ECONOMIC GEOLOGY RESEARCH UNIT

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CONTINENTAL SEDIMENTATION AND VOLCANISM IN THE DOMINION GROUP OF THE WESTERN TRANSVAAL : A REVIEW

M. B. WATCHORN

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UNIVERSITY OF THE WITWATERSRAND
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by

M. B. WATCHORN
(Research Assistant, Economic Geology Research Unit)

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CONTENTS

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ABSTRACT

The Dominion Group is developed in the southwestern Transvaal where it rests unconformably on a granite-greenstone basement. The sequence comprises a basal clastic unit overlain by a considerable thickness of volcanic rocks. The sediments, which are up to 120 metres thick, are mainly arkosic arenites with numerous interbedded conglomerates. The majority of these conglomerates are laterally impersistent, although two of them have attracted attention due to the presence of placer mineralization. Limited palaeocurrent data display a unimodal distribution, suggesting that deposition was controlled by a braided fluvial environment, which derived sediment from an eastern highland. A gradual upward increase in the proportion of volcanic material indicates a period of coeval sedimentation and volcanicity.

The upper, predominantly volcanic succession attains a maximum thickness of 2 600 m. It may be subdivided into a lower formation dominated by basic to intermediate lavas and pyroclastics, overlain by an upper sequence of felsic lavas with interbedded tuffs. In the Ottosdal area, a number of pyrophyllite-rich horizons are developed in the upper stratigraphy. These are interpreted as beds of volcanic ash, which were subjected to secondary removal of silica by percolating ground water.

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CONTINENTAL SEDIMENTATION AND VOLCANISM IN THE DOMINION GROUP OF THE WESTERN TRANSVAAL : A REVIEW

I. INTRODUCTION

The original term "Dominion Reef Series" was coined by Molengraaf (1905) for a succession of clastic sediments which he considered to conformably underlie the Witwatersrand Supergroup. However, subsequent mapping by Nel (1935) showed that the Dominion sediments are succeeded by a sequence of lavas, which he included in the "Dominion Reef Series" as the lowermost subdivision of the Witwatersrand Supergroup. Molengraaf had previously assigned these lavas a Ventersdorp age.

Numerous attempts have been made to correlate the Dominion Group with other volcanic and volcano-sedimentary units in South Africa. These include the Godwan Formation (Truter, 1949), which recent work has suggested is equivalent to the upper division of the Witwatersrand Supergroup (Button, 1978) and the Kanye Volcanic Group (Du Toit, 1946) which probably represents a Ventersdorp protobasin (Tyler, 1979). Correlation with the Nsuze Group is rejected due to the greater age of the Nsuze lavas (Burger and Coertze, 1973), whereas lithologic similarities suggest a parallelism between the Pietersburg Sequence and the Swaziland Supergroup (Saager and Muff, 1978). Consequently, present evidence implies that the development of the Dominion Group was restricted to the Western Transvaal, where it represents a precursor to the main Witwatersrand basin.

II. GEOLOGICAL SETTING

Exposure of the Dominion Group is most extensive to the west of Klerksdorp and in the Ottosdal district, where it comprises a lower arenaceous unit, succeeded by a thick sequence of volcanic rocks (Figure 1). The basal sediments rest nonconformably on a potassic granite with an Rb-Sr age of 2 900 m.y. This is consistent with radiometric data from the Dominion lavas, which indicate an age of approximately 2 800 m.y. (Burger and Coertze, 1973). The Dominion Group is generally topographically subdued and is unconformably overlain by the more prominent basal members of the Witwatersrand Supergroup (Malan, 1959). Much of the Dominion succession is obscured by widespread Ventersdorp lavas, and discrimination between representatives of these two ages of volcanic rocks is often difficult (von Backström, 1962).

