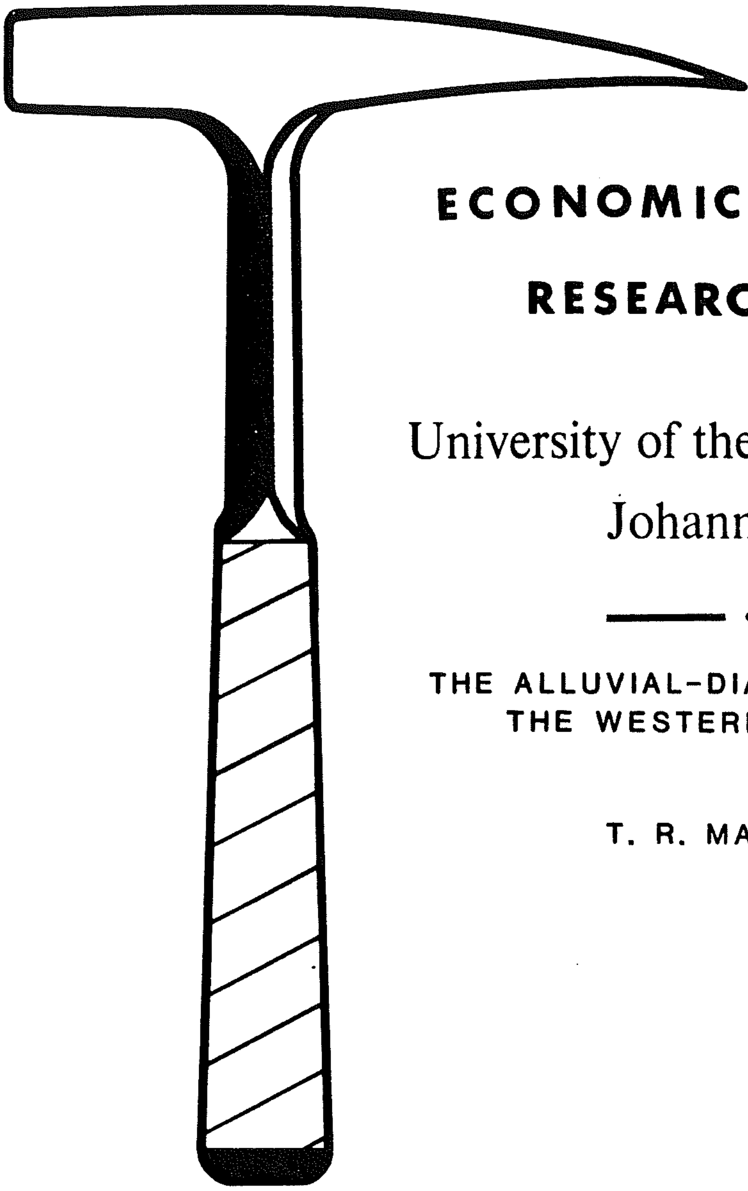

ECONOMIC GEOLOGY RESEARCH UNIT

University of the Witwatersrand
Johannesburg

THE ALLUVIAL-DIAMOND FIELDS OF THE WESTERN TRANSVAAL

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UNIVERSITY OF THE WITWATERSRAND

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by

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ABSTRACT

The alluvial diamonds of the western and southwestern Transvaal appear to be confined to the Vaal-Harts interfluve, the dolomite plain, and the present channels of the Vaal River and its right-bank tributaries. The total area embraced is of the order of 25 000 sq. km.

An analysis of the gravels indicates that they have been derived mainly from local sources of Karoo, Ventersdorp, and Dwyka lithologies, as well as from detritus on the dolomite plain, and from the reworking of pre-existing gravels. A small component of extra-basinal clasts was derived from eastern Botswana, northern Transvaal, and the Lesotho plateaux. A review of literature concerning the diamonds from these deposits reveals that most are of unknown origin. Others can be traced to the uraniferous banket of the Klerksdorp Goldfield or to kimberlitic intrusions of the northern Transvaal and Orange Free State.

Previous theories have suggested that the gravels and the diamonds are derived from far to the north and were transported to their present position by palaeo-streams. It has been shown, however, that most of the gravels are of local origin, and, thus, the diamonds should be as well. Recent studies indicate that exposed granite basement in the area is the result of a structural dome in the basement. Kimberlites occur on the northern and southern flanks of the upwarp, and it is suggested that other kimberlite was emplaced over the crest of the upwarp. The accentuated uplift over the culmination led to the erosion of the kimberlite and the development of a lateritized, Tertiary erosion-surface on which the diamonds and gravel occurred as a lag-accumulation. Quaternary fluvial processes reworked the gravels and redistributed them into the present-day drainage-systems.

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THE ALLUVIAL-DIAMOND FIELDS OF THE WESTERN TRANSVAAL

CONTENTS

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THE ALLUVIAL-DIAMOND FIELDS OF THE WESTERN TRANSVAAL

INTRODUCTION

The alluvial-diamond fields of the western Transvaal are confined to the Vaal-Harts interfluve, the northern dolomite plain, and the present channels of the Vaal River and its right-bank tributaries, downstream of Vereeniging. A total of 14,4 million carats, with a value of some R141,6 million, has been recovered from these fields, between 1904 and 1984. This is comparable to the 14,5 milion carats, valued at R100,0 million, yielded by the Big Hole at Kimberley after 44 years of mining.

Traditional theories on the genesis of the alluvial-diamond fields suggest that southerly-flowing palaeodrainage-ways from eastern Botswana and the northern Transvaal are the sources of both the gravels and the diamonds. Recent findings, however, indicate a local source for the diamonds and gravels and suggest that deflation over a structural culmination, along with numerous phases of alluvial and colluvial reworking from the mid-Tertiary through to the Holocene, are the processes causing concentration of alluvial diamonds.

METHODS

The statistical data regarding diamond-sales (taken as production) since 1904 were gathered (Marshall, 1986a) from the Transvaal Diamond Registers in the archives of the South African Minerals Bureau and from the Gold and Diamond Division of the South African Police. These statistics, being the official sales listings, are taken as being a fairly complete and accurate reflection of the actual production of diamonds from the alluvial fields. The diamond- production is recorded as total carats and Pound (pre-1961) or Rand values per month per farm. No information concerning the size, value, or type of individual stones is recorded in the registers. It has, therefore, been necessary to rely upon descriptions of the diamonds from early workers, such as Merensky (1907), Harger (1909), Wagner (1914), Williams (1932), and du Toit (1951), for this information.

The descriptions of the gravel-deposits have, in the first instance, been drawn from the published works of du Toit (1951), Stratten (1979), and Helgren (1979), and, in the second instance, from a reconnaissance field-trip, by the author, to the fields concerned. The findings of this field-work have resulted in the initiation of a research project into the re-evaluation of the gravel deposits of the western Transvaal.

