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# Source region analyses of the morainal detritus from the Grove Mountains: Evidence from the subglacial geology of the Ediacaran–Cambrian Prydz Belt of East Antarctica

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ABSTRACT

The Grove Mountains are the inland exposures of the Prydz Belt in East Antarctica. Although the 550–500 Ma orogenic event was recognized as the latest major magmatic–metamorphic activity in the Prydz Belt, its subduction–collision origin was not confirmed until the discovery of high-pressure (HP) mafic granulite erratic boulders in the glacial moraines from the Grove Mountains. Because no HP metamorphic bedrock is exposed in this area, an understanding the regional geology required a thorough study of the morainal debris mineralogy and detrital zircon U–Pb chronology. Detrital zircon U–Pb age histograms show 550–450 Ma, 900–800 Ma, and 1100–1000 Ma modes from three morainal deposits and one paleosol samples. The oldest ages were 2300 to 2420 Ma. Detailed electron probe microanalyses (EPMA) for the detrital mineral grains were compared with the minerals from the nearby exposed bedrock. The mineral chemistry indicates that the exposed bedrock in the Grove Mountains was not the sole source for morainal materials. This new U–Pb zircon geochronology and microprobe mineral data support the previous interpretation that the 550–500 Ma tectonic activity was the final collisional event that formed the Prydz Belt and amalgamated East Antarctica.


## 1. Introduction

The East Antarctic continent is part of the Gondwana supercontinent and is comprised of several Archean–Paleoproterozoic cratons (Black et al., 1986; Fanning et al., 1995; Harley and Black, 1997; Oliver and Fanning, 1997; Peucat et al., 1999; Oliver and Fanning, 2002) and Proterozoic–Paleozoic orogenic belts (Tingey, 1991; Kinny et al., 1993; Flöttmann and Oliver, 1994; Chen et al., 1995; Meert and Van Der Voo, 1997; Harley et al., 1998; Fitzsimons, 2000a; Powell and Pisarevsky, 2002; Meert, 2003; Boger and Miller, 2004; Kelsey et al., 2008; Meert and Lieberman, 2008; Boger, 2011; Harley et al., 2013). Previous studies suggested that East Antarctica formed from several fragments during Neoproterozoic to Cambrian time (Black et al., 1992; Shiraishi et al., 1992; Dirks and Wilson, 1995; Hensen and Zhou, 1995; Jacobs et al., 1995; Sheraton et al., 1995; Hensen and Zhou, 1997; Motoyoshi and Ishikawa, 1997; Fitzsimons, 2000a; Fraser et al., 2000; Powell and Pisarevsky, 2002; Meert, 2003; Shiraishi et al., 2003; Boger and Miller, 2004; Meert and Lieberman, 2008; Boger, 2011; Godard and Palmeri, 2013; Harley et al., 2013; Meert, 2014). The margins of stable continental blocks evolved in multiple stages and the orogenic belts contain complicated late Meso–early Neoproterozoic (Grenvillian) to Neoproterozoic–Cambrian (Pan-African) overlapping frameworks during cyclical continental evolutions (Fitzsimons, 2000a; Meert, 2003; Veevers, 2004; Will et al., 2009, 2010; Godard and Palmeri, 2013; Meert, 2014). The term Pan-African has been used to describe Neoproterozoic to early Paleozoic (870–550 Ma) protracted tectonic, magmatic, and metamorphic activities covering a wide range of spatial scales within Gondwana (Kröner, 1984; Stern, 1994; Kröner and Stern, 2004). The 550–500 Ma tectonism along the margins of Antarctica, southern India and into the Zambezi and Damara Belts were named the Kuunga Orogeny (Meert et al., 1995; Meert and Van Der Voo, 1997; Meert, 2003). Within the mobile belts, the high-pressure (HP) metamorphic rocks are the critical indicators revealing the collisional continental boundaries (Di Vincenzo et al., 1997; Di Vincenzo and Palmeri, 2001; Board et al., 2005; Palmeri et al., 2007; Liu et al., 2009b; Romer et al., 2009; Godard and Palmeri, 2013). East Antarctic HP rocks are mostly buried under the large ice sheets and are rarely exposed (Godard and Palmeri, 2013), so any evidence of HP metamorphic rocks in this part of Antarctica is worthy of attention. Based on the timing of tectonic activity and the presence of HP metamorphic rocks in outcrop and glacial deposits, the Prydz Belt and Lützow Holm Belt was identified as the loci of suture zones that assembled East Antarctica from three continental fragments (Dirks and Wilson, 1995; Hensen and Zhou, 1997; Fitzsimons,

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2000a; Zhao et al., 2000; Boger et al., 2001; Fitzsimons, 2003; Harley, 2003; Meert, 2003; Zhao et al., 2003; Liu et al., 2006, 2007a, 2009a,b; Harley et al., 2013).

The Prydz Belt is Ediacaran–Cambrian age mobile belt extending from Prydz Bay to the Gamburstsev Subglacial Mountains (Fitzsimons, 2000a; Zhao et al., 2003; Liu et al., 2006, 2009a,b). The Grove Mountains are located about 400 km inland from Prydz Bay in line with the Prydz Belt and are composed of isolated nunataks (Fig. 1). Adjacent to nunatak exposures in the central Grove Mountains, irregular morainal deposits form elongated bands distributed on the ice sheet (Fig. 2). The morainal detritus originated by rock fragments accumulating by the weathering of the nearby cliffs and material excavated from the bedrock under the ice cap during the movement of glaciers.

