possibilities for alternative correlations of the Vestfold Hills with a number of Archaean areas in northern India and Bangaladesh (e.g. Fitzsimons, 2003), it is important that its Pressure–Temperature–time (P–T–t) history and geological evolution is well characterised and distinguished from those of neighbouring terranes in Antarctica.

Within Antarctica the craton that includes the Vestfold Hills is separated from other Archaean areas such as the Napier Complex of Enderby Land (Tingey, 1991; Harley and Black, 1997) and the Ruker Complex of the Southern Prince Charles Mountains (Mikhalsky et al., 2001; Boger et al., 2006) by Neoproterozoic and Cambrian high-grade belts that form much of Prydz Bay and MacRobertson Land (Fitzsimons, 2000a,b; Boger et al., 2000, 2001; Harley, 2003). Previous geochemical, isotopic and geochronological studies demonstrate that the Archaean basement of the Vestfold Hills is distinct from the Napier Complex and Ruker Terrane (Black et al., 1991; Snape and Harley, 1996; Snape et al., 1997). Adjacent to the Vestfold Hills is the complex poly-deformed and poly-metamorphosed Rauer Terrane (Harley, 2003), which includes both Archaean and Mesoproterozoic crustal components, deformed under high-grade conditions in events at 1030–990 Ma and 530–510 Ma. Although the Archaean component of this terrane was initially thought to be a reworked equivalent of the Vestfold Hills basement (Collerson and Sheraton, 1986a, b), isotope geochemistry