ECONOMIC GEOLOGY

RESEARCH UNIT

University of the Witwatersrand
Johannesburg

THE ARCHAEAN KRAAIPAN GROUP VOLCANO-SEDIMENTARY ROCKS AND ASSOCIATED GRANITES AND GNEISSES OF THE SOUTHWESTERN TRANSVAAL, NORTHWESTERN CAPE PROVINCE AND BOPHUTHATSWANA

EXCURSION GUIDEBOOK

C.R. ANHAEUSSER

INFORMATION CIRCULAR No. 244

UNIVERSITY OF THE WITWATERSRAND
JOHANNESBURG

THE ARCHAEAN KRAAIPAN GROUP VOLCANO-SEDIMENTARY ROCKS AND ASSOCIATED GRANITES AND GNEISSES OF THE SOUTHWESTERN TRANSVAAL, NORTHWESTERN CAPE PROVINCE AND BOPHUTHATSWANA - EXCURSION GUIDEBOOK

Compiled and Edited by

C.R. ANHAEUSSER
(Economic Geology Research Unit, Department of Geology,
University of the Witwatersrand, Private Bag 3,
P.O. WITS 2050, South Africa)

ECONOMIC GEOLOGY RESEARCH UNIT
INFORMATION CIRCULAR No. 244

December, 1991

THE ARCHAEAN KRAAIPAN GROUP VOLCANO-SEDIMENTARY ROCKS AND ASSOCIATED GRANITES AND GNEISSES OF THE SOUTHWESTERN TRANSVAAL, NORTHWESTERN CAPE PROVINCE AND BOPHUTHATSWANA - EXCURSION GUIDEBOOK

Excursion Guidebook for a Geological Society of South Africa
Summer Field School organised by the Department of Geology,
University of the Witwatersrand, Johannesburg,
and the Geological Survey of South Africa
1-3 November, 1991

Compiled and Edited by

C.R. Anhaeusser

Contributors

C.R. Anhaeusser, I.M. Jones, T.R. Marshall, L.J. Robb and O.T. Zimmermann

Organizing Committee

C.R. Anhaeusser, University of the Witwatersrand, Johannesbury
L.J. Robb, University of the Witwatersrand, Johannesburg
H.F.J. Moen, Geological Survey of South Africa, Pretoria
N. Keyser, Geological Survey of South Africa, Pretoria
I.M. Jones, Geological Survey of South Africa, Pretoria

_____oOo_____

Published by the Economic Geology Research Unit,
Department of Geology,
University of the Witwatersrand,
1 Jan Smuts Avenue,
Johannesburg 2001,
South Africa

ISBN 1 874856 62 1

1991 SUMMER FIELD SCHOOL - KRAAIPAN EXCURSION

INTRODUCTION

The first regional geological synthesis of the area to be visited on the 1991 Summer Field School was undertaken by A.L. du Toit during 1906-1907. His involvement in the region, extending from Mafeking (Mafikeng) to south of Vryburg, was spurred on by the discovery of gold in the early part of this century and by the subsequent small-scale mining and prospecting which ensued. Du Toit (1906, 1908) identified three narrow belts consisting mainly of "banded ironstones" and cherty rock that extended approximately north-south from the Bechuanaland (Botswana) border into the western Transvaal. The western belt passed through Mosita and Stella, the central belt passed through Pitsani and Kraaipan, and the eastern belt was best preserved in the Madibe area southeast of Mafikeng. The central belt outcrops were the best exposed and least disturbed and Du Toit (1906) gave the name Kraaipan Formation to the succession in the vicinity of Kraaipan Siding which was used as the type area. Du Toit (1906) further noted the resemblance of the Kraaipan rocks to the "Primary" successions at Abelskop near Amalia, 100km to the south, and to similar rocks in the Pietersburg and Barberton regions. Du Toit (1908) reported that more than half the succession in the type area, which he estimated to be over 3000m thick, was made up of volcanic rocks. Investigations of the exposures along the Setlagole River led to him subdividing the succession into ten "zones", four being volcanic in origin. Du Toit also established that the Kraaipan rocks were older than the Ventersdorp System because rocks belonging to the latter rest on steeply dipping Kraaipan successions and conglomerates contain boulders of Kraaipan rocks. Rogers (1908) changed the name to Kraaipan Series which was followed by Du Toit (1926, 1956) when he included the Kraaipan successions in his "Primitive or Basement Systems".

Since the early work of A.L. Du Toit, cited above, there have been other studies in which minor reference is made to Kraaipan rocks (De Wet, 1942; Truter, 1950; Von Backström et al., 1953; Van Eeden et al., 1972; Visser et al., 1989).

In 1963 a regional geological map and explanation of the area around Schweizer-Reneke was published (Van Eeden et al., 1963) and, still later, Van Zyl (1972) prepared a report on the geology in the Kraaipan Siding area.

The generally poorly understood nature of the Kraaipan Group of rocks (SACS,1980), coupled with a resurgence of exploration interest in the western sector of the Kaapvaal Craton during the 1980's led to several new studies being undertaken in the region. The majority of this new work initially formed part of an FRD-sponsored research programme undertaken by the Economic Geology Research Unit, Department of Geology, University of the Witwatersrand, to examine aspects of the hinterland to the Dominion and Witwatersrand successions in the Witwatersrand Goldfield. Later, a collaborative arrangement was established by this group with the Geological Survey leading to regional mapping projects being undertaken in the northern Kraaipan region (extending from Stella to the Botswana border and east to Mafikeng and Madibe), and in the southern Kraaipan area south of Amalia.

The Combined field and laboratory studies have not all been completed but some preliminary results are described in various sections of this guidebook. Reference to published findings are also made where appropriate in the text that follows.

The geology of the Kraaipan Group and surrounding granites and gneisses remains unclear because of the poor outcrop availability and the generally weathered or altered nature of the exposures. Kalahari sand or calcrete covers vast expanses of the northern Kraaipan region whereas, in the southern area, poor exposure and rocks of the Ventersdorp Supergroup also obscure the Archaean basement successions.

The 1991 Summer Field School is designed to show the main features of the Kraaipan succession as well as the surrounding intrusive granitic and gneissic rocks in both the southern and northern regions of the western sector of the Kaapvaal Craton (Figure 1). Unfortunately, due to the poor exposure, the outcrops of interest are widely spaced and usually have to be seen in isolation as contact relationships are rarely encountered. Future studies in the area will depend heavily on geophysical methods, coupled with drilling or trenching to establish critical relationships and the nature of the sub-Kalahari sand cover.

The Organizing Committee of the 1991 Summer Field School, listed earlier, will also act as guides to the geology seen on the excursion. This guidebook was compiled and edited from contributions provided by Ian Jones, Tania Marshall, Laurence Robb, Oliver Zimmermann and Carl Anhaeusser. Mrs. Elizabeth Sole is thanked for providing organizational and administrative assistance, while Lyn Whitfeld and Janet Long assisted with draughting and secretarial help in producing the guidebook.

C.R. Anhaeusser.

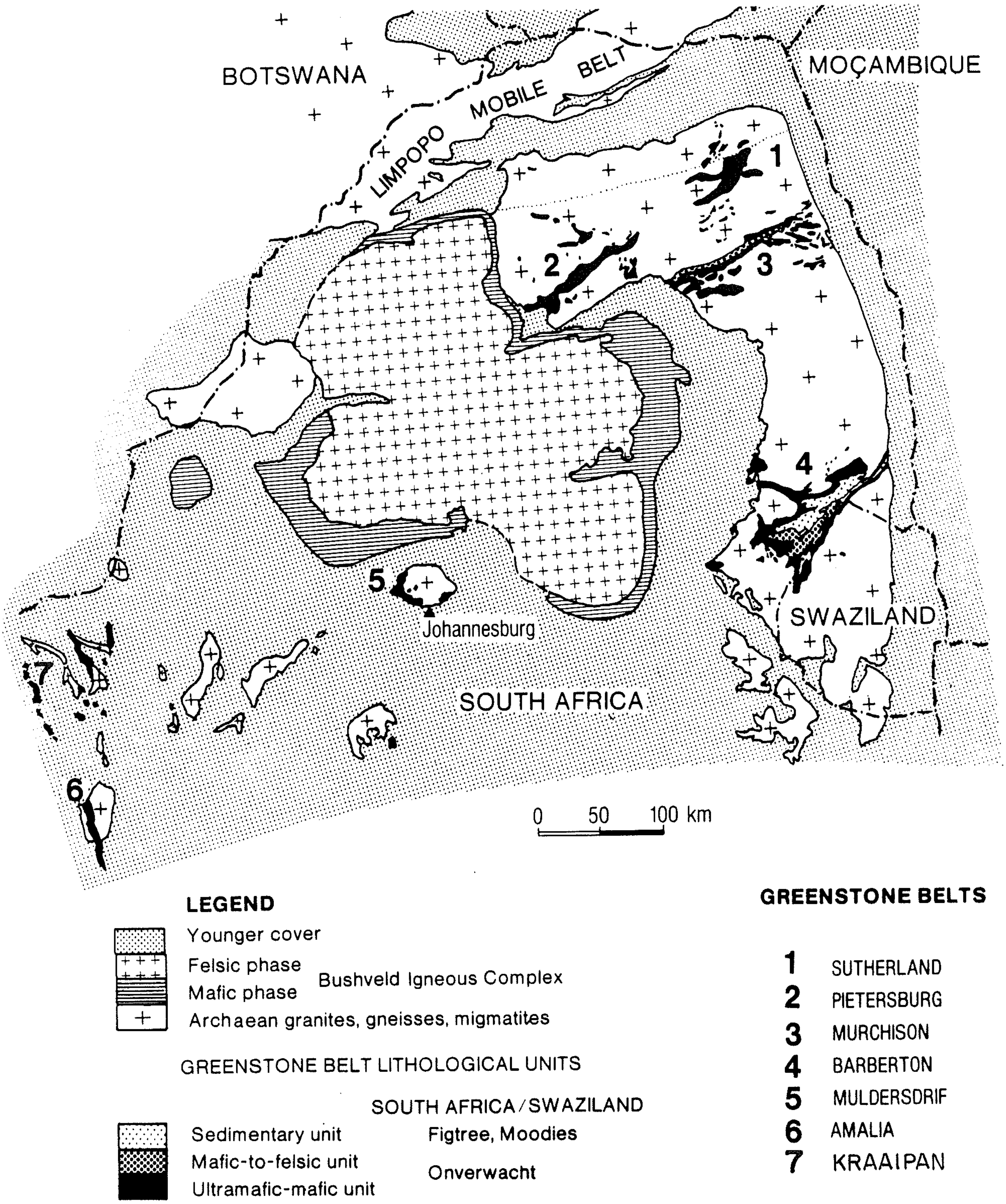


Figure 1: Map illustrating the exposed Archaean granite-greenstone terrane of the Kaapvaal Craton, southern Africa.

F I E L D E X C U R S I O N (Figure 2)

DAYS 1 - 3: ROCK TYPES, STRUCTURES, MINERALIZATION, AGE RELATIONSHIPS AND METAMORPHISM IN VARIOUS LITHOLOGIES OF THE ARCHAEAN BASEMENT IN THE SOUTHWESTERN TRANSVAAL, NORTHWESTERN CAPE PROVINCE AND BOPHUTHATSWANA

DAY 1 (P.M.) SEVERAL OUTCROPS OF GRANITES AND GNEISSES IN AND ADJACENT TO THE SCHWEIZER-RENEKE GRANITE DOME AND SELECTED OUTCROPS IN THE AMALIA GREENSTONE BELT IN THE VICINITY OF THE GOUDPLAATS GOLD MINE

Friday, November 1, 1991

7.00 a.m. Excursion leaves from the Geology Department, University of the Witwatersrand, Johannesburg travelling via Potchefstroom and Klerksdorp to Wolmaransstad along R29 (approximately 345km). From Wolmaransstad follow R504 for approximately 29km to first stop en route to Schweizer-Reneke (69km). See Figure 2 for route and stops.

THE DIAMONDIFEROUS GRAVELS OF THE SOUTHWESTERN TRANSVAAL

T.R. MARSHALL

A detailed analysis of the alluvial diamond deposits of the southwestern Transvaal has indicated that these deposits are more complex than was previously thought (Marshall, 1991). The gravels consist of a basal alluvial deposit overlain by a colluvial deposit and a younger fluvial sequence. The basal, **Primary Alluvial Gravels** occur below hardpan calcrete in palaeodrainage channels (Figure 3). Where exposed, the sequence consists of up to 2m of clast-supported gravels with angular to subrounded clasts (1-10cm in size) of quartzites, vein quartz, amygdules, volcanic rocks, banded iron-formation, and shale. The -5mm matrix consists of essentially the same components.

The gravels are variously calcretized, with hardpan calcrete usually developed at the surface. Late-stage decomposition of the hardpan calcrete has resulted in the formation of makondos (solution hollows in calcrete), in which the **Eluvial Gravel** component has accumulated. The clasts in the eluvial deposits are composed almost exclusively of chemically resistant, siliceous lithologies.

The **Colluvial Gravels** are thin (usually $<$ 1m), areally extensive deposits that are the result of deflation of the southwestern Transvaal landsurface. They are best developed on deeply weathered Ventersdorp lava in which pseudokarst solution features have been etched by laterization processes.

The younger **Terrace Gravels** are found everywhere along Plio-Pleistocene drainage lines at depths of 3-9m. The deposits consist of

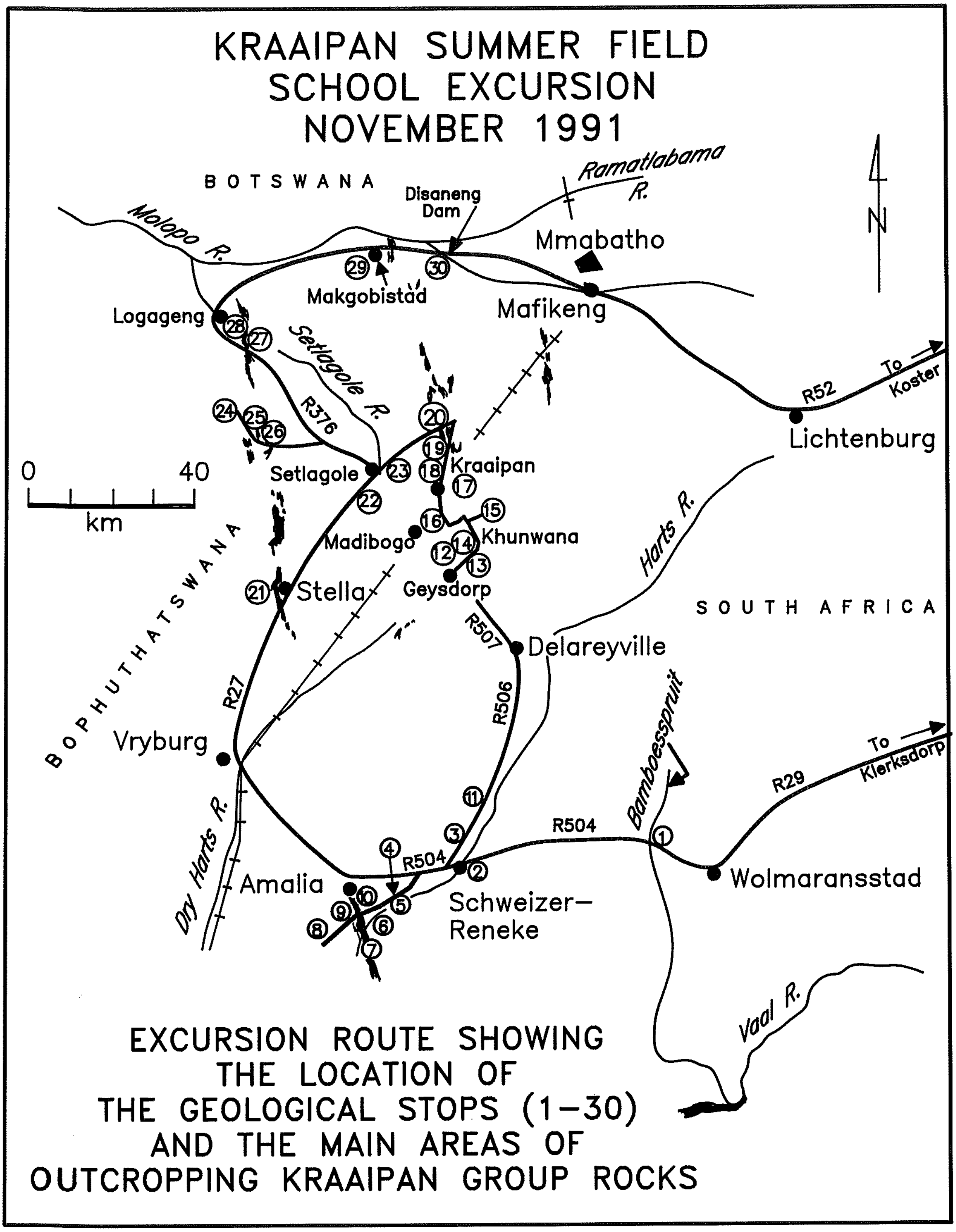
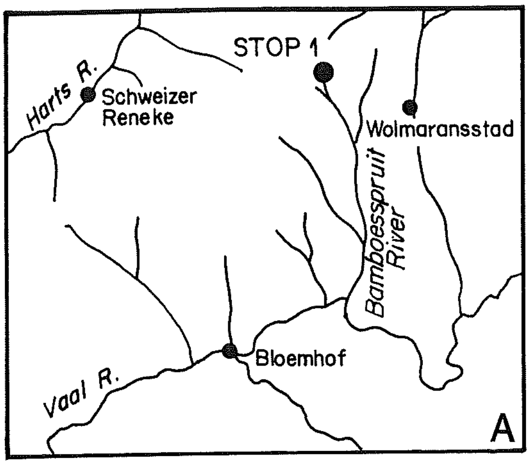


Figure 2: Kraaipan excursion route, western Transvaal, northern Cape Province and Bophuthatswana.



