ECONOMIC GEOLOGY RESEARCH UNIT

University of the Witwatersrand
Johannesburg

SEDIMENTOLOGICAL CONTROLS ON STRATABOUND PLACER MINERALIZATION IN THE LOWER WITWATERSRAND WEST RAND GROUP, SOUTH AFRICA

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INFORMATION CIRCULAR NO. 153

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by

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March, 1981

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ABSTRACT

Economic placer deposits in the Lower Witwatersrand West Rand Group are restricted to the Florida Formation in the northwestern portion of the basin. This gold and uranium mineralization is associated with quartz-pebble conglomerates which originated as gravel bars in the midfan section of prograding fan-deltas. Sedimentation was controlled by a braided fluvial system, which transported detritus from an eastern highland and constructed a series of deltas directly on a shallow shelf. Heavy minerals were readily available in these medial reaches, where they were concentrated on erosion surfaces, in particular at channel bases. Unmineralized fluvial conglomerates in the West Rand Group are characterized by considerably smaller clasts and occasional heavy mineral laminae, which demarcate trough foresets. These deposits represent the distal equivalents of the Florida Formation, whilst palaeocurrent data indicate that sediment was derived from a northern provenance-area. Heavy minerals are comparatively scarce, probably due to the lower energy-level of the fluvial regime. This indicates a strict sedimentological control on the formation of placer mineralization in the West Rand Group, which was probably related to syndepositional tectonism.

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

ISBN 0 85494 672 1

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I. INTRODUCTION

South Africa produces approximately 60% of the World's gold and nearly 15% of its uranium (Vermaak, 1979). These deposits are located mainly in the early Proterozoic sediments of the Witwatersrand Supergroup, where they occur as placer accumulations associated with fluvial clastics. The gold and uraninite are preferentially associated with quartz-pebble conglomerates, but are subordinate to a variety of other heavy minerals, in particular detrital pyrite (Feather and Koen, 1975). Placer concentrations are frequently related to internal scour surfaces, such as foresets, in addition to disconformities within the sequence. Anomalously-high gold and uranium values may also be associated with thin carbon seams, which probably represent fossilized algal mats (Hallbauer and van Warmelo, 1974).

The 2 500 Ma-old Witwatersrand basin displays a general regressive tendency through time (Brock and Pretorius, 1964), resulting in a transition from marine sediments, at the base of the succession, to predominantly fluvial deposits, towards the top. Consequently, the majority of the mineralization has been recovered from the upper stratigraphy or Central Rand Group (Figure 1), although a number of small mines exploited similar sediments in the lower Witwatersrand or West Rand Group. The latter were restricted to the northwestern portion of the basin, centred around the town of Klerksdorp, in the western Transvaal (Figure 2). A recent investigation of these deposits suggests a unique stratigraphic setting, when compared with the associated sedimentary formations (Watchorn, 1980b).

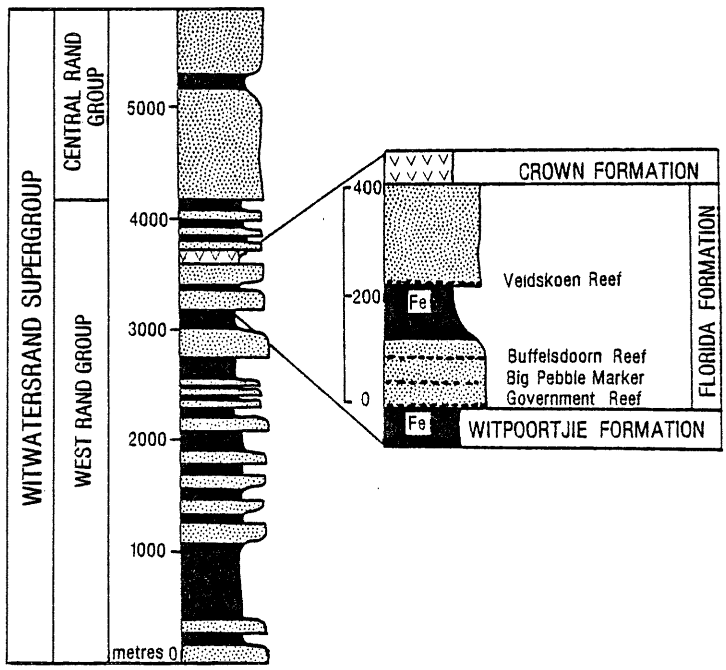

Figure 1 : *The stratigraphic setting of the Florida Formation in the Klerksdorp region of the Witwatersrand basin.*