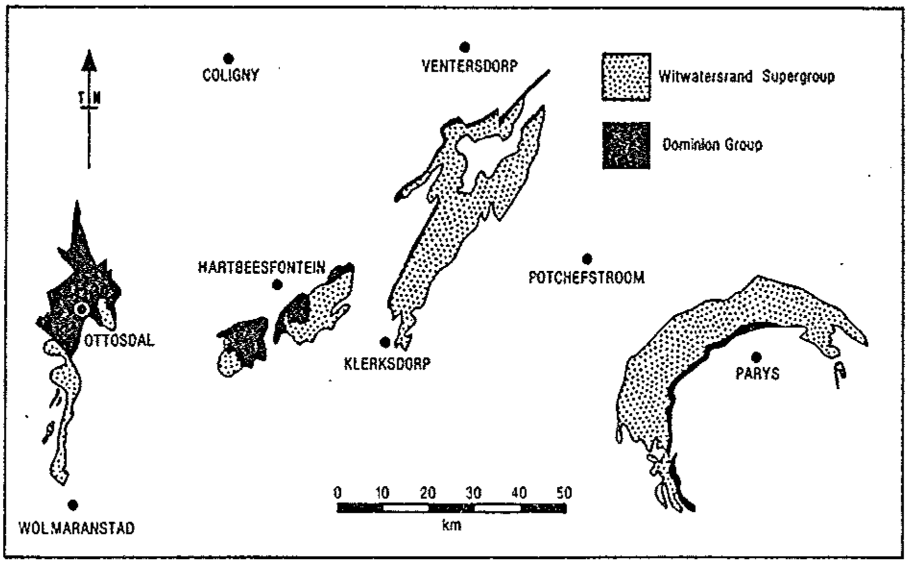

Figure 1 : *Distribution of the Dominion Group and its relationship with the Witwatersrand Supergroup in the southwestern Transvaal.*

In the areas surrounding Ottosdal and west of Klerksdorp, the Dominion Group is preserved in three broad synformal structures, which plunge towards the south and southwest. These major structures apparently have been refolded by a series of smaller-scale open folds, with axes oriented north-south and northeast-southwest. Intervening antiforms are concealed, either by Ventersdorp lavas, or as the result of brittle fracture. North of Klerksdorp, volcanic rocks belonging to the Dominion Group are exposed on the south-eastern limb of the Varkenskraal anticline, which plunges towards the northeast. The change in plunge direction of the major structures from southwest, in the Ottosdal area, to northeast, on the Varkenskraal anticline, is possibly attributed to the Molopo anticlinal warp of Pretorius (1979).

Dominion strata also crop out on the northern rim of the Vredefort dome, where a dark-coloured amygdaloidal rock forms an easterly-thinning unit (Nel, 1927). This volcanic sequence is overturned towards the south and southeast and lies unconformably beneath the Orange Grove Formation.

III. THE STRATIGRAPHY OF THE DOMINION GROUP

The stratigraphic framework of the Dominion Group was originally constructed by Nel (1935) for the area west of Klerksdorp. Subsequent studies by von Backström (1952, 1962) in the Ottosdal district and by Malan (1959) on the basal sediments at the Dominion Reefs mine generally concurred with Nel's (1935) original column. Since then, the South African Committee for Stratigraphy (in prep.) have refined the stratigraphic nomenclature for the sequence, in addition to further subdividing the upper volcanic suite (Figure 2). In the following sections, discussion of the stratigraphic relationships in the Dominion Group will be confined to the Hartbeesfontein and Ottosdal areas, where the succession is best developed.