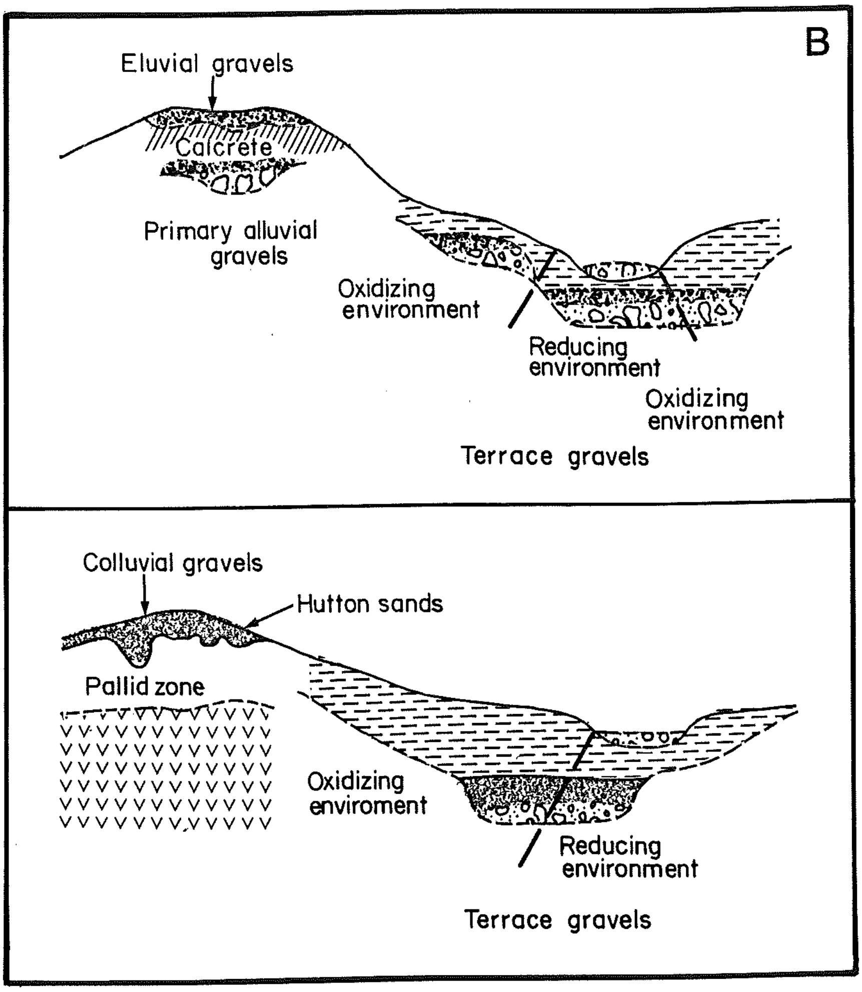


Figure 3: A. *Map showing the locality of Stop 1 on Bamboesspruit near Wolmaransstad.*

B. *Schematic sections showing the relationship between the eluvial, colluvial and alluvial diamondiferous gravels in the western Transvaal (after Marshall, 1991).*

an approximately 5m-thick, upward-fining, alluvial sedimentary sequence deposited on an uneven floor of Ventersdorp lavas. The entire sequence is variably calcretized and the lower portions of the package are either oxidized or reduced, depending on the proximity of the water table.

It appears as if there is a direct correlation between the gravel stratigraphy of the southwestern Transvaal and that which is developed along the lower Vaal River in the Barkly West district. The Primary Alluvial Gravels appear to be time correlatives of the Older Gravels of Barkly West; the derived eluvial components of the southwestern Transvaal, and the Terrace Gravels are most likely equivalent to the Rietputs Formation of Helgren (1979).

Diamonds are found in the alluvial as well as the colluvial and eluvial gravels. In the latter deposits there does not appear to be any sorting of the diamonds within the gravels. In the alluvial deposits, however, the diamond acts as a heavy mineral and is, therefore, concentrated by sedimentary processes. Economic deposits of diamonds are to be found in point bars, downstream of confluences, adjacent to dykes, and wherever the hydraulic conditions were optimum for gravel deposition.

The evolution of the southwestern Transvaal landscape can be explained within the framework of the accepted geomorphological model for southern Africa. It is envisaged that kimberlites were emplaced somewhere in the southwestern Transvaal during the late Cretaceous. Following the rifting of Gondwanaland, an early Tertiary drainage system developed on the ensuing African surface. As a result of the extremely long period of laterization that followed, the erosion surface was substantially lowered and a residual soil accumulated over the surface. Post-African I uplift in the Miocene not only caused piracy and reversal of certain stream segments, but it also resulted in the leaching of the African surface and the redistribution and concentration of the colluvial diamondiferous deposits. Subsequent Post-African II uplift in the Pliocene resulted in the incision in the Terrace Gravel drainage system which reworked portions of the older colluvial and alluvial gravels. Minor climatic and sea-level oscillations have, further, resulted in the cutting of the present Vaal River terraces.

STOP 1: Bamboesspruit on main road between Wolmaransstad and Schweizer-Reneke. At this locality can be seen the alluvial diamond diggings typical of those found along old drainage courses in the southwestern Transvaal.

THE SCHWEIZER-RENEKE DOME

L.J. ROBB

The Schweizer-Reneke granite (s.l.) is one of several domal exposures of the Archaean basement that occur along the northern and western margins of the Witwatersrand Basin. It is entirely surrounded by rocks of the Ventersdorp Supergroup, which unconformably overlie the granite. The dome itself is underlain by a variety of massive, medium- to coarse-grained granites and is also bisected by the linear, north-south trending Amalia schist belt (Fig. 4), which comprises Kraaipan Group rocks.

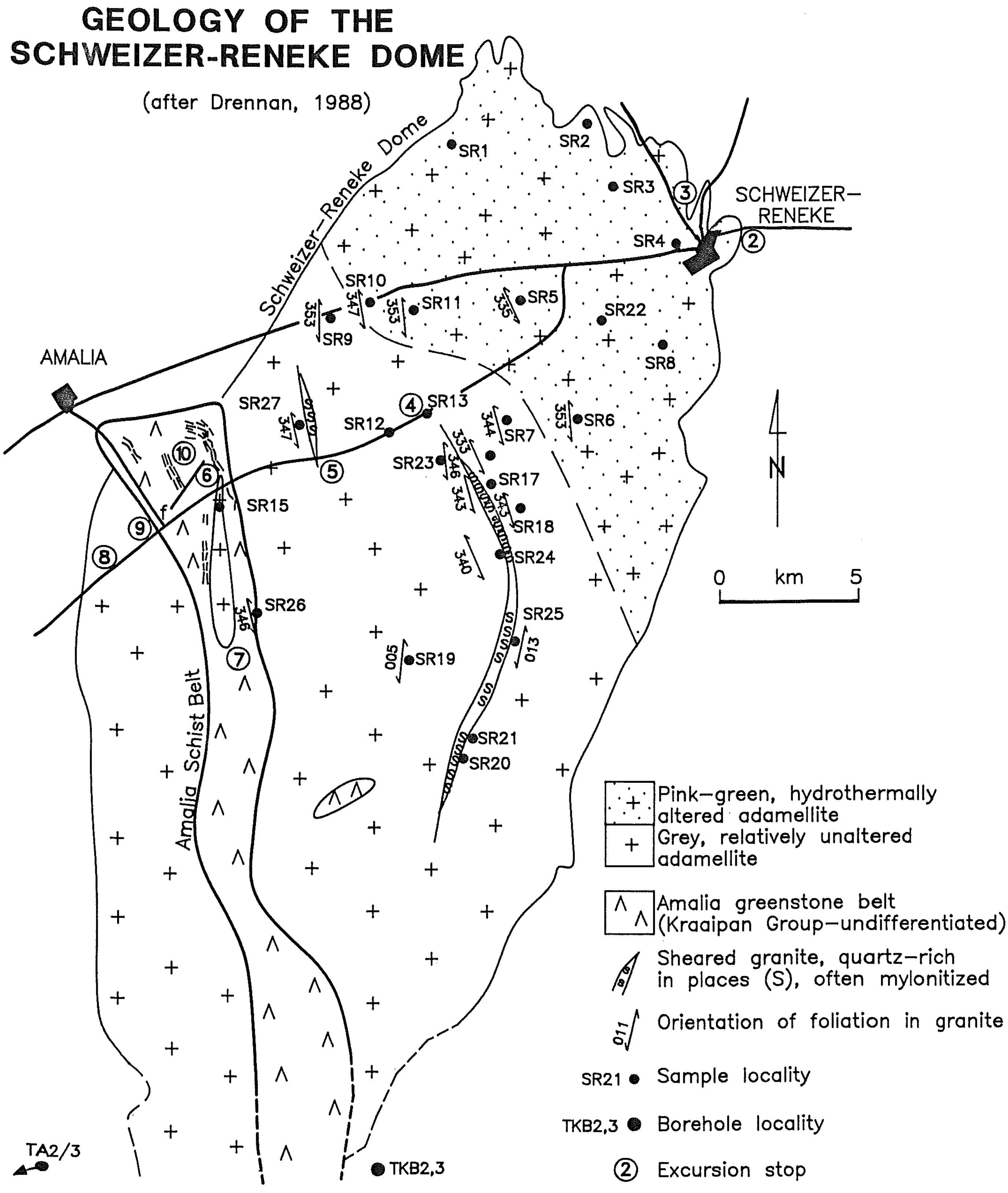


Figure 4: Schematic geological map of the Schweizer-Reneke dome in the western Transvaal showing the geology and excursion stops in the granites and adjacent Amalia greenstone belt.

Geology and Petrography

The Schweizer-Reneke dome contains sporadic exposures of granitic material which are best developed in the northeastern and central portions of the dome. The composition of the dome is generally adamellitic and two varieties of granitic (s.l.) material can be recognized. The northeastern portion is underlain by a distinctive green-to-pink adamellite (Figure 4), in which the coloration is caused by hydrothermal alteration of the feldspars and biotite. Microcline is stained pink by a fine-dusting of micro-crystalline hematite, while plagioclase is ubiquitously sericitized and epidotized. Biotite is partially altered to chlorite and minor carbonate alteration is observed. Minor, intergranular fluorite occurs in places and accessory minerals are dominated by monazite, with only rare zircon and apatite being observed. The remainder of the dome is underlain by greyish, occasionally porphyritic, adamellite which is less altered than the material from the northeastern segment. Mineralogical characteristics of this adamellite are similar to those from the northeastern segment except that pervasive sericitization, epidotization, hematitization and carbonate alteration is noticeably less evident.

The Schweizer-Reneke adamellite is cut by several quartz-filled, partially mylonitized, shear zones of which only the larger ones have been shown in Figure 4. The adamellite is generally massive, but the central portions of the dome display a broadly north-south trending mineral foliation. Detailed measurements of this fabric (Drennan, 1988) showed that the foliation orientation closely follows the trend of the major shear zone in the centre of the dome (Figure 4) and also increases in intensity as the shear zone is approached.

Adamellites of the Schweizer-Reneke dome are also intersected in boreholes TKB2 and 3 (Figure 4) where they are seen to underlie mid-Ventersdorp sediments. The adamellite immediately adjacent to the unconformity is highly sericitized and argillitized (perhaps a regolith) and contains concentrations of pyrite as well as large (up to 3mm in diameter), highly uraniferous, kerogen nodules.

The Schweizer-Reneke adamellite has intruded into a suite of complex, deformed migmatites and tonalitic gneisses. These country rocks can be observed at Stop 2 in a quarry on the eastern outskirts of Schweizer-Reneke, and are also intersected in boreholes TA2 and 3 drilled to the southwest of the dome. In borehole TA2 well-banded tonalitic gneisses are cut by prominent quartz-microcline-rutile-chlorite-pyrite hydrothermal veins which are believed to be genetically related, but exogenous to, the Schweizer-Reneke adamellite intrusion (see later).

Geochemistry

Table 1 provides major and trace element analyses for a variety of the adamellites sampled over the dome. Major elements confirm the generally adamellitic composition of the rock and also indicate that the granite is a low-CaO, marginally peraluminous variety. Rb/Sr ratios are generally around unity and the rock exhibits fairly steep LREE trends (La 100X enriched with respect to chondrites) with flatter HREE slopes (Drennan, 1988). The altered northeastern sector adamellites are enriched in LREE compared to unaltered adamellite, but are markedly depleted in uranium, suggesting that this element has been leached from the hydrothermalized variety. Th/U ratios in the altered adamellite are

Table 1: Major and Trace Element Analyses of Selected Samples from the Schweizer-Reneke Dome (after Drennan, 1988)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	SR1	SR3	SR4	SR5	SR6	SR7	SR9	SR10	SR12	SR13	SR14	SR17	SR19	SR20	SR22	SR26
SiO2(wt%)	75.68	74.42	-	74.9	72.72	74.05	75.32	74.53	74.69	75.74	74.52	74.53	74.9	73.82	74.82	70.42
TiO2	0.05	0.1	-	0.1	0.08	0.06	0.08	0.06	0.04	0.03	0.04	0.1	0.04	0.08	0.08	0.19
Al2O3	14.12	13.76	-	13.83	15.33	14.31	13.79	14.29	14.2	12.98	11.85	13.98	13.93	14.61	14.02	14.69
*Fe2O3	0.77	1.52	-	1.26	1.1	0.84	1.2	0.84	1.09	0.68	1.56	1.44	1.17	1.67	0.83	1.29
MnO	0.01	0.01	-	0.04	0	0.02	0.01	0.02	0	0.01	0.02	0.03	0.03	0.02	0.02	0.03
MgO	0.31	0.34	-	0.39	0.3	0.25	0.29	0.18	0.25	0.16	0.01	0.19	0.22	0.26	0.18	0.75
CaO	0.32	0.55	-	0.77	0.61	0.7	0.7	0.58	0.66	0.46	0.45	0.85	0.75	0.7	1.09	1.13
Na2O	2.9	3.06	-	3.83	3.48	4.35	3.58	4.35	3.67	4.45	5.16	3.58	3.49	3.8	3.66	5.56
K2O	5.42	5.48	-	4.07	5.7	4.2	4.37	4.07	4.9	3.78	4.75	4.36	4.5	4.56	4.11	2.2
P2O5	0	0.01	-	0.01	0.01	0.07	0	0.03	0.03	0.01	0	0.02	0.01	0	0.01	0.05
L.O.I.	0.52	0.4	-	0.48	0.49	0.56	0.42	0.54	0.3	0.39	1.11	0.29	0.32	0.35	0.46	2.06
TOTALS	100.1	99.65	-	99.67	99.82	99.41	99.76	99.35	99.83	98.69	99.47	99.29	98.61	99.81	99.28	99.37
Sc(ppm)	-	1.39	1.32	-	-	-	1.54	-	0.97	-	-	1.61	0.65	-	-	-
Cr	-	2.05	2.07	-	-	-	1.99	-	1.31	-	-	1.42	0.72	-	-	-
Co	-	1.39	1.33	-	-	-	1.77	-	1.18	-	-	1.76	1.36	-	-	-
Ni	-	2.57	2.61	-	-	-	3.14	-	2.55	-	-	3.11	3.65	-	-	-
As	-	0.23	0.27	-	-	-	0.49	-	0.75	-	-	0.31	0.43	-	-	-
Rb	188	174	189	168	217	141	183	138	217	185	71	205	159	176	163	42
Sr	157	268	266	230	252	270	211	263	111	144	1223	270	245	272	240	112
Zr	-	162	136	-	-	94	131	99	81	63	127	106	114	472	324	110
Sb	-	0.11	0.1	-	-	-	0.1	-	0.12	-	-	0.09	0.1	-	-	-
Cs	-	3.39	3.8	-	-	-	10.4	-	6.15	-	-	11.6	8	-	-	-
Ba	621	730	646	356	656	792	574	788	561	443	-	816	591	-	-	1406
La	-	45.8	32.4	-	-	-	24.3	-	15.6	-	-	22.8	10.1	-	-	-
Ce	-	103	75.2	-	-	-	60.4	-	28.3	-	-	41.7	21	-	-	-
Nd	-	36.8	30.8	-	-	-	24.3	-	16.5	-	-	22.3	10	-	-	-
Sm	-	4.27	3.41	-	-	-	3.8	-	3.39	-	-	3.38	1.73	-	-	-
Eu	-	0.91	0.61	-	-	-	0.68	-	0.54	-	-	0.8	0.57	-	-	-
Tb	-	0.2	0.2	-	-	-	0.2	-	0.36	-	-	0.23	0.1	-	-	-
Yb	-	0.58	0.7	-	-	-	0.55	-	1.01	-	-	0.69	0.29	-	-	-
Lu	-	0.08	0.11	-	-	-	0.12	-	0.19	-	-	0.1	0.06	-	-	-
Hf	-	3.64	3.51	-	-	-	2.33	-	1.81	-	-	2.8	2.1	-	-	-
Ta	-	0.1	0.1	-	-	-	0.29	-	0.19	-	-	0.2	0.12	-	-	-
W	-	-	0.38	-	-	-	-	-	-	-	-	-	0.51	-	-	-
Th	-	23.5	21.7	-	-	-	21.8	-	12.9	-	-	22.7	11.5	-	-	-
U	-	0.95	1.18	-	-	-	1.8	-	4.93	-	-	1.54	2.57	-	-	-
Au(ppb)	-	1.1	2.7	-	-	-	0.9	-	2.5	-	-	0.6	1.1	-	-	-

typically in the range 15-20 suggesting that U might have been depleted by a factor of four in these rocks.

Isotopic Data

The Schweizer-Reneke adamellite was one of the first rock units to have been dated by radiogenic isotope means in this country. In 1964 the late Professor Hugh Allsopp published a letter in "Nature" presenting a Rb-Sr whole-rock isochron for eight samples collected at various localities on the Schweizer-Reneke dome, which yielded an age of 2700 ± 55 Ma. This age, together with other Rb-Sr data, was used until very recently as an indication that the Witwatersrand and Ventersdorp successions were younger than 2700 Ma (Allsopp, 1964).

The Schweizer-Reneke adamellite was re-examined by Barton et al. (1986) who produced whole rock Rb-Sr and Pb-Pb isochron ages of 2767 ± 110 Ma and 2780 ± 70 Ma respectively. All of these previous whole rock ages are now known to represent a later (undefined) thermal event, which has widely reset Rb-Sr and Pb-Pb isotope systems in granitic rocks adjacent to the Witwatersrand Basin. The Schweizer-Reneke adamellite has recently been re-dated using extremely precise single-grain U-Pb techniques at the Royal Ontario Museum in Toronto, Canada. These determinations, carried out on single, abraded monazite grains from borehole TKB2 yielded an age of 2880 ± 2 Ma, which is regarded as the best estimate for emplacement of the adamellite (Figure 5).