OBSERVATIONS AND RESULTS

The Gravels

The alluvial gravels are concentrated into three discrete fields: the Northern (Lichtenburg-Bakerville) Field, the Eastern (Ventersdorp-Potchefstroom-Klerksdorp) Field, and the Southern (Christian-Schweizer-Reneke-Wolmaransstad) Fields (Fig. 1). The area between these fields is by no means barren, but the deposits are more widely scattered.

In the Northern Field and portions of the Eastern Field, the older diamond-bearing gravels occur mostly on the dolomite plain as runs or pot-

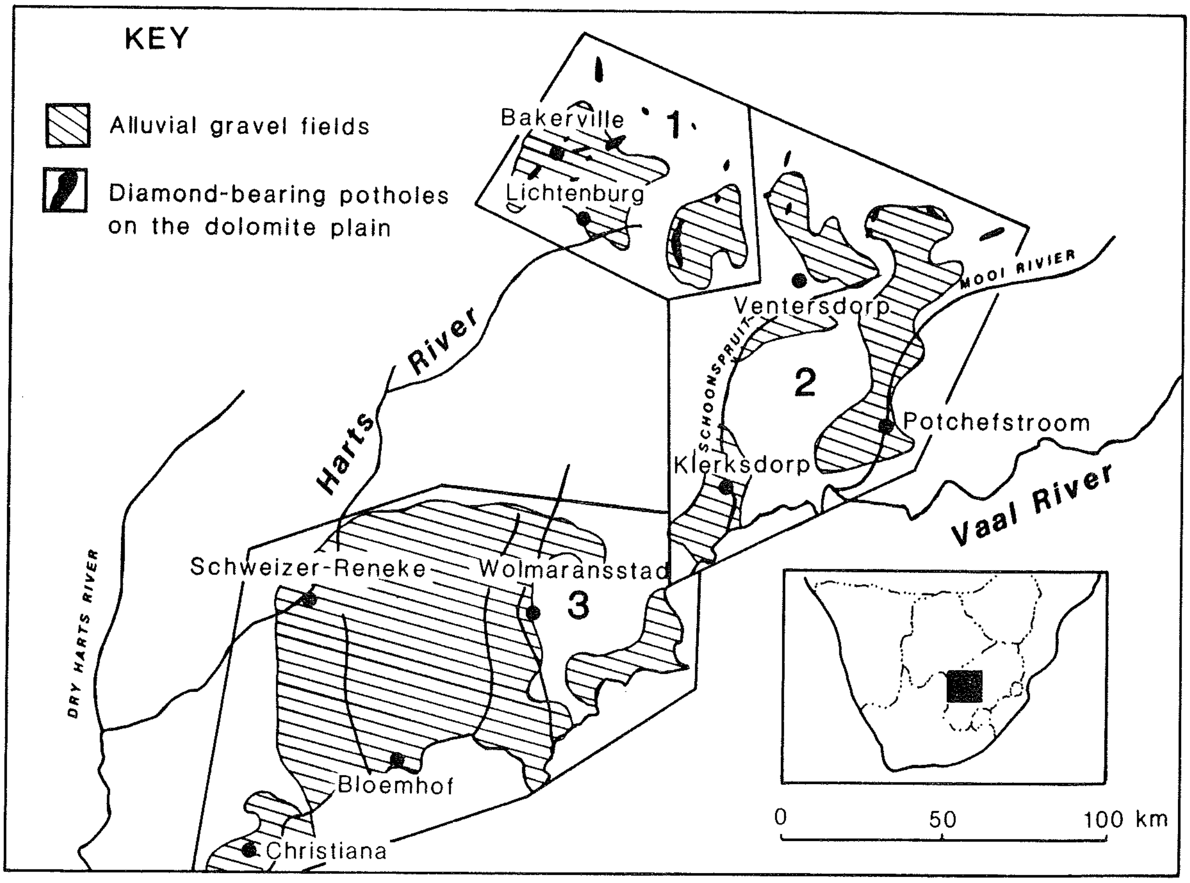

Figure 1 : *Locality of the diamond-bearing, alluvial gravels of the Western Transvaal, showing the Northern (Bakerville-Lichtenburg) Field (1), the Eastern (Ventersdorp-Potchefstroom-Klerksdorp) Field (2), and the Southern (Christiana-Schweizer-Reneke-Wolmaranstad) Field (3).*

holes (du Toit, 1951). The gravel-runs, presumably deposited in palaeo-drainage lines, usually occur as slightly-positive features, such as mounds, above the level of the dolomite. Such inverted topography is characteristic of the erosion of dolomite plains under arid-to-semi-arid climatic conditions (Sweeting, 1972). Richer deposits are found in sink-holes, or potholes, which contain remarkably uniform gravels (Fig. 2). The basal, white layer is a white, clayey-to-gritty deposit, containing angular, small-sized material, almost entirely composed of chert and vein-quartz. The matrix consists largely of disintergrated chert and chert-breccia, together with a moderate amount of kaolin. The deposit is clearly of local origin and represents detritus from a dolomite plain with a veneer of Karoo strata (du Toit, 1951, p.22).

The overlying, lower, red zone is rich in both agates and diamonds. It is in these gravels that abundant chromium garnets were found in the Ruigtelaagte 205 pothole, as was spinel on Grasfontein 240. Characteristic of these lower gravels are agates of various kinds. The smaller varieties are usually rounded, but the larger ones are mostly angular. Two possible sources of the agates have been proposed. Beetz (1930) has suggested that the agates were derived from silicification of the dolomite surface or intense aridity in the late-Cretaceous. To the contrary, du Toit (1951) has shown that the agates are likely to have been stained by iron and manganiferous hydroxides derived from the enclosing, red, clay matrix of the gravels. Three, possible, parent-volcanic formations were suggested by du Toit (1951) as the source of the agates: the Ongeluk lavas of the Transvaal Sequence; the Ventersdorp lavas; and the Bushveld amygdaloid. A fourth possibility, the Stormberg lavas, can also be added to this list.

Overlying the productive lower red zone is the intermediate zone which, although lithologically indistinguishable from the lower zone, contains no agates and very few diamonds. Capping the deposits is the productive, upper layer. This zone is grey-to-pale-brown, as a result of strong surface-weathering. In many places, the gravels pass beneath a sandy cover or a lateritic horizon. In some places, an angular unconformity is developed between the upper and lower divisions.

