2. GEOLOGY

2.1 Stratigraphy and field relationships

The alluvial gravels in the Bakerville district were deposited on a peneplain of quasi-horizontally bedded dolomite. The dolomite forms part of the Chuniespoort Group which attains a thickness of almost 1 200 metres in the Lichtenburg area (Du Toit, 1951). This group is divided into several formations on the basis of their chert content (Table 1).

The bedrock in the Grasfontein area is the Monte Christo Formation (figs. 1 and 2), which corresponds with the upper chert-rich zone of Du Toit (1951).

The dolomite is a fine-grained, blue to blue-greyish rock with a characteristic "elephant-skin" surface due to preferential weathering along abundant joints. Pale-coloured chert occurs in layers and lenses up to 500 mm thick. Stromatolites are abundant in the dolomite.

Nodules of manganese oxides, which form during the weathering of the dolomite, constitute a significant proportion of the gravels. They are important in the recovery of the diamonds because they facilitate the separation of diamonds from the lighter gravel fraction during washing. In places these nodules are also exploited as an ore of manganese.

Two sets of dykes, (probably dolerite, Mr R. Day, personal communication) which strike NNW and ENE cut the dolomite of the Lichtenburg-Zeerust area. They are generally deeply weathered and outcrops are sporadic so that most of them have been mapped with the aid of photogeological, aeromagnetic and electromagnetic surveys (Wilson, 1977; Richards and Day, 1975; Day, 1976; Hauger, 1973). One of these dykes, the Grasfontein dyke, crosses the area investigated, but only outcrops further to the east (Mr R Day, personal communication).

TABLE 1

SEQUENCE	GROUP		FORMATION	LITHOLOGY
TRANSVAAL	PRETORIA			
	CHUNIESPOORT		PENGE	BANDED IRON FORMATION
		SUBGROUP MALMANI	FRISCO	CHERT-FREE DOLOMITE
			ECCLES	CHERT-RICH DOLOMITE
			LYTTELTON	CHERT-FREE DOLOMITE
			MONTE CHRISTO	CHERT-RICH DOLOMITE
			OAKTREE	DARK COLOURED DOLOMITE
			BLACK REEF	QUARTZITE

Stratigraphical subdivision of Transvaal sequence.
(South African committee for stratigraphy, Feb 1979, unpubl)