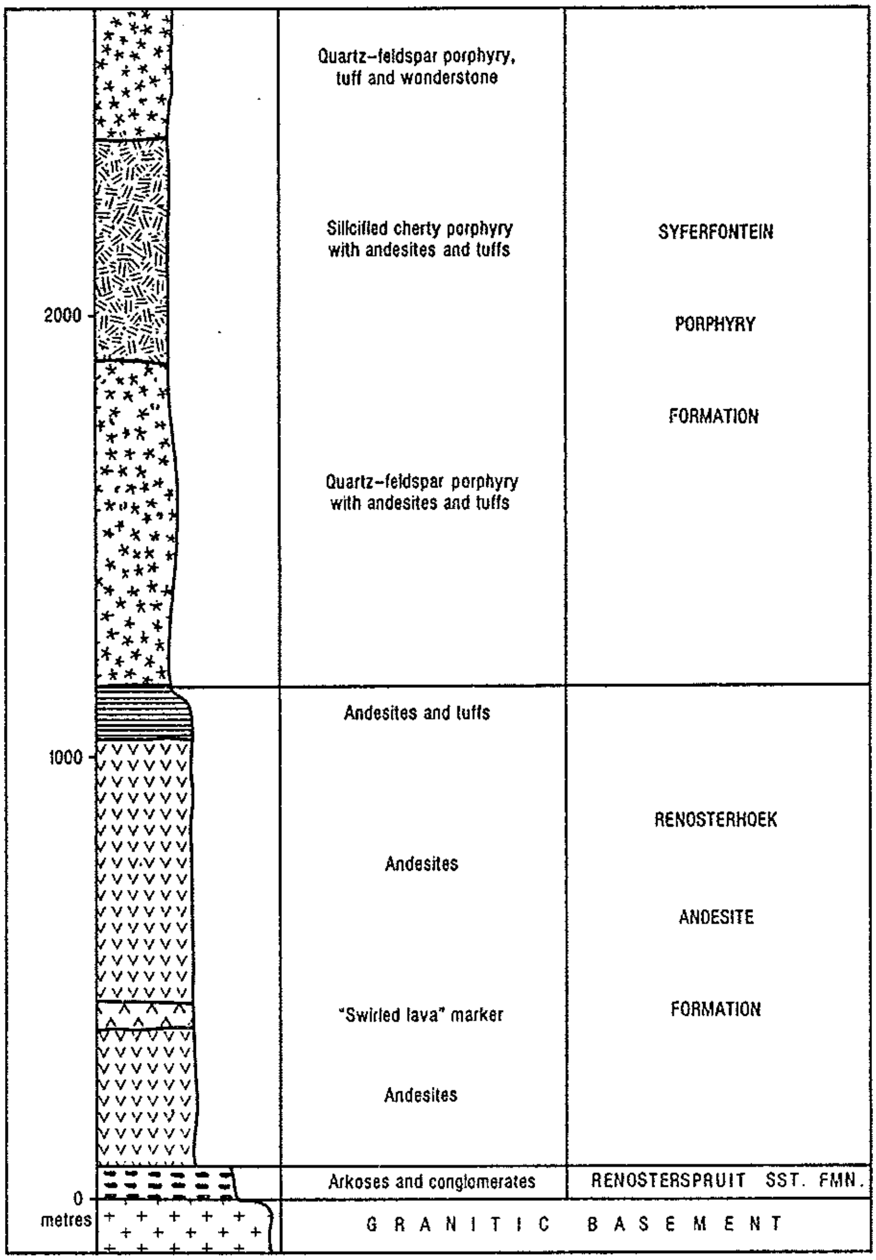

Figure 2 : General stratigraphic subdivision of the Dominion Group (after S.A.C.S., in prep.)

A. *The Basement Granite*

The potassic granite forming the basement for the Dominion Group is sporadically exposed as a series of low, rounded outcrops, reflecting the effects of spheroidal weathering (Plate 1A). It is predominantly a homogeneous rock and is light-greyish in colour, although occasional porphyritic phases have been observed (von Backström, 1962). Petrographically, the granite is an hypidiomorphic rock, consisting essentially of quartz, small flakes of biotite, and microcline and oligoclase feldspars, with the potassic variety predominant. Rare cross-cutting pegmatites are comprised of quartz, microcline, and muscovite (Nel, 1935).

Approaching the base of the Dominion Group, the granite tends to become schistose over a thickness of up to 6 m. The schists are composed primarily of quartz and sericite and are blackish at the base, becoming a greenish colour towards the contact, where occasional pebbles are present (Malan, 1959). They are thought to represent a palaeosoil horizon which developed a schistosity, due to movement along the unconformity during deformation (Button and Tyler, 1979).

B. *The Renostersprujt Sandstone Formation*

The Renosterspruit Formation at the base of the Dominion Group is composed predominantly of coarse arkosic sediments, lenticular grits, and conglomerates. Towards the top of the unit, there is an increasing proportion of intercalated lavas and tuffs with a gradational transition into the overlying Renosterhoek Andesite Formation (Figure 3). The Renosterspruit Formation varies in thickness between 20 m and 120 m, due to the lenticular nature of the upper volcanic and clastic members and the irregular palaeotopography of the granitic basement. In this formation, most attention has been focused on two relatively persistent conglomerates near the base of the succession, due to their economic potential for placer-type gold and uranium mineralization. These deposits were previously exploited at the old Dominion Reefs and Klerksdorp Consolidated mines. The Afrikander Lease mine resumed production in December, 1979.