II. GEOLOGICAL SETTING

The Florida Formation at the base of the Jeppestown Subgroup hosts all the previously-exploited deposits of gold and uranium in the West Rand Group. The formation, which is approximately 400 metres in thickness, is exposed in the Rietkuil syncline, west of Klerksdorp, and as a linear belt extending northwards from the town, on the eastern limb of the Varkenstraal anticline (Figure 2). It has clearly-defined stratigraphic boundaries with the Witpoortjie and Crown Formations and comprises two sandstone-conglomerate horizons, both of which erosively overlie magnetic mudstones (Figure 1). The sandstones are essentially coarse arkosic arenites, with minor quartz arenites and numerous beds of conglomerates. The most common sedimentary structures are plane beds and trough cross-beds, both of which are often accentuated by black limonite laminae after pyrite (Plate 1A).

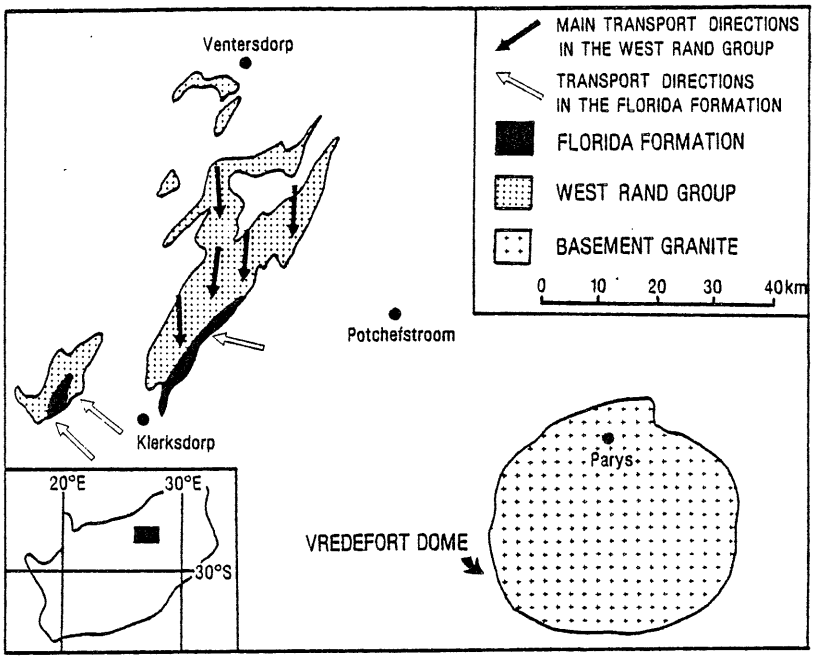

Figure 2 : The distribution of the Florida Formation in the Klerksdorp area and the main directions of sediment transport.

Four main conglomerate horizons are developed in the Florida Formation, all of which have been exploited, or extensively prospected, for gold and uranium. These are the Government Reef, the Big Pebble Marker and the Buffelsdoorn Reef, all in the lower Florida Formation, and the Veldskoen Reef in the upper stratigraphy (Figure I). These are composed essentially of vein-quartz pebbles, although lava and chert clasts are also present, in addition to occasional mudstone flakes. The thickness of these conglomerates is highly variable, ranging between 20 centimetres and 5 metres, and all display considerable lenticularity, suggesting channel-control (Plate 1B). Associated heavy minerals are often concentrated as a residual lag at the base of these conglomerates (Plate 1B) and, in the case of the Buffelsdoorn Reef, at the upper contact as well.