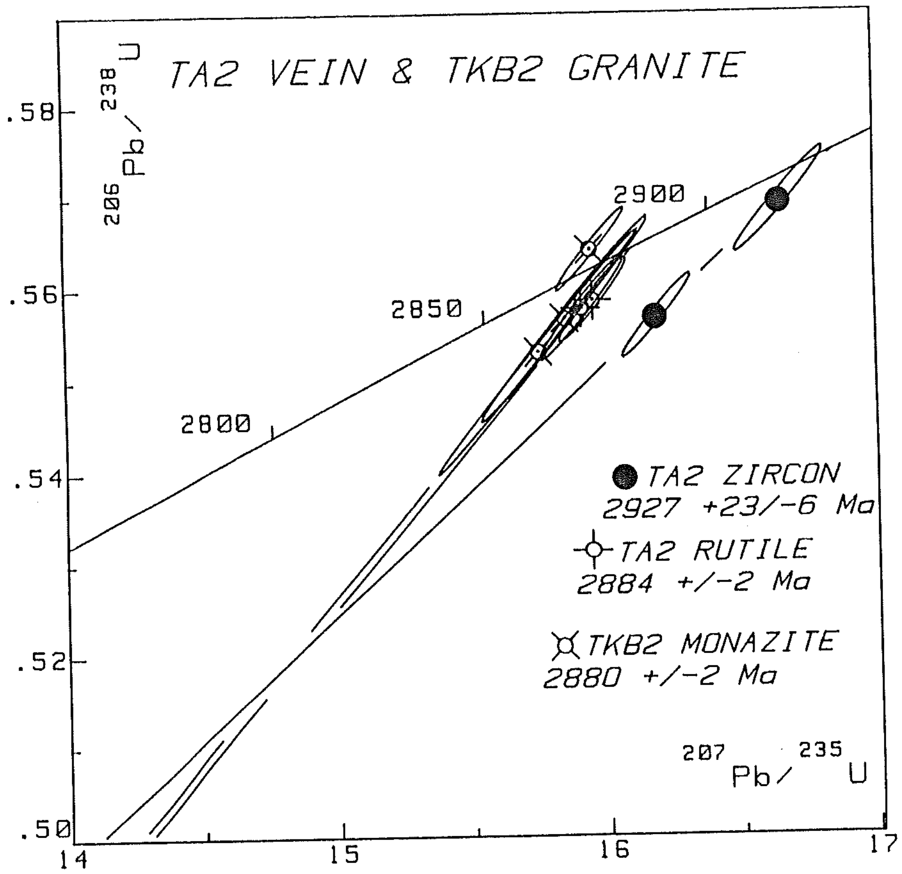


Figure 5: *$^{206}Pb/^{238}U$ versus $^{207}Pb/^{235}U$ concordia plot for samples of the Schweizer-Reneke adamellite (TKB2) and surrounds. TA2 zircons were extracted from tonalitic gneisses and migmatites to the southwest of the dome. TA2 rutile was obtained from a hydrothermal vein cutting the tonalitic gneiss.*

The age of the tonalitic gneisses and migmatites into which the Schweizer-Reneke adamellite intrudes is not certain. Similar gneisses in the Kimberley region have been dated by Dr. Richard Armstrong of the University of Cape Town with the SHRIMP in Canberra, Australia. Zircons from these rocks have cores which yielded ages of 3250 Ma and metamorphic overgrowths at 2940 Ma (Drennan et al., 1990). Tonalitic gneisses from borehole TA2, southwest of the Schweizer-Reneke adamellite, contain zircons which yielded an imprecise age of 2927 + 23/-6 Ma, which is, within error, the same as the age of metamorphic overgrowths in zircons from the tonalitic gneisses of the Kimberley region. The age of 2930-2940 Ma may, therefore, represent the period during which migmatitization of these rocks occurred, with the original tonalitic protoliths being older, possibly 3250 Ma.

The tonalitic gneisses and migmatites intersected in the TA2 borehole are characterized by an array of hydrothermal veins, comprising quartz-microcline-rutile-chlorite-pyrite-chalcopyrite, which cut across the foliation and compositional banding of the gneisses and, therefore, post-date the migmatitization. Rutile extracted from these hydrothermal veins yielded a very precise U-Pb concordia age of 2884 ± 2 Ma (Figure 5). This age is the same within error, as the Schweizer-Reneke adamellite in borehole TKB2 and it seems probable, therefore, that the veins represent an exogenous hydrothermal manifestation of the nearby adamellitic intrusion.

STOP 2: Abandoned quarry on the eastern outskirts of Schweizer-Reneke. The quarry exposes highly weathered foliated gneisses with lenses and bands of altered biotite schist. The foliation in the gneisses is highly variable over short distances ranging from subvertical to subhorizontal. The strike of the foliation is also variable but generally conforms to the regional orientation parallel to the Amalia and Kraaipan greenstone-gneiss trend (i.e. NNW-SSE). These gneisses represent the country rocks into which the Schweizer-Reneke adamellite has intruded.

Also seen in this quarry are boulders of Ventersdorp lavas (Allanridge Formation). The lavas display reddish chert or jasper inclusions or amygdules. The diamond diggers in the region refer to the small greenish-coloured agates and inclusions they find in the diamondiferous gravels as "groenertjies" (green peas).

Schweizer-Reneke Town History

In 1885 the Transvaal government launched an attack on a rustlers' hideout on Massouskop on the north bank of the Harts River. Ten government men were killed but the hill was captured and the rustlers, a mixed crowd of Europeans, Hottentots and Tswana, were driven away.

A town which later grew up at the foot of the hill was named after two of the soldiers who died in the skirmish - Captain G.A. Schweizer and Field-Cornet G.N. Reneke.

STOP 3: Proceed, via town centre, for 2km along the Schweizer-Reneke - Vryburg main road (R34). Turn right into track on Townlands farm, pass through gate and continue to quarry (1,2km).

Quarry north of Schweizer-Reneke on northeastern rim of dome. The quarry exposes a homogeneous, medium-to coarse-grained, pinkish-green coloured adamellite representative of the hydrothermally altered northeastern portion of the Schweizer-Reneke dome (Figure 4, Table 1). Subhorizontal joints separate relatively unaltered adamellite from extensively altered surficial material. Weathering of the adamellite also occurs along joints and fractures in the granitic rocks (see eastern quarry face).

Excursion returns to Schweizer-Reneke and follows the main road west towards Amalia (R504) for 5,3km. Turn left onto

Diewedraai sand road (D502) and continue for 9km to Stop 4 (Figure 4).

STOP 4: Boulders of leuco-granite piled on north side of road and low pavement exposures in the general area provide representative examples of the relatively unaltered type of Schweizer-Reneke granitic material. Excursion proceeds west for 5km to Stop 5.

STOP 5: Shear zone (Figure 4) exposed in low outcrops on north side of road near turnoff to farmhouse. The large shear zone that occurs in the central part of the dome is of a similar nature but, in places, has prominent white vein quartz outcrops and shearing affects the granitic rocks more extensively on either side of the main shear zone.

Excursion proceeds west for 6,5km to Stop 6. The usually dry river course of the Harts River can be seen south of the road. In places the river bed is grass covered and is not incised into the land surface.

THE KRAAIPAN GROUP - AMALIA GREENSTONE BELT, SOUTHWESTERN TRANSVAAL

I.M. Jones and C.R. Anhaeusser

Introduction

The Archaean Kraaipan Group of rocks on the western edge of the Kaapvaal Craton in the region embraced by the southwestern Transvaal, northwestern Cape Province and Bophuthatswana lies in the hinterland and provenance area of the Witwatersrand Basin.

The Kraaipan succession is generally poorly exposed and deeply weathered or covered by windblown Kalahari sands (especially in the north). Resistant banded iron formation (BIF) units are most commonly seen, and form positive relief features in the form of long parallel ridges. These units often allow exposure of normally hidden Kraaipan Group lithologies by protecting the schists or other softer rock types from physical weathering. The entire sequence of the Kraaipan Group lithologies consists of 3 broadly defined, semi-parallel, NNW-striking greenstone belts (Figure 1). The lack of outcrop both between and within the belts, as well as the highly deformed nature of the rocks, has rendered it difficult to establish an acceptable regional stratigraphy. Stratigraphic type sections have therefore been established for each of the belts and are only accurate within the specified belt.

The Amalia Greenstone Belt

The Amalia greenstone belt is situated in the southwestern Transvaal, approximately 5km south of the town of Amalia (Figure 2). The belt has a NNW-SSE trend and is flanked on the east by granitic rocks of the Schweizer-Reneke dome (Figure 4). Tonalitic and trondhjemitic gneisses containing xenoliths of amphibolite occur to the west of the Amalia belt (Stop 8). The exposed lithologies in the Amalia belt generally occur as steeply east dipping greenschist facies metamorphic assemblages comprising units of oxide facies BIF, quartz-chlorite schist, amphibole-chlorite schists and quartz-carbonate rocks. The BIF horizons vary considerably in thickness and lateral extent (in places over extremely short distances). The BIF consists of fine layers (commonly 1-10mm thick) of alternating hematite/magnetite and microcrystalline chert. These iron-rich units display folding on various scales and intensity, from broad warps to very tight disharmonic folds. Local boudinaging of the chert horizons and of entire BIF horizons is common and indicative of a high strain environment. Poor outcrop has hampered attempts to precisely determine fault traces, but some borehole control and the presence of quartz veins in places provide indications of faulting and fluid channelways. The pervasive deformation seen in the exposed greenschist lithologies, together with the trend of the formations, suggests the belt may be coincident with a major shear zone or series of shears. Evidence suggesting this possibility can be seen south of the Goudplaats Gold Mine, where exposed mylonites and gossaniferous schists occur in the shear zone trace.

The eastern and western contacts of the greenstone belt and adjacent granitic rocks are never exposed and only inferred contacts can be shown. The northern part of the belt disappears under the cover of Ventersdorp lavas in the vicinity of Amalia. These lavas do not show the type of deformation seen in the older Kraaipan assemblages.

Three periods of deformation have affected the Amalia greenstone belt. An early compressional phase of deformation (d_1) along a northeast-southwest axis was responsible for early small-scale tight folds seen in the BIF. The principle deformation event (d_2), probably due to the intrusion of the granitic rocks, caused large-scale folding and warping of the BIF and greenstone lithologies (Figure 6). This same compressional tectonic regime was responsible for the development of the cleavage seen throughout the belt. Late-stage, right-lateral movement along a major NE-SW-trending shear zone (exposed at Goudplaaats Gold Mine) caused extensive rotational slip and deformation of the BIF, the greenschists and the granitic rocks. This deformation (d_3) also produced minor structures, including late-stage, small-scale, disharmonic F_3 folds and faults, kinking of the d_2 cleavage and lineations seen in the BIF and greenschist, as well as causing bedding parallel slip and host rock brecciation, the latter influenced by repeated replacement by quartz and calcite veins. Mineralization of the BIF is closely associated with the degree of deformation (boudinaging of the BIF units into pod-like bodies) imposed by the d_2 event, and the amount of mineralizing fluid that was able to pass through the BIF following faulting and brecciation caused by the d_3 event.

Locally enriched zones of sulphide and accompanying gold mineralization have long been known to be present in two areas of the Amalia greenstone belt. In both deposits (Goudplaats and Bothmasrust (Figure 6), the gold mineralization has been concentrated in fault zones in late-stage quartz-calcite veins within BIF horizons. Mining operations associated with these two deposits were discontinued well over three decades ago, but renewed interest has led to further recent gold exploration in the belt.

Recent field work carried out by I.M. Jones has focussed on the regional-scale mapping of the belt as a whole and on detailed grid mapping (on a scale of 1:100) of four selected outcrop areas. These four areas are all mineralized portions of the Amalia belt, and all contain various old mining or prospectng pits and trenches. The excursion will visit two of the best mineralized and best exposed areas, namely Goudplaats and Bothmasrust (Stops 7 and 10).

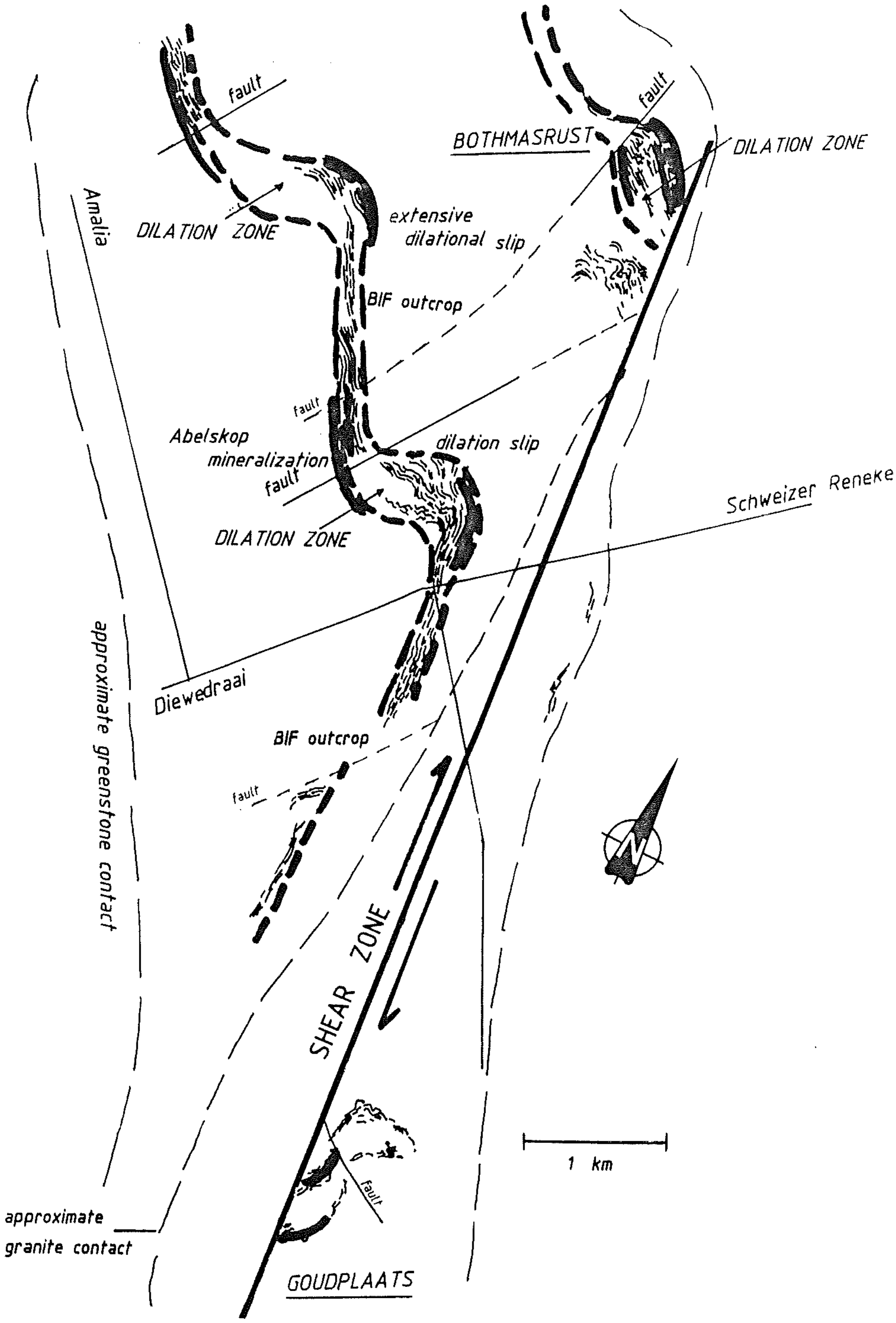


Figure 6: Simplified structural map of the Amalia greenstone belt showing the deformed banded iron formations in the Abelskop, Bothmasrust and Goudplaats areas.

Geology of the Goudplaats Gold Mine (Stop 7)

The Goudplaats Gold Mine is situated in the southwestern portion of the farm Goudplaats 96 HO. A simplified geological map of the mine area is shown in Figure 7 and a plan showing the underground workings is

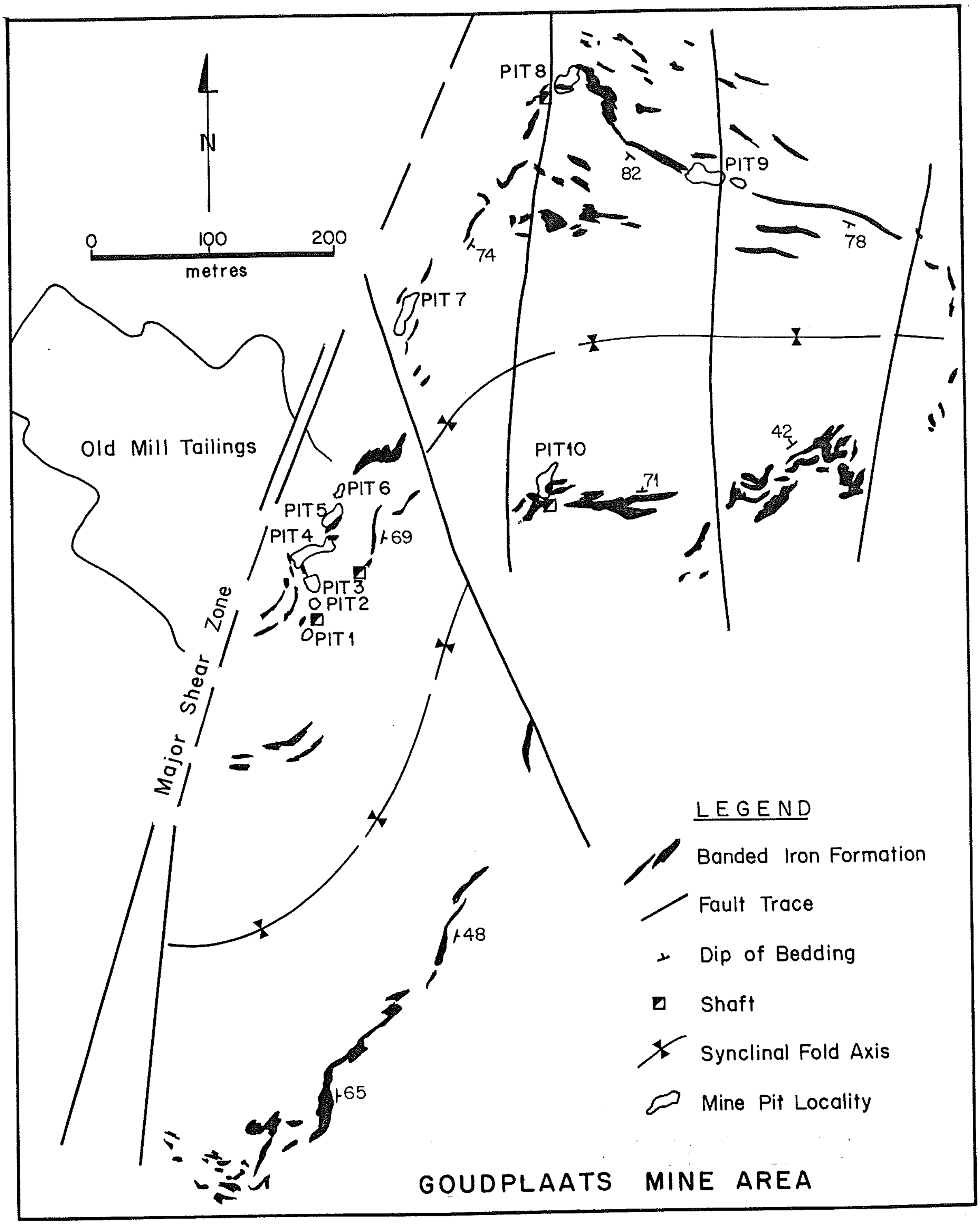


Figure 7: Simplified geological plan of the Goudplaats Mine area showing the location of the old mine shafts and open pits. The banded iron formations are tectonically dismembered but can be seen to form a sinuous folded synclinal structure, the trend of the fold axis varying from north-east to east-west.

provided in Figure 8. The small-scale operation was mined intermittently between 1910 and 1940 with the recorded gold production amounting to only 154kg gold.