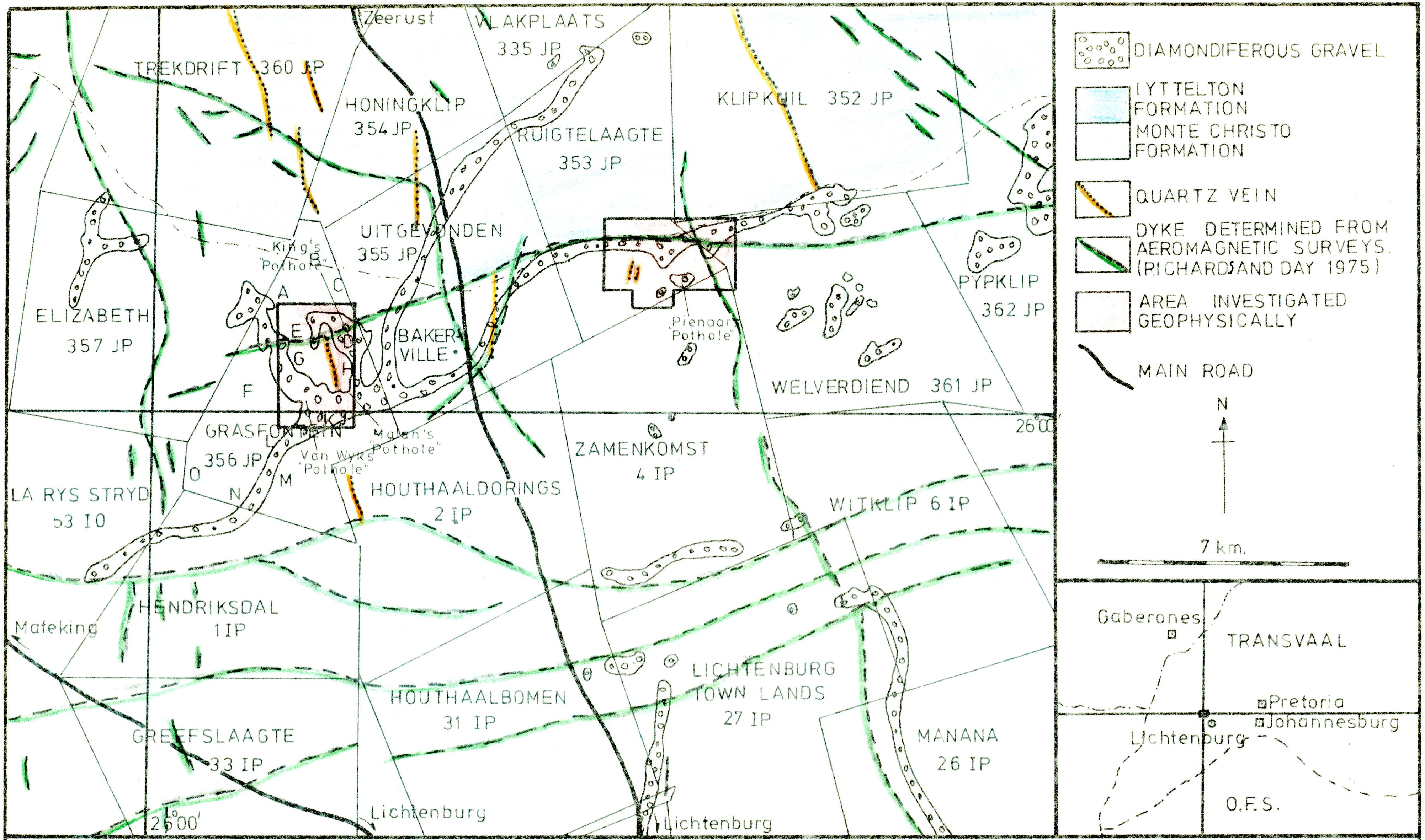


FIGURE 1: THE GEOLOGY AND DISTRIBUTION OF THE DIAMONDIFEROUS GRAVEL IN THE AREA SURROUNDING BAKERVILLE.

Additionally several quartz veins, striking north-south cross the area and delineate well-defined ridges from 5 to 10 metres in width (fig.1).

2.2 Geomorphology

The surface features developed on the dolomite throughout the Lichtenburg area are manifestations of typical karst topography. Regional features include numerous depressions and sinkholes which vary considerably in size and depth.

Other well developed, smaller scale karst features in the study area are the following :