The argillaceous sediments in the Florida Formation are predominantly interlaminated and interbedded mudstones and siltstones, with disseminated magnetite being restricted to the finer-grained members. Thin diamictites occur as lenses within the argillites and consist of immature clasts in a matrix of quartz wacke.

III. PALAEOENVIRONMENTAL RECONSTRUCTION

Palaeocurrent data from the arkosic arenites in the Florida Formation have a strong unimodal distribution towards the west and northwest (Figure 2). This, in conjuction with the textural and mineralogical immaturity of the sandstones, suggests that deposition occurred in a braided fluvial system. The high proportion of conglomerates and their lenticular geometry implies considerable channel-development, probably on the medial portion of an alluvial fan. The conglomerates originated as lags, which in the major channels accreted vertically to form longitudinal gravel bars. A steep gradient and high discharge flushed fine sediment from the fluvial system, thereby inhibiting the development of overbank deposits. However, the presence of angular mudstone chips in the conglomerates indicates that some argillaceous sediments did accumulate, probably in abandoned channels. These apparently had a low preservation-potential due to bank instability and the lateral migration of the facies tract. In order to maintain optimum gradient conditions, continual channel-switching took place, resulting in the formation of tabular sandstone bodies.

Quartz arenites intercalated with the arkosic sandstones are up to 2 metres thick. The most conspicuous of these occurs immediately above the Buffelsdoorn Reef, where it has been used as a stratigraphic marker. Palaeocurrent measurements from this horizon and a similar unit above the Veldskoen Reef consistently produce bimodal, bipolar patterns, oriented northwest-southeast. This suggests that the original arkosic arenites were reworked by tidal currents during a brief transgressive cycle.

The argillaceous sediments comprising the middle Florida Formation are interpreted as shelf deposits, which received fine-grained detritus from the fan system. These clays and silts settled from suspension in an area below wave-base, whilst iron precipitated as magnetite in the most distal zones. In the absence of volcanism, the iron was probably derived from continental weathering, whereas the formation of primary oxides implies a low, but significant, oxygen concentration in the early Witwatersrand basin. Periodic slumping in the nearshore area led to the generation of subaqueous debris-flows which introduced coarse diamictites into the shelf environment.

The sharp basal contacts that the Florida sandstones have with the associated shelf sediments suggest the development of rapidly prograding fan-deltas. A similar relationship has been described in the modern Gum Hollow delta, Texas, where sediment is distributed on the delta plain by braided distributaries (McGowen, 1971). Such deltas are characteristically short-headed (Flores, 1975) and indicate a high rate of sedimentation. Consequently, the Florida fan deltas were probably related to local uplift and the establishment of an eastern highland.

IV. THE FLORIDA FORMATION IN PERSPECTIVE

Although the lithologies and envisaged depositional environments of the stratigraphically-associated sediments are broadly similar to the Florida Formation, there are two significant differences. The first involves the nature of the conglomerates, which, outside the Florida Formation, tend to be less common and less prominent, mainly due to a reduced pebble-size. In the Florida Formation, clasts have a mean diameter of 4-5 centimetres and reach a maximum of 25 centimetres in the Big Pebble Marker (Plate 2A). In other West Rand conglomerates, pebbles rarely exceed 2 centimetres, and there is a higher proportion of chert (Plate 2B). In addition, these small-pebble varieties often have tabular geometries, which suggest only minor channel-incision. Heavy-mineral concentrates are restricted to trough-shaped scours in the small-pebble conglomerates, whilst the associated sandstones are generally barren. Conversely, pyritic foresets are frequent in the Florida sandstones, whereas, in the conglomerates, placer mineralization is normally most conspicuous at the base of channels. These fundamental differences in the geometry, mineralogy, and texture of the conglomerates in the West Rand Group are attributed to the type of sediment available, the gradient, the discharge, and, hence, the position on the alluvial fan. Consequently, in the more proximal reaches, represented by the Florida Formation, coarse debris was deposited in well-defined channels, whilst abundant heavy minerals could be transported due to the competent discharge. Bedforms migrating within active channels sorted and concentrated these heavy minerals, which were probably derived from a local source. During periods of negligible sediment increment these placer minerals were concentrated on erosion surfaces such as channel bases. Stream-power apparently deteriorated rapidly down the palaeoslope, so that, in the more distal reaches, conglomerates tend to be less robust and contain appreciably lower contents of heavy minerals.

