The diamondiferous sediments on the farm Nooitgedacht (66), Kimberley South Africa

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ABSTRACT

Diamonds were mined on the farm Nooitgedacht (66) in the Kimberley area between 1908 and 1930, 1948 and 1981, and from 1996 onwards. Although the records are incomplete, at least 80 000 carats of diamond had been recovered by 1963 with an average stone size of 0.9 ct/stone. It also produced at least 15 diamonds larger than 100cts in weight, including one of the biggest alluvial diamond ever found in South Africa, the Venter diamond (511.25cts).

The farm can be divided into the east-central and high level part where most of the digging occurred, and the western part associated with younger and lower level terraces of the Vaal River. The former area is characterised by near surface and surface outcrop of late Archaean Ventersdorp lava with typical corestone development. Between the corestones and the overlying Quaternary Hutton sands there is a thin diamondiferous gravel, composed mainly of resistant material derived from the Ventersdorp volcanics, and isolated well-rounded and extrabasinal clasts from remnants of Dwyka Group sedimentary rocks. This diamondiferous deposit on Nooitgedacht was part of a tributary that occupied a wide and shallow valley draining the Kimberley area into the palaeo-Vaal River. This tributary flowed over Ecca Group shales which underlie the area between Nooitgedacht and Kimberley, and which offer poor trapsite potential. In contrast, the exhumed pre-Karoo high of Ventersdorp on Nooitgedacht promoted the high concentration of (big) diamonds on the farm as a result of an increase in bed-roughness associated with corestone development of these lavas forming preferred trapsites. Most diamonds are unabraded and are sourced from the Kimberley cluster of kimberlites along with kimberlitic ilmenites that can also be matched to that population. The presence of highly abraded diamonds indicates that the palaeo-Vaal River was already transporting diamonds from other sources in its headwaters. Based on geomorphological evidence it appears that the Nooitgedacht deposit is associated with the African erosion cycle and is therefore probably Late Cretaceous or Early to Middle Tertiary in age.

Introduction

The farm Nooitgedacht (66) borders the east bank of the Vaal River just upstream from Barkly West and 15km northwest of Kimberley (Figure 1). Nooitgedacht is famous for the glacial pavements that depict ice flow of the Permo-Carboniferous period (Visser and Loock 1988).

The farm has also been of interest because of the alluvial diamond deposits that occur on the south-eastern part of the farm. The mineral rights of the farm were always held under a Free State title and hence any digging thereon was considered a private digging thus not controlled by the provisions of the Precious Stones Act of 1927. However, from 1949 to 1981 the southern half of the farm was opened to diggers.

The diggings were closed again in 1981 because of problems with supervision, maintenance and supply of water. The diggings were again opened in 1996 after the minerals rights had been sold to the surface owner and have since seen three alluvial diamond miners on the farm.

The diggings are far removed from the river and have often been referred to as 'dry diggings'. Although some alluvial mining has been attempted directly along and even within the Vaal River along the western border of the farm, very few diamonds were found there. The purpose of this paper is to review the 'dry diggings' because of the unusual nature of this sedimentary deposit and its relationship with the Vaal River, and to propose an origin for the diamonds there.

Historical background and diamond production

The diggers worked with basic tools and screened most of the surface material to a range of minus 25mm to plus 1.6mm. This was fed into a rotary pan. The pan concentrate was then jigged and sorted by hand.

By 1963 the diggers produced some 80 000cts, with an average stone size of 0.9 ct/stone. The largest diamond, the Venter diamond, was found in 1951. It is a yellow diamond and weighed 511.25cts (Figure 2). Other large stones found were a 325ct and a 315ct diamond (Stratten 1970).

Since 1996 three companies, Dry Harts Diamonds (1998 to 2000), C. Potgieter (1998) and Dwyka Diamonds Ltd (since 2001) exploited the alluvial deposit.

Dwyka Diamonds Ltd (2001) reported a production of around 1000 –1200cts per month from Nooitgedacht and De Hoop (65), a farm directly north of Nooitgedacht. However during 2001/2 only some 1481cts had been produced from Nooitgedacht (Dwyka Diamonds 2002b). They do report that big stones are present and in that period diamonds weighing 39.6, 61.4, 90.2 and 142.2cts had been recovered (Dwyka Diamonds 2002b). Their grades were running between 1.09 (Dwyka Diamonds 2002a) to 0.74 (Dwyka Diamonds 2002b) carats per 100 Tons and the average