(1) LAPIES

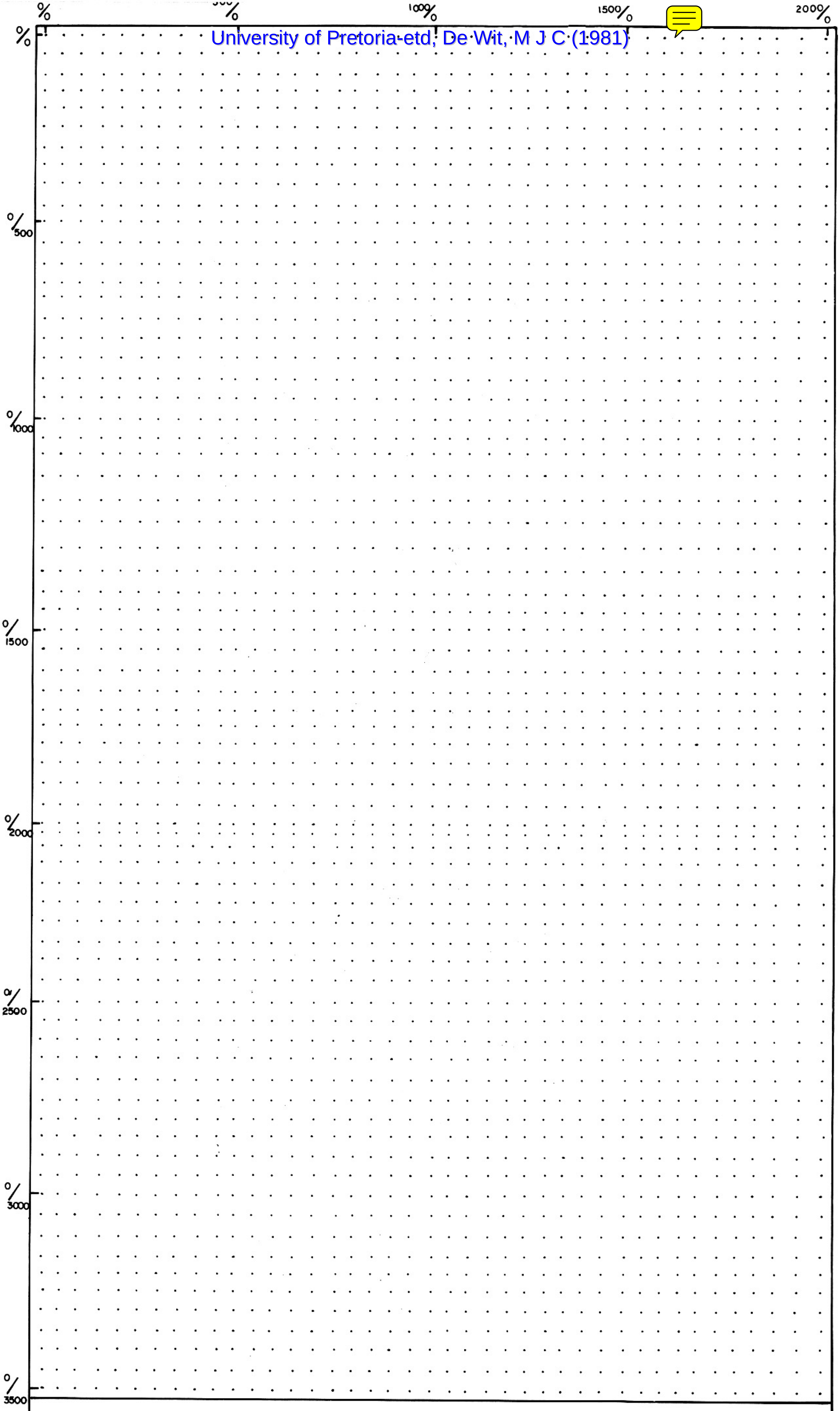
These are V-shaped solution channels. They vary in depth from 2 to 10 metres and range in length from one to fifteen metres. These structures are best exposed on the farms Uitgevonden 355 JP and Welverdiend 361 JP.

A number of solution channels are invariably associated with the gravel runs. The majority of these have been excavated and their entire contents removed by prospecting.