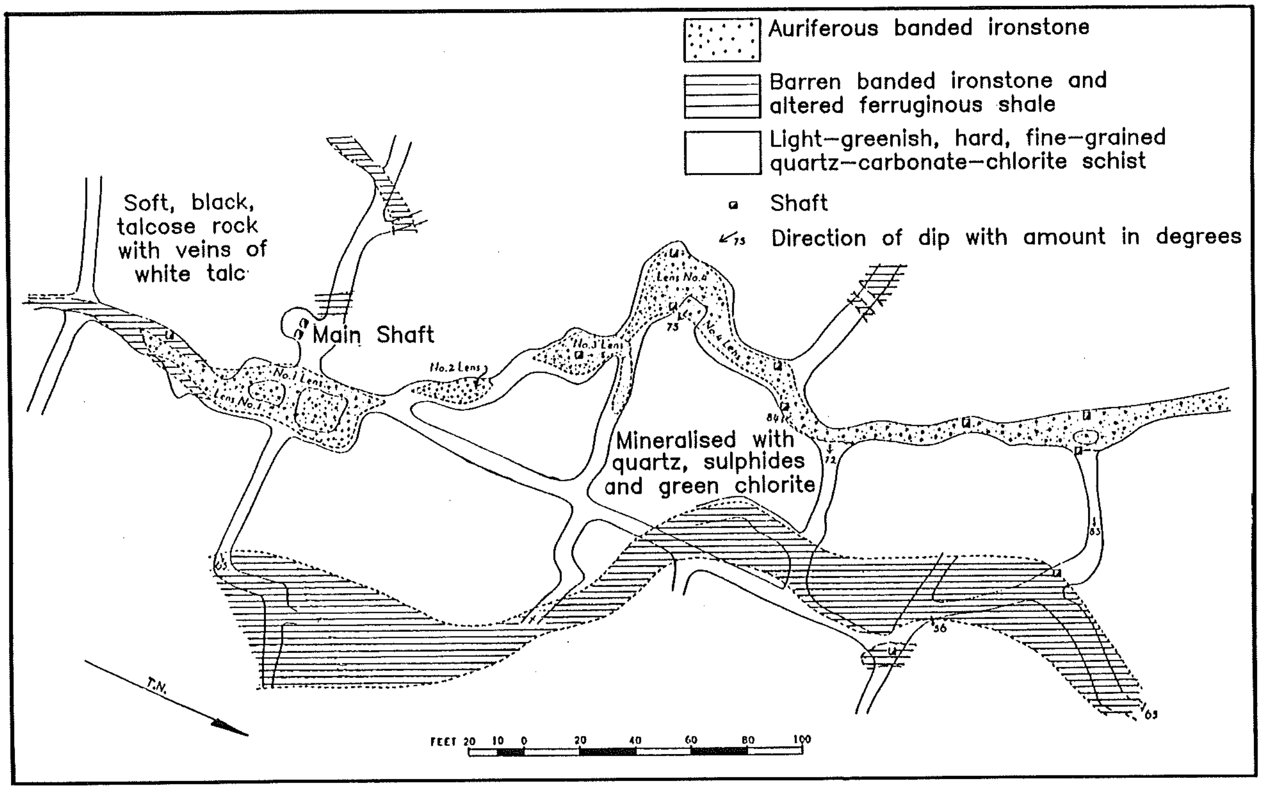


Figure 8: Plan of the 1 Level underground workings of the Goudplaas Gold Mine as at March, 1939.

The sequence exposed on the farm Goudplaats and in the vicinity of the mine comprises mainly BIF and altered mafic volcanic rocks. Four separate BIF units are seen in outcrop close to the remains of the mine (also referred to as the Esperanza Gold Mine). A poorly outcropping granitic body cuts obliquely across the succession west of the mine workings and trends in a northeasterly direction towards the Bothmasrust workings (see Figure 6). Outcrops of this granite north of the Harts River show it to be a coarse, pinkish-grey, homogeneous granite similar in character to the Schweizer-Reneke adamellite seen at Stop 3 (Figure 4). The granitic body is flanked by greenstones showing it to be intrusive into the Amalia belt but no contact relationships have been located.

Figure 7 shows the broad structural nature of the mine area as well as the positions of the old shafts, mining pits (numbered 1-10) and slimes dams. The remains of the old crushing plant, mill site, geological core yard and treatment tanks are still to be seen. The slimes dams cover a relatively large area to the west of the old mine site and the temporarily suspended Gemex crushing mill and treatment plant is located to the south of the mine shafts.

The pit exposures provide an opportunity to examine the nature of the lithologies and the structural relationships at Goudplaats. The four BIF units developed in the sequence are characterized by extremely complex deformation and are manifest as thin alternating bands of hematite/magnetite and chert. Carbonate-rich BIF is developed in places in the ferruginous sediments, especially near mineralized areas. Small-scale faulting, folding and intense brecciation (coupled with shearing and quartz vein development) is also present in areas of mineralization as is carbonate alteration of the BIF and the intervening mafic volcanic rocks. Boudinaging of the individual chert layers is seen throughout the area on various scales. On a large scale entire BIF units may be deformed and boudinaged forming dismembered pod-like bodies. These bodies contain the highest concentration of mineralization and have been extensively mined (Figure 9). The outcrop pattern of the BIF's is consequently complex and often tracing a single BIF unit is impossible over very short distances. The BIF outcrop pattern is thus a series of independent lenses (pods) and fault-bounded fragments. The general outcrop pattern of the BIF's and the corresponding dip and strike orientations also suggests the exposed units form part of a large tightly folded synclinal structure (Figure 9). This syncline closes in the northeastern portion of the farm where the outcrop is lost under cover. The open end of the syncline is exposed at the southwestern corner, where it is terminated against a sheared contact with the central granite body. The syncline shows an arcuate fold axis, trending northeast in the southwest, north in the central portion, and again northeast in the northern sector. The entire structure has been truncated near the main mining pits by a late-stage cross-cutting fault with a left-lateral sense of movement of at least 50m. Various smaller-scale cross-cutting shear zones also transect the syncline at various localities, with consequent smaller scales of movement. The main exploration and mining pits are sited where the shear zones intersect the BIF units.

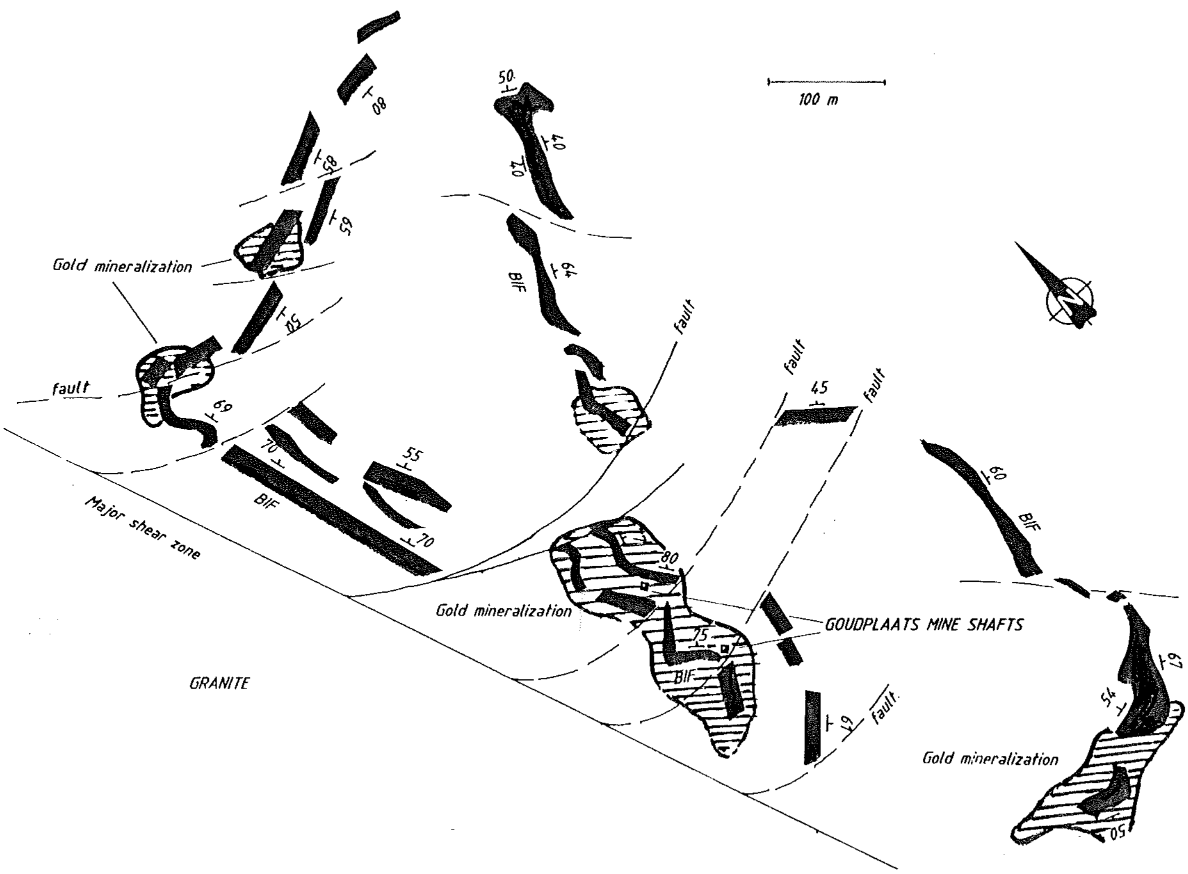


Figure 9: Simplified structural and geological map of the Goudplaats Mine showing the dismembered boudins of banded iron formation (black) and the areas of maximum concentration of gold mineralization (shaded areas).

The two limbs of the syncline terminate in the southwest against a linear NNE-trending right lateral shear zone (Figure 9) which forms the contact to the central granite body that can be traced from the Goudplaats Mine northwards to the Bothmasrust outcrop area (Figure 6). On Goudplaats the shear zone is up to 70m wide and is best exposed in mafic agglomerates. Discrete, thin, grey-green bands of mylonite are developed in the shear zone. The rock is highly deformed and possesses a fine-grained quartz-chlorite matrix. Minor disseminated pyrite mineralization is seen in the rock. Similar sheared mafic agglomerates and lavas occur along the same structural zone 1km to the northeast of the Goudplaats Mine.

Extensive quartz veining, with individual veins attaining a maximum length of 6m and a width of 70cm, is concentrated along the shear zone trace in the mafic schists. Outcrops occur north of the main mine pits, but there are no mylonites at this locality.

Quartz and calcite veins are also present but only occur on a small scale and the calcite veining is restricted to areas where carbonate alteration is most intense.

The mafic rocks exposed on the farm Goudplaats display varying degrees of carbonate alteration. A strong and pervasive fabric is developed in the schists exposed near the shear zone along the western boundary. The schistocity is often obliterated by the carbonate alteration in areas close to mineralization. By contrast the mafic rocks seen in outcrop in the nose of the fold (north of the main pits) appear to have escaped intense deformation, and pilloidal structures are visible in the grey-green, fine-grained, quartz-chlorite rocks.

Furthermore, near the western edge of Pit 5 (Figure 7), a small outcrop of dark-green mafic rock displays a spinifex-like texture, suggesting subaqueous extrusion of these lavas. Most of the lavas are, however, massive and fine grained with a dark grey-green colour. Borehole control in the vicinity of the Goudplaats Mine has enabled a detailed study of these normally unexposed lithologies.

Mineralization in the BIF's may be found in outcrop in various localities. For example, in situ fine-grained pyrite mineralization, concentrated in the iron-rich layers, is evident in Pit 7 (Figure 7). Pyrite and chalcopyrite, associated with quartz and calcite, occurs near shear zones cross-cutting the BIF. This relationship is, however, best seen in borehole core. Some indication of the nature of the mineralization at Goudplaats may also be obtained by examining ore samples on old mine dumps in the area. Caution should be exercised in this regard as ore from the Bothmasrust workings was also stockpiled at Goudplaats prior to treatment.

Geology of Bothmasrust (Stop 10)

The Bothmasrust gold prospect is situated on the western edge of the farm Bothmasrust 76 HO, approximately 2,5km northwest of the main Schweizer-Reneke/Diewedraai gravel road. A simplified geological map of the sequence of rocks exposed on the farm is seen in Figure 6. The outcrop pattern of the BIF's and various mafic lithologies in the area, including that on the adjacent Abelskop hill to the southwest, is extremely complex due to the intense deformation that has affected the rocks. The BIF units generally trend NW-SE and the rocks dip mainly to the east at 50-60°.

However, dip variations to the west and south are not uncommon as the units have been folded about northerly trending cross folds (Figure 6).

The old workings of the Bothmasrust Mine include a main shaft and a smaller ventilation shaft and an old reservoir built for water supplies to the underground workings. The mine is now flooded and the main shaft sealed. Several deep exploration trenches and pits have been excavated exposing highly brecciated and stockworked BIF northwest of the old workings.

As at Goudplaats and Abelskop, the BIF units at Bothmasrust are highly deformed and outcrop is very discontinuous. The principal rock types seen at this locality include oxide facies BIF, metamorphosed mafic lavas, quartz-rich schists, breccia horizons, and an outcrop of accretionary lapilli. The BIF's are highly brecciated and fractured throughout the area. Unmineralized BIF in the Bothmasrust prospect area occurs as magnetite-quartz(chert)-rich rock, the cherty quartz layers being jaspillitic in places. The magnetite commonly shows alteration to hematite (the magnetite often being completely enclosed by a rim of hematite). Disharmonic folding, brittle faulting and ductile shear zones are seen on various scales in the BIF.

A variety of quartz veins are also seen in many of the BIF exposures on surface and in old trenches and pits (Figure 10). These include stockwork vein quartz and a fibrous vein type, the latter described by Vearncombe (1986) as being an important indicator of a suitable tectonic setting for gold mineralization in the Bothmasrust prospect area.

The eastern margin of the Bothmasrust prospect appears to be truncated by the shear zone extending north from the Goudplaats Mine (Figure 6). Outcrops are poor in the area but thematic imagery of the Amalia belt serves to confirm this relationship.

Some unusual lithological types are present in the Bothmasrust area. Apart from the ubiquitous BIF and associated, generally poorly outcropping, mafic schists (mainly chlorite schists), exposures of fuchsitic green quartzitic material occur as pod-like bodies and are also present in the side wall of an exploration shaft near the main Bothmasrust mine shaft. Fuchsitic rocks were also noted on Abelskop. A second unusual rock type, outcropping very poorly between units of BIF, is an exposure of accretionary lapilli set in a finely bedded mafic tuffaceous unit. The accretionary lapilli are small, pea-sized structures (Figure 11) composed entirely of clastic volcanic material, primarily glass or its alteration products. Their presence suggests the rocks were formed during volcanic eruptions which occurred intermittently between periods of sedimentation giving rise to the iron formations in the area. The lapilli, which are zoned, are believed to have developed in an ash-charged volcanic cloud by accretion of ash around a core due to the condensation of moisture on the core, and fell to the ground like hailstones (Moore and Peck,1962).

The accretionary lapilli unit displays heterogeneous strain with some lapilli still perfectly intact and showing clearly defined zoned growth rings. Bands of intensely sheared lapilli material may occur only centimetres away from undeformed lapilli. Where sheared, lapilli structures are sliced into segments or may be reduced to slivers in a mylonitic matrix (Figure 11).

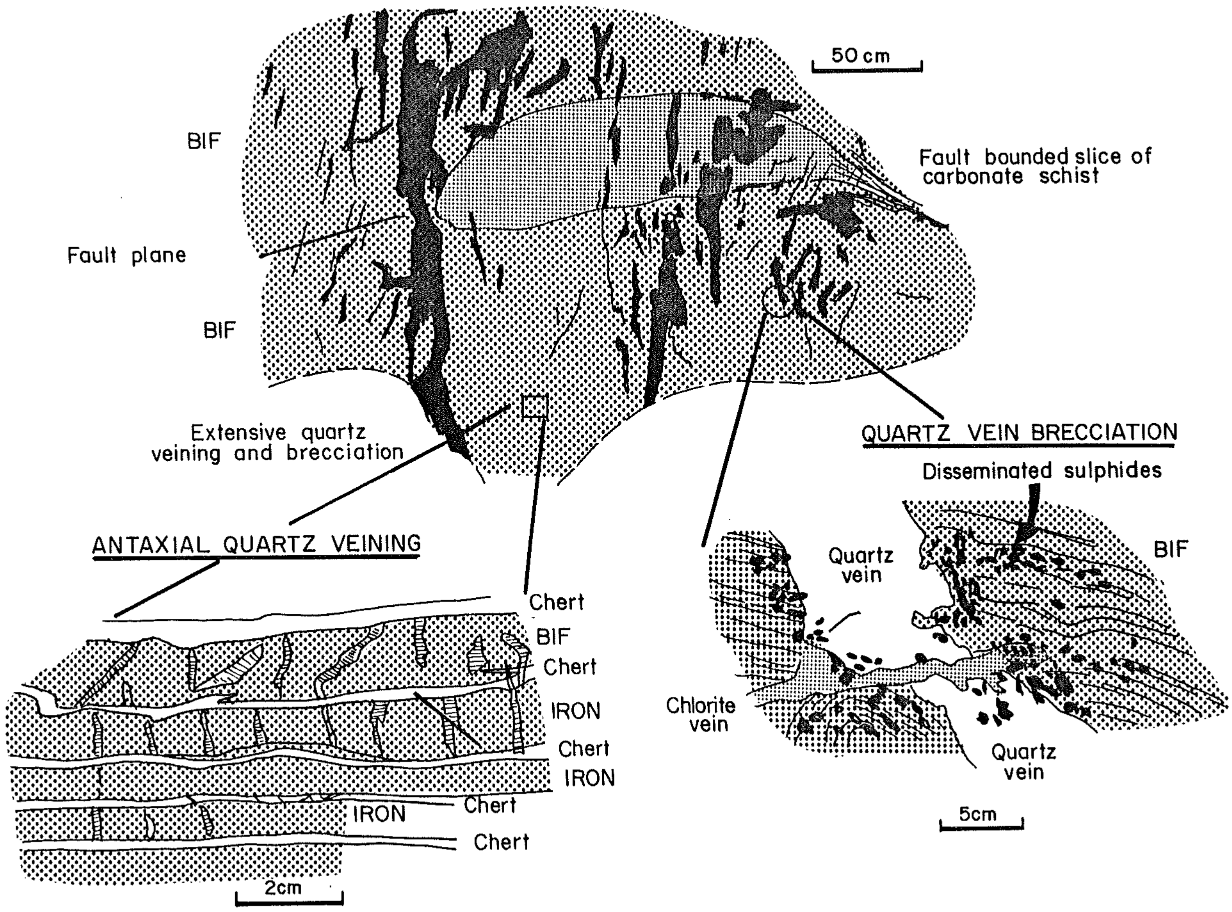


Figure 10: Structural relationships seen in BIF-hosted gold prospect pits and mine workings in the Bothmasrust Mine area, Amalia greenstone belt.