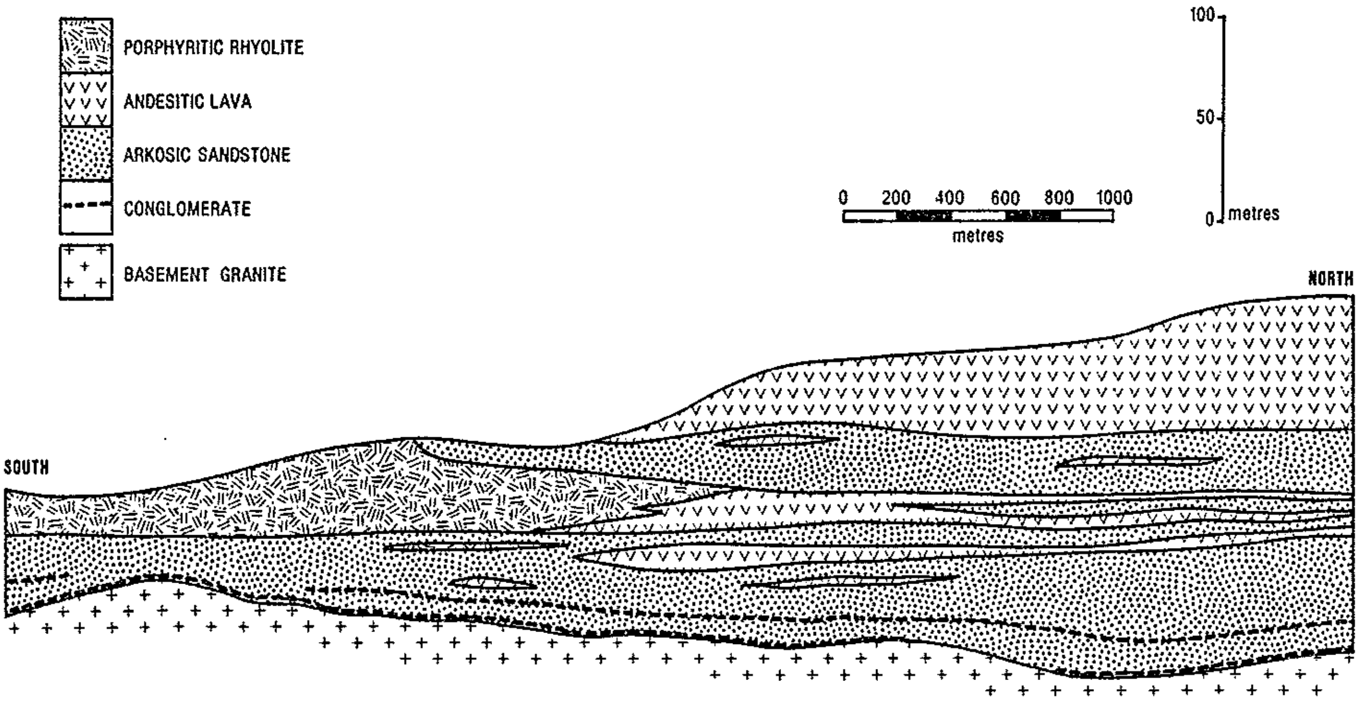

Figure 3 : Stratigraphy of the Dominion Group from the Ottosdal area (after von Backström, 1962).

The Lower Reef is a large-pebble conglomerate which nonconformably overlies the greenschist footwall (Plate 1B). Individual clasts are predominantly rounded vein-quartz, with a mean diameter of 7,5 cm, although occasional cobbles may reach 17,5 cm (Malan, 1959). The conglomerate has a coarse sericitic sandstone matrix and is up to 120 cm in thickness, including occasional thin lenses of sandstone. This conglomerate is primarily auriferous, with only minor and sporadic uranium mineralization (Hiemstra, 1968).

The Upper Reef in the Renosterspruit Formation is generally a small-pebble conglomerate, with a mean thickness of 22,5 cm (Plate 1C). It is a relatively persistent horizon and is chiefly a uranium-bearer, with little or no associated gold (Simpson, 1954). The bulk of the mineralization in the Upper Reef is contained in what Malan (1959) refers to as a 2,5 cm "argillaceous band" within which there is a significant concentration of heavy minerals. This lamina is generally developed at the top contact of the Upper Reef and, excluding the heavy-mineral fraction, is composed essentially of chlorite, with occasional biotite flakes and quartz grains and pebbles. Since the association of heavy minerals is incongruous with suspension sediments, the chlorite and biotite probably represent the alteration products of dense ferromagnesian minerals. These were concentrated, along with other heavy minerals, on an extensive erosion surface overlying the Upper Reef. The mineralization in the matrix of the Upper Reef suggests that uraninite filtered down into the underlying gravel framework.

Above the Upper Reef, there are varying proportions of intercalated tuffs, lavas, and clastics. The sandstones are medium- to coarse-grained arkoses, with impersistent gritty phases near the base, and display a gradual upward-increase in interbedded volcanic units. The lavas are essentially porphyritic andesites, although more felsic varieties may be present. They frequently form lensoid bodies which have a maximum thickness of 60 m.

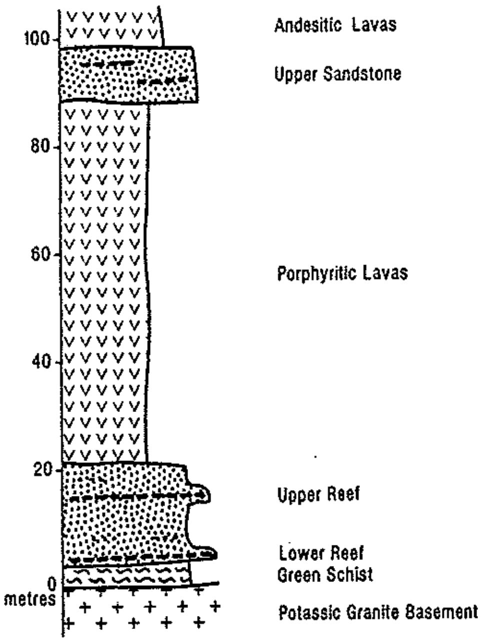

Figure 4 : Stratigraphy of the Renosterspruit Sandstone Formation from Dominion Reefs mine (after Malan, 1959).

