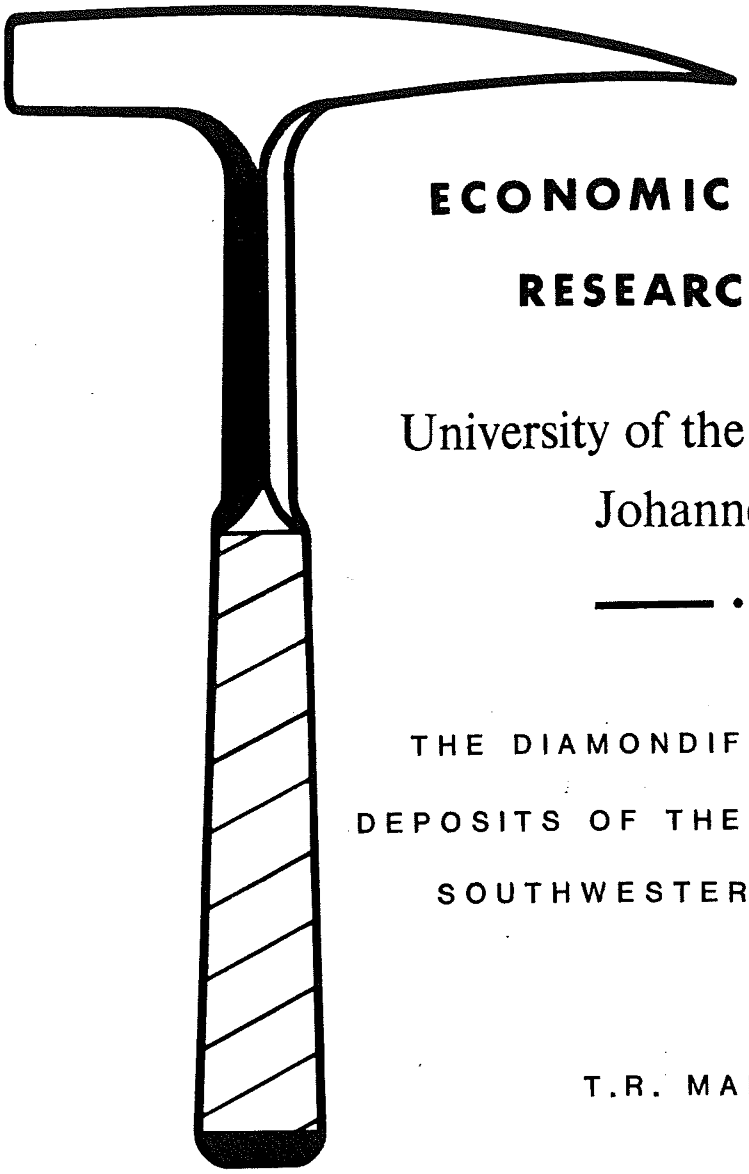

ECONOMIC GEOLOGY RESEARCH UNIT

University of the Witwatersrand
Johannesburg

THE DIAMONDIFEROUS GRAVEL DEPOSITS OF THE BAMBOESSPRUIT, SOUTHWESTERN TRANSVAAL

T.R. MARSHALL

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UNIVERSITY OF THE WITWATERSRAND
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by

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ABSTRACT

Field evidence indicates that there are two, fundamentally-different types of diamondiferous gravels associated with the Bamboesspruit. The oldest *(Rooikoppie)* gravels occur as a 1-2m-thick, unsorted, matrix-supported, generally-upward-fining unit that has been completely lateritized. These gravels usually occur on hillcrests or on the upper sections of hillslopes and are generally overlain by a thin (0,5-1,0m), soil overburden. Younger, terrace-type deposits *(the oxidized and reduced gravels)* occur on the lower slopes of the present tributary valleys. These gravels, averaging 1-4m thick, are developed below 8-10m of sand, mud, and calcrete overburden. The gravels closer to the present stream-channels have a greenish, clay matrix which becomes more oxidized (and, hence, brownish) away from the channels. Deposits of economic concentrations of diamonds in these gravels are found in potholes in the lavas of the channel floors, behind obstructions in the channels, associated with large boulders, and in meander point-bars. The youngest *(spruit gravel)* deposits occur in the present channels of the Vaal River tributaries and represent recent reworking of all the older deposits.