STOP 6: Road cutting and quarry exposing rocks of the Amalia greenstone belt (schist belt). A short traverse (approximately 150m) on the north side of the road provides a glimpse of at least 4 banded iron-formation units interlayered with chloritic schists. Some brecciation of the BIF's is evident with vein quartz filling the breccia cavities. The crenulated chloritic schists and the interlayered BIF's dip to the east at approximately 45°. Minor folds in the deformed schists produce sub-horizontal cleavage crenulation lineations which plunge to the northeast. On the south side of the road boulders of BIF, brecciated BIF, chloritic schist (some with vein quartz), and massive altered mafic volcanic material is available for examination in a roadside quarry.

Excursion proceeds south at T-junction on the Bloemhof road (D462), crosses the Harts River bridge and turns right into farm gate 2.2km from Stop 6. The GEMEX signboard is displayed at the gate. Continue for approximately 3km along track which bears left (south), passing through a second gate as well as a motor gate before arriving at the GEMEX crushing and treatment plant (Stop 7).

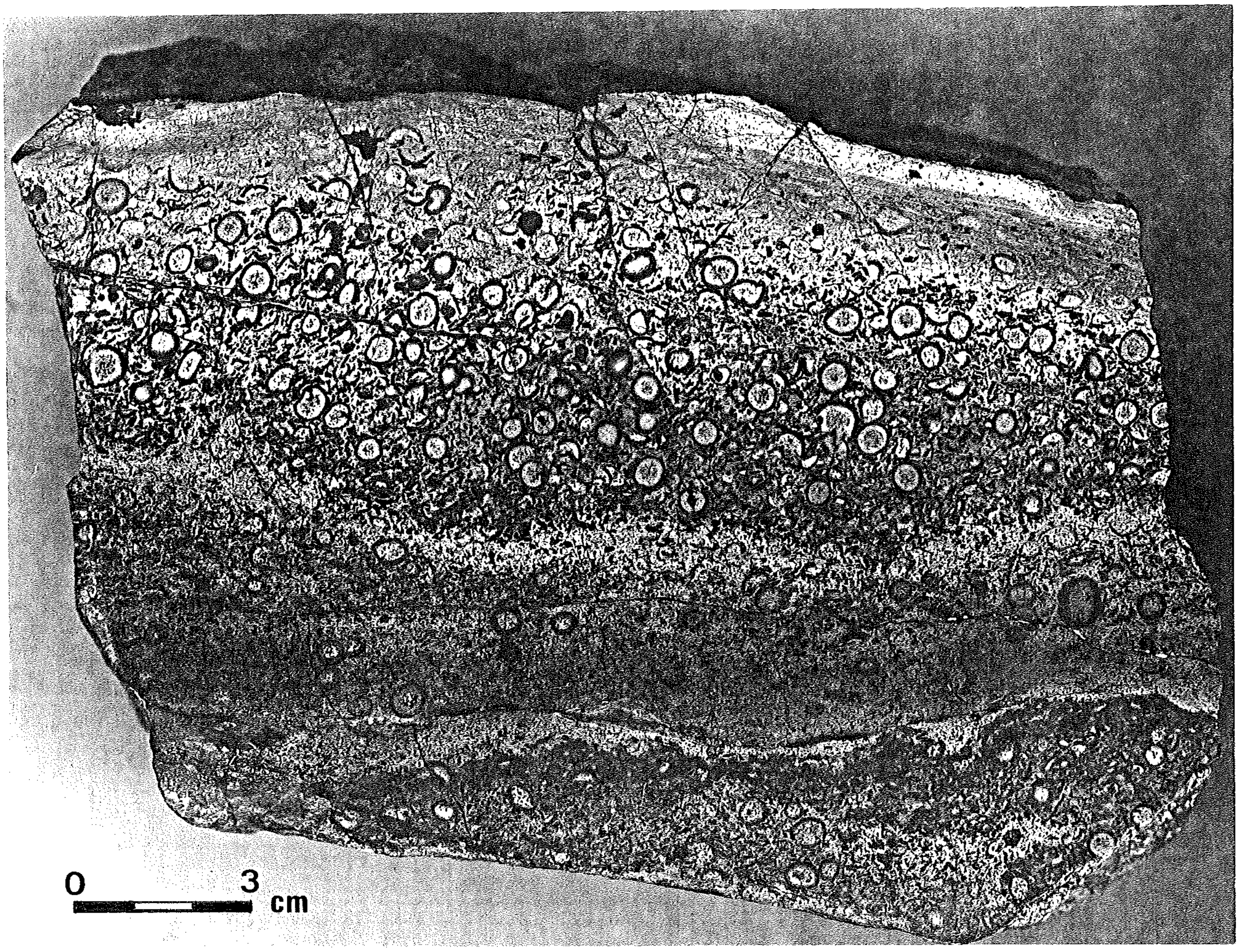


Figure 11: *Accretionary lapilli showing delicate concentric layers and pumice lapillus nuclei. Note the broken lapilli and fragments of the dark outer layers scattered through the matrix. Sheared or mylonitic layers in the rock cause flattening and breakup of the lapilli. Some lapilli are sliced into segments along minor shear surfaces (top left). Some outcrop material shows graded bedding of the tuffs and enclosed lapilli spheroids.*

STOP 7: Goudplaats Gold Mine. The excursion will be guided through the old mine workings examining various outcrops, pits, trenches, and quarries which display the main lithological and structural features in the mine area. The Goudplaats Mine is displayed on the regional 1:125 000 map sheet 2427B (Pudimoe) and 2725A (Schweizer-Reneke) produced by the Geological Survey in 1962 (Van Eeden et al., 1963). Local detail is also included in Figures 6-9 in this guidebook.

Excursion returns to the T-junction at Stop 6, turns left (west) along the Diewedraai road (D502) and continues beyond T-junction signposted to Amalia to Stop 8. Stop 8 is 3,4km from Stop 6.

STOP 8: Outcrops of tonalitic/trondhjemitic gneiss on west side of Amalia greenstone belt. The outcrops to be visited occur between 150-300m on the north side of the Diewedraai road. The outcrop closest to the road consists of foliated gneiss, but the furthest exposures are the most interesting as they contain amphibolite xenoliths as well as several cross-cutting granitic phases. The foliation in the gneisses and amphibolite remnants is aligned parallel to the Amalia greenstone belt which trends approximately NNW-SSE. In the exposures, coarse-textured grey gneiss is intruded by leuco-gneiss bands. Some of the foliated leucogneiss is conformable with the foliation of the grey gneisses but transgressive contacts can also be seen. The amphibolite xenoliths represent metamorphosed remnants of the Amalia greenstone belt prized off the main body by lit-par-lit intrusion of dominantly sodic granitic magma. No chemical analyses are yet available but petrological examination showed the rocks contain mainly albite and quartz together with chlorite, biotite, magnetite, and carbonate. The plagioclase is partially altered to sericite and epidote. Despite the dark colour of the rock no hornblende is present, this mineral having been totally altered to chlorite. Hornblende is, however, present in the amphibolite xenoliths together with quartz, sericite and epidote (altered plagioclase), chlorite and carbonate.

A third exposure of granitic rocks in the river west of the two outcrops described above shows strongly jointed gneisses.

Excursion returns 1,6km to the T-junction signposted to Amalia, turns left (north) stopping at a quarry on the west side of the road (Stop 9).

STOP 9: Borrow Pit exposing mafic schists of the Amalia greenstone belt. The rocks in the pit consist mainly of chloritic schist but some coarser-textured gabbroic rocks occur on the western edge of the quarry. The schists are strongly crenulated producing kink band folds as well as rodded and lineated schists and pencil cleavage. The lineations and rodding varies in attitude from subhorizontal to vertical and the pencil cleavage is produced by the intersection of cleavage and stratification in the greenschist metamorphic rocks.

Excursion proceeds north to Amalia (9km) and then continues a further 50km to Vryburg for overnight stop at the Grand Hotel.

Vryburg Town History - Mayhew (1978)

In the wars between the Tlapin tribe and the Korana Hottentots, a large number of European adventurers served as mercenaries with the two sides. At the end of the fighting, in July 1882, 416 of the mercenaries who had fought for the Hottentots received payment in the form of farms.

These mercenaries then proclaimed their block of ranch land a republic and named it Stellaland because of a comet which had been visible while the fighting was in progress.

Vryburg, the "town of freedom" was laid out as a capital for this roughneck republic. A flag was designed, postage stamps issued (great collectors' pieces), a jail built, and the state was launched. Its life was short. The Transvaal Republic and the British government in the Cape refused to tolerate continuous frontier disturbances. An expeditionary force under Sir Charles Warren was sent up from the Cape with orders to "remove filibusters from Bechuanaland and restore order in the country". Stellaland was occupied in 1885, and the flag was sent to Queen Victoria and hung in Windsor Castle until 1934, when King George V returned it to Vryburg. It remains in the town hall. King George was the proud possessor of a full set of Stellaland stamps.

Vryburg is today the centre for ranching on a vast scale. In the stockyards many thousands of head of cattle are auctioned each week, and railed for slaughter all over South Africa.

There is a museum and the ruins of the original jail. In its heyday the area was a roaming ground for rustlers and horse thieves, including the renowned Scotty Smith. Scotty was born in Perthshire in 1845 and arrived in South Africa in 1877. He joined the Frontier Armed and Mounted Police and served through the Ninth Frontier War and the Griqua Rebellion. With the coming of peace he found army life boring and deserted. His career as a rebel had begun.

Scotty was a quixotic character, capable of the most outrageous deeds. Like Robin Hood, he robbed the rich to help the poor. The diamond diggings and the northern Cape were his favourite fields of operation. He became a gun-runner, illicit diamond buyer and horse rustler. He also spent much of his time ranching on the verges of the desert in the northern Cape, where he hid most of his loot.

Leitland's Pan was his main stronghold and from here he carried out raids on stockholders in the district. He was respected by the Bushmen, who acted as his trackers and informed him of the movements of the police. Even when the law caught up with him he was a hard man to hold - he escaped from custody several times.

Despite his restless and often hazardous life, Scotty died on 26 October, 1919 in an ironically mundane fashion - during an influenza epidemic. His grave can be seen in the cemetery at Upington.

DAY 2: OUTCROPS IN THE VICINITY OF THE BOTHMASRUST GOLD PROSPECT, AMALIA GREENSTONE BELT, AND SELECTED OUTCROPS IN THE GEYSDORP KHUNWANA-KRAAIPAN AREA NORTHWEST OF DELAREYVILLE

Saturday, November 2, 1991

7.45 a.m. Excursion leaves from the Grand Hotel, Vryburg, travelling via Amalia to the Bothmasrust gold prospect southeast of the town. From Amalia the route followed is south to the Diewedraai-Schweizer-Reneke road (9km), then east for 2,8km along D502 to farm gate on north side of road. Enter gate and proceed approximately 2km to Bothmasrust gold occurrence (Stop 10).

STOP 10: Bothmasrust Gold Prospect.
The excursion will be guided to selected outcrops in the vicinity of the mine workings and to trenches, pits and quarries displaying structurally disturbed BIF which acts as host rocks to epigenetic gold-pyrite mineralization (Vearncombe, 1986). In addition to the BIF exposures outcrops of fuchsitic quartzite and accretionary lapilli will be examined.

Excursion returns to D502 and continues east to Schweizer-Reneke (24,8km). The route then proceeds north along R506 towards Delareyville. Approximately 10km north of Schweizer-Reneke a roadside stop will be made to examine volcanic rocks at Stop 11.

STOP 11: Ventersdorp lava (Allanridge Formation).
Boulders of dark-green massive to amygdaloidal andesitic lava are exposed on the west side of the main road. These lavas extend north to Delareyville and completely cover all Archaean basement rocks north of the Schweizer-Reneke dome. In thin section the rocks contain plagioclase, altered to epidote and sericite, and chlorite (alteration product of clinopyroxene). Minor magnetite and leucoxene are also present.

Excursion proceeds a further 53km to Delareyville. En route (approximately 18km south of the town) the first of four large pans developed on the Ventersdorp surface may be seen. Salt is recovered from brines in the pans closest to Delareyville.

Delareyville - Western Transvaal

Delareyville is a small agricultural town in the maize producing area of the western Transvaal. The town was founded in 1914 and named in honour of the Anglo-Boer war hero, General Jacobus de la Rey. In addition to maize, ground nuts and sunflowers are important crops in the area and salt is extracted from the shallow pans south of the town.

From Delareyville the excursion proceeds northwest along R507 continuing beyond Geysdorp to the RSA-Bophuthatswana border (34,7km). Turn right (east) and proceed for 3,5km along sand road passing over a magnetite quartzite BIF horizon to a second ridge of BIF (Figure 13). Turn left (north) and proceed along east side of fence, forking to the right (northeast) for approximately 1km past some huts to a gap in the iron formation ridge. Walk north across magnetite quartzite BIF (Gold Ridge Formation) for approximately 300-450m to Stop 12.

THE NORTHERN KRAAIPAN GRANITE-GREENSTONE TERRANE

O.T. ZIMMERMANN and C.R. ANHAEUSSER

Small-scale mining and prospecting for gold was undertaken during the early part of the century in the area referred to here as the northern Kraaipan granite-greenstone terrane. Gold was found associated with the banded iron formations and small mines were opened at Madibe (approximately 20km southwest of Makikeng), Muirs Mine (immediately north of Kraaipan Siding) and in other areas. At Madibe, gold occurred partly in the form of tellurides together with quartz, calcite, tourmaline and pyrite. Initially, good values were obtained due to secondary enrichment in the supergene zone but later grades were inconsistent and mining ceased in the 1930's. The iron formations also attracted attention and at one stage were viewed as large, low-grade ore deposits. As a consequence of the prospecting and mining a regional geological synthesis of the area was undertaken by A.L. du Toit during 1906-1907. His reports (also referred to by SACS, 1980) and one by Van Zyl (1972) remained the only geological account of the region extending from Vryburg and Delareyville in the south to the Botswana border in the north, an area well in excess of 10 000 km^2. Recently, renewed investigations in this area were undertaken as part of a collaborative programme involving the Geological Survey and the Economic Geology Research Unit of the Department of Geology, University of the Witwatersrand. Preliminary results are available in an unpublished report (Zimmermann, 1991).

In broad terms the Kraaipan Group of rocks crop out in three narrow belts here referred to as the western, central, and eastern belts. The western belt occurs mainly north of Stella, the central belt extends through the Kraaipan Siding area and the eastern belt passes through the Madibe area (Figure 2). Only the most resistant rock types form the distinct but nevertheless discontinuous outcrops in the region which is covered by extensive Kalahari sand, gravel and calcrete/silcrete deposits. In the south (Stella-Delareyville) Ventersdorp volcanic rocks cover the Kraaipan formations.

Stratigraphy

The type area for the Kraaipan succession occurs on the farms Ferndale 286 and Gold Ridge 295 (Figure 15) north of Kraaipan Siding. Here the rocks have been subdivided into the Gold Ridge, Ferndale and Khunwana Formations. The Gold Ridge Formation is constituted of shale, grit and greywacke, magnetic shale and quartzite, banded chert, banded iron formation, jaspilite, crystalline limestone, and intercalations of amphibolite or mafic schist which represent metabasaltic lavas (SACS, 1980; Visser et al., 1989). In the upper part of the sequence altered lava and chert of the Khunwana Formation follows on banded jaspilite of the Ferndale Formation.

Because of the generally poor exposure and the similarity of the various iron formation, jaspilite, ferruginous chert and metavolcanic units, it is not easy to correlate the rock units with precision or certainty across the entire region. The excursion is designed to show as many of the lithostratigraphic components as possible but, because of logistic difficulties, some of the rock units such as shale, greywacke, limestone, and phyllite will not be seen. Furthermore, many of the lithologic units can only be seen in isolation as contacts are commonly obscured by cover of sand. Even when more than one component is present at a specific locality the relationships are not always apparent. Just such an example is the case at Stop 12 which shows a pod-like body of serpentinite enveloped by magnetite-quartzites. Ultramafic rocks occur sporadically in the Kraaipan successions and some are extensively altered and replaced by carbonate. Some of the so-called dolomite or limestone may, in fact, be carbonated ultramafic rock.

A wide variety of iron formation types is present throughout the area ranging from coarse-granular or clastic magnetite quartzite to finely layered oxide facies BIF and jaspilitic iron formation. Ferruginous cherty BIF, similar to that seen in the Goudplaats-Bothmasrust mine area in the Amalia greenstone belt are also present in the northern Kraaipan outcrops.

Exposure of the mafic volcanic rocks associated with the iron formations is also not good but a number of localities will be visited demonstrating the nature of these assemblages. In many areas the mafic volcanics have been deformed and metamorphosed to chlorite-amphibole schists. Boreholes drilled in the Gold Ridge farm area (near Stop 18, Figure 15) by the Geological Survey confirmed the presence of schistose metavolcanics between the iron formation ridges in the type locality.

In the areas the volcanic rocks are relatively well preserved and show excellent pillow structures (Stop 27, Figure 16 and Stop 29, Figure 17) indicating the subaqueous deposition of the lavas and the iron formations. The mafic volcanic rocks are generally altered, being either metamorphosed (greenschist or amphibolite facies) or extensively saussuritized to chlorite-amphibole-epidote assemblages (e.g. Stop 29 at Makgobistad on the Molopo River).

