THE GEOLOGY, GEOCHEMISTRY AND STRATIGRAPHIC CORRELATIONS OF THE FARM RIETFONTEIN 70 JS ON THE SOUTH-EASTERN FLANK OF THE DENNILTON DOME, TRANSVAAL, SOUTH AFRICA.

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ABSTRACT

The study area is located between Loskop Dam and the town of Groblersdal, on the southeastern flank of the Dennilton dome, and is underlain by lithologies of the Pretoria Group, Bushveld Complex mafics and ultramafics and acid lavas that resort under the Rooiberg felsites. Field work comprised of geological mapping, soil-, hard-rock- and stream sediment geochemistry, various geophysical techniques and diamond drilling. The rocktypes that resembles the Rustenburg Layered Suite on the farm Rietfontein 70JS is subdivided into a Mixed Zone, Critical Zone and Main Zone, on grounds of geochemical and certain geophysical attributes. The Mixed Zone that overlies the Bushveld Complex floor-rocks, is furthermore separated into an i) Lower-, ii) Middle- and, iii) Upper Unit. The Lower Unit of the Mixed Zone consists primarily of magnetite-gabbros, iron-rich pegmatites, harzburgites and feldspathic pyroxenites. The Fe-rich constituents of this stratigraphic horizon generates a pronounced magnetic anomaly within the study area.

On the basis of, amongst other parameters, Zr/Rb and Sr/Al_2O_3 ratios, the magnetite-gabbros are postulated to conform to lithotypes in the vicinity of magnetite layers 8 to 14 of Upper Zone Subzone B in a normal Bushveld Complex stratigraphical scenario. Similarly, it is argued that the feldspathic pyroxenites and norites that display elevated chromium values are analogues to normal Critical Zone rocktypes of the Rustenburg Layered Suite. A more elaborate and precise stratigraphic correlation for the Critical zone was, however, not possible.

It is advocated that a volume imbalance was created by the hot, ascending mafic magmas of the intruding Bushveld Complex, resulting in the updoming of certain prevailing basement features such as the Dennilton Dome. In addition to this ideology, it is proposed that the Mineral Range Fragment is in fact a large xenolith underlain by mafics, after being detached from the Dennilton Dome during the intrusion event. Evidence generated by this study unequivocally indicate that the potential for viable PGE's, Ni, Cu and Au within a Merensky Reef- type configuration or a Plat Reef-type scenario under a relatively thin veneer of acid Bushveld Complex roof-rocks on the eastern flank of the Dennilton Dome, appears feasible.

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1. INTRODUCTION

The farm Rietfontein 70 JS is situated 7 km north of Loskop Dam in the central Transvaal (figure 1) on the south-eastern flank of the Dennilton Dome, and is located on lithologies of, inter alia the Pretoria Group (Bushveld Complex floor-rocks), Rooiberg Group (Bushveld Complex roof-rocks) and the mafics and ultramafics of the Bushveld Complex (figure 2).

Field work that consisted primarily of the establishment of a grid system, geochemical soil- and hard rock sampling, geological mapping, geophysical surveys and Landsat- and aerial photograph interpretations was conducted, in order to ascertain the nature and economic viability of essentially the Bushveld Complex rocktypes adjacent to the Dennilton Dome. Five diamond drill boreholes were subsequently drilled, that virtually covered the entire stratigraphical package between the base of the Bushveld Complex Main Zone and the Pretoria Group sediments.

The principal objective of this dissertation is to provide an overview of the geology, geochemistry and geophysical signature of the mafic and ultramafic suite in the study area, and to ultimately attempt to postulate a meaningful stratigraphic correlation with the normal sequence of the Rustenburg Layered Suite in the eastern Bushveld Complex. The possibility of additional ore deposit targets that may emanate from the interpretations of this study, will also be investigated.

Preliminary assessments of the farm Rietfontein 70 JS indicate that the potential for economic viable platinum group element (PGE), copper, nickel and/or gold certainly appears feasible. Mineralization associated with, i) a Merensky Reef-type environment, ii) a Plat Reef style (contact-type) scenario, as well as iii) fault-related deposits of hydrothermal origin, is envisaged.

If the concept of, among others, Molyneux and Klinkert (1978) that certain Transvaal Sequence (including Malope- and Dennilton dome) represents updomed portions of the basement rocktypes as opposed to other popular beliefs that these bodies are Bushveld Complex floor xenoliths, is favoured and if the idea of the Bushveld Granite transgressing the

Bushveld mafic phase is accepted, the implication that economically important units (Merensky Reef, UG2 Reef) may be developed at shallow depths on the rim of the relevant dome, as well as the possibility that units stratigraphically below the Bushveld Upper Zone could exist directly below the Bushveld acid phase (granites, granophyres) definitely becomes a reality.

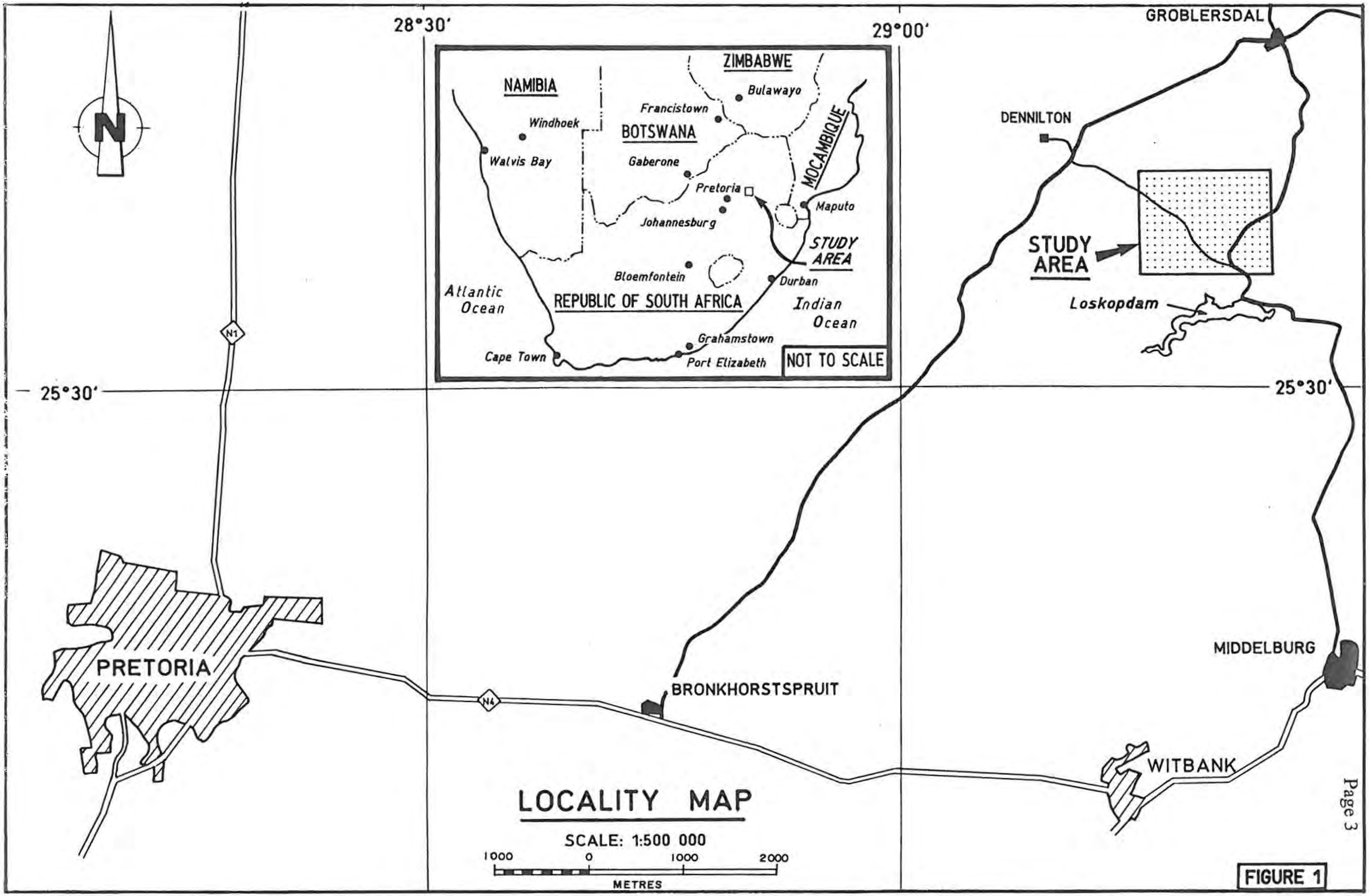
2. REGIONAL GEOLOGICAL SETTING AND PHYSIOGRAPHY

The mafics and ultramafics underlying the area of interest on the southern perimeter of the Dennilton Dome is regarded as part of the so-called Groblersdal sector of the eastern lobe of the Bushveld Complex, and is positioned between the Dennilton Dome and the northern limit of the Cullinan-Middelburg Basin (figures 2 & 32).

A diverse assemblage of lithotypes underlies the study area, and comprises predominantly of mafic rocktypes of the Bushveld Complex, as well as the Transvaal Sequence floor- and roof portions of the Bushveld Complex. The quartzite (that presumably resorts under the Daspoort Formation) on the northern boundary of the farm Rietfontein 70 JS gives rise to a very prominent escarpment that forms the southern boundary of the Dennilton Dome.

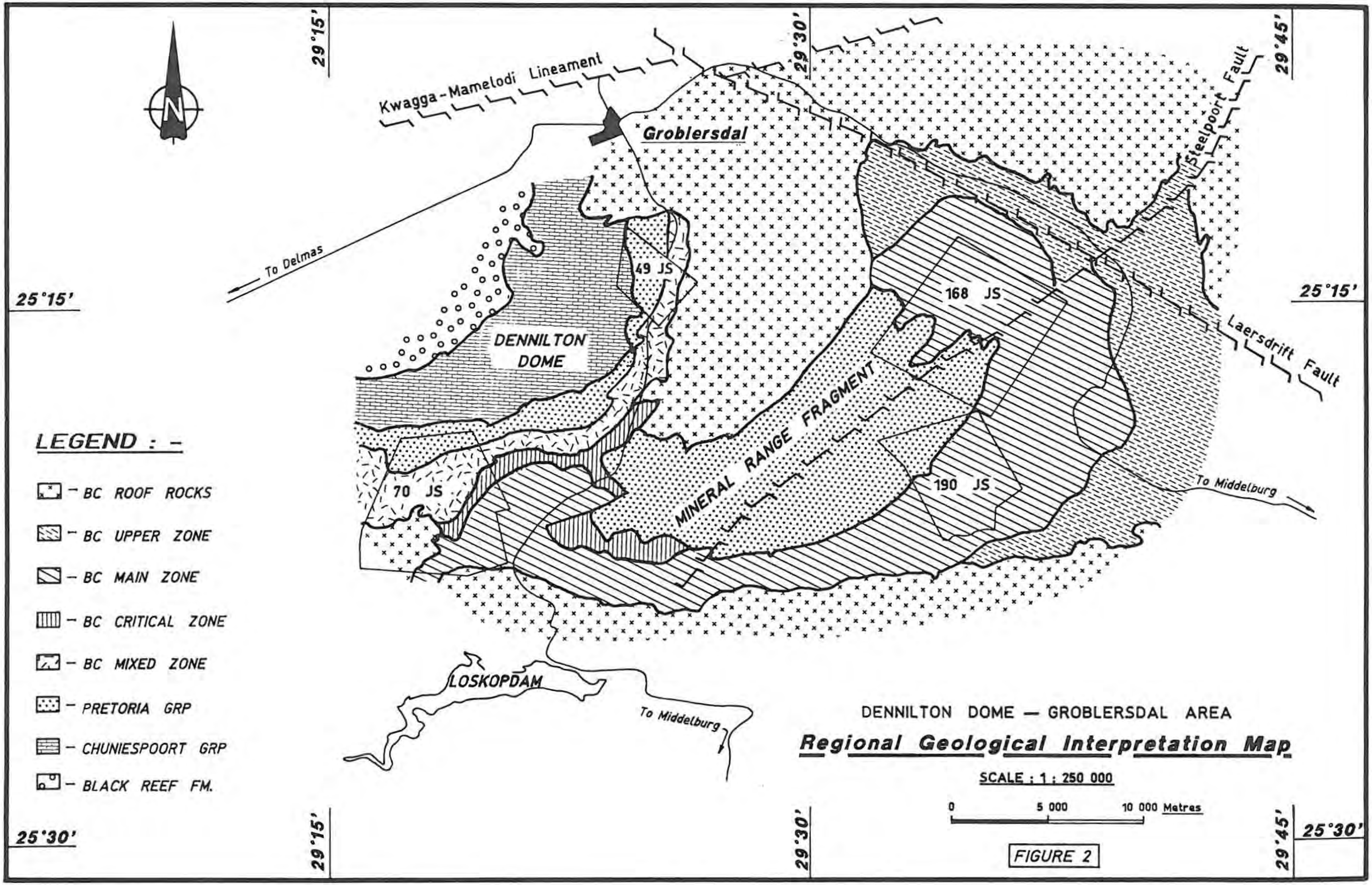
The topography of the region is rather undulating in places and surface elevations range between 980 metres above mean sea level (mamsl) in the central portion of the farm Rietfontein 70JS (figure 4), to 1325 mamsl on the hilly terrain that is overlain by Bushveld Complex roof-rocks, in the south-western sector of the latter farm.

An ephemeral stream traverses Rietfontein in an east-west direction, and effectively dissects the two main drainage domains, namely the northern area where the drainage direction is southwards from the Pretoria Group sediments, and the southern domain where drainage is in a northerly direction from the roof-rocks.



28°30'
29°00'
25°30'
25°30'
N
NAMIBIA
ZIMBABWE
BOTSWANA
MOCAMBIQUE
Windhoek
Walvis Bay
Francistown
Bulawayo
Gaberone
Pretoria
Johannesburg
Maputo
STUDY AREA
Bloemfontein
Durban
Atlantic Ocean
Indian Ocean
REPUBLIC OF SOUTH AFRICA
Grahamstown
Cape Town
Port Elizabeth
NOT TO SCALE
GROBLERSDAL
DENNILTON
STUDY AREA
Loskopdam
N1
PRETORIA
N4
BRONKHORSTSPRUIT
MIDDELBURG
WITBANK
LOCALITY MAP
SCALE: 1:500 000
1000
0
1000
2000
METRES

FIGURE 1



DENNILTON DOME — GROBLERSDAL AREA

Regional Geological Interpretation Map

FIGURE 2

FIGURE 3

DENNILTON DOME - GROBLERSDAL AREA

LANDSAT [TM] IMAGE OF A PORTION OF WRS 169-78 BANDS RGB = 731

SCALE 1 : 250 000

Image produced by Gold Fields Remote Sensing Unit

3. GEOLOGY AND LITHOSTRATIGRAPHY

As previously mentioned the study area is underlain by Transvaal Sequence rocktypes, as well as various units that conform to the Rustenburg Layered Suite of the Bushveld Complex. Due to the seemingly incomparitive nature of certain lithologies to the accepted traditional stratigraphical subdivision of the standard eastern Bushveld Complex, reference is made to a "Mixed Zone". Based on certain criteria (mineralogy, geochemistry) this Mixed Zone includes units that conforms to the Lower Zone, Upper Zone and possibly Critical Zone of the normal Bushveld Complex in the eastern Bushveld, and an attempt will be made to prove this apparent correlation by means of, inter alia, geochemical associations. For the purpose of this dissertation, however, the Critical Zone rocktypes are divorced from the Mixed Zone and are thus discussed as a separate unit, but could most certainly be classified under the Mixed Zone.

All lithotype descriptions and subdivisions discussed below are derived from limited outcrop (especially the mafic rocks) in the field, and to a greater extent from borehole core, and therefore less emphasis was placed on the roof-rocks (leptite, felsites). LANDSAT-images aided greatly in the interpretation of the geology in the study area (figures 3 & 33).

3.1 THE BUSHVELD COMPLEX FLOOR-ROCKS

3.1.1 The Pretoria Group

The quartzites and shales of the Pretoria Group of the Transvaal Sequence which is of early-Proterozoic age (Button, 1986) represent the oldest rocktypes in the study area, and is located on the northern boundary of Rietfontein 70JS (figures 5 & 28), and include a number of formations that range from the 2263 Ma (Burger & Walraven, 1980) Timeball Hill Formation to the Silverton Shale Formation. The Dennilton Dome itself comprises of the pre-Black Reef Formation lithotypes in the north, which is made up of the Dennilton Formation (gneiss, acid lava, tuff, granulitic schists) and the Bloempoort Formation (quartzite, andesite, shale), which together constitute the Groblersdal Group. The quartzites, grits and conglomerates of the Black Reef Formation are overlain by the chert-carbonate units of the

Chuniespoort Group, which is in turn overlain by progressively younging rocks of the Pretoria Group. The Pretoria Group is only represented up to roughly the Silverton Formation on the southeastern flank of the Dennilton Dome, after the overlying units were detached from the dome by the intruding Bushveld Complex.

Some of the latter rocktypes were subjected to metamorphism, evidently caused by the intrusion of the Bushveld Complex. This metamorphic event resulted in the disturbance of the normal stratigraphic sequence of the floor-rocks in terms of thickness and continuity of certain units. Worst (1944) produced evidence to illustrate that the degree of metamorphism decreases from the hornfelses overlying the Daspoort Fm. quartzites, to the quartz-sericite-schist overlying the Timeball Hill Fm. quartzites i.e. from south to north.

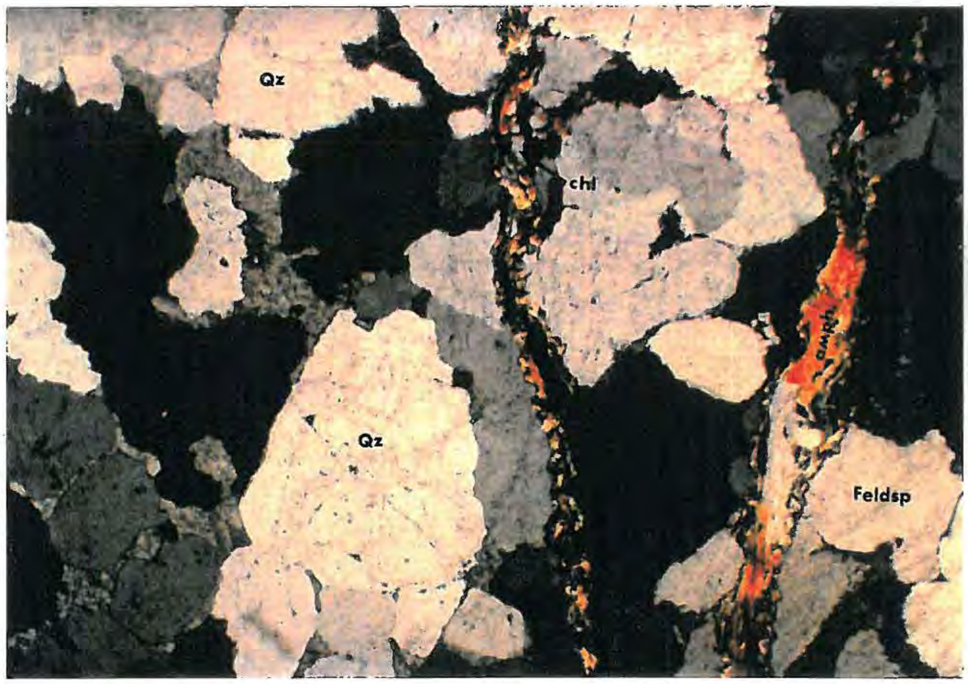


Plate 1. *Metamorphosed quartzite* : -recrystallysed quartz grains with interstitial plagioclase and K-feldspar; chloritization and sericitization evident together with amphibolization in fractures and veins. [RF2/485,81. crossed nicols @ 50x magnification]

The mafic phase of the Bushveld Complex thus not only instigated the formation of xenoliths, but also generated several hornfels types. Sandwiched between the Pretoria Group quartzites and the basic rocktypes of the Bushveld Complex, two continuous hornfels units can be recognised. A *cordierite hornfels* which displays a dark brown weathered surface and a distinct purple-blue colour with a glassy appearance on a fresh surface. The main mineral constituents in this rocktype are plagioclase and cordierite, with biotite as the most common accessory mineral. It is possible that this hornfels type represents the metamorphic product of a shaly unit of some kind (part of Silverton Shale Formation ?).

Overlying the cordierite hornfels is a *mafic hornfels* that is essentially made up of clinopyroxene, hornblende, plagioclase and minor biotite, and possesses a dark brown-grey weathered appearance. This mafic hornfels was in many instances erroneously classified as a micro-gabbronorite due to the striking similarity in geochemical composition, texture and macroscopic appearance. Evidence of metamorphism and recrystallysation does, however, favour the former nomenclature.

Based on thin section studies it appears that the dominant components of the meta-quartzites (xenoliths) are quartz and feldspar, with secondary chlorite, sericite and amphibole (tremolite). The original matrix has been subjected to a high degree of metamorphism, and is recrystallysed to potassium feldspar and plagioclase, which occurs in interstices between the subrounded quartz grains. Sericitization and chloritization is commonly developed with tremolite in veins and fractures (plate 1).

Due to the apparent lower economic importance of the floor-rocks, no detailed studies were conducted on them. A regional dip of the bedding of the Pretoria Group sediments on Rietfontein 70JS was measured at 43° in a southerly direction.

Xenoliths of quartzite, meta-sediment and hornfels occur throughout the mafic sequences in the study area, and is not restricted to the lower Mixed Zone.

3.2 BUSHVELD COMPLEX MAFICS AND ULTRAMAFICS

3.2.1 The Mixed Zone

The so-called Mixed Zone on Rietfontein 70JS conforms to some extent to certain units of the Lower Critical Zone and Lower Zone of the normal Rustenburg Layered Suite stratigraphy in the eastern Transvaal. Locally, the Mixed Zone is subdivided into the Upper-, Middle- and Lower Units, which basically comprise of Bushveld Complex mafic lithotypes intruded by a number of dykes and sills of granitic composition. The entire Mixed Zone package contains a whole range of quartzite and hornfels xenoliths. These xenoliths are not restricted to the basal portion of the Mixed Zone.

3.2.1.a. Lower Unit

A *micronorite* marks the base of the Mixed zone, and occurs stratigraphically just above the mafic hornfels. This very fine-grained rock consists primarily of plagioclase and orthopyroxene, and frequently contain granitic intrusive material. The micronoritic unit is overlain by a *sulphidic norite* that is made up of essentially finely disseminated chalcopyrite and pyrrhotite that is set in a fine- to medium grained orthopyroxene-plagioclase matrix. This sulphide-bearing norite often has a red-brown weathered appearance that displays spheroidal weathering in places.

A medium-grained *gabbro-norite* occurs above the sulphidic norite, and occasional contains minor disseminated sulphides. This gabbro-norite is in turn overlain by a *magnetite-gabbro* zone. In some cases, seemingly massive magnetite layers could be recognised within the magnetite-gabbro units. Klemd et.al. (1985) concluded that the magnetite from the massive layers of the eastern Bushveld complex are enriched in elements such as Ti, Mg, Al and Si, which indicates that this magnetite crystallised by spontaneous nucleation and rapid crystallisation under conditions of disequilibrium with the magma. These authors furthermore ascribe the upward increase in Cr content of magnetite to a combination of i) olivine crystallisation at the expense of pyroxene in the upper subzones, and ii) a possible escalation in the partition coefficient of chromium between spinel and liquid with a decline in the

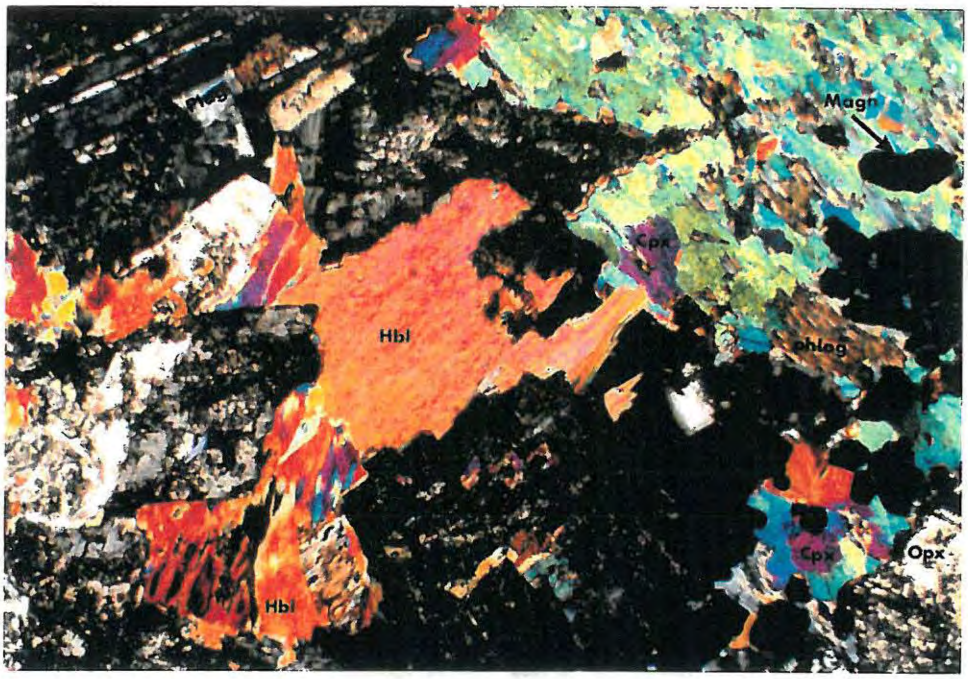


Plate 2. *Iron-rich pegmatite* :- pegmatitic phase with late stage amphibolization (hornblende); clinopyroxene, plagioclase, quartz, magnetite and phlogopite (altered to chlorite, sericite, clay) [RF2/282,81. crossed nicols @ 50x magnification]

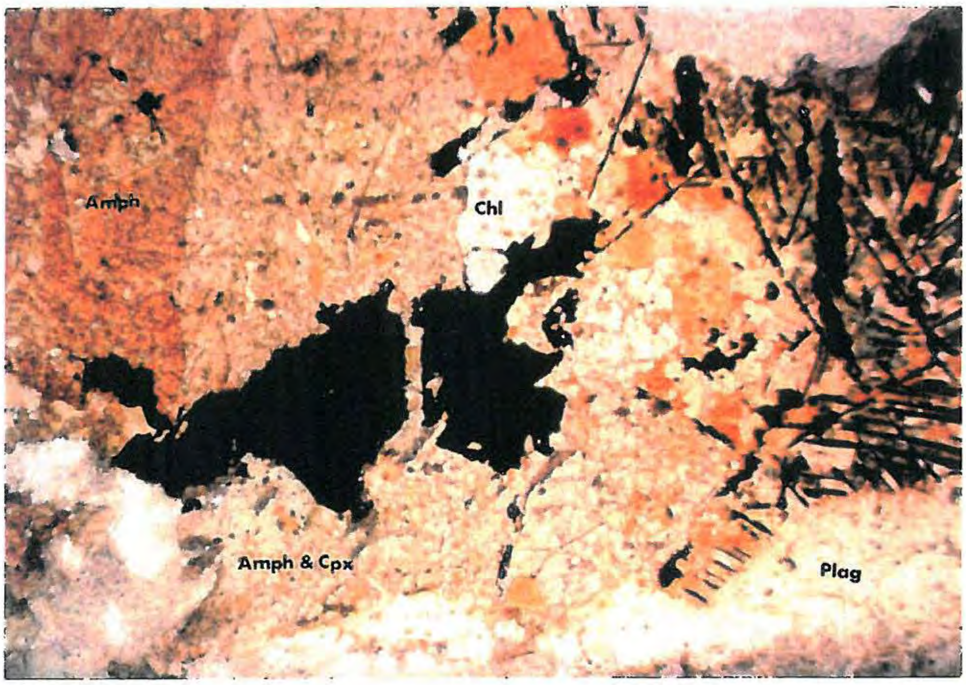


Plate 3. *Iron-rich pegmatite* :- altered pegmatitic rock with pyroxene, plagioclase and amphibole; magnetite seems to be replaced by silicates (+ exsolutions of ilmenite) [RF4/185,12 uncrossed nicols @ 20x magnification]

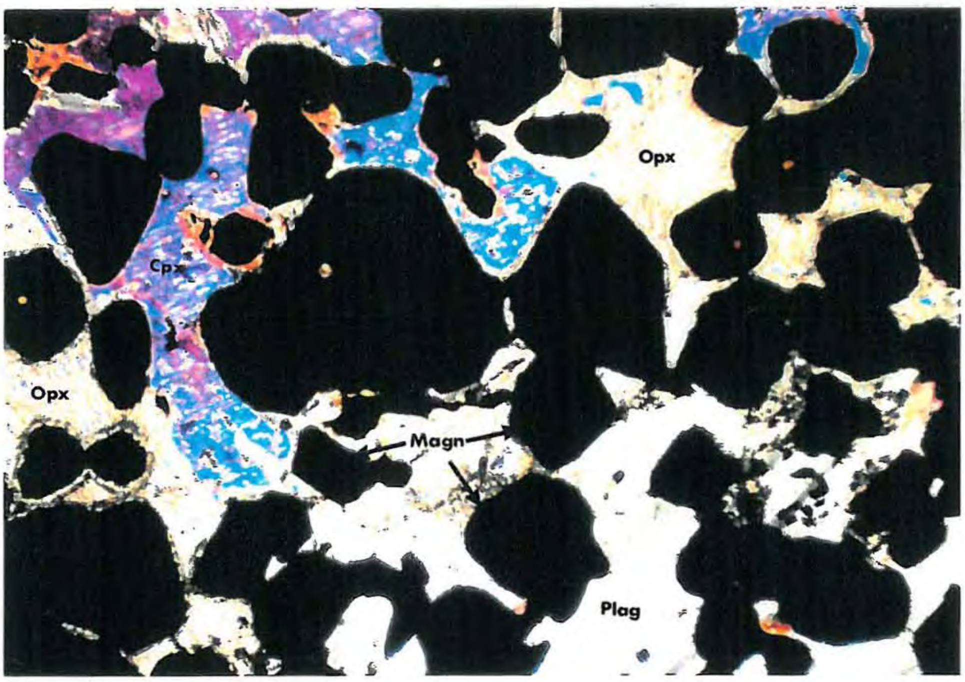


Plate 4. *Coarse-grained magnetite-gabbro* :- cumulus magnetite, pyroxene, plagioclase and minor amphibole [RF5/99,22 crossed nicols @ 20x magnification]

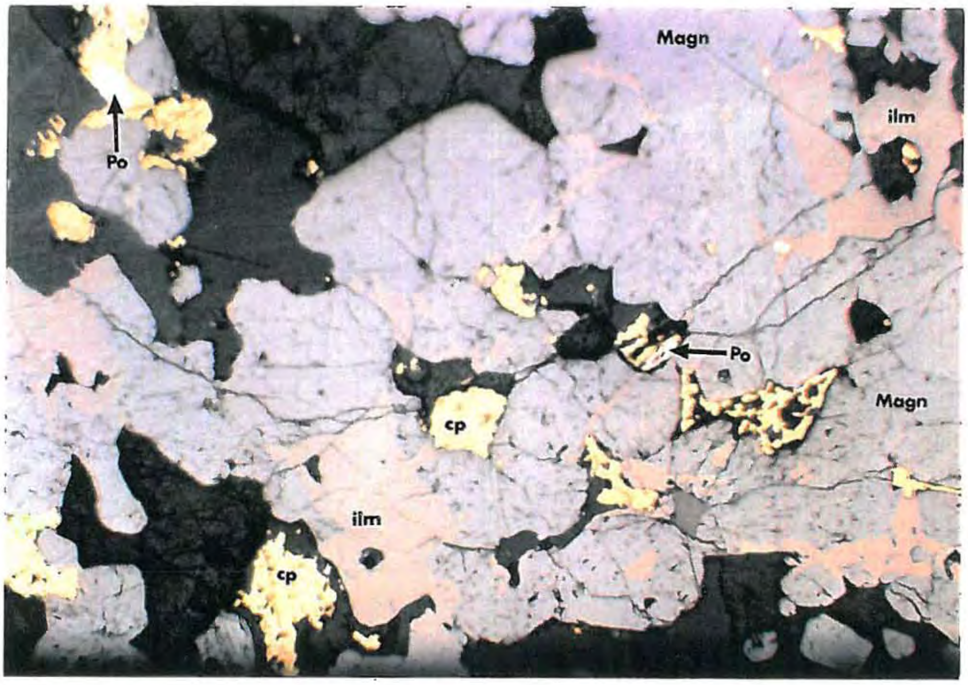


Plate 5. *Magnetite-gabbro* :- lobate magnetite and ilmenite grains with chalcopyrite and pyrrhotite [RF5/617,12 uncrossed nicols @ 20x magnification]

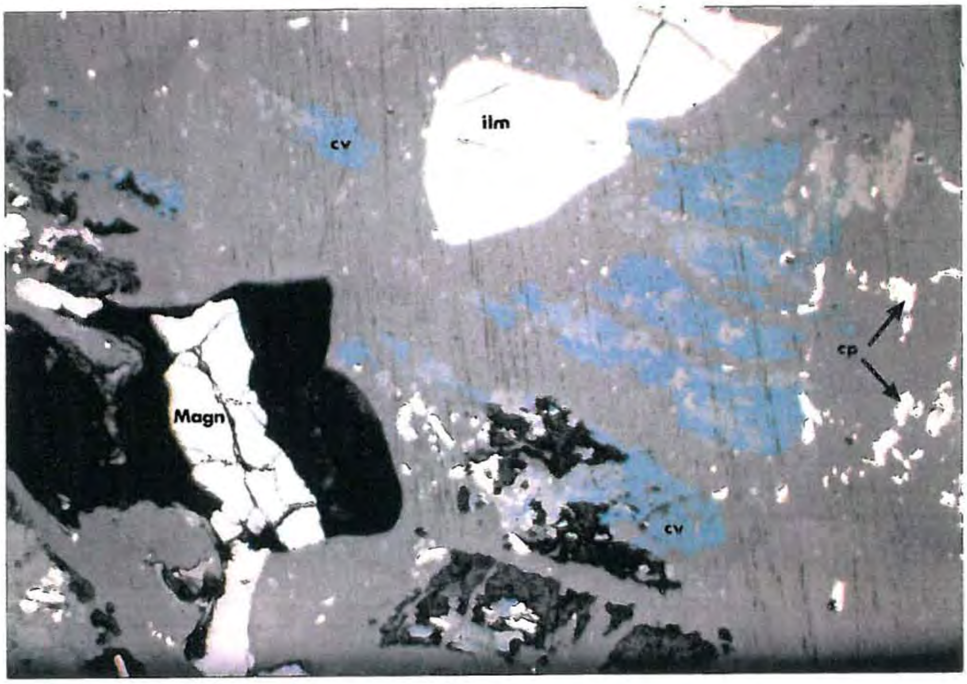


Plate 6. *Magnetite-gabbro* :- covellite, magnetite, ilmenite and chalcopyrite

[RF1/42,69 uncrossed nicols @ 20x magnification]

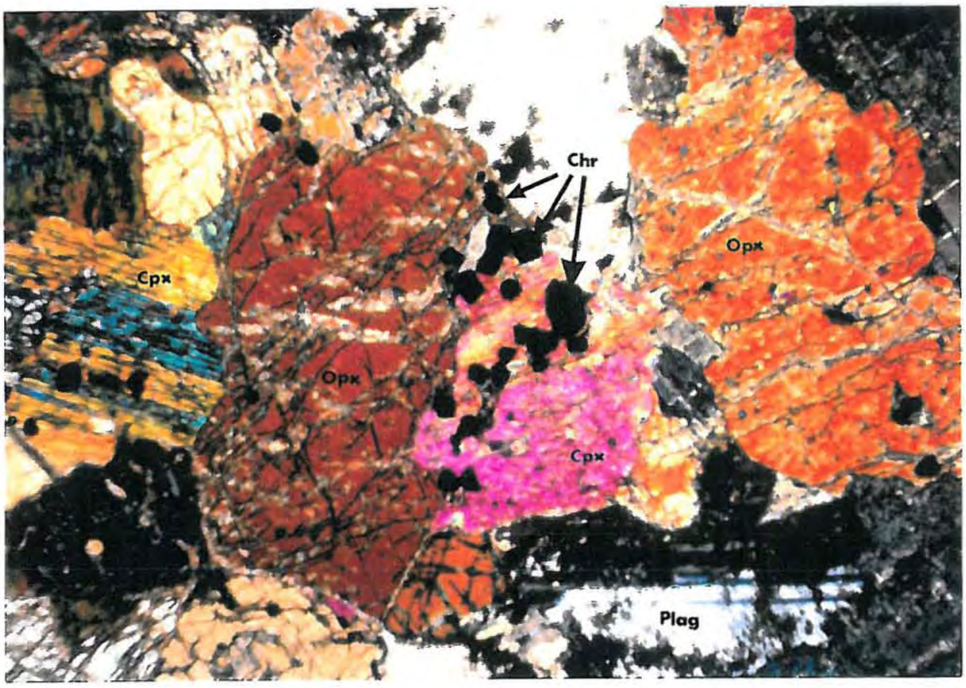


Plate 7. *Feldspathic pyroxenite* :- orthopyroxene, clinopyroxene and plagioclase (slightly altered in parts) with disseminated chromite [RF2/280,33 crossed nicols @ 20x magnification]

crystallisation temperature. A relatively high chromium content was associated with the magnetite-bearing horizons of the Mixed Zone Lower Unit on Rietfontein 70JS. Microscope studies of the magnetite-gabbros show that it consists primarily of plagioclase (subhedral crystals), clinopyroxene (augite) as cumulus and intercumulus phases that in some cases display exsolution lamellae, and orthopyroxene. The subsidiary minerals include amphibole (hornblende), chlorite and minor sericite and phlogopite. The principal opaque minerals are magnetite, ilmenite, chalcopyrite, pyrite, pyrrhotite and covellite. In the majority of cases the magnetite occurs as a cumulus phase, and is frequently partially or completely replaced by ilmenite.

