

THE DEHYDRATION, REHYDRATION AND TECTONIC SETTING OF GREENSTONE BELTS IN A PORTION OF THE NORTHERN KAAPVAAL CRATON, SOUTH AFRICA; D.D. van Reenen, J.M. Barton Jr., C. Roering, J.C. van Schalkwyk, C.A. Smit (Dept. of Geology, RAU, P.O. Box 524, Johannesburg 2000, S. Africa) J.H. de Beer (NPRL, CSIR, P.O. Box 395, Pretoria 0001, S. Africa) and E.H. Stettler (Geological Survey, Private Bag X112, Pretoria 0001, S. Africa).

High-grade gneiss terranes and low-grade granite-greenstone terranes are well known in several Archaean domains. The geological relationship between these different crustal regions, however, is still controversial. One school of thought favors fundamental genetic differences between high-grade and low-grade terranes while others argue for a depth-controlled crustal evolution. The detailed examination of well-exposed Archaean terranes at different metamorphic grades, therefore, is not only an important source of information about the crustal levels exposed, but also is critical to the understanding of the possible tectonic and metamorphic evolution of greenstone belts with time.

Many features of a metamorphic and deformational transition from a typical greenschist facies granite-greenstone terrane to a high-grade gneiss terrane are illustrated in the crustal section of the northern portion of the Kaapvaal Craton over the 60 km between the Pietersburg greenstone belt and the granulite facies Southern Marginal Zone of the Limpopo Belt. In this section, steeply-dipping, typical greenstone belt lithologies occur at higher and higher grade moving from south to north. In the south, the Pietersburg belt comprises an at least 3450 Ma mafic, felsic and ultramafic volcanic and volcano-sedimentary assemblage (the Pietersburg Group) unconformably overlain by a sedimentary assemblage (the Uitkyk Formation), probably deposited between about 2800 Ma and 2650 Ma. The Pietersburg Group is surrounded by the approximately 3500 Ma tonalitic and trondhjemitic Baviaanskloof Gneiss and is intruded by the approximately 2800 Ma Hout River Gneiss. The belt is apparently intruded by approximately 2650 Ma, largely undeformed, granodioritic plutons. Metamorphic grade within the Pietersburg belt increases from greenschist facies in the southwestern and central parts to amphibolite facies in the northeast, consistent with the regional metamorphic pattern.

North of the Pietersburg belt are situated mafic, felsic and ultramafic volcanic and sedimentary rocks of the Rhenosterkoppies greenstone belt. The Sutherland greenstone belt, composed of mafic and ultramafic and mafic-to-felsic volcanic rocks and sedimentary rocks, occurs to the east. Both belts are surrounded by the Baviaanskloof Gneiss. The ages of the lithologies within the Rhenosterkoppies and Sutherland belts are unknown, but both have been metamorphosed under amphibolite facies conditions.

In the Southern Marginal Zone, highly attenuated and boudinaged granulite facies greenstone belt lithologies (mafic, ultramafic and metapelitic gneisses and banded iron formation) occur within the Baviaanskloof Gneiss. These assemblages are intruded by the approximately 2650 Ma deformed Matok charnockitic-granodioritic pluton while the undeformed Palmietfontein granite was emplaced at about 2450 Ma.

The transition from the lower-grade granite-greenstone terrane to the Southern Marginal Zone is not only reflected by an increase in the grade of metamorphism but also by an increase in the intensity of deformation. The structural grain of the entire area trends roughly east-northeast with an almost vertically dipping schistosity or gneissosity. In the Southern Mar-

ginal Zone, the distended nature of the granulitic greenstone remnants is in sharp contrast to the more continuous outcrop pattern of the greenstone lithologies to the south. The magnetic lineation patterns of the area change abruptly at the boundary of the granulite facies terrane and seismic velocities increase sharply at the same point, possibly as a result of mantle material being at a higher level.

The crustal behavior of the entire region must have been consistent with the observation that the rocks of the Southern Marginal Zone were depressed into deep crustal levels. This movement probably implies that the lower-grade terranes were depressed in a sympathetic manner. In the Southern Marginal Zone, the maximum prograde conditions ($P > 9.5$ kb and $T > 800^\circ\text{C}$) reached during this tectonic event are recorded by the assemblage garnet + hypersthene + quartz + plagioclase +/- biotite +/- kyanite in metapelite. These conditions were followed by rapid, nearly isothermal, decompression between approximately 2700 Ma and 2650 Ma, recorded by decompression textures of cordierite and hypersthene after garnet. P-T conditions of this decompression event were $T = 800^\circ\text{C}$ with P decreasing to 7.0 kb. The Matok pluton was emplaced toward the end of the isothermal decompression. The southern margin of this dehydrated terrane was then subjected to a regional encroachment of CO_2 -rich hydrating fluids before approximately 2450 Ma, the time of emplacement of the Palmietfontein granite. This infiltration produced the retrograde orthoamphibole isograd defined by the reactions: hypersthene + quartz + $\text{H}_2\text{O} = \text{anthophyllite}$ and cordierite + $\text{H}_2\text{O} = \text{gedrite} + \text{kyanite} + \text{quartz}$. These reactions occurred at $T = 650^\circ\text{C}$ to 600°C and a total P less than 6 kb at $\text{PH}_2\text{O} = 0.2 P_{\text{total}}$. Completely hydrated and recrystallized rocks south of this isograd are characterized by the assemblage anthophyllite + gedrite + kyanite + biotite + quartz + plagioclase. The fluids responsible for rehydration are believed to have been derived from hydrated granite-greenstone lithologies.

Metamorphic assemblages in the area south of the retrograde isograd are still insufficiently documented to delineate isograds but the overall increase in the grade of metamorphism from south to north is illustrated by comparing assemblages in chemically similar granite-greenstone lithologies from different crustal levels:

LITHOLOGIES	PIETERSBURG BELT (Central/South West part)	RHENOSTERKOPPIES AND SUTHERLAND BELTS	SOUTHERN MARGINAL ZONE OF LIMPOPO BELT
Meta-sediments	Qz + Chl + feldsp + sericite \pm Carb	Orthoamph + Biot + Qz + Plag + Garn \pm Kyan	Hyp + Biot + Qz + Plag + Garn + cord
Mafic Rocks	Ab + Ep + Chl + Act + Qz \pm Carb	Hbl + Plag (An 33) + Qz \pm Sf \pm Diop	Opx + Cpx + Plag (An 49) + Mt \pm Hbl \pm Qz
Ultramafic Rocks	Trem + Chl \pm Talc \pm Carb	Trem + Chl \pm Ol \pm Carb	Ol + Opx + Sp + Ca- Amph

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Gravity and resistivity data indicate that the Pietersburg, Rhenosterkoppies and Sutherland greenstone belts are shallow crustal features, rarely exceeding 5 km in depth. This depth is in marked contrast to the thickness of the various lithologic successions measured across the stratification. These observations plus the fact that the crustal thicknesses determined from stratigraphic sections are far in excess of those which can be accepted from the metamorphic data, suggest that major crustal thickening took place in this area by tectonic stacking. A steeply northward dipping shear zone with near vertically plunging mineral lineations is exposed along the Hout River. This shear zone is believed to be associated with the tectonic stacking but, as yet, the sole thrust for this proposed stacking has not been recognized. The hydrating fluids responsible for establishing the retrograde orthoamphibole isograd could have been derived by dehydration of over-ridden lower-grade crustal rocks during and after thrusting.