In the Southern Field, the older, diamondiferous gravels are found on Palaeozoic terraces cut into Ventersdorp lavas, on Archaean granite, and on post-Karoo lithologies. The oldest gravels occur on pre-Karoo terraces that have been exhumed by Cretaceous and Tertiary erosion and represent remnants of original, fluvial gravels of a high-competence river (the ancestral Vaal) and of predominantly-colluvial gravels spread across generally-planer segments of the pre-Karoo landscape. They have been described as "an erratic, infrequently preserved, depositional residue of a long period of continuing erosion" (Helgren, 1979, p.180).

The older gravels of both the Northern and Southern fields are separated from the younger gravels by fluvial incision up to 18m in vertical amplitude (Fig. 2). The younger gravels (the Rietputs and Riverton formations) occur alongside the Vaal River and its right-bank tributaries. These two, separate, depositional pulses represent reworking of the older gravels, as well as erosion of local material.

A detailed analysis of the gravels of the Southern Field has revealed that the clasts have been derived from both local and extra-basinal sources (Helgren, 1979):

(a) Locally, the Karoo rocks have been eroded to produce clasts of shale, dolerite, and fossil wood. It has also been suggested that some of the agates may have been derived from the Stormberg basalts. Xenoliths of Karoo rocks in the kimberlite pipes at Kimberley indicate that the Karoo cover extended at least as far as the north-eastern Cape in the late-Cretaceous. The chert and dolomite clasts, abundant in the Northern Field, have also been derived locally from the exhumed dolomite plain surrounding the deposits. Local Dwyka tillite and dropstone beds have been eroded, to produce the striated pebbles of Waterberg and Transvaal material. These products were initially derived from the northern Transvaal and were transported southwards by the Dwyka glaciers. Although their initial source is from some distance away, the clasts have been derived from a secondary, more-immediate source.

(b) The material that has been eroded from primary, extra-basinal sources is that which is found in the London Run, as well as the finer bedload of all the gravels. Some of the lithologies in the London Run, between Schweizer-Reneke and Bloemhof, have been identified as emanating from eastern Botswana. The finer bedload found in all the gravels is identical to that found in all rivers which drain the high (Lesotho) plateaux. This fact serves to emphasize that far-travelled material occurs as fine bedload and not as pebbles (rounded or otherwise). This highlights the possibility that the gravel-clasts have been derived from local sources, and are unlikely to have travelled hundreds of kilometres by fluvial transport.

In summary, apart from the minor amounts of material derived from eastern Botswana and the Lesotho highlands, all pebbles in the western Transvaal alluvial gravels can be accounted for as being of local origin.

NORTHERN FIELD		SOUTHERN FIELD
<u>PRODUCTIVE UPPER PALE ZONE</u> Leached by strong weathering. In sinkholes it passes beneath lateritized soil. Some enrichment due to leaching and re-working along incised drainage lines.	Younger Gravels	**<u>RIVERTON GRAVELS</u>** Cycles of further alluvial reworking along incising drainage lines. Recent downcutting of the Vaal River and its tributaries. **<u>RIETPUTS GRAVELS</u>** Cycles of alluvial and colluvial reworking of the Older Gravels, separated by periods of downcutting. Overlain by deposits of Hutton Sands in an arid environment. (Kalahari Sands equivalent).
Angular unconformity often present (vertical amplitude up to 18m)		
<u>PRODUCTIVE LOWER RED ZONE</u> Descends into hollows and deep potholes. Diamonds and agates are abundant. Matrix is reddish brown-black (Fe weathering). **<u>BASAL WHITE LAYER</u>** White clayey-gritty deposit of chert and vein quartz, angular small pebbles on a dolomite plain, with veneer of Karoo cover.	Older Gravels	**<u>DERIVED GRAVELS</u>** Rudaceous, colluvially-reworked Primary Alluvial Gravels; reminiscent of long periods of subaerial exposure. **<u>PRIMARY ALLUVIAL GRAVELS</u>** Deposits of alluvial gravel - calcreted original fluvial gravels of a high-competence river (ancestral Vaal River); on pre-Karoo planar surfaces.

<u>*Figure 2*</u> : *Simplified stratigraphy of the alluvial-diamond fields (after du Toit, 1951; Helgren, 1979).*

The Diamonds

Consideration of the diamond-production data shows distinct differences between the three gravel fields (Fig. 3). Although only in operation since 1926, the Lichtenburg-Bakerville Field has produced almost 68 per cent of all the western Transvaal alluvial diamonds, that is, 9,7 million carats. These diamonds have a low average value of only R5,34 per carat. In the Eastern Ventersdorp-Potchefstroom-Klerksdorp Field, the average value is R8,54 per carat (the Eastern Field and the scattered deposits together constitute 18 per cent of the diamonds). This difference between the two fields can be explained in terms of reworking. The diamondiferous gravels trapped in the karst hollows were sheltered from later reworking by fluvial processes. The gravels of the Eastern Field, however, have been subjected to further reworking in which many of the lighter, smaller diamonds have been flushed out of the system. This is substantiated by the current distribution of the diamonds. The highest concentrations (in terms of total production figures) occur along the present drainage lines in the Ventersdorp district and around the potholes of the Northern Field (Fig. 3).