Two distinct generations of ilmenite can be distinguished, and sometimes exist as rounded grains, co-existing with the magnetite. The chalcopyrite and pyrrhotite mostly occur in interstices between the rounded magnetite/ilmenite grains, where the chalcopyrite occupy the borders of large pyrrhotite grains or along vein-like pyrrhotite grains (commonly intergrown). Minor covellite was observed as laths and platy crystals, and displayed an exceptionally high pleochroism and anisotropy (orange colours).

A number of relatively thin, fine-grained *feldspathic pyroxenites* are interlayered with the rather thick magnetite-gabbro pile. These pyroxenitic zones very regularly contain a high proportion of *iron-rich pegmatites*, that consist mainly of large phenocrysts of orthopyroxene, plagioclase, mica (biotite) and frequently magnetite. In many instances the pyroxenes have been altered to amphibole, which appears to be tremolite. Veins and blebs of equigranular magnetite, together with sporadic occurrences of sulphides (predominantly pyrrhotite and chalcopyrite) occur throughout the pegmatitic zone.

On a microscopic scale, the primary minerals consist of plagioclase, orthopyroxene, clinopyroxene (augite) and amphibole (hornblende), with the accessory minerals being sericite, chlorite, calcite, biotite, phlogopite and tremolite. Kaersutite, a titanium-rich amphibole was also identified (G.Martin, pers.comm., 1995). The possibility of the existence of sphene is also likely, but still uncertain. Both tremolite and hornblende occur as alteration products of the pyroxenes in some cases. Ilmenite is the most abundant opaque mineral, with lesser magnetite, pyrrhotite and chalcopyrite. The ilmenite is often observed as exsolution lamellae of the magnetite (lath-like appearance), and the chalcopyrite occur mostly on the rims of the larger pyrrhotite grains.

Several, thin *harzburgite* layers are interwoven with the feldspathic pyroxenites. More than often, these harzburgites contain minor disseminated sulphides, and in certain instances the olivines of have been severely altered. In thin section, these harzburgites consist predominantly of olivine (cumulus) and orthopyroxene, with subordinate clinopyroxene and amphibole. More than often the orthopyroxenes are poikilitic and contain inclusions of clinopyroxene, and is often seen to be altered. Chloritization and minor disseminated magnetite are also present in some instances.

A medium- to coarse-grained micaceous, *feldspathic pyroxenite* caps the Lower Unit of the Mixed Zone. This feldspathic pyroxenite frequently contains minor disseminated sulphides. Numerous veins of granitic intrusive material are present within the Lower Unit. An extremely conspicuous magnetic signature marks the Lower Unit of the Mixed zone (figure 29).

3.2.1.b. Middle Unit

The bulk of the Middle Unit of the Mixed Zone is made up of *pegmatitic pyroxenites* (pyroxene, plagioclase, biotite and amphibole) at the base, and medium-grained *norites* as the topmost member of this unit. Frequently, the pyroxenes of the pegmatitic rocktypes have been partially or completely altered to tremolite, resulting in a pegmatitic amphibolite. The norites that overly the pegmatitic assemblages seem to represent a fairly homogeneous stratigraphic horizon.

3.2.1.c. Upper Unit

A very discernible (low) magnetic signature (refer to figure 29) demarcates the *gabbronorites* of the Upper Unit. Apart from having a much higher clinopyroxene content, these gabbro-norites are slightly more coarser-grained than the overlying Critical Zone norites. Unfortunately, no geochemical data is available for this layer.

3.2.2 The Critical Zone

The *spotted norites* of the Critical Zone are well exposed on surface and although it possesses a unique geochemical signature, magnetics can also be used to fingerprint this zone and separate it from the adjacent stratigraphic zones. The principal constituents of these norites are orthopyroxene and feldspar, with visible disseminated sulphide mineralization in places. The norites sometimes adopts a somewhat anorthositic character.

Medium-grained *feldspathic pyroxenite* units are present interbedded with some of the noritic layers, and in some cases take on a pegmatitic nature with abundant disseminated sulphides. Coarser pyrrhotite and chalcopyrite can intermittently be observed within these feldspathic, pyroxenitic pegmatites. Chromite blebs are occasionally present at certain intervals throughout the feldspathic pyroxenites. Outcrop of the feldspathic pyroxenites is limited, but when exposed on surface these lithotypes are extremely weathered.

Worst (1944) makes mention of chromitites that are intimately associated with a pyroxenite unit, which overlies a mottled anorthosite layer. According to Worst (op.cit.), this mottled anorthosite layer is the southernmost of three anorthosite layers encountered on the farms De Wagendrift and Kameeldoorn to the west of Rietfontein 70JS. Presumably, the southernmost mottled anorthosite is the same "mottled marker" at the base of the Main Zone on Rietfontein. Although no chromitites were observed in the study area, The Critical Zone feldspathic pyroxenite that displayed elevated chromium values on Rietfontein, is therefore probably the equivalent of the pyroxenite associated with the chromitite, as reported by Worst (op.cit.).

Medium-grained *gabbro*, as well as *gabbro-norite* constitute the uppermost units of this zone. These gabbroic units appear to be devoid of any significant mineralization.

Thin section studies revealed that the bulk of the Critical Zone norites is made up of plagioclase and orthopyroxene representing the cumulus phase, with minor clinopyroxene as intercumulus phase. Chlorite, sericite and clay occur as secondary minerals. In some cases the orthopyroxenes and plagioclases are altered to an amalgamation of the latter secondary minerals. In certain instances the clinopyroxenes display a poikilitic texture, and sometimes encloses plagioclase and orthopyroxene crystals. Exsolution lamellae of the clinopyroxenes are quite common. Minor chromite can be observed as the opaque minerals. The feldspathic pyroxenites of the Critical Zone essentially also consist of cumulus plagioclase (often saussuritized) and orthopyroxene, with some subordinate intercumulus clinopyroxene and minor olivine. As in the case of the norites, the clinopyroxenes often show exsolution lamellae, and is at times poikilitic with feldspar inclusions. Sericite, chlorite, clay and amphibole make up the accessory minerals, with fine disseminated chromite being the main opaque mineral.

3.2.3 The Main Zone

The bulk of the Main Zone in the study area is made up of medium- to coarse grained, rather monotonous gabbro. This gabbro does contain a certain amount of orthopyroxene, based on thin section studies a classification of gabbro would be more appropriate. Apart from the gabbros that obviously predominate in the Main Zone, a fine- to medium-grained norite is also in relative abundance.

A relatively thin mela-hyperite unit is exposed, sandwiched between two anorthositic layers in a streambed near gridline 13A on Rietfontein 70JS. The only reliable dip on in situ mafic phase rocks was also measured in the vicinity of this outcrop, and revealed a dip of 25° in a south-westerly direction. A very conspicuous mottled anorthosite unit marks the base of the Main Zone. Typical Main Zone gabbros were, however, intersected in boreholes below the stratigraphic position of the Mottled Marker, within the Mixed Zone lithologies.

Thin section investigations indicate the Main Zone gabbro in this area to consist mainly of clinopyroxene, plagioclase and orthopyroxene, with amphibole, chlorite and minor magnetite as accessory minerals. The clinopyroxene was identified as augite, and predominates over the orthopyroxenes, which are of bronzitic composition. The subhedral plagioclase crystals are often saussuritized and occur as a cumulus phase. The anhedral pyroxenes are in most cases serrated, and exist as an intercumulus phase. The amphiboles are present at the edges of the pyroxene crystals, and appear to be an alteration product of the pyroxenes in some cases.

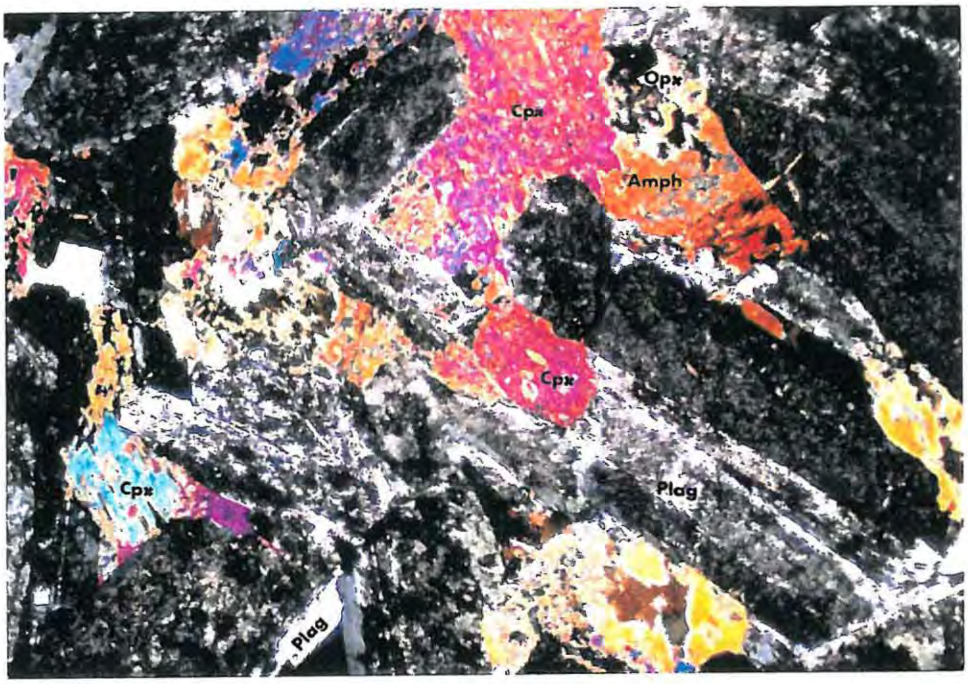


Plate 8. *Coarse-grained gabbro* :- plagioclase, orthopyroxene, clinopyroxene, amphibole and chlorite (opx often as lamellaes in cpx) [RF2/164,44 crossed nicols @ 20x magnification]

3.3 BUSHVELD COMPLEX ROOF-ROCKS

3.3.1 The Leptites

The term "Leptite" is described by the glossary of geology (Bates & Jackson) as a "granular quartzofeldspathic metamorphic rock formed by regional metamorphism of the highest grade". Henriques (1966) defined a leptite as a recrystallized supra-crustal rock , of approximately granitic composition, which has a secondary grain size between 0,03mm and 0,05mm as a lower limit, excluding phenocrysts which may be present. A leptite can thus be described as a highly metamorphosed, granular quartz/potassium-feldspar lithotype, with no genetic implication as to the parent material.

The two most popular theories for the origin of the leptites are : i) a *metamorphosed felsite*, or ii) a *restite*, after partial melting of the Rooiberg acidic lavas. Clubley-Armstrong (1977) postulated that the leptites near Loskop Dam in the eastern Bushveld could be a metamorphic derivative of an original arkose rather than a felsite, due to the strong K-feldspar and quartz intergrowth. A number of researchers did, however, produce evidence that a felsic lava was the parent rocktype to the leptites. Molyneux (1974) reports the existence of dark green amphibolitic patches with the attitude of amygdales in dark red leptite in the Sekhukhuneland area, which indicate that the original unmetamorphosed rock could only have been a lava.

Von Gruenewaldt (1968) clearly stated that the leptites in the Blood River Valley area were produced by metamorphism of a dark-coloured felsite, and Willemse (1964) furthermore claimed that a notable gradation was observed from leptite to felsite. Henriques (op.cit.) also advocated that the phenocryst-bearing, red leptites that were investigated in Scandinavia were definitely a metamorphosed product of a rhyolitic lava.

The leptite on Rietfontein 70 JS is represented by an orange-pink, fine- to medium grained (coarser grained than the adjacent felsites) quartz-feldspar rock with a granular texture, and evidently originates from the felsites, thus a meta-felsite.

3.3.2 The Rashoop Granophyres

Stratigraphically, the granophyres are situated between the Bushveld mafic phase and the acid roof-rocks, Von Gruenewaldt (1972) posed the hypothesis that the granophyres originated by partial melting of the Rooiberg felsites, and that evidence for this partial melting is particularly extensive in the highly metamorphosed felsite of the eastern Bushveld. According to heat transfer calculations by Irvine (1970) it was determined that the heat generated by the intrusion of magmas of the Rustenburg Layered Suite (RLS) possessed the capability to melt up to 1000m of felsic roof-rocks.

Von Gruenewaldt (1991) stated that the chemical ranges that are quoted for the Bushveld granophyres by Walraven (1985) correspond to an evolved low-MgO magma. In response to this ideology, Walraven (op.cit.) pointed out that the majority of granophyres pre-date the RLS, which therefore indicates that not all granophyre types could have been formed by partial melting.

Walraven (op.cit.) adopted an alternate approach towards the genesis of the granophyres, and proposed the granophyres (and in particular the Stavoren granophyres) to be intrusive, sill-like equivalents of the Rooiberg felsite magmas and hence are older than the RLS. The latter viewpoint is also advocated by Schweitzer & Hatton (1995), and appears to be the most feasible theory at this stage if it is borne in mind that exposures where the BC gabbros display an intrusive relationship towards the granophyres can be observed in the eastern Bushveld (Molyneux, 1974). This ideology is also contrary to the idea of the upward migration and coalescence of melts during emplacement of the RLS magmas that gave rise to the "granophyre sills".

Kleeman (1987) does, however, refer to outcrops to the east of Groblersdal where angular fragments of felsite can be seen in granophyre and inclusions of granophyre in Upper Zone lithologies, as well as examples were the granophyre is intruded by Nebo Granite and BC mafic phase.

It was furthermore postulated by Schweitzer & Hatton (1994) that the high Na and Al_2O_3 content (7,5 and 2,0 wt% respectively) of the amphiboles within the granophyres suggests that elevated metamorphic conditions prevailed during formation of this rocktype.

In conclusion, it would appear that a variety of granophyre types with different genetic heritages exist for the Bushveld Complex roof, and that each area type must be treated as a separate entity when an attempt is made to determine intrusive/genetic relationships.

On Rietfontein 70JS the granophyre occur as an orange-red coloured, medium to coarse grained rock that comprises primarily of quartz and potassium-feldspar with minor hornblende. Examples of granophyric texture (quartz/K-feldspar intergrowth) are quite common throughout.

If viewed on a macroscopic scale, the granophyres in the study area creates the impression of sheet-like intrusions (sills) between the overlying felsites and the leptites. As discussed elsewhere in this dissertation, the intrusive micro-granitic veins also display graphitic intergrowth in many instances.

3.3.3 The Rooiberg Group Felsites

At present, the most meaningful stratigraphic position of the Rooiberg Group felsites seems to be as the terminal volcanic phase of the Transvaal Sequence, where it was subsequently intruded by the layered mafic rocks and the acidic granites of the Bushveld Complex. The 2100Ma felsite pile is 3 to 5 km thick with an eruption volume of 200 000 km^3 (Twist & Bristow, 1990), covering an area of approximately 50 000 km^2. Numerous authors have attempted to subdivide the Rooiberg felsites, and the earlier efforts include Wolhuter (1954), Von Gruenewaldt (1968), Groeneveld (1970) and Clubley-Armstrong (1977). A more recent classification by Twist (1985) makes provision for nine distinct units that are distinguished by means of, amongst other criteria, geochemical composition viz. MgO-, TiO_2-, P_2O_5-, Zr-, Y- and Sc- content.

The felsite that occupies a large portion of the mountainous area on the south-western boundary of Rietfontein 70JS is well exposed and can be recognised as a fine-grained, reddish in appearance, porphyritic, rhyolitic lava , with irregular intergrowth of quartz and feldspar in places. The matrix of the felsite consists principally of quartz and feldspar , with phenocrysts of feldspar and blackish, needle-like amphiboles (hornblende) in parts. This felsite is part of Von Gruenewaldt's (1968) Lower Felsite Zone, and will conform to Clubley-Armstrong's (1977) granophyric, red felsite of the Damwal Formation. As far as Twist's (op.cit.) subdivision is concerned, the Rietfontein felsites correlate with the low-MgO ($MgO < 1,0\%$) - higher zirconium and yttrium, Unit 1 at the base of the standard Rooiberg felsite sequence.

3.3.4 The Nebo Granite

The Bushveld Complex granites, and in particular the Nebo Granite represents the final phase of magmatism in the BC and does not outcrop on Rietfontein 70JS, but is well exposed just to the west of the latter farm towards Dennilton. The Klipkloof Granite can also be seen overlying the Nebo Granite in this area. As discussed at a later stage, the interface between the Klipkloof- and Nebo granites appears to be an important factor as far as mineralization in the Groblersdal area is concerned. This contact may have a bearing when making an attempt to devise potential ore deposits in the Dennilton Dome area.

3.3.5 Aplitic intrusions

An abundance of micro-granitic and micro-granophyric veins are visible on Rietfontein just north of the Loskop Dam - Dennilton tar road, near the western boundary of the farm, as well as in a number of the boreholes. These veins that can be described as aplitic, occur as relatively thin veins that often display granophyric intergrowth that can be observed on macroscopic scale. The aplitic intrusions are presumably the melting product of the leptites that originated during emplacement of the mafic magmas of the Bushveld Complex, where the majority of these veins are in close proximity to the RLS/BC roof - contact.

According to thin section work this panidiomorphic, medium-grained aplite has a small mafic constituent, that is mostly concentrated in interstices with serrated edges. The main mineral components of the aplites are quartz, feldspar, green amphibole (tremolite?) and chlorite, with minor brown amphibole (hornblende), mica (biotite), hypersthene, augite and calcite. The plagioclase is in some cases somewhat altered. The greenish amphibole occurs at the borders of mineral grains and in fractures, and is often replaced by the brownish hornblende. The chlorite is iron-rich, and is most probably the alteration product of biotite.

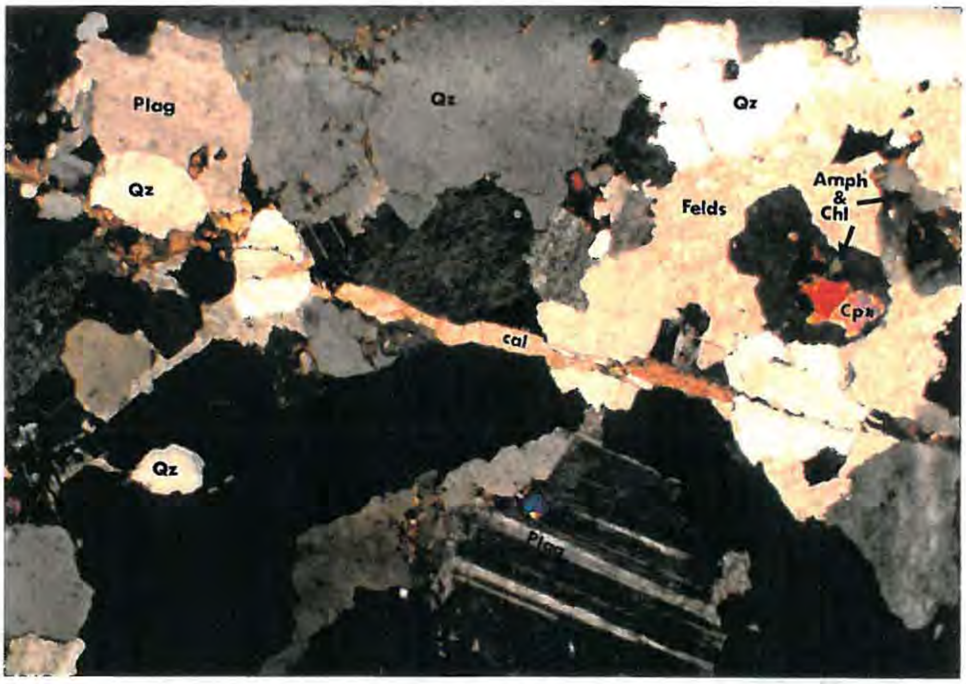


Plate 9. *Aplite* :- panidiomorphic texture with quartz, feldspar, amphibole, biotite and chlorite ; $CaCO_3$ crystallisation along vein [RF1/36,50 crossed nicols @ 50x magnification]

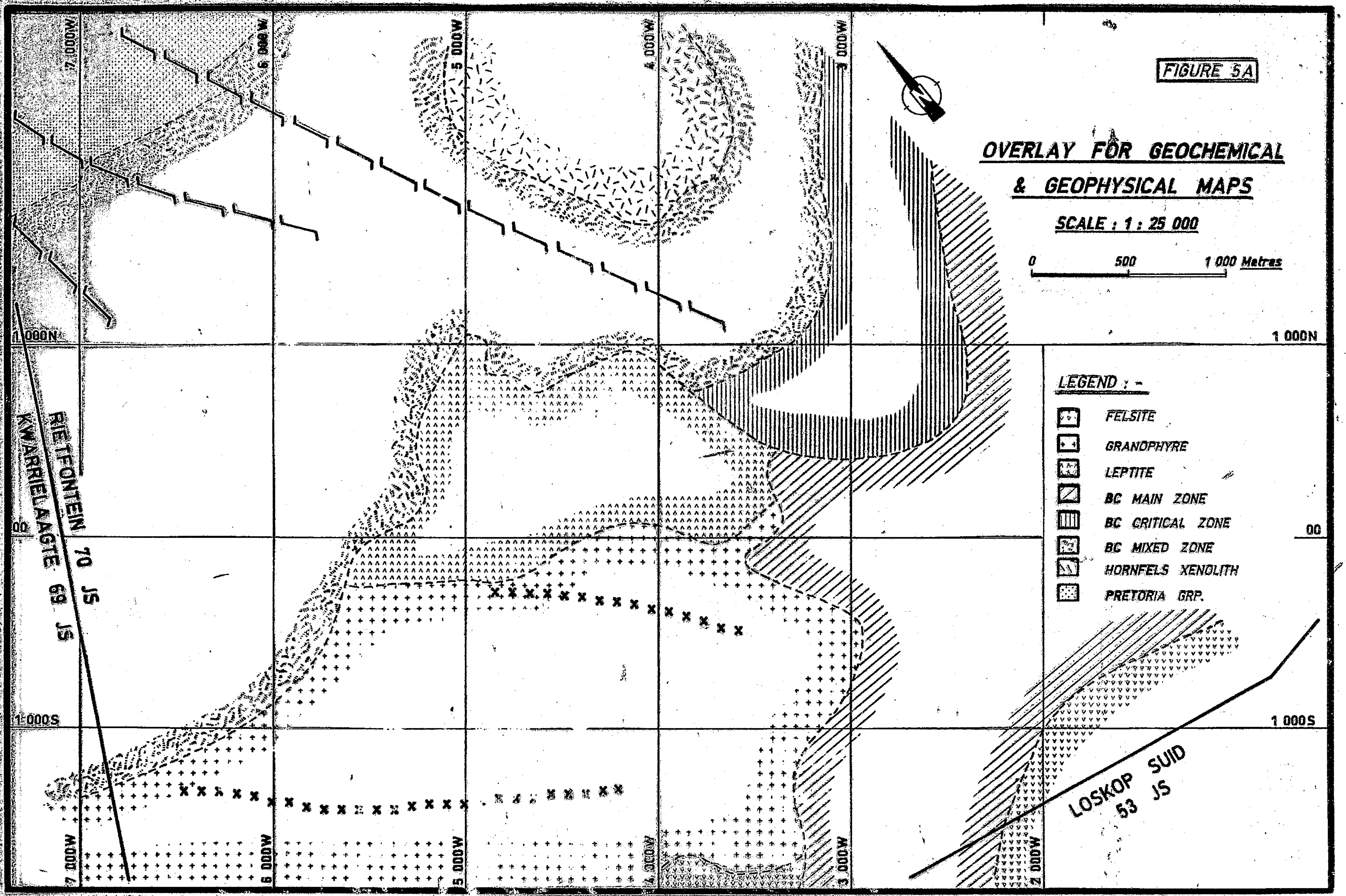
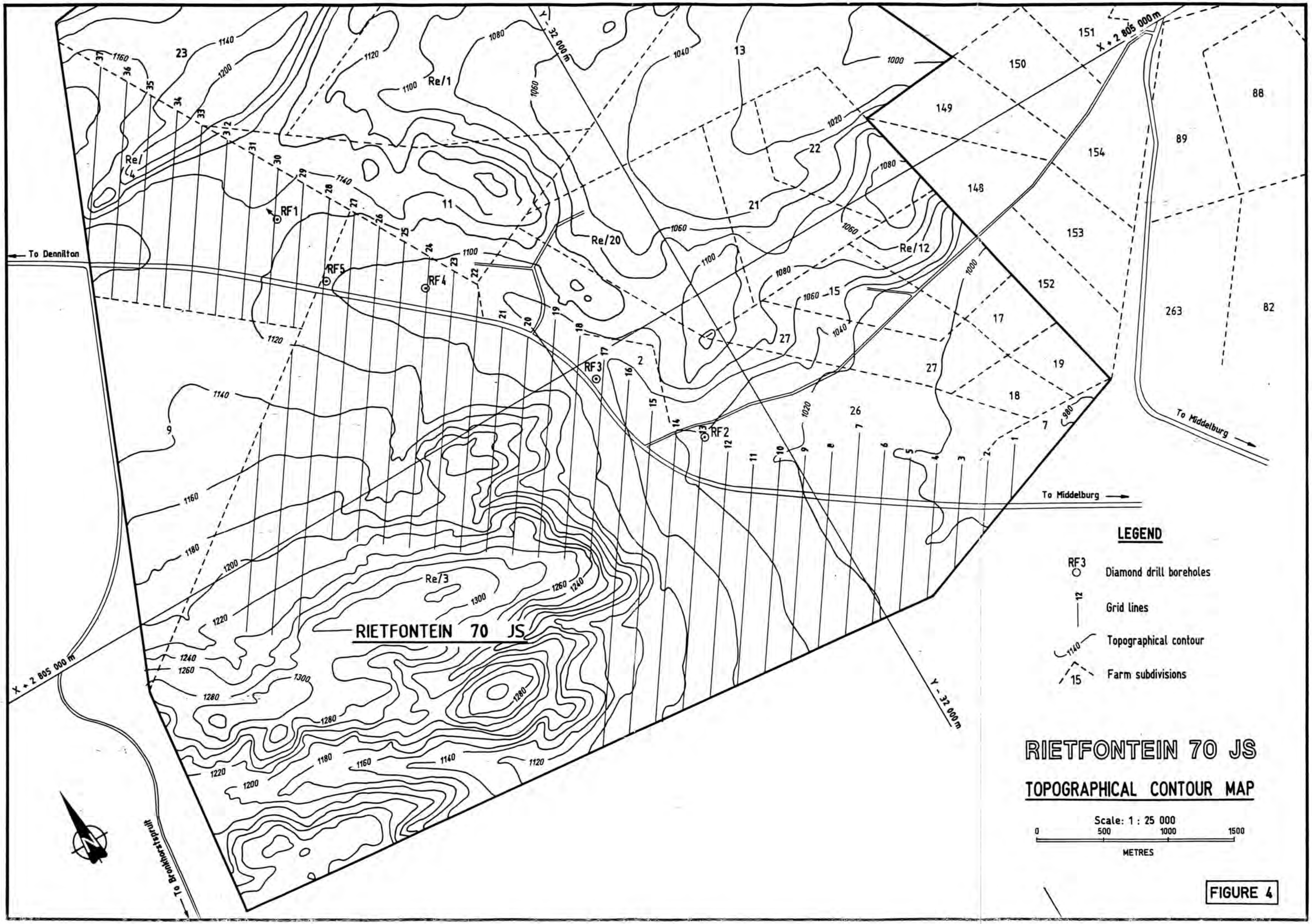


FIGURE 5A
OVERLAY FOR GEOCHEMICAL
& GEOPHYSICAL MAPS
SCALE : 1 : 25 000
0
500
1 000 Metres
LEGEND : -
FELSITE
GRANOPHYRE
LEPTITE
BC MAIN ZONE
BC CRITICAL ZONE
BC MIXED ZONE
HORNFELS XENOLITH
PRETORIA GRP.
RIETFONTEIN 70 JS
KWARRIELAAGTE 69 JS
LOSKOP SUID
53 JS
7 000W
6 000W
5 000W
4 000W
3 000W
2 000W
1 000N
00
1 000S



To Dennilton
To Middelburg
To Middelburg
To Bronkhorstspruit
X + 2 805 000 m
X + 2 805 000 m
Y - 32 000 m
Y - 32 000 m
RF1
RF2
RF3
RF4
RF5
Re/1
Re/3
Re/4
Re/12
Re/20
RIETFONTEIN 70 JS
LEGEND
Diamond drill boreholes
Grid lines
Topographical contour
Farm subdivisions
RIETFONTEIN 70 JS
TOPOGRAPHICAL CONTOUR MAP
Scale: 1 : 25 000
0
500
1000
1500
METRES
FIGURE 4

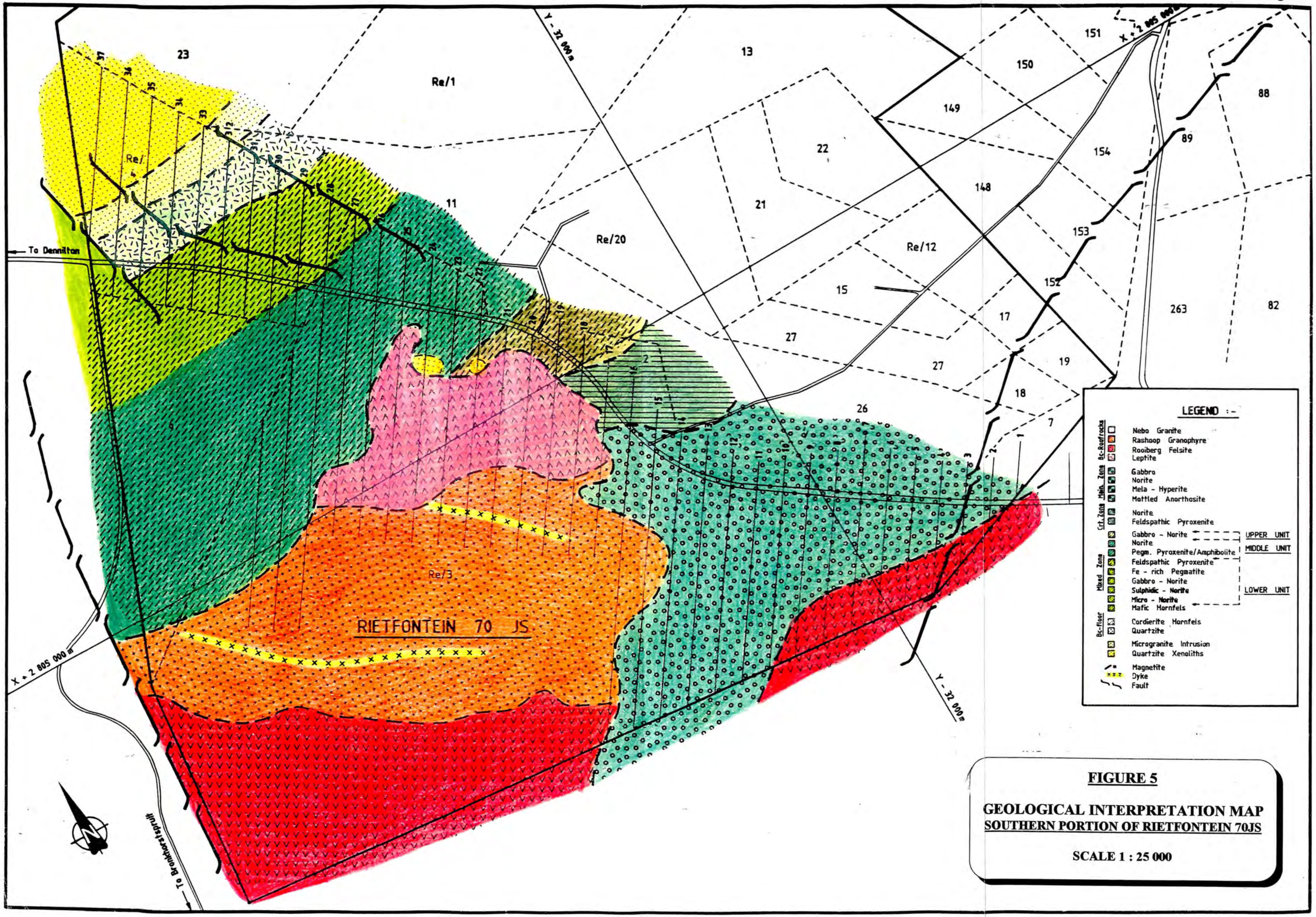


FIGURE 5

GEOLOGICAL INTERPRETATION MAP
SOUTHERN PORTION OF RIETFONTEIN 70JS

SCALE 1 : 25 000

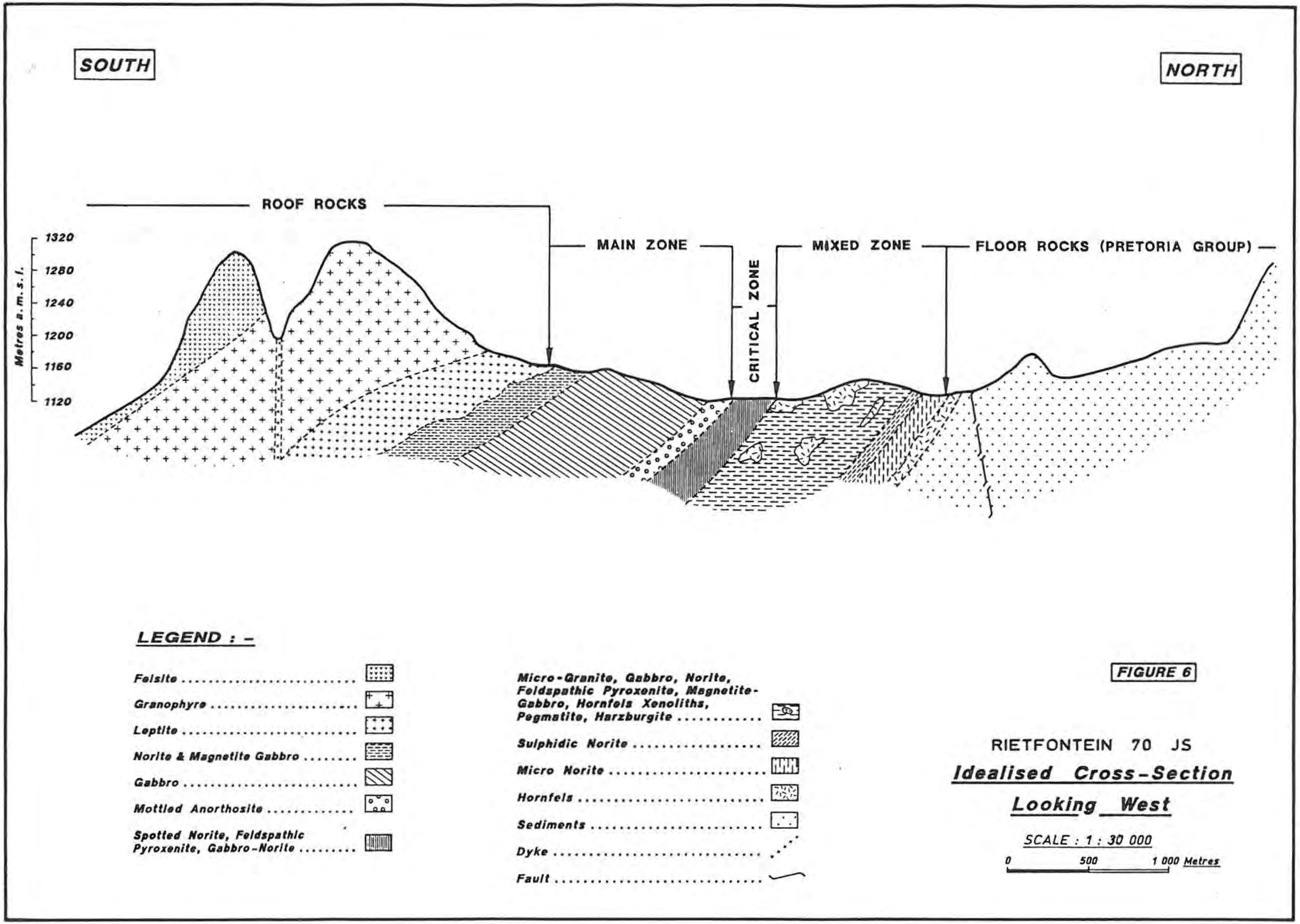


FIGURE 6

RIETFONTEIN 70 JS

Idealised Cross-Section

Looking West

4. STRUCTURAL SETTING

The southern portion of the farm Rietfontein 70JS is traversed by a number of minor near north - south trending faults, besides the NE - SW trending Bapsfontein Fault near the eastern boundary of the farm. It is highly likely that the Bapsfontein Fault is the southern extension of the Steelpoort Fault.

