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Two distinct Precambrian terranes in the Southern Prince Charles Mountains, East Antarctica: SHRIMP dating and geochemical constraints

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Abstract

The Southern Prince Charles Mountains (SPCM) are mostly occupied by the Archaean Ruker Terrane. The Lambert Terrane crops out in the northeastern part of the SPCM. New geochemical and zircon U–Pb SHRIMP ages for felsic orthogneisses and granitoids from both terranes are presented. Orthogneisses from the Ruker and Lambert terranes differ significantly in their major and trace-element compositions. Those from the Ruker Terrane comprise two distinct groups: rare Y-depleted and abundant Y-undepleted. U–Pb isotopic data provide evidence for tonalite–trondhjemite emplacement at 3392±9 and 3377±9 Ma, pre-tectonic granite emplacement at 3182±9 Ma, metamorphism(?) at c. 3145 Ma, and thermal events at c. 1300(?) and 626±51 Ma. The Lambert Terrane orthogneisses probably originated in a continental magmatic arc. Zircon dating shows a very different geological history: pre-tectonic granitoid emplacement at 2423±18 Ma, metamorphism at 2065±23 Ma, and syn-tectonic granitoid emplacement at 528±6 Ma, syn-tectonic pegmatite emplacement at 495±18 Ma. The Lambert Terrane can be correlated with neither the Meso- to Neoproterozoic Beaver Terrane in the Northern PCM, which differs in isotopic composition, nor with the Archaean Ruker Terrane, which differs in both granitoid chemical composition and the timing of major geological events. It represents a Palaeoproterozoic orogen which experienced strong tectonic re-activation in Pan-African times. The Lambert Terrane has some geochronological features in common with the Mawson Block, which comprises south Australia and some areas in East Antarctica.

Keywords: Orthogneiss; SHRIMP dating; Geochemistry; Precambrian; Antarctica

1. Introduction

The Prince Charles Mountains (PCM) constitute the best exposed cross section through the East Antarctic Shield, extending for over 500 km along the drainage basin of the Lambert Glacier–Amery Ice Shelf system. Early workers, on the basis of lithology and numerous Rb–Sr ages, recognised two major tectonic provinces in the PCM, roughly corresponding to the mountain belt topography. These were an Archaean province in the Southern PCM (SPCM; the Southern Zone of Solov'ev, 1972, the Southern Province of Tingey, 1991, and the Ruker Terrane of Mikhalsky et al., 2001), and a Meso- to Neoproterozoic province in the Northern PCM (NPCM; the Northern Zone of Solov'ev, 1972, the Northern Province of Tingey, 1991, and the Beaver–Lambert Terrane of Mikhalsky et al., 2001). It should be noted that Solov'ev (1972), having no isotopic ages from this region, suggested that his Southern Zone was Palaeo- to Mesoproterozoic, whereas the Northern Zone — Archaean.

Kamenev et al. (1993) proposed a threefold subdivision of the area on structural and lithological grounds. They distinguished a relatively stable South Lambert (Ruker) Province, consisting of granite–greenstone and granite–gneiss–schist belts, in the SPCM, and a North Lambert (Beaver) Province, comprising a charnockite–granulite belt which was highly mobile until Cambrian, in the NPCM. These provinces were separated by a third province of supracrustal and granitic rocks in the central part of the PCM (including the central and northern Mawson Escarpment). This area was termed the Lambert Province (Kamenev et al., 1993) and its component

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rocks the Lambert Complex. The Lambert Province was considered to be either a tectonic 'buffer' zone formed by interaction between the granite–greenstone and charnockite–granulite belts at mid-crustal levels, or the higher-grade equivalents of the granite–greenstone belts themselves (Kamenev et al., 1990). Recent workers (Boger et al., 2001; Fitzsimons, 2003) termed this area the Lambert Terrane, but explained its geological features differently. Boger et al. (2001) considered the Lambert Terrane a Cambrian suture and correlated it with a high-grade belt exposed in the Prydz Bay area, while Fitzsimons (2003) supported this model, but noted that c. 550–500 Ma tectonism was reported only from the Mawson Escarpment. The crustal prehistory of the Lambert Terrane was not discussed by these authors.

The Beaver and Lambert terranes were considered to be sections of an extensive Meso- to Neoproterozoic mobile belt extending through most of the peripheral part of the East Antarctic Shield (the Late Archaean–Proterozoic Wegener–Mawson Mobile Belt of Kamenev, 1991, and Circum-Antarctic Mobile belt of Yoshida, 1992, 1994). Fitzsimons (2000) considered the NPCM as a part of the Rayner Province extending from western Enderby Land to the Lambert Glacier area.

Kamenev and Krasnikov (1991) distinguished yet another tectonic province, the Fisher Terrane, in the central PCM, based on its distinctive lithology and geological history. This terrane is characterized by essentially calc-alkaline magmatism, and probably represents an active continental margin or a collage of island arcs and foreland domains (Mikhalsky et al., 1996, 1999).