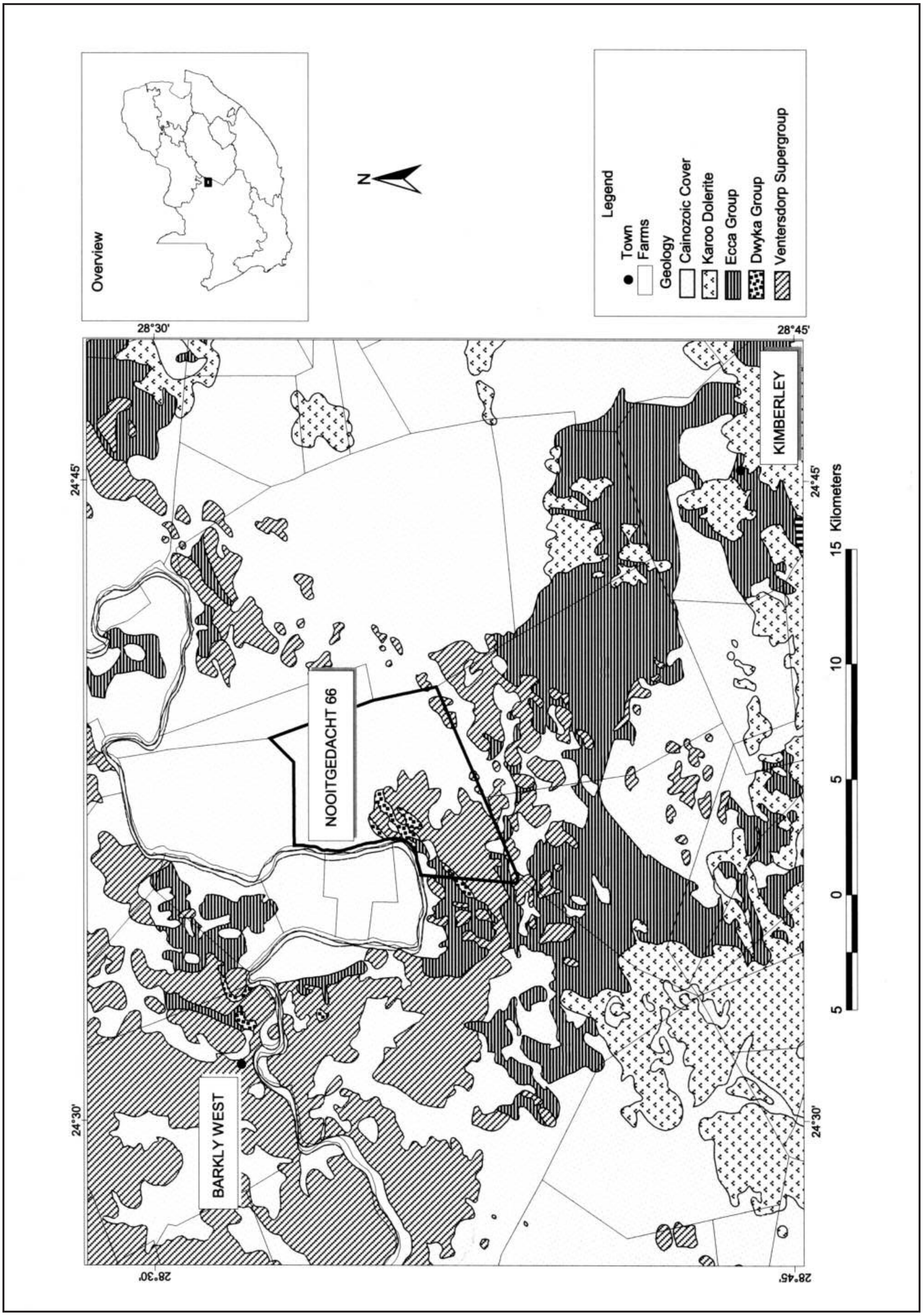

Figure 1. Regional geology and location map of the Nooitgedacht area.

Figure 2. The Venter diamond, a yellow stone of 511.25cts, found on Nooitgedacht in 1951 on the claim of J. Venter and his partner E. du Plessis (Courtesy of De Beers Archives). It was a perfect octahedron and was loosely classed as a yellow, but could be more accurately described as being between a yellow and a bywaker. Unfortunately it had a fairly large spot and a cluster of fine spots slightly towards one of its points (The Diamond news and the SA Watchmaker and Jeweller, August and September 1951). The coin is 32.3mm in diameter.

price received for diamonds sold during 2002 was US$ 504 per carat (Dwyka Diamonds 2002b).

Geology

Most of the farm is underlain by rocks of the late Archaean Ventersdorp Supergroup (Figure 1). However remnants of Permo-Carboniferous Dwyka Group rocks are preserved in the dissected part of the farm (Visser and Loock 1988).

The diamondiferous sediments are concentrated on the upper elevated or plateau part of the farm away from the river and although no geological age has been assigned to these it has been argued to be Tertiary in age (Helgren 1979). Most of the upper part of the farm, including part of the diamondiferous sediments, is covered by Red Hutton sands, also referred to as reddened Kalahari sand that is of Quaternary age (Van Riet Lowe 1952; Haddon 2000).

Ventersdorp Supergroup

The Ventersdorp Supergroup in the Northern Cape was first described by Du Toit (1907) and was referred to as the Pniel Series. These form the upper part of this supergroup and are composed of basic lavas, breccias, quartzites and conglomerates (Du Toit 1907). SACS (1980) has subdivided the Ventersdorp Supergroup into a lower Klipriviersberg Group, middle Platberg Group and Bothaville and Allanridge Formations. The Allanridge Formation covers the rocks described by Du Toit (1907) as the Pniel Series.

Du Toit (1907) has subdivided the Pniel Series from the base upwards into the three following zones: quartzites and conglomerates, dolerites, and andesitic lavas. Tuffs, breccias and brecciated lavas occur in all three zones. The uppermost zone, characterised by the presence of porphyritic lavas, has been described near Waldeck's plant on the farm Pniel (281) some 25km west-north-west of Nooitgedacht. Here there are alternations of dolerites, amygdaloid andesitic lavas and volcanic breccias, and at Sydney on Vaal (280), next to Pniel, there is an intercalated bed of quartzite 7m thick. The quartzites weather with a rough brown exterior and may contain small spherical concretions (Du Toit 1907). Andesites, with and without amygdales, are widely exposed on the 'highlands' of the Vaal-Harts interfluve including the upper part of the farm Nooitgedacht (Helgren 1979). The amygdales in the vesicular rocks are generally smaller than 1cm in diameter. These are composed of jasper, carnelian and agate, and include colours such as red, blue, grey and black. Lenses and layers of laminated chert are interbedded with the basic lavas. These are very finely laminated tuffs and are yellow-grey, dark green and blue in colour. Weathering of the Ventersdorp lavas has resulted in blocky and exfoliated bedrock morphology. This has been enhanced by jointing and has produced a surface of "corestones" (Figure 5).

Dwyka Group

Permo-Carboniferous Dwyka Group rocks are concentrated in the lower lying parts of the farm directly adjacent to the Vaal River. Here the irregular topography in these lower lying areas has preserved isolated patches of Dwyka tillite and shale. During this period the Vaal Valley (or Kaap Valley, Visser and Loock 1988) acted as one of the main conduits of the ice as it flowed from the Cargonian Highlands in the north to the main Karoo basin in the south-west (Stratten 1968, Visser and Loock 1978, Helgren 1979). This and the presence of roche moutonnées on the Ventersdorp bedrock, illustrate that the pre-Karoo topography was far from planar.