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INTRODUCTION

From 1904 to 1984, the alluvial diamond deposits between Lichtenburg, Ventersdorp, Potchefstroom, and Christiana produced some 14,4 million carats, valued at over R141,6 million. The apparent absence of an obvious, local, primary source for these diamonds has led to a proliferation of hypotheses dealing with the origin of both the gravels and the diamonds. By far the majority of these studies have concentrated on either the dolomite-hosted gravels of the Lichtenburg-Ventersdorp districts or the terrace-type gravels of the lower Vaal River basin (du Toit, 1951; Retief, 1960; Partridge and Brink, 1967; Helgren, 1979).

Few studies have addressed the nature of the alluvial and colluvial deposits of the southwestern Transvaal, between Wolmaransstad, Christiana, and Schweizer-Reneke. Due to the present drought, many of the farmers in these districts have opened up large tracts of land in, and adjacent to, dry Vaal River tributaries and are prospecting for diamonds, as an alternate source of revenue. This has provided an ideal opportunity to study the gravel deposits that have been inaccessible hitherto. This study has concentrated on the Bamboesspruit and valley, a tributary of the Vaal River, which extends from NNW of Wolmarmansstad to SE of Bloemhof (Fig.1). This affords a total stream-valley study-length of approximately 180km.

The Bamboesspruit flows (in wetter years) over the amygdaloidal Ventersdorp lavas of the Makwassie Group. For the most part, these lavas have weathered to a thick fertile soil that has been exploited by maize farmers in the district. Much of the gently-undulating, southwestern Transvaal landscape is covered with a layer of red Hutton Sands and yellow-to-red apedal soils (Fitzpatrick *et al.*, 1986).

GRAVEL DEPOSITS

There are two fundamentally-different types of gravels occurring along the Bamboesspruit, viz. the derived gravels and the reworked alluvial gravels. The derived gravels occur on hillslopes and interfluves at depths of less than 1m, and the alluvial gravels occur in the present river-valleys at depths of between 5 and 8m below surface. The deposits differ in age and, more fundamentally, in the processes which were responsible for their formation.

(a) Derived Rooikoppie Gravels

The Rooikoppie gravels are so named because of their red-to-reddish-brown colour. They occur on interfluves, the upper sections of hillslopes, and on hillcrests. The Rooikoppie gravel profile consists of three components: the overlying red sands; the diamondiferous gravels; and the much-altered, uneven, basal deposits.

The younger, overlying,red-reddish-brown sands have been classified as Hutton Sands (Fitzpatrick *et al.*, 1986). A typical Hutton profile has a shallow (0-150mm) A-horizon, consisting of friable, fine sandy-loam and few, medium-grained, indurated, iron-manganese nodules. The B-horizon is most commonly a red apedal soil and consists of friable, fine sandy-clay-loam, with few, medium, indurated, iron-manganese nodules,