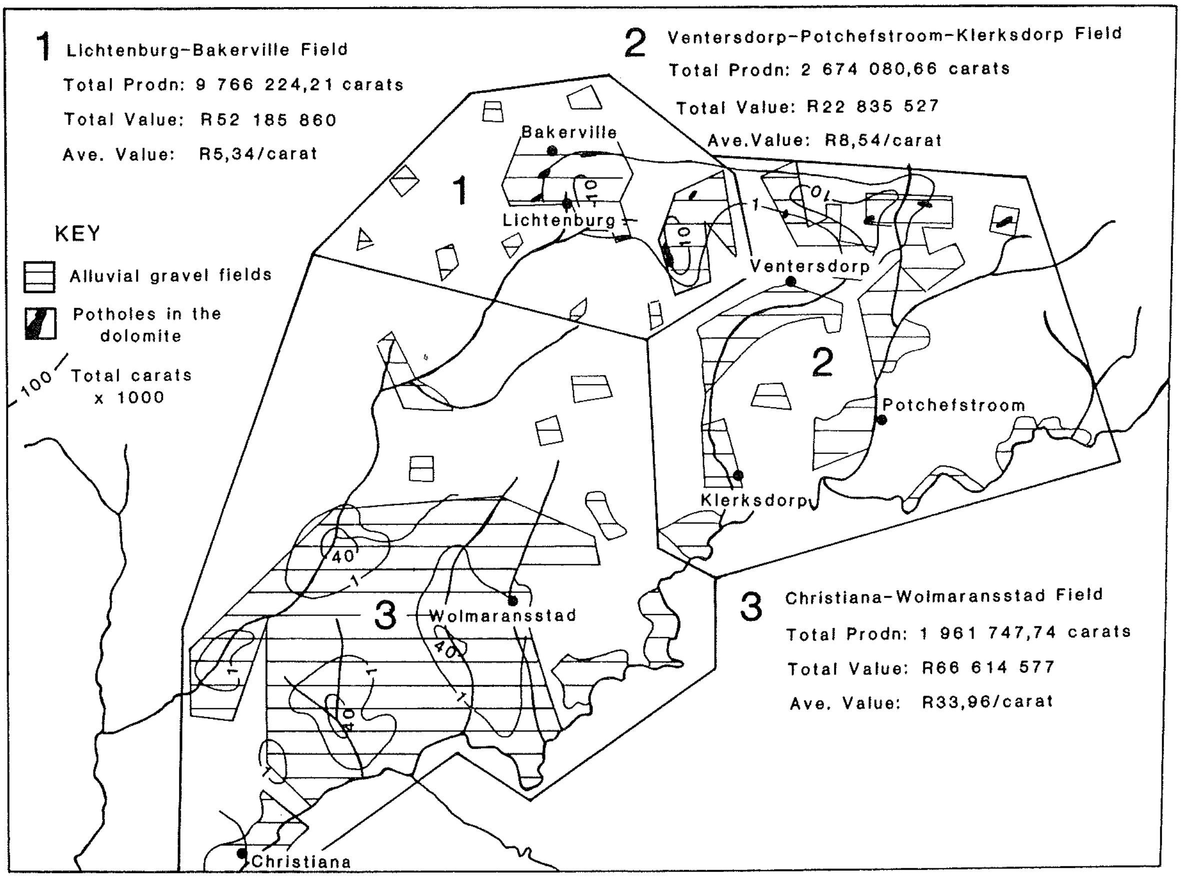

Figure 3 : *Distribution of diamonds (total carats) in the western Transvaal, showing the concentration along modern river valleys and in the potholes on the Lichtenburg dolomite plain. Also indicated are the production figures and average value per carat for the three diamond fields.*

The Southern Field has contributed 14 per cent of the alluvial diamonds, but, with an average value of R33,96 per carat, has realized over R66,6 million. The richness of these deposits can be attributed to two factors: first, the gravels have undergone at least four phases of fluvial and/or colluvial reworking, flushing out the poorer-quality diamonds; and, second, there appears to be an abundance of superior-quality, pure snowy-white, brilliant stones and blue-white cleavages in the Christiana district (Harger, 1909; Wagner, 1914). As in the Eastern field, much of the diamond-bearing gravel of the Southern Field is concentrated in, and along, present drainage- courses, indicating the effectiveness of the Quaternary reworking of the pre-existing gravels.

A review of the existing literature on diamond characteristics from the western Transvaal suggests that, although the majority of the diamonds are of unknown origin, at least some of the stones are traceable:

(a) *the banket stones* : pale-green diamonds are found only in the Schoonspruit and are derived from the Witwatersrand conglomerates of the Klerksdorp Goldfield (Wagner, 1914); the pale-green colour of the diamonds is likely due to exposure to the uranium in the banket rocks; the initial source of these diamonds is unknown, but it is most probably intimately associated with that of the Witwatersrand sediments, gold, and uranium, and is Precambrian, rather than Cretaceous;

(b) *the tillite stones* : "the distinct wear seen on many of the river diamonds suggests attrition due to slow moving ground moraine at or near the base (of a glacier)" (Harger, 1909, p.144); these diamonds have been transported by the Dwyka glaciers in the same manner as the striated Waterberg and Transvaal clasts; their initial source was, consequently, outside the Vaal basin and is likely to have been in the Precambrian terrane of the northern Transvaal; their more immediate source is, however, the local Dwyka tillite and dropstone beds; and

(c) *pipe and fissure stones* : many of the diamonds found in the Southern Field have been reported as being similar to those mined from the pipes of the Orange Free State (Harger, 1909); if this is true, then at least some of the O.F.S. diamonds must have found their way into the diamond-fields north of the Vaal River; this immediately raises questions, since no diamondiferous gravels have yet been found on the O.F.S. side of the Vaal River; it is, further, significant that few diamonds correlatable with the fissures at Swartruggens or the pipes at the Pilanesberg and Jwaneng have been reported in the gravels.

By far the majority of the diamonds found in the western Transvaal are of unknown origin. The most spectacular of these are the white, brilliant stones and the blue-white cleavages from the Christiana district and the peculiar, frosted, "cross-grained" diamonds from the Schweizer-Reneke alluvial diggings (Wagner, 1914). It has been assumed (Stratten, 1979) that these diamonds have been eroded from pipes to the northeast and northwest and washed down, along with the gravels, to form the alluvial deposits of the western Transvaal.

Palaeo-Drainage Interpretation

The prevailing theory regarding the deposition of the alluvial gravels and diamonds of the western Transvaal assumes that the sources for these must have lain to the north and, consequently, that they must have been brought to their present locality by ancient rivers. This conclusion has been based on an interpretation of 58 palaeocurrent-directions measured in the western Transvaal (Stratten, 1979). From these palaeocurrent-measurements and roundness-indices, the sources of the diamond-bearing gravels were interpolated as being northeast of Swartruggens, southeastern

Botswana, towards the east, and the reworked Northern gravels (Fig. 4). A comparison of these palaeocurrent-measurements with the Quaternary drainage system, however, shows that the majority of the palaeocurrent-directions can be accommodated by Recent fluvial-reworking processes. Furthermore, recent research (N. Owen, pers. comm., 1985) has shown that many of the runs in the Northern and Eastern fields do not represent single episodes of fluvial deposition, as supposed by du Toit (1951) and Stratten (1979). The same study has also questioned the validity of many of the palaeocurrent data, having found indications of a southerly source for many of the gravel deposits.

