

Declaration

I declare that this thesis is my own original work, conducted under the supervision of Prof. Nicolas Beukes, Prof. Jens Gutzmer and Prof. David Evans. It is submitted for the degree Doctor of Philosophy at the Faculty of Science at Rand Afrikaans University, Johannesburg. No part of this research has been submitted in the past, or is being submitted, for a degree or examination at any other University.

H.C. Dorland



ISAIAH 40:28

²⁸Do you not know?

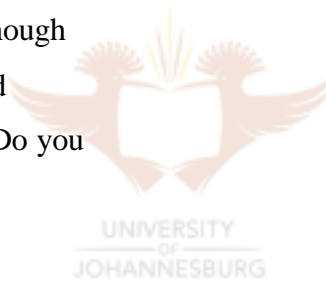
Have you not heard?

The LORD is the everlasting God,
the Creator of the ends
of the earth.

He will not grow tired or weary,
and his understanding
no one can fathom.

JOHN 11:25, 26

²⁵Jesus said to her, “I am the
resurrection and the life. He who
believes in me will live, even though
he dies; ²⁶and whoever lives and
believes in me will never die. Do you
believe this?”

**1 CORINTHIANS 15:3-6**

³For what I received I passed on to
you as of first importance: that Christ
died for our sins according to the
Scriptures, ⁴that he was buried, that he
was raised on the third day according to
the Scriptures, ⁵and that he appeared to
Peter, and then to the Twelve. ⁶After
that, he appeared to more than five
hundred of the brothers at the same
time, most of them whom are still living,
though some have fallen asleep.

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Soli deo Gloria

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Abstract

The Kaapvaal craton is one of the best-preserved Archean cratons known. It is covered by sedimentary sequences that include the Archean to late Paleoproterozoic Witwatersrand-Pongola Supergroup, the Ventersdorp Supergroup, the Wolkberg Group, the Transvaal Supergroup and several late Paleoproterozoic red bed successions. Source areas for these cover sequences are largely unknown. During this study a set of representative quartzite samples were collected throughout the Neoproterozoic to late Paleoproterozoic sedimentary successions for zircon SHRIMP analyses in order to obtain the ages for source areas and test ideas about the plate tectonic history of the Kaapvaal craton. In addition, zircons were analysed from the Ongeluk lava, Waterberg quartz porphyry and Entabeni granite to obtain ages of magmatic events.

Regarding ages of magmatic events zircon age data from the Ongeluk/Hekpoort lava indicate that it formed around 2.22Ga confirming earlier Rb/Sr and Pb/Pb ages. Other important formational ages were obtained for the Waterberg and Soutpansberg Groups. The lack of well-defined radiometric ages for late Paleoproterozoic red bed successions has led to uncertainty about their correlation and relative ages. Zircon SHRIMP ages of 2054 ± 4 Ma and 2051 ± 8 Ma were obtained for quartz porphyritic lava flows near the base of the Waterberg Group and the laterally correlative Rust de Winter Formation. This indicates that the deposition of the Waterberg Group commenced soon after the emplacement of the Bushveld Complex. A zircon SHRIMP age of 2021 ± 5 Ma was acquired for the Entabeni granite that intrudes the Southern Marginal Zone of the Limpopo metamorphic complex. The Soutpansberg Group overlies the Entabeni Granite with an erosional surface. These ages suggest that at least part of the Waterberg Group is older than the Soutpansberg Group.

The most important characteristics displayed by the detrital zircon $^{207}\text{Pb}/^{206}\text{Pb}$ age populations measured for the different Neoproterozoic to late Paleoproterozoic sedimentary sequences may be summarized as follows:

- a) There is a systematic younging of the youngest zircons upwards in stratigraphy from one unconformity-bounded sequence to the next. This may indicate that new source areas were continuously being exposed during the deposition of the different unconformity-bounded sequences.
- b) There are abrupt changes in prominent detrital zircon populations across major sequence boundaries. This may indicate that unconformities are related to tectonic events, with source areas either being removed or added to the Kaapvaal craton.
- c) There is a scarcity of middle to late Archean detrital zircons in most of the sequences suggesting that the Kaapvaal craton contributed little to the sediments of the sequences.
- d) Most of the zircons appear to have been derived from source areas other than the Kaapvaal craton. This may indicate that the craton was involved in plate tectonic processes similar to those observed at present.

Based on the detrital zircon populations three of the most important findings are as follows:

The Duitschland and Timeball Hill Formations carry a very interesting population of detrital zircons that have $^{207}\text{Pb}/^{206}\text{Pb}$ ages of between 2450-2550Ma. 2450-2550Ma is approximately the time period during which carbonates and banded iron formations of the Transvaal Supergroup were deposited. It is suggested that these zircons were derived from an unknown craton that collided with the Kaapvaal craton at approximately 2320Ma.