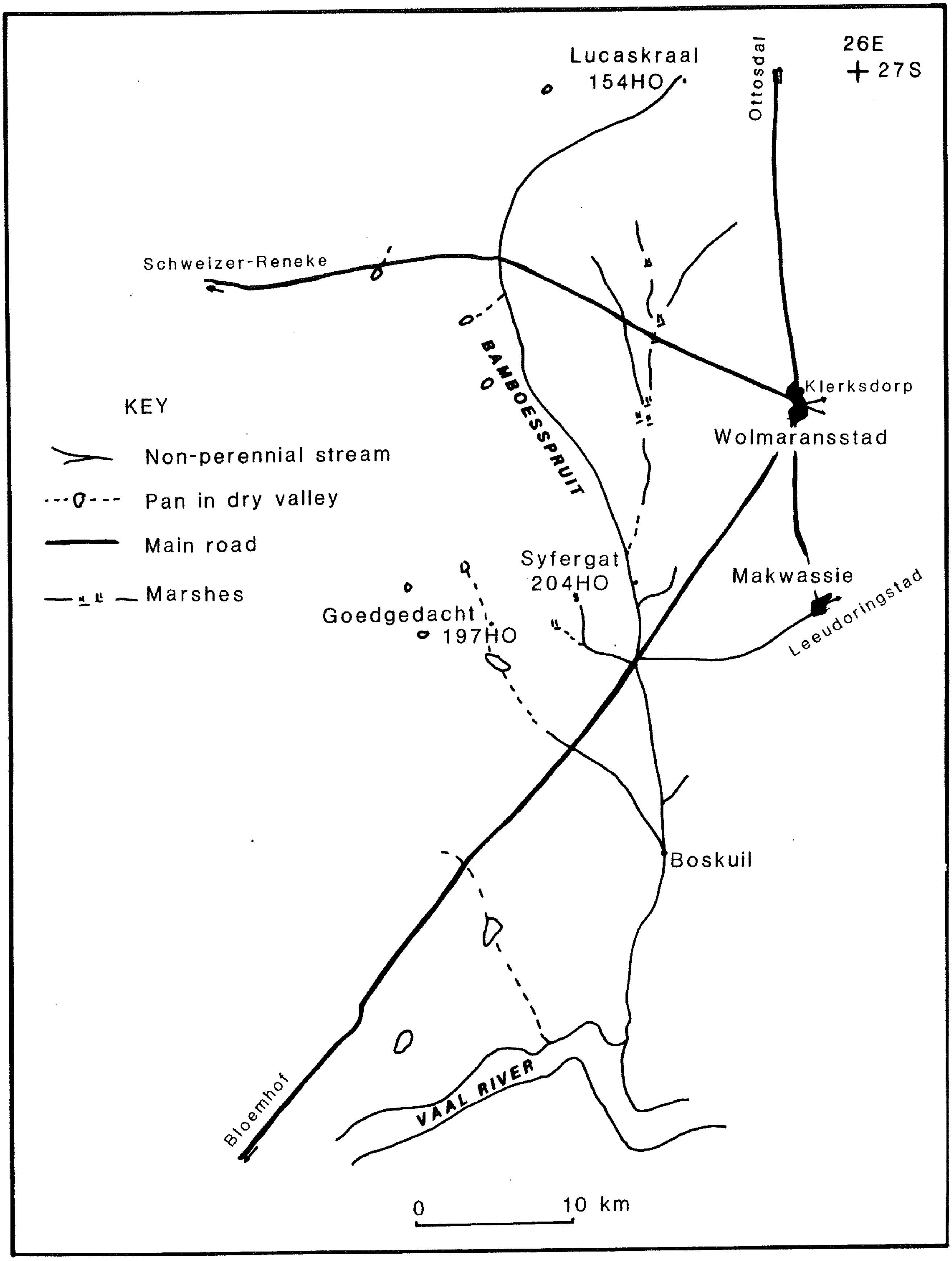

Figure 1: Location of the Bamboesspruit, southwestern Transvaal.

fragments from the underlying horizon, and is separated from it by a clear, undulating boundary. The clay content is usually in the 4-12% range, but may reach up to 25%. The sand-fraction contains no readily-weatherable minerals and is dominated by medium-fine-grade, well-sorted and rounded quartz. The red colour is produced by iron-oxide coatings on the sand-grains (Helgren, 1979). The Hutton Sands have been described as being derived from the ancient floodplains of the Vaal and Harts rivers by deflation processes and have been remobilized several times between periods of vegetation colonization (Helgren, 1979). Other sources describe the Hutton Sands as having been derived from the Kalahari, aeolian dune-fields during an arid phase in the Quaternary (Mayer, 1986). In either case, the Hutton Sands are a much younger feature than the underlying gravel deposits.

The layer of diamond-bearing Rooikoppie gravel varies in thickness from a single-pebble layer to approximately 40cm, but can be upwards of 2m thick in pseudokarst features in the underlying laterite surface. The clast-content of the gravel comprises well-rounded, quartz pebbles, ranging in size from 4 to 10cm. The matrix consists almost entirely of rounded vein-quartz with iron-stained rims and a small component (5%) of volcanics (possibly Ventersdorp lavas). Where the gravels have been concentrated in the palaeokarst features of the underlying laterite surface, they have delivered extremely-high diamond values (Goedgedacht, 197HO, for example, yielded over 14 000 carats). The form of the Rooikoppie gravel is determined, to a large extent, by the nature of the surface on which it is deposited, a feature which highlights the probability that the Rooikoppie is a derived and not a primary gravel.