(2) YAMAS

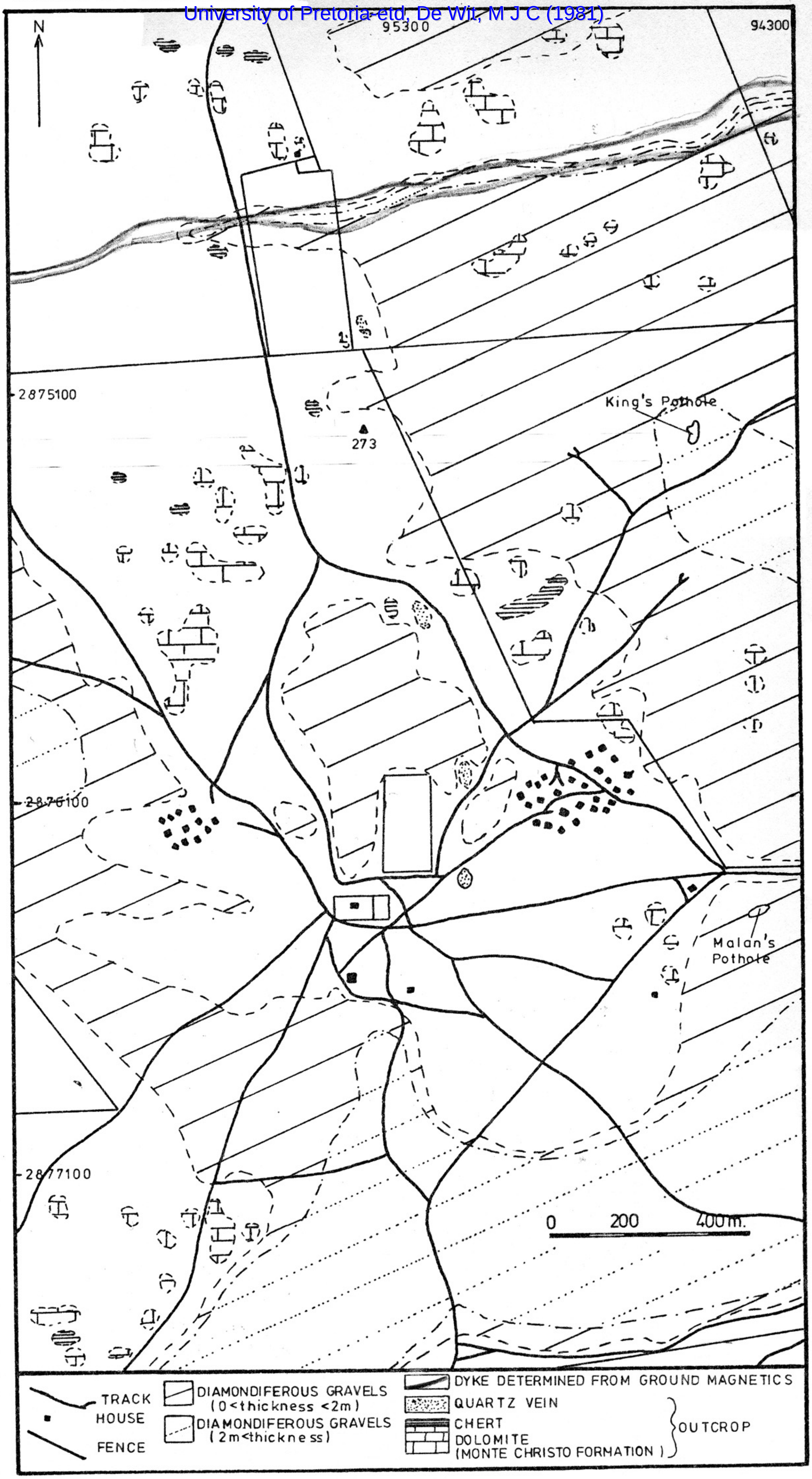
These are vertical shafts of up to 15 metres in diameter and they normally merge into caves at depth. Both King's and Malan's potholes are good examples (fig. 7).

According to Cvijic (1924), joints, fissures, rock texture and composition, surface slope and precipitation are the main factors controlling the formation of lapies. Cvijic (1924) also observed that lapies form only on exposed rock surfaces. This implies that, at least in the Lichtenburg area, the formation of the dolomite peneplain had already reached an advanced state before the gravels were deposited (Harger,1922).