A second major difference expressed by the sediments of the Florida Formation, relative to other fluvial deposits in the West Rand Group, is the area of sediment derivation. Palaeocurrent measurements from the Florida Formation imply an eastern or southeastern source-terrane, whereas the other formations in the Klerksdorp area consistently indicate a northern provenance (Figure 2). The phenomenon of syndepositional tectonism in the Witwatersrand basin has been discussed by a number of authors (Brock and Pretorius, 1964; Pretorius, 1976a; Vos, 1975, amongst others) and is believed to have been a governing factor in the site and style of sedimentation. During much of the early history of the northwestern Witwatersrand basin, deposition was controlled by a structurally-active northern margin. The pulsatory reactivation of these major structures apparently influenced the facies distribution within the depository, in addition to providing much of the clastic detritus. However, depositional loci were also affected by a grid pattern produced by superimposed fold axes (Pretorius, 1976b). Therefore, it is speculated that the deposition of the Florida Formation in the Klerksdorp area was influenced by a second-order intrabasinal structure, the most obvious of which is represented by the Vredefort dome (Figure 2). This is a structural culmination consisting of basement granitic rocks probably produced by the interference between two anticlinal axes (Pretorius, 1979).

V. CONCLUSIONS

Pretorius (1974) suggested that the hydrodynamic regime was of fundamental importance in the concentration of placer minerals in the Witwatersrand basin. Consequently, optimum gold could be expected in the midfan area of an alluvial system, whilst concentrations of less-dense uraninite would be highest further down the palaeoslope. There would, however, be considerable overlap between these two mineral species, depending on grain-size, relative availability, and local hydraulic conditions. In the West Rand Group, midfan deposits, represented by coarse conglomerates in well-developed channels, are rarely preserved due to the gradual decrease in the extent of the Witwatersrand basin through time. Consequently, the sediments deposited at the basin-margin during its early history were largely reworked to supply detritus for the Central Rand Group. Therefore, under normal conditions, the West Rand strata would appear to have a relatively low gold, but moderate uranium, potential. However, in the Klerksdorp area, a structural high within the depository briefly influenced sedimentation and apparently created suitable conditions for placer concentration.

Evidence of this eastern source-terrane was also found associated with the placer deposits of the Dominion Group, which represents a Witwatersrand protobasin developed in the western Transvaal (Watchorn, 1980a). The mineralization in the Dominion Group also occurs in conglomerates of fluvial origin, which are reminiscent of those occurring in the Florida Formation. This suggests that the positive structural element located to the east of Klerksdorp may have been rejuvenated through time and acted as an important external control for the formation of placer deposits during the early history of the northwestern Witwatersrand basin.