The surface that the Rooikoppie gravels are deposited on is an ancient one. The original deposits have been so extensively altered by laterization that they are often impossible to identify. On the farm Syfergat 204HO, the laterite succession consists of an 80cm-thick, enriched zone passing progressively through a 50cm, mottled zone into a thick, pallid, or leached zone (of the order of 2m) and, eventually, into fresh, unaltered bedrock (Ventersdorp lavas). The surface shows evidence of having undergone extensive leaching. This process has dissolved out many of the soil-constituents, resulting in a landscape very much akin to karst. Such a landscape has been termed a pseudokarst landscape. The leaching process has evolved along inherent planes of weaknesses in the original rocks, such as joint-planes, and results in the development of fissure-like grikes (corrosion-opened joints). On the farm Goedgedacht 197HO, diggings have exposed pseudokarst grikes with dimensions in the order of 1-2m width, 50-200m length, and 5-10m depth. Laterization in these grikes has proceeded to depths of over 1m, with the pallid zone descending to below the bottom of the opened joint. The original composition of the lateritized sediment at this locality appears to have been a small-pebble conglomerate. The lateratized conglomerate passes laterally into an interbedded-sandstone-and-shale facies, before disappearing beneath the pan-sediments of the Goedgedacht pan. Cross-bedding in the sandstones indicates that the palaeocurrent direction was predominantly from north to south. The pseudokarst grike in which the sandstones are exposed is less than 1,5m deep, and it is not known what the vertical extent of the profile is. It is possible, however, that a gravel horizon should exist at depth (the basal facies of a palaeo-diamond-bearing stream perhaps?).

The Rooikoppie gravels occur as infill in the grikes. The gravels fine inwards from the grike-walls and also down- and upwards from a zone 1,5-3,0m below the surface (Fig. 2). There are no slump features in the gravels adjacent to the walls, indicating that the infilling of the grike occurred contemporaneously with the dissolution or leaching that formed the grike. The infilling of the grike with gravels is unlikely to have been the result of river-action, but, more likely, the result of flash-floods in a semi-arid environment.