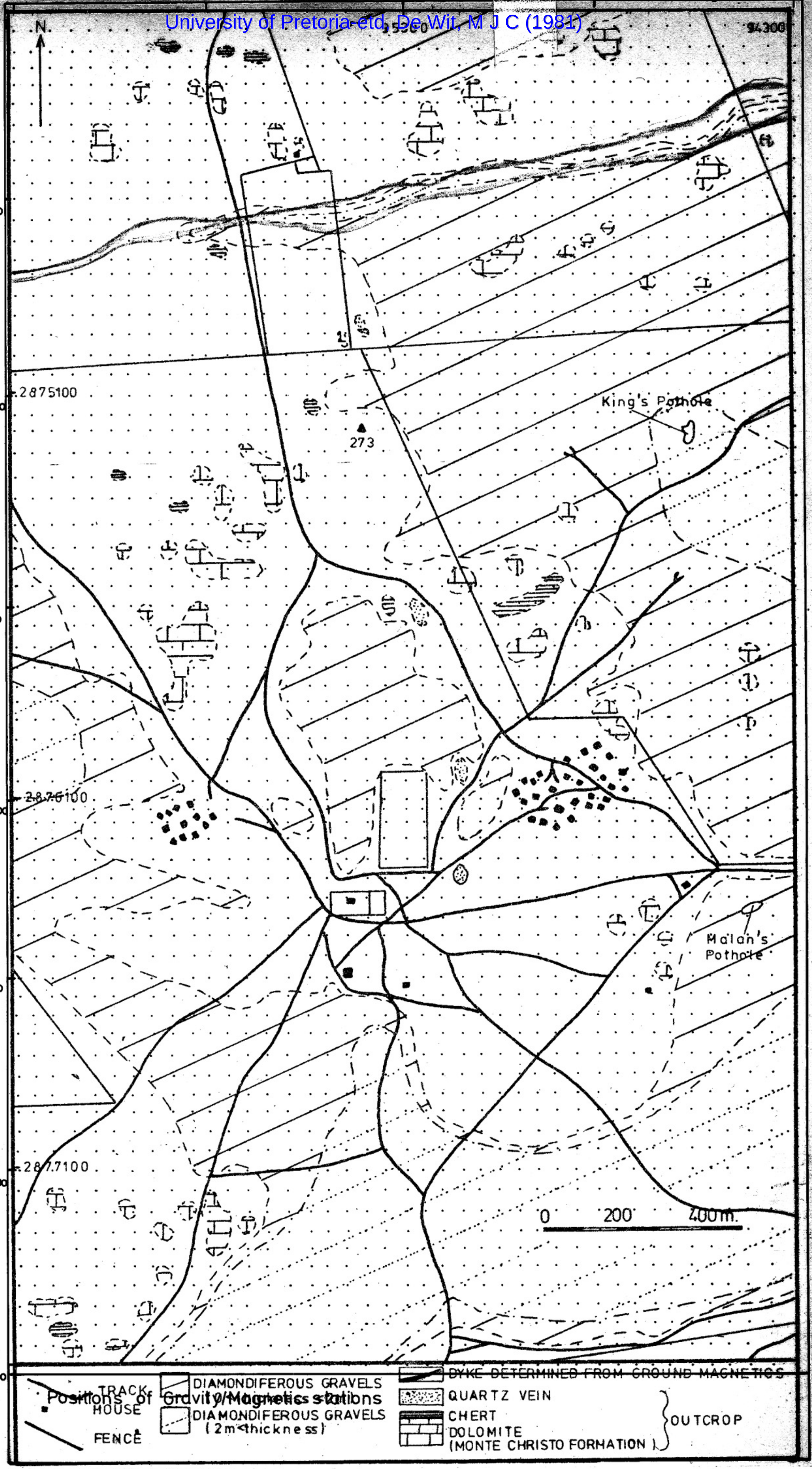
· Positions of Gravity/Magnetic stations

GEOLOGY OF THE GRASFONTEIN AREA (Outcrop map) Figure 2



GEOLOGY OF THE GRASFONTEIN AREA (Outcrop map

Figure 2



Positions of Gravity/Magnetics stations

The direction of the solution channels is usually controlled by joint patterns (Cvijic 1924, Moneymaker 1941).