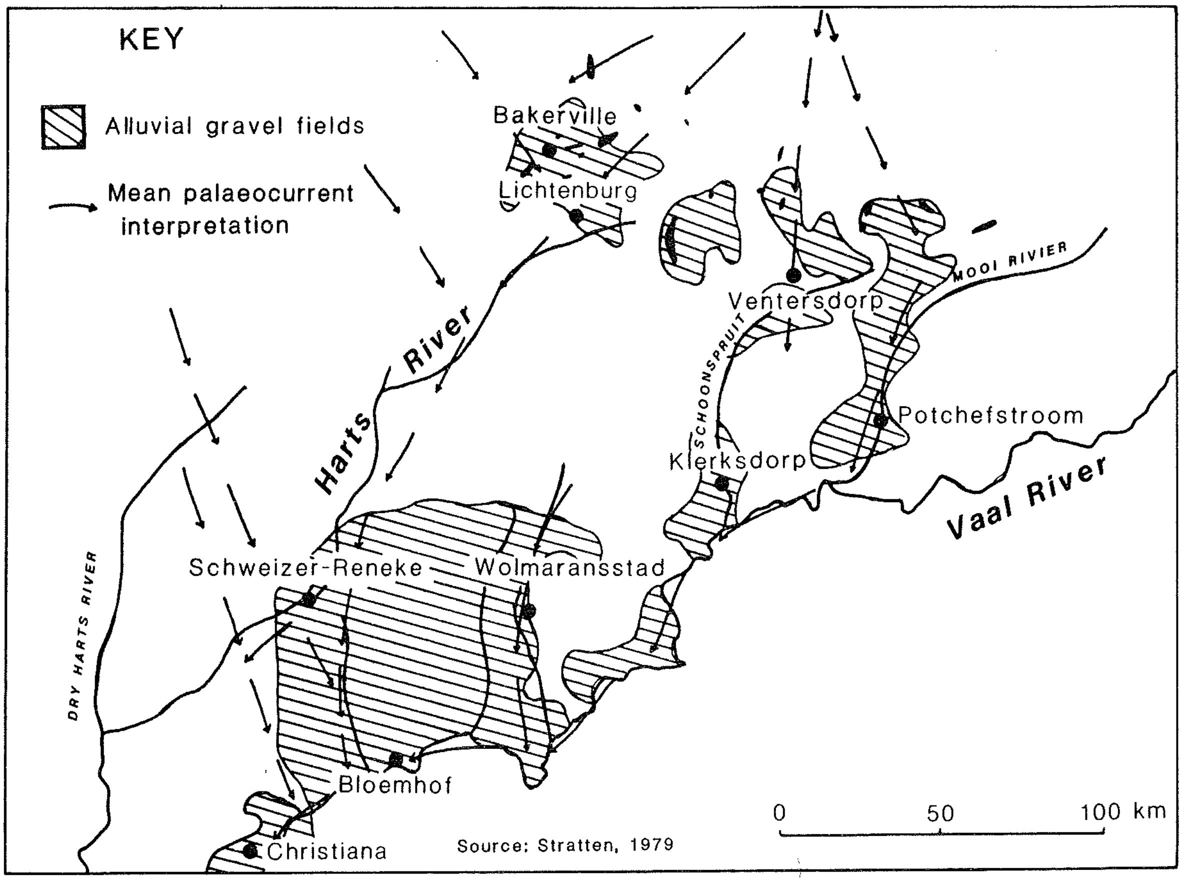

Figure 4 : *Palaeo-stream trends, as interpreted from palaeo-current-measurements and roundness-indices (after Stratten, 1979).*

A more detailed study of the palaeo-drainage of the area north of the Vaal River suggests little deviation from the present pattern. LANDSAT interpretation shows that the main Vaal channel has migrated southeastwards with time, yet keeping much the same shape as it has today. Along with LANDSAT, an analysis of the pans and palaeo-valleys between Bloemhof, Schweizer-Reneke, and Mafikeng indicates the presence of a southerly-flowing river which was ancestral to the Harts River (Mayer, 1973). A reconstruction of this palaeo-stream (Fig. 5) shows how gravel lithologies could have been transported from eastern Botswana to Bloemhof via the London-Klipbankfontein run. Mayer (1973) has assumed that this palaeo-Harts river was captured by headward erosion of a tributary of the Dry Harts, in the late-Tertiary or early Pleistocene, as a result of intermittent uplift along the Griqualand-Transvaal axis.

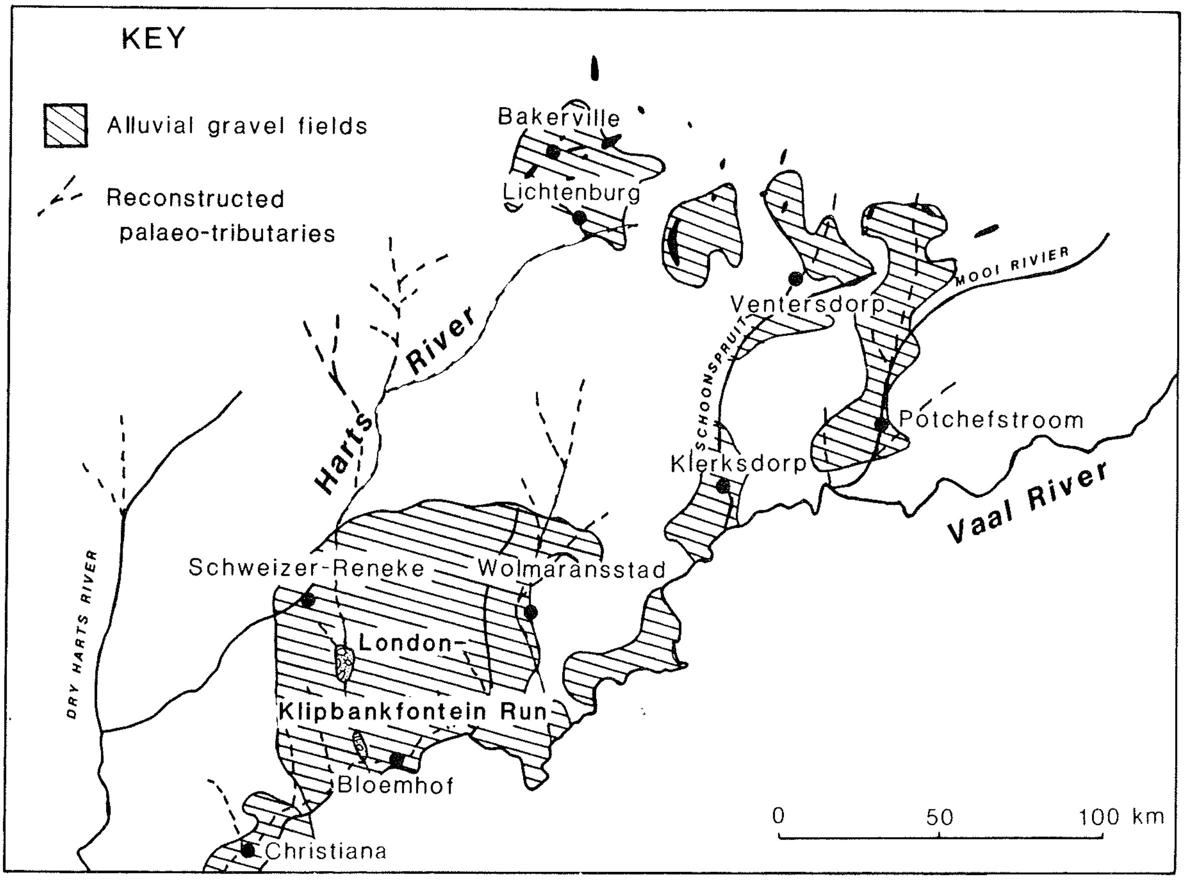

Figure 5 : *Palaeo-drainage reconstruction, as interpreted from LANDSAT imagery.*

Although the presence of this southerly-flowing stream from eastern Botswana shows how some of the gravels, and possibly some of the diamonds, may have been transported from the north to the Southern Fields, it does not account for all the diamondiferous gravel.

