Available online at www.sciencedirect.com
ScienceDirect
Precambrian Research 155 (2007) 159–203
Precambrian Research
www.elsevier.com/locate/precamres

Adjacent terranes with ca. 2715 and 2650 Ma high-pressure metamorphic assemblages in the Nuuk region of the North Atlantic Craton, southern West Greenland: Complexities of Neoarchaean collisional orogeny

Allen P. Nutman[a,b,c,*], Clark R.L. Friend[d]

[a] *Research School of Earth Sciences, Australian National University, Canberra, ACT 0200, Australia*
[b] *Department of Earth and Marine Sciences, Australian National University, Canberra, ACT 0200, Australia*
[c] *Beijing SHRIMP Centre, Institute of Geology, Chinese Academy of Geological Sciences, 26 Baiwanzhuang Road, Beijing 100037, PR China*
[d] *45, Stanway Road, Headington, Oxford OX3 8HU, UK*

Received 18 August 2006; received in revised form 20 December 2006; accepted 21 December 2006

Abstract

In the gneiss complex of the Nuuk region of the North Atlantic Craton in southern West Greenland, terrane juxtaposition was followed by Neoarchaean folding under amphibolite facies conditions, with widespread low-pressure recrystallisation (5 kbar and 550–700 °C). The complex metamorphic overprinting requires that the *P–T* history related to actual terrane assembly has to be extracted from very small relicts of older metamorphic assemblages combined with the U/Pb dating, petrology and geochemistry of metamorphic zircons.

In the south of the region, the Færingehavn terrane (Eoarchaean orthogneisses) is tectonically overlain by a supracrustal package of amphibolites and paragneisses (ca. 2840 Ma felsic volcano-sedimentary protoliths). This package is juxtaposed against a higher tectonic level represented by the Tre Brødre terrane (2825 Ma orthogneisses) and the Tasiusarsuaq terrane (2920–2810 Ma orthogneisses). The terranes were assembled by 2710–2720 Ma, as shown by dating of granitic sheets intruded along the terrane boundary mylonites. In the Færingehavn terrane and in the overlying 2840 Ma supracrustal package, relict early high-pressure assemblages (12–8 kbar, 700–750 °C) are clinopyroxene + garnet + plagioclase + quartz ± hornblende in mafic rocks and garnet + kyanite + rutile bearing assemblages in paragneisses. These are commonly replaced by lower pressure assemblages (7–5 kbar) such as cordierite ± sillimanite ± garnet in paragneisses and hornblende + plagioclase + quartz ± garnet in mafic rocks. *In situ* partial melting took place during both low- and high-pressure regimes. Metamorphic zircon in the high- and low-pressure assemblages yields dates of ca. 2715 Ma, mostly with errors of <±5 Ma, thereby demonstrating rapid decompression at high temperatures. Zircons in the overlying Tre Brødre and Tasiusarsuaq terranes show little response to the ca. 2715 Ma event supporting structural interpretations that they were at a higher structural level at ca. 2715 Ma. High temperature recrystallisation continued after ca. 2715 Ma, as demonstrated by intergrowth of sillimanite with 2680 Ma metamorphic zircon.

The Kapisilik terrane (3050–2960 Ma orthogneisses) and another supracrustal assemblage of amphibolites and ca. 2800 Ma quartzo-feldspathic metasedimentary rocks are exposed north of the Færingehavn terrane and within fold cores along its western margin, are bounded by folded Neoarchaean mylonites. The Kapisilik terrane and this supracrustal assemblage include high-pressure metamorphic remnants in amphibolites and metasediments (metamorphic segregations with garnet + clinopyroxene and kyanite, respectively) that formed at ca. 2650 Ma. These remnants are overprinted by high temperature, but lower pressure metamorphic events at ca. 2630, 2610 and 2580 Ma. Thus remnants of early metamorphism

* Corresponding author at: Beijing SHRIMP Centre, Institute of Geology, Chinese Academy of Geological Sciences, 26 Baiwanzhuang Road, Beijing 100037, PR China. Tel.: +86 10 6899 2239.
E-mail address: nutman@bjshrimp.cn (A.P. Nutman).

doi:10.1016/j.precamres.2006.12.009

reveal mutually exclusive ca. 2715 and 2650 Ma high-pressure events in adjacent tectonically juxtaposed terranes. Repeated high-pressure metamorphism in adjacent terranes is observed in younger complex collisional orogens.