An east-west orientated section across the Harts and Vaal Rivers (Figure 3) clearly illustrates these irregularities. Here the Harts Valley displays the typical "U"shape, particularly along the western flank. The elevation variation of the eastern side of this valley provides some indication to what level the Nooitgedacht area was subjected to the Dwyka valley glaciation. Furthermore thickness variations of the Karoo at the Kimberley mines (between 80 to 120m; Hawthorne 1975) provide further evidence of the scale of this irregular pre-Karoo topography.

The coarser diamictite litho-facies are concentrated within the Kaap Valley while finer-grained tillites and shales are found higher up and further away from the main valley (Visser and Loock 1988). Isolated remnants of Dwyka rocks have been mapped on the elevated or plateau area of the farm (Figure 4; sections 5.2 and 5.3.2).

The main clast lithologies in the Dwyka Group are laminated chert, brown and cream coloured quartzites, andesitic lavas, quartz porphyries, red porphyritic granites, white coarse-grained granite, ironstone and rare jasper.

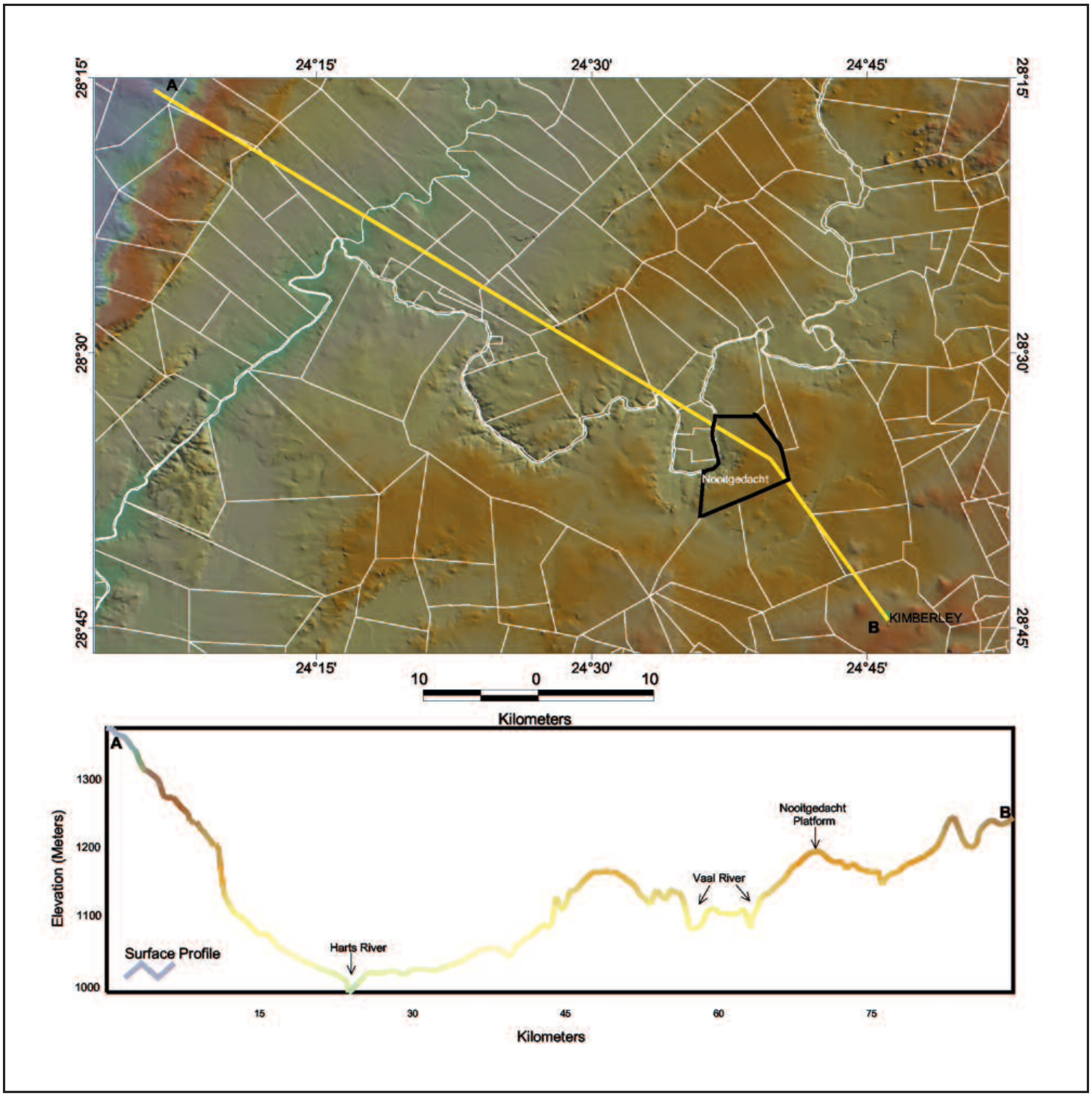

Figure 3. East-west section through the Kaap Valley, which includes the Hart and Vaal Rivers, displaying its "U" shape particularly in the western half. The Kimberley area is underlain by between 80 to 120m of Karoo sedimentary rocks.

Post-Gondwana sequences

Vaal River Terraces

The farm is situated in the broad Kaap Valley, today occupied by the Harts and the Vaal Rivers, which stretches from the Ghaap plateau in the west, to east of Nooitgedacht, a distance of some 70km (Figure 3). The Vaal River valley, with which the Nooitgedacht deposits are more directly associated, is between 15 and 20km wide (Figure 3).

Between Barkly West and Windsorton there are several terraces that are directly linked to the palaeo-Vaal River (Helgren 1977; 1979). In addition, another gravel type that has been recognised has loosely been referred to as 'derived' gravel, 'redistributed older' gravel, 'older red' gravel, and 'rooikoppie' gravel. This occurs as a thin surface gravel seldom more than 1m but generally only 30cm thick. These are particular well developed near Holpan, Barkly West, Droogeveldt and in the Bloemhof/Schweizer Reneke area (Marshall 1987). Cooke (1947) was one of the first to comment on their origin and has questioned these to be purely alluvial. He suggested that these had been reworked by colluvial processes. Weathering has removed all but the resistant silica-rich pebbles such as chalcedony, agate, quartz, quartzite, jasper, silicified wood, chert and trace amounts of diamond (Cooke 1947). Clasts seldom exceed 5cm in diameter. They represent a colluvially derived concentrate from older sediments.