The stratigraphy of the Renosterspruit Formation indicates that a considerably thicker volcano-sedimentary pile accumulated in the Ottosdal area than in the region south of Hartbeesfontein (Figures 3 and 4). This is possibly related to differential rates of subsidence.

C. *The Renosterhoek Andesite Formation*

The Renosterhoek Formation consists predominantly of intermediate lavas and tuffs which gradationally overlie the volcano-sedimentary Renosterspruit Formation. The lavas which form the bulk of the Renosterhoek are green-to-grey in colour and are probably mainly andesitic in composition (von Backström, 1962). They are highly altered and contain intercalations of cherty amygdaloidal varieties and felsic porphyries. According to the South African Committee for Stratigraphy (in prep.), the Renosterhoek Formation attains a thickness of 1 100 m and has a brecciated lava 300 m above the base.

Petrographically, the intermediate lavas contain microcrystalline andesine laths and spherulitic growths of hornblende, in addition to chlorite and epidote (Malan, 1959). Only one geochemical analysis is available for the Renosterhoek Formation, which von Backström (1952) believes to be a typical Dominion andesite (Table I). However, a comparison between the major elements of this rock and those of average tholeiitic andesites and basalts from elsewhere in the world (Table I) suggests that this particular Dominion lava has closer affinities with a basaltic composition. This is best demonstrated by the higher MgO and CaO and lower SiO_2 and $K_2O + Na_2O$ contents of the Dominion lava, when compared with a typical andesite.

D. *The Syferfontein Porphyry Formation*

The Syferfontein Formation attains a thickness of 1 500 m and consists of porphyritic felsic lavas, with numerous interbedded tuffs and cherty amygdaloidal volcanics (South African Committee for Stratigraphy, in prep.). The predominant lava-type has been identified as a soda-rhyolite composed of quartz and albite phenocrysts in a silicified matrix (Nel et al., 1937). In places, these lavas are flow-banded, and flow-top breccias are developed (Plate 1D). A geochemical analysis of a typical Syferfontein rhyolite indicates that it is enriched in SiO_2 and depleted in Al_2O_3 and alkalies, relative to average rhyolite (Table I). This is possibly related to the secondary silicification of these rocks, at the expense of alkali feldspars.

TABLE I

	1	2	3	4	5	6	7
SiO_2	53,07	53,80	58,31	50,83	77,31	73,23	73,66
Al_2O_3	13,93	13,90	13,77	14,01	10,31	14,03	13,45
Fe_2O_3	1,86	2,60	3,37	2,88	1,02	0,60	1,25
FeO	7,93	9,30	6,48	9,00	3,46	1,70	0,75
MgO	6,90	4,10	2,27	6,34	0,46	0,35	0,32
CaO	10,30	7,90	5,58	10,42	0,17	1,32	1,13
Na_2O	2,07	3,00	3,91	2,23	1,75	3,94	2,99
K_2O	0,99	1,50	1,88	0,82	2,83	4,08	5,35
TiO_2	0,65	2,00	1,71	2,03	0,43	0,24	0,22
P_2O_5	0,11	0,40	0,46	0,23	0,12	0,05	0,07
MnO	0,14	0,20	0,23	0,18	0,03	0,02	0,03

1. "Typical Andesite" from the Dominion Group (von Backström, 1952).
2. Average Tholeiitic Basalt - Columbia River (Irvine and Baragar, 1971).
3. Average Tholeiitic Andesite from oceanic and non-orogenic regions (Irvine and Baragar, 1971).
4. Average Tholeiitic Basalt (Nockolds, 1954).
5. "Typical Rhyolite" from the Dominion Group (von Backström, 1952).
6. Average Rhyolite - Cascades Volcanics (Irvine and Baragar, 1971).
7. Average Calc-alkali Rhyolite (Nockolds, 1954).

North of Ottosdal, a series of lenticular pyrophyllite-rich zones are developed in the upper stratigraphy of the Syferfontein Formation (Nel et al., 1937). These units are up to 70 m thick and are exposed as a number of resistant ridges. Locally, this rock-type is known as "wonderstone" and is quarried on the farms Gestoptefontein IO349 and Driekuil IP280. Commercial uses of pyrophyllite include the manufacture of electrical insulators and synthetic diamonds, in high-temperature and -pressure apparatus and as monument stone (Coetzee, 1976). Mineralogically, wonderstone consists of approximately 90 per cent pyrophyllite, with subordinate porphyroblasts of chloritoid and epidote and microcyrstalline needles of rutile. Geochemical analyses indicate that it has a remarkably uniform composition and consists almost entirely of silica and alumina, with significant titania (Table II). Wonderstone is generally massive, although there is minor evidence of current activity in the form of ripples and cross-stratification. Nel et al. (1937) suggested that it originated as water-lain volcanic ash from which silica was leached to form an alumino-silicate residual. Subsequent regional metamorphism was responsible for the recrystallization as pyrophyllite.

