# AFI 7-03: The age, structure, origins and evolution of the Antarctic continent: new insights from zircons

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**Abstract**

Here we undertake a major study into the crustal evolution of the Antarctic continent, as preserved in the isotope and trace elemenet record in detrital zircon population in sedimentary and metasedimentary rocks, augmented by an integrated whole rock-zircon case study of magmatism from the exposed Antarctic basement. The objective is to generate key geochemical data to constrain the geological evolution of East Antarctica.

## 1. Introduction

The continental crust is unique to the Earth. It was first formed 4400 million years ago, shortly after planetary accretion, and it is still being generated, albeit relatively slowly. Previous isotope and dating studies seem to suggest that continental crust growth in the early Earth was episodic, whereby the 'background' of continental growth was punctuated by pulses of accelerated growth, each of which spanned several hundred million years (Hawkesworth & Kemp, 2006). The striking periodicity lies at the heart of debates on the development of the continental crust. It has been argued that the 'background' signal of crustal growth could be due to continuous subduction-zone magmatism, while the episodic peaks in the Earth's early history may be attributed to major thermal pulses associated with the emplacement of mantle 'super-plumes'.

However, it remains unclear, whether the age distribution observed to date is representative, or whether the peaks are merely artefacts of selective sampling. So far, no data of crustal growth ages are available for Antarctica, which constitutes $\sim 9\,\%$ of the continental crust and contains several areas of very old crust.

This study undertakes the first major study into the crustal evolution of the East Antarctica, as preserved in zircon. Zircons ($ZrSiO_4$) are physicochemically robust, virtually ubiquitous in crustal rocks, and survive multiple episodes of sedimentary and magmatic recycling. Zircon crystals can be dated and then analysed for various isotopes and trace elements. These data can be interpreted to show whether the rocks from which they were extracted were generated directly from the mantle (and so represent new additions to the crust), or whether they were simply recycled from existing volcanic or sedimentary rocks. The critical question is **'how much new crust was generated at which time?'**.

Dronning Maud Land (DML) was situated along the axis of a huge Himalaya-type mountain belt in Late Precambrian-Early Palaeozoic times ($\sim 600-470$ million years ago), known as the *Pan-African* belt. This was one of the largest mountain chains ever to have existed on Earth, and

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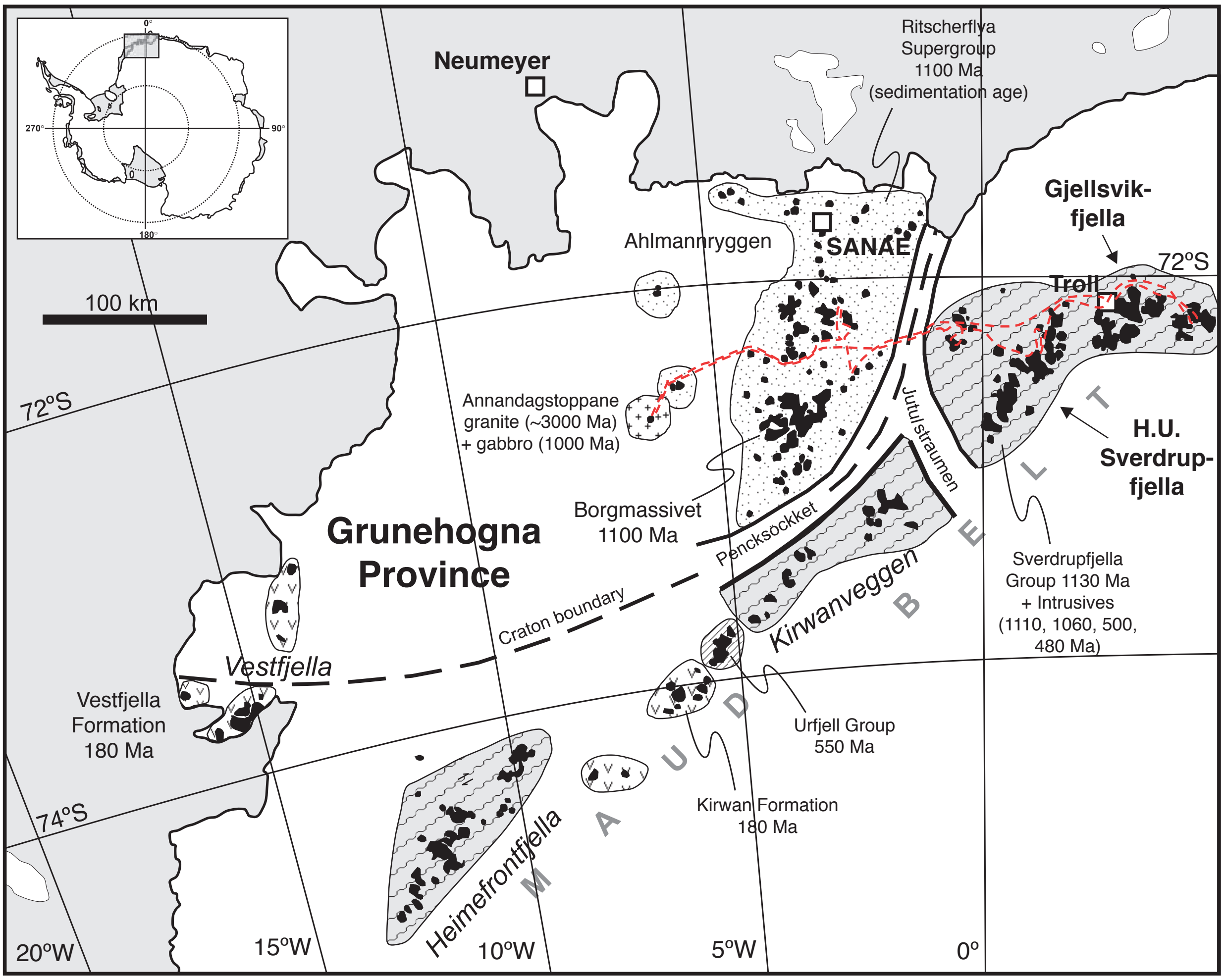