On a more regional scale , there are four major fault zones that are arranged in more or less a rectangular manner. The Steelpoort-, Laersdrift-, Sekhukhune- and Wonderkop Faults appears to be dipping in towards the centre of this rectangle, thus causing the areas outside of this rectangle to be elevated above the inside block. The Kwagga-Mamelodi Lineament (KML) traverses the downthrown block in a 078° direction (figures 23, 32 & 33). This lineament display affinity with a steep-dipping normal fault over the BC roof-rocks to the northeast of Rietfontein 70JS. The Dennilton Dome north of Rietfontein represents an open anticline plunging to the southeast (160°).

From large scale (1:500 000, 1:1 000 000) total magnetic field and Landsat images, it is quite clear that the Kwagga-Mamelodi Lineament extends all the way from the Indian Ocean into the west coast of Namibia, thus constituting a major cross-continent, deep-seated structural component, that is associated with numerous mineral occurrences (especially in the vicinity of the Bushveld Complex granites). The latter mineral occurrences will be discussed at a later stage in this dissertation.

At the intersection point of the KML with the Laersdrift fault (figure 23) it can be seen that the KML is in actual fact displaced by the Laersdrift fault. The southernmost splay of the KML is present in the vicinity of the northern boundary of Rietfontein 70JS (figure 23), but does not seem to have any structural influence on the immediate lithologies.

Clubley-Armstrong (1977) determined that two main joint systems exist within the study area, namely a master joint system (104°) which corresponds to the Laersdrift Fault direction (115°) and a minor joint system (042°) which is virtually the same as the Steelpoort Fault direction (037°). It becomes therefore quite clear that The Steelpoort Fault and the 042° (minor joint system) direction can be correlated with a post-BC-mafic phase / pre-BC-granite age bracket. These two main joint directions, incidentally, match the Vryburg Arch (Laersdrift Fault, 104°) and the Great Dyke direction (Steelpoort Fault, 042°). Clubley-Armstrong and Sharpe (1979) argued that the Dennilton Dome originated as a result of interference of two fold phases and also that block faulting implies that doming persisted after the intrusion of the Rustenburg Layered Suite.

Sharpe and Chadwick (1982) furthermore state that the latter folding events and associated principal stress directions indicate a genetic link between regional joint stresses and dome formation, where the Dennilton Dome is believed to have grown from a pre-existing positive feature in the floor or its basement.

A number of small scale faults with limited displacement are present near the western boundary of Rietfontein, close to where the mafics terminated against the granites (figure 5). These relatively small, localised faults are near north-south trending, and the ineffectual displacement of mainly the Transvaal Sequence rocks can be seen on figure 5.

Other lineaments that conform to the Laersdrift Fault direction, as previously discussed can be observed (figure 23) extending towards Botswana from the study area, and forms part of the so-called "Botswana Dyke Swarm".

All the joints on Rietfontein are steep-dipping or vertical, and all the joint systems discussed here are well developed on the latter farm (especially in the felsites). Although other directions are also exposed, they (minor joint directions) can most probably be attributed to the cooling of magma and consequent contraction, thus contraction-joints. These contraction-joints are, nevertheless, not as prominent as the two main joint directions (104°, 042°) Clubley-Armstrong (op.cit.).

5. GEOCHEMISTRY

5.1 SOIL AND HARDROCK GEOCHEMICAL STUDIES

A grid system of 200m x 50m (baseline = 7,5km) was established on the southern portion of Rietfontein 70JS (figure 4), and was soil sampled which resulted in 1308 soil samples being collected. All soil samples were screened by means of a -80# mesh fraction sieve and were submitted for copper (Cu), nickel (Ni), chromium (Cr), cobalt (Co), titanium (TiO_2) and vanadium (V) analysis. The results of these soils were contoured for each individual element and are depicted in figures 7 to 17. Background values for the different elements were calculated by statistical methods. The contour intervals were determined by using multiples of the relevant threshold values.

Threshold values were ascertained by means of histograms and by the equation ;

$$T/H = \tilde{a} + 2\left(\sqrt{\frac{\Sigma (a - \tilde{a})^2}{n - 1}}\right)$$

,where all results were treated as a single population of values with a symmetrical distribution. (a = actual assay value, **ã** = mean, **n** = number of observations). To determine the class intervals (ψ) for the frequency histograms the formula

$$\psi = (A - B) / K$$

was utilised, where A is the highest value in the data range, **B** the lowest value, and **K** is a constant determined by **K = 1+1,33 logN**.

These calculations were merely done to obtain useful background values for each element, and the background values are presented in table 1.

ELEMENT	*BACKGROUND VALUE*
COPPER	**50 p.p.m.**
NICKEL	**47 p.p.m.**
COBALT	**26 p.p.m.**
CHROMIUM	**147 p.p.m.**
TITANIUM	**1,17 %**
VANADIUM	**116 p.p.m.**

Table 1. Calculated background values for various elements in -80# soils.

With the exception of gold, platinum, palladium and rhodium, all elements were determined by the X-ray fluorescence method. The ETA analytical technique was used to assay for PGE's + Au at p.p.b. level, with a lower detection limit of 10 p.p.b.

The highest of the values of the different elements in soils are summarised in table 2 below;

COPPER	NICKEL	COBALT	CHROMIUM	TITANIUM	VANADIUM
696 ppm	1155 ppm	558 ppm	2748 ppm	5,04 %	770 ppm
389 ppm	305 ppm	111 ppm	1324 ppm	4,58 %	727 ppm
328 ppm	304 ppm	88 ppm	1276 ppm	4,32 %	641 ppm

Table 2. Highest values for elements encountered in grid soils.

Two streams near the southern boundary of Rietfontein 70JS, predominantly overlain by Rooiberg felsites and Rashoop granophyres were subjected to a stream sediment sampling survey. A total of 84 samples were collected during this program and subsequently analysed for Cu, Ni, Cr, Co, TiO_2 and V. Results of the stream sediment samples indicated an area of slightly anomalous copper which seem to be associated with a mafic dyke. The Cu values over the relatively anomalous area ranged from 112 to 278 p.p.m.Cu. This dyke was also clearly identified on the LANDSAT (bands 731) image.

In order to facilitate mapping and interpretation studies, 179 hardrock samples of different lithologies were collected and assayed for Cu, Ni, Cr, TiO_2, V and PGE+Au. Relatively anomalous Cr, Ni and PGE+Au are associated with essentially the norites of the Critical Zone and the pegmatites of the Mixed Zone Middle Unit. The highest hardrock assay results (including Pt-Pd ratios for selected samples) and associated lithologies are given in table 3 . Half core samples from the five boreholes were submitted for analysis of Cu, Ni, Cr, TiO_2, V, Co (RF4 & RF5), S^{-2} (sulphide sulphur for selected RF5 samples only) and PGE+Au (RF5 and selected samples from RF1 & RF2). PGE+Au denotes three (Pt, Pd, Rh) platinum group elements and gold in all cases.

SAMPLE NUMBER	PGE+Au ppb	Cu ppm	Ni ppm	Cr ppm	Pt ppb	Pd ppb	ROCKTYPE
1113	125	41	497	1325	90	35	Norite, Critical Zone
1116	270	233	631	1161	200	40	Norite, Critical Zone
201	10	477	126	315	-	-	Hornfels
205	10	75	455	1453	-	-	Gabbro-norite, Mixed Zone (lower unit)
211	40	165	502	269	-	-	Gabbro-norite, Mixed Zone (lower unit)
229	10	19	295	919	-	-	Sulphidic norite, Mixed Zone (lower unit)
316	10	98	53	720	-	-	Magnetite, Mixed Zone (middle unit)
320	185	13	296	170	185	-	Pegmatite, Mixed Zone (middle unit)
321	10	5	296	867	-	-	Norite, Mixed Zone (middle unit)
322	10	14	732	2028	-	-	Pegmatite, Mixed Zone (middle unit)
325	255	61	286	134	150	90	Pegmatite, Mixed Zone (middle unit)
330	20	119	253	542	-	-	Norite, Mixed Zone (middle unit)
332	210	325	515	1215	200	10	Norite, Mixed Zone (middle unit)
340	55	1125	168	59	-	-	Hornfels
349	10	386	5	75	-	-	Leptite
356	105	36	98	98	30	75	Norite, Critical Zone
357	430	50	84	97	50	380	Norite, Critical Zone
373	60	37	284	695	40	20	Norite, Critical Zone
374	10	50	689	2307	-	-	Norite, Critical Zone
375	100	9	270	477	60	40	Norite, Critical Zone
377	10	39	200	662	-	-	Norite, Critical Zone
381	10	58	400	1027	-	-	Norite, Critical Zone

Table 3. Highest assay values in hardrock samples

Again, the most anomalous values of the different elements that were reported for the boreholes (RF1 - RF5) are summarised in tables 4 to 8. Complete bar graphs depicting the geochemical content of each individual element for the various boreholes are presented in appendix B, C, D, F, G, H, J, K, L, N, O, P, R, S and T.

DEPTH meter	WIDTH mm	Cu ppm	Ni ppm	Cr ppm	TiO_2 %	V ppm	PGE ppb	Pt ppb	Pd ppb	ASSOCIATED LITHOTYPE
52,91	400	2845	818	8906	5,28	2763	395	210	150	Pyroxenite + sulphides
72,00	740	2211	552	127	0,41	225	190	100	75	Norite + sulphides
51,82	580	1556	643	845	1,61	766	210	120	75	Gabbro + sulphides
59,63	200	1214	427	2780	3,55	1508	225	160	50	Magnetite layer
55,88	390	583	1065	809	0,50	408	270	115	115	Pyroxenite + sulphides
51,10	720	590	993	800	1,33	584	60	20	25	Pyroxenite + sulphides
44,10	1530	597	607	6002	4,22	2264	200	110	90	Fe - Gabbro
42,09	250	398	292	1007	8,07	4922	20	10	10	Fe - Gabbro
42,69	290	346	281	1443	6,93	4006	165	130	35	Fe - Gabbro
37,53	1220	233	206	537	5,77	2794	<10	<10	<10	Fe - Gabbro
40,31	980	326	211	539	5,22	2588	35	20	15	Fe - Gabbro

Table 4. Highest values in borehole RF1 core samples.

DEPTH meter	WIDTH mm	Cu ppm	Ni ppm	Cr ppm	TiO_2 %	V ppm	PGE ppb	Pt ppb	Pd ppb	ASSOCIATED LITHOTYPE
274,74	260	1438	1336	1236	0,17	94	1020	370	540	Pegmatite + sulphides
263,79	210	1028	918	809	0,16	71	1315	515	690	Norite
249,00	3000	29	462	5640	0,38	206	90	80	10	Harzburgite
254,00	1568	63	457	5369	0,28	160	415	220	180	Norite + Cr, sulphides
252,00	2000	83	576	4941	0,33	196	580	240	300	Harzburgite
246,00	3000	19	354	4846	0,35	186	25	25	0	Harzburgite
279,00	3000	237	490	5463	0,23	150	105	60	45	Feldsp.Pyroxenite + Cr
282,00	3000	214	446	3264	0,27	150	90	50	40	Pegm.Pyroxenite
266,50	500	698	816	446	0.2	62	645	215	365	Norite
255,68	320	60	314	1842	0,23	117	520	265	225	Norite + Cr, sulphides
270,00	3000	524	749	889	0,23	105	470	185	240	Pegm.Pyroxenite
256,00	1000	40	270	1124	0,26	99	455	210	230	Norite + Cr, sulphides
275,00	1000	568	576	366	0,13	46	365	135	205	Altered Norite
276,00	3000	200	442	1242	0,26	113	350	140	190	Norite

Table 5. Highest values in borehole RF2 core samples.

DEPTH meter	WIDTH mm	Cu ppm	Ni ppm	Cr ppm	TiO_2 %	V ppm	ASSOCIATED LITHOTYPE
149,23	980	30	1471	4258	0,22	102	Coarse-grained Olivine-pyroxenite
150,21	1200	26	1116	3397	0,22	93	Coarse-grained Olivine-pyroxenite + magnetite
153,30	1700	48	1081	3529	0,29	126	Harzburgite & Pegmatitic Pyroxenite
148,60	630	28	1060	3135	0,24	112	Fine-grained Feldspathic Pyroxenite
99,00	520	32	664	2898	0,23	125	Norite (medium-grained)
20,00	490	18	602	1791	0,34	125	Gabbro-Norite (weathered)

Table 6. Highest values in borehole RF3 core samples.

DEPTH meter	WIDTH mm	Cu ppm	Ni ppm	Cr ppm	TiO_2 %	V ppm	Co ppm	ASSOCIATED LITHOTYPE
269,00	1120	573	290	303	3,93	560	99	Magnetite-rich Felsp.Pyroxenite + sulphide
307,16	840	516	102	231	2,71	337	100	Magnetite-Gabbro + sulphides
308,00	900	441	119	143	2,18	233	92	Magnetite-Gabbro + sulphides
285,44	1560	68	571	4791	0,56	215	83	Medium-grained Feldspathic Pyroxenite
287,00	2000	83	573	4100	0,34	181	77	Feldspathic Pyroxenite + minor Cr
289,00	640	66	586	4430	0,30	192	80	Feldspathic Pyroxenite + minor Cr
290,80	1300	56	240	9300	1,81	404	59	Feldspathic Pyroxenite + Cr
188,47	1330	155	136	262	6,19	2066	80	Anorthosite
191,00	2600	140	17	166	6,19	956	110	Feldspathic Pyroxenite + diss.sulphides
275,20	720	80	22	600	7,68	839	96	Magnetite-rich Felsp.Pyroxenite + sulphide
292,10	660	96	31	965	9,44	1081	121	Magnetite-rich Feldspathic Pyroxenite + Cr
293,60	2400	57	5	603	8,01	879	94	Magnetite-Gabbro
296,00	3000	73	17	698	8,16	898	100	Magnetite-Gabbro
299,00	1000	141	19	596	7,71	774	88	Magnetite-Gabbro

Table 7. Highest values in borehole RF4 core samples.

DEPTH meter	WIDTH mm	Cu ppm	Ni ppm	Cr ppm	TiO_2 %	V ppm	Co ppm	PGE ppb	Pt ppb	Pd ppb	ASSOCIATED LITHOTYPE
331,62	200	4700	24	58	2,00	220	9	10	<10	<10	Magnetite-Gabbro
462,90	630	2492	774	130	0,45	180	70	2430	1270	800	Magnetite-Gabbro *
427,96	380	2200	618	132	0,52	243	58	2045	1050	720	Magnetite-Gabbro **
414,13	500	1978	662	223	0,33	206	72	1200	635	350	Pegmatite + coarse sulphides ***
413,50	630	1626	665	288	0,37	274	83	910	450	350	Pegmatite + coarse sulphides ****
467,41	330	1900	1162	3344	6,55	2800	153	1020	640	295	Magnetite-Gabbro
396,22	860	241	919	497	0,61	460	90	10	<10	<10	Fine-grained mafic intrusion
421,04	660	1500	788	1093	2,05	1016	116	1120	570	415	Harzburgite
412,50	300	1346	517	328	0,40	245	74	895	470	300	Pegmatite + coarse sulphides
470,27	450	1063	434	4458	5,08	2300	100	295	170	105	Magnetite-Gabbro + diss.sulphides
426,00	300	423	562	2379	2,74	1444	85	315	130	145	Fine-grained Pyroxenite
533,00	1000	119	450	1884	0,53	232	73	10	<10	<10	Feldspathic Pyroxenite
676,88	1220	65	475	1876	0,54	300	73	10	<10	<10	Feldspathic Pyroxenite
426,30	200	666	427	1589	3,45	1503	87	935	435	425	Fine-grained Pyroxenite
426,50	400	677	623	1476	0,37	213	93	445	225	160	Fine-grained Pyroxenite
411,20	1300	130	540	1333	0,29	187	81	100	55	30	Pyroxenite + diss.sulphides
409,00	1460	499	581	1239	0,49	194	72	255	145	75	Pyroxenite + diss.sulphides
640,00	1500	717	499	1216	8,34	3600	145	10	<10	<10	Magnetite-rich zone + sulphides
476,02	780	1062	502	1137	7,78	3800	144	40	20	20	Magnetite-Gabbro
334,70	770	215	151	-	7,05	3100	64	10	<10	<10	Magnetite-Gabbro
361,02	980	218	252	29	6,38	2400	110	10	<10	<10	Magnetite-Gabbro
91,48	520	1100	418	170	6,32	2500	130	10	<10	<10	Magnetite-Gabbro
110,14	980	1073	392	292	6,34	2700	132	10	<10	<10	Magnetite-Gabbro
669,78	750	226	256	561	6,30	2400	106	10	<10	<10	Magnetite-Gabbro
357,56	880	236	71	48	1,83	8789	44	10	<10	<10	Magnetite-Gabbro

[(*340ppb Au, 1,40% S^{-2}) (**260ppb Au, 0,03% S^{-2}) (***215ppb Au, 0,55% S^{-2}) (****110ppb Au, 0,44% S^{-2})]

Table 8. Highest values in borehole RF5 core samples.

5.1.1 Copper

The broad background levels of copper in unmineralised mafic rocktypes (Levinson, 1980) are quoted as 100 p.p.m.Cu, and for sedimentary rocktypes 10 p.p.m.Cu (sandstone) and 50 p.p.m.Cu (shale). As far as soils are concerned, an average background range of 2 to 100 p.p.m.Cu is given, which conforms to the calculated background value of 50 p.p.m.Cu for Rietfontein.

In the secondary environment copper is an extremely mobile element in oxidising, acidic conditions, but its mobility reduces rapidly as more alkaline conditions predominate. It is therefore imperative that the mobility of Cu in the secondary environment is kept in mind when assessing the dispersion patterns of the soil anomalies on Rietfontein 70JS. It is evident that the highest values that were encountered in soils (696, 389 p.p.m.Cu) are several orders of magnitude greater than the background value 50 p.p.m.Cu and is thus highly anomalous.

Bearing the moderately undulating topography (figure 4) and near neutral soil conditions on Rietfontein in mind, it can be seen that the Cu anomalies correspond well with the elevated Ni and Cr values in soils, and can be attributed to the sulphide mineralization (mostly disseminated chalcopyrite and pyrrhotite) within the ultramafic lithologies (harzburgites, pyroxenites) and the iron-rich gabbros of the Mixed Zone (refer to figures 7, 28 and 29).

5.1.2 Nickel

On a global scale, the average background values for nickel in igneous rocks are 75 p.p.m.Ni (with average Ni values of 0.5 p.p.m. for the felsic component and 150 p.p.m. for the mafics) and for sedimentary rocktypes are between 2 p.p.m.Ni (sandstone) and 70 p.p.m.Ni (shale), with an intermediate value for limestones (12 p.p.m.Ni). Levinson (op.cit) does, however, allocate an average value of 50 - 200 p.p.m.Ni to a black shale scenario. As a general rule of thumb within the Bushveld Complex scenario, ranges of 200 - 400 p.p.m.Ni for the mafic units (e.g. norites), 400 - 800 p.p.m.Ni for the ultramafic portions (e.g. pyroxenites) and > 800 p.p.m.Ni for the olivine-rich rocks can be accepted.

According to whole rock analysis of certain units intersected in boreholes RF1 to RF5 (table 10), the nickel values conformed rather well to the latter rule of thumb, except for the harzburgitic units in borehole RF2 that could possibly fit better into the range proposed for olivine-poor ultramafics. The exceptionally high assay values that were encountered for the magnetite-gabbro units in borehole RF5 can possibly be attributed to nickel contained in sulphides.

In the secondary environment, nickel is considered as an immobile element in reducing hydrogen sulphide environments and under alkaline conditions. Under more oxidising, acidic conditions, Ni will behave slightly less mobile than Cu. The anomalous Ni values encountered on Rietfontein can thus be expected to be in close proximity to the source of the anomaly. The relatively high inherent Ni content of the ultramafic lithologies (e.g. harzburgite) due to the silicate Ni in the lattice, must also be brought into account when interpreting the dispersion pattern of Ni. The abundance of Ni in olivine is approximately two orders of magnitude more than the Ni content of pyroxenes. Nickel is therefore an extremely useful element to demarcate the olivine-rich units (olivine-pyroxenites, harzburgites, dunites) of the Lower- and Critical Zone of the Bushveld Complex.

The more primitive magmas in the lower parts of intrusions such as the Bushveld Complex possesses a higher forsterite (Fo) content than the evolved magmas at higher levels in the succession. The position of the low-Ni, olivine-rich rocktypes can thus be determined, which may be indicative of a nickel sulphide orebody. The high Fo-olivines are more susceptible to weathering, with the subsequent formation of magnesite ($MgCO_3$) and the possible contemporaneous release of Ni.

The highest Ni values in the soils on Rietfontein are in the order of 305 p.p.m., with minor highly anomalous values (1155 p.p.m.Ni) over some of the apparently mineralized areas, where the Ni anomalies occur in close association with Cu and Cr (figures 8, 28). Since Ni is one of the principal pathfinder elements for PGE's, it is considered to form an integral part of this survey.

5.1.3 Chromium

Chromium can be used as a tool to ascertain the modal abundance of pyroxene, and also the degree of fractionation of the parent liquid of the pyroxenes in a chromite-free environment. This parent liquid becomes progressively depleted in Cr, as a result of the highly compatible nature of Cr for pyroxene, and to a lesser extent olivine. The margins of a fresh magma pulse, as well as the mixing of primitive and evolved magmas can be ascertained by means of inverse Cr values, provided the inversion is not the result of modal/lithological variations.

The assemblage of the pyroxenes is dependant on variables such as Na- and Mg content of the magma and the temperature, and the presence of clino-pyroxene may indicate the non-deposition of economic chromium due to the relatively high Cr_2O_3 in the clino-pyroxene lattice. The latter condition does, however, not necessarily indicate that the presence of ortho-pyroxene signifies the existence of viable Cr.

In a number of cases visible chromite was observed in the core of certain boreholes viz. RF2 at a depth of 254m and 281m (appendix E, pg.3) and RF4 at 286m and 291m (appendix M, pg.3). In all of these cases, elevated Cr assay values clearly corresponded with these depths (appendix F, pg.2 and appendix N, pg.3). The exact Cr assay values for boreholes RF1 to RF5 are presented in tables 4 to 8, where it can clearly be seen that the Cr values are highly anomalous.

Although it is possible that in the absence of chromite, chromium can substitute in magnetite, it appears that a closer association with the pyroxenes is evident. The anomalous Cr levels can consistently be related to the pyroxenitic and harzburgitic units of essentially the Mixed- and Critical Zones on Rietfontein 70JS, where the actual Cr values are in the order of 3000 to 9300 p.p.m.Cr. There are, however, isolated cases (associated with the Mixed Zone) where magnetite-bearing units are responsible for anomalous Cr values.

In the secondary environment chromium occurs as remarkably stable, detrital chromite grains, which display the tendency to concentrate in the heavy fraction of soils and sediments. Levinson (1980) quote the average background levels for Cr in soils as 50 p.p.m.Cr, but which can fluctuate between 5 and 1000 p.p.m.Cr. On Rietfontein 70JS background values of 147 p.p.m.Cr in soils were calculated, with the highest values encountered being 1324 and 2748 p.p.m. Bearing in mind the mobility of Cr in the secondary environment, it can be seen in figure 9 (viewed in conjunction with figure 5) that the anomalous Cr values seem to effectively outline the pyroxenitic units of the Mixed Zone, as well as the Critical Zone lithologies south of the Loskop Dam-Dennilton tar road. This anomaly over the Critical Zone corresponds well with the anomalous signature displayed by nickel in soils (figure 8), but unfortunately the copper in soils could do not show any significant response over this area (figure 7).

Worst (1944) quotes a Cr_2O_3 content of 31,6 % for chromitites in supposedly Critical Zone rocktypes on the farm De Wagendrift to the east of Rietfontein 70JS.

5.1.4 Titanium and Vanadium

The elements titanium and vanadium can be used to establish fractionation trends for chemically more evolved rocktypes at higher stratigraphical levels in this layered intrusion. Rocktypes such as the titano-magnetite layers and magnetite-gabbro units that resort under the Bushveld Complex Upper Zone can thus be differentiated on grounds of, amongst other parameters, the titanium and vanadium trends and signatures.

For a normal Bushveld Complex situation, the TiO_2-content of the magnetite-bearing units gradually increases upwards in the Upper Zone succession, with an associated decrease in V_2O_5. Klemm et.al. (1985) provide compositional variations for the Upper Zone units, and distinguishes between massive magnetite layers and units containing disseminated magnetite. The massive magnetite layers clearly show distinct lower V_2O_5 values to that of the units with the disseminated magnetite. This phenomenon can be probably be ascribed to the massive magnetite layers that crystallise at a higher oxygen fugasity.

An average value of 135 p.p.m. vanadium is proposed (Levinson, 1980) for igneous rocks, where the more felsic lithotypes would have values in the order of 20 p.p.m.V and the mafics considerably higher at 250 p.p.m.V. An acceptable TiO_2 value for basic igneous rocks is quoted as 0,25% TiO_2. The magnetite-bearing rocktypes on Rietfontein 70JS display assay values of up to 9,44% TiO_2 and 8789 p.p.m.V, but according to XRF determinations, the average titanium and vanadium values for the magnetite-rich units are in the region of 6,63 % and 2724 p.p.m. respectively. Whole rock analysis of selected magnetite-bearing core samples determined TiO_2 and V, as well as certain important trace elements viz. Sc, Rb, Sr, Y and Zr values (refer to table 11).

Calculated background values for TiO_2 and V on Rietfontein 70JS are 1,17 % and 116 p.p.m. respectively, with the highest soil values in the order of 770 and 727 p.p.m.V and 5,04 % TiO_2. The vanadium and titanium (in soil) contour maps (figures 10, 11) clearly outline the magnetite-rich units of the Mixed Zone on the southern portion of the farm Rietfontein.

5.1.5 Cobalt

The average value for cobalt in soils is given as ranging between 1 and 40 p.p.m.Co (Levinson, 1980), where the calculated background value for the study area of 26 p.p.m.Co fits well into this field. Only the soils, stream sediment and boreholes RF4 and RF5 core samples on Rietfontein 70JS were assayed for cobalt. This was mainly due to the existence of a number of relatively small Co occurrences (i.e. Kruisrivier) in proximity to the study area. All of these occurrences are believed to be of hydrothermal origin. The cobalt mineralization that was discovered at Kruisrivier in 1868 occurs in a feldspathic quartzite of the Pretoria Group, in proximity (~ 1m) to a geological contact between these quartzites and a diabasic sill of Transvaal age. It is possible that the Steelpoort fault or one of its subsidiary splays was instrumental in the genesis of the mineralization (figure 32).

An anomalous dispersion halo covering essentially the entire Mixed Zone can be observed in figure 12. Although an isolated high value of 558 p.p.m.Co was encountered in the soils, it could not be repeated with follow-up sampling and drilling. The relatively elevated Co values quoted in tables 2, 7 and 8 can possibly be explained by the limited Co substitution of certain sulphides (Ni-bearing ?) and Fe-Mg silicates in the Mixed Zone lithotypes.

5.1.6 PGE's and Gold

For obvious reasons only selected borehole core and hard rock samples were analysed for PGE's and Au. The most encouraging PGE values are associated with the Critical Zone norites and the pegmatitic rocktypes of the Mixed Zone Middle Unit. Only three platinum group elements were assayed for viz. platinum (Pt), palladium (Pd) and rhodium (Rh), together with Au.

The highest PGE value encountered was 2430 p.p.b. total PGE (1270 p.p.b.Pt, 800 p.p.b.Pd, 340 p.p.b.Au) over a 630mm intersection of a pegmatitic, magnetite-gabbro in the Mixed Zone. This was, incidentally, also the best gold value that was intersected in any of the boreholes.