Butzer *et al.* (1973) refer to the 70m plus terrace as the older deposit. These include the Nooitgedacht

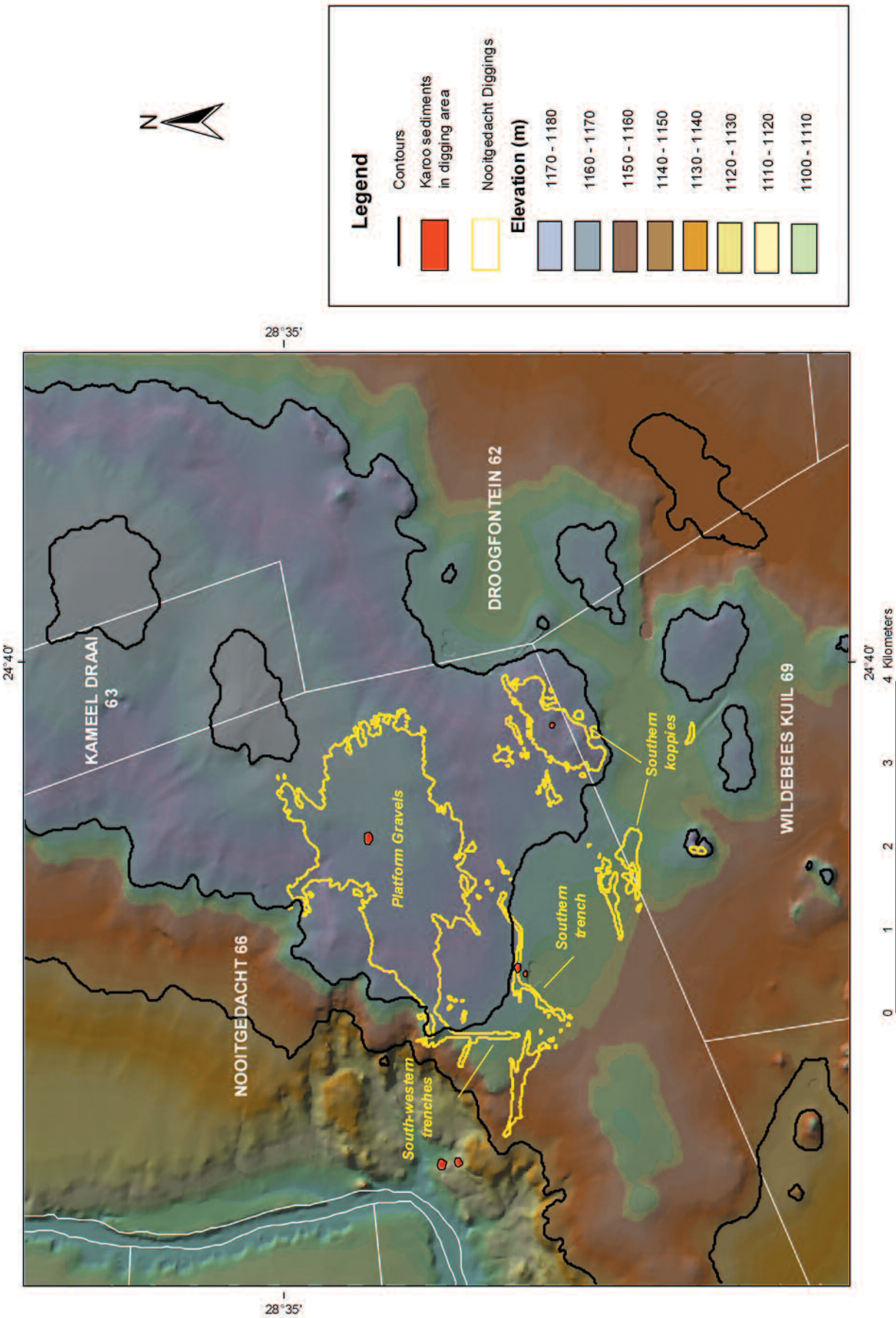

Figure 4. Digital terrain model (DTM) of the Nooitgedacht digging and surrounding area based on 5m contours digitised from the 1:10 000 1984 orthophotographs. Note that the diggings are concentrated in the south-central part of the farm. Other areas include the southern Koppies area along the Nooitgedacht-Wildebeeskuil farm boundary, and the linear "sluits" in the southwest of the digging area.

gravels at 85m, which Helgren (1977) suggests to be the oldest Vaal River terrace. These have been regarded as contemporaries of the gravels that occurs some 40km downstream on Droogeveldt and which occur at approximately the same elevation, between 75 and 120m, above the present-day river. These have been described by Spaggiari *et al.* (1999) as fluvial channels associated with palaeo-Vaal drainage.

The Droogeveldt diamond deposits are famous for their 'sluits' which are linear and straight channels, orientated in a west-southwest to east-northeast orientation (Spaggiari *et al.* 1999). These were interpreted as a series of palaeo-Vaal River channels that crossed the farm. Shallow diggings occur in between and are regarded as 'overflow' areas (Spaggiari 1993).

Partridge and Brink (1967) have described a younger suite of terraces between Windsorton and Holpan, at approximately 60m, 30m and 20m above the present river level. They interpreted the uppermost terrace on Holpan and Klipdam, as an extension of the post-African pediplain. It has been suggested by these authors that the 60m gravels are Pliocene in age and the 20m terraces Middle Pleistocene. In general these gravels contain a lower concentration of diamond than the derived gravels (Van Riet Lowe, 1952).

