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Metamorphic P–T paths of metapelitic granulites from the Larsemann Hills, East Antarctica

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ABSTRACT

Through detailed textural observations, a peak M1 assemblage garnet + orthopyroxene + cordierite + K-feldspar has been identified in a structurally early Al-rich metapelitic granulite lens from the Larsemann Hills, East Antarctica. The M1 assemblage has been overprinted by M2 cordierite corona and M3 orthopyroxene + cordierite symplectite on garnet grains. Quantitative modeling for the peak M1 assemblage via the THERMOCALC program in the KFMASH system suggests that it was formed by the crossing of the univariant reaction garnet + biotite =cordierite + orthopyroxene + K-feldspar+ melt under P–T conditions of 6–8 kbar and 840–880 °C, followed by post-peak near isobaric cooling. However, the average P–T calculations for the boron-bearing pelitic granulite indicate that peak M1 conditions reached ~9.0 kbar and ~900 °C, and the overprinting M2 assemblage formed under P–T conditions of ~7.0 kbar and 800–850 °C, reflecting a post-peak near isothermal decompression. P–T estimates show that M3 conditions reached 4–5 kbar and 700–750 °C. These imply that the M1 metamorphic evolution of the region displays contrasting P–T paths, while M2 to M3 evolution indicates a decompression-cooling process. The available chronological data support that the M1 metamorphic evolution occurred during the late Proterozoic (1000–900 Ma) Grenvillian high-grade compression tectonic event (D1), and was accompanied by strong magmatism, showing a close affinity to the northern Prince Charles Mountains and the Rayner complex. However, the overprinted M2 to M3 metamorphic evolution formed during the early Palaeozoic (~530 Ma) Pan-African high-grade tectonic events (D2–D3), and was associated with an important intracontinental reworking. This study presents an example for interpreting a complex polymetamorphic history.

1. Introduction

The Larsemann Hills and adjacent areas occur as an important part of the early Palaeozoic (550–500 Ma) Pan-African high-grade tectonic mobile belt (the Prydz Belt) in East Antarctica (Carson et al., 1996; Dirks and Wilson, 1995; Fitzsimons et al., 1997; Hensen and Zhou, 1995; Ren et al., 1992; Zhao et al., 1992, 1995). However, until recently, a long-standing debate still exists concerning the tectonic nature of the Prydz Belt, namely whether it represents a Pan-African suture zone associated with the final assembly of east Gondwana (Fitzsimons, 2003; Fitzsimons et al., 1997; Hensen and Zhou, 1997; Zhao et al., 2003), or is a Pan-African intraplate orogen related to intracontinental reworking (Phillips et al., 2007; Wilson et al., 2007; Yoshida, 2007). This controversy resulted from the contrasting interpretations of the metamorphic P–T history of the Larsemann Hills and adjacent areas. For instance, it was thought that decompression-dominated P–T paths in the regions evolved during a single Pan-African (~530 Ma) metamorphic event (Carson et al., 1997; Fitzsimons, 1996, 1997; Grew et al., 2006; Thost et al., 1994), but other studies suggested that the paragneisses experienced both the ~1000 Ma and the ~530 Ma high-grade metamorphic events (Dirks and Hand, 1995; Tong and Liu, 1997; Tong et al., 1998, 2002; Zhang et al., 1996). Latter suggestion is further supported by recent new SHRIMP U–Pb age data from the paragneisses in the region (Grew et al., 2012; Wang et al., 2008). Clearly, the complete P–T paths involving the ~1000 Ma and ~530 Ma events have not yet been fully sorted out for this region, even though they are critical to our understanding of the tectonic nature of the ~1000 Ma event in the Prydz Belt and the assembly process of east Gondwana.

This paper aims to clarify the complete P–T history of the Larsemann Hills via investigations into structurally early metapelitic granulites. A garnet–orthopyroxene–cordierite-bearing pelitic granulite with multiple reaction textures will be modeled using the THERMOCALC program (Powell et al., 1998) with the dataset of Holland and Powell (1998) and the model for silicate melts in the

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KFMASH system (Holland and Powell, 2001), combined with P–T calculations through the average P–T method (Powell and Holland, 1994). Thus, P–T paths for the early ~1000 Ma event and the overprinting ~530 Ma metamorphic event are being integrated for the region. It is suggested that the M1 metamorphic event involved a contrasting process of post-peak cooling and decompression, similar to that of the northern Prince Charles Mountains and the Rayner complex, whereas the overprinting ~530 Ma metamorphic events (M2–M3) were actually resulted from an extensive intracontinental reworking.