Basement Architecture and Local Kimberlite Occurrences

Structural studies in progress (D.A. Pretorius, pers. comm., 1986) indicate that the exposed basement granite between Lichtenburg and Wolmaransstad is the result of a structural culmination between two curvilinear N-S- and NE-SW-trending upwarps in the granitic basement (Fig. 6). To the north of this topographic high occur the kimberlitic fissures and pipes of Swartruggens, the Pilanesberg, and southeastern Botswana, and to the south are the pipes and fissures of the Kimberley and Barkly West districts, as well as the numerous intrusions in the Orange Free State.

It is noticeable that the kimberlite occurrences closest to the basement culmination, in the north (Swartruggens) and in the south (Barkly West district), are in the form of fissures, and those farther out occur as pipes. It is also true that the degree of erosion of the pipes tends to decrease away from the culmination. For example, to the north of the alluvial-diamond fields, less erosion has taken place on the Jwaneng pipe (eastern Botswana) than on the Swartruggens fissures, and, to the south, the degree of preservation increases from the Barkly West fissures to the pipes at Kimberley (Hawthorne, 1975). There, thus, appears to be a progressive increase in the amount of erosion that has taken place towards the

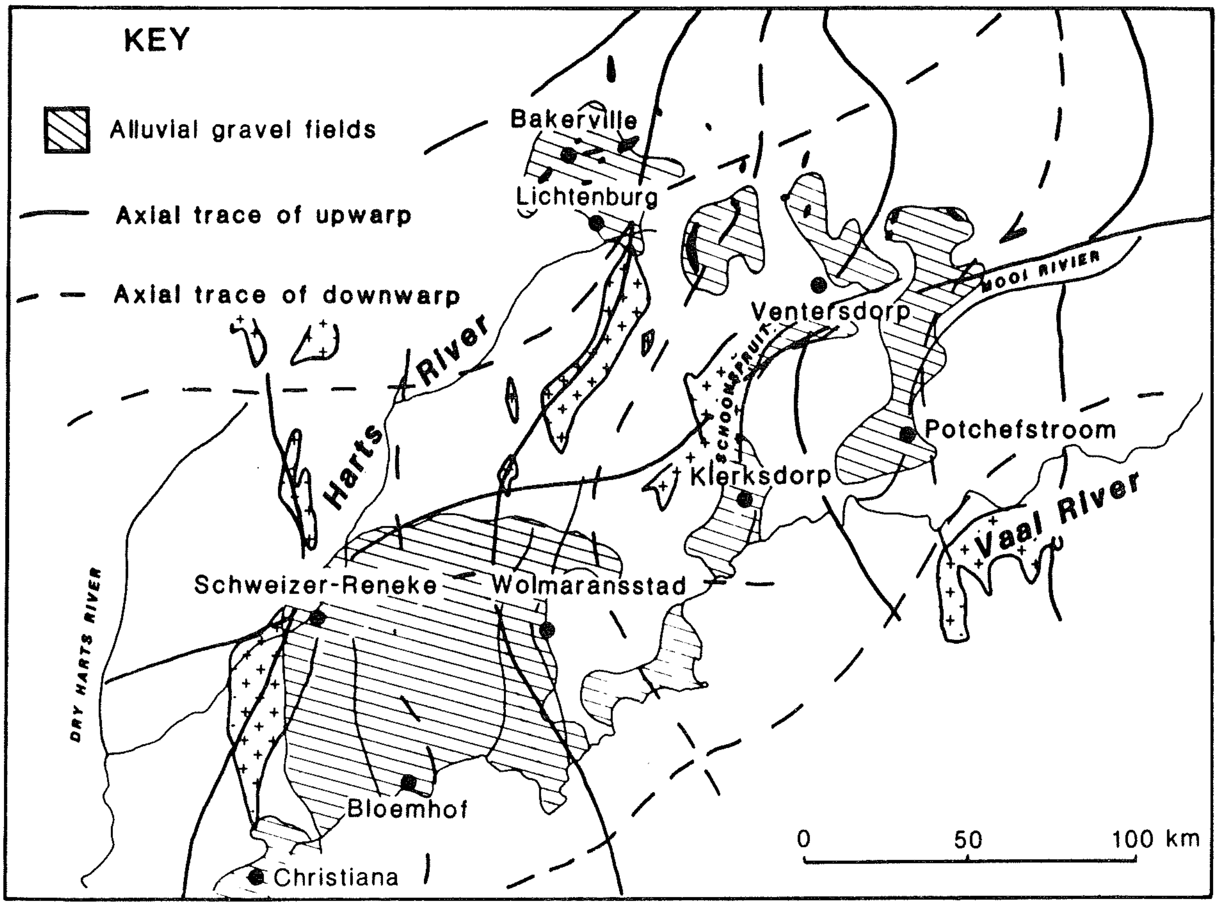

Figure 6 : *Interpretation of the Bouguer gravity anomalies over the western Transvaal indicate that the granite domes are the result of the culmination of two approximately-orthogonal upwarp-trends in the basement. The alluvial-diamondiferous gravels are concentrated in the troughs and basins between the upwarp-culminations.*

exposed basement high on the Vaal-Harts interfluve. This is substantiated by the surface geology. Along the Vaal-Harts interfluve, Precambrian Ventersdorp lavas, Witwatersrand and Dominion group sediments, and Archaean granite-greenstone terranes are exposed, indicating a higher degree of erosion than elsewhere. Furthermore, to the north, occur the extensive Kalahari deposits, an indication of subsidence and sedimentation, and, to the south of the structural culmination, some Karoo cover-rocks remain, suggestive of relatively low rates of erosion. Thus if diamondiferous kimberlites would have intruded into the crest of the culmination, they would have been eroded deeply, thereby releasing a large amount of diamonds to the drainage systems. The kimberlites would be difficult to detect on the present surface as only narrow fissures from the root zones would be preserved.