Fig. 1. Simplified map of Dronning-Maud Land (modified after Board *et al.*, 2005) showing the study area and the approximate travel route marked in red. The major geologic units are the high-grade metamorphic *Maud Belt* (sampled in Gjellsvikfjella and H.U. Sverdrupfjella), the sediments and sills in the *Ritscherflya Supergroup* (sampled in Ahlmannryggen), and the Archean basement of the *Grunehogna craton* (sampled at Annandagstoppane).

was formed when East Gondwana (Australia, India and most of East Antarctica) collided with West Gondwana (Africa and South America). The deep roots of this mountain belt are now exposed in East Africa and Antarctica.

DML comprises an Archean craton (∼ 3000 million years old) overlain by Mesoproterozoic clastic sediments (∼ 1100 million years old) in the West and a high-grade metamorphic belt in its central and eastern part (Fig.1). Archean rocks are exposed at one locality (*Annandagstoppane* at W 006°30′), while the sediments show large areas of outcrop in the *Ahlmannryggen* (W 001° to 003°). They are composed of sandstones, greywackes, conglomerates and mudstones and are intruded by large mafic sills. The metamorphic belt (the *Maud Belt*; Fig.1) is composed of high-grade gneisses intruded by km-sized magmatic plutons and countless dykes. The Pan-African collision is thought to have reworked rocks that originally formed much earlier (∼ 1100 million years ago in another period of crustal reworking called *Grenvillian*). Metamorphism in the Maud belt, therefore, is related to two orogeneses, namely the Grenvillian and Pan-African events.

The Maud Belt was sampled in the *H.U. Sverdrupfjella* (E 000° to 001°30′) and in the Gjelsvikfjella (E 002°30′ to 004°) (Fig.1). Jurassic plutons and basalt dykes (180 million years old) related to the rifting and break-up of Gondwana are also exposed in central and western DML.

Fig. 2. View from the southern tip of *Ahlmannryggen* over the $\sim 50$ km wide *Viddalen* glacier and the *Borgmassivet*.

## 2. Field work

Field work was carried out between 01 December 2007 and 05 February 2008 with 58 days in the deep field (Fig.2). One scientist (Dr Horst R. Marschall, Geologist, University of Bristol) accompanied by a field guide (Sune Tamm-Buckle, Field GA, Halley Winter GA 2007) started from the Norwegian station "Troll" (E 002°30′; Fig.1), and travelled 1,480 km on Skidoo (see Fig.1 for route).

Outcrop conditions in the entire field area were superb, with $300-900$ m high walls of vertical outcrop of metamorphic (Fig.3), sedimentary (Fig.4) and magmatic (Fig.5) sequences. Weathering is restricted to the tops of the nunataks and most outcrops are accessible on foot, after driving to the foot of the nunataks by skidoo. 208 samples were taken and stored into 18 rock boxes (total weight $\sim 500$ kg), which are anticipated to arrive in the UK in late April 2008.

## References


Board WS, Frimmel HE, Armstrong RA (2005) Pan-African tectonism in the Western Maud Belt: $P-T-t$ path for high-grade gneisses in H.U. Sverdrupfjella, East Antarctica. *J Petrol* 46: 671–699

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Fig. 3. Three generations of magmatic dykes cross-cutting through high-grade gneisses at *Jutulhogget*, close to Troll station (note the person for scale).

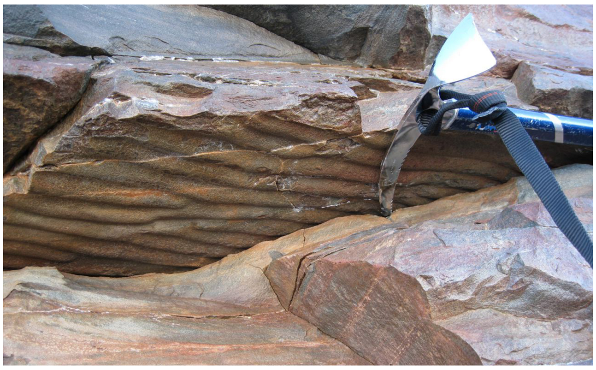

Fig. 4. Wave ripples in sandstone produced by a river $\sim 1,100$ million years ago.

Fig. 5. Cliff of $\sim 3,000$ million year old granite exposed at *Annandagstoppane* ("The Boxing-day tops"). Note the person on top for scale.