Cvijic (1924) recognised that different forms of lapies delineate various stages of the erosion cycle and classified them accordingly :

(i) Young - characterised by shallow channels separated by sharp and irregular ridges.

(ii) Mature - characterised by deep irregular channels separated by rounded ridges.

(iii) Old - characterised by deep smooth channels separating low rounded dolomitic buttresses or monoliths.

Lapies of the mature and old stages predominate in the Lichtenburg area. Lapies of the young stage are only preserved below the gravel cover, as seen in cross-section close to King's pothole.

Harger (1922) was one of the first workers to realise the full economic implications of the geomorphological evolution of the Lichtenburg karst terrain. In particular he emphasised the importance of underground erosion integrated with the structural control of joints during the deposition of the diamondiferous gravels.

Harger (1922) argued that during Karoo sedimentation waters which percolated into the dolomite basement initiated chemical erosion. Subsequently the basement was gradually stripped of its cover of Karoo sediments, leaving only remnants of Dwyka tillite trapped in sinkholes.

The dolomite has undergone chemical erosion by percolating waters probably since pre-Karoo times. This is confirmed by the regional hydrogeology; there is a virtual absence of any flow of surface water due to numerous underground cavities and joints. Springs emerge only locally from the formation, where dykes, acting as barriers force the water flow to change direction.

2.3 Areal distribution and lithology of the gravels

The gravels in the Lichtenburg area are preserved in zones over an area covering approximately 3 000 km² and may be up to 20 metres thick. Significant variations in both thickness and lateral extent are known to occur. According to Du Toit (1951) all gravels were deposited in mid-late Tertiary.

The alluvial runs presently stand out in the landscape as positive topographical ridges due to chemical weathering of the dolomite following the deposition of the gravels (Du Toit, 1951).

The Welverdiend-Grasfontein run which constitutes the main alluvial run crosses the southern part of the study area in a northeast-southwest direction and can be traced from Welverdiend 361 JP, Hendriksdal 1 IP, to La Rys Stryd 53 IO (fig. 1). A secondary NW-SE run is present between Grasfontein 356 JP and Elizabeth 357 JO.

The central and eastern parts of the study area are covered by thin gravel, varying in thickness between one and two metres. In the northern part of the investigated area a deeper and major east-west run of younger gravels is referred to as the "Rooisloot" (Beetz, 1927; Du Toit, 1951) but this run is not manifested as a positive feature in the landscape.

The runs contain two types of gravel, namely (1) alluvial and (2) eluvial.

The contact of the alluvial gravel with the dolomite walls is often sharp and distinct although slumping is evident in several places. The eluvial material generally overlies the alluvial gravel but in places can also be found in weathered zones in the dolomite where no alluvial gravel exists.

2.3.1 Alluvial gravel

Two separate diamond-bearing alluvial gravel deposits have been recognized (Beetz , 1927).

(a) The older or high level gravels, of which the main Welverdiend-Grasfontein run forms part, are confined to the above-mentioned well-defined ridges (fig. 8). Clasts are predominantly chert and have a wide range in both roundness and size. These gravels have been interpreted as reworked gravel (Beetz 1927, Retief 1960), and are enriched in diamonds, but the content is variable. The gravels of the main Welverdiend-Grasfontein run were very rich on the farm portions D, H, K, L and M (fig. 1) of Grasfontein 356 JP, for example, but from M towards La Rys Stryd 53 IO diamond contents decreased significantly. Concomitantly the width of the run narrows down to 200 metres and the deposit thins considerably.

(b) The younger gravels were deposited in local hollows and channels of variable size. The "Rooisloot" which forms part of these gravels, consists of infilling of laterite, lateritic soil and sporadic layers of water-worn pebbles. Bedding can often be recognized in the "Rooisloot" and diamonds, although not in the quantities as found in the high level gravels, have been recovered from it (figs. 3 & 4).

The high level gravels can be further subdivided into the following four subdivisions (based on sections from deep workings and potholes; slightly modified after Du Toit, 1951).