TABLE II

	1	2	3	4	5	6	7	8	9
SiO_2	56,18	57,19	54,56	56,76	55,50	56,71	56,84	54,96	54,20
Al_2O_3	32,76	32,78	32,83	32,39	34,30	33,27	33,57	34,03	34,39
Fe_2O_3	0,64	0,72	2,38	1,54	0,82	1,48	0,75	0,86	1,06
MgO	0,78	0,36	0,50	0,31	0,28	0,26	0,29	0,31	0,21
CaO	0,72	0,40	0,32	0,25	0,16	0,14	0,07	0,18	0,12
TiO_2	2,45	2,08	2,58	2,80	2,60	2,30	2,25	2,75	2,50
L.O.I.	6,60	6,54	6,82	6,37	6,71	6,15	6,42	7,63	7,40
Total	100,07	100,14	99,99	100,42	100,37	100,31	100,19	100,54	100,4

Pyrophyllite samples from the Dominion Group on the farm Gestoptefontein IO349 (von Backström, 1962).

IV. MINERALOGY OF THE RENOSTERSPRUIT SANDSTONE FORMATION

Studies of the heavy-mineral suites in the Upper and Lower Reefs of the Renosterspruit Formation have indicated significantly-different populations in the two conglomerates (Table III). The Lower Reef is characterized by a concentration of gold, leucoxene, zircon, and, occasionally, uraninite, whereas the mineralogy of the Upper Reef is far more diverse. It contains appreciable uraninite, monazite, and zircon, intermediate amounts of cassiterite, pyrite, arsenopyrite, and garnet, and generally low gold contents. The notable differences in placer proportions are probably related to mineral availability in the source-area. It is conceivable that the Lower Reef was derived from an essentially granitic hinterland, whereas the mineralogy of the Upper Reef suggests that it is the product of a complex granite-greenstone terrane, with associated sediments and pegmatites. This change is probably attributable to a tectonically-controlled switch in the provenance-area.

TABLE III

MINERAL	UPPER REEF	LOWER REEF
Uraninite	+ Common	+ Rare - Moderate
Gold	Rare - Absent	+ Common
Pyrite	+ Moderate	Rare - Absent
Arsenopyrite	+ Common - Moderate	Rare
Leucoxene	Rare	+ Moderate - Common
Monazite	+ Common	Rare - Absent
Cassiterite	+ Moderate - Common	Rare
Zircon	+ Common	+ Rare - Moderate
Euxinite	Rare	Absent
Chromite	+ Moderate - Rare	Rare
Molybdenite	Rare	Absent
Magnetite	Rare	Absent
Thucholite	Rare	Absent
Garnet	+ Moderate	Rare

A comparison between the relative frequencies of the heavy-mineral suites in the Upper and Lower Reefs (after Liebenberg, 1955; Malan, 1959; and Hiemstra, 1968).

\+ denotes minerals present in significant quantities.

The degree of rounding in the ore minerals of the Upper and Lower Reefs and their mutual correlation led Malan (1959) and Hiemstra (1968) to unequivocally state that the grains were of detrital origin. However, Hiemstra (op. cit.) suggested that there had been some hydrothermal remobilization of gold, since it generally has an irregular shape and occurs in cross-cutting veinlets. Furthermore, he detected a sympathetic relationship between gold and leucoxene, which he attributed to the migration of gold into porous leucoxene grains.

Simpson and Bowles (1977) concluded that, in the Dominion and Witwatersrand basins, uraninite accumulated both as detrital grains and as chemical precipitates associated with carbonaceous mudstones. Moreover, they postulated an oxidising atmosphere for uranyl ions to remain in solution, whereas the uraninite, which is high in thorium, would be relatively resistant to oxidation. An analogy was drawn between these deposits and the presence of detrital pyrite in the modern Indus River. However, Saager and Muff (1978) questioned these deductions, as the Indus deposits probably have not experienced the periodic exposure to which the Dominion placers were subjected.

V. ORIGIN OF THE DOMINION GROUP

Limited palaeocurrent data from the area south of Hartbeesfontein indicate that the sediments of the Renosterspruit Formation prograded in a westerly direction (Figure 5a). This unimodal dispersal pattern and the nature of the clastics suggest that deposition in that area was controlled by a braided fluvial regime, which received detritus from an eastern highland (Figure 6a). These sediments overlie an extensive palaeosoil horizon which was derived by continental weathering prior to the evolution of the Dominion basin.