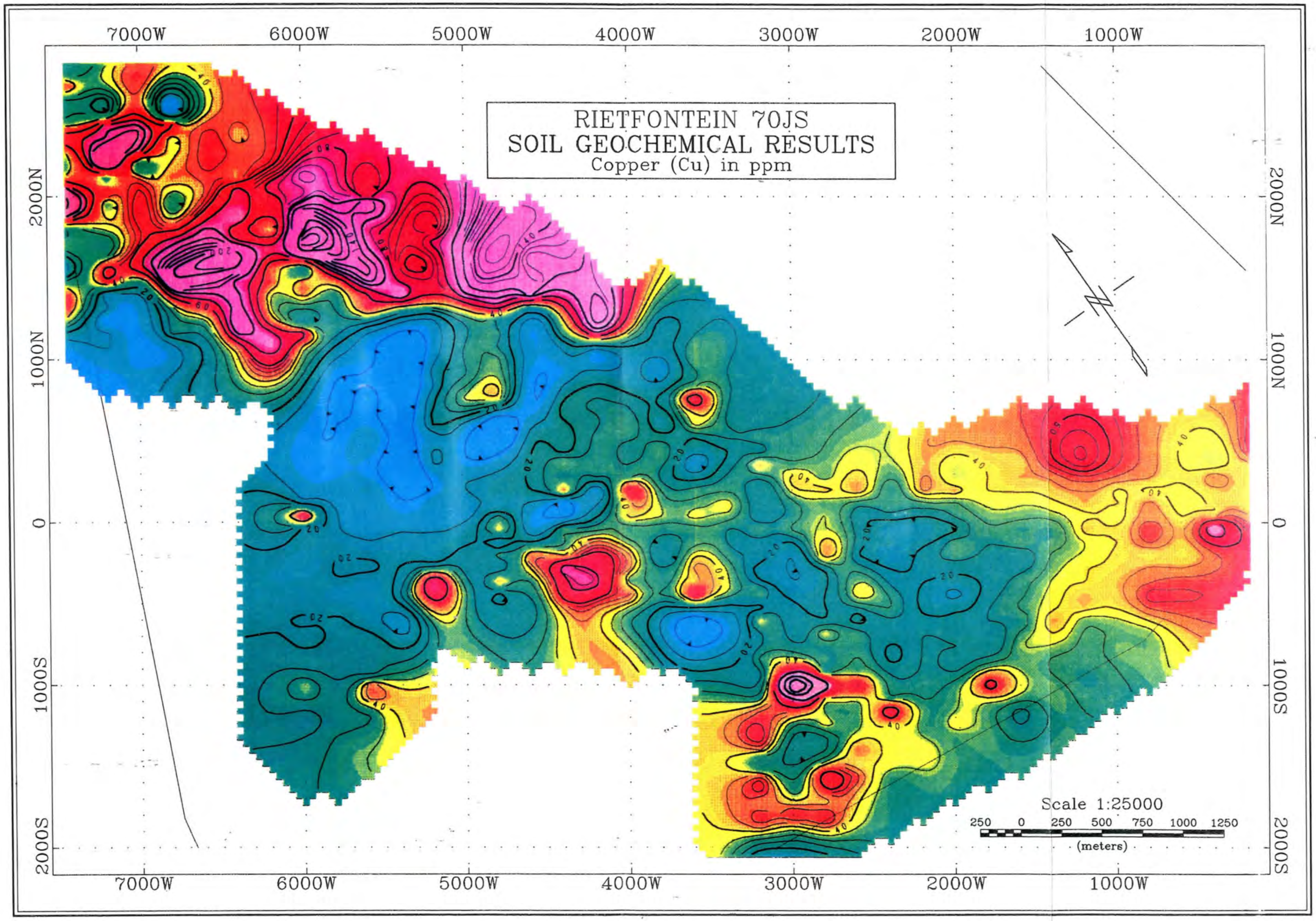

RIETFONTEIN 70JS
SOIL GEOCHEMICAL RESULTS
Copper (Cu) in ppm
7000W
6000W
5000W
4000W
3000W
2000W
1000W
2000N
1000N
0
1000S
2000S
Scale 1:25000
250 0 250 500 750 1000 1250
(meters)

FIGURE 7

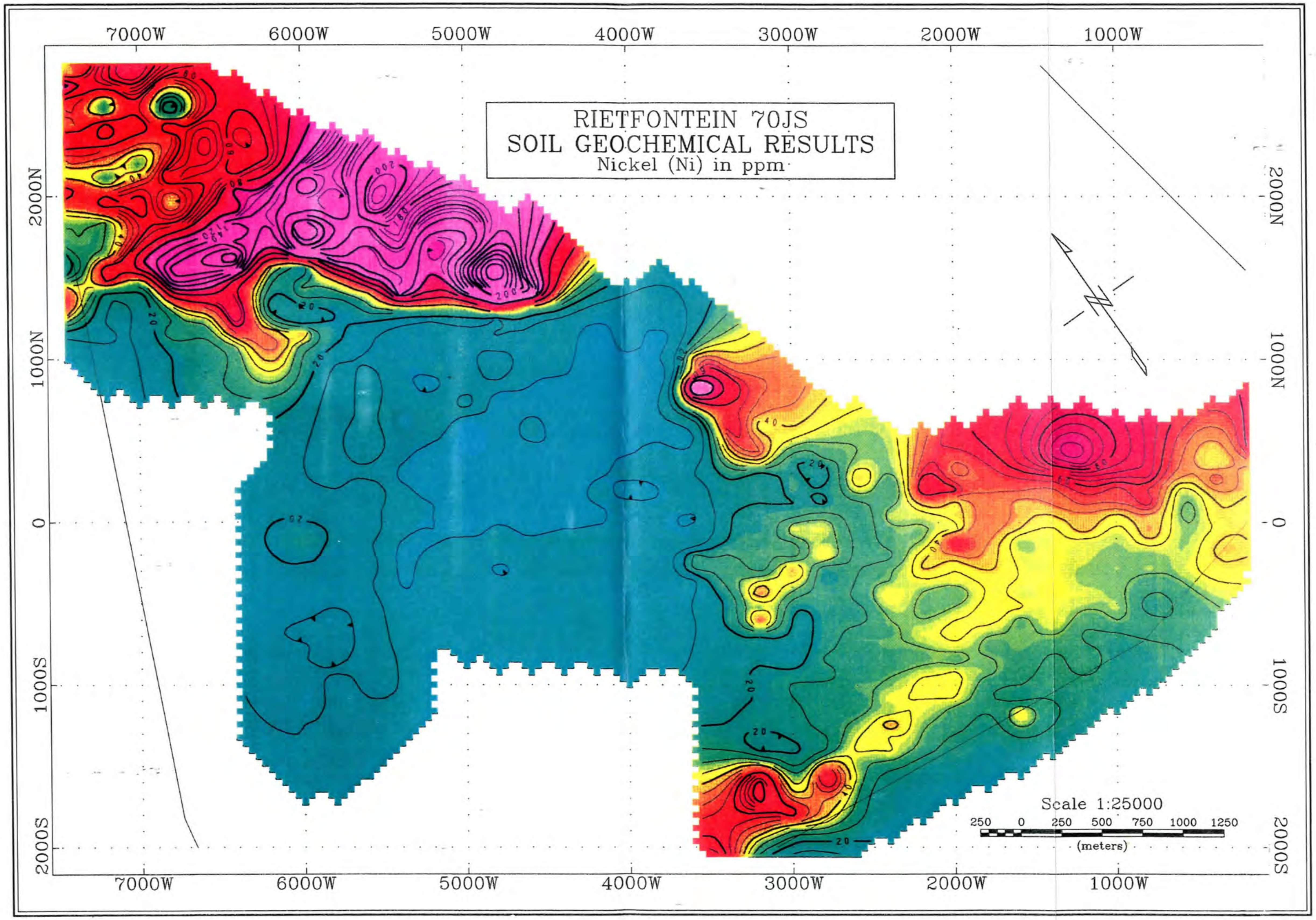

RIETFONTEIN 70JS
SOIL GEOCHEMICAL RESULTS
Nickel (Ni) in ppm
7000W
6000W
5000W
4000W
3000W
2000W
1000W
2000N
1000N
0
1000S
2000S
Scale 1:25000
250 0 250 500 750 1000 1250
(meters)

FIGURE 8

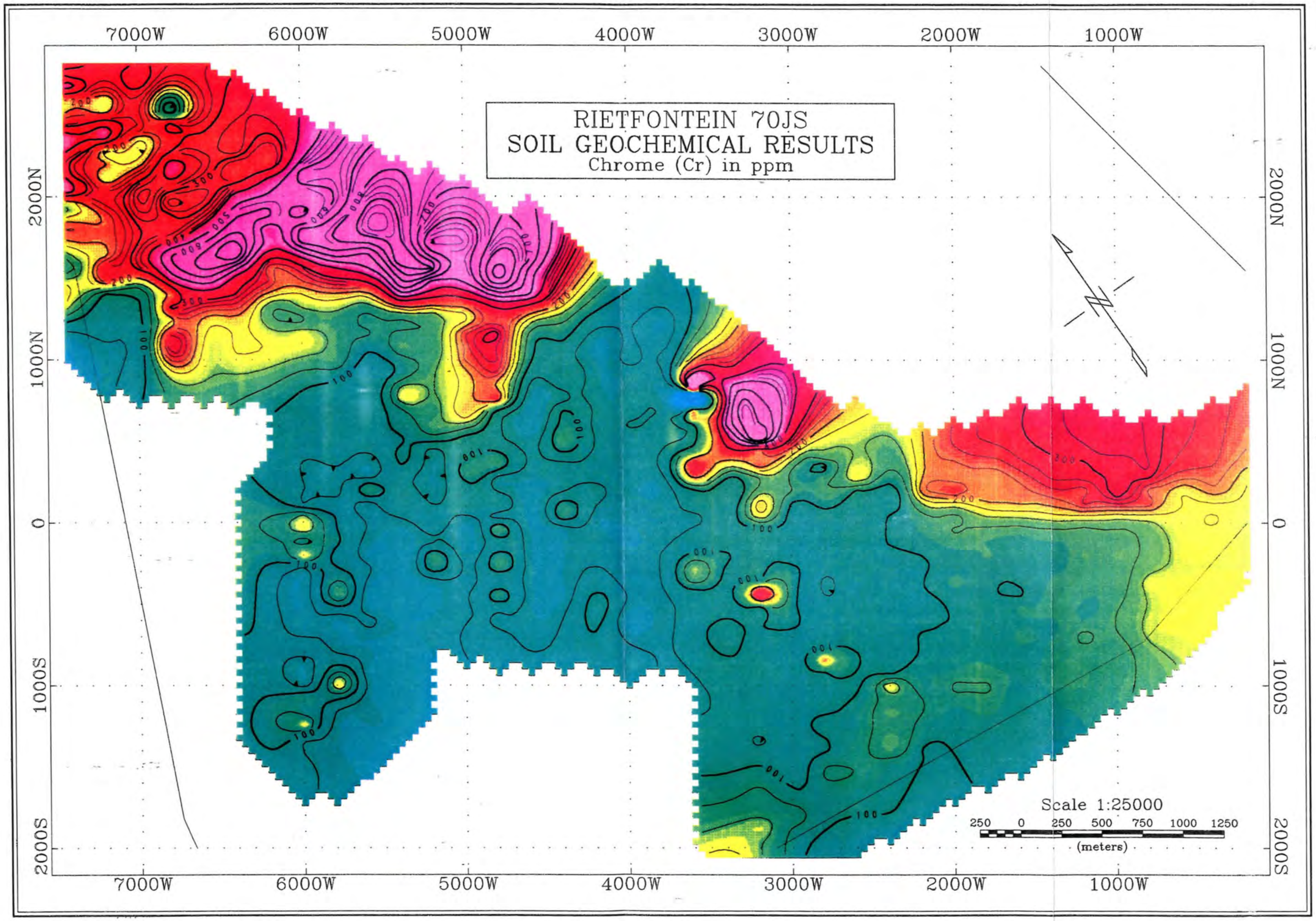

RIETFONTEIN 70JS
SOIL GEOCHEMICAL RESULTS
Chrome (Cr) in ppm
7000W
6000W
5000W
4000W
3000W
2000W
1000W
2000N
1000N
0
1000S
2000S
Scale 1:25000
250 0 250 500 750 1000 1250
(meters)

FIGURE 9

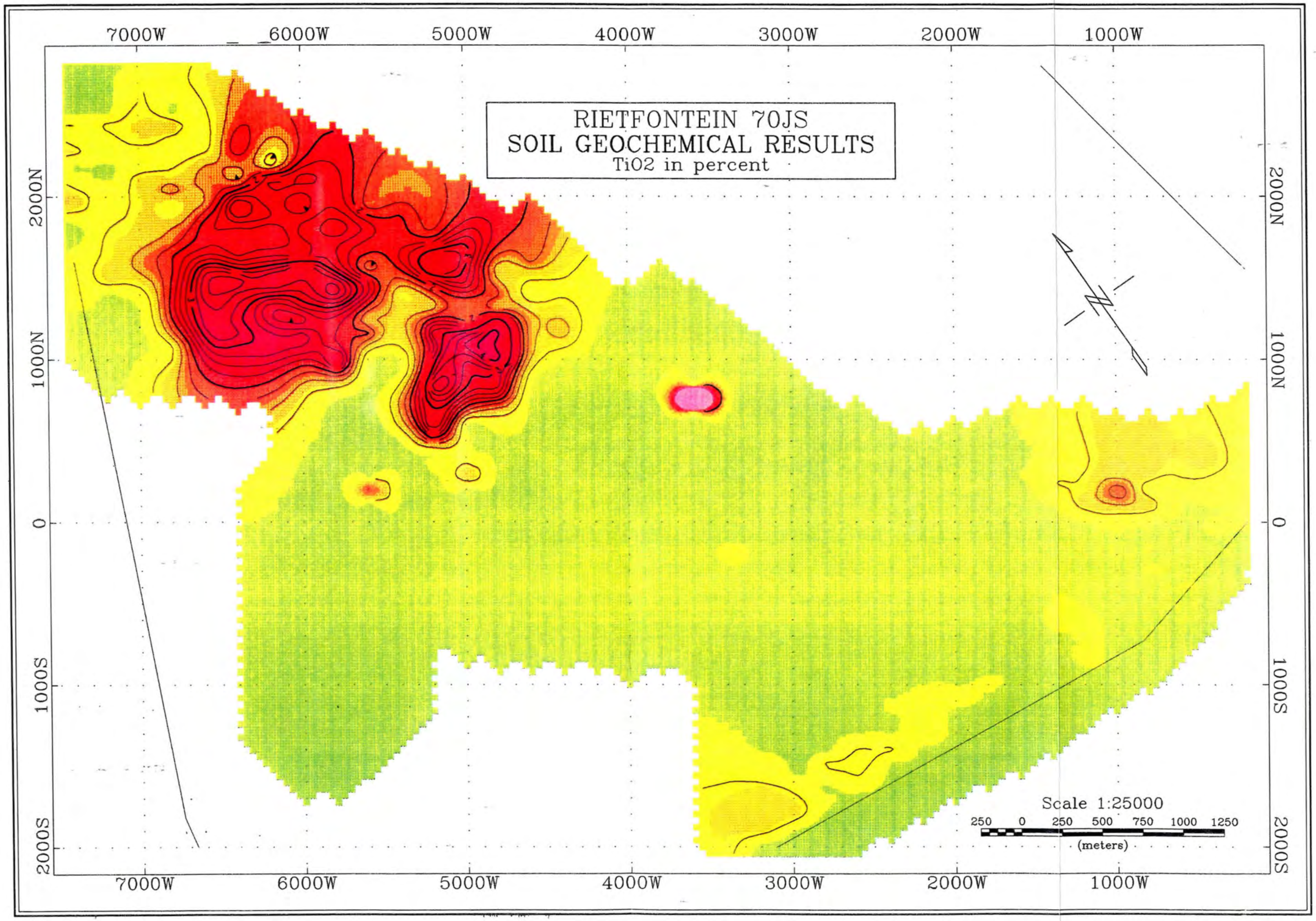

RIETFONTEIN 70JS
SOIL GEOCHEMICAL RESULTS
TiO2 in percent
7000W
6000W
5000W
4000W
3000W
2000W
1000W
2000N
1000N
0
1000S
2000S
Scale 1:25000
250 0 250 500 750 1000 1250
(meters)

FIGURE 10

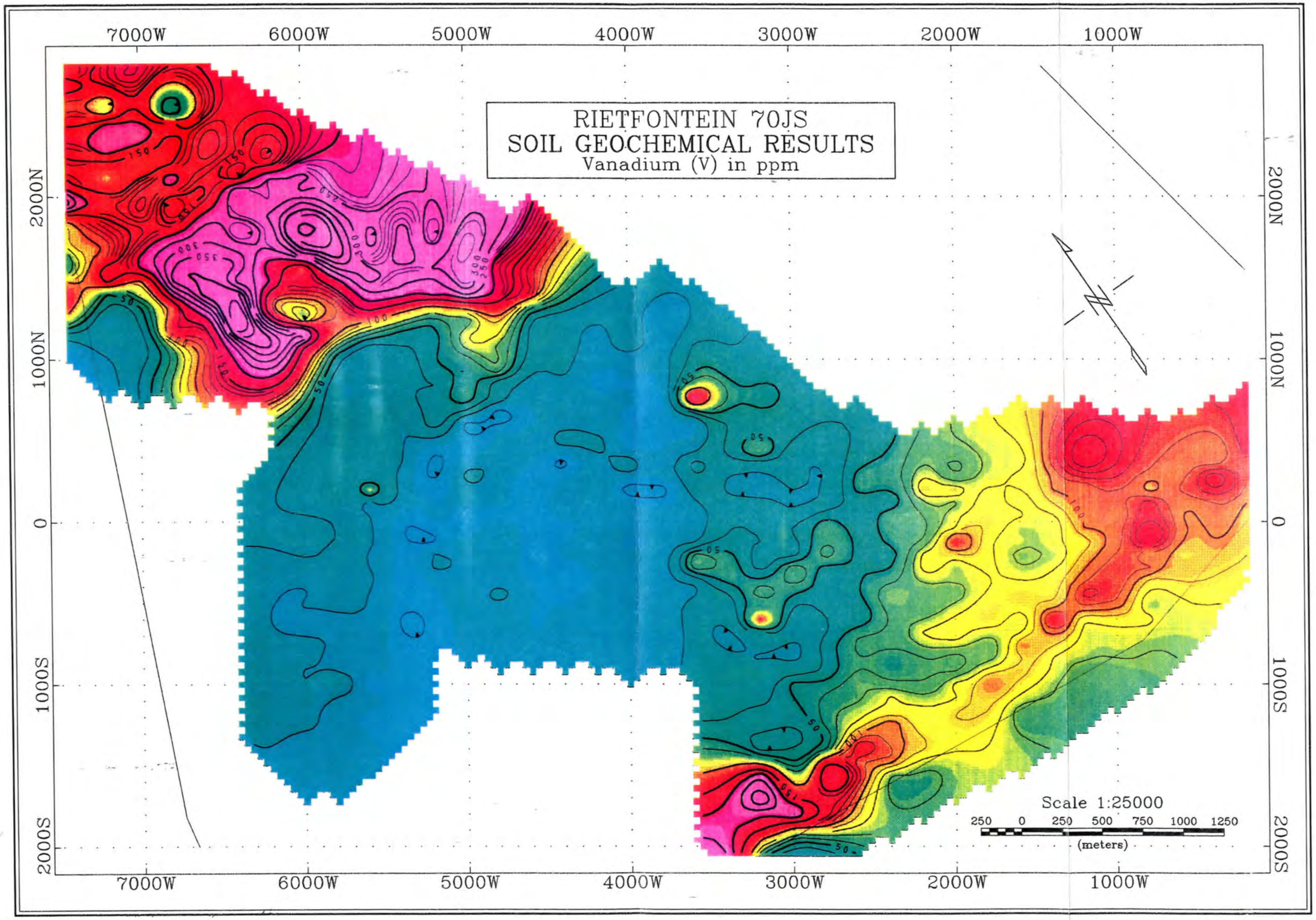

RIETFONTEIN 70JS
SOIL GEOCHEMICAL RESULTS
Vanadium (V) in ppm
7000W
6000W
5000W
4000W
3000W
2000W
1000W
2000N
1000N
0
1000S
2000S
Scale 1:25000
250 0 250 500 750 1000 1250
(meters)

FIGURE 11

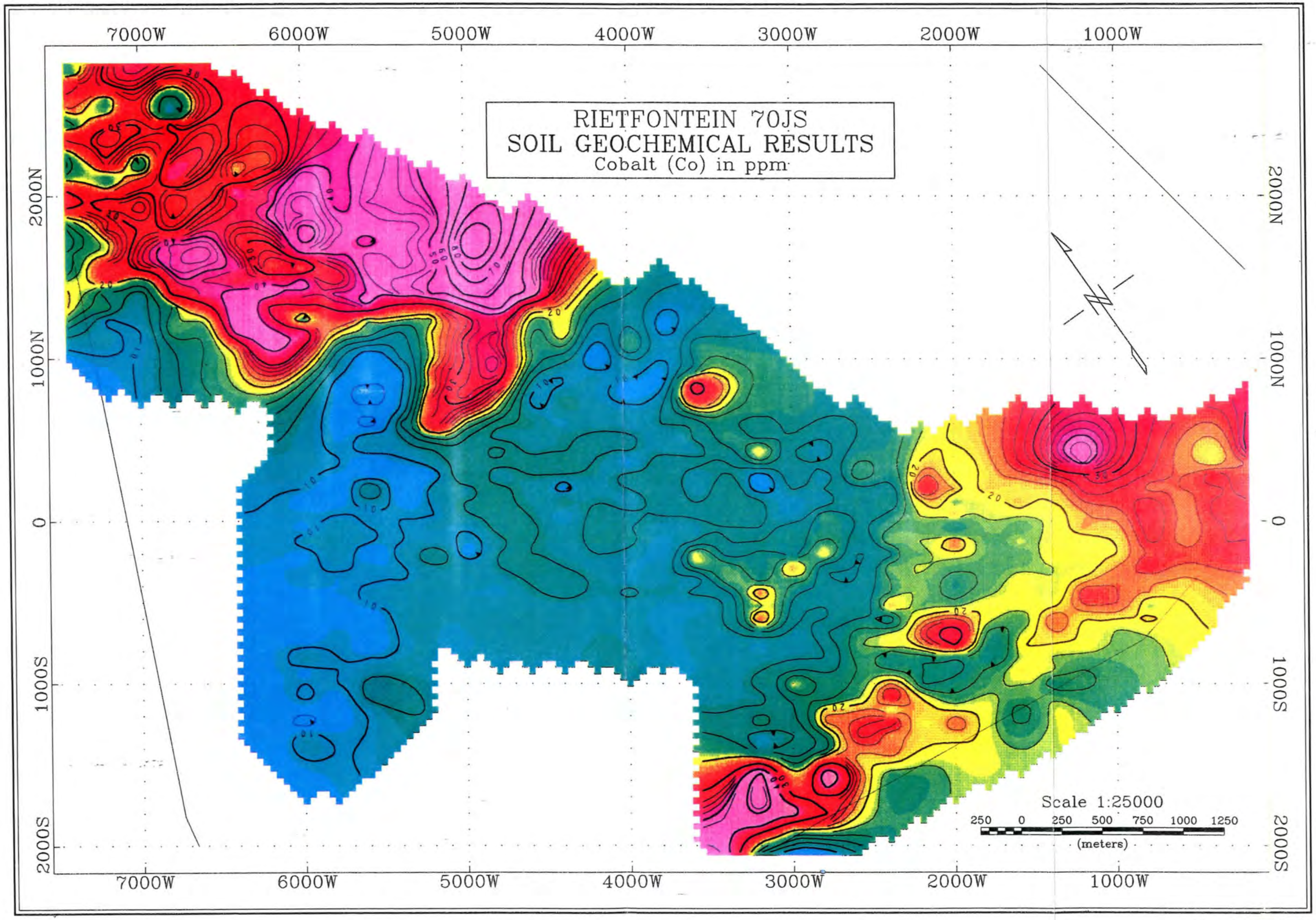

RIETFONTEIN 70JS
SOIL GEOCHEMICAL RESULTS
Cobalt (Co) in ppm
7000W
6000W
5000W
4000W
3000W
2000W
1000W
2000N
1000N
0
1000S
2000S
Scale 1:25000
250 0 250 500 750 1000 1250
(meters)

FIGURE 12

SAMPLE No.	SiO2 %	TiO2 %	Al2O3 %	Fe2O3 %	FeO %	MnO %	MgO %	CaO %	Na2O %	K2O %	P2O5 %	Cr2O3 %	NiO %	LIO %	H2O %	TOTAL %
RF1/38,48	34,265	5,561	13,183	32,130	0,000	0,229	3,725	7,188	1,370	0,916	0.016	0,000	0,000	0,185	0,190	98,958
RF1/54,44	48,693	0,627	3,927	18,706	0,000	0,293	13,073	13,748	0,486	0,172	0,024	0,000	0,000	0,164	0,249	100,161
RF1/61,65	50,376	0,387	14,935	12,007	0,000	0,209	7,075	10,891	2,043	0,860	0,026	0,000	0,000	1,081	0,224	100,115
RF2/35,44	53,530	0,374	18,570	7,734	0,000	0,132	5,220	10,647	2,461	0,640	0,055	0,000	0,000	0,603	0,204	100,170
RF2/43,75	53,090	0,312	22,995	4,050	0,000	0,069	2,558	10,341	3,092	1,321	0,069	0,000	0,000	1,554	0,215	99,665
RF2/110,55	52,519	0,317	18,834	7,531	0,000	0,130	5,825	10,472	2,282	0,645	0,049	0,000	0,000	1,142	0,204	99,951
RF2/128,60	53,224	0,330	22,079	4,122	0,000	0,073	3,358	11,034	3,368	0,918	0,057	0,000	0,000	1,229	0,249	100,040
RF2/246,41	50,310	0,247	11,216	11,353	0,000	0,159	15,168	5,930	0,655	0,337	0,014	0,000	0,000	3,253	0,340	98,983
RF2/260,24	52,085	0,216	7,425	11,939	0,000	0,201	18,801	6,010	0,509	0,131	0,012	0,000	0,000	2,189	0,388	99,906
RF2/268,97	49,701	0,147	21,735	5,654	0,000	0,106	7,354	11,042	1,776	0,698	0,014	0,000	0,000	1,341	310	99,878
RF2/289,29	52,081	0,353	6,536	16,813	0,000	0,279	16,368	5,989	0,750	0,192	0,039	0,000	0,000	0,403	0,209	100,012
RF2/313,03	50,336	0,141	19,445	6,098	0,000	0,108	8,674	11,161	1,605	0,486	0,009	0,000	0,000	1,449	0,186	99,698
RF3/41,53	53,383	0,281	5,087	12,746	0,000	0,229	22,034	5,282	0,732	0,242	0,004	0,000	0,000	0,162	0,207	100,388
RF3/70,23	49,240	0,152	17,021	9,551	0,000	0,174	9,057	9,794	1,508	1,268	0,003	0,000	0,000	1,753	0,274	99,796
RF3/72,19	50,245	0,122	15,146	10,792	0,000	0,200	11,888	8,263	1,503	1,190	0,000	0,000	0,000	0,971	0,218	100,538
RF3/150,03	47,073	0,238	4,268	11,302	0,000	0,187	25,534	5,998	0,089	0,194	0,040	0,000	0,000	4,518	0,520	99,963
RF3/171,73	52,191	0,404	6,407	10,618	0,000	0,191	14,952	13,372	1,125	0,246	0,054	0,000	0,000	0,461	0,238	100,258
RF3/200,53	51,715	0,417	10,789	11,298	0,000	0,187	12,141	10,786	1,814	0,491	0,071	0,000	0,000	0,394	0,153	100,255
RF3/239,19	50,902	0,648	14,166	11,080	0,000	0,165	8,461	10,768	2,422	0,485	0,118	0,000	0,000	0,841	0,249	100,305
RF3/248,30	50,738	0,660	14,014	11,562	0,000	0,177	8,045	10,536	2,568	0,583	0,112	0,000	0,000	0,768	0,221	99,983
RF4/33,55	37,619	3,154	12,012	27,949	0,000	0,250	5,706	7,935	2,290	0,0546	2,816	0,000	0,000	-0.848	0,364	99,792
RF4/99,80	44,763	2,296	13,985	23,250	0,000	0,264	4,110	7,989	2,791	0,612	0,211	0,000	0,000	-0,431	0,188	100,028
RF4/133,13	41,282	3,935	12,985	27,737	0,000	0,283	3,946	7,327	2,568	0,584	0,209	0,000	0,000	-0,909	0,232	100,178
RF4/171,21	47,917	2,623	19,757	13,635	0,000	0,134	1,077	7,719	3,770	1,295	0,216	0,000	0,000	1,080	0,175	99,400
RF4/174,77	50,667	1,363	20,589	10,724	0,000	0,120	1,220	7,384	4,069	1,445	0,303	0,000	0,000	1,361	0,207	99,452
RF4/208,36	35,992	4,962	11,405	35,255	0,000	0,316	5,478	5,480	2,165	0,285	0,114	0,000	0,000	-1,632	0,116	99,936
RF4/274,56	49,637	0,945	17,065	9,574	0,000	0,154	5,793	11,107	2,569	0,943	0,034	0,000	0,000	1,544	0,371	99,736
RF4/288,74	51,992	0,172	7,215	12,328	0,000	0,211	21,519	4,332	0,771	0,449	0,002	0,000	0,000	0,798	0,247	100,036
RF4/297,79	29,436	8,918	14,719	37,150	0,000	0,211	1,481	6,091	2,602	0,232	0,086	0,000	0,000	-1,006	0,050	99,971
RF4/300,32	50,403	0,217	20,250	6,773	0,000	0,123	5,665	11,260	2,364	1,211	0,014	0,000	0,000	1,393	0,214	99,886
RF4/304,09	49,025	0,160	22,317	4,579	0,000	0,073	5,214	11,240	2,149	1,999	0,011	0,000	0,000	2,620	0,352	99,738
RF4/318,18	40,361	3,636	13,167	28,899	0,000	0,261	5,162	6,577	2,393	0,439	0,143	0,000	0,000	-0,982	0,104	100,161
RF5/61,32	49,946	1,387	14,536	15,238	0,000	0,193	4,762	9,704	2,781	0,909	0,129	0,000	0,000	0,238	0,119	99,944
RF5/304,37	42,354	4,087	15,666	23,909	0,000	0,175	2,440	7,225	2,631	0,931	0,141	0,000	0,000	-0,048	0,211	99,723
RF5/548,01	52,220	0,299	10,041	13,126	0,000	0,203	15,798	6,191	1,626	0,261	0,042	0,000	0,000	0,352	0,218	100,378
RF5/565,65	50,749	0,751	9,436	19,776	0,000	0,300	10,144	6,515	1,557	0,616	0,140	0,000	0,000	-0,108	0,167	100,043
RF5/586,55	47,669	2,303	17,636	16,581	0,000	0,121	2,085	7,445	2,742	1,594	0,095	0,000	0,000	1,330	0,167	99,768
RF5/635,28	52,668	0,421	20,939	6,893	0,000	0,094	3,276	8,331	3,278	1,539	0,053	0,000	0,000	2,184	0,259	99,935
RF5/650,35	49,791	0,314	17,561	11,312	0,000	0,157	5,079	9,065	2,474	1,424	0,051	0,000	0,000	2,193	0,330	99,751

TABLE 9 : WHOLE ROCK ANALYSIS RESULTS (MAJOR OXIDES) OF SELECTED UNITS FROM BOREHOLES RF1 - RF5

SAMPLE No.	Zn ppm	Cu ppm	Ni ppm	Co ppm	Cr ppm	V ppm	Ba ppm	Sc ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	ASSOCIATED LITHOLOGY
RF1/38,48	237	248	215	123	194	2491	214	36	52	208	7	41	2,92	Magnettite-Gabbro
RF1/54,44	114	471	495	122	237	555	46	86	9	49	20	26	0	Coarse-gr. Pyroxenite + minor disseminated sulphides
RF1/61,65	141	91	125	63	142	280	175	44	49	247	14	24	0	Medium-gr. Norite + minor diss. sulphides
RF2/35,44	67	39	91	38	59	133	186	22	17	269	12	62	1,93	Medium-gr. Gabbro
RF2/43,75	39	22	43	18	28	73	315	12	45	375	9	54	1,57	Spotted Anorthosite
RF2/110,55	58	34	107	40	75	117	177	21	18	279	10	46	1,61	Medium-gr. Gabbro
RF2/128,60	34	23	62	22	54	84	216	15	31	347	10	59	2,20	Mottled Anorthosite (MZ base)
RF2/246,41	76	24	353	76	4026	173	62	28	21	116	6	24	0,94	Medium-gr.Harzburgite
RF2/260,24	106	55	498	91	1893	158	31	36	4	77	9	31	0	Medium-gr.Harzburgite
RF2/268,97	49	80	223	39	710	73	194	17	33	318	4	12	0	Spotted Norite
RF2/289,29	127	70	319	101	843	192	41	46	9	90	13	28	0,17	Medium-gr. Pyroxenite
RF2/313,03	43	35	185	46	573	92	123	20	20	314	3	8	0	Spotted Norite + minor diss.sulphides
RF3/41,53	83	63	618	104	2339	144	78	38	11	87	7	13	0,38	Fine-gr. Pyroxenite
RF3/70,23	78	87	213	60	212	123	210	37	88	364	4	7	0	Fine-gr. Norite
RF3/72,19	101	49	269	67	417	122	261	35	82	334	2	2	0	Fine-gr. Norite
RF3/150,03	91	62	1231	106	3683	129	77	33	12	47	13	43	1,44	Coarse-gr. Olivine-Pyroxenite
RF3/171,73	66	148	490	77	1667	227	92	57	10	123	15	30	0	Fine-gr. Feldspathic Pyroxenite
RF3/200,53	74	142	375	71	542	221	175	44	24	245	14	27	0,42	Medium-gr. Gabbro-Norite
RF3/239,19	88	86	225	61	354	222	192	37	18	301	16	21	1,51	Fine-gr. Feldspathic Pyroxenite + minor diss. sulphides
RF3/248,30	109	99	206	61	342	239	234	38	26	322	17	24	0,43	Fine-gr. Feldspathic Pyroxenite + minor diss. sulphides
RF4/33,55	105	177	28	127	11	93	194	14	16	241	31	46	0,21	Coarse-gr. Magnetite-Gabbro (BC Upper Zone)
RF4/99,80	140	112	29	80	14	76	246	34	18	324	15	38	2,81	Coarse-gr. Magnetite-Gabbro (BC Upper Zone)
RF4/133,13	168	48	28	83	24	163	252	37	17	288	16	45	3,22	Coarse-gr. Magnetite-Gabbro (BC Upper Zone)
RF4/171,21	87	39	14	33	117	124	369	15	48	515	12	61	3,39	Spotted Anorthosite + minor diss. ChPy and Pyrr.
RF4/174,77	59	30	9	29	49	51	376	14	61	500	13	49	1,89	Spotted Anorthosite + minor diss. ChPy and Pyrr.
RF4/208,36	187	135	37	145	13	382	169	26	4	236	7	31	3,03	Feldspathic Pyroxenite + magnetite & diss. sulphides
RF4/274,56	77	32	148	47	126	278	249	32	45	336	12	20	0,53	Spotted Anorthosite
RF4/288,74	122	59	642	90	4595	170	110	30	24	140	4	13	0	Med-gr. FeldspathicPyroxenite + minor diss. chromite
RF4/297,79	200	98	41	119	218	954	156	22	2	311	3	30	2,64	Medium-gr. Magnetite-Gabbro
RF4/300,32	61	21	110	38	93	127	305	20	53	367	7	13	0	Coarse-grained Gabbro (BC Main Zone ?)
RF4/304,09	37	15	157	31	503	99	467	19	117	365	5	12	0,55	Spotted Anorthosite + minor magnetite
RF4/318,18	157	131	40	131	41	381	196	25	10	265	12	35	1,37	Med-grained Magnetite-Gabbro + diss. Pyrr. & ChPy.
RF5/61,32	98	183	46	64	5	373	243	43	42	275	22	71	1,08	Coarse-gr. Magnetite-Gabbro (BC Upper Zone)
RF5/304,37	163	309	78	84	0	1379	308	27	40	293	15	68	4,51	Coarse-gr. Fe-Gabbro + abundant diss. sulphides
RF5/548,01	96	50	350	77	1698	198	107	33	8	182	8	26	0	Fine-gr. Feldspathic Pyroxenite
RF5/565,65	171	268	226	97	223	300	153	42	31	153	19	59	0,70	Pyroxenitic Pegmatoid + coarse & diss. sulphides
RF5/586,55	100	147	92	57	16	1033	331	23	86	326	17	69	3,78	Medium- to coarse grained Magnetite Gabbro
RF5/635,28	121	201	50	33	110	312	309	25	122	334	9	43	0,80	Medium- to coarse grained Magnetite Gabbro
RF5/650,35	107	81	100	61	217	349	236	30	135	254	11	31	0,46	Medium- to coarse grained Magnetite Gabbro

TABLE 10 : WHOLE ROCK ANALYSIS RESULTS (TRACE ELEMENTS) OF SELECTED UNITS FROM BOREHOLES RF1 - RF5

5.2 GEOCHEMICAL ELEMENT RATIOS

A number of hard-rock samples were collected from the various stratigraphic units on Rietfontein, and was submitted for Cu, Cr, Ni, TiO_2, and V analysis. These values were used in an attempt to separate certain units on grounds of geochemical element ratios. Preliminary studies showed that the ratios Cr/Ni*TiO_2 and V/TiO_2 produced distinct, separate populations for the various rocktypes and thus the most meaningful results (figures 16 & 17). These element groupings were ultimately utilised to aid in the interpretation and separation of the different stratigraphic entities of essentially the Mixed Zone.

Certain ratios such as V/TiO_2, Cr/Ni and Cr/TiO_2 were empirically derived to assist in the characterisation of mainly the finer grained rocktypes (e.g.. micro-gabbronorites, hornfelses) in borehole core of RF1 to RF5, that were difficult or impossible to identify on macroscopic scale (appendices D, H, L, P, T).

5.3 WHOLE ROCK ANALYSIS

In order to investigate overall fractionation patterns within the layered sequence on the southeastern flank of the Dennilton Dome, thirty nine (39) selected half core samples from boreholes RF1 to RF5 were subjected to whole-rock analysis. This included major- and trace elements, and results are depicted in tables 9 and 10.

All the major oxides were determined by means of the Norrish method. Duplicate fusion discs (approximately 0,28g each) of each sample was made. The H_2O and LOI (Lost On Ignition) content of each sample was ascertained gravimetrically (+/- 2,0g powder) prior to the manufacturing of the fusion discs.

Any FeO that might be present in the sample was oxidised to Fe_2O_3, resulting in certain anhydrous lithotypes possessing a negative (thus a weight gain) LOI. The lower limit of determination (LLD) was calculated for each sample, and can be defined as six times the standard deviation of the background countrate which is expressed as a concentration.

The TiO_2 and associated V values that are reported for the magnetite-bearing rocktypes (table 9, 10) are significant in that it may provide answers as to the possible stratigraphic correlation of the latter units with a normal Bushveld Complex Upper Zone scenario. The trace elements Sr, Rb, Y, Sc and Zr will aid greatly to achieve this objective. Some of the relevant values are presented in table 11.

SAMPLE	TiO2	V	Sc	Rb	Sr	Y	Zr	LITHOLOGY
1/38,48	5,56	2491	36	52	208	7	41	Magnetite-Gabbro
4/297,79	8,92	954	22	2	311	3	30	Magnetite-Gabbro
4/208,36	4,96	382	26	4	236	7	31	Magn.-Felds.Pyroxenite
4/318,18	3,64	381	25	10	265	12	35	Magnetite-Gabbro
5/304,37	4,09	1379	27	40	293	15	68	Magnetite-Gabbro
5/586,55	2,30	1033	23	86	326	17	69	Magnetite-Gabbro

Table 11. Analysis of selected elements for magnetite-bearing lithologies in borehole core.

If the trends of the indicator elements in the Bushveld Complex Upper Zone are considered, it can be seen that the values of the selected elements collected from the study area fall within the prescribed range. In general, the Zr/Rb ratios of the magnetite-gabbros of the Mixed Zone have values in the region of 2,55, which fall within the Zr/Rb range mentioned by Cawthorn and McCarthy (1985) for the magnetite-rich units of the upper 500m of the Rustenburg Layered Sequence.