Nooitgedacht gravel

The Hutton sands and diamondiferous gravel are concentrated on an upper pre-Karoo platform of Ventersdorp andesite, some 85m above the river (Figure 4), also referred to as the Nooitgedacht platform (Helgren, 1979). Helgren (1979) suggests that, since these are the highest elevated gravels in the Lower Vaal basin and exhibit the most intensive post-depositional weathering, these are the oldest rudaceous deposit in the Lower Vaal basin. The only description of this deposit is by Helgren (1979) and he subdivided it into three units: basal unit 3 –the exfoliated Ventersdorp andesite bedrock with corestones with a sandy and gravelly matrix; unit 2 – a 0.1 to 0.3m thick uncemented generally granular to coarser pebble size 'gravel' mixed with angular to sub-angular locally derived andesite; and an upper unit 1 – dark red (Hutton) sands which varies between 0.5 to 1.0m in thickness (Figure 6).

Helgren (1979) further suggests that unit 2 is not primary, but rather a colluvial and a weathered product of an earlier alluvial deposit. Whether this is an earlier deposit that was formed by an ancestral Vaal River or by a tributary is unclear (Helgren, 1979).

In much of the central and south-western part of the farm the gravel (Unit 2) is near surface or at surface and is generally preserved between the corestones of the underlying weathered Ventersdorp bedrock.

Hutton sands

The Hutton sands overlie the Ventersdorp bedrock and, in the south-east, the diamondiferous sediments as well. The sands are typically between a few tens of cm to several metres thick and red in colour (2.5 YR). Although this sand increases in thickness towards the north, directly south of the main mining area there is a subdued depression where the sand may be several meters thick.

It has been suggested that these sands have been derived from local weathering of the andesite bedrock and that they represent the eastern limits of the Kalahari sands (Helgren 1979).

Local geomorphology

Butzer *et al.* (1973) recognise several fluvial platforms at different elevations along the Vaal River between Windsorton and Barkly West. The highest of which, the Nooitgedacht platform, cuts cross the Ventersdorp andesites at an average elevation of 1160m (Figure 4). Although the origin of this +85m platform was not fully resolved, Butzer *et al.* (1973) argued that these may represent remnants of a river-cut platform since there are appreciable gravel deposits on top of this feature near Nooitgedacht.

Helgren (1979) recognised that some of these surfaces frequently preserve glacial-age erosional markers and local fills of Dwyka sediments hence he concluded that the ultimate origin of these surfaces such as the Nooitgedacht platform must be sought during or before the Dwyka glaciation.

The 5m contours were digitised from the 1:10 000 scale 1984 Orthophotography (Figure 4). This highlights the upper Nooitgedacht platform above the 1160m contour, and a lower lying and highly dissected terrain bordering the Vaal River also associated with the Dwyka pavements (Figure 4).

The Nooitgedacht diggings are associated with the Nooitgedacht platform (Helgren 1979). Although isolated Ventersdorp andesite koppies occur in the south, the Nooitgedacht platform is relatively flat and extends on to the farms Kameeldraai (63) and Droogfontein (62) to the east, and Wildebeestkuil (69) to the south (Figure 4). This platform measures 12 x 7km in a northeasterly orientation. Helgren (1979) has recognised this as the highest platform in the lower Vaal basin. The edge of the platform follows the 1160m contour line and an extension of this platform occurs on the border of the farms Pniel and Rooipoort (Helgren 1979).

Rare occurrences of Dwyka tillite and shale have been preserved on this surface (Figure 4). These tend to occur in shallow depressions and are in places overlain by the Hutton sands.

Nooitgedacht diggings

The diggings were mapped using the 1984 Orthophotographs, and the 1993 and 2001 aerial photographs, combined with field checking which was done between 2000 and 2003 (Figure 4). There are three different sub-environments, which have been subjected to digging activities. Firstly, there is the Nooitgedacht platform gravel in the south central area, and which has been the focus of most intense mining activities.

Figure 5. Exfoliated Allanridge andesites of the Ventersdorp Supergroup in the Southern Koppies area.

Secondly, there are the 'koppies' in the southeast of the farm close to the southern edge of the Nooitgedacht platform, and thirdly there are the linear features or 'sluits' in the southwest which are associated with some very straight and distinct linear airphoto features (Figure 4).

Nooitgedacht platform gravels

The gravels cover some 5% of the Nooitgedacht plateau area and are concentrated in the southern part over an area of 2.5 by 1.5km (Figure 4). The main digging area has a broad front along its southeastern edge, it then curves around with a much narrower and focussed 'exit' towards the southwest where gravels have been trapped in linear fractures of the Ventersdorp bedrock (Figure 4). Towards the north the gravel is "banked" against the higher part of the plateau at 1180m. Most of the bigger diamonds, such as the Venter diamond and the more recent 142ct stone, have been recovered from the plateau digging area.

The bedrock is highly irregular on a decimeter scale and provides the roughness to trap the diamonds. No channels have been recognised. Hence the mineralised sediments almost form a sheet rarely thicker than 15cm. Although the gravel can be patchy it generally follows the bedrock even in local small depressions tens of centimeters deep (Figure 6). Weathering of the local Ventersdorp bedrock produce well defined corestones (Figure 5) and gravel has also been trapped between individual corestones, even down to 1m. The grades vary according to the rock type that forms the bedrock. The more massive andesites form an exfoliated surface characterised by corestones and coarse boulder-size andesite rubble, which increases the bed roughness and hence improves its ability to trap diamonds. Smoother surfaces are associated with a softer and more easily weathered facies of the Ventersdorp and are less conducive to concentrate diamonds.

The gravel is bimodal with boulders and large pebbles from local exfoliated andesite bedrock representing the bulk of the sediment. The remainder is formed by sub-angular, poorly sorted granular to large pebble size material, which are composed of subangular vein quartz, amygdales (pipe and almost spherical), cherty tuffs and brown quartzite (Figure 7). These are generally matrix-supported although clast-supported material is also present. Occasional rounded pebbles are present, such as cream coloured quartzite and quartz porphyry granite. The matrix is a ferruginous red and is lightly cemented by iron oxide.

The gravel can be covered by variable thicknesses of Hutton sands from zero in the south-east to over several meters in the northern part of the digging area.