Evidence for Extensive Laterization in the Western Transvaal

Evidence will be presented to suggest that, at least, two periods of extensive erosion occurred in the western Transvaal. The earliest of these is associated with the older gravel deposits. The basal zone of the gravels in the Southern Field represents remnants of a high-competence, ancestral Vaal River, indicating relatively-humid conditions. Other factors which indicate humid climates during this period are : the presence of bauxitic clays in the lower, red gravels infilling the potholes of the Northern and Eastern fields (du Toit, 1951); the abundance of mulberry wash (black, manganiferous concretions) in the lower gravels; hard, lateritic clay deposits in the Schoonspruit valley (Helgren, 1979);and the generally-reddening of the lower gravel deposits in all of the fields. The implication of these deposits is that the long period of erosion was accompanied by a relatively humid climate, thus allowing for the development of a lateritic soil-horizon. Such laterization was not simply a final stage in the development of an erosion-surface, but was formed beneath a soil-cover, as erosion lowered the underlying rock-surface, as described by de Swardt and Trendall (1969). Under such circumstances, much of the iron-content of the laterite is residual and represents material originally present in the rocks which were removed during the lowering of the landscape, in this case the Stormberg and Ventersdorp lavas.

The second, younger period of erosion evidenced in the alluvial gravels is that which resulted in the calcretization of the Rietputs and Riverton deposits. The presence of calcareous palaeosols and windblown sand deposits is evidence that the climate became increasingly more-arid in the late-Tertiary-to-early-Quaternary. Helgren (1979) has dated the unconformity between the older and younger gravels as Pliocene, by the presence of Acheulian implements and middle-Pleistocene fauna in the overlying, younger, gravel deposits. The period of calcretization post-dates this. The present-day drainage-system, which deposited the younger gravels, must therefore have been established by the Pliocene.

DISCUSSION

This study, and earlier ones, have demonstrated that the majority of the pebbles in the gravel deposits of the western Transvaal has been derived from local sources. Small amounts of gravel have obviously been transported from eastern Botswana (via the palaeo-Harts drainage-line) and the northern Transvaal (via the Dwyka glaciers), and it is likely that some diamonds have come from these sources. The bulk of the diamonds, however, remain unexplained. These diamonds (approximately 14,4 million carats) may all have originated from one pipe, the size of the Kimberley Big Hole (470m x 450m x 1098m, and covering an area of 0,04 sq. km), or from a number of smaller pipes and/or fissures. In either case, in order to liberate such a large amount of diamonds, the pipe(s) from which the diamonds were derived must have been partially or totally eroded.

In agreement with Helgren (1979), it is being suggested here that the source of these diamonds is related to a hypothetical line of kimberlite fissures on the Vaal-Harts interfluve. Hawthorne (1975) has shown that, during the mid-Cretaceous (80-140 my), diamondiferous kimberlites were intruded through approximately 1400m of Karoo cover in the Kimberley area. It is postulated that kimberlites were intruded along the flanks and crest of an already existing structural-topographic high (the structural culmination on the Vaal-Harts interfluve). Diamonds and resistant kimberlitic ejecta gathered as a residual lag on the surrounding landsurface, as it was lowered. Accentuated uplift over the basement culmination resulted in the net lowering of the landscape at an average rate of 20mm per 1000 years. Denudation rates of 2-8mm per 1000 years are common today in areas of subdued relief and temperate, continental climates, while, in areas of high relief or seasonally-humid, tropical climates, denudation rates can vary from 9 to 100mm per 1000 years (Saunders and Young, 1983). From these figures it is reasonable to expect a lowering, through over 1400m of Karoo cover, from the time of kimberlite intrusion to the time of the mid-Tertiary erosion-surface, through deflation processes. During this time, it has been shown that extensive laterization of the soil-profile took place, and although these conditions are likely to have destroyed the kimberlitic indicator-minerals, such as pyrope garnets, chrome spinels, and magnesian ilmenites, some pyropes are found in the fine-grained matrix of gravels in deep potholes. Their surface characteristics, grain size, and mineral chemistry have still to be investigated in greater detail, but it can be said that their occurrence strengthens the case for the existance of kimberlites or lampriotes and thus for a local origin of the diamonds in the western Transvaal.

The degradation of the Tertiary surface resulted in the deflating of the gravel alluvium and lag-deposits onto numerous pre-Karoo planar segments, as they were gradually exhumed, and in the washing of diamond-bearing material into potholes and stream-beds of the northern dolomite terrane. It was during this time that the palaeo-Harts river was able to wash material down from eastern Botswana into the London Run. This long period of tectonic quiescence was interrupted in the mid-Tertiary by renewed activity along the structural features of the southern sub-continent. The structural movements had the effect of cutting off the palaeo-Harts from the Vaal River through river-piracy by the Dry Harts river tributary (Mayer, 1973) and the initiation of incision that produced the unconformity between the older and younger (or lower and upper) gravels. The ensuing period of fluvial aggradation was accompanied by a desicating climate, as evidenced by the increasingly-arid depositional facies of the Rietputs Formation. The deposits of the Rietputs Formation contain fossils and stone-tool assemblages of the Pliocene epoch which are found only in, and along, modern stream-channels. This indicates that the position of the present Vaal-system had been established by the end of the Pliocene.

Toward the end of the Pliocene and early-Pleistocene, gravel-aggradation in the Vaal basin was once again interrupted. This time the main factor appears to have been climatic change (Helgren,1979; Lancaster,1978). During the early-Quaternary, the environmental conditions varied through climates wetter, colder, and more arid than those of the present. Whether or not they were accompanied by isostatic readjustments of the local structural features is difficult to assess. Whatever the causes may have been, the channels of the Vaal River and its tributaries incised into the Rietputs gravels, reworked them, and redeposited them in the Riverton Formation. Further Quaternary climatic variations and isostatic movements on the exposed and buried structural features initiated the recent phases of gullying and downcutting associated with the Vaal River and its right-bank tributaries.

Morphotectonic analysis of the palaeo-drainage-patterns of the Orange Free State (Marshall, 1986b) has indicated that the ancestral Vaal River (pre-Miocene structural reactivation) had a left-bank tributary extending southwards from Christiana (Fig. 7). The structural movements in the mid-Tertiary had the effect of cutting off this tributary from the Vaal channel by the headward erosion of the Kimberley River (another left-bank, palaeo-tributary of the Vaal River, to the north of Kimberley). Prior to its being pirated by the Kimberley River, the palaeo-tributary may have transported diamond-bearing alluvial gravel from the deflation-surface surrounding the Kimberley-Boshof pipes to the main Vaal channel at, or near, Christiana. Following its mid-Tertiary capture, the upper reaches of this stream may have continued feeding diamondiferous gravels down the Kimberley River. The headwaters of the Kimberley River were finally captured by the Modder River in the late-Tertiary, and, as a result of both structural warping in the middle reaches of the Kimberley River and a desicating climate, the Kimberley River ceased to exist. The downwarped sections of the palaeo-Kimberley River are present today either under metres of cultivated soil or as pans. It is, therefore, possible that the gravels of this ancient river contain alluvial-diamond deposits similar to those found on the northern bank of the Vaal River.