The conglomerates in the Renosterspruit Formation are the product of coalesced gravel bars which accreted vertically within the major channels of the fluvial system. In the Lower Reef, pebbles and cobbles accumulated by rolling along the channel floor, as indicated by the preferred orientation of long axes

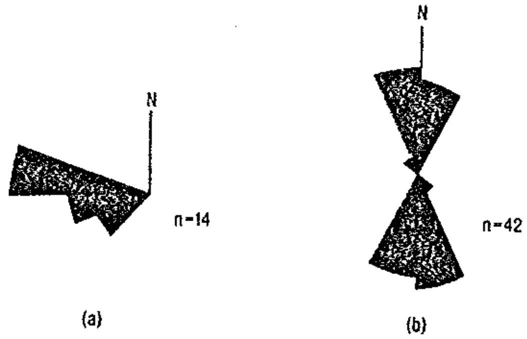

Figure 5 : a. *Unimodal westerly palaeocurrent distribution from the Renosterspruit Formation as indicated by trough cross-beds on the farm Oorbietjiesfontein IP292.*

b. *North-south alignment of long axes of clasts from the Lower Reef on the farm Oorbietjiesfontein IP292.*

perpendicular to the mean flow-direction (Figure 5b). Frequent channel-switching, in order to obtain optimum gradient conditions, led to development of numerous lenticular conglomerates. The two reef horizons, which are comparatively persistent, may reflect periods of limited sediment availability, with the resultant formation of broad pediments on which heavy minerals and gravels were concentrated.

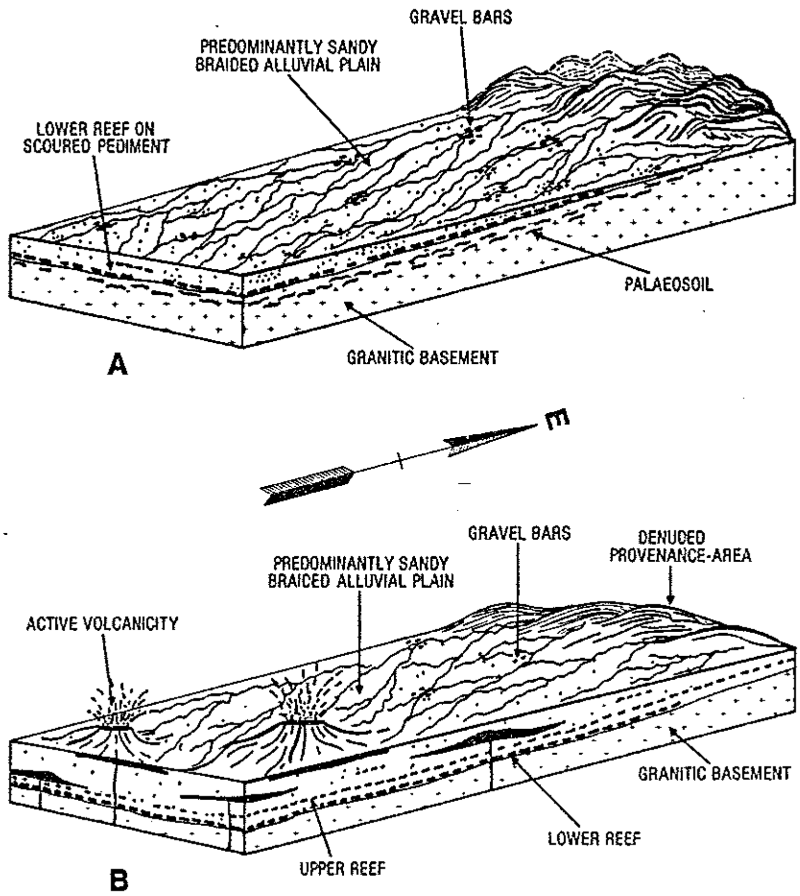

Figure 6 : a. *Block diagram showing the envisaged depositional setting for the basal Renosterspruit Formation.*

b. *Schematic representation of the interpreted depositional environment for the upper Renosterspruit Formation.*

The increased proportion of lenticular volcanic units towards the top of the Renosterspruit Formation indicates a period characterized by coeval volcanism and sedimentation (Figure 6b). The clastics are probably still of fluvial origin, although their decreased grain-size suggests a more gentle palaeoslope. The volcanics belonging to both the upper Renosterspruit and overlying Renosterhoek Formation are predominantly andesites and basalts, which have similarities with typical tholeiitic lavas. The Syferfontein Formation is characterized by rhyolites, with numerous pyroclastic phases and occasional intermediate flows. These lavas have undergone extensive secondary silicification, partly due to the leaching of silica from tuffaceous units, in response to the percolation of either surface or ground water.