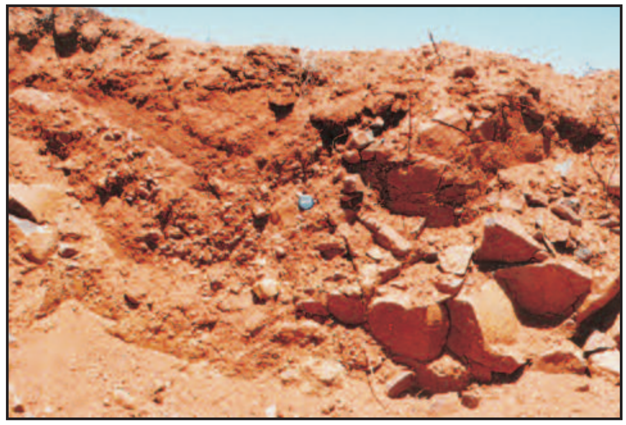

Figure 6. Exfoliated and fractured Ventersdorp bedrock overlain by 20 to 30cm of red pebbly soil. Note small depression roughly 50cm deep with matrix supported gravel composed of subangular small to medium pebbles.

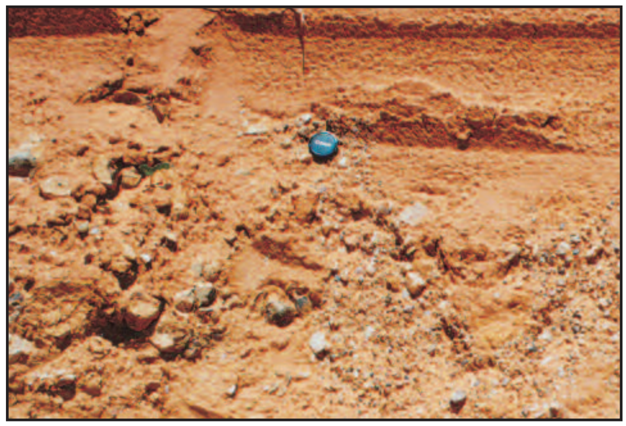

Figure 7. Highly weathered Ventersdorp bedrock with remnants of diamondiferous sediments mainly composed of subangular and local derived gravel. Isolated rounded pebbles are present which have been derived from erosion of Dwyka remnants. Note that the gravel is preserved in a shallow depression on bedrock that has been completely altered

Southern Koppies

On the border with Wildebeestkuil, there are several andesite koppies or inselbergs (Figure 4). These koppies are seperated from the platform gravels by a shallow depression covered by Hutton sand. These are part of a north-east south-west orientated set of koppies, which

Figure 8. Blocks of exfoliated Ventersdorp andesite (figure 5) on the Southern Koppies areas, with Kimberley on the horizon. The overlying Karoo sedimentary rocks starting several kilometers towards Kimberley.

stretches from Wildebeestkuil to Droogfontein and can be traced for almost 1.5km over a width of some 300m (Figure 4). The area in and around these inselbergs have been extensively mined.

The koppies are elevated at least 15m above the surrounding plain (Figure 8) and are probably related to a structural feature in the Ventersdorp bedrock. They are composed of fine-grained andesite lavas and dolerite. Isolated remnants of Dwyka tillites are preserved within these koppies. The Ventersdorp rocks in the koppies form a joined and exfoliated base which has developed into a surface of corestones (Figure 8). A thin and irregular cover of red sand and pebbly gravel, dominated by angular vein quartz, is present in places. This diamondiferous material is often wedged and trapped in between the corestones and the joints of the bedrock. The gravel is even more irregularly distributed than on the plateau area and never reaches more than 20cm in thickness. Most of the pebbles are sub-angular and composed mainly of vein quartz with isolated brown quartzite. Rare well-rounded quartzite and quartz porphyry granite are present locally. This is also the area with the highest concentrate of kimberlite minerals such as picro-ilmenite and minor garnet (Kevin Harris, personal Communication).

Diggings associated with linear features

Although there are many linear airphoto features on the farm, several have been exhumed by digging operations and are left as long trenches. These are present in the south-western "exit" of the platform gravel; two close to the south-western edge of the platform and one that occur directly south of the platform diggings (Figure 4).

South-western trenches

The two that are on the edge of the Nooitgedacht platform, appear similar to the sluits on the farm Droogeveldt 40km to the west-southwest as described by Spaggiari *et al.* (1993). These follow two main trends: one almost north to south and the other west-northwest to east-southeast and can be traced over a distance of more than 1km. The absence of polished and water-worn side walls of these trenches suggest that these were not necessarily channels but rather exhumed lineaments in which some of the diamondiferous sediment was trapped.

The north to south trending fracture west of the platform is dominated by white vein quartz. This is found as rubble between the corestones but also concentrated in vertical veins, some 20cm wide, within the andesite. Hence this feature is thought to be a major fault within the Ventersdorp that was exhumed after the Karoo period and subsequently formed a trap whilst streams from the plateau area found their outlets towards the palaeo-Vaal here. Hence, the sediments within these traps are probably related to the final stages