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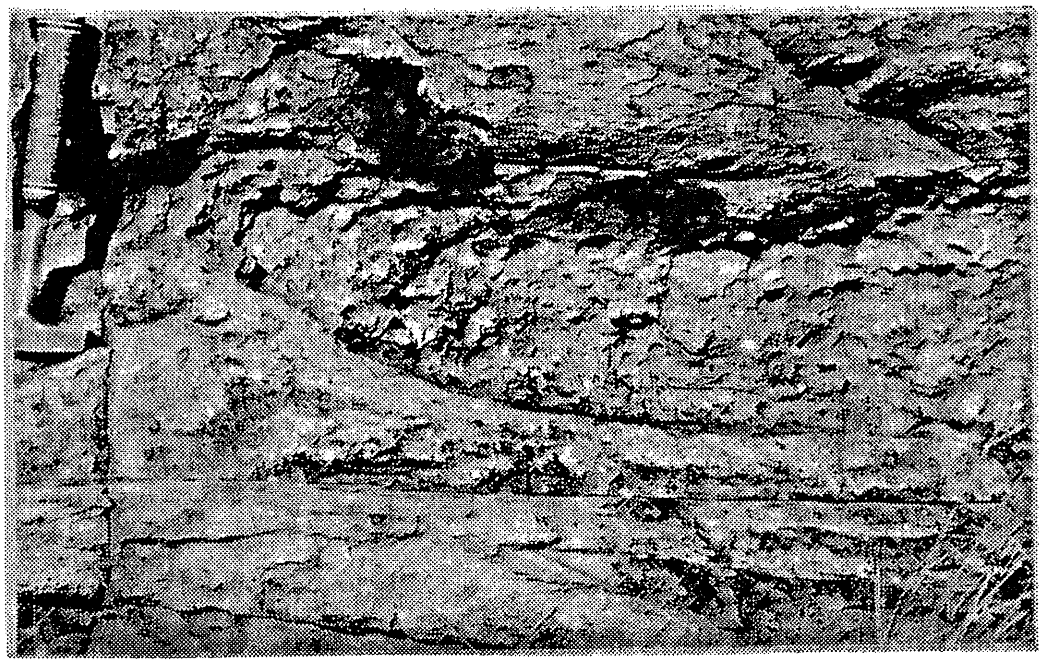
PLATE 1

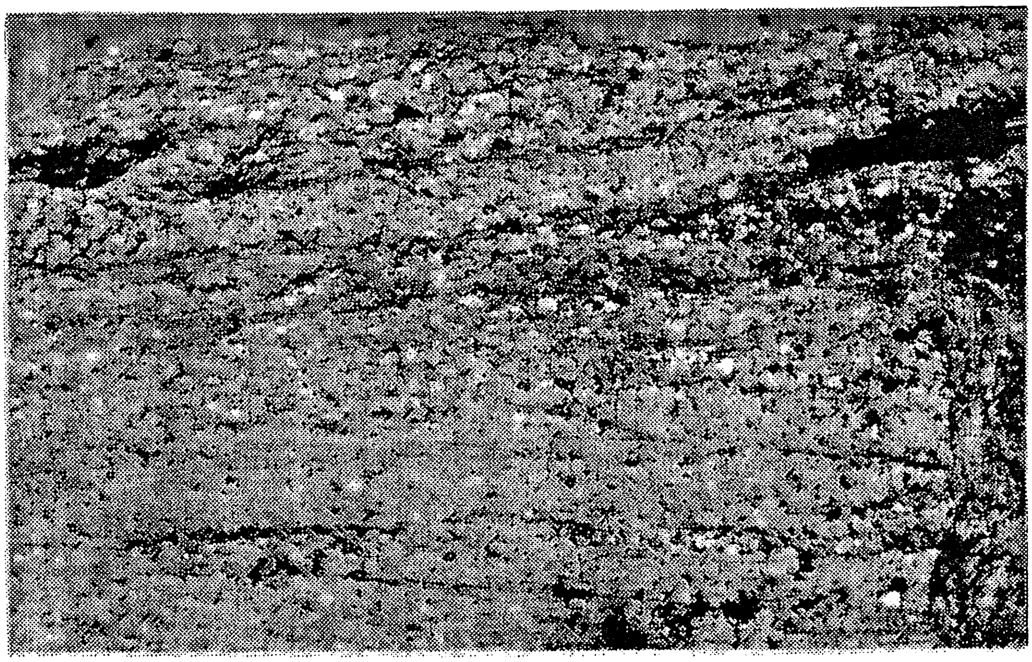
A Black limonite laminae after pyrite accentuating a transverse section of trough cross-stratification in the lower Florida Formation.



B Lenticular conglomerate filling a channel in the lower Florida Formation. Note the black iron staining after pyrite at the channel base.

PLATE 2

A Robust conglomerate comprising the Big Pebble Marker in the lower Florida Formation.



B Small-pebble conglomerate in the lower West Rand Group. Note the fine black laminae demarcating original pyritic foresets.