The magnetite-gabbros of the Mixed Zone on Rietfontein 70JS that are located closer to the floor contact does, however, display extraordinary low Zr/Rb ratios such as 0,23 and 0,35, as a result of anomalously low Rb values. Cawthorn and McCarthy (op.cit.) postulate that rocks rich in magnetite will have anomalously high (~10) Zr/Rb ratios, as the Zr is incorporated into the cumulus phase of the magnetite. In the upper 500m of the Bushveld Complex sequence the incompatible elements Rb, Zr, Y and Nb show distinct trends where the content of the latter elements increases notably with stratigraphic height (Cawthorn and McCarthy, op.cit.).

The magnetite-rich lithologies on Rietfontein fit well into the middle of this 500m zone for all four elements.

The calculated Sr/Al_2O_3 ratio values for the magnetite-gabbros from the study area are overall in the order of 5 units higher than the Sr/Al_2O_3 ratios quoted by Hoyle (1994) for the western Bushveld Complex Upper Zone Subzone A (UZA), but seem to match comfortably with the normal Upper Zone Subzone B (UZB).

Hoyle (1992) furthermore used the oxides TiO_2 and P_2O_5 as parameters to distinguish between different stratigraphic units in the vicinity of the Pyroxenite Marker moreover within the Upper Zone. If only the TiO_2 levels of whole rock analysis data taken from magnetite-rich rocks from Rietfontein is used, these lithotypes can be matched with either the typical C- or B-subzones of the Upper Zone. The P_2O_5 content of the latter rocks, though clearly indicate an association with the UZB.

Similarly, units that fall within the Main Zone on Rietfontein display Sr/Al_2O_3 ratios of 14,5 to 14,8 for the Main Zone gabbros, and 15,7 to 16,3 for the Main Zone anorthosites, which is also in agreement with the range for normal Main Zone stratigraphy of the Rustenburg Layered Suite.

Based on data supplied by Harmer and Sharpe (1985), the peridotitic lithotypes of the lower portions of the Mixed Zone on Rietfontein can undoubtedly be correlated with the olivine-rich marginal rocks of the eastern Bushveld Complex, where an MgO content of 26 - 35 wt%, SiO_2 of 41 - 49 wt% and Rb/Sr ratios of >0,1 is required to fit the stratigraphic category.

In conclusion the magnetite-rich units that occur on Rietfontein 70JS thus conform to the stratigraphy in the vicinity of magnetite layers 8 to 14 of Subzone B in a normal Bushveld Complex Upper Zone scenario. Although the Main Zone gabbros on Rietfontein conform to a typical Rustenburg Layered Suite Main Zone on grounds of whole rock geochemistry, it is not possible to make any further detailed stratigraphic correlation.

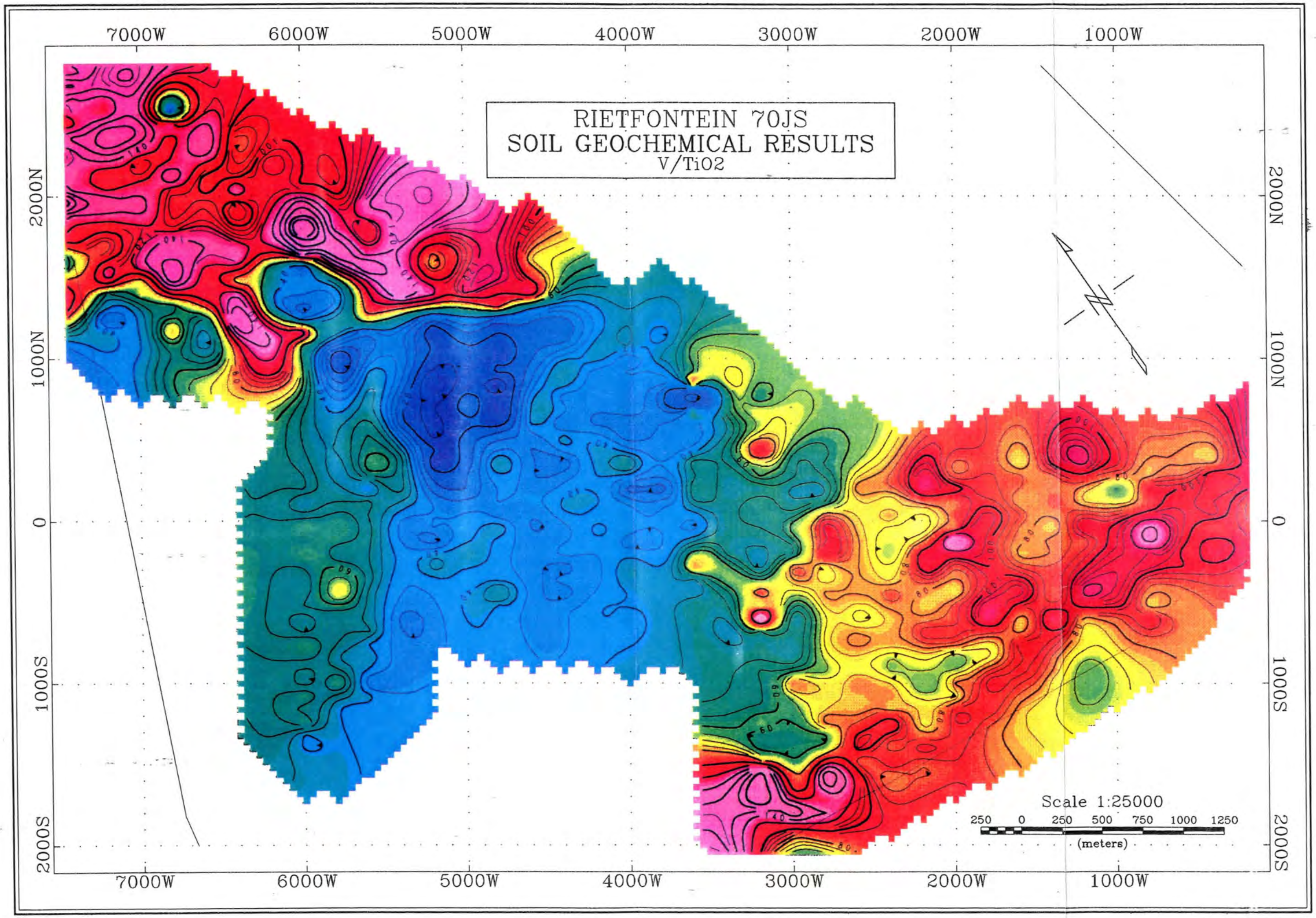
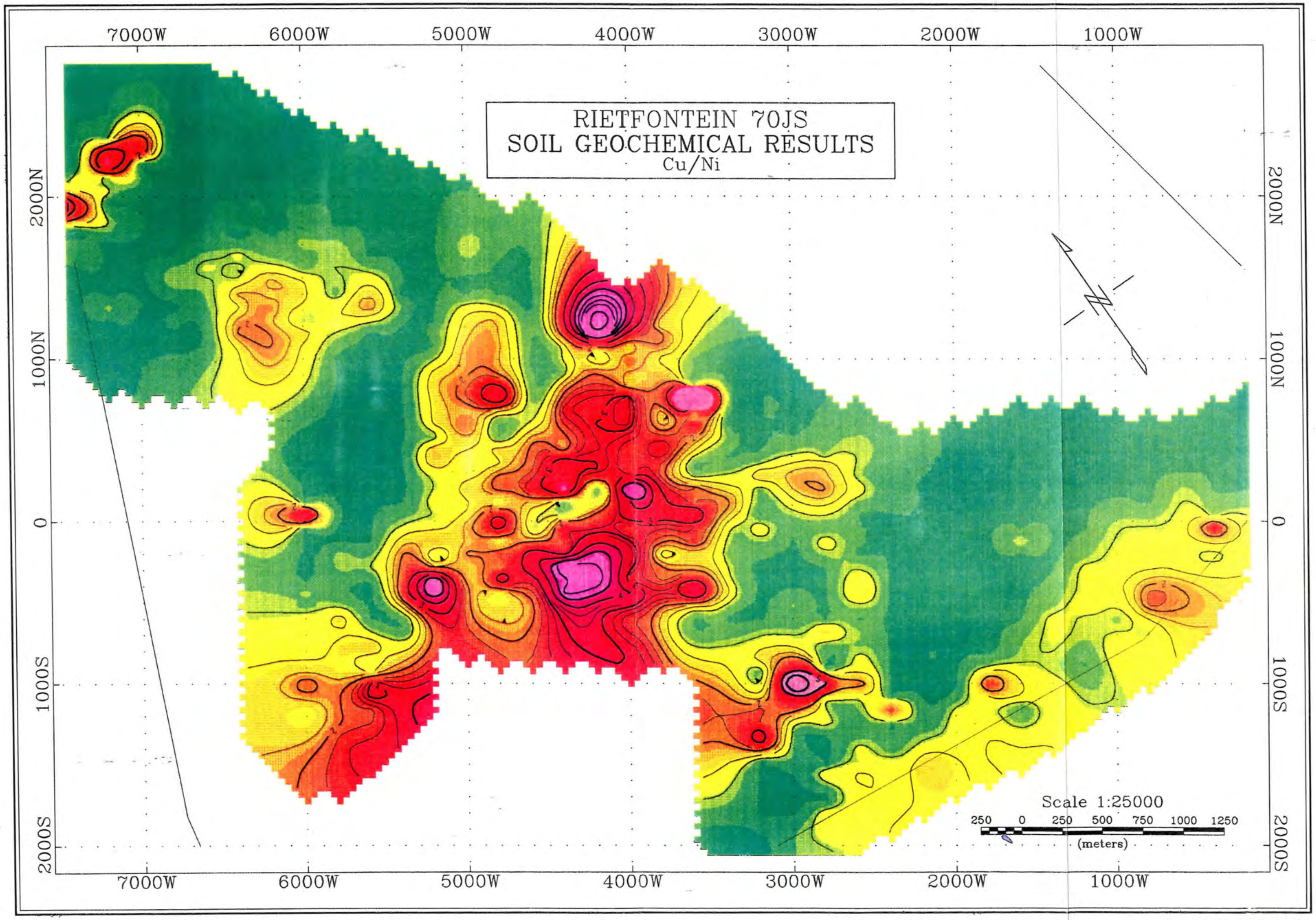

RIETFONTEIN 70JS
SOIL GEOCHEMICAL RESULTS
V/TiO2
7000W
6000W
5000W
4000W
3000W
2000W
1000W
2000N
1000N
0
1000S
2000S
Scale 1:25000
250 0 250 500 750 1000 1250
(meters)

FIGURE 13



RIETFONTEIN 70JS
SOIL GEOCHEMICAL RESULTS
Cu/Ni
7000W
6000W
5000W
4000W
3000W
2000W
1000W
2000N
1000N
0
1000S
2000S
Scale 1:25000
250 0 250 500 750 1000 1250
(meters)

FIGURE 14

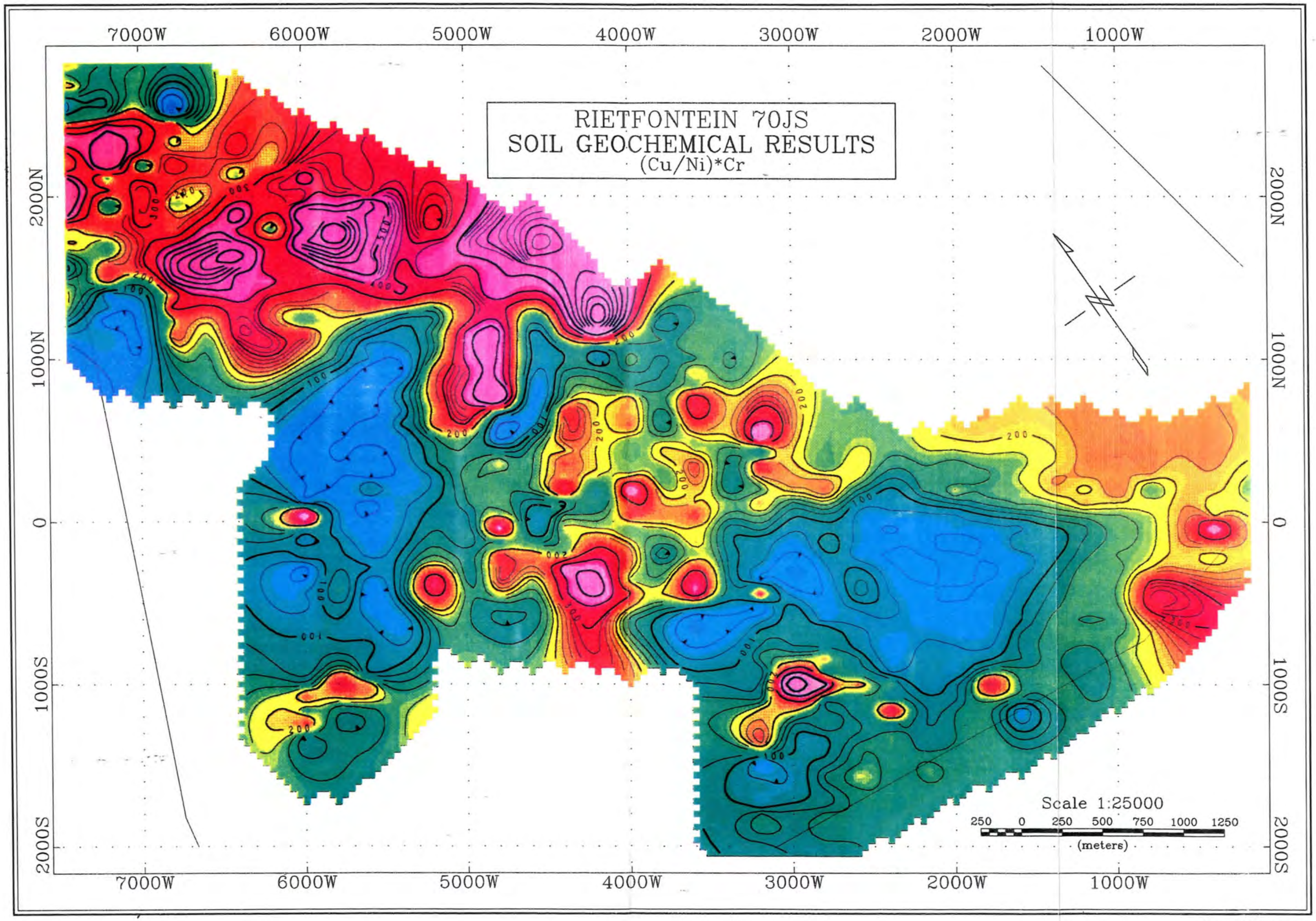

RIETFONTEIN 70JS
SOIL GEOCHEMICAL RESULTS
(Cu/Ni)*Cr
7000W
6000W
5000W
4000W
3000W
2000W
1000W
2000N
1000N
0
1000S
2000S
Scale 1:25000
250 0 250 500 750 1000 1250
(meters)

FIGURE 15

RIETFONTEIN 70 JS

Geochemical Element Ratio Groupings (Cr/Ni * TiO_2)

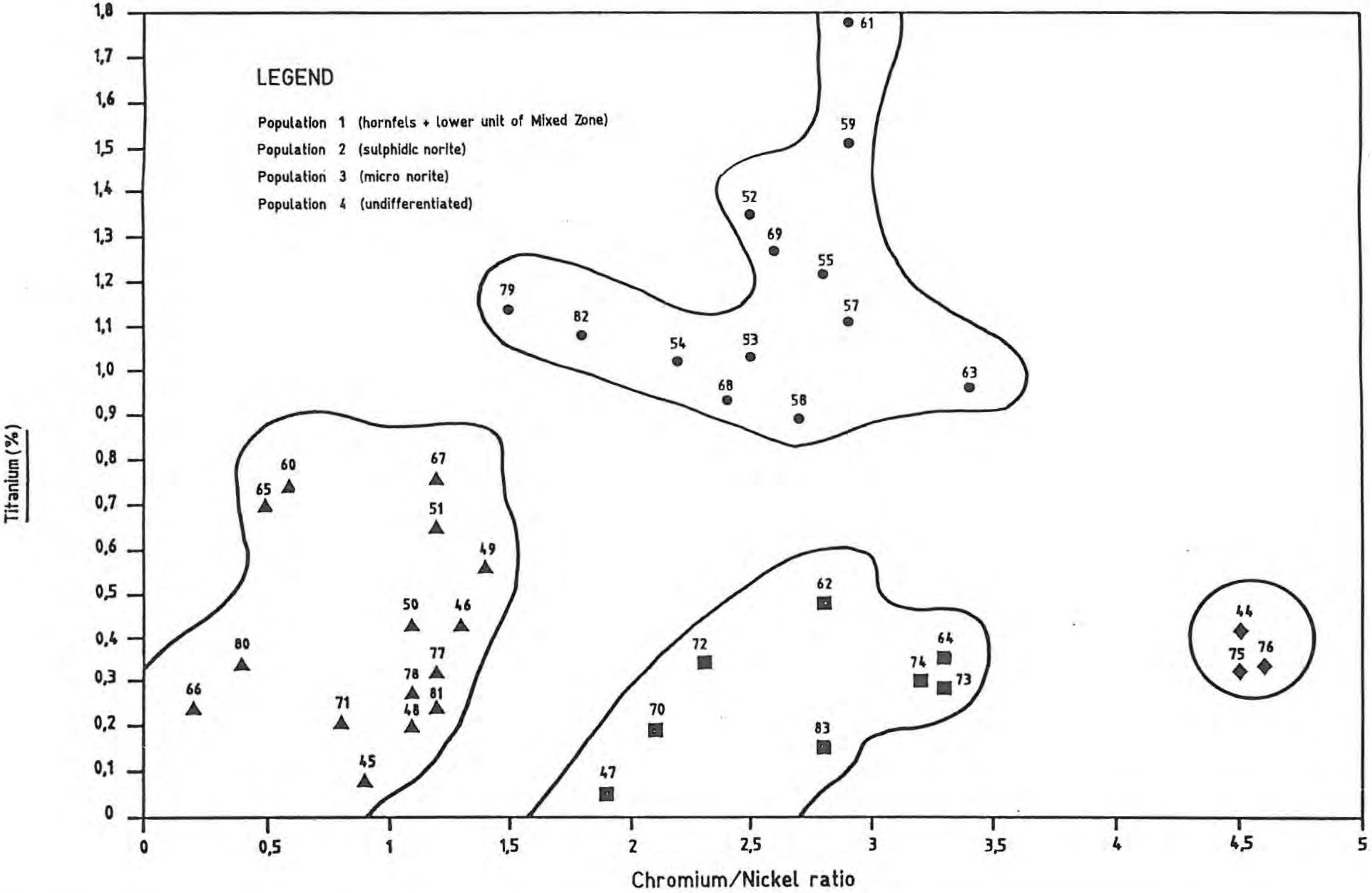
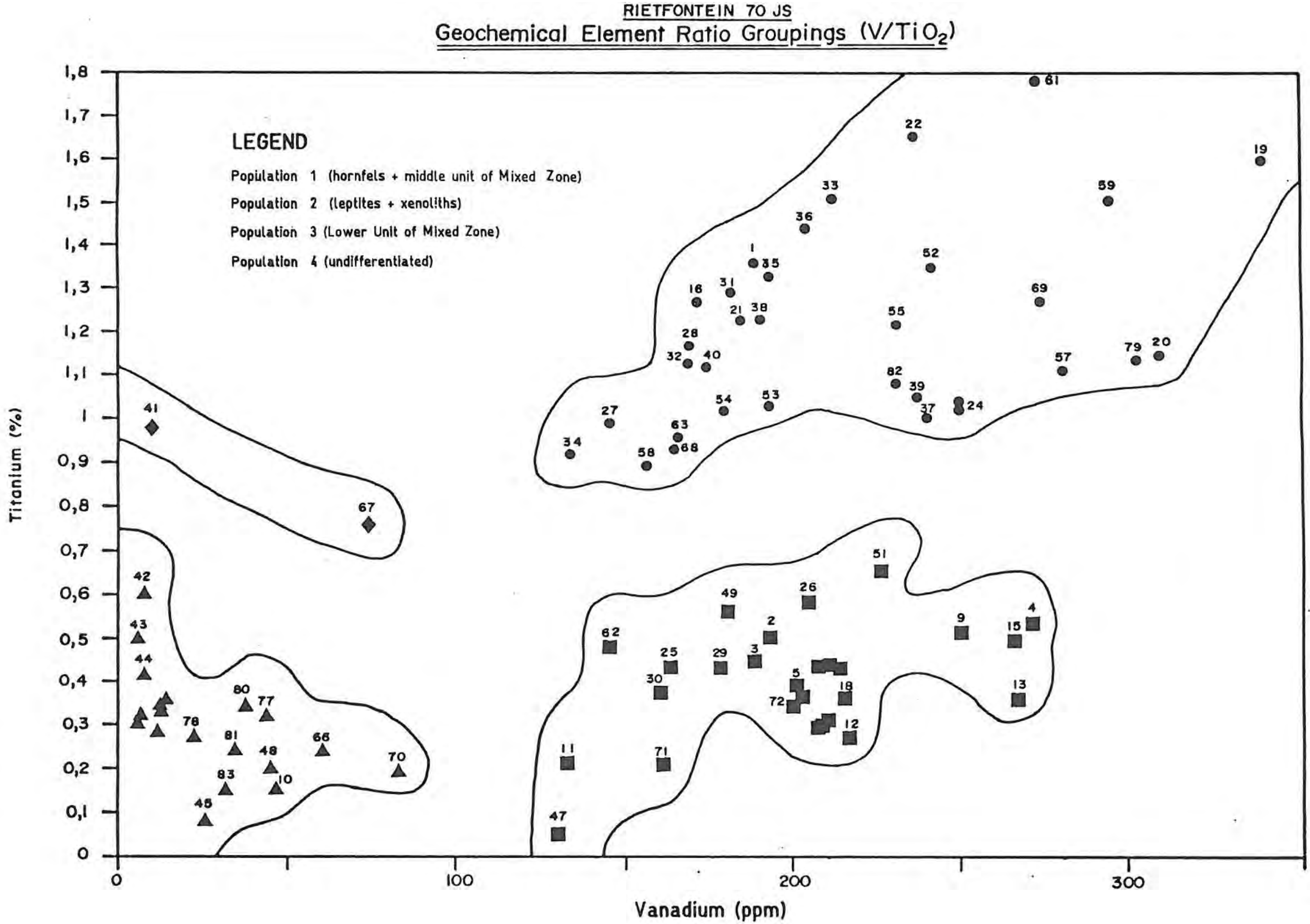


FIGURE 16



RIETFONTEIN 70 JS
Geochemical Element Ratio Groupings (V/TiO2)
LEGEND
Population 1 (hornfels + middle unit of Mixed Zone)
Population 2 (leptites + xenoliths)
Population 3 (Lower Unit of Mixed Zone)
Population 4 (undifferentiated)
Titanium (%)
Vanadium (ppm)

FIGURE 17

6. DRILLING

Five diamond drill boreholes, RF1 (-45°), RF2 (-90°), RF3 (-90°), RF4 (-90°) and RF5 (-90°) were drilled on Rietfontein 70JS (figure 4) and reached final depths of 130,55m, 545,00m, 250,48m, 389,00m and 680,30m respectively. The purpose of these boreholes was to evaluate the mineralization within the mafic lithologies, locate possible mineralization near the Bushveld/Pretoria Group contact (Platreef-type), and to follow up the Cr and Cu anomalies encountered in the soil sampling.

Borehole RF1 was drilled at an inclination of -45° (azimuth angle = 350°, where N = 0°), and was collared in hornfels (metamorphosed floor fragment). A number of different mafic lithologies like gabbro, pyroxenite, magnetite-gabbro and norite were intersected before the hornfels above the floor contact was encountered (figure 18).

The detailed geological descriptions of the core from borehole RF1 are presented in appendix A. Thin layers and fingers of an aplitic intrusion of some kind were often detected in RF1. The nature of these aplites is discussed in more detail in paragraph 3.3.5. of this dissertation. Due to the cross-cutting relationship that is displayed by the aplites, it is clear that these intrusions post-date all the rocktypes on Rietfontein 70JS. Granophyric intergrowth textures are often observed in the aplites that range from very coarse- to fine-grained.

Borehole RF2 was collared just in the hanging-wall of a conspicuous mottled anorthosite unit, and intersected mainly Main Zone gabbro-norites, gabbros, norites and feldspathic-pyroxenites, before a harzburgitic unit was intersected at a depth of 245,96m (figure 19). Below this harzburgite typical Critical Zone norites (often with disseminated chalcopyrite and pyrrhotite) and chromite-rich feldspathic pyroxenites were noted (appendix B).

Unfortunately, a relatively large hornfels xenolith was encountered at 325,04m before other potential Critical Zone lithologies could be investigated. Relatively high Cr and Cu responses were detected over these zones (appendix F pg.2 & appendix G pg.2).

Borehole RF3 drilled essentially through packages of Critical Zone feldspathic-pyroxenites and norites (figure 20). This statement is supported by the elevated Cr and Ni signatures across these units (appendix J pg.1 & 2). Again, harzburgitic and olivine-rich pyroxenite units were recognised (appendix I) between the normal Critical Zone type lithologies (as was the case with RF2).

Borehole RF4 displayed rather thick sequences of typical Upper Zone magnetite-gabbro, anorthosite and what was interpreted as a magnetite-rich feldspathic pyroxenite (figure 21). Due to a hornfelsic rocktype at 337,11m - 389,00m (final depth of borehole) the borehole had to be stopped prematurely.

Rocktypes that would conform to a Critical Zone type environment (pegmatoid with disseminated sulphides, chromite-bearing feldspathic pyroxenite, anorthosite) were exposed between magnetite-rich (Upper Zone) units at a depth of approximately 280m (appendix N).

As expected, the magnetite-gabbros and magnetite-rich feldspathic pyroxenites are marked by very pronounced TiO_2 anomalies (appendix N pg.1-3), whereas elevated Cr and Ni values were experienced over the feldspathic pyroxenites at a depth of 285,63m to 293,64m (appendix N pg.3). Visible chromite was logged in the borehole core at the latter depths (appendix M pg.3).

Borehole RF5 intersected similar rocktypes to RF4 (magnetite-gabbro, feldspathic-pyroxenite) and two harzburgite layers (with anomalous Cr) were encountered (figure 22) at a depth of 416,38m (appendix Q pg.4). These harzburgites, incidentally, produced elevated PGE values (appendix S pg.2).

Thick intrusions of granitic composition can be observed at 311,21m and at 373,44m. These granitic intrusions are of the same composition as the fine- to coarse-grained aplites that were encountered in other boreholes and in outcrop on Rietfontein 70JS.

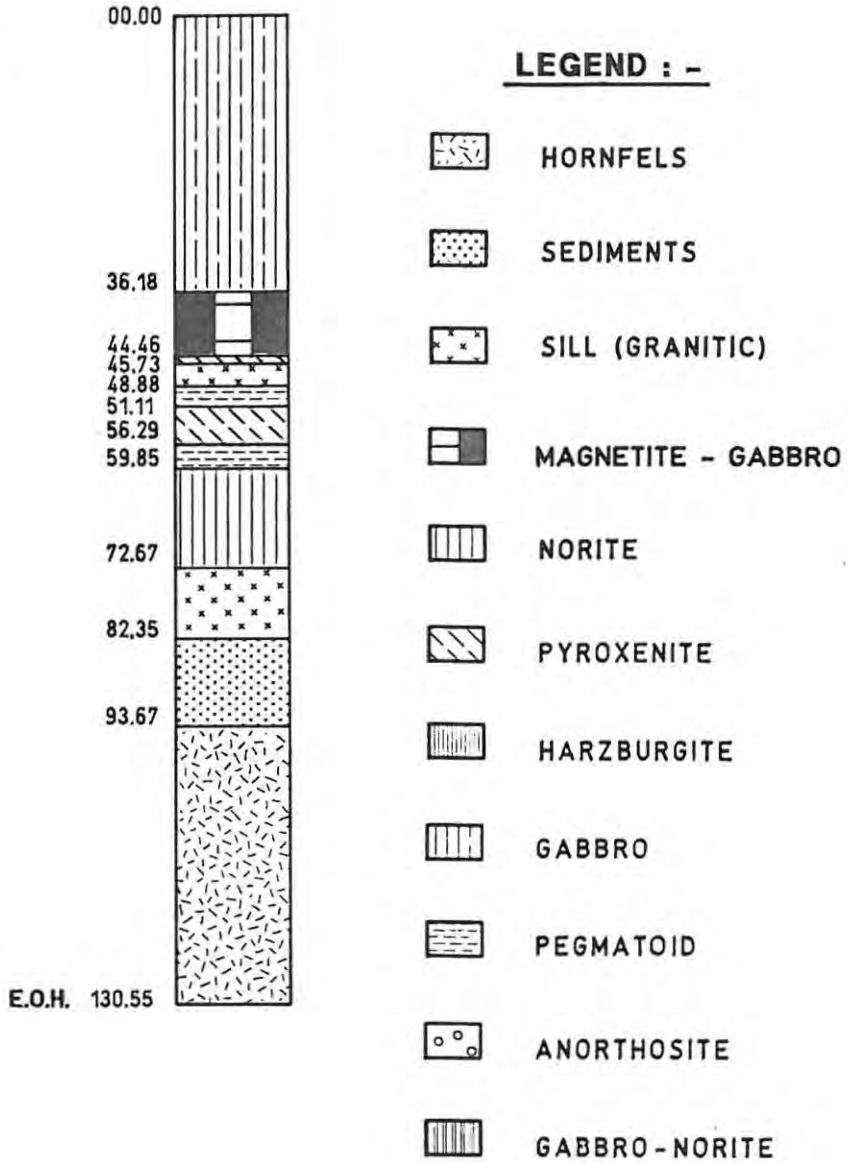
RF 1

Approximate Co-ordinates :

X + 2 802 812m
Y - 29 490m

Elevation : 1 128,5 m.a.m.s.l.
Inclination : -45°
Azimuth : 350° (N=0°)
E.O.H. = 130.55m

Farm : RIETFONTEIN 70 JS



BOREHOLE RF 1

Simplified borehole profile

Vertical Scale : 1 : 1 000

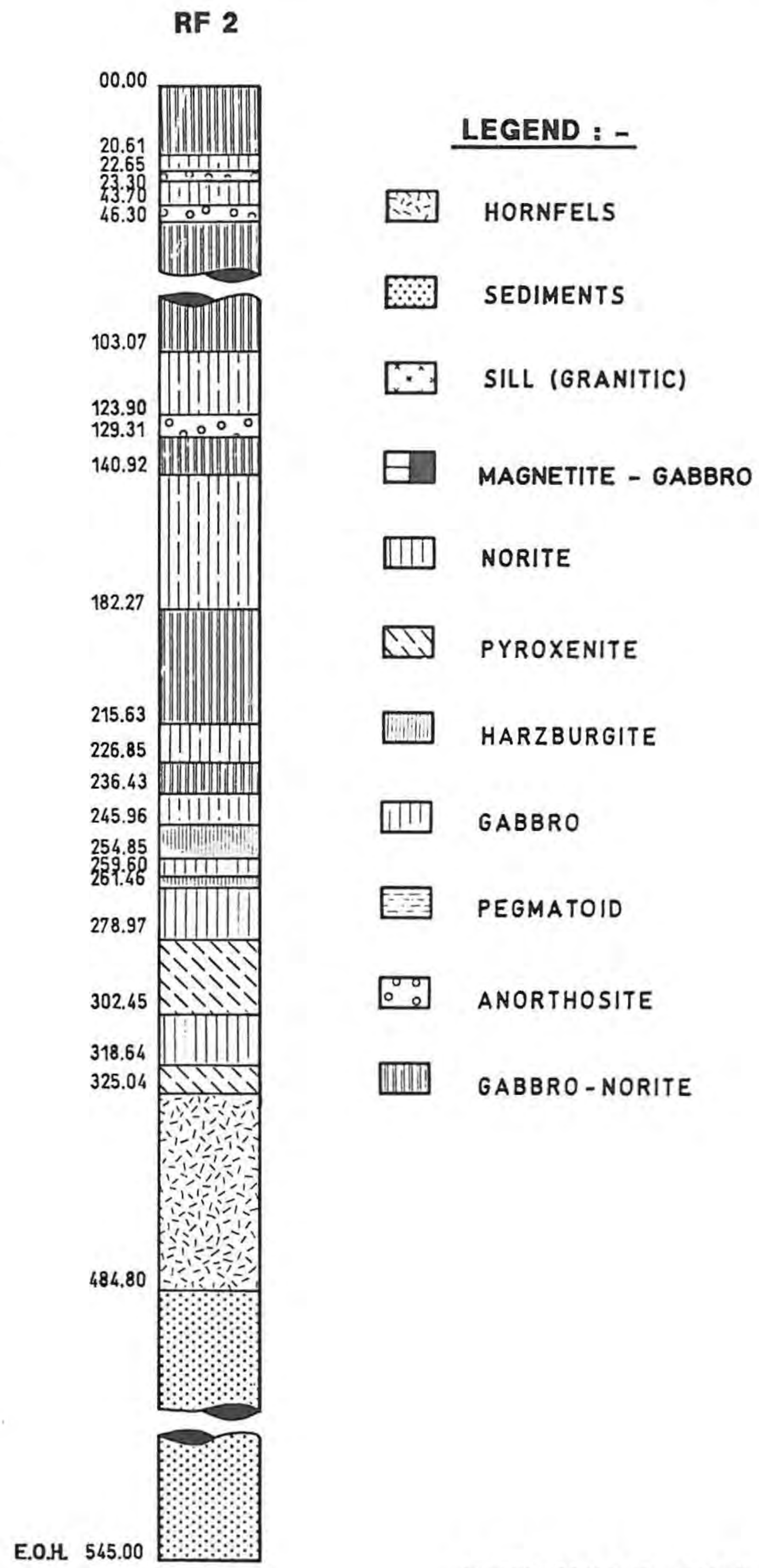
FIGURE 18

Approximate Co-ordinates :