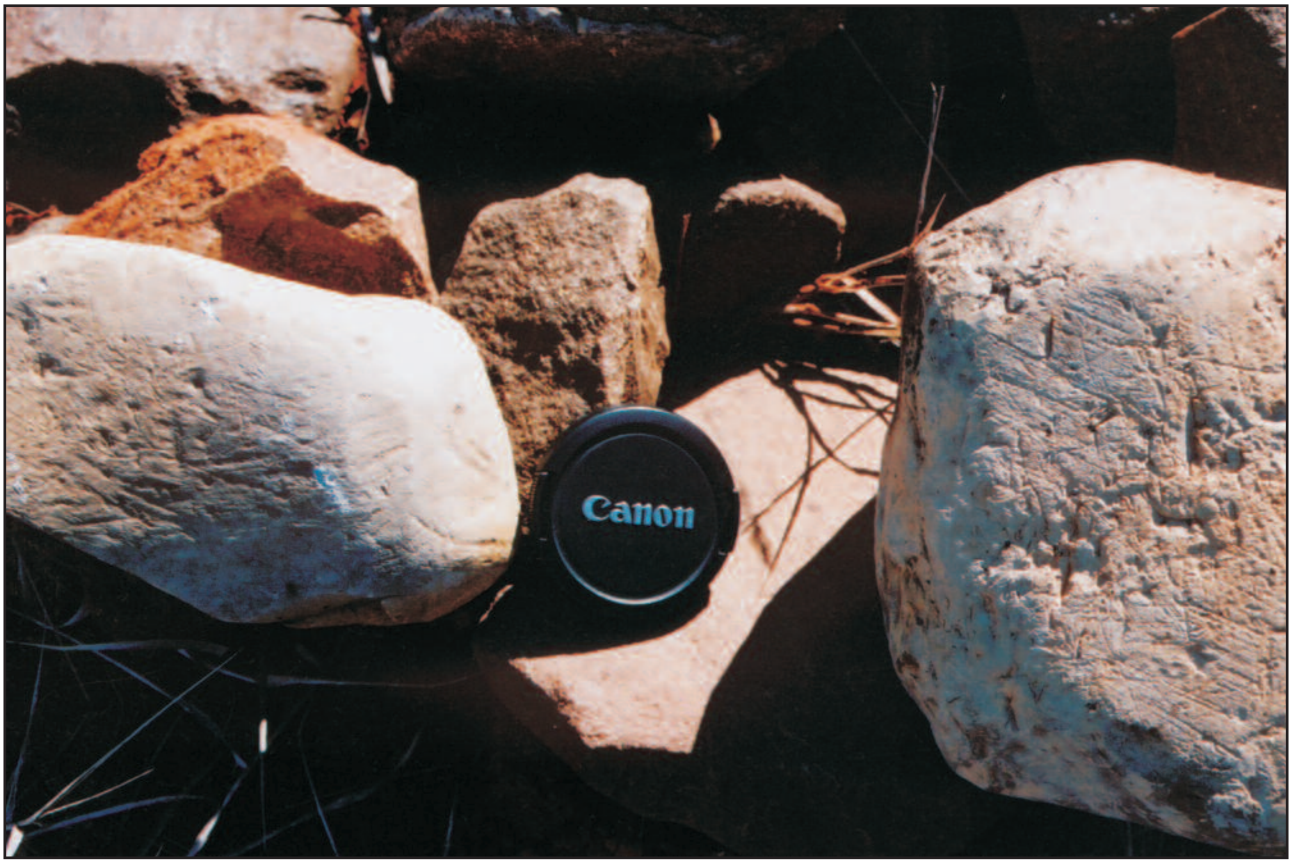

Figure 9. Striated boulders of quartzite and quartz porphyry granite from the southern Trench.

of the streams which deposited the platform sediments themselves. This is supported by the fact that there is no evidence of any water action or polished side walls. No Dwyka rocks have been found within these structures.

The west-northwest orientated fracture does not contain any vein quartz but are in filled almost entirely with locally derived exfoliated Ventersdorp rubble. Several of these linear features have been dug to between 1 and 2m depth.

Southern trench

The major trench east of the south-western trenches is straight with some acute angles forming a dogleg (Figure 4), the orientation of which is northeast to southwest with a central segment trending west-northwest to east-southeast, which coincides with the orientation of the major lineaments in the area (Helgren 1979). This feature is between 1 and 2m wide and can be traced over 1.5km. It has been dug to approximately 1m depth. It contains some very large, locally derived angular brown quartzite blocks (Ventersdorp Supergroup). These can be up to 1m in size. Although this quartzite is in abundance along the whole length of the lineament in boulder and pebble sizes, the large blocks are concentrated in the western section of this trench and are sub-angular to sub-rounded in shape.

The presence of foreign lithologies such as quartz porphyries, granite and cream coloured quartzite are noteworthy. These are generally well rounded and some are striated (Figure 9) and still have Dwyka tillite matrix attached to them. The large rafts of quartzite suggest that relatively thin horizons of quartzite were exposed within these lineaments especially since the boulders and pebbles show no sign of transport. It suggests that this lineament might be part of a fault which has exposed the quartzites.

A shallow pit dug just south of one of these features and directly north of a major pan has intersected remnants of upper Dwyka shales which is surrounded by outcrop of Ventersdorp rock.

Although these trenches were diamondiferous there is little evidence that these were major conduits. Some of them acted rather as traps firstly of Dwyka tillites and later of diamondiferous material that was passed over the area.

Satellite mineral and diamond studies

Kimberlitic indicator minerals are abundant in the southern Koppies and several hundred grains were recovered for detailed surface texture and mineral chemistry studies. Several hundred diamonds were also made available by Dwyka Diamonds Ltd for detailed examination.

Satellite minerals

Although kimberlite indicator minerals are abundant in the Southern Koppies area, too few garnets and spinel

Figure 10. Diamonds from Nooitgedacht highlighting the two populations; an abraded (the top 3 diamonds) and an unabraded population (photo R. Ferraris, February, 2003).

Figure 11. Portion of the diamond parcel from Nooitgedacht illustrating the presence of boart especially in the larger size range (photo R. Ferraris, February, 2003).

were recovered for further analysis. The ilmenites were separated into different class sizes (+2mm; +2-1mm; +1-0.5mm; +0.5-0.3mm) and studied both using a binocular microscope, SEM and electron microprobe analyses (Safranek 2003).

From detailed surface texture studies it was noted that most ilmenites are moderately to extensively abraded and approximately 5% have fresher primary surfaces, however these do show abrasional rounding along the edges. There are a few composite ilmenites present but these are fragile and should not survive lengthy or abrasive transportation. It is concluded that the ilmenite grains represent a single population whose surface texture suggest a moderate degree of abrasional rounding. It is estimated that the ilmenites had been transported over a distance of between 25 and 30km (Owen Garvie, personal communication, 2003). Although Kimberley is only 16km away, transport along sinuous channels would clearly agree with derivation from Kimberley.