(1) Basal white layer

This consists mainly of a white clay with abundant angular and weathered clasts of chert, dolomite and vein quartz. Sporadic rounded clasts have been encountered. Slump structures are evident in places. This layer normally directly overlies the dolomite. Infrequently it is underlain by wad, which as the drilling results have indicated, contain many cavities (up to 3 metres in diameter) or highly weathered dolomite still in situ. No diamonds are known to occur in this layer.

Fig. 3. Section through Rooisloot.

Fig. 4. Grading in the Rooisloot gravels. Diagonal across is the contact with the weathered dolomite.

(2) Productive lower red zone

This gravel, which has a high diamond content, generally consists of well-rounded pebbles of agate, chert, vein quartz, sandstone and dolomite. These well-rounded, water-worn pebbles may constitute nearly 90 per cent of the gravel in which instance it is referred to as "potato gravel" (fig. 5). Large boulders of chert and less frequently of sandstone, up to 700 mm in diameter are reasonably common.

The matrix varies in colour from off-white to shades of pink, red, brown and black. It consists mainly of argillaceous detritus probably derived from dolomite, sandstone and volcanics (Du Toit, 1951).

A point of interest is the origin of the volcanic detritus and associated agates. The agates range in colour from a bluish or deep green through greenish to yellow and even smokey-brown. A wine-red colour or even a darker tint, approaching that of almandine garnet, is especially common in agates from the deeper levels. According to Du Toit (1951) these peculiar wine-coloured agates are unknown elsewhere in South Africa.

Agates attain a size of several tens of millimetres in diameter but bigger agates are not uncommon. The smaller ones are all usually well rounded and even polished, but the bigger specimens may be angular, cylindrical to slab-shaped.

It has been claimed that most of the agates found in the Bakerville gravels are similar to the agates found on the Springbok Flats which were derived from the Bushveld basalt (Du Toit 1951, Retief 1960).

(3) Poor intermediate zone

The lithology of this zone is similar to that of the productive lower zone, but despite scattered agates and even sporadic diamonds, this zone is generally uneconomic. The zone is not always clearly

Fig. 5. Potato gravel.

Fig. 6. Potato gravel lying on weathered chert and dolomite.

developed and the transition from the productive lower red zone to the overlying productive upper layer may be gradual.

Du Toit (1951) believed the interface between the productive upper and the lower gravels to represent an unconformity which he recognized [illegible] in a number of places. Unfortunately lack of exposure, due to infilling of tailings in most of the excavations, prevented the verification of such an unconformity.

(4) Productive upper layer

The upper layer is mainly composed of rounded pebbles, although angular chert clasts are present. The matrix is generally pale-grey in colour (compared with that of the lower productive layer), probably due to more extensive leaching. Diamonds are as abundant as in the lower productive zone. Retief (1960) described the occurrence of reworked gravels composed of chert fragments with a wide range in degree of rounding and in size. These reworked gravels occur at a depth of no more than 1-1½ metres and are usually found in the vicinity of the alluvial gravels, commonly flanking the runs (Retief,1960). A common feature of these deposits is that the pebbles are usually in an advanced state of weathering. The thickness of this productive upper zone can be as much as seven metres.

2.3.2 Eluvial gravel

It appears that solution of the basement dolomite with interbedded chert has left the chert as a residue of insoluble silica clasts. These angular clasts vary in size from millimetres to metres in diameter. They are very poorly sorted and are densely packed. There is no field evidence to suggest that these gravels have been transported horizontally.

The field relation suggests that this gravel accumulated on the dolomite surface and within the depressions of the chemically weathered dolomite. Previously deposited alluvial gravel may be completely covered by this eluvial material. In many instances there is a clear break between the alluvial and eluvial material on top. Elsewhere the deposits consist entirely of eluvial chert.