2. Geological background

The Larsemann Hills, located in the middle part of the Prydz Bay coast, are composed mainly of upper amphibolite to granulite facies psammitic to pelitic paragneiss, mafic–felsic composite orthogneiss and Blundell Orthogneiss (970–980 Ma), with minor leucogranitic gneiss and syn- or post-tectonic granite (Fig. 1) (Carson and Grew, 2007; Grew et al., 2012). The paragneiss sequence and composite orthogneiss were also referred to as the Brattstrand Paragneiss and Søstrene Orthogneiss respectively by Fitzsimons (1997) for the metasedimentary unit and mafic–felsic metaigneous unit in the region and adjacent areas along the Prydz Bay coast (Carson et al., 1995a; Dirks and Wilson, 1995; Fitzsimons, 1997; Grew et al., 2012; Stüwe et al., 1989; Thost et al., 1991). The paragneisses on Stornes Peninsula, Stornesbukta and Seal Cove of Mirror Peninsula contain borosilicate minerals prismatine and grandidierite (Carson et al., 1995b; Cooper et al., 2009; Grew et al., 2006, 2007; Ren and Liu, 1994; Ren and Zhao, 2004), and a sapphirine-bearing assemblage was also reported from Stornes Peninsula (Grew et al., 2006, 2007; Ren et al., 2008; Tong and Liu, 1997). The paragneisses experienced extensive partial melting and migmatization (Dirks et al., 1993), and were considered to represent part of an extensive basinal sedimentary sequence extending about 130 km from the southern Rauer Group to the Bolingen Islands (Carson et al., 1995a, 1997). The mafic–felsic orthogneisses and paragneisses were generally interpreted as tectonically interleaved Proterozoic basement and sedimentary cover sequence in the region (Carson et al., 1995a; Dirks and Hand, 1995; Dirks et al., 1993; Fitzsimons and Harley, 1991; Sheraton et al., 1984; Stüwe et al., 1989).

However, different peak metamorphic conditions were reported for the high-grade rocks in this region and adjacent areas (Table 1), and these led to distinct explanations regarding the P–T history of the Prydz Bay coast. For example, the region was initially

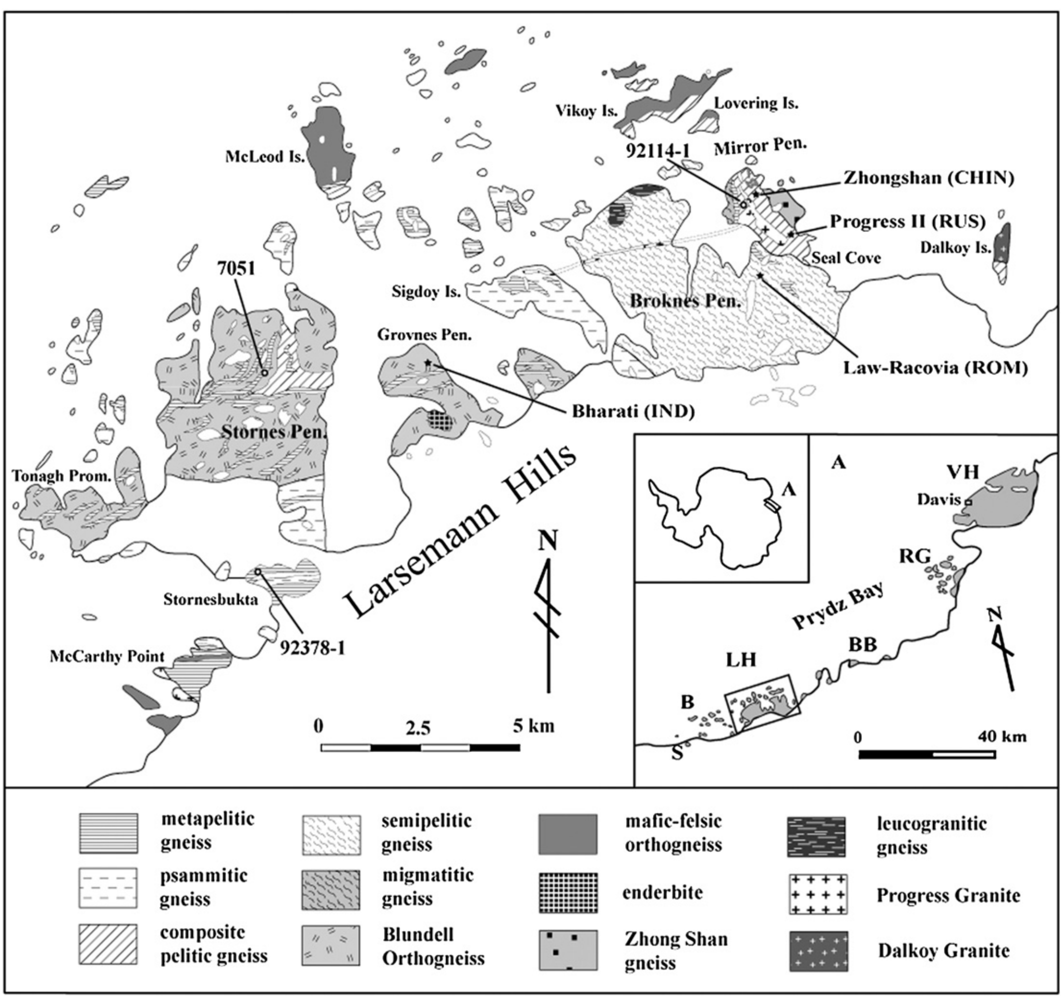

Fig. 1. Geological map of the Larsemann Hills, east Antarctica, showing the major lithological units and sample locations (after Carson and Grew, 2007; Carson et al., 1995a; Tong et al., 2002). Inserted map shows the site of the Larsemann Hills in Prydz Bay, LH, Larsemann Hills, S, Søstrene Island, B, Bolingen Islands, BB, Brattstrand Bluffs, RG, Rauer Group, VH, Vestfold Hills.