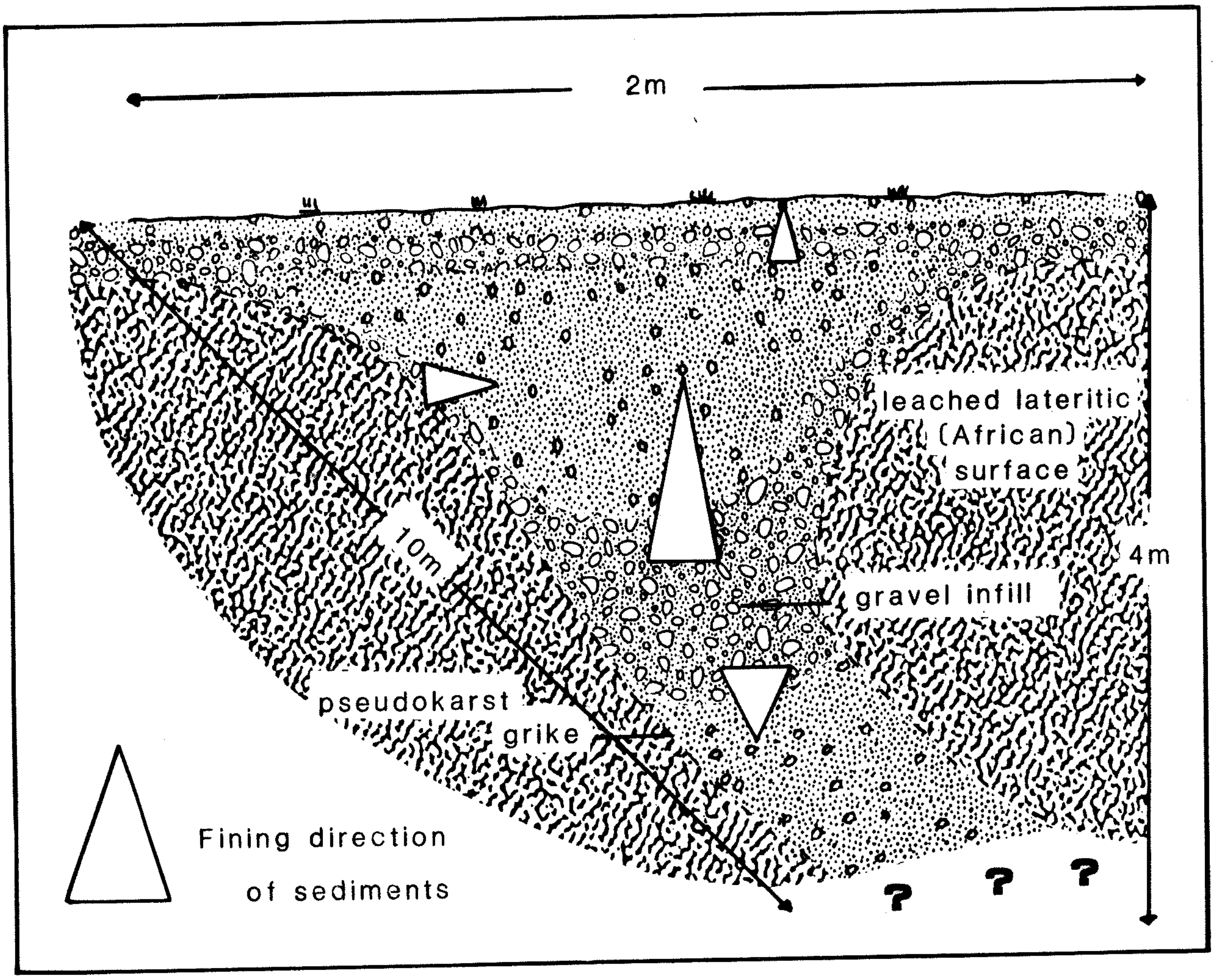

Figure 2. *Rooikoppie gravel infill of laterite pseudokarst grikes (Goedgedacht 197 HO).*

Up until now, these Rooikoppie gravels have been assumed to be remnants of high-level terraces and, thus, referred to as runs. This is because, in many cases, the deposits tend to parallel the modern streams at distances of between 500 and 1000m. It is, however, difficult to reconcile these deposits with true, alluvial deposits in terms of their clay content (12-25%) and their morphology - they occur almost parallel to the modern streams on both sides of the valleys, which is difficult to explain as fluvial terraces, unless invoking several, closely-spaced, very-wide rivers. The gravels, rather, have the characteristics of the derived, colluvially-reworked gravels of the lower Vaal basin (Partridge and Brink, 1967; Helgren, 1979). As such, the Rooikoppie gravels probably represent colluvial and elluvial detritus scattered over a deflation surface that is extensively laterized. The derived gravels in the lower Vaal basin contain Cretaceous-age pollens (T.C. Partridge, pers. comm., 1987), and it is possible that the Rooikoppie gravels are of a similar age. If so, then the pseudokarstic landscape on which the gravels were deposited must represent the African surface, which is elsewhere characterized by extensive and intensive weathering and laterization (Partridge and Maud, 1987).

(b) Younger Terrace Gravels

The terrace gravels occur everywhere along the length of the Bamboesspruit, flanking the dry and marshy sections of the valley to widths of up to 100m. In general, the terrace deposits consist of a 5-8m, upward-fining, alluvial, sedimentary sequence, deposited on an uneven floor of Ventersdorp lavas and capped by 1-2m of soil (locally known as brown-black turf). The entire sequence is calcretized. The lower portions are either oxidized (brown-orange in colour) or reduced (grey-green), depending on the proximity of the water-table.

Due to the nature of the diggings, it is almost impossible to see any sedimentary structures within the gravel profile. The action of the graders and backacters destroys the exposed surface and all but the coarsest sedimentary indicators. From a careful examination of the gravels and overlying, calcreted sediments, it is apparent that the overall sequence is upward-fining. The boulders at the base of the channel are in the range of 30-40cm (long axis diameter), but can be as large as 3-4m (long axis diameter). They consist entirely of amygdaloidal, Ventersdorp lavas and dolerite. The gravel clasts consist of two populations, i.e. a sub-angular population, consisting mainly of Ventersdorp lavas and dolerites, and a sub-rounded-to-rounded population of resistant, siliceous rocks, mainly quartz, chert, and quartzite. The latter population represents clasts which have been reworked from an earlier, alluvial event (or which have travelled a long distance), and the former population represents locally derived detritus. Since the smooth, sub-rounded-to-rounded clasts are indistinguishable from those found in the Rooikoppie deposits, it is presumed that these deposits have been reworked, to release their clasts into the streams, to be deposited along with the more-abundant, locally-derived Ventersdorp lavas. The agates that occur in the terrace gravels can also be found, more abundantly, in the older Rooikoppie gravels, and it is, therefore, assumed that this is their immediate (if secondary) source. The original source of the agates is problematic, but has been ascribed tentatively to the Stormberg lavas (R. Armstrong, pers. comm., 1986).