2.4 Sinkholes

The three major potholes in the area are known as King's, Malan's and Van Wyk's potholes. The former two are in fact two deep gorge-like features, and thus should strictly speaking be called yamas (see section 2.2). Van Wyk's Pothole (situated on the main run near peg no. 900/3200, fig. 2), merely a large depression and also famous for the diamond production, is now completely filled with tailings.

The water table in King's Pothole is approximately 30 metres below the ground level, with approximately another 4 metres to the bottom of the hole. The pothole is nearly 15 metres wide. Its long axis strikes nearly in a north-south direction (fig. 7). At right angles to this, following an east-west joint in the dolomite, is a diamond-rich gravel run, erroneously referred to as a fissure by some local diggers. On both sides of the pothole, the diamondiferous gravel is covered by a thick layer of angular, weathered chert.

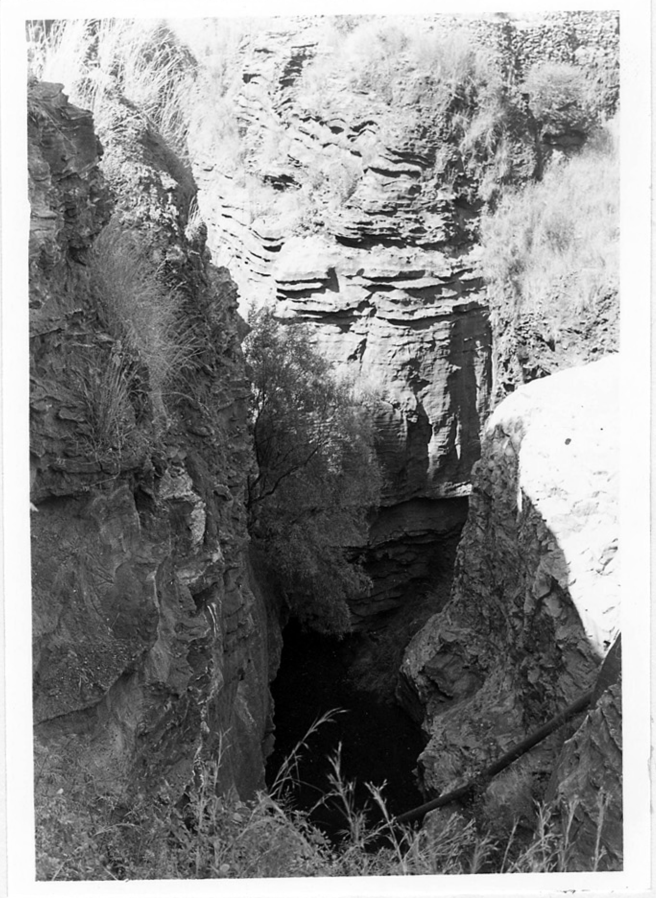
The long axis of Malan's Pothole is nearly east-west parallel to the "fissure" in King's Pothole and also parallel to the trends of the runs. The diamondiferous gravel here is also covered by about 5 to 10 metres of angular chert and weathered dolomite fragments. Fractures are perpendicular to the long axis of Malan's Pothole.

The dimensions of both potholes are similar. It is interesting to note that neither of these two potholes is situated along the main run.

A.

B.

Fig. 7A & B.
King's Pothole
(Facing south).



2.5 Chert ridges

Several small ridges of chert are present in the study area. They are thought to be the remnants of the weathered chert/dolomite sequence. According to local diggers who have been working on Manana 261 IP, some of the long channels in the run are truncated by the chert bars. These bars evidently acted as weirs across the channel. Large concentrations of diamonds were found on the northern and western sides of these barriers depending on the direction of the channel. They have apparently acted as trap sites and diamond concentrations are probably due to changes in current direction and velocity (turbulence) at these obstructions within the channels.

Although these bars have not been observed within the main run of the investigated area, they are present in the more central part of the study area. Here only thinner gravels exist, with thicknesses of between 1 and 2 metres and containing smaller and fewer pebbles than the main run.