Keywords: Archaean; Collisional orogeny; *P–T–t* paths; Zircons; Greenland

1. Introduction

High-pressure granulites and eclogites are commonly formed during collisional events, in deeply buried crust just after tectonic thickening (e.g., O'Brien and Rötzler, 2003). Near-isothermal decompression commonly follows the crustal thickening, when initially deeply buried rocks are rapidly exhumed as the crust is thinned by structural collapse, extension and erosion (Hermann et al., 2001 and references therein). Hence, the diagnostic metamorphic fingerprint of deeply buried crust at the site of a collisional orogeny is the formation of high-pressure granulites ± eclogites followed by recrystallisation to lower pressure assemblages within a clockwise *P–T–t* (pressure, temperature and time) path (e.g. England and Thompson, 1984; O'Brien and Rötzler, 2003). Phanerozoic and Neoproterozoic collisional orogens are yielding increasingly reliable data on the high temperature parts of *P–T–t* clockwise loops following initial crustal thickening. The data have been acquired by combining zircon *in situ* U/Pb dating, rare earth element (REE) chemistry, and inclusion petrology (e.g. distinguishing coesite versus quartz inclusions in zircons) together with identification of the metamorphic parageneses to which they belong (e.g. Hermann et al., 2001; Rubatto and Hermann, 2001). Zircon is particularly useful in this methodology because of its common growth during high-grade metamorphism and its high effective blocking temperatures (>900 °C) for U and Pb diffusion (Lee et al., 1997). Providing that zircon is not later recrystallised, it can retain its true age through superimposed tectonothermal events and hence preserve the age of its associated metamorphic paragenesis.

In many Phanerozoic collisional orogens, the increasingly detailed dating of metamorphic zircons integrated with metamorphic petrology of relicts of high-pressure granulites and eclogites is providing evidence for more than one high-pressure metamorphic event. This metamorphic history indicates repeated crustal thickening caused by complex collisions between multiple continental blocks, such as in the European Alps (e.g. Rubatto et al., 1998; Rubatto and Scambelluri, 2003; Liati et al., 2005). In this paper, the integrated metamorphic petrology–zircon geochronology and geochemistry approach is used to study Neoarchaean metamorphism in the Nuuk region of North Atlantic Craton in southern West Greenland (Fig. 1). The results presented here demonstrate different Neoarchaean high-pressure metamorphic events (ca. 2715 and 2650 Ma) in neighbouring terranes that are separated by folded mylonites. The more detailed studies of the 2715 Ma event show that crust buried by tectonic thickening was rapidly exhumed. These results are presented as new evidence for complex collisional orogenic systems operating more than 2500 million years ago. This work builds upon the terrane assembly model in the Nuuk region developed by Friend et al. (1987, 1988) and Friend and Nutman (2005a), recent mapping under the auspices of the Geological Survey of Denmark and Greenland (GEUS—Friend and Nutman, 2005b) and earlier metamorphic studies from the southern part of the Nuuk region that first recognised a clockwise *P–T* loop (Nutman et al., 1989).

2. Neoarchaean geological evolution of the Nuuk region

2.1. Tectono-stratigraphic terrane concept

Friend et al. (1987, 1988) demonstrated that several unrelated orthogneiss complexes are present in the Nuuk region, in the form of tectono-stratigraphic terranes bounded by folded amphibolite facies Archaean mylonites. This interpretation was in contrast to previous studies (e.g. Bridgwater et al., 1974; Wells, 1976) based upon reconnaissance mapping that led to assumptions that there was a regional continuity in metamorphic history and rock ages. Terrane accretion in the south of the Nuuk region has been independently verified by detailed structural mapping and U/Pb mineral dating across the southern end of the Qarliit Nunaat fault near Færingehavn (Fig. 1; Crowley, 2002).

The tectono-stratigraphic terranes had different early histories (ages of tonalitic gneisses and intra-terrane metamorphism) prior to tectonic juxtaposition along the mylonites and later Archaean pan-terrane deformation and metamorphism (Friend et al., 1987, 1988; Nutman et al., 1989). Nutman et al. (1989) showed that the structurally deepest levels in the southern part of the