The geochemical features of granites and felsic orthogneisses from the Ruker and Beaver terranes have been the subject of detailed studies by Sheraton and Black (1988) and Sheraton et al. (1996). These authors described the chemical evolution of granitic rocks in the PCM and adjacent areas, including the Archaean cratons, but concentrated on either Archaean orogenic or Early Palaeozoic post-orogenic granitoids, and did not distinguish Proterozoic orthogneisses of the northern SPCM (Lambert Terrane) as a separate unit. They considered this area as part of the Beaver Terrane, but new isotopic data (see below) preclude such a correlation.

In this paper we present new geochemical and U–Pb isotopic (SHRIMP) data for rocks from the Lambert and Ruker terranes obtained by earlier Russian Antarctic expeditions and by the Prince Charles Mountains Expedition of Germany and Australia (PCMEGA 2002/2003), and address the hitherto enigmatic relationships between these areas. The main goal of this study is to compare the age data and compositional features of the two terranes and highlight their significant differences.

2. Geological background

Most of the SPCM (the area south of about 72° 30′S) are underlain by the Ruker Terrane, except for the central and northern Mawson Escarpment, together with a few nunataks to the north and west (e.g., Mt Johns and Shaw Massif), which have not yet been studied in detail, and probably belong to the Beaver Terrane (Fig. 1). However, the age and composition of many outcrops in this area remain not sufficiently studied, so that the true extent of the Lambert Terrane is not yet clear.

The Ruker Terrane comprises an Archaean granite–gneiss basement (Mawson Orthogneiss and variously deformed granitic plutons), which appears to be overlain by a variety of metasedimentary and metavolcanic rocks of three distinct lithological units: the Menzies, Ruker, and Sodruzhestvo Series. The age of the presumed granitic basement and overlying metasediments was first determined by Rb–Sr studies, whole-rock isochron ages of 2700±90, 2750±400, and 2760±200 Ma being reported by Tingey (1982). A few imprecise Meso- to Neoproterozoic ages were also obtained (1400±150 Ma, 1170±230 Ma, c. 1040 Ma, c. 830 Ma; Tingey, 1982; Mikhalsky et al., 2001, and references therein). These were interpreted as reset ages, and provide some evidence for Mesoproterozoic thermal reworking of the area, possibly in response to high-grade metamorphism in the NPCM. Muscovite-bearing pegmatites cutting the metasediments were dated at 2589, 2100, 1995, and 1708 Ma, and it was suggested that Palaeoproterozoic, as well as Archaean, sequences may be present (Tingey, 1982). Conventional zircon U–Pb studies gave an age of 3005±57 Ma for the Mt Ruker granite pluton, and showed that zircon crystallization in metasedimentary and metavolcanic rocks in the same area occurred between 3200 and 2500 Ma ago, with a prominent thermal event at 532±20 Ma (Mikhalsky et al., 2001). Recent zircon SHRIMP studies on rocks from the southern Mawson Escarpment (Boger et al., 2001) gave ages of c. 3370 Ma (interpreted as representing inheritance from the source region), 3160 Ma (maximum age of deformation), and 2650 Ma (pegmatite crystallization and minimum age of deformation). Sm–Nd whole-rock and mineral data for mafic metamorphic rocks of volcanic and plutonic origin from Mt Ruker define isochron ages of 2917±82 and 2878±65 Ma, respectively (Beliatsky et al., 2003), which probably represent the time of metamorphism, although low Nd_i values (0.50845, 0.50799) preclude long pre-metamorphic crustal residence times. Hornblende–biotite granite gneisses from the southern Mawson Escarpment have given a Sm–Nd whole-rock isochron age of 3230±130 Ma; tonalitic orthogneisses from the same area have given very imprecise Sm–Nd whole-rock and mineral (orthopyroxene, plagioclase)-whole-rock isochron ages of c. 3000 and c. 1900 Ma, respectively (Mikhalsky et al., in press).

The Late Archaean Menzies Series includes pelitic and calcareous metasediments, amphibolites, and conglomerates, commonly associated with prominent thick white to greenish quartzite units. It typically contains lower amphibolite-facies assemblages of relatively high-pressure Barrovian type (staurolite+kyanite±garnet). Presumably late Archaean Ruker Series consists of relatively low-grade (greenschist facies) mafic to felsic schists (probably metavolcanic rocks) and associated metadolerite sills, metapelitic schist, slate, phyllite, diamictite (tillite?), and banded ironstone. Metamorphosed mafic and ultramafic rocks occur as boudins, lenses, and blocks within high-strain shear zones in the southern Mawson Escarpment. The presumed (?Neo) proterozoic Sodruzhestvo Series is also