



GÖTEBORGS UNIVERSITET

Precambrian Crustal Evolution of the Rehoboth Province, Southern Africa

Valby van Schijndel

Institutionen för geovetenskaper
Naturvetenskapliga fakulteten

Akademisk avhandling för filosofie doktorsexamen i Geologi, som med tillstånd från
Naturvetenskapliga fakulteten kommer att offentligt försvaras fredag den 31a maj,
2013 kl. 10.00 i stora Hörsalen, Institutionen för geovetenskaper,
Guldhedsgatan 5C, Göteborg.

Examinator: Prof. Rodney Stevens

Fakultetsopponent: Dr. Roger Key

ISBN: 978-91-628-8701-8

ISSN: 1400-3813 A147

Internet-id: <http://hdl.handle.net/2077/32673>

Abstract

This thesis uses U-Pb, Sm-Nd Lu-Hf, Ar-Ar and Oxygen isotope data on well-documented rock samples, to investigate crustal evolution of the Precambrian Rehoboth Province of Southern Africa. This province is defined by its smooth magnetic character, reflecting deep magnetic basement in contrast to the adjoining mobile belts and the Kaapvaal Craton. Most of the area is covered by sedimentary sequences and the Kalahari sands.

A first indication of old crust in the Rehoboth Province was provided by granitoid and mafic cobbles from the ~300 Ma Dwyka glacial diamictite. The granitoid cobbles have Archaean ages between 3100 to 2500 Ma and a Palaeoproterozoic group between 2050 and 2020 Ma. The mafic cobbles yield ages of 1123–1111 Ma. The likely provenance of the Dwyka cobbles is the basement of the Rehoboth Province or the Kalahari Line east of Rietfontein. A source within the Kaapvaal Craton is excluded by the absence of typical Kaapvaal cover rocks in the diamictite cobbles. Previous theories of crustal growth or collision between the Rehoboth Province and the Kaapvaal Craton at either 1800 or 1200 Ma are not supported by these data.

The Rehoboth Basement Inlier (RBI) is a tectonic terrane at the northern margin of the Rehoboth Province, thrust up in the ~600 Ma Damara foreland. U-Pb, Lu-Hf and Oxygen isotope data for zircon from metasedimentary and magmatic rocks provide new insights on the crustal evolution of the Rehoboth Province. A small group of 3.41 to 2.45 Ga U-Pb zircon ages found in the metasediments of the RBI strengthens the concept of an Archaean foundation to the Rehoboth Province. A group of Palaeoproterozoic ages ranging from 2.2 to 1.92 Ga have not been identified in outcropping magmatic rocks. The Lu-Hf isotope character of these zircons requires mixing between Archaean crustal source rocks and juvenile mantle material. This again points to the presence of an Archaean nucleus within the Rehoboth Province. The 2.05 Ga event, seen in both Dwyka cobbles and detrital zircons, corresponds in age to the Bushveld event and thermal peaks in the Kaapvaal Craton and Limpopo Belt. It suggests that the Rehoboth Province was attached to the Kaapvaal Craton before 2.05 Ga, but after 2.45 Ga.

A large age peak at 1.87 Ga corresponds in age to the largely metabasaltic 1870 ±5Ma Elim Formation, now the oldest dated unit in the RBI. However, the Lu-Hf isotope data of the detrital zircons from metasediments shows a source with distinctly older crustal residence and it is likely that the magmatic event at 1.87 Ga was widespread over the Rehoboth Province.

The detrital zircon ages that correspond to the younger Palaeoproterozoic (1.83–1.72 Ga) magmatic ages of the RBI show similar Lu-Hf character and the source for these zircons was thus mainly provided by rocks related to the same subduction phase. The Palaeoproterozoic magmatic rocks of the RBI reveal a complex arc-related tectonic history which probably represents an Andean subduction setting.

The Kaaien Terrane in South Africa is part of the complex suture zone between the Kaapvaal Craton, Kheis Province, Rehoboth Province and the Namaqua–Natal Province related to a ~1200 Ma collision event. New metamorphic pressure-temperature (PT)-calculations combined with geochronology for unusual garbenschiefer rocks of the Groblershoop Formation reveal a unique burial and uplift history. A segment of the Kaaien Terrane reached depths around 40 km. This caused peak metamorphism at 1164 Ma (Lu-Hf on garnet), followed by rapid exhumation to hornblende and white mica Ar-Ar closure temperatures by ~1140 Ma, thought to be controlled by a change in the tectonic regime. This is the highest pressure found thus far in the Namaqua-Natal Province, most others being less than 5kb. Other parts of the Kaaien Terrane remained at the surface during this period.

The Rehoboth Province is thus revealed as an ancient crustal block with Archaean foundations, which may have been attached to the Kaapvaal Craton prior to 2.05 Ga. Major Palaeoproterozoic events within the Rehoboth Province involved mantle additions mixed with reworked Archaean crust. Finally, the Rehoboth Province played a major role during the evolution of the Mesoproterozoic Namaqua–Natal Province, which led to the formation of the Kalahari Craton.

Keywords: Rehoboth Province, Rehoboth Basement Inlier, Kaaien Terrane, Dwyka Diamictite, U-Pb, Sm-Nd, Lu-Hf, Ar-Ar Geochronology, Oxygen isotopes, Zircon, Baddeleyite