The glacial deposits are important in the study of Antarctic geology because of limited bedrock exposures, especially for the inland parts of the Antarctic continent (Di Vincenzo et al., 1997; Peucat et al., 2002; Di Vincenzo et al., 2007; Elliot and Fanning, 2008; Veevers et al., 2008; Veevers and Saeed, 2013; Elliot et al., 2015). The morainal deposits from the edge of the glaciers and the inland continental ice sheet usually carry considerable information about the subglacial bedrock (Jenkins and Alibert, 1991; Goodge et al., 2004; Jamieson et al., 2005; Veevers and Saeed, 2008; Goodge and Fanning, 2010; Veevers and Saeed, 2011, 2013). The 542 to 545 Ma HP metamorphosed mafic granulites, which are the fundamental evidence of the subduction–collision feature of the Prydz Belt, were collected from the morainal boulders at the Gale Escarpment, Grove Mountains (Liu et al., 2009a). The HP granulite bedrock exposures have not yet been found. Therefore, locating the source of the high-pressure metamorphosed mafic granulites required that our study focus on morainal deposits from different glacial valleys to analyze the detrital mineral assemblages and the detrital zircon U–Pb geochronology. The chemical character of detrital minerals from the Grove Mountains was compared with the mineral chemistry of the local and regional bedrock to identify the source regions of the morainal deposits. This morainal gravel study has provided additional evidence for the metamorphic processes of the Prydz Belt and the evolution of East Antarctica.

## 2. Regional context and previous study of the Grove Mountains

### 2.1. Regional context

East Antarctica, part of eastern Gondwana, experienced multiple orogenic events. Several subduction–collision events sutured Archean–Paleoproterozoic terranes during both the late Mesoproterozoic to early

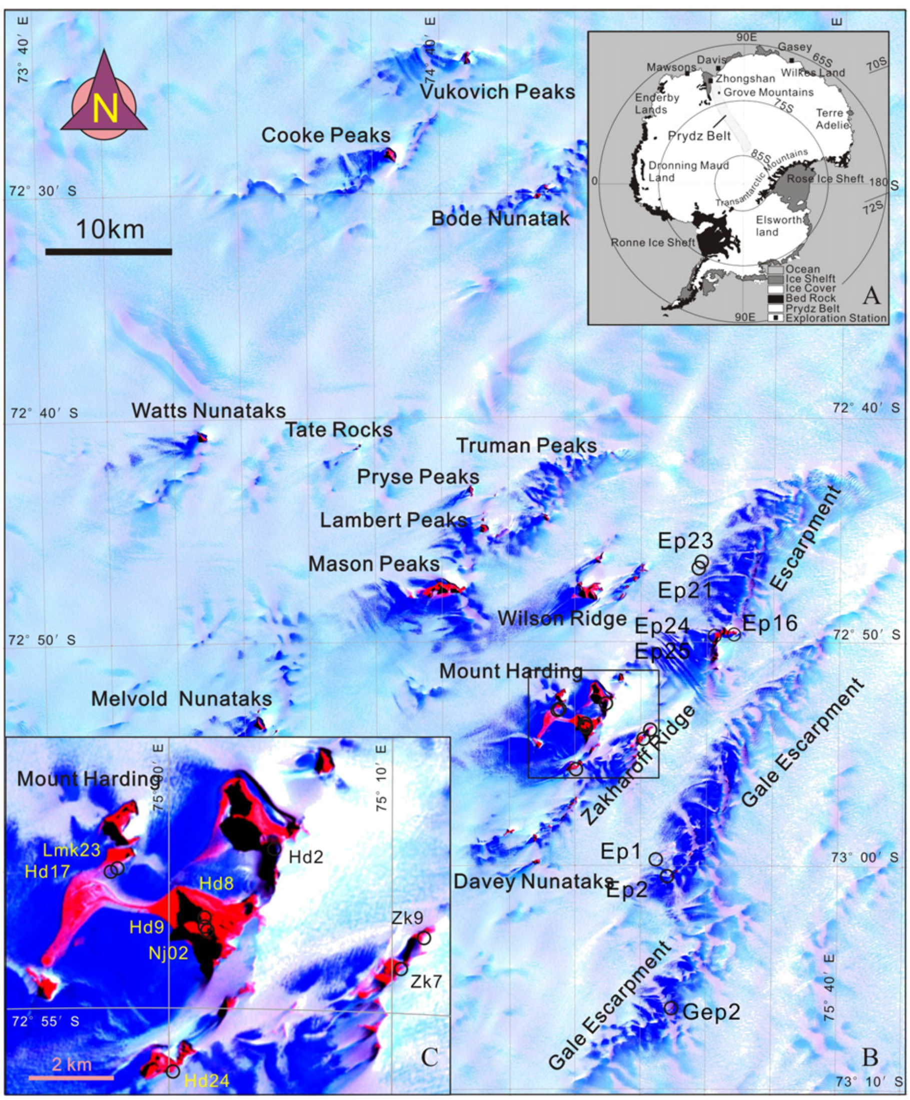


**Fig. 1.** Remote sensing image of the Grove Mountains, Antarctica. This image includes three parts: A) the upper right corner shows the bedrock distribution in Antarctica and the locations of the Grove Mountains and Prydz Belt, B) the center remote sensing image is the Grove Mountains area, showing the locations of all the nunataks and the sample locations at Gale Escarpment, C) the lower left corner shows the Mount Harding area and the sample locations.