Although the overall form of the gravels is a massive, upward-fining sequence, there are numerous sedimentary facies representing changes in hydraulic regime and sediment-characteristics along the palaeochannel. An example of this is found on Rooibult 152HO. The overall gravel sequence is 4m thick, but, within the calcretized gravel sequence, there are numerous, fine-grained, calcrete lenses which may represent original shale or fine-sand lenses in the gravels. A few tens of metres away, in the same digging, the gravel is upward-fining at the base, for about 2,5m, and then it becomes upward-coarsening. Only the lower sequence is diamondiferous. On the Boskuil diggings, on Uitkyk 248HO, gravel lenses and stringers are found within the calcreted sands, some 1-2m above the gravel unit. On Rietkuil 186HO, the gravel-facies variation is quite considerable. In one instance, the gravel unit consists of a single unit, less than 2m thick, which suddenly increases to 3,5m in a pothole in the Ventersdorp-lava floor. Some 50-60m downstream, the gravel unit thickens considerably to about an average of 4m, but is pervasively interbedded with sandstone-and-mud lenses. The diamond-content of the gravel had also diminished considerably. This leads to the recognition of obvious relations between hydraulic conditions and deposition of diamonds.

A number of empirical observations have been made concerning the depositional sites of the diamonds:

(1) The coarser the gravels, the larger the average diamond-size.
(2) Diamonds tend to concentrate in pockets in potholes in the floor of the channel, in front of (and, in some cases, behind) obstructions in the channel, in traps formed by the presence of large (3-4m) boulders in the channels, downstream of constrictions in the channels, and in the point-bars of meanders in the palaeochannel (Fig.3).
(3) The terrace gravels tend to be richer where the nearby Rooikoppie gravels were (or are) rich and, similarly, where the Rooikoppie gravels are not so rich, the terrace gravels also tend to be relatively poor.

For the most part, the alluvial gravels occur at depths of between 4 and 8m. Both the oxidized and the reduced varieties are usually at the same elevation. There is only one recorded occasion where the two gravel terraces are at two different elevations. On the farm Rooibult 152HO, reduced gravels are developed below 6-7m of calcrete and turf. Approximately 100m away (upslope) from these gravels are distinctly-shallower, oxidized gravels at 3-4m below surface. According to the digger-farmer, the reduced gravels extend 50-60m from almost the present spruit into the mielielands at roughly the same elevation (not depth below surface, due to the effects of topography). There is then a gap of some 10-20m, where the calcreted sediments lie directly on top of Ventersdorp lavas, until the oxidized gravels are encountered at 3-4m below surface.

The oxidized terrace gravels at this locality are not sufficiently different from those developed elsewhere along the Bamboesspruit to warrant the assumption that they represent an earlier terrace than other oxidized gravels in the area. That the oxidized gravel is older than the reduced gravel on Rooibult 152HO is undisputable, but it does not suggest that all such oxidized gravels are older than, or at different elevations from, all reduced gravels. The explanation offered for the different terrace elevations here is that, at the time of downcutting by the palaeo-Bamboesspruit, the channel was in a position somewhat to the south of its present position and at a depth of ± 2m below present and deposited what is today the oxidized gravel. Before the period of incision was complete, the river-channel changed position quite substantially, re-established itself farther north, and deposited the present reduced gravel. This may have been the result of stream cut-off of a meander to form an oxbow-lake at a higher elevation to the main stream. Alternatively, a local obstruction in the channel up- or downstream may have induced the channel to change direction at that point.

In two localities (Roodepan 163HO and Uitkyk, 248HO), the gravels occur in a channel that is approximately 30m wide and 6-7m deep. But, in other localities, diggings and refilled dumps suggest that gravels up to 200m in width have been excavated. It is most unlikely that these represent palaeochannels of 200m-wide rivers. Rather, it is more probable that they represent channel-migration of palaeostreams less than 30m wide. In places where the gravels are mined over widths greater than 50m, there is little or no channel-definition, suggesting channel-migration.

The palaeochannel of the Bamboesspruit occupies the same valley as the present spruit. The meander wavelength, however, is different from that of the present. This is as a result of a wider channel (± 30m, as opposed to the present ± 10m) and a higher volume of water that must have flowed through it. Consequently, the palaeochannel meanders about the present Bamboesspruit. The gravels of the older channel, therefore, sometimes occur on one or other side of the present stream, in the present channel, or on both sides of the present stream, depending on the interference-pattern set up by the two meander-patterns (Fig. 3). Where the older channel sediments occur in, or very near to, the present channel and the water-table, they are reduced and, hence, green in colour. Conversely, where the older sediments are further away from the water-table, they are more oxidized and, thus, more yellow-orange in colour. Consequently, there is no regular pattern to the occurrence of oxidized or reduced Terrace Gravels about the present Bamboesspruit.