With the older age of at least part of the Waterberg Group relative to the Soutpansberg Group established, it becomes a very interesting geological question to establish geochronological correlations of other red bed successions in southern Africa with the Soutpansberg Group. A correlation based on detrital zircon ages is presented in which it is suggested that the late Paleoproterozoic red beds were deposited during three periods namely:

- 1) 2055-ca.1940Ma. Deposition of the Waterberg Group. Possible correlatives for the Waterberg Group may include the Blouberg Formation in the Northern Transvaal and the Lower Neylan Formation in Griqualand West.
- 2) 1930-1850Ma. Deposition of the Sibasa Formation of the Soutpansberg Group, the Roodeberg Formation and the Palapye Group.
- 3) 1850-1800Ma. Deposition of the Wylliespoort, Ngwanedsi and Nzhelele Formations of the Soutpansberg Group. These may be correlated with the Groblershoop Formation in Griqualand West.

The Wolkberg Group may be correlated in time to the Schmidtsdrif Subgroup at the base of the Transvaal Supergroup in Griqualand West. The Schmidtsdrif Subgroup possibly contains the best-preserved Neoproterozoic carbonate platform succession known between ca. 2670-2640Ma. This is the same time period during which granulite facies metamorphism is thought to have occurred within the Limpopo Metamorphic Complex. This granulite facies metamorphism has been thought to occur during collision between the Kaapvaal and Zimbabwe cratons. However, the Wolkberg Group does not contain zircons with ages between 2640 and 2700Ma. The carbonate platform of the Schmidtsdrif Subgroup suggests that the Kaapvaal craton was in a passive margin setting from approximately 2600-2700Ma. The absence of zircons that are similar in age to granulite facies metamorphism and the intrusion of post tectonic granites in the Wolkberg Group together suggest that Neoproterozoic granulite facies metamorphism in the Limpopo Belt was not associated with a collision between the Kaapvaal craton and the Zimbabwe craton.

Uittreksel

Die Kaapvaalkraton is een van die bes bewaarde Argeïese kratone bekend. Dit word oordek deur Argeïese tot laat Paleoproterosoïese sedimentêre opeenvolgings wat die Witwatersrand-Pongola Supergroep, Ventersdorp Supergroep, Wolkberg Groep, Transvaal Supergroep en verskeie laat Paleoproterosoïese rooilaag opeenvolgings insluit. Brongebiede vir hierdie opeenvolgings is grotendeels onbekend. Tydens hierdie studie is 'n stel verteenwoordeginde kwartsietmonsters versamel vanuit die Neo-Argeïese tot laat Paleoproterosoïese sedimentêre opeenvolgings. Uit hierdie verteenwoordeginde monsters is sirkone geskei. SHRIMP ontledings is daarna op die sirkone uitgevoer om die radiometriese ouderdomme van brongebiede te bekom en om idees aangaande die plaattektoniese geskiedenis van die Kaapvaalkraton te toets. Verder is sirkone van die Ongeluklawa, Waterbergkwartsporfier en Entabeni Graniet geanaliseer om radiometriese ouderdomme vir magmatiese gebeurtenisse te bekom.

Betreffende die ouderdomme van magmatiese sirkone wys data uit die Ongeluk/Hekpoortlawa dat dit ongeveer 2.22Ga gelede uitgevloei het, wat vroe?re Rb/Sr en Pb/Pb ouderdomme bevestig. Verdere belangrike magmatiese ouderdomme is verkry uit die Waterberg en Soutpansberg areas. Die gebrek aan goed gedefinieerde radiometriese ouderdomme van laat Paleoproterosoïese rooilaag het gelei tot onsekerheid in verband met korrelasie en relatiewe ouderdomme. Sirkoon SHRIMP ouderdomme van 2054±4Ma en 2051±8Ma is verkry vir kwartsporfirietiese lawaaitvloeiings naby die basis van die Waterberg Groep en die lateral-korreleerbare Rust de Winter Formasie. Hierdie goed-gedefinieerde radiometriese ouderdomme dui daarop dat die afsetting van die Waterberg Groep byna direk na die inplasing van die Bosveld Kompleks in aanvang geneem het. 'n Sirkoon SHRIMP ouderdom van 2021±5Ma is verkry vir die Entabeni Graniet wat die Suidelike Marginale Sone van die Limpopo metamorfiese gordel indring. Die Soutpansberg Groep oorlê die Entabeni Graniet met 'n erosiewe kontak. Hierdie ouderdomme dui daarop dat ten minste 'n gedeelte van die Waterberg Groep ouer is as die Soutpansberg Groep.