X + 2 805 947m
Y - 31 470m

Elevation : 1 036,7 m.a.m.s.l.
Inclination : -90°
Azimuth : -
E.O.H. = 545.00m

Farm : RIETFONTEIN 70 JS



BOREHOLE RF 2

Simplified borehole profile

Vertical Scale : 1 : 2 000

FIGURE 19

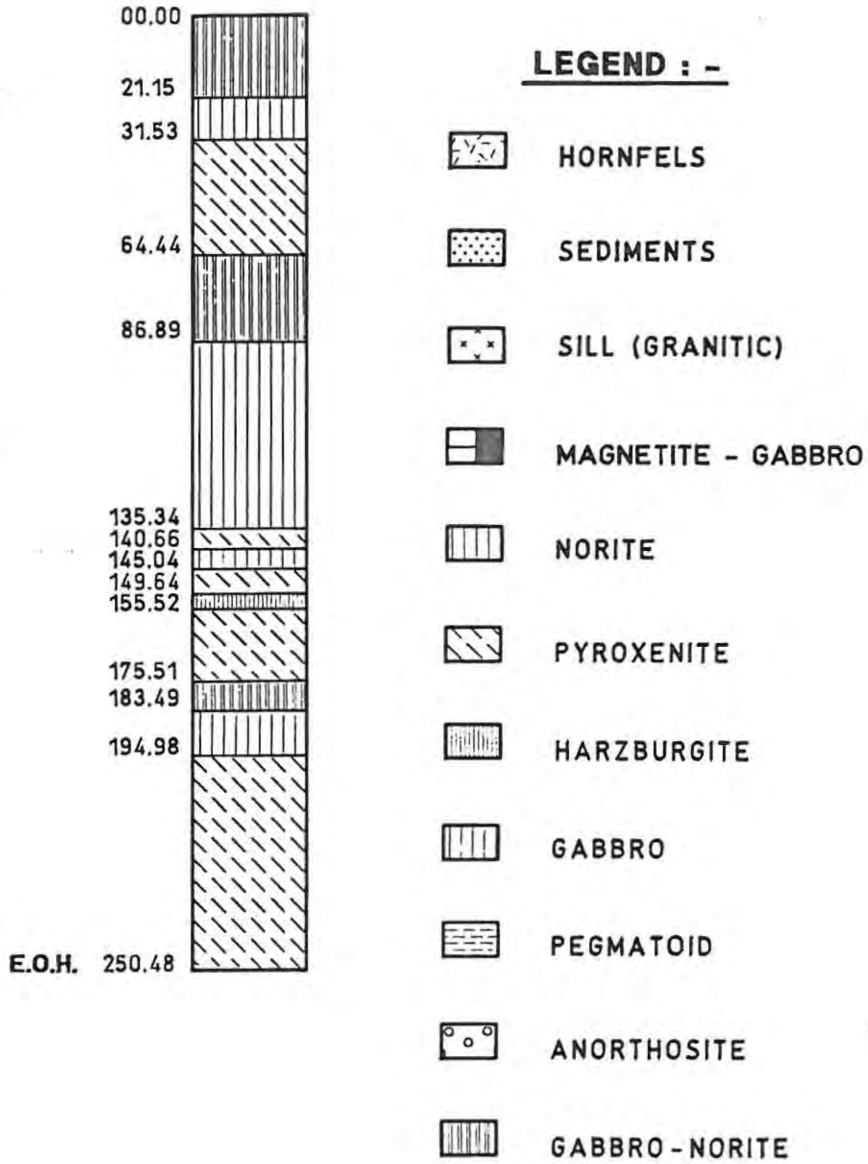
RF 3

Approximate Co-ordinates :

X + 2 805 155m
Y - 31 000m

Elevation : 1 067,2 m.a.m.s.l.
Inclination : -90°
Azimuth : –
E.O.H. = 250.48m

Farm : RIETFONTEIN 70 JS



BOREHOLE RF 3

Simplified borehole profile

Vertical Scale : 1 : 2 000

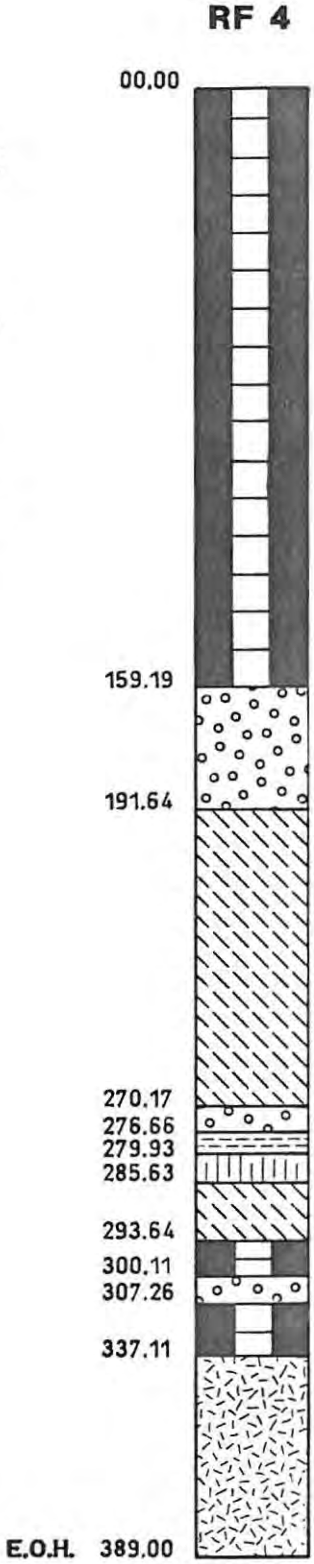
FIGURE 20

Approximate Co-ordinates :

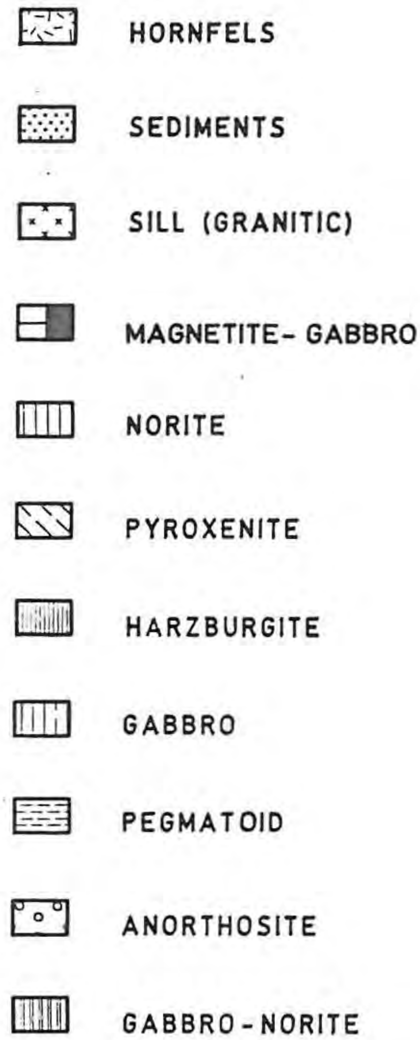
X + 2 803 890m
Y - 30 206m

Elevation : 1 089,3 m.a.m.s.l.
Inclination : -90°
Azimuth : —
E.O.H. = 389.00m

Farm : RIETFONTEIN 70 JS



LEGEND : -



BOREHOLE RF 4

Simplified borehole profile

Vertical Scale : 1 : 2 000

FIGURE 21

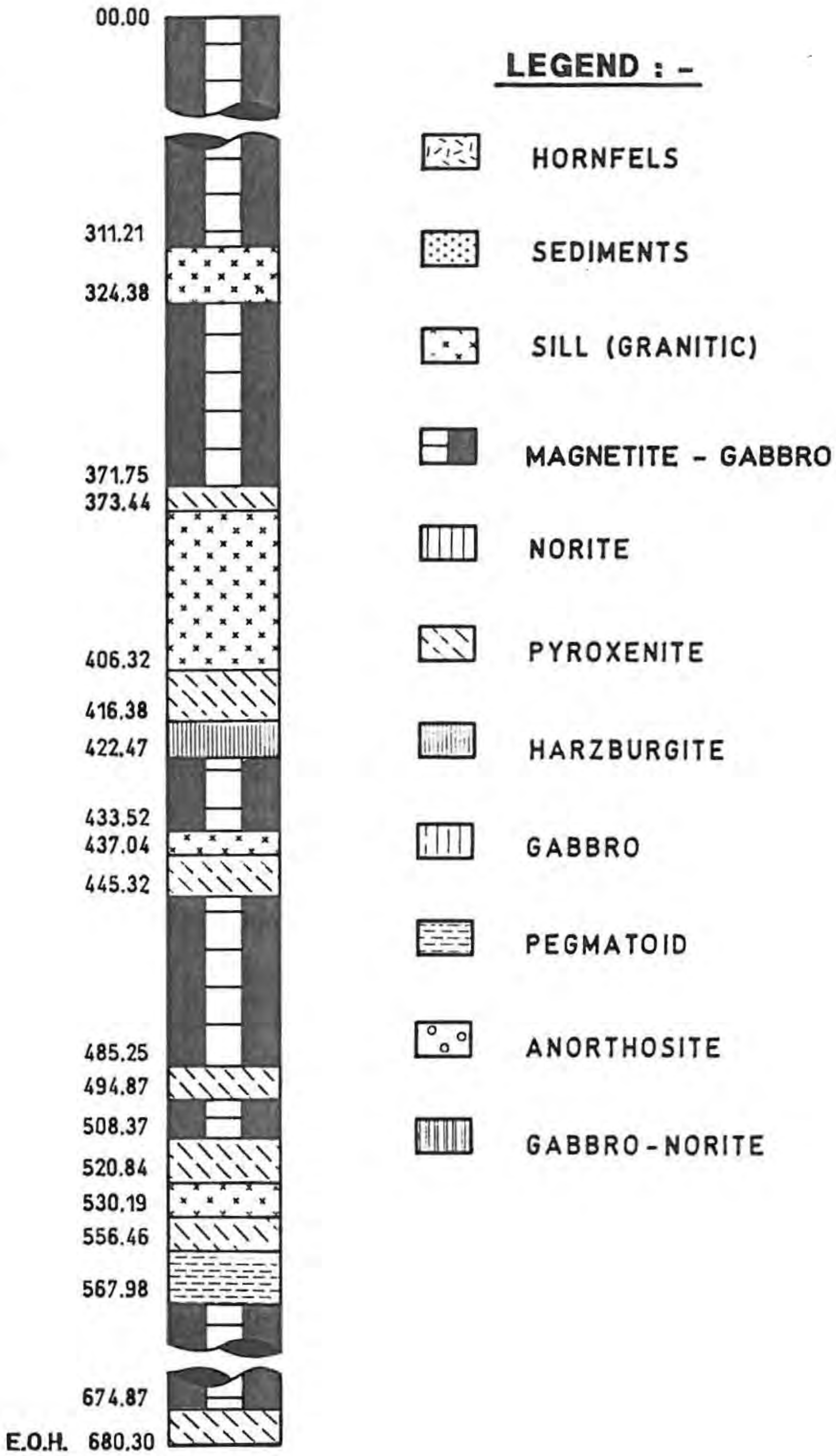
RF 5

Approximate Co-ordinates :

X + 2 803 395m
Y - 29 600m

Elevation : 1 102,7 m.a.m.s.l.
Inclination : -90°
Azimuth : -
E.O.H. = 680.30m

Farm : RIETFONTEIN 70 JS



BOREHOLE RF 5

Simplified borehole profile

Vertical Scale : 1 : 2 000

FIGURE 22

7.GEOPHYSICAL COMPONENTS

In conjunction with the geochemical sampling programmes on Rietfontein 70JS, a groundmagnetic and regional infill gravity survey was initiated. Groundmagnetic readings were recorded on an existing grid system with 200m line spacings and 10m station intervals and covered all the lithologies on the southern portion of the farm (figure 4).

Interpretation results of the groundmagnetics indicate a number of very prominent magnetic highs and lows (figure 24). These magnetic anomalies effectively demarcate the different stratigraphic units on a broad scale (figure 29), and also coincide with the different zones delineated by geochemistry. The groundmagnetic highs reach values in excess of 31 000 nanotesla in certain areas (magnetite-rich pegmatites, magnetite-gabbro units), whereas the felsites are well defined by a magnetic signature of greater than 29 400 nT. The Main Zone gabbro depicts a very pronounced low (<29 200 nT) magnetic background value.

The Pretoria Group sediments as well as the hornfels unit near the mafic/floor contact can also quite easily be outlined by means of groundmagnetics (figures 24 & 29).

The total field government aeromagnetic data (figure 26) not only shows the existence of an extremely prominent magnetic high on Rietfontein 70JS, but also supports the theory that mafic lithologies of the Bushveld Complex does occur as one continuous body all the way from Rietfontein on the southern rim of the Dennilton Dome up to the mafics to the east of Groblersdal.

Southeast of Groblersdal on the eastern flank of the Dennilton Dome, the BC mafics are possibly covered by a thin veneer of granites and granophyres, and it is also postulated that these mafic lithologies may continue northwards (up between Groblersdal and the Aangewezen Basin) under a thicker cover of acid phase rocks. The possibility of Bushveld mafic phase below the granites to the east of Marble Hall can therefore not be excluded.

On a more regional scale, the government Bouguer gravity data was supplemented with infill gravity figures obtained in the area, in order to produce a composite Bouguer gravity contour map of the entire southern and eastern flank of the Dennilton Dome. This contoured gravity image enhances the argument posed for the existence of mafics below the granites around the eastern perimeter of the Dennilton Dome.

Two very pronounced gravity anomalies (> -100 mgal) are situated directly to the south of Groblersdal, and can possibly be ascribed to BC mafics in contact with inter alia, carbonate-rich lithotypes of the Malmani Subgroup and the granites/granophyres, on or near a conspicuous SE-NW trending lineament (parallel to the Laersdrift direction). These anomalies may represent a skarn-type orebody or event Platreef-type mineralization of significant magnitude.

Hattingh (1980) made an attempt to interpret the structural relationships of the Bushveld Complex by means of gravity data in the Groblersdal sector of the eastern limb, and recognised the gravity low over the Dennilton Dome. Hattingh (op.cit.) stated that the gravity highs in this area signify the existence of Bushveld mafic rocks, and concluded that the prominent gravity high approximately 10 km southeast of Groblersdal possibly represents BC mafics under the granophyre.

Hattingh (op.cit.) certainly acknowledges the fact that Bushveld mafic phase rocks do exist adjacent to the south-eastern flank of the Dennilton Dome, but poses a number of scenarios for the genesis of this phenomenon. In one instance the possibility of a "separate intrusion of mafic rocks on the flank of the Dennilton Dome, unrelated to the mafic rocks of the Bushveld or the basic lava (Ventersdorp)", was posed.

Molyneux and Klinkert (1978) also investigated the nature of the mafic sequence of the eastern limb of the Bushveld Complex by utilising gravity and aeromagnetic data obtained from this area. Although they largely concentrated their efforts on the Marble Hall area, valuable conclusions can be applied to the Dennilton Dome scenario. Results of their gravity modelling indicate the presence of a thick sequence of mafic rocks under the Transvaal Sequence rocks, and that the layered sequence becomes thinner in a westerly direction from the Main Zone outcrop. Molyneux & Klinkert (1978) also suggested that no feeders of basic rocks need to be created to explain the existence of the observed anomalies.

Hall (1985) found a number of weaknesses in Molyneux & Klinkert's model, after a more thorough gravity survey of the area. Some of the more important weaknesses are ;

i) the wide spacing between observations viz. 8 km,
ii) the distance of the observation point from the profile-line (± 2 km),
iii) all densities used were estimates and not measured, and
iv) the accuracy of the readings due to smoothing of government aeromagnetic data appears suspect.

A subsequent drilling program by Gold Fields (boreholes AD3 & ED1) near Marble Hall totally disproved Molyneux & Klinkert's model.

Density and magnetic susceptibility measurements were conducted in a number of boreholes that were drilled on Rietfontein 70JS. The results are depicted in figures 30 and 31.

Average magnetic susceptibility values ranging between 5 000 and 11 000 cgs were recorded for the magnetite-gabbros and magnetite-bearing pyroxenites. It is clear that these values are several orders of magnitude higher than the magnetic susceptibilities encountered for the adjacent lithologies.

The magnetite layers, or remnants thereof, displayed magnetic susceptibilities in the order of 23 815 cgs (figure 31, RF4 at 291m), 38 630 cgs (figure 31, RF5 at 89 - 92m) and > 50 000 cgs (figure 31, RF5 at 360m). The concentrations of magnetite can thus quite easily be distinguished on grounds of magnetic susceptibilities.

Although rather subtle, the zones of chloritization and serpentinization could unquestionably be differentiated from the surrounding units. These alteration zones displayed values of 700 to 900 cgs against background values of less than 100 cgs (figure 31, RF3 in vicinity of depths 36m, 57m, 111m and 161m).

Average values for the more feldspar-rich constituents such as the norites reflected values of 80 cgs, but as the pyroxene- and also the sulphide (in particular pyrrhotite) content increases the magnetic susceptibility also increases through the gabbronorites to the feldspathic pyroxenites, to reach values of 200 cgs.

Obviously the iron that is present in the olivines of the more peridotitic rocks would produce elevated magnetic susceptibilities. Background values for the harzburgites are given as 1600 cgs.

Average densities for the various rocktypes were measured as 3,15 g/cm^3 for ferro-gabbro, 3,45 - 3,80 g/cm^3 for the magnetite layers, 3,00 g/cm^3 for feldspathic pyroxenite, 2,95 g/cm^3 for the peridotites and 2,85 g/cm^3 for norites, gabbros and anorthosites.

The meta-quartzites showed background values of 2,6 g/cm^3 (figure 30, RF2 at 485 - 545m), whereas the late-stage aplitic intrusions have densities in the order of 2,80 g/cm^3.

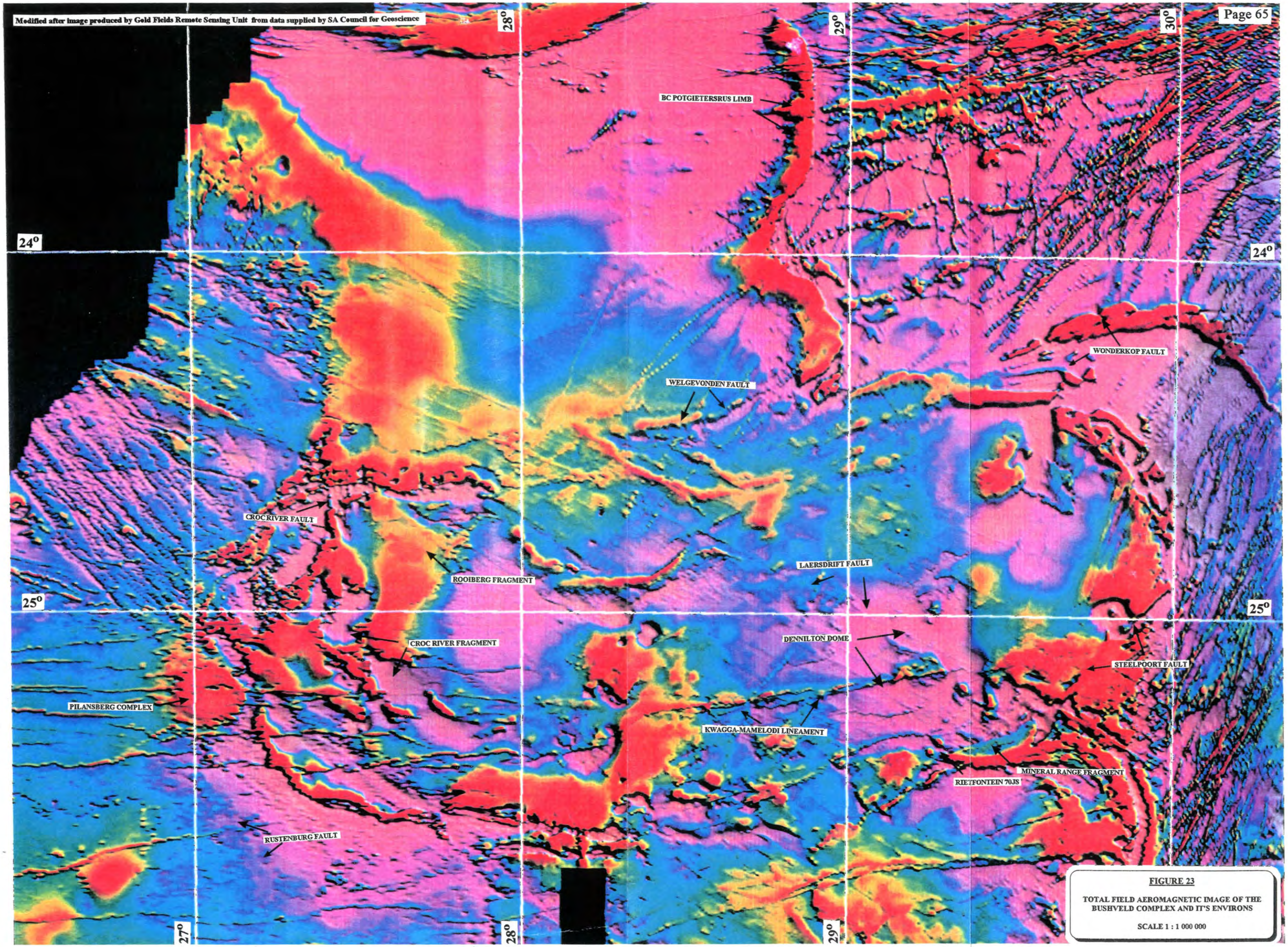


FIGURE 23

TOTAL FIELD AEROMAGNETIC IMAGE OF THE BUSHVELD COMPLEX AND IT'S ENVIRONS

SCALE 1 : 1 000 000

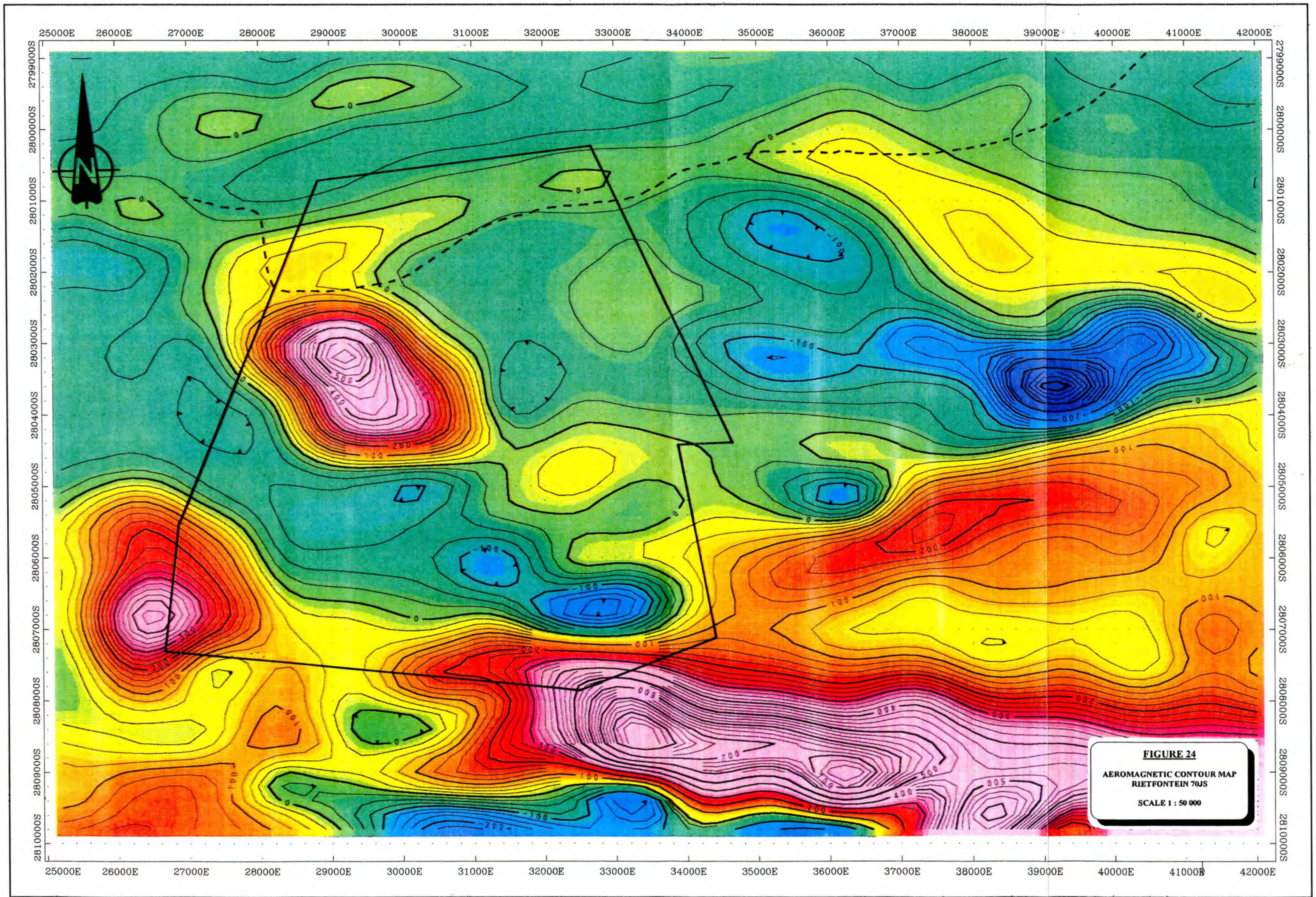
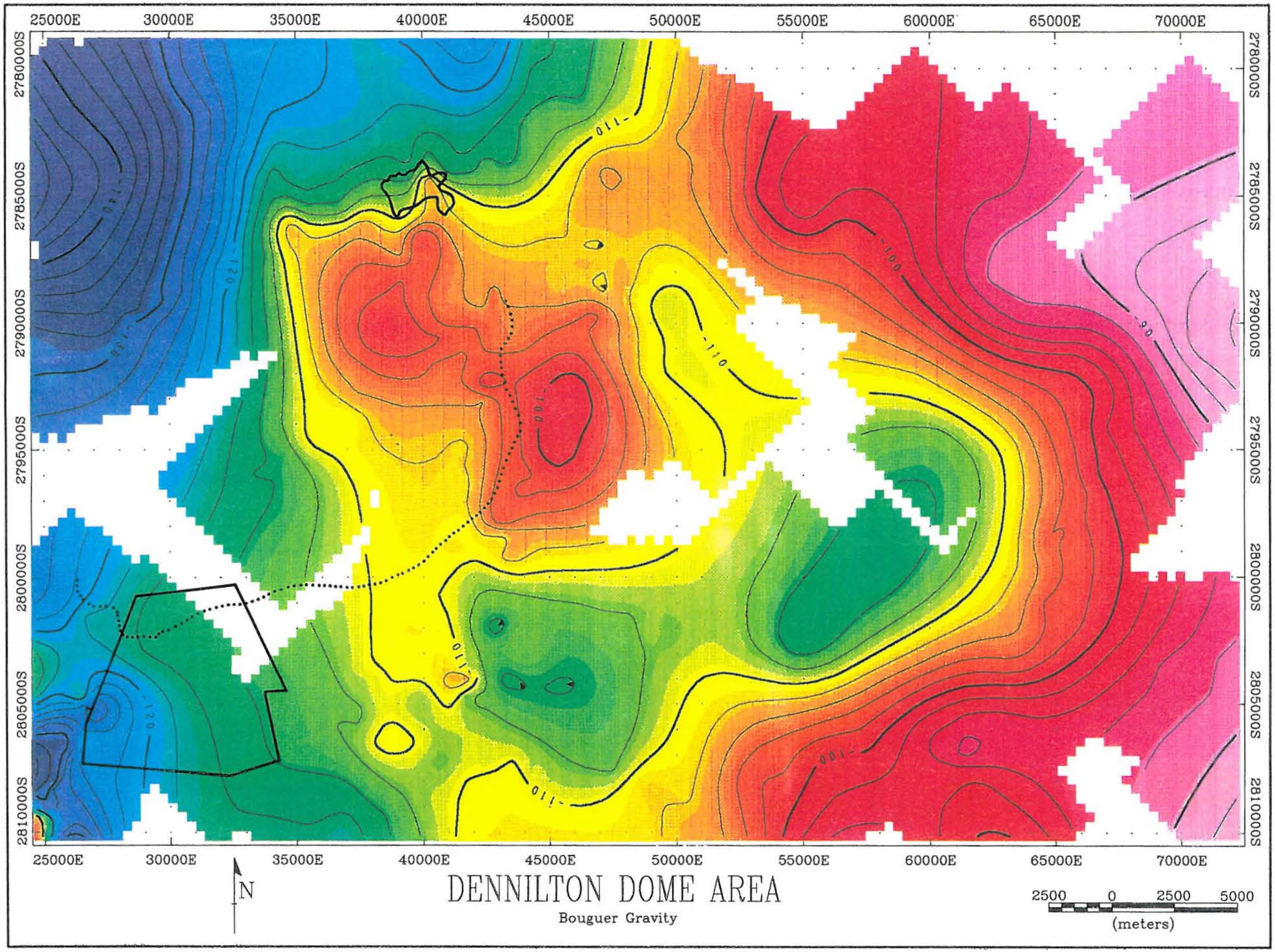


FIGURE 24

AEROMAGNETIC CONTOUR MAP
RIETFONTEIN 70JS

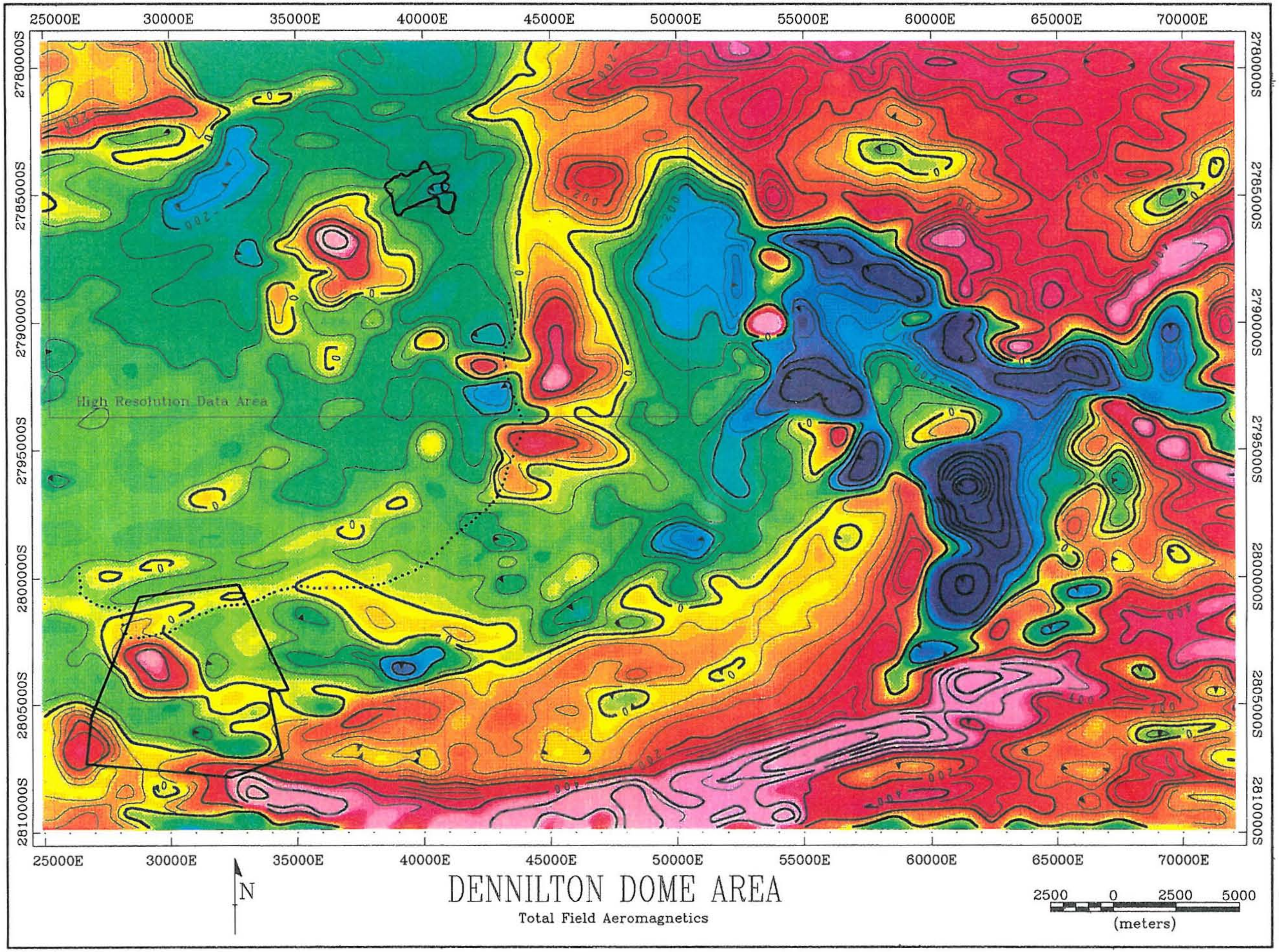
SCALE 1 : 50 000



DENNILTON DOME AREA

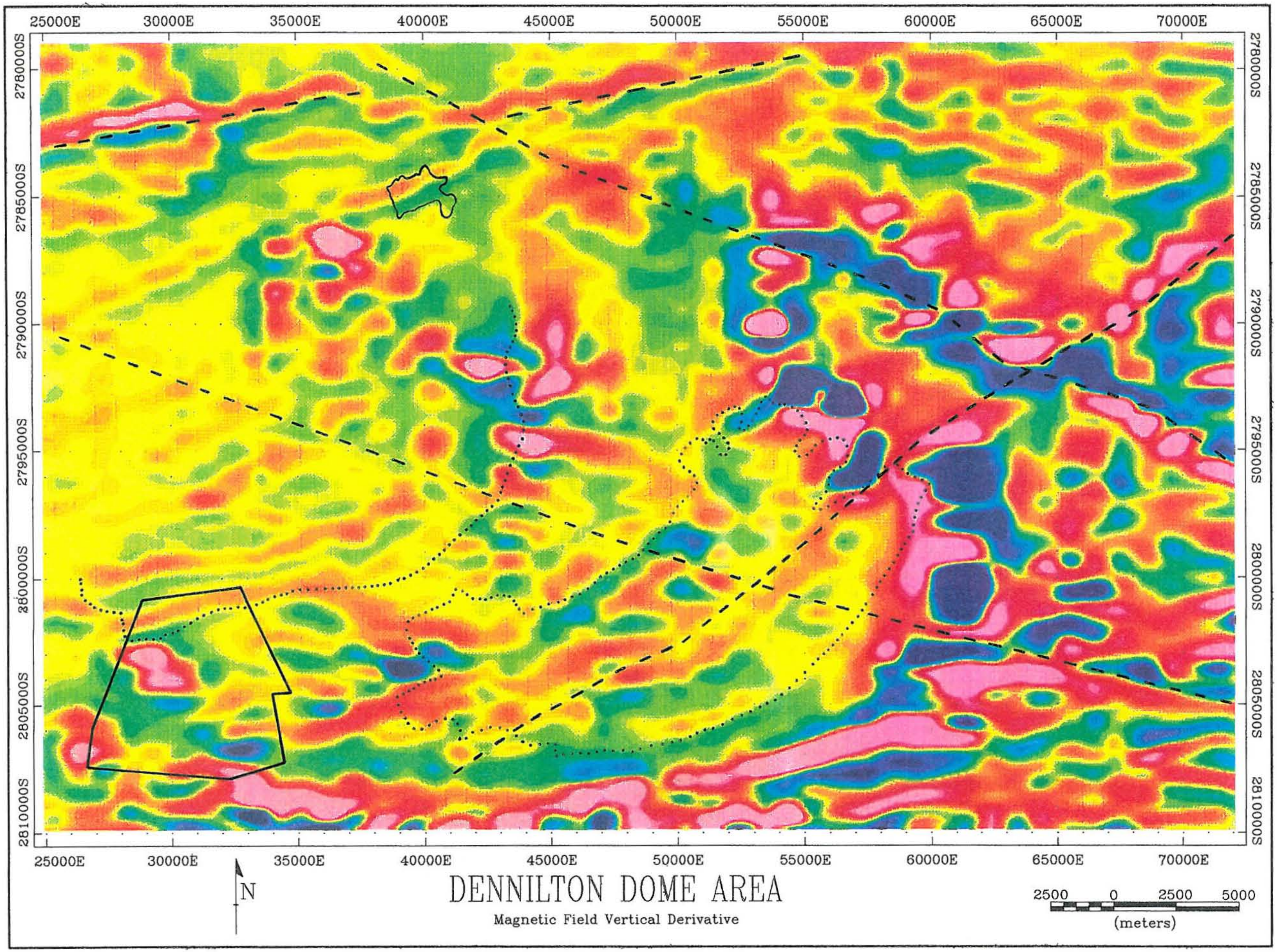
Bouguer Gravity

FIGURE 25



25000E
30000E
35000E
40000E
45000E
50000E
55000E
60000E
65000E
70000E
2780000S
2785000S
2790000S
2795000S
2800000S
2805000S
2810000S
High Resolution Data Area
N
DENNILTON DOME AREA
Total Field Aeromagnetics
2500 0 2500 5000
(meters)