DISCUSSION

(a) Correlation with Vaal River Stratigraphy

The stratigraphy of the lower Vaal River gravels has been subdivided into the Older and Younger gravels (Partridge and Brink, 1967; Helgren, 1979). Two distinct types of Older Gravels have been described, viz. the Primary Alluvial Gravels and the Derived Gravels. Distinctive similarities exist between the Rooikoppie Gravels and the Derived Gravels. Both deposits consist almost entirely of chemically-resistant lithologies, mixed with a small proportion of local Ventersdorp lavas, and exhibit colluvial redistribution-features. They contain no record of the time, place, or character of their initial, presumably alluvial, aggradation, but are simply a weathered lag derived from an earlier deposit.

Correlations of the Primary Alluvial Gravels (the initial, presumably-alluvial deposits) have not yet been encountered in the southwestern Transvaal. It is the opinion of the author that such alluvial gravels may be found beneath the Rooikoppie Gravels, where these lie on a calcrete bottom. Where the Rooikoppie Gravels overlie a lateritized pseudokarst surface, these are likely the only vestiges of a colluvially-reworked slope-deposit.

The Younger Gravels of the lower Vaal River basin have been divided into the Rietputs (A-D) and Riverton (I-V) formations, representing numerous episodes of cut-and-fill under varying climatic regimes (Helgren, 1979). The Terrace Gravels of the southwestern Transvaal may be tentatively correlated with the Rietputs-A and -B formations. The basal