Electron microprobe analyses of the ilmenites was conducted at the De Beers Geoscience Centre in Johannesburg (Safranek 2003) and six principal components (MnO, Al2O3, FeO, TiO2, Cr2O3 and MgO) were used to compare the Nooitgedacht ilmenite chemistry with those from some of the kimberlites in the Kimberley cluster. It was concluded that there is a large degree of overlap between the Nooitgedacht and Kimberley kimberlite cluster ilmenites, and that the Nooitgedacht ilmenites had been derived from the nearby Group 1 kimberlites in and around Kimberley (Safranek 2003).

Diamonds

A total of 185 diamonds (338ct) from Nooitgedacht were studied in detail (Viljoen and Ferraris 2003). However but due to the fact that mining took place over different sites on the farm, the exact location of the diamonds is not known. The most important observation is that there are two diamond populations. Most diamonds are unabraded, whilst almost 15% of the stones are markedly abraded (Figure 10).

In addition virtually all the large (+10 carat) stones are of boart quality. This is not very common among the smaller stones (Figure 11). Another important observation is that green and brown stained and/or spotted stones, due to a particle irradiation in an old sedimentary environment, are markedly absent suggesting derivation from a more recent most probably Cretaceous primary source (Viljoen and Ferraris 2003).

The absence of abrasion on some diamonds, the presence of poor quality diamonds and boart, and yellow stones (such as the Venter diamond) further suggest that the unabraded diamonds are derived from Kimberley. This is further supported by the presence of very large diamonds *i.e.* close to source and a generally poorly sorted population of diamonds.

Discussion

The main diamondiferous 'gravel' body has formed on the southern slope of the Nooitgedacht platform. The central elevated area of this platform formed an almost natural northern 'bank', and confined the unabraded and locally derived diamonds to the south-eastern portion of the farm. It is also highly likely that these unabraded diamonds were derived from the Kimberley sources to the southeast. The presence of remnants of the diamondiferous gravels in the southern koppies supports this suggestion. Other evidence comes from the abundance of moderately to extensively abraded ilmenites which are closely matched with grains from primary sources in Kimberley.

The sheet geometry of the sediment and the absence of any channels suggest that the process of deposition was in a shallow and wide depression. The often matrix supported sediment and the poorly sorted nature of the deposit suggest that there was little sorting and deposition by a process of sheet wash or hill wash is advocated.

Since Kimberley is still underlain by shale of the Prince Albert Formation (Ecca Group), it is safe to assume that these occurred across the Kaap Valley during the initial post-Gondwana period and that the run-off from the Kimberley area towards the palaeo-Vaal was dominated by fine-grained sediment. Erosion of the Kimberley pipes would have provided rare diamonds, heavy minerals and isolated dolerite fragments to form the bedload material. Hence the residue would have been composed of sand and silt with occasional diamonds. These would have washed down this broad and shallow valley sloping towards the palaeo-Vaal. There is no evidence to suggest that this was part of a major channel. There were no bedrock structures on these Karoo shales to trap the diamonds. Hence during the very early stages of erosion of the kimberlites in the Kimberley area, diamonds would have been removed by these small tributaries into the then existing palaeo-Vaal system without the development of concentration of diamond on Karoo bedrock.

The first area of Ventersdorp bedrock to be exhumed was around the Southern Koppies and these would have acted as the first traps for diamonds and satellite minerals coming from Kimberley. The main platform area may well be a remnant of a river-cut platform as suggested by Butzer *et al.* (1973) where diamonds from Kimberley were mixed with those already being transported by the palaeo-Vaal. Erosion of isolated thin patches of Dwyka diamictites provided some of the rounded pebbles such as quartz porphyry granite and white quartzite. These were mixed with material derived from weathering of Ventersdorp bedrock such as amygdales, vein quartz and quartzite clasts.

Since the Nooitgedacht deposits occur as elevated isolated entities, it is suggested that these are erosional remnants of a small and early tributary system feeding into the palaeo-Vaal. The main period of erosion in post-Gondwana times was the Cretaceous. The start of the Tertiary marks a major reduction in erosion rates (Partridge and Maud 1987; Brown *et al.*, 2002). And although artifacts are often found near the pavements and on surfaces of gravel terraces, these are not incorporated within the gravel. Hence, it is concluded, also based on geomorphological grounds, that these sediments are at least Early to Middle Tertiary or perhaps even Late Cretaceous in age.

The presence of an abraded and hence transported population among the diamonds suggests that the Nooitgedacht area may well have been influenced by the ancestral Vaal (or Karoo *sensu,* De Wit, 1999) River which because it was stripping Karoo shales and sandstones in it source area in the North-West and Gauteng Provinces, had no coarse bedload at that time. An intermediate source like the Dwyka tillites in the headwaters can however be ruled out. The presence of highly abraded diamonds indicates that this palaeo-Vaal River was already transporting diamonds to the coast along the Karoo River (De Wit, 1999). But since the ancestral terraces of the Vaal River would have been fine-grained the potential to preserve significant diamond placers would have been low.

Conclusions

The fact that the Nooitgedacht sediments were derived from a source to the southeast suggest that there was a palaeo-slope towards the north-west. This was towards a palaeo-Vaal which must have been in existence during the initial post-Gondwana period. It should also be pointed out that diamonds were already being transported in the palaeo-Vaal drainage in the vicinity of Nooitgedacht at that time. A major increase of the supply of diamonds to the coast via the Karoo River would have started directly after the emplacement and subsequent erosion of the kimberlites in the Kimberley areas around 90 Ma. This increase of supply of diamonds would have entered the Vaal/Orange system via tributaries from Kimberley as it flowed over shale bedrock. At some point in time, probably towards the end of the Cretaceous, Ventersdorp bedrock was exhumed, first at the southern Koppies area and then in the platform area, and diamonds would have been trapped for the first time close to Kimberley. Continued in situ weathering was not conducive to preservation, and these deposits as they are being exploited today are therefore best classified as derived or Rooikoppie gravels.

It is also proposed here that these deposits represent the last remnants of an early tributary to the palaeo-Vaal River that existed in the Cretaceous. These were locked in its present position sometime during the Late Cretaceous or Early Tertiary period when there was a major change in climatic conditions and a significant reduction in landscape denudation. The Nooitgedacht deposit is therefore associated with the African erosion cycle (*sensu* Partridge and Maun 1987).

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