Table 2 provides major and trace element analyses for a number of

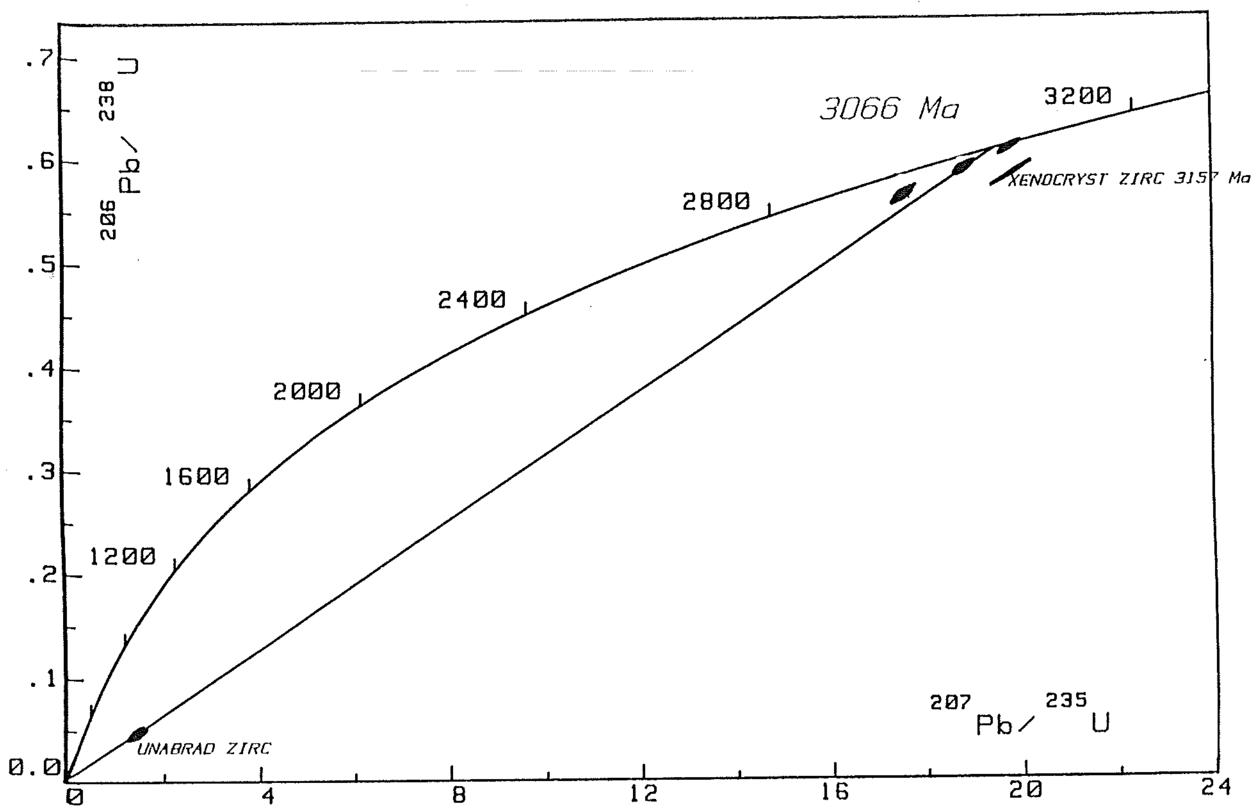


Figure 12: 206Pb/238U versus 207Pb/238U concordia plot for zircon extraction from felsic schists of the Kraaipan Group.

basaltic rocks in the northern Kraaipan area. Most of the rocks are normal oceanic tholeiitic basalts. Some samples have relatively high magnesium values but komatiites or komatiitic basalts generally appear to be rare or absent.

Granitic Rocks

The Kraaipan formations are surrounded and intruded by a variety of granitic rock types (Jorissen, 1905; Du Toit, 1906, 1908; SACS, 1980). Essentially three varieties have been recognized and these include:

(i) foliated leucogneisses and migmatites containing remnants of Kraaipan metavolcanics (amphibolites) and BIF xenoliths (e.g. in the Tlhakajeng River east of Khunwana, Stop 15, Figure 14; in the river exposures at Stop 23 near Setlagole, and in the Disaneng Dam Spillway at Stop 30 near the Botswana border);

(ii) medium-grained, homogeneous, pinkish-grey granite or granodiorite of the type seen at Stop 17 near Kraaipan Siding, but also present as intrusive, cross-cutting dykes and veins in the Disaneng Dam area at Stop 30. Similar but weakly foliated pink granitic rocks also occur at Stop 22 near Setlagole; and

(iii) coarse to very coarse-grained, homogeneous, pink granite of the type found in the Mosita area and seen at Stop 24.

All the above-mentioned granites contain xenoliths of Kraaipan rocks and the basement gneisses appear to represent altered tonalitic or trondhjemitic gneiss of an early generation like those reported as being between 2900 - 3250 Ma in the Amalia-Kimberley area (see earlier section on Isotopic Data in the Schweizer-Reneke area by L.J. Robb).

Very little is known of the absolute ages of the granitic rocks in the northern Kraaipan region. Preliminary whole rock lead ages of 2670 Ma were obtained for the pinkish granodiorites in the Kraaipan Siding area by F. Walraven (pers. comm. 1991). Walraven also obtained a whole rock lead age of 2260 Ma for the Mosita Granite. Rb/Sr analyses showed considerable scatter of the data reflecting open system behaviour. Other techniques will be necessary to determine accurately the ages of these rocks.

U-Pb ISOTOPE DETERMINATIONS - FELSIC VOLCANICS, KRAAIPAN GROUP

L.J. ROBB

A preliminary attempt has been made at dating the Kraaipan Group using the high-precision, single grain U-Pb zircon technique developed at the Royal Ontario Museum in Toronto, Canada. Zircons were extracted from units of felsic schist sampled by C.R. Anhaeusser at two localities to be visited on the excursion (viz. Stop 16, Figure 2 and Stop 19, Figure 15).

The zircons extracted from the samples were extremely small and of poor quality which, despite abrasion, yielded imprecise results. Five zircon fractions, each containing between one and three grains were analysed and the results are plotted on the 206Pb/238U versus 208Pb/235U concordic diagram in Figure 12. Three abraded fractions plot close to concordia and yield 207Pb/206Pb ages of between 3020 - 3088 Ma,

TABLE 2.

SELECTED CHEMICAL ANALYSES FROM THE NORTHERN KRAAIPAN GROUP ROCKS

	FRG-1	FRG-21	FRG-40	SET-22	LOG-6	M-1	OT
SiO_2 (wt %)	53.96	52.84	49.27	52.09	53.81	52.80	49.94
TiO_2	.52	.54	1.31	.07	1.06	.74	1.51
Al_2O_3	14.06	14.43	12.58	12.03	12.54	12.40	16.69
FeO	6.86	6.78	n.a.	n.a.	n.a.	n.a.	6.90
Fe_2O_3	2.01	1.43	16.03	11.72	16.71	13.00	2.01
MnO	.17	.14	.16	.20	.15	.20	.17
MgO	7.35	7.59	5.91	9.73	5.66	5.90	7.28
CaO	8.37	11.07	5.38	10.17	3.19	8.29	11.86
Na_2O	2.79	2.95	2.02	1.92	2.52	2.90	2.76
K_2O	.16	.21	.05	.48	.46	0.00	.16
P_2O_5	.04	.03	.10	.13	.25	.06	
H_2O^-	.36	.10	0.00	0.00	0.00	n.a.	
H_2O^+	2.06	1.61	n.a.	n.a.	n.a.	n.a.	
CO_2	.10	1.68	n.a.	n.a.	n.a.	n.a.	
L.O.I.	--	--	7.67	1.41	3.91	3.77	

* FRG-1, FRG-21 and FRG-40 - core from borehole FR-1 (Figure 15).
* SET-22 - amphibolite from Setlagole area
* LOG-6 - basalt from Logageng area (Figure 16).
M-1 - epidotized pillow basalt from Makgobistad (Figure 17).
OT - oceanic tholeiite (average given by Engel et al., 1965).

* (after Zimmermann, 1991)

whilst a fourth unusually large grain, also abraded, yielded an age of 3157 Ma. A fifth fraction was not abraded and provided extremely discordant isotope ratios and a meaningless 207Pb/206Pb age. The large grain with the 3157 Ma age is believed to represent an inherited or xenocrystic zircon and is not considered in further regression attempts. Regression of the three near-concordant data points yields an upper intercept concordia age of 3083 + 40/-14 Ma whereas regression of the data, including the highly discordant point gives 3066 ± 32 Ma. The mean of these two figures, 3075 Ma, is identical to the age of 3074 Ma for the Dominion lavas obtained by Dr. R. Armstrong of UCT (pers. comm.).

It is thus possible that the Kraaipan is a distal equivalent of the Dominion Group, representing rift-related volcanism that developed close to the edge of the continental margin (Robb et al., 1991; Jackson, 1991). More precise determinations from a representative sample of the Kraaipan Group is needed before a definitive age can be obtained for these rocks. The initial indications, however, are that the Kraaipan rocks are considerably younger than the 3,45 Ga Barberton greenstone belt, and may represent a time-equivalent of the Dominion volcanic event.

STOP 12: Serpentinized ultramafic body encircled by magnetite quartzites of the Gold Ridge Formation of the Kraaipan Group (Figure 13). Massive, easterly dipping, magnetite quartzites showing granular texture are traversed before reaching the ultramafic rocks which extend for approximately 500m and occur interlayered (?) or intruded (?) into the iron formations.

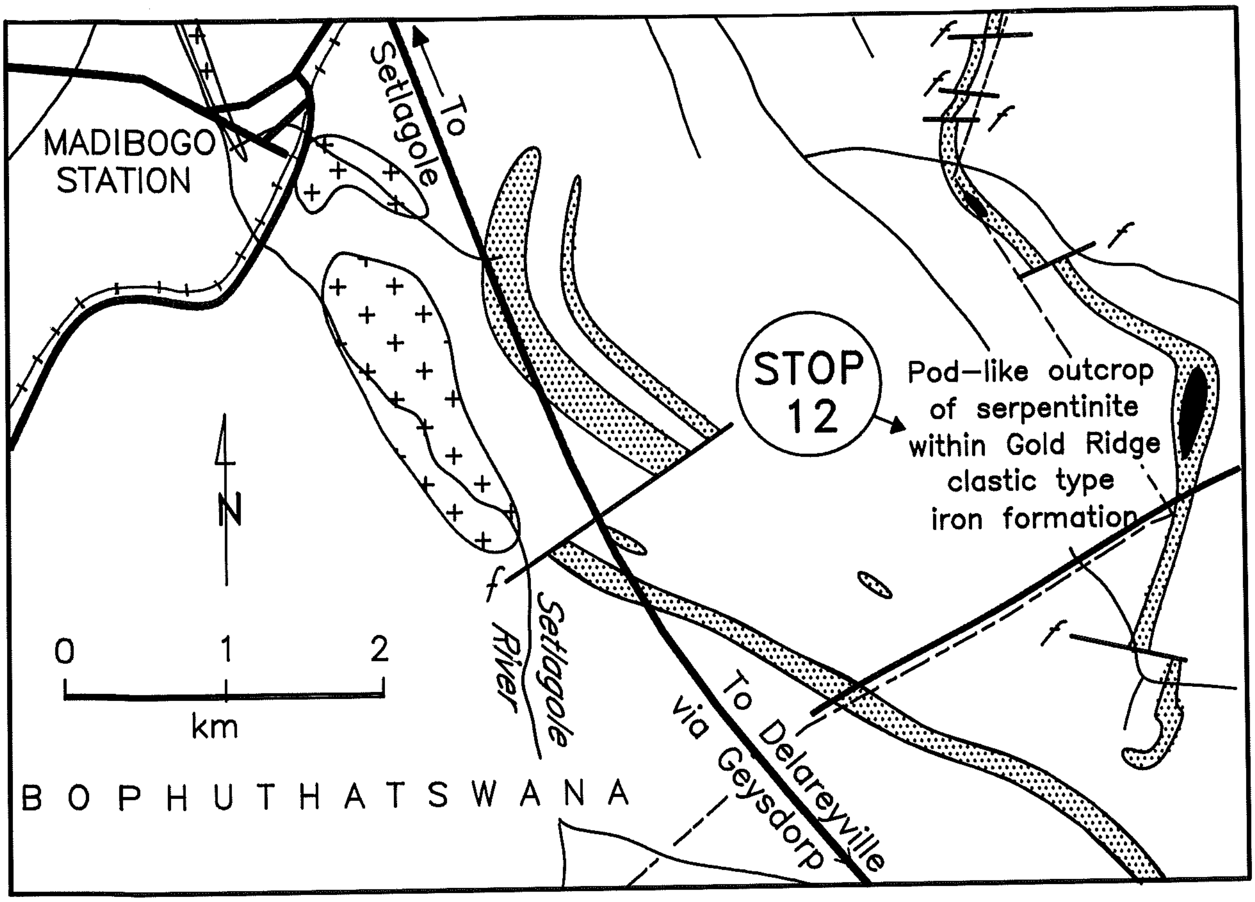


Figure 13: Schematic geological map of the area west of Madibogo. Pod-like serpentinite bodies (black) are associated with Gold Ridge Formation msgnetite-quartzites (spotted). The remainder of the area is sand covered except near Madibogo where granitic rocks outcrop along river channels.

The ultramafic rocks consist mainly of greyish-yellow serpentinites and form rough, weathered, surface exposures. In places relatively fresh ultramafic rocks may be seen which have a blue-green colour and which show coarse-grained textures reminiscent of the harzburgitic rocks seen in the layered ultramafic complexes in the Barberton greenstone belt (Anhaeusser, 1985). In thin section the ultramafic rocks are generally seen to be altered to antigorite, magnetite and chrysotile but the harzburgitic rocks contain serpentine veinlets, talc, magnetite, and tremolite (the latter probably representing altered clinopyroxene).

Magnetite, formed by the release of iron from the serpentinization of olivine, occurs as disseminated crystals in the serpentinites or concentrates into magnetite veins in places exceeding 5cm in width. Altered ultramafic rocks occur elsewhere associated with Kraaipan Group rocks but are less well-preserved and are never as extensive as seen at Stop 12.

Excursion rejoins the track 1km south and continues left (east) for 3.7km to Stop 13.

STOP 13: Massive white quartz vein ridge representing a shear zone in the Kraaipan succession occurs on south side of road.

Excursion continues east for 3km and turns left (north) just beyond a small spruit, continuing a further 1,3km along a bush track to an iron-formation ridge at Stop 14.

STOP 14: Contorted banded magnetite-chert iron formation. The ridge exposes spectacular outcrops of intensely folded chert-rich iron formation of a type unlike the magnetite-quartz zites seen at Stop 12. The iron-formations generally dip approximately 45°E and the isoclinal folds plunge approximately 70°NNE, as do the lineations seen on most surfaces in the area. The BIF ridge occurs in total isolation with respect to the surroundings and no other rock types are exposed in the vicinity. The hill probably constitutes a southward verging fold structure (?).

Excursion returns to the track 1,3m south, turns left (east) and proceeds for 1,1km to T-junction. Turn left (north) to Khunwana, continue through village, cross river, and head east to second T-junction 11,1km from first T-junction. Turn left (north) to Kraaipan Siding and proceed for approximately 1km. Turn right (east) and follow track for 1,7km. Walk east through thick bush for 100-200m to river bed (Stop 15).

STOP 15: Migmatites and gneisses on eastern edge of Kraaipan greenstone belt. The usually dry river bed provides the only exposures of Archaean basement granitic rocks in the area. The most interesting exposures are to be seen in a bend in the Tlhakajeng River (Figure 14) where, over a distance of about 100m, gneissic granitic rocks intertongue with greenstone assemblages of the Kraaipan Group.

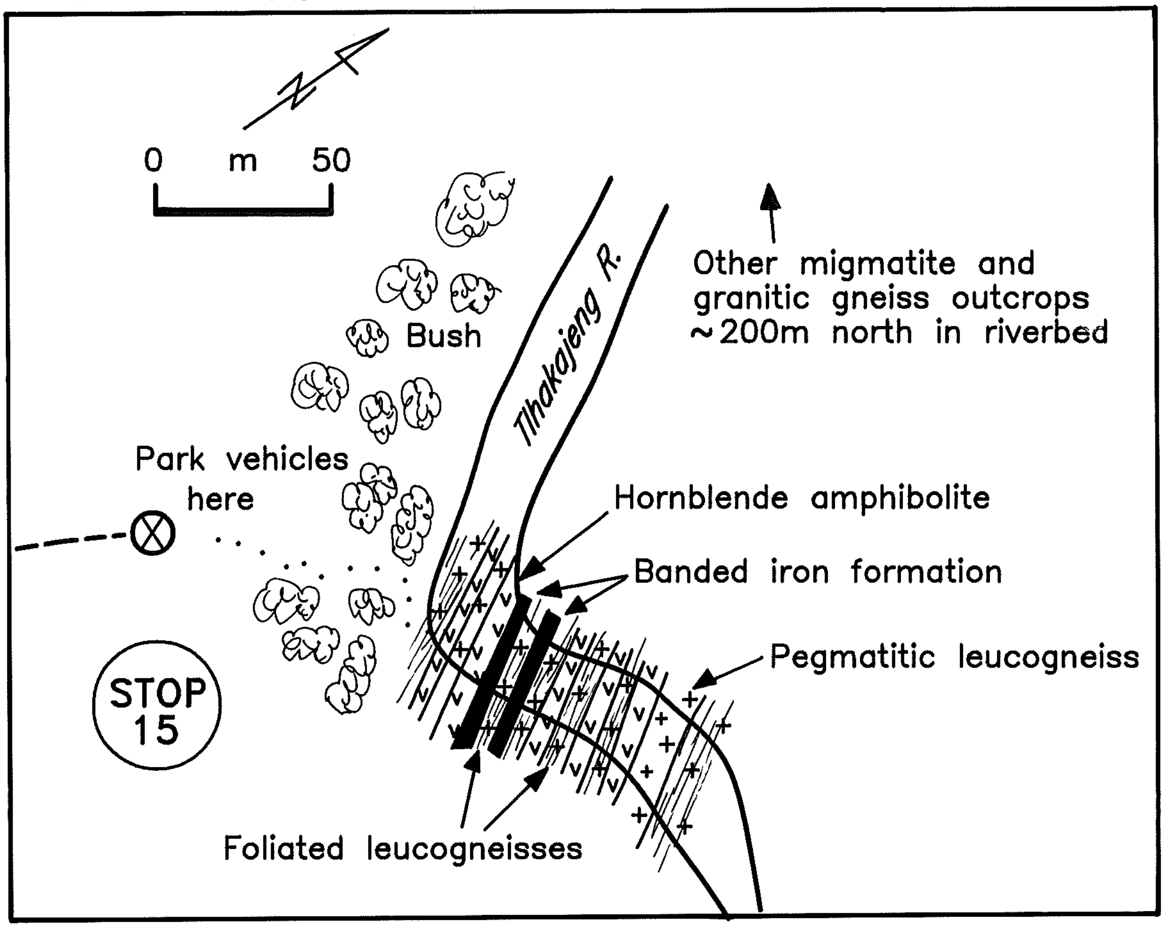


Figure 14: Schematic geological map of exposures seen in a bend of the Tlhakajeng River on the eastern edge of the Kraaipan greenstone belt northeast of Khunwana.