Die belangrikste eienskappe wat deur die detrale sirkoon $^{207}\text{Pb}/^{206}\text{Pb}$ populasies vertoon word vir die verskillende Neo-Argeïese tot laat Paleoproterosoïese sedimentêre opeenvolgings kan as volg opgesom word:

- a) Daar is 'n sistematiese verjonging van die jongste sirkone stratigrafies opwaarts van een diskordansie begrensde opeenvolging na die volgende. Dit mag daarop dui dat nuwe brongebiede deurlopend blootgelê is gedurende die afsetting van die verskillende diskordansie begrensde opeenvolgings.
- b) Daar is skielike veranderings in prominente sirkoonpopulasies oor belangrike opeenvolginggrense heen. Dit mag daarop dui dat diskordansies verwant is aan tektoniese gebeurtenisse, met brongebiede wat verwyder of toegevoeg word tot die Kaapvaal kraton.
- c) Meso tot Neo-Argeïese detrale sirkone is skaars in meeste van die opeenvolgings, wat daarop dui dat die Kaapvaal kraton min tot die sedimente van die opeenvolgings bygedra het.

- d) Die meeste van die sirkone was oënskynlik vanaf brongebiede verkry wat nie op die oomblik aan die Kaapvaal kraton verwant is nie. Dit mag daarop dui dat die kraton betrokke was in plaattektoniese prosesse vergelykbaar met die wat vandag plaasvind.

Die drie belangrikste bevindings wat uit die sirkoon populasies afgelei kan word is: Die Duitschland en Timeball Hill Formasies dra 'n baie interessante groep detrale sirkone wat $^{207}\text{Pb}/^{206}\text{Pb}$ ouderdomme van tussen 2450-2550Ma het. Gedurende die tydperk is die karbonate en gebande ysterformasies van die Transvaal Supergroep afgeset is. Daar word voorgestel dat hierdie sirkone verkry is vanaf 'n onbekende kraton wat gebots het met die Kaapvaalkraton ongeveer 2320Ma gelede.

Die geochronologiese korrelasie van ander rooilae in suidelike Afrika relatief tot die Soutpansberg Groep is 'n baie interessante geologiese vraagstuk omdat ten minste 'n gedeelte van die Waterberg Groep ouer is as die Soutpansberg Groep. 'n Korrelasie gebaseer op detrale sirkoon ouderdomme word voorgestel. Hierin word aangedui dat die laat Paleoproterosoïese rooilae gedurende drie tydperke afgeset is:

- 1) 2055-ongeveer 1940Ma. Afsetting van die Waterberg Groep. Moontlike korrelasies vir die Waterberg Groep kan die Blouberg Formasie in die Limpopo Provinsie en die onderste gedeelte van die Neylan Formasie in Griekwaland Wes insluit.
- 2) 1930-1850Ma. Afsetting van die Sibasa Formasie van die Soutpansberg Groep, die Roodeberg Formasie en die Palapye Groep.
- 3) 1850-1800Ma. Afsetting van die Wylliespoort, Ngwanedsi en Nzhelele Formasies van die Soutpansberg Groep. 'n Moontlike korrelasie hiervan is die Groblershoop Formasie in Griekwaland Wes.

Die Wolkberg Groep kan tydsverwant wees met die Schmidtsdrif Subgroep aan die basis van die Transvaal Supergroep in Griekwaland Wes. Die Schmidtsdrif Subgroep bevat moontlik die besbewaarde Neoargeïese karbonaat platvorm opeenvolging bekend en het 'n ouderdom van tussen 2670 –2640Ma. Dit is bekend dat granulietfasies metamorfose gedurende dieselde tydperk in die Limpopo Metamorfe Kompleks voorgekom het. Die Wolkberg Groep bevat nie sirkone met ouderdomme tussen 2640Ma en 2700Ma nie. Die karbonaatplatvorm van die Schmidtsdrif Subgroep dui aan dat die Kaapvaalkraton tektonies stabiel was tussen 2600-2700Ma. Die afwesigheid van sirkone met 'n soortgelyke ouderdom as die granulietfasies metamorfose in die Wolkberg Groep, en die indringing van na-tektoniese graniete in die Limpopo Gordel, dui daarop dat Neo-Argëiese metamorfose in die Limpopo Gordel nie verwant was aan 'n botsing tussen die Kaapvaalkraton en die Zimbabwekraton nie.