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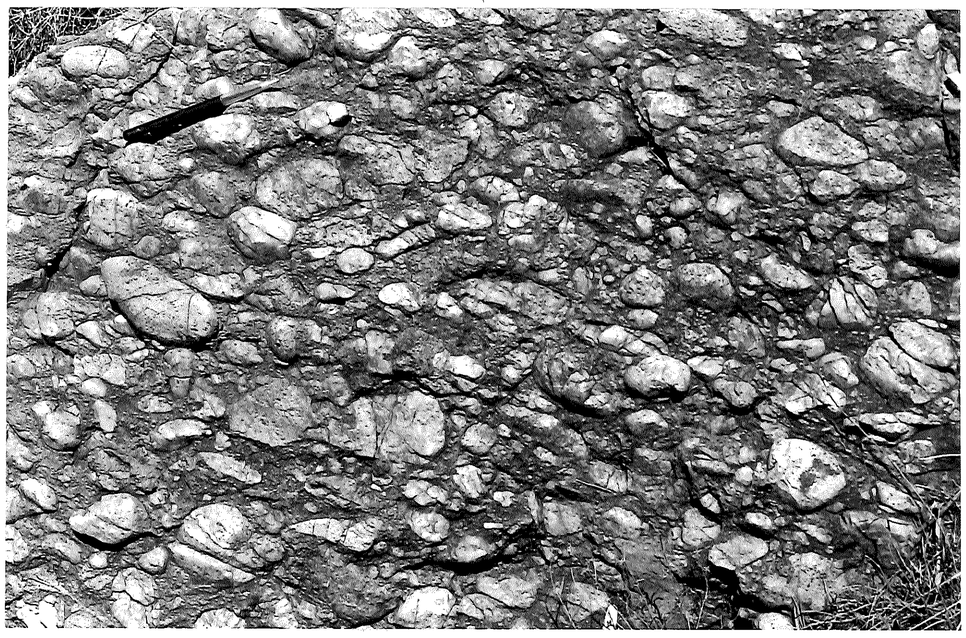
PLATE 1

A

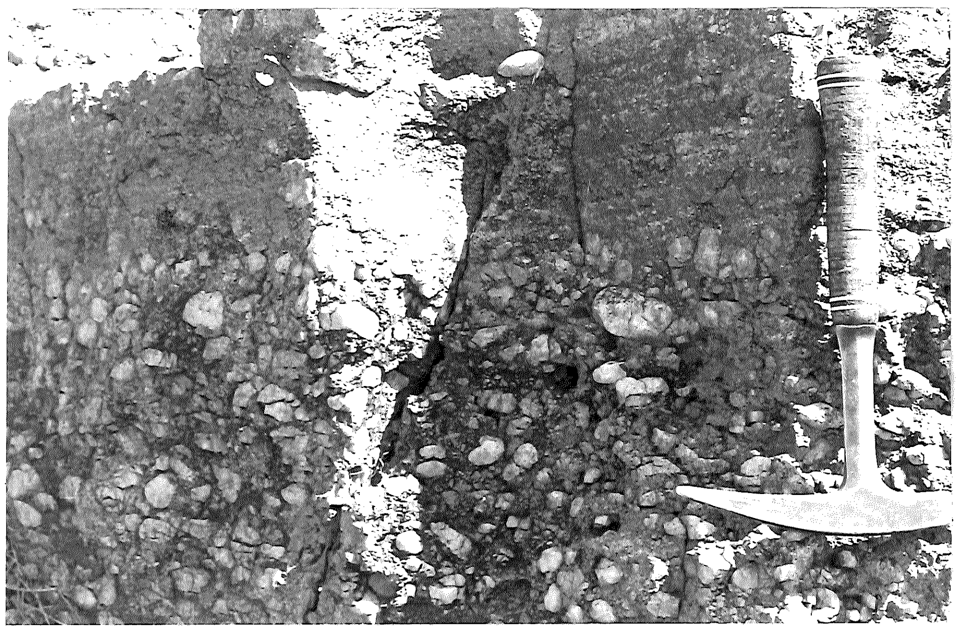
Typical rounded outcrops of Basement Granite on the farm Oorbietjiesfontein IP292.

B



The Lower Reef in the Renosterspruit Sandstone Formation on the farm Oorbietjiesfontein IP292.

C



The Upper Reef and associated plane bedded sandstone on Oorbietjiesfontein IP292.

D

Flow top breccia from the Syferfontein Porphyry Formation on the farm Schoemansfontein IP396.