Pegmatitic rocks, foliated gneisses, amphibolites and BIF units are repeated across the traverse section. The gneisses are intruded as lit-par-lit veins or sheets into the amphibolites and BIF's and are clearly later than the greenstone successions. These exposures typify the Archaean granitic gneiss basement in the area and similar rocks can be seen 50km to the north at the Disaneng Dam spillway (Stop 30). Likewise, the gneisses seen near Schweizer-Reneke (Stop 2) and west of the Amalia greenstone belt (Stop 8) are considered to be of this type and represent the oldest granitic rocks recognized in the western part of the Kaapvaal Craton.

Excursion returns to Khunwana-Kraaipan road, turns right (north) and proceeds for approximately 8km to village near Kraaipan Siding. Turn left (west) near bus stop sign and follow track towards a windmill and then further south to the Khunwana River (Stop 16).

STOP 16: Sheared felsic schists in Khunwana River. These outcrops occur in isolation in the river bed, being surrounded by sand and debris in the water course. Further to the west, magnetite quartzites of the Gold Ridge Formation are present, together with sporadic showings of extensively carbonated ultramafic rocks. The felsic schists consist of mylonitic quartz-sericite rocks with crenulation folding evident in places. Samples from this locality, together with others from felsic interlayers in banded cherts at Stop 19, contained small, poor quality zircons used to date the Kraaipan rocks (see earlier).

Excursion returns to main road, continues north to turnoff right (east) located just before railway track and grain elevators at Kraaipan Siding. Proceed east for 1,6km to granite outcrops (Stop 17).

STOP 17: Medium-fine-grained, pink, homogeneous granite forming domical exposures. This granite type outcrops extensively north and east of Kraaipan Siding and is considered to be intrusive into the gneisses and migmatites of the type seen at Stop 15. No contact relationships are known between the two granitic varieties. The rock contains microcline, plagioclase, quartz, and accessory amounts of biotite. Similar pinkish-grey homogeneous granites can be seen on the east bank of the Disaneng Dam approximately 50km to the north (Stop 30). A pinkish, foliated variety of this granite may also be seen at Stop 22 southeast of Setlagole.

Excursion returns to main road, crosses railway line, and proceeds 11,6km to Stop 18.

STOP 18: Gold Ridge-Ferndale farm area (Figure 15). This region has been identified as the type locality for the Kraaipan Group of rocks (Van Zyl, 1972; SACS, 1980; this report - see earlier). Recent mapping by O.T. Zimmermann and drilling by the Geological Survey has provided new information in this area (Zimmermann, 1991). Various iron-formation units and chert horizons of the Gold Ridge, Ferndale and Khunwana Formations occur to the west of the road and the intervening sand covered valleys are underlain by schistose metabasaltic volcanic rocks. These mafic schists can be seen in pits and trenches near borehole locality FR2 (Stop 18).

Excursion continues north for 1,4km past farmhouse and labourers' houses to Stop 19 (Figure 15).

STOP 19: Banded chert, jaspilite and minor interlayered silicified felsic agglomerates and tuffs of the Ferndale Formation (?). Samples of the tuffaceous components found interlayered with the cherts west of the road yielded some small, poor quality zircons, which together with those from locality Stop 16, were used to obtain an age of approximately 3075Ma for the Kraaipan Group (see earlier).

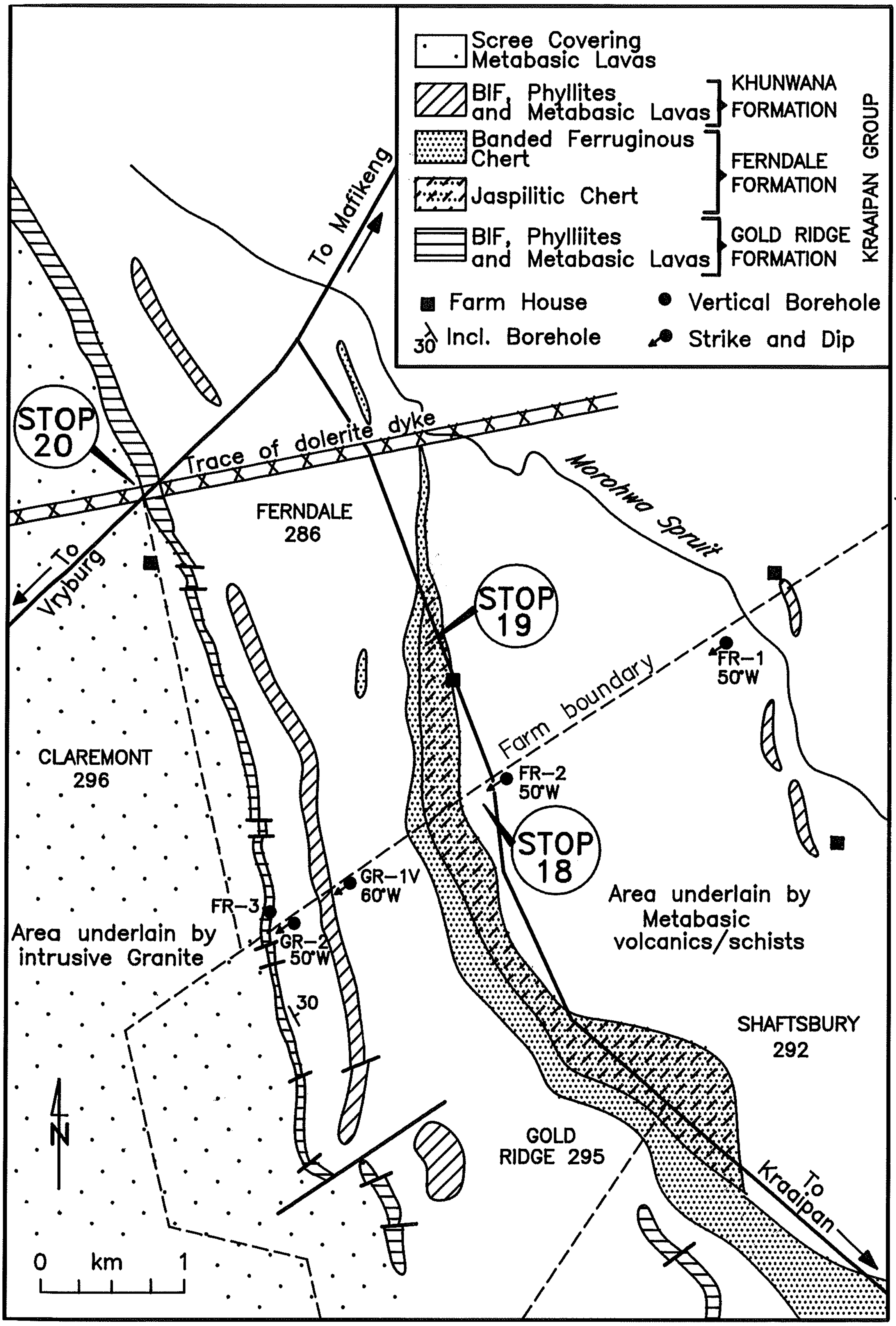


Figure 15: Schematic geological map of the Kraaipan Group type locality on the farms Gold Ridge 295 and Ferndale 286, north of Kraaipan Siding. The positions of boreholes drilled by the Geological Survey are indicated northeast and southwest of Stop 18.

Excursion continues north for 2,6km to the Vryburg-Mafikeng tar road (R27). Turn left (southwest) and proceed for 2km to Stop 20 (Figure 15).

STOP 20: Gold Ridge Formation banded iron formation.
Massive magnetite-quartzite iron formation unit dipping east at approximately 60°. Poor exposures do not permit contacts to be seen with granitic rocks to the west. Mafic volcanic rocks occur to the east in the sand-filled valley separating the Gold Ridge Formation from iron formations of the Khunwana Formation.

Excursion proceeds southwest to Setlagole, Stella and Vryburg for overnight stop at the Grand Hotel (95km).

DAY 3: OUTCROPS OF THE NORTHERN KRAAIPAN GROUP IN THE STELLA, SETLAGOLE, MOSITA, LOGAGENG, MAKGOBISTAD AND MAFIKENG AREAS

Sunday, November 3, 1991

7.45 a.m. Excursion leaves from the Grand Hotel, Vryburg, travelling north on R27 for 43,9km to Stop 21. En route, a few kilometres north of Vryburg, hills seen to the west comprise southerly dipping units of the Vryburg Siltstone Formation, the latter overlain by the Campbell Group which consists mainly of the Ghaap Plateau Dolomite Formation (SACS, 1980). The flat terrain north of Vryburg is underlain by Ventersdorp Supergroup rocks but approximately 10km southeast of Stella, hills of Kraaipan Group rocks can be seen protruding through the flat-lying Ventersdorp rocks east of the road.

STOP 21: Kraaipan banded iron formation breccia.
A road cutting 2km south of Stella displays spectacular iron formation breccia. The best, most photogenic relationships are seen in large boulders piled on the east side of the cutting. Here large blocks of BIF are encased in a matrix of iron-rich material, quartz and finer chert and iron-formation grit. Folded BIF fragments are also present indicating that the breccia seen at Stop 21 developed after the Kraaipan rocks had been deformed. The breccia seen at Stella can be traced intermittently for over 30km in a northerly direction to Papiesvlakte where the rocks consist mainly of siliceous cherty breccia. The brecciated Kraaipan rocks seen at this locality probably developed at the edge of regional fault scarp.

Excursion continues north along R27 for 39km to Setlagole. Before T-junction to Mosita turn right into farm gate and proceed to west bank of Setlagole River (Stop 22).

STOP 22: Outcrops in Setlagole River of pinkish, fine-grained, foliated granite similar to that seen at Stop 17 near Kraaipan Siding. The granite has a vertical to steeply NW-dipping foliation, is generally homogeneous, but in places shows minor hydraulic brecciation and porphyritic texture. In thin section the rocks contain quartz, microcline, plagioclase, magnetite and biotite, the latter being aligned in the plane of the foliation.

Excursion returns to main road, turns right (northeast) and crosses the bridge over the Setlagole River to examine outcrops at Stop 23.

STOP 23: Amphibolite xenoliths, pegmatites and foliated gneisses in Setlagole River and on east bank of river. This exposure is similar to that seen at Stop 15 on the eastern side of the Kraaipan greenstone belt and represents the early basement in the area, the latter intruded (?) by the pinkish-grey foliated granite seen at Stop 22. *

Excursion returns to T-junction near Setlagole, turns right (northwest to Mosita) and continues along R376 sand road to a second T-junction 16,8km from Setlagole. Turn left (west to Mosita) and proceed for 28km to Stop 24.

STOP 24: Mosita granite exposures in and near spruit (named Mosita se Laagte). Outcrops occur mainly on south side of road forming extensive exfoliated platforms and water-worn river exposures. The Mosita Granite is a coarse-grained pinkish granite with a very even homogeneous texture. Some jointing can be seen in places and one very small mafic xenolith can be seen in the river bed. Large xenoliths of Kraaipan BIF occur to the northeast of this locality on property used as a military base. This area is generally inaccessible to the public. Clearly, however, the Mosita Granite represents a late granite variety and in thin section is made up of quartz, microcline, perthite, plagioclase (largely altered to sericite), hematite and magnetite. The feldspars appear to be hydrothermally altered and show potassium metasomatic replacement textures.

Excursion returns along same road (travelling east) for 2km to Stop 25.

STOP 25: Kraaipan Group banded chert ridge on south side of road. This chert horizon forms part of the western or Stella belt of Kraaipan rocks but correlation with other units is rendered difficult due to the isolated nature of the exposures. On the west side of the banded chert poor outcrops of altered porphyritic basalt can be seen. In thin section acicular needles of plagioclase occur in an aphanitic matrix containing relic clinopyroxene crystals, the latter almost totally altered to chlorite. Some iron ores (hematite/magnetite) are also present.

Excursion continues east for 13,2km to a small river exposure at Stop 26.

* Approximately 300m downstream (north of bridge) is a spectacular platform exposure of megabreccia containing a variety of rock types, including large fragmental blocks of foliated granitic gneiss. The megabreccia is of uncertain age and derivation, but is possibly linked to the explosive activity associated with Makwassie volcanism (Platberg Group , Ventersdorp Supergroup).

STOP 26: Bosch Kop Formation sediments in watercourse on north side of road. A traverse of approximately 100m in the river bed shows a succession of conglomerates, sandstones and shales. According to Du Toit (1906) these rocks occur between Setlagole and Mosita and they also underlie the town of Mafikeng 75km to the northeast (see also SASCS, 1980). Du Toit (1906) noted that these sediments pass upwards into diabases and amygdaloidal volcanic rocks.

The conglomerate consists of angular and rounded fragments of locally derived rocks in a matrix varying from coarse grained to gritty. Clasts of BIF and jaspilite are angular to subrounded. The lava clasts are normally small and well rounded and two types are present. These include schistose and non-schistose types that are green and fine to very fine grained. Some of the pebbles of non-schistose lava contain amygdales. Pebbles of two types of granite are also present (granite and granitoid gneiss), both of which are usually well-rounded. Following the visit to Stop 24 some of the granite clasts might readily be equated with the coarse-grained Mosita Granite. Another pebble type recorded includes sugary, medium-to-coarse-grained grey quartzite. The Bosch Kop Formation contains pebbles of schistose lava, iron formation and jaspilite which undoubtedly derives from the Kraaipan succession. The amygdaloidal lava pebbles, according to SACS (1980), stem from the Platberg Group which suggests the Bosch Kop rocks are post Ventersdorp in age. The presence of Mosita Granite pebbles in the conglomerates suggest this intrusive granite type is at least as old as the Ventersdorp succession but probably precedes it.

Excursion continues east for 5,1km to T-junction and turns left (northwest), before proceeding along R376 for 22,5km to forked road (signposted to Maretsane). Continue left (northwest) along R375 for 17,6km and turn right (northeast) into farm gate on Martins Bush 200 (Figure 16). Follow track along fence until it splits into three tracks. Follow middle track to fence and over ridge of BIF/jaspilite. Continue along fence turning south and proceed to edge of outcrops of amygdaloidal Ventersdorp (?) or Bosch Kop (?) lavas (total distance from main road is 2km). Walk along footpath alongside fence for approximately 400m to Stop 27 (Figure 16).

STOP 27: Outcrops of jaspilitic iron formation and interbedded mafic lava. At this locality red jaspilitic iron formation can be seen to be overlain by a mafic volcanic layer approximately 1m thick in which pillow structures showing younging directions to the east are evident. The pillow lava unit is, in turn, overlain by more red jaspilitic BIF. The rocks are folded in places and continuity of exposure is limited to only a few metres. Other outcrops in the immediate vicinity show mafic lava intertonguing in what appears to be a magmatic/volcanic "intrusive" relationship. A thin section examination of the amygdaloidal basalt revealed the presence of fine-

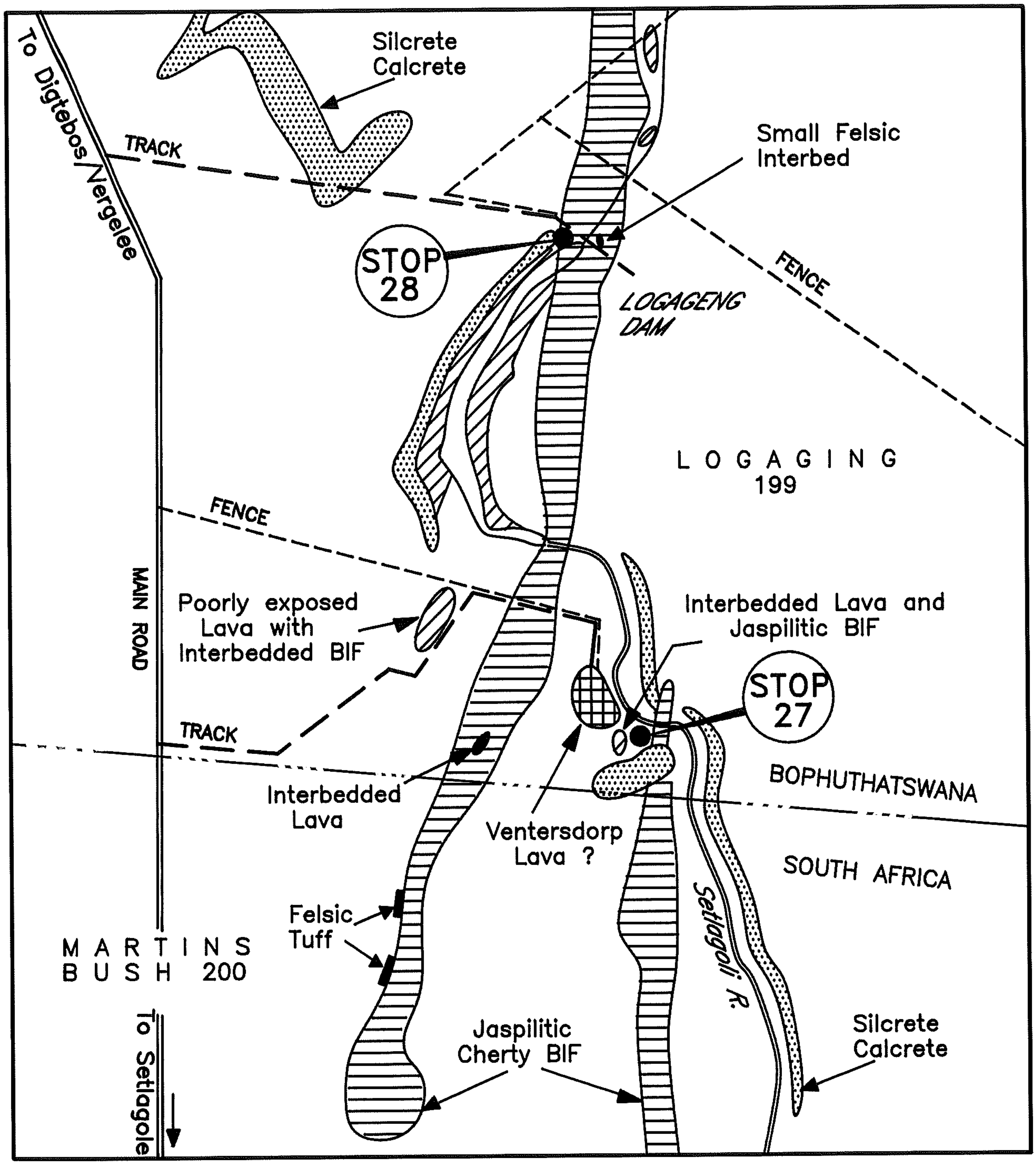


Figure 16: Schematic geological map of the Logageng exposures on the farms Logageng 199 and Martins Bush 200 northwest of Setlagole.

grained chlorite, sericitized plagioclase, and minor carbonate. Iron-oxides occur in the fine matrix. The rock shows no signs of deformation. The outcrop described above is a NO HAMMER EXPOSURE, but bring your camera.