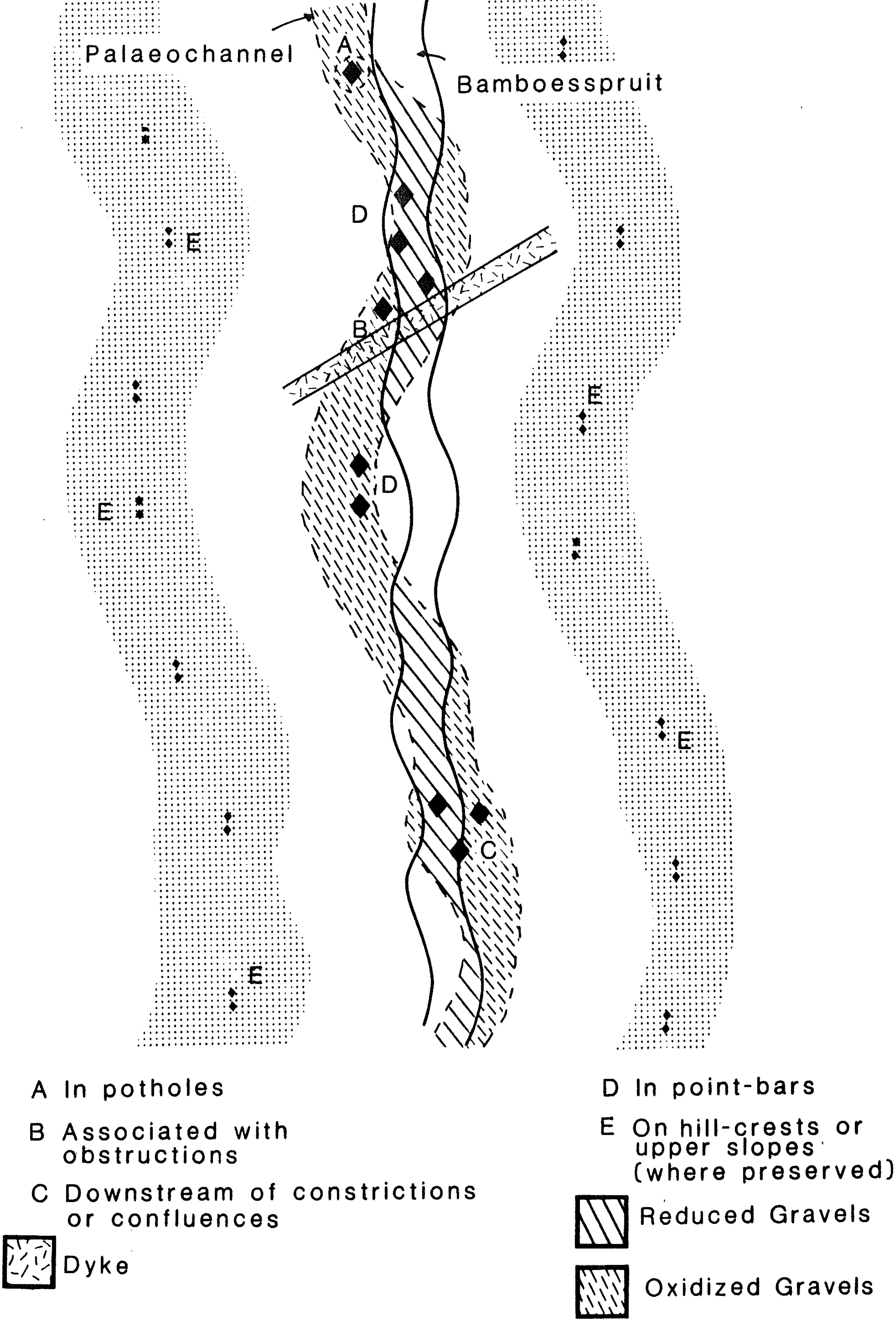

Figure 3: *Schematic plan-diagram of the interference-pattern set up by the meandering of the palaeochannel about the present, dry Bamboesspruit. The stippled pattern represents the possible original extent of the Rooikoppie (derived colluvial) gravels and the diamond shapes represent economic concentrations of diamonds.*

fines and the gravels themselves may be attenuated correlations of the Rietputs-A formation (representing humid aggradation). The calcreted sediments overlying the gravels are possibly time-equivalents of the Rietputs-B formation. In both cases, the deposits are calcreted. The calcretization is not pedogenic, but the result of precipitation from through-flow and surface waters draining the upslope areas.

(b) Environment of Deposition

From an analysis of the Rooikoppie and Terrace gravels and a comparison with the Older and Younger gravels of the lower Vaal Basin, the following sequence is proposed for their deposition and subsequent evolution:

(1) During the long period of stillstand associated with the African erosion-surface, primary alluvial gravels were reworked predominantly by slope-processes and redistributed over an intensively-lateritized, pseudokarst surface. This surface is the African landsurface and may be Cretaceous- mid-Tertiary in age.

(2) Following this extended period of stillstand, incision of the Vaal River and its tributaries occurred. This was followed by aggradation of the Rietputs-A basal fines and gravel formation under relatively humid conditions. The incision is probably associated with late-Pliocene uplift along the Griqualand-Transvaal axis (Marshall, 1986).

(3) During this period of aggradation, the climate appears to have become significantly more desiccating, with the deposition of the Rietputs-B sediments and subsequent calcretization of the entire sequence. The period of aridification was finally climaxed by the deposition of the Hutton Sands - mixed alluvial and aeolian sands of apparently Kalahari origin.

(4) Subsequent phases of incision and aggradation took place along the main Vaal River and extended along many of its tributaries (the Bamboesspruit, for example). These deposits, which occur in the present channel of the Bamboesspruit, have reworked the diamondiferous gravels, in places, and may, themselves, be diamond-bearing.

CONCLUSION

Field evidence indicates that there are two fundamental types of gravel deposits in the southwestern Transvaal, viz. the Rooikoppie (Derived) Gravels and the Terrace Gravels. The Rooikoppie gravels usually occur as a thin veneer on hillslopes and as infill of pseudokarst grikes in the underlying lateritized surface. These colluvially-reworked and re-distributed gravels represent the remains of an ancient, presumably-alluvial deposit.

The Terrace Gravels, which range in colour from green through grey to brown, occur in the valley of the present Bamboesspruit. The variation in colour is the result of the degree of calcretization and oxidation-reduction that has occurred in the gravels. These gravels are a result of incision and subsequent aggradation of the Vaal River and its tributaries, most likely during the Tertiary warping of the central interior.

The present distribution of the gravels can be explained in terms of colluvial and alluvial reworking of earlier deposits. The diamond-concentration within the gravels is controlled by hydraulic conditions present in the channel. Economic concentrations of the diamonds occur in potholes in the channel-floor, associated with obstructions (such as dykes) in the channel, downstream of constrictions and confluences, and in the meander point-bars of the palaeostream.

The question regarding the ultimate source of the gravels and diamonds still remains unanswered. A possible relation can be seen to occur between some small pans adjacent to a number of Rooikoppie deposits and a very early palaeodrainage system (possibly related to the Cretaceous African surface). The analysis of this palaeodrainage system may indicate the source of the diamond-bearing gravels, if the problems associated with the laterization can be overcome. This line of investigation is being further pursued by the author.

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