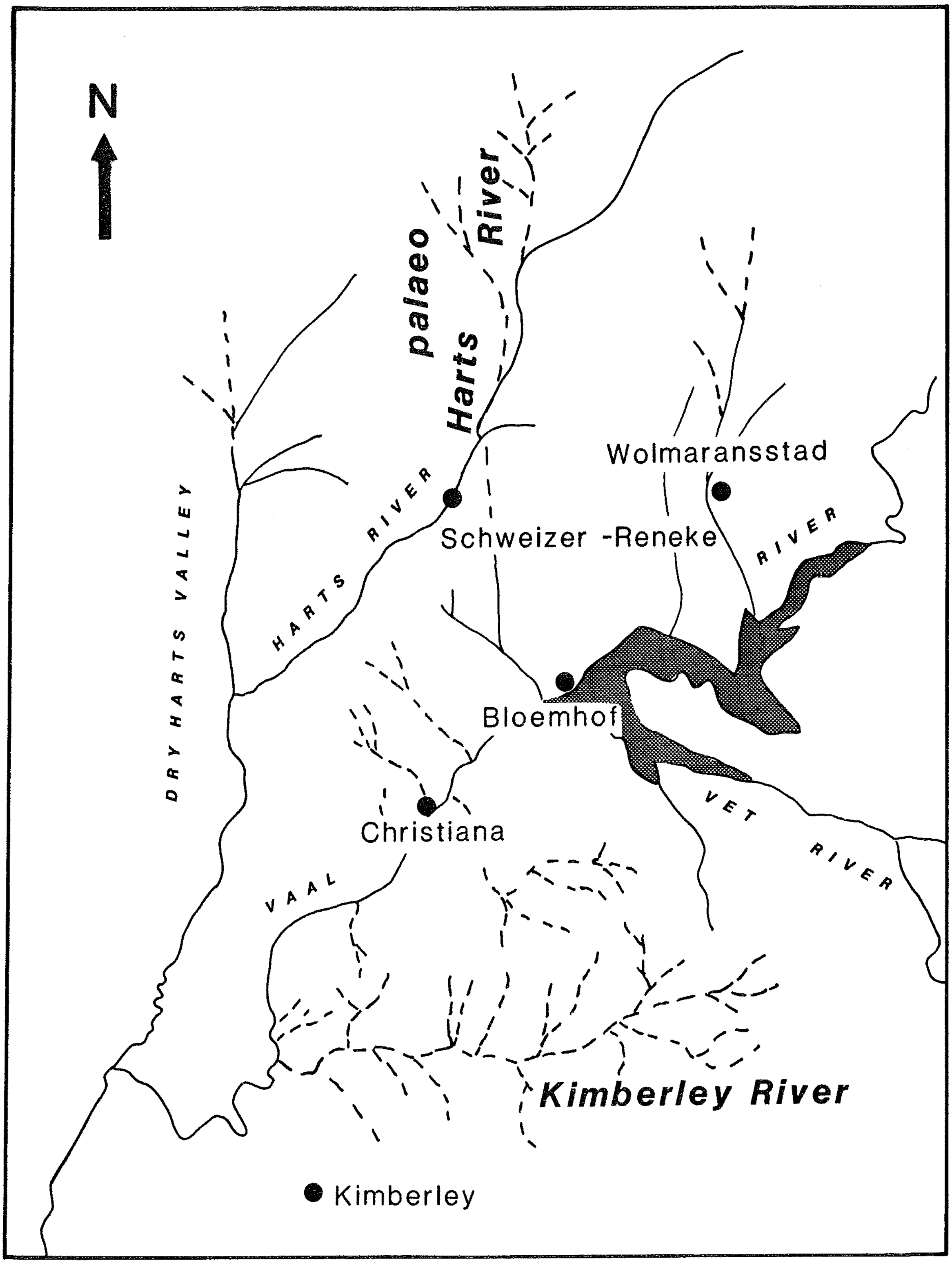

Figure 7 : *Fluvio-morphic reconstruction of the palaeo-Kimberley River and proto-Kimberley River, left-bank tributaries to the Vaal River in the middle-late Tertiary.*

CONCLUSION

In contrast to traditional theories which argue for an extrabasinal source for all the gravels and diamonds of the western Transvaal, the present study puts forward a case for a local source for the bulk of both the gravels and the diamonds. Helgren (1979) has demonstrated that, apart from minor amounts of material from eastern Botswana and the Lesotho plateaux, the gravels of the western Transvaal were derived from local sources of Dwyka tillite, Ventersdorp lavas, and dolomitic chert breccia. Limited amounts of Cr-garnets, ilmenites, and pyroxenes have been reported from two potholes, suggestive of a local kimberlite source for both the indicater minerals and the diamonds. Furthermore, small kimberlite occurrences have been reported on the Vaal-Harts interfluve (Helgren, 1979) and near Ventersdorp.

Finally, based on an interpretation of LANDSAT imagery, it can be seen that only limited palaeo-drainage flowed from the north, and could only account for but a small proportion of the western Transvaal alluvial gravels.

This review of the difficulties in tracing the origin of the diamonds and alluvial gravels of the western Transvaal has identified a noticeable lack of available information necessary to test the hypothesis satisfactorily. It suggests that a major research project be initiated to investigate the following five topics:

(a) A detailed morphotectonic study of the erosion surfaces and palaeo-drainage of the western Transvaal.

(b) A sedimentological and mineralogical study of the gravel deposits, with respect to the clasts and especially the fines, taking special note of the size, geochemistry, and mineralogy of kimberlitic and lamproitic indicater minerals.

(c) A mineralogical study of the diamonds to determine whether or not they show any similarities with known kimberlite pipes, as alleged by Wagner (1914), and whether any inclusions in the diamonds can be matched geochemically with the indicater minerals that are present.

(d) To investigate the hypothetical line of kimberlite occurrences reported by Helgren (1979) on the Vaal-Harts interfluve. A possible alternative is that the diamonds were derived from lamproites which have fewer types and finer-grained indicater minerals than kimberlites, and generally contain chromite and chrome pyrope only. This alternative is strengthened by the presence of lampriote at Swartruggens. The possible presence of such lampriotes is an alternative that will have to be investigated.

(e) The Kimberley River needs to be investigated in more detail, by a study of the terraces and gravels associated with it in much the same way as the deposits of the western Transvaal.

As a result of the obvious need for conclusive evidence concerning the origin of the diamonds and gravels of the western Transvaal a research project, dealing with aspects of the suggestions made above, has been initiated. It is hoped that the results will verify the existence of local kimberlitic (or lamproitic) sources for the diamonds and explain, unequivocally, the origin of the alluvial gravel deposits of the western Transvaal.

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