Excursion returns to main road, turns right (north) and proceeds for 2,2km to gate. Turn right (east) and follow along south side of fence for 1,7km to Logageng Dam wall (Stop 28, Figure 16).

STOP 28: Logageng Dam Wall - jaspilitic banded iron formation. The dam wall on the Setlagole River is sited in a gorge where the river cuts through a spectacular development of colourful jaspilite. The jaspilite is well exposed and shows numerous features of interest including local brecciation, quartz replacement in hydraulic fractures and intricate folding. Cross over dam wall for further good exposures. On the west bank of dam near the dam wall is a pinkish brown weathered felsic volcanic rock referred to by Du Toit (1906) as being of rhyolitic character. A thin section examination showed that the rock is made up of very fine grained sericite and feldspar with minor chlorite present. Oxidation along fissures and joints results in staining by iron oxides. Du Toit's assessment of the rocks being rhyolitic appears to be soundly based.

Excursion returns to main road passing over the edge of some Kalahari silcrete and calcrete containing fragments of lava and jaspilite (see Figure 16). At the gate turn right (north) and proceed 6,1km to T-junction (small farm store with Joko sign). Turn right (east) and continue for 3,3km to river. Continue beyond river for 9,7km to Logagane turnoff. Turn right (east) and drive 43,2km to Makgobistad (Figure 17). Turn left (north) and drive through village (3,8km) to Stop 29.

STOP 29: Kraaipan pillow lavas and banded iron formation along south bank of Molopo River on the Bophuthatswana-Botswana border. This stop is designed to show the undeformed nature of the Kraaipan volcanic rocks in the area. Well-formed pillow lavas showing interpillow carbonate and quartz fillings, pillow selvedges, amygdales and gas vesicles are abundant in the area. The volcanic rocks are extensively altered, however, with epidote being seen in veins and cavities as well as pervasively influencing the massive lavas. The iron formations seen in the area are of the Gold Ridge Formation type comprising bedded coarse-granular magnetite-quartzite.

Excursion returns to main road, turns left (east) and continues 21,3km to turnoff to Disaneng Dam. Continue for 4,4km to dam spillway on west side of dam wall (Stop 30).

STOP 30: Disaneng Dam Spillway. Basement gneisses and migmatites as well as later, cross-cutting, granite dykes and veins. This stop again shows gneisses and migmatites which are considered to be the oldest granitic rocks present in the western sector of the Kaapvaal Craton. The rocks in the spillway are altered but nevertheless demonstrate the nature of the gneisses and their contained greenstone (amphibolite) xenoliths. Pinkish-red pegmatites and finer-grained homogeneous granites cut the gneisses. On the eastern edge

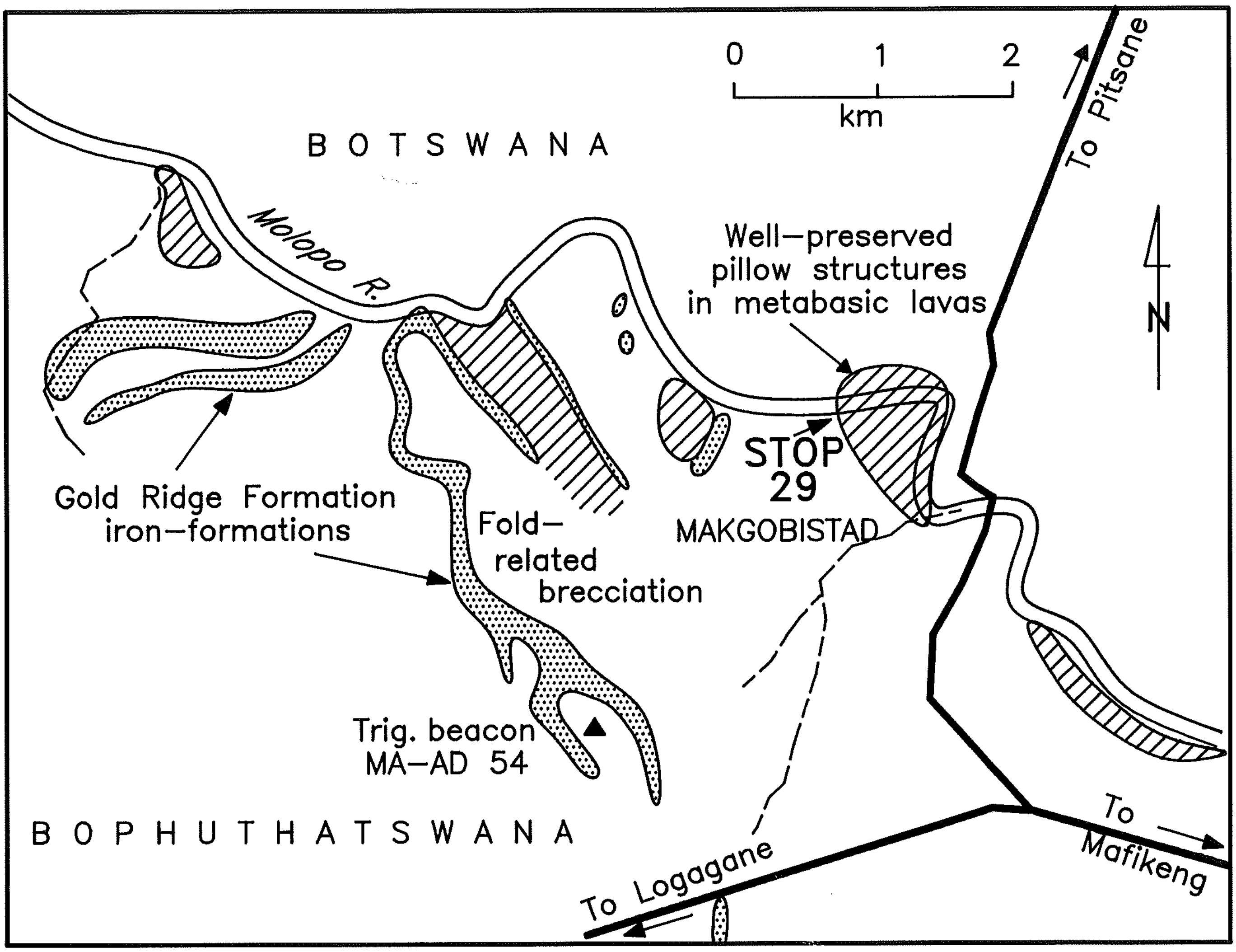


Figure 17: Schematic geological map of the Kraaipan exposures along the Molopo River between Botswana and Bophuthatswana in the Makgobistad area. Kraaipan rocks extend north for approximately 15km into Botswana but are also poorly exposed, being covered by Kalahari sand.

of the dam the pink, homogeneous granites are identical to those seen at Stop 17 near Kraaipan Siding.

Excursion returns to main road, turns right (east) and continues 32,2km to Mafikeng. The excursion ends officially in Mafikeng, but continues to Johannesburg via Lichtenburg (63km), Koster (84km), Magaliesberg (69km) to Johannesburg (45km).

PRELIMINARY GEOPHYSICAL INVESTIGATIONS OF THE KRAAIPAN GRANITE-GREENSTONE TERRANE

The Geological Survey has undertaken preliminary geophysical investigations in the region extending from the Botswana border south through Stella and Kraaipan to Vryburg. A regional gravity survey (Figure 18A) as well as an aeromagnetic survey (Figure 18C) have been completed and the results evaluated by Stettler et al. (1990). In the north, near the Botswana border, the gravity contour map indicates the Kraaipan rocks correlate with two major gravity highs. These two highs are interconnected with a gravity-high plateau (profiles ABC and DE in Figure 18C) that becomes narrower northwards and which correlates with the western belt of outcrops. It is believed that the gravity highs are caused by the magnetite quartzites and banded iron formations but it is uncertain as to what causes the gravity high plateau. Arguments used by Stettler et al. (1990) suggest that Kraaipan rocks cause the plateau and are more extensively developed below the Kalahari sand cover than was previously believed. Profile FGH in Figure 18C suggests also that an extensive development of Kraaipan rocks must still occur beneath the Ventersdorp lavas in the region northeast of Vryburg.

The magnetic data also correlate well with the outcrop pattern of the banded iron formations (Figure 18B). However, palaeomagnetic samples collected in the BIF's show a variable strong remanent magnetic component that hampers the interpretation of the magnetic data.

Preliminary interpretative results of the geophysical data suggests the Kraaipan rocks belong to a complex synclinal structure with a minor central anticline.

oOo

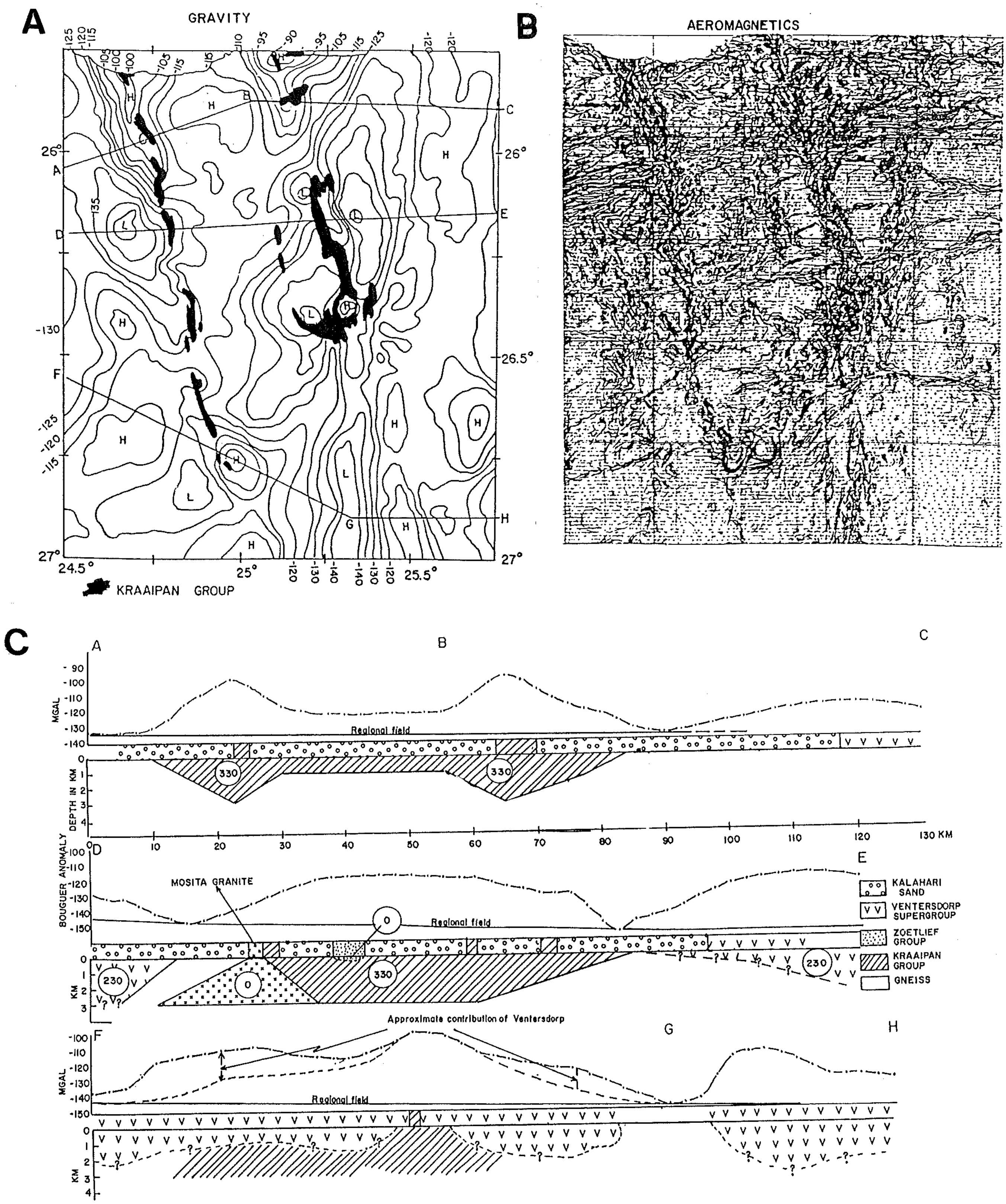


Figure 18. A. *Regional gravity survey covering the Kraaipan granite-greenstone terrane of the western and central belts in the Stella-Kraaipan-Mafikeng area. The results are shown as Bouguer anomaly contours in milligal.*

B. *Aeromagnetic pattern covering the same area.*

C. *Bouguer gravity profiles ABC, DE, and FGH across the northern Kraaipan granite-greenstone terrane (after Stettler et al., 1990).*

REFERENCES

Allsopp, H.L. (1964). Rubidium/strontium ages from the western Transvaal. Nature, 204 (4956), 361-363.

Anhaeusser, C.R. (1985). Archean layered ultramafic complexes in the Barberton Mountain Land, South Africa, 281-301. In: L.D. Ayres, P.C. Thurston, K.D. Card and W.Weber (Eds.), Evolution of Archean Supracrustal Sequences. Spec. Pap. Geol. Assoc. Canada, 28, 380pp.

Barton, E.S., Barton, J.M.Jr., Callow, M.J., Allsopp, H.L., Evans I.B. and Welke, H.J. (1986). Emplacement ages and implications for the source regions of granitoid rocks associated with the Witwatersrand Basin. Ext. Abstr. Geocongress '86, Geol. Soc. S.Afr., Johannesburg, 93-97.

De Wet,N.P. (1942). Die geologie en hydrologie in die omgewing van Vryburg, Kaap-provinsie. D.Sc Thesis (unpubl), Univ. Pretoria.

Drennan, G.R. (1988). The nature of the Archaean basement in the hinterland to the Welkom Goldfield. M.Sc Thesis (unpubl), Univ. Witwatersrand, Johannesburg, 187pp.

Drennan, G.R., Robb, L.J., Meyer, F.M., Armstrong,R.A. and De Bruiyn, H. (1990). The nature of the Archaean basement in the hinterland of the Witwatersrand Basin: II. A crustal profile west of the Welkom Goldfield and comparisons with the Vredefort crustal profile. S.Afr. J. Geol., 93 (1), 41-53.

Du Toit, A.L. (1906). Geological survey of portions of the divisions of Vryburg and Mafeking. Ann. Rep. Geol. Comm. Cape of Good Hope (1905), 205-258.

Du Toit,A.L. (1908). Geological survey of portions of Mafeking and Vryburg. Ann. Rep. Geol. Comm. Cape of Good Hope (1907), 123-157.

Du Toit, A.L. (1926). The Geology of South Africa. Oliver and Boyd, Edinburgh, 463pp.

Du Toit, A.L. (1956). The Geology of South Africa. Oliver and Boyd, Edinburgh, 3rd ed., 611pp.

Engel, A.E.J., Engel,C. and Havens, R.G. (1965). Chemical characteristics of oceanic basalts and the upper mantle. Bull. Geol. Soc. Amer., 76, 719-734.

Helgren, D.M. (1979). River of Diamonds: an Alluvial History of the Lower Vaal Basin. Univ. Chicago, Dept. Geogr. Res. Pap., 185, 399pp.

Jackson, M.C. (1991). The Dominion Group: a review of the late Archaean volcano-sedimentary sequence and implications for the tectonic setting of the Witwatersrand Supergroup, South Africa. Inform. Circ. Econ. Geol. Res. Unit, Univ. Witwatersrand, Johannesburg, 240, 40pp.

Jorissen, E. (1905). Notes on some intrusive granites in the Transvaal, the Orange River Colony and in Swaziland. Trans. Geol. Soc. S. Afr., 7(3)(1904), 151-160.

Marshall,T.R. (1991). The diamondiferous gravels of the southwestern Transvaal. Abstr.Vol.5th Int. Kimberlite Conference, Araxà, Brazil.

Mayhew, V. Editor (1978). Reader's Digest Illustrated Guide to Southern Africa. Reader's Digest Assoc., Cape Town, 544pp.

Moore, J.G. and Peck, P.L. (1962). Accretionary lapilli in volcanic rocks of the western continental United States. J. Geol., 70, 182-193.

Robb, L.J., Davis D.W. and Kamo, S.L. (1991). Chronological framework for the Witwatersrand Basin and environs: towards a time-constrained depositional model. S.Afr. J. Geol., 94, 86-95.

Rogers, A.W. (1908). Geological survey of parts of Vryburg, Kuruman, Hay and Gordonia. Ann.Rep. Geol. Comm. Cape of Good Hope (1907), 9-122.

South African Committee for Stratigraphy (SACS)(1980). Stratigraphy of South Africa. Part I (Comp. L.E. Kent). Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia, and the Republics of Bophuthatswana, Transkei and Venda. Handbk. Geol. Surv. S. Afr., 8, 690pp.

Stettler, E.H., Du Plessis, J.G. and Share, F.G. (1990). Preliminary results of a geophysical investigation into the Kraaipan rocks. Ext. Abstr. Geocongress '90, Geol. Soc. S. Afr., Cape Town. (Late Abstracts p25-28).

Truter, F.C. (1950). A review of volcanism in the geological history of South Africa. Proc. Geol Soc. S. Afr., 52 (1949), xxix-lxxxix.

Van Eeden, O.R. Compiler (1962). The geology of the Republic of South Africa. An explanation of the 1:1000000 map, 1970 edition. Spec. Publ. Geol Surv. S. Afr., 18, 85pp.

Van Eeden, O.R., De Wet, N. P. and Strauss, C.A. (1963). The geology of the area around Schweizer-Reneke. Expl. sheets 2427B (Pudimoe) and 2725A (Schweizer-Reneke). Geol Surv.S.Afr., 76pp. (1:125000 scale map produced in 1962).

Van Zyl, C.Z. (1972). Die geologie van Blad 2625A (Kraaipan). Unpubl. Rep. Geol. Surv. S. Afr.

Vearncombe, J. R. (1986). Structure of veins in a gold-pyrite deposit in banded iron formation, Amalia greenstone belt, South Africa. Geol. Mag., 123 (6), 601-609.

Visser, D.J.L. Compiler (1989). The geology of the Republic of South Africa, Transkei, Bophuthatswana, Venda and Ciskei and the Kingdoms of Lesotho and Swaziland. Explan. 1:1000000 Geol Map, 4th ed., 1984. Geol Surv. S. Afr., 491pp.

Von Backström, J.W., Schumann, F.W., Le Roex, H.D., Kent, L.E. and Du Toit, A.L. (1953). The geology of the area around Lichtenburg. Explan. sheet 54 (Lichtenburg). Geol Surv. S. Afr., 61pp.

Zimmermann, O.T. (1991). Geological aspects of the Kraaipan Group in the northern Cape Province and Bophuthatswana. Unpubl. Rep. Geol. Surv. S. Afr., 114pp.