FIGURE 26



DENNILTON DOME AREA

Magnetic Field Vertical Derivative

FIGURE 27

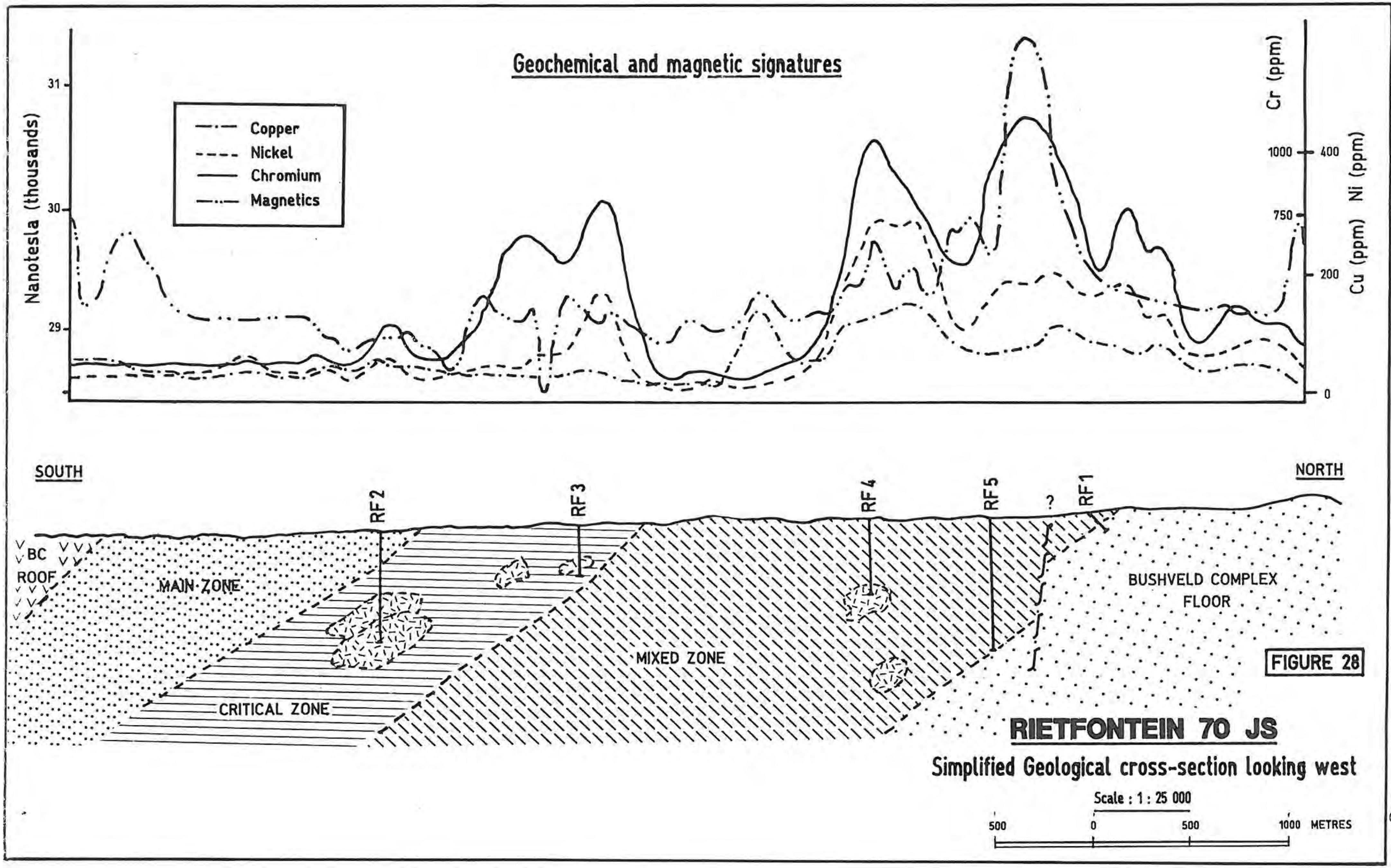


FIGURE 28

RIETFONTEIN 70 JS

Simplified Geological cross-section looking west

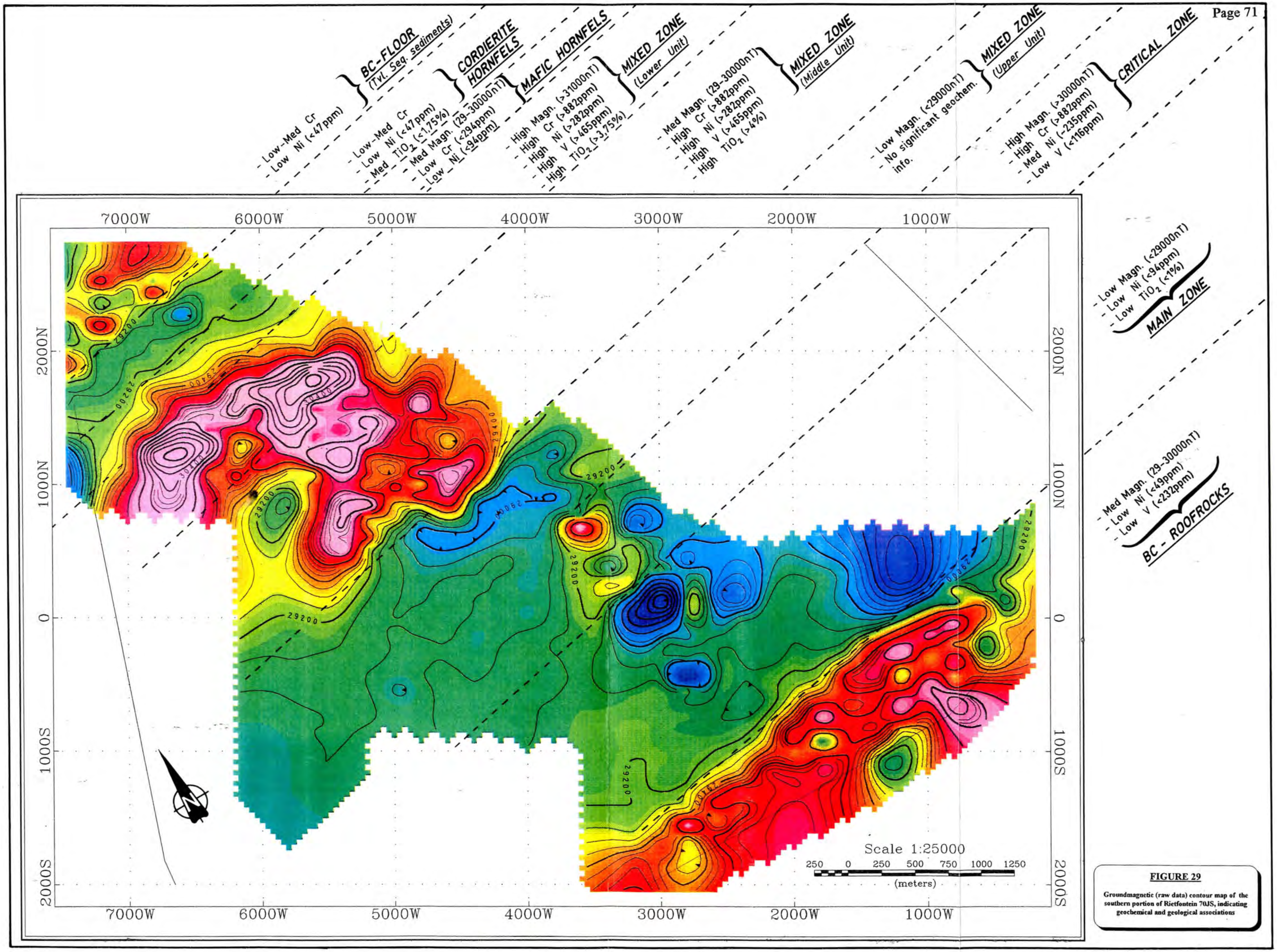


FIGURE 29

Groundmagnetic (raw data) contour map of the southern portion of Rietfontein 70JS, indicating geochemical and geological associations

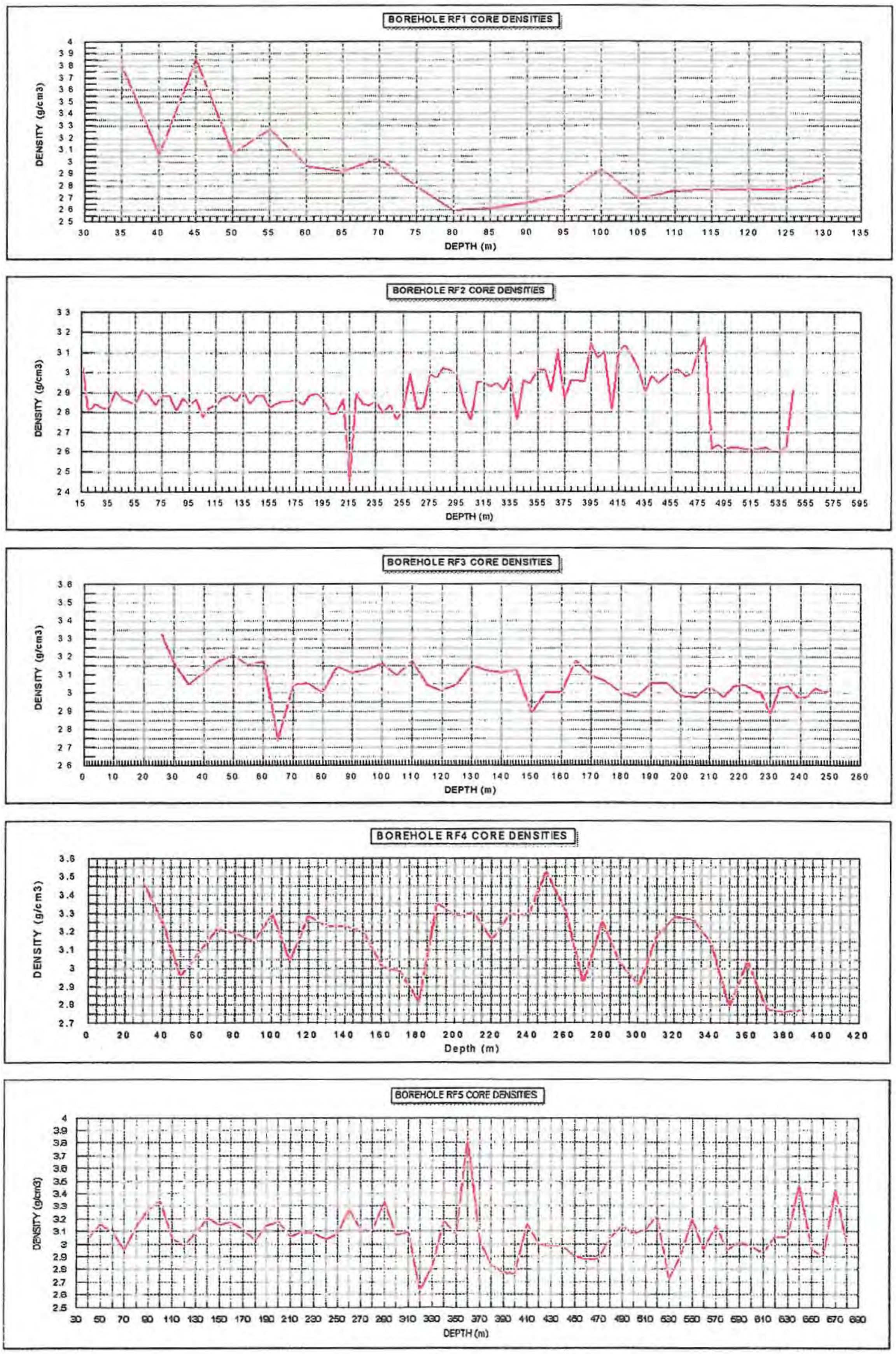


FIGURE 30. DENSITY GRAPHS FOR BOREHOLES RF1 - RF5 ON RIETFONTEIN 70JS

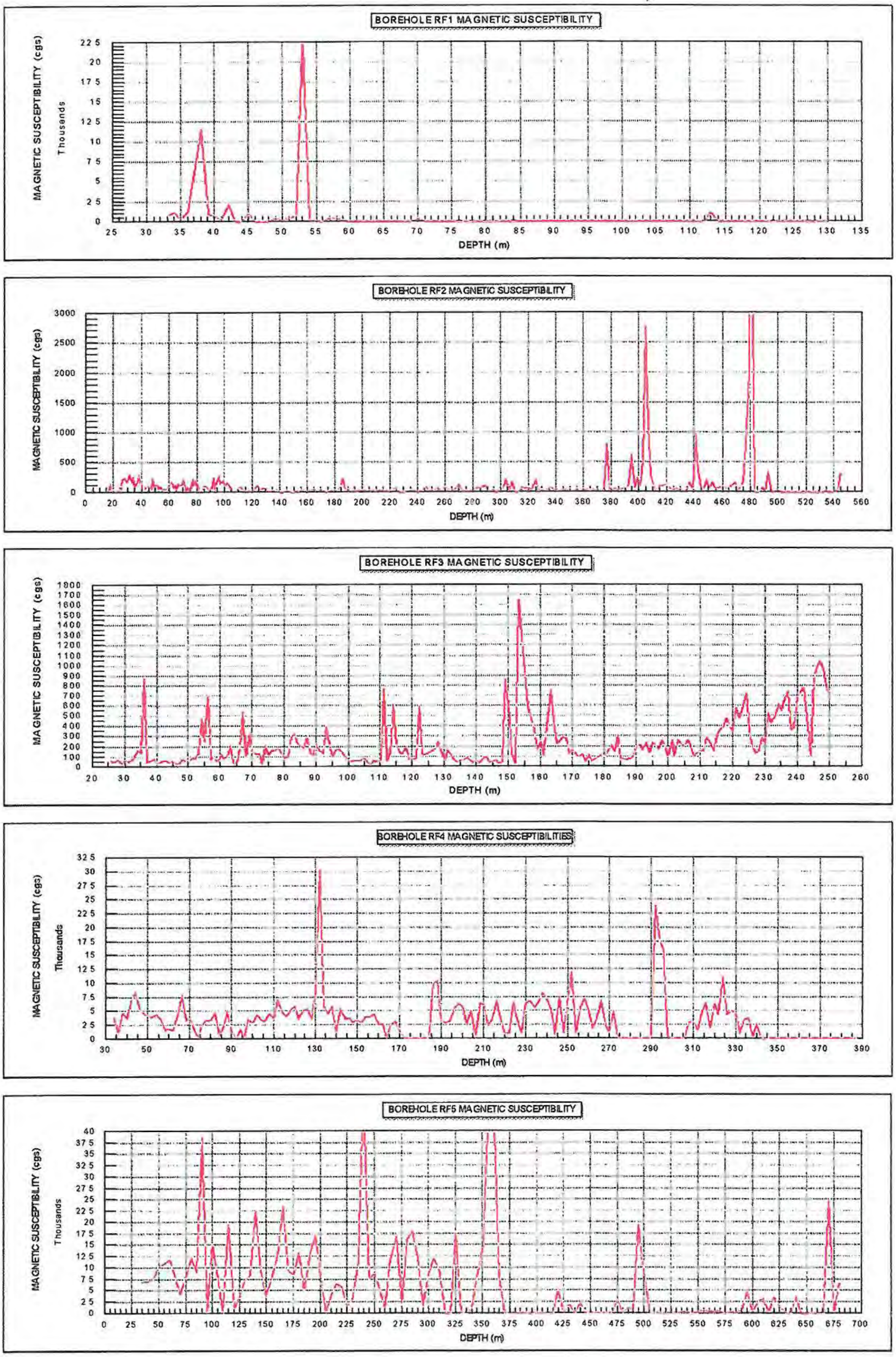


FIGURE 31. MAGNETIC SUSCEPTIBILITY FOR BOREHOLES RF1 - RF5

8. DISCUSSION AND CONCLUSIONS

The objectives of this study to provide an overview of the geological, geochemical and geophysical signatures of the study area were met. As far as furnishing a meaningful stratigraphic correlation of the Rietfontein area with the normal Rustenburg Layered Sequence is concerned, it is evident that the mafic- and ultramafic lithologies on the southern and eastern flank of the Dennilton dome should be treated as a separate entity.

Although certain analogies and relationships such as correlating the magnetite-gabbros on Rietfontein 70JS with Subzone B of the standard Bushveld Complex Upper Zone stratigraphy could be drawn on grounds of incompatible trace element geochemistry, the hybrid nature and geological/geochemical complexity of the rocktypes in the study area does not render itself to a meaningful stratigraphic correlation. The intrusion of pre- and syn-Rustenburg Layered Suite gabbroic sills in the vicinity of the Bushveld Complex marginal rocks, further complicates any attempts at any stratigraphical correlations of these hybrid rocks. The relatively unaltered Main Zone gabbros on Rietfontein does, however, conform on a broad basis to normal Main Zone lithologies on grounds of geochemistry and petrography.

It is advocated that during the Bushveld Complex intrusion event, hot magma was removed from the underlying magma chamber. This ascending magma created a volume imbalance, which resulted inter alia in the updoming of certain prevailing basement features such as the Dennilton Dome. Eriksson et.al. (1995) agree to the possibility of localised updoming of the basin floor, but argues that another cause for the updoming event could be syn-sedimentary tectonism during late-Pretoria Group to Rooiberg Group times as a result of the ascending Rooiberg acidic lavas, which led to central basinal thermal updoming.

The argument is put forward that the Mineral Range Fragment (figure 2) is in actual fact a large xenolith floating in a sea of mafics, after being detached from the rest of the Pretoria Group sediments at some stage during the intrusion of the Bushveld Complex. The sediments of the Mineral Range Fragment consist of rocktypes that resort under the Magaliesberg Formation, Lakenvallei Formation and Steenkampsberg Formation of the Pretoria Group. The absence of formations such as the Vermont Formation can possibly be ascribed to the low resistance to weathering of the mudstones of this unit, resulting in the non-exposure thereof.

The sediments of the Mineral Range Fragment were intruded by gabbroic and noritic sills. Eriksson et.al. (1987) claimed that the equivalent of these sills in the Rustenburg area that intruded the upper Transvaal Sequence to be genetically related to the Rustenburg Layered Suite. These Transvaal sills were emplaced during pre- and syn-Bushveld Complex intrusion times. The remaining basement-attached sediments that are in contact with the mafics on Rietfontein 70JS thus belongs to the Daspoort Formation of the Transvaal Sequence.

On the basis of geophysical interpretations and evidence in the field, it is highly likely that the Bushveld Complex mafic phase on the eastern flank of the Dennilton Dome is connected to the mafics to the south of the Aangewezen Basin, and forms a continuous sequence below a cap of granitic and granophyric roof-rocks. A northward extension towards Marble Hall can also not be excluded.

Three possible explanations are posed to elucidate the enigma of the occurrence of Critical Zone lithologies stratigraphically above the magnetite-bearing rocktypes of the Upper Zone. It is assumed that the Critical Zone was already in place and solidified at the time of Upper Zone intrusion.

1. The Upper Zone magma possibly intruded into weak zones below the Critical Zone conceivably caused by the updoming of the Dennilton Dome, thus following the path of least resistance. Walraven (1974) makes mention of two locations north of the Pilansberg Alkaline Complex in the western lobe of the Bushveld complex, where the ferro-gabbro units cut discordantly across older layers of the mafic sequence as far as the underlying Transvaal Sequence strata. The magnetite layers developed within the ferro-gabbros adapt the new attitude of the cross-cutting ferro-gabbros which were subsequently subjected to a folding event.

2. An alternative scenario is premised whereby large fragments of crystallised Critical Zone were broken off and transported by the intruding Upper Zone magma, together with various foreign fragments (e.g. hornfels). These large Critical Zone and Bushveld floor "xenoliths" were obviously exposed to re-melting and re-crystallization processes, resulting in a myriad of diverse rocktypes of complicated hybrid

compositions. The latter ideology may also explain the erratic distribution of the anomalous Cu, Ni, Cr and PGE values in close proximity to these "xenoliths", which then could represent a Plat Reef type model whereby contamination on certain lithological interfaces induced precipitation of the various ore minerals.

3. It is furthermore suggested that the updoming process of the Dennilton Dome was re-activated several times during the emplacement of the Bushveld Complex layered suite. In accordance with theories posed by Scoon and Mitchell (1994), the magnetite-rich gabbros and pegmatites may have formed by magmatic replacement of existing cumulates in response to infiltration of Fe-rich melts. In a normal Bushveld Complex set-up these Fe-rich replacement units become progressively enriched in Fe and Ti oxides with stratigraphic height, where preferential replacement of anorthositic cumulates takes place (Scoon and Mitchell, op.cit.) to result in the formation of essentially Fe-Ti-rich pegmatites. This differentiation with height is partly due to fractional crystallisation of the more evolved magmas.

Considering the fact that magnetite was identified as a cumulus phase in magnetite-gabbros on Rietfontein together with the layered effect displayed by these Fe-gabbros, as well as the discordant nature of certain Fe-Ti-rich pyroxenitic pegmatites, a combination of the latter three theories would provide a solution for the genesis of the Fe-rich lithologies in the study area.

The mere existence of a Critical Zone type environment with cumulus chromite and plagioclase, elevated Ni, Cr and PGE values should provide an incentive for further exploration in the area. Critical Zone type rocks are present in an erratic fashion on the southeastern and southern rim of the Mineral Range Fragment. These Critical Zone rocktypes, bearing cumulus chromite and displaying elevated PGE values were observed on the farm Blaauwbank 168JS. The latter Cr and PGE-bearing units are present stratigraphically below the Tennis Ball Marker, and seem to be correlatable with the Critical Zone on Rietfontein 70JS, even if it is located on different sides of the Steelpoort Fault.

On Rietfontein 70JS the possibility exists that the original mineralization may have been destroyed or dispersed by the apparent transgressive character of the Upper Zone lithotypes. Bearing the geophysical signature, and in particular the magnetics, of the rocktypes on the eastern flank of the Dennilton Dome in mind, it becomes clear that the more evolved, Fe/Ti-rich rocks either thins or becomes absent as one progresses further northwards from Rietfontein 70JS. The Bushveld Complex roof-rocks seemingly transgresses the mafic phase rocks, resulting in a complex condition whereby mafic and ultramafic units stratigraphically below the Upper Zone can directly underly the acidic roof.

It is therefore postulated that the potential for viable PGE's, Au, Cu and Ni within a,
i) Merensky Reef-type scenario, and ii) contact-type (Plat Reef style) situation under a thin veneer of acid Bushveld Complex roof-rocks, appears feasible. It is thus imperative that other guidelines and parameters be employed to demarcate these favourable units viz. the *Critical Zone norites and feldspathic pyroxenites*, as well as the *contact between the ultramafics and Pretoria Group sediments* on the eastern flank of the Dennilton Dome, where economically significant units viz. Merensky Reef may be developed at shallow depths.

The two conspicuously prominent gravity anomalies just to the south and south-southeast of Groblersdal (figure 25) certainly warrant further investigation. The nature of these anomalies are possibly indicative of the existence of mineralized Bushveld Complex mafics/ultramafics below the acidic roof-rocks (easternmost anomaly), and perhaps the presence of a *skarn-type orebody* (westernmost anomaly) where the Nebo Granites and Rashoop Granophyres are in contact with the carbonate-rich lithotypes of the Malmani Subgroup . The latter dolomitic units may also be in contact with Bushveld ultramafics in depth, which unequivocally poses an additional exploration target.

In view of the geochemical results that were encountered on Rietfontein, it is quite clear that the elements Cu, Ni, TiO_2 and Cr determined by XRF ostensibly represent the most suitable pathfinder elements for locating potentially viable PGE mineralization. Similarly, the element ratios such as Cu/Ni*Cr and Cr/Ni*TiO_2 proved to be invaluable in discriminating between different lithological units and also in providing answers as to the nature of the mineralization, when present. The -80# fraction sieve adequately enhanced relatively anomalous areas in soils.

The structural framework seems to have had very limited influence on the proposed PGE-bearing ore deposit models. Evidently, prospective faults and fractures and their associated patterns and character may provide opportunities for hydrothermal/epigenetic mineralization. It is argued that the Kwagga-Mamelodi Lineament (KML) which is undeniably a deep-seated, cross-continent structural feature, had a significant controlling effect on essentially epigenetic mineralization in the study area and it's environs. Numerous Sn, Mo, Ag, Cu, Au, Ni, As, Co, Zn and Pb occurrences are included in the KML trend between the Spitskop Alkaline Complex and Pretoria. The interface between the Klipkloof- and Nebo Granites also seems to play a role as far as mineralization related to the Bushveld Complex granites in the area is concerned.

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APPENDICES A to T

PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 31-03-1995
FARM: RIETFONTEIN 70JS	0.00 to 23.00 metres	Scale: 1:100
CONTRACTOR: GFC	MACHINE: TONE TL	

Geological Description	Depth m	Legend	Depth Metres
0.00 to 11.00 m: Percussion pilot hole (predominantly micaceous pyroxenite & hornfels chips).	0.00		10.00
11 to 32.11 m: Rubble, mostly hornfels and quartzite SCREE.	11.00		20.00

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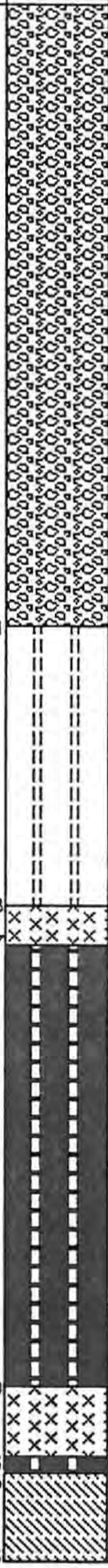
PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 31-03-1995
FARM: RIETFONTEIN 70JS	23.00 to 46.00 metres	Scale: 1:100
CONTRACTOR: GFC	MACHINE: TONE TL	

Geological Description	Depth m	Legend	Depth Metres
			30.00
32.11 to 36.18 m: Slighty magnetic, medium-grained GABBRO. Concentration of mica (biotite) at 36,03-36,13m.	32.11		
36.18 to 36.77 m: Fine-grained granitic intrusion (sill?), with irregular top and bottom contacts.	36.18		
36.77 to 43.20 m: Coarse-gr, MAGNETITE-GABBRO. Micaceous in places. Concentration of magnetite at 37,12-37,22m; 37,51-38,29m; 38,42-38,72m. Minor disseminated sulphides in places Pyroxenitic unit at 39,36-39,54m. Magnetite-rich zones at 39,72-39,76m; 40,47- 41,19m; 42,15-42,42m; 42,70-42,98m. Altered, feldspar-rich zone at 3976-39,95m.	36.77		40.00
43.2 to 44.23 m: Granitic INTRUSION, as before. (Irregular contacts).	43.20		
44.23 to 44.46 m: Coarse-grained, MAGNETITE-GABBRO.	44.23		
44.46 to 45.73 m: Coarse-grained, FELDSPATHIC PYROXENITE (apparent dip at contact = 50 degrees). Unit often micaceous. Micaceous, magnetite-rich zone at	44.46		
	45.73		



PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 31-03-1995
FARM: RIETFONTEIN 70JS	46.00 to 69.00 metres	Scale: 1:100
CONTRACTOR: GFC	MACHINE: TONE TL	

Geological Description	Depth m	Legend	Depth Metres

44,96-45,36m.

45.73 to 47.07 m:
Granitic intrusion as before, with steep irregular contacts. Relatively small pegmatitic pyroxenitic fragments within granitic matrix.

47.07 to 47.60 m:
Pyroxenitic PEGMATOID (Pyroxene, feldspar,minor mica) with minor disseminated chalcopyrite and pyrrhotite.

47.6 to 48.88 m:
Granitic sill as above. Sharp irregular contacts. Zone of magnetite-bearing gabbro + minor disseminated sulphides at 48,08-48,38m. Pyroxenitic band at 48, 40-48,50m.

48.88 to 48.92 m:
Micaceous PEGMATOID, as before.

48.92 to 49.36 m:
Coarse-grained PYROXENITE with some disseminated sulphides (chalcopyrite & pyrrhotite) and minor olivine (?) present.

49.36 to 50.08 m:
Micaceous PEGMATOID, as above.

50.08 to 50.41 m:
Coarse-grained PYROXENITE, as before, with disseminated sulphides in places. Top contact very sharp and conspicuous @ apparent dip = 40 degrees).

50.41 to 51.11 m:
PEGMATOID with minor sulphide mineralization.

51.11 to 51.61 m:
Coarse-grained, sulphide-bearing PYROXENITE. Top contact app. dip = 40 degrees.

51.61 to 52.35 m:
Coarse-grained, magnetite-bearing GABBRO, with some disseminated sulphides.

52.35 to 53.32 m:
Medium-grained, non-magnetic PYROXENITE. Magnetite + disseminated sulphides (Pyrrhotite & chalcopyrite) at 52,99m-53,32m.

53.32 to 54.41 m:
Coarse-grained, non-magnetic GABBRO with minor disseminated sulphides. Micaceous zone at 53,77-53,87m. Becomes somewhat anorthositic at base of unit.

54.41 to 56.29 m:
Coarse-grained, non-magnetic PYROXENITE. Increase in disseminated sulphide content from 54,85m. Sulphide blebs in places. Feldspathic patch at 55,65-55,89m

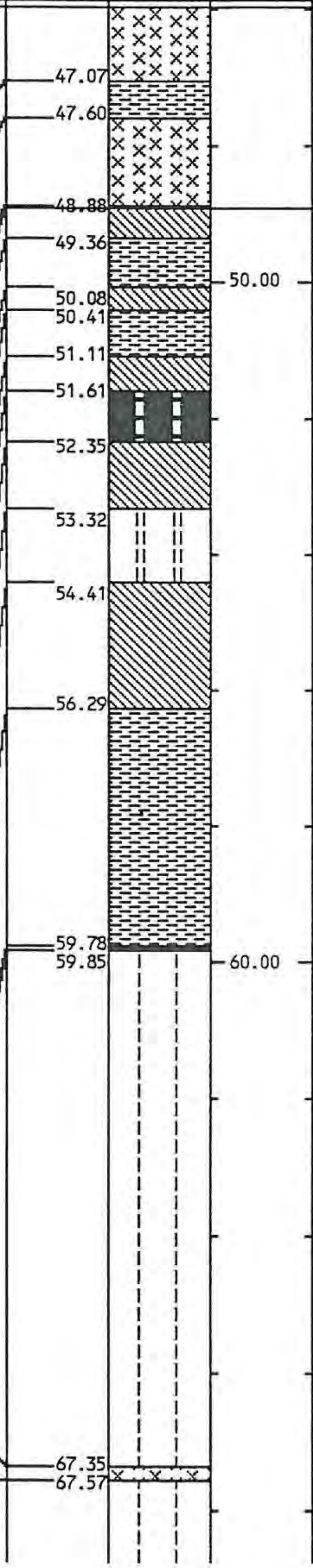
56.29 to 59.78 m:
Pyroxenitic PEGMATOID with feldspar-rich units in places. Becomes medium-coarse grained with drastic increase in feldspar content (with fine disseminated sulphides) from 59,28m.

59.78 to 59.85 m:
Magnetite-rich band with abundant disseminated sulphides.

59.85 to 67.35 m:
Medium-grained, non-magnetic NORITE, with minor disseminated sulphide mineralization. Unit appears fairly homogenous.

67.35 to 67.57 m:
Fine-grained granitic intrusion. (app.dip = 70 degrees).

67.57 to 69.94 m:
Medium-grained, non-magnetic NORITE, with minor disseminated sulphides in places. Unit often becomes more gabbroic in parts.



LOGGED BY: S.P.CROUS	APPENDIX A	Page 3 of 6.

PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 31-03-1995
FARM: RIETFONTEIN 70JS	69.00 to 92.00 metres	Scale: 1:100
CONTRACTOR: GFC	MACHINE: TONE TL	

Geological Description	Depth m	Legend	Depth Metres

69.94 to 70.20 m:
Micaceous PEGMATOID, as before.

70.2 to 70.58 m:
Granitic INTRUSION, as before.

70.58 to 70.88 m:
Fine-grained, non-magnetic GABBRO.

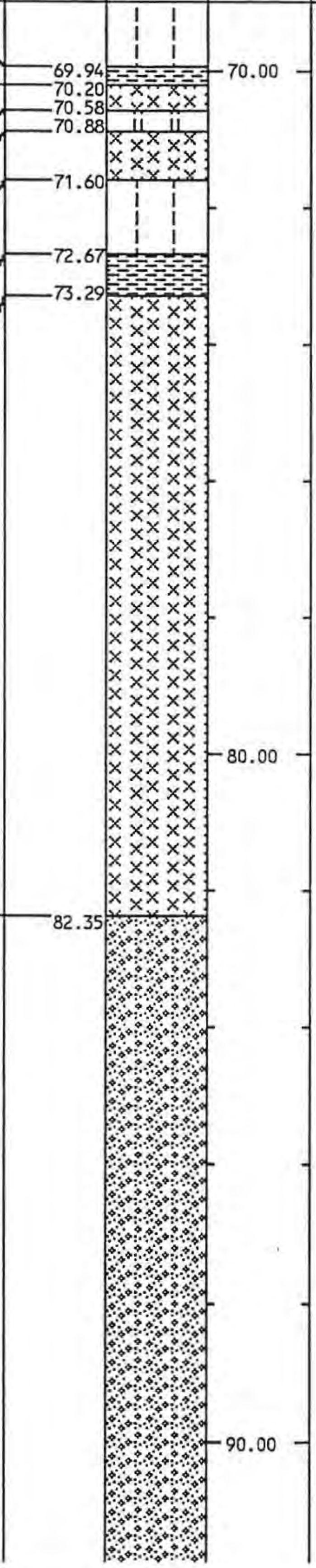
70.88 to 71.60 m:
Granitic INTRUSION. (change from NQ-NXM @ 71,49m).

71.6 to 72.67 m:
Medium-grained, (slightly magnetic) NORITE, with disseminated chalcopyrite and pyrrhotite and minor biotite. Increase in sulphide content towards base of unit.

72.67 to 73.29 m:
Non-magnetic, micaceous PEGMATOID (mica, pyroxene, feldspar) with some disseminated chalcopyrite.

73.29 to 82.35 m:
Fine-medium grained granitic INTRUSION, with angular fragments of fine-grained pyroxenite in granitic matrix. Brecciated appearance.

82.35 to 93.67 m:
Mixed zone of meta-sediment, granitic sill material and hornfels. (Hornfels & meta-sediment = xenoliths?).



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PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 31-03-1995
FARM: RIETFONTEIN 70JS	92.00 to 115.00 metres	Scale: 1:100
CONTRACTOR: GFC	MACHINE: TONE TL	

Geological Description	Depth m	Legend	Depth Metres
93.67 to 129.20 m: HORNFELS, green, glassy in appearance, with abundant amphiboles and micas. Some pyrite & pyrrhotite blebs in vicinity of 113-114m, associated with thin carbonate fractures.	93.67		100.00 110.00

LOGGED BY: S.P.CROUS	APPENDIX A	Page 5 of 6.

PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 31-03-1995
FARM: RIETFONTEIN 70JS	115.00 to 130.55 metres	Scale: 1:100
CONTRACTOR: GFC	MACHINE: TONE TL	

Geological Description	Depth m	Legend	Depth Metres
			120.00
129.2 to 130.55 m: Fine-grained, micaceous meta-sediment. E.O.H.= 130,55m.	129.20		130.00
End of hole at 130.55 metres.	130.55		

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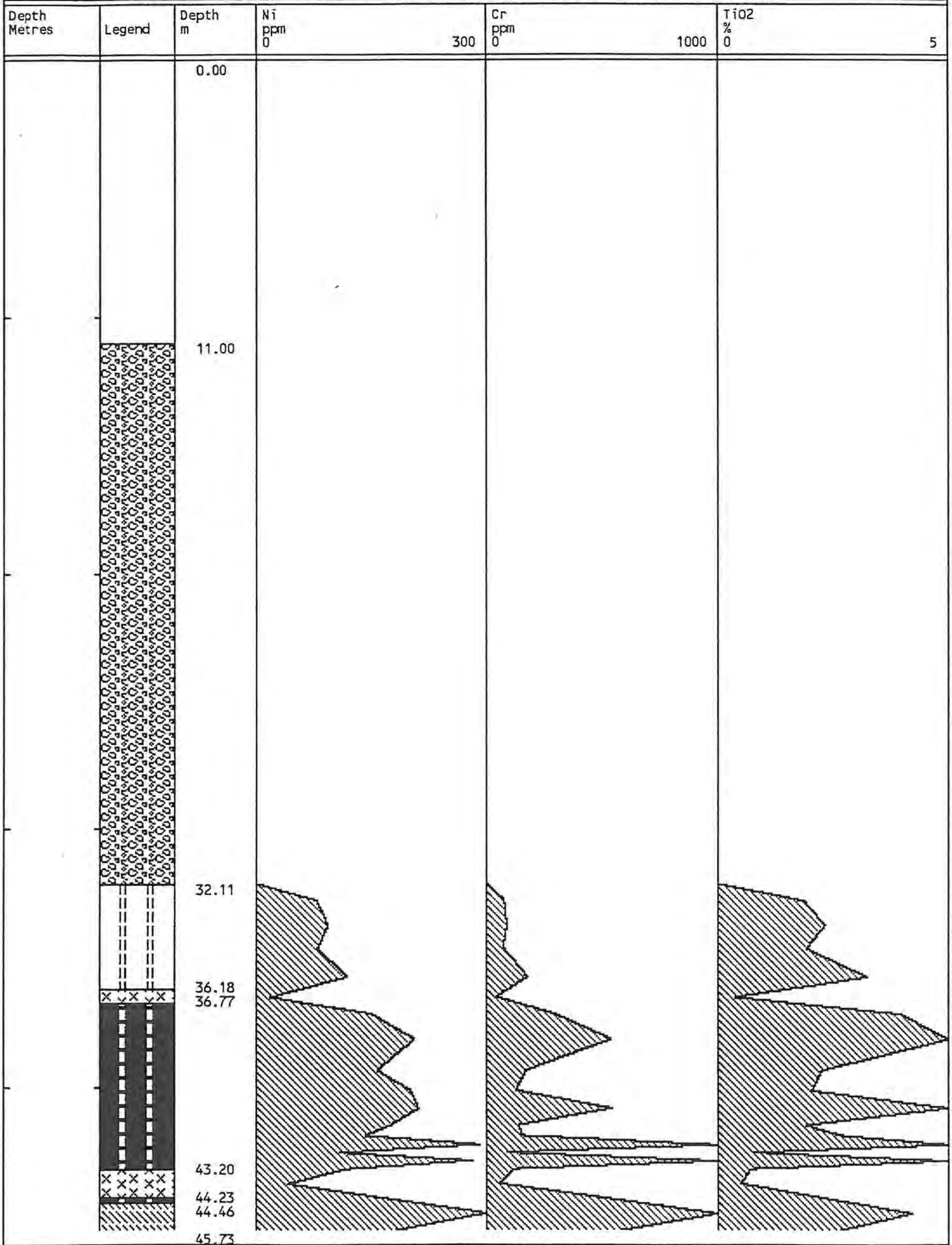
APPENDIX A

PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 04-04-1995
FARM: RIETFONTEIN 70JS	0.00 to 46.00 metres	Scale: 1:200

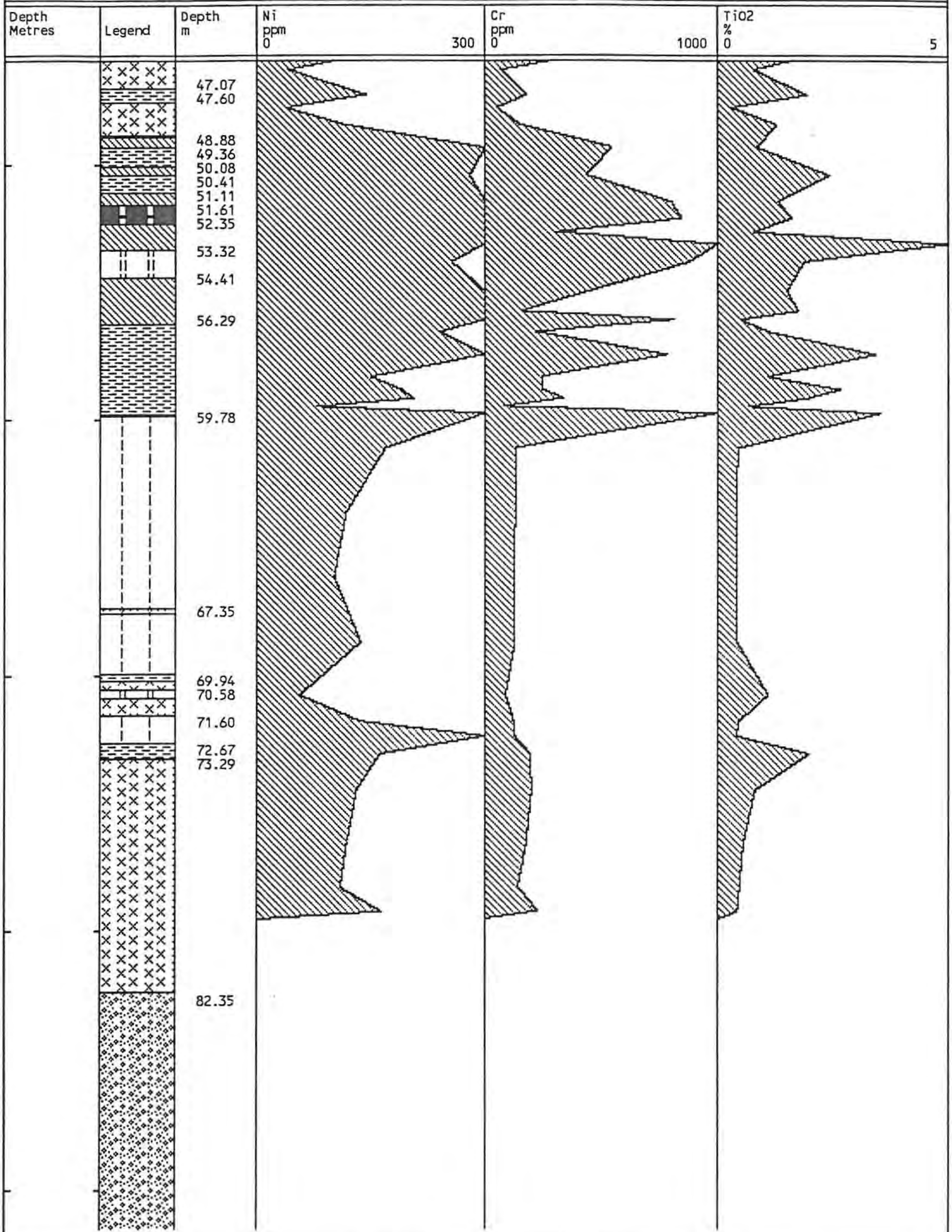
ROUTINE GEOCHEMICAL PROFILES



APPENDIX B

PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 04-04-1995
FARM: RIETFONTEIN 70JS	46.00 to 92.00 metres	Scale: 1:200

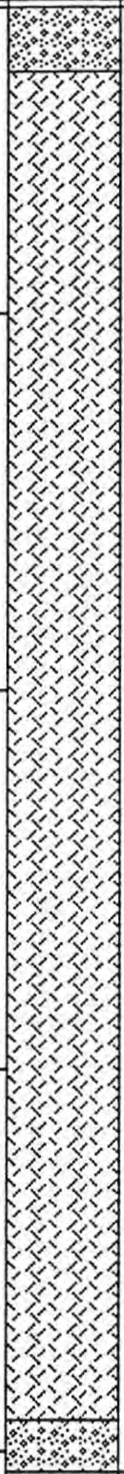
ROUTINE GEOCHEMICAL PROFILES



APPENDIX B

PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 04-04-1995
FARM: RIETFONTEIN 70JS	92.00 to 130.55 metres	Scale: 1:200

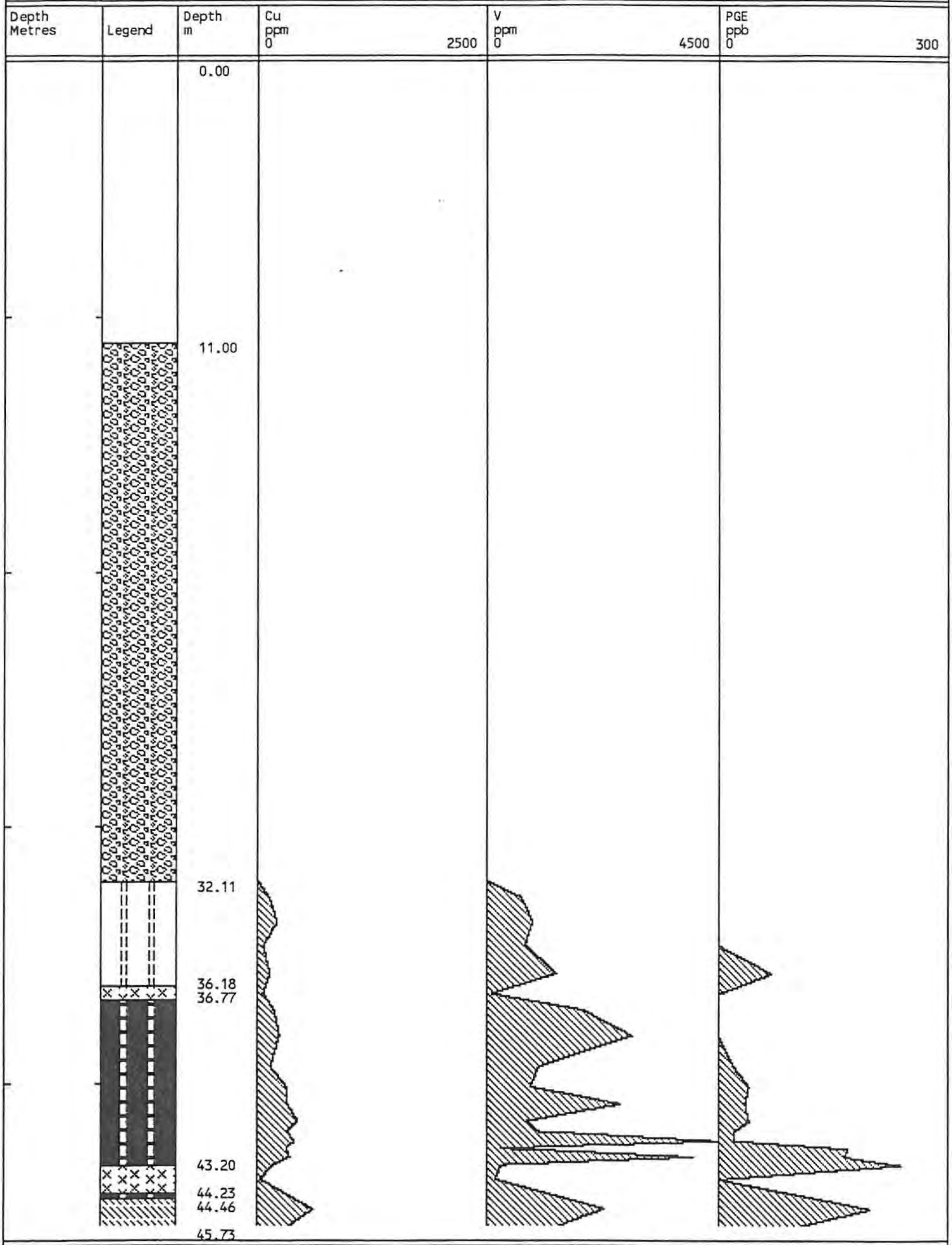
R O U T I N E   G E O C H E M I C A L   P R O F I L E S

Depth Metres	Legend	Depth m	Ni ppm 0 – 300	Cr ppm 0 – 1000	TiO2 % 0 – 5
100.00		93.67 129.20 130.55			

APPENDIX B

PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	0.00 to 46.00 metres	Scale: 1:200

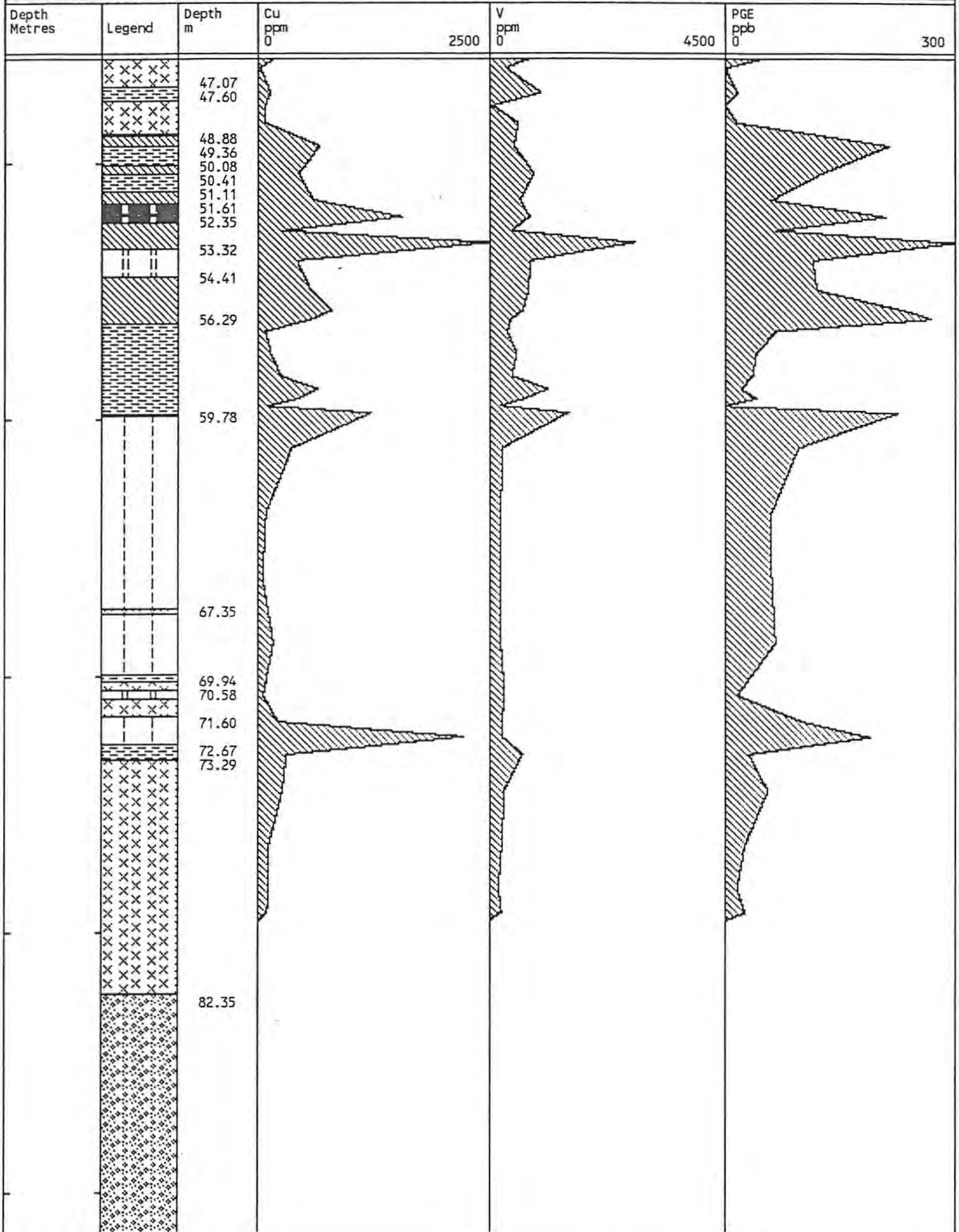
ROUTINE GEOCHEMICAL PROFILES



APPENDIX C

PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	46.00 to 92.00 metres	Scale: 1:200

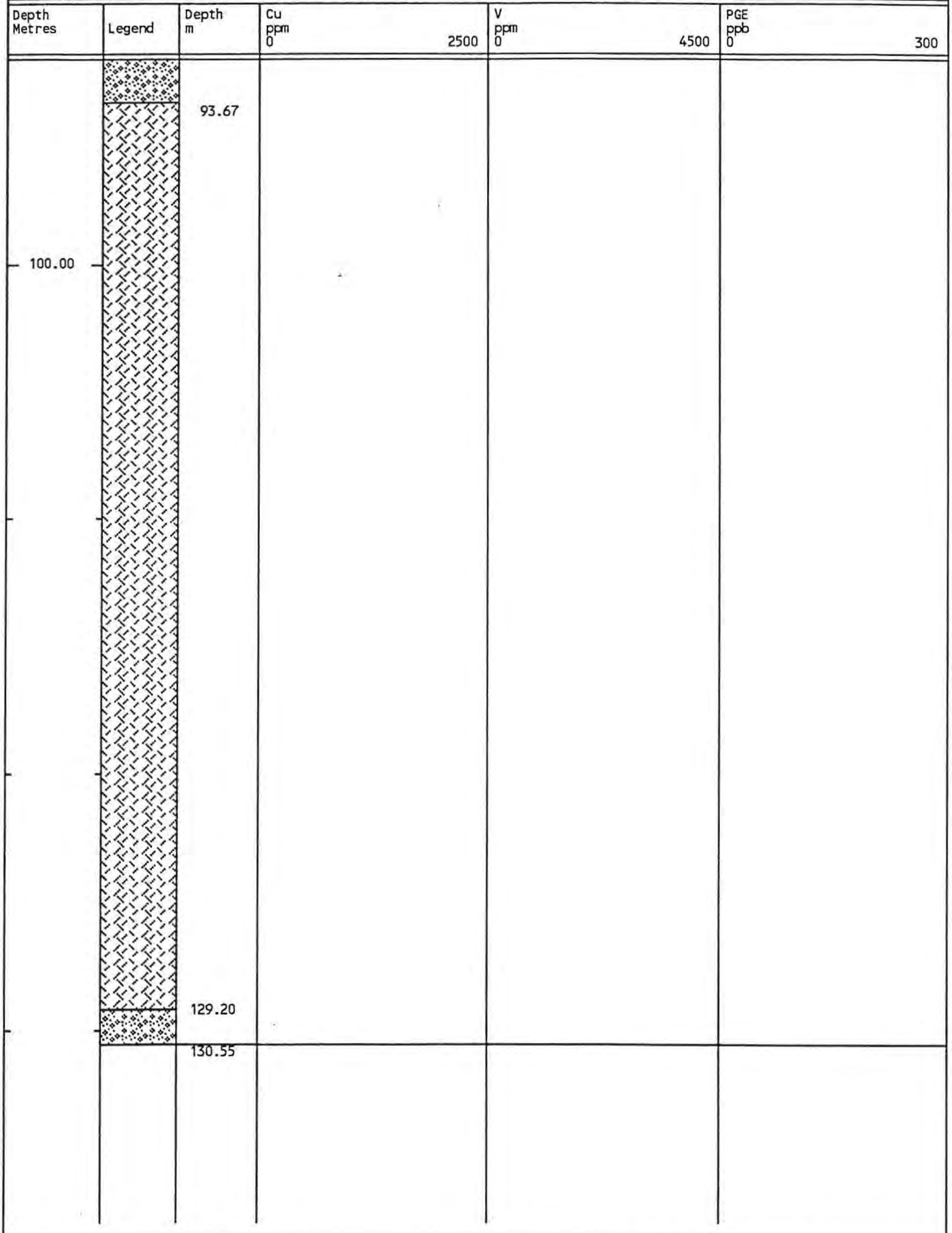
R O U T I N E   G E O C H E M I C A L   P R O F I L E S



APPENDIX C

PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	92.00 to 130.55 metres	Scale: 1:200

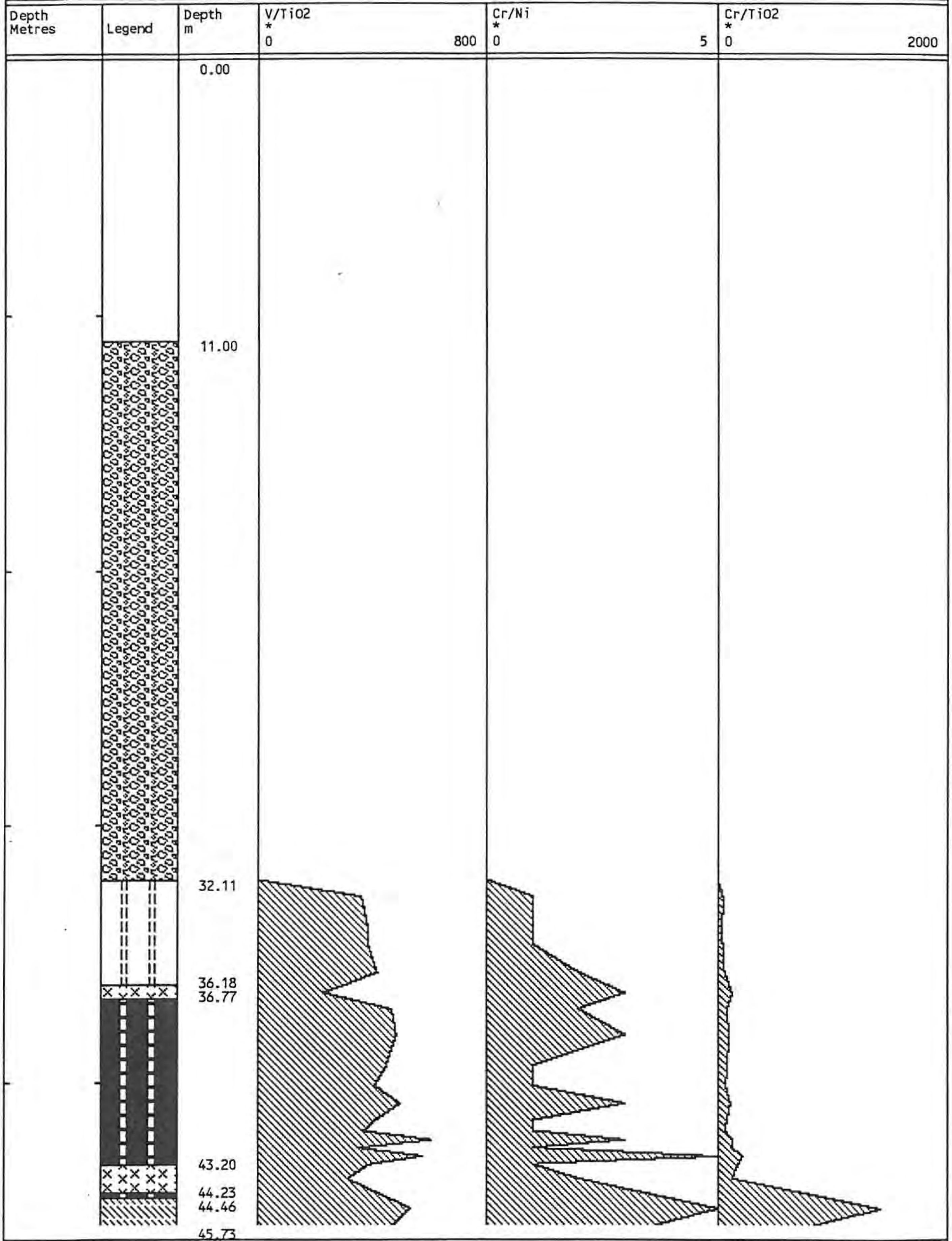
R O U T I N E   G E O C H E M I C A L   P R O F I L E S



APPENDIX C

PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	0.00 to 46.00 metres	Scale: 1:200

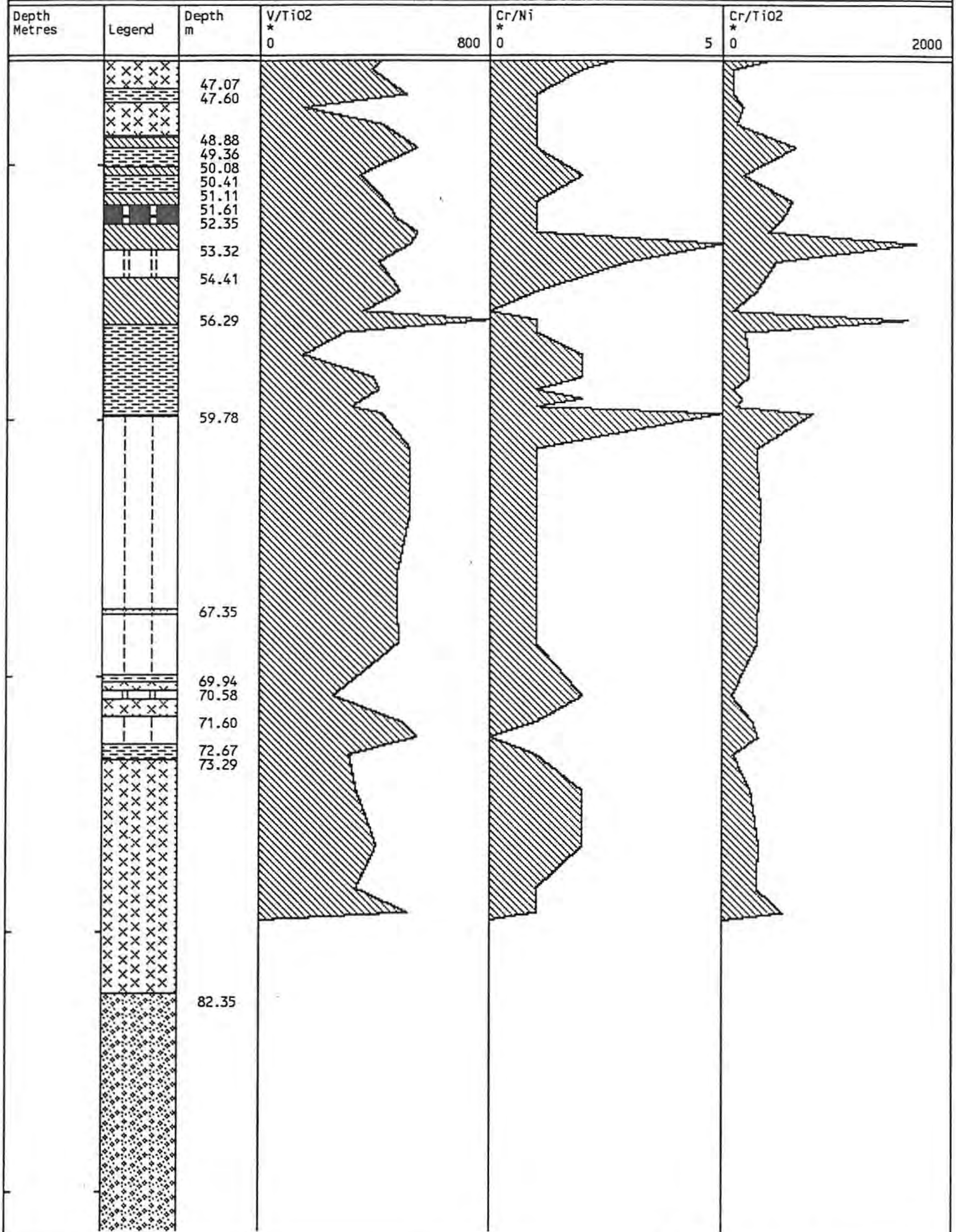
ROUTINE GEOCHEMICAL PROFILES



APPENDIX D

PROJECT: MINERAL RANGE	BOREHOLE NO: RF1(-45)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	46.00 to 92.00 metres	Scale: 1:200

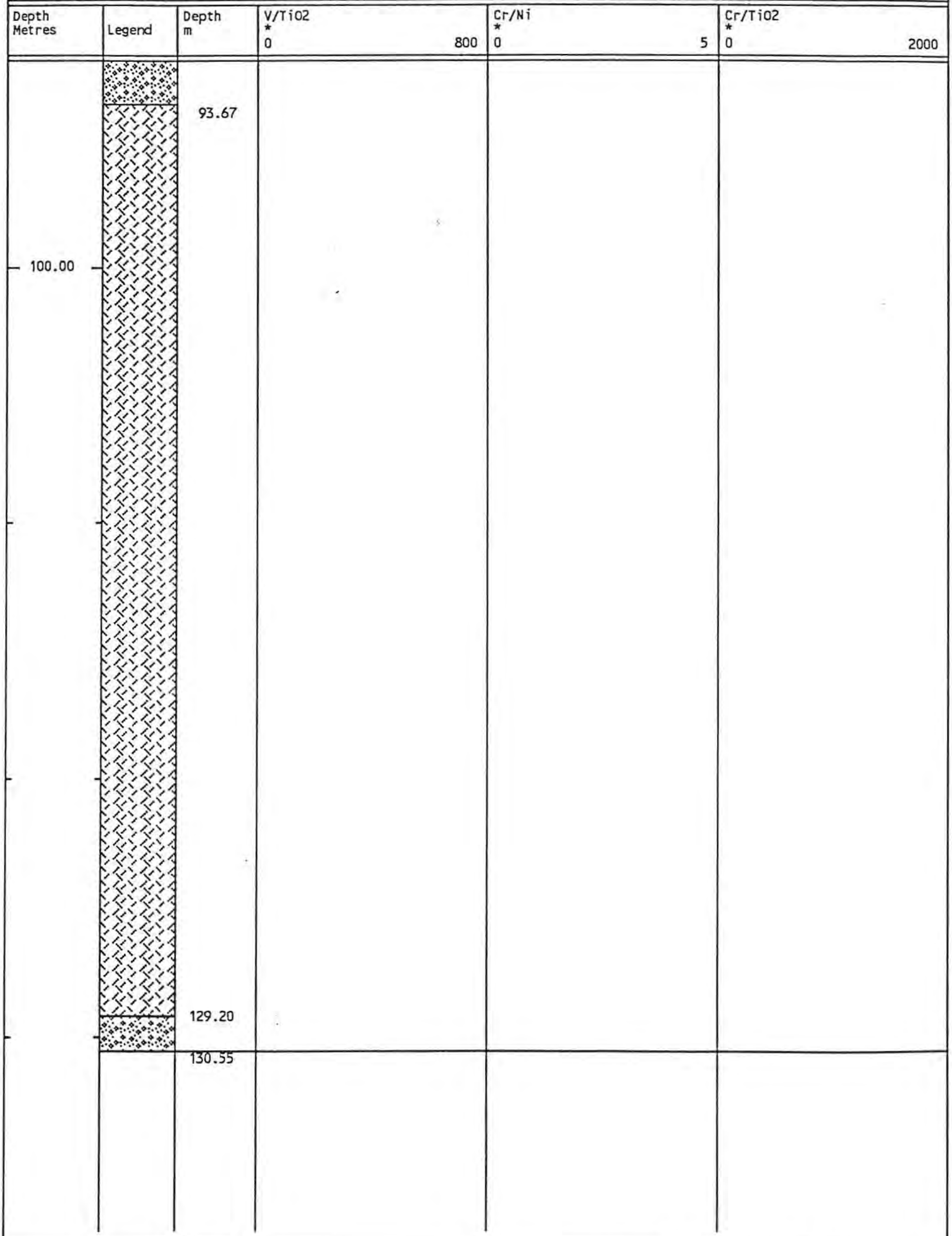
ROUTINE GEOCHEMICAL PROFILES



PROJECT: MINERAL RANGE | BOREHOLE NO: RF1(-45) | Date: 06-04-1995

FARM: RIETFONTEIN 70JS | 92.00 to 130.55 metres | Scale: 1:200

R O U T I N E   G E O C H E M I C A L   P R O F I L E S



APPENDIX D

PROJECT: MINERAL RANGE	BOREHOLE NO: RF2	Date: 29-03-1995
FARM: RIETFONTEIN 70JS	0.00 to 115.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
0.00 to 13.80 m: Augur to 13.00m. Large diameter core to 13.80, poor recovery.	0.00		10.00
13.8 to 20.61 m: Medium-grained GABBRO-NORITE, becomes pyroxenitic in places. Gradational lower contact.	13.80		20.00
20.61 to 22.65 m: Medium grained non - magnetic GABBRO. Feldspars slightly altered (pinkish coloured) in places. Gradational lower contact.	20.61		
22.65 to 23.30 m: Medium grained GABBRO-NORITE. Sharp, distinct lower contact (apparent dip = 19 deg.)	22.65		
23.3 to 24.05 m: Spotted ANORTHOSITE - pyroxene spots of +/- 1 cm diameter. Sharp lower contact.	23.30		30.00
24.05 to 43.70 m: Medium grained GABBRO.Derease in feldspar content below 37.12 m. Gradational lower contact.			40.00
43.7 to 44.79 m: Spotted ANORTHOSITE - pyroxene spots of +/- 1 cm diameter. Sharp lower contact	43.70		
44.79 to 46.30 m: Medium grained NORITE (non - magnetic). Gradational lower contact.	44.79		
46.3 to 71.82 m: medium-grained GABBRO-NORITE. Metaquartzite xenolith @ 70.37 - 70.44 m. Minor disseminated sulphides at base of xenolith. Sharp lower contact.	46.30		50.00 60.00
71.82 to 72.59 m: Fine to medium grained NORITE. Sharp lower contact at apparent dip of 26 degrees	71.82		70.00
72.59 to 103.07 m: Medium-grained GABBRO-NORITE as before. Granitic intrusion @ 82.72 - 82.92 m with irregular contacts. Prominent carbonate / chlorite fractures (fault ?) @ 83.93 - 84.21 m (Dip = 58 degrees). Pyroxenite patches from 98.00 - 102.30m. Gradational lower contact.			80.00 90.00 100.00
103.07 to 123.90 m: Medium grained homogeneous GABBRO. Gradational bottom contact.	103.07		110.00

LOGGED BY: SP CROUS | APPENDIX E |

PROJECT: MINERAL RANGE	BOREHOLE NO: RF2	Date: 29-03-1995
FARM: RIETFONTEIN 70JS	115.00 to 230.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
			120.00
123.9 to 125.09 m: Medium-grained GABBRO-NORITE. Sharp lower contact.	123.90		
125.09 to 125.82 m: Spotted ANORTHOSITE. Pyroxene spots +/- 5 mm.	125.09		
125.82 to 127.10 m: Medium grained GABBRO. Distinct lower contact.	127.10		
127.1 to 129.31 m: Mottled ANORTHOSITE. "Mottled marker" - base of Main Zone ?? Mottles 3 to 6 cm diameter. Decrease in feldspar content of mottles below 128.44 m.	129.31		130.00
129.31 to 135.80 m: Medium grained GABBRO-NORITE (non - magnetic). Gradational lower contact.	135.80		
135.8 to 136.54 m: Medium grained GABBRO. Gradational lower contact.			140.00
136.54 to 140.92 m: Medium grained GABBRO-NORITE (non - magnetic).	140.92		
140.92 to 182.27 m: Medium grained GABBRO. Pegmatite with minor magnetite in places, at 45.70 - 147.72 m in fracture (Dip 75 deg.). Carbonate-qtz common in fracture (fault ?). Pegmatite with chlorite at 162.65 - 162.85 m. Minor disseminated sulphides (chpy,pyrr) associated with pegmat's & fract's. Fract.zone at 177.35m (65 deg).	182.27		150.00 160.00 170.00 180.00
182.27 to 190.00 m: Medium grained GABBRO-NORITE. Minor disseminated sulphides in places (mainly chalcopyrite). Gradational bottom contact.	190.00		
190 to 190.94 m: Medium grained GABBRO. Gradational contacts.	190.94		190.00
190.94 to 215.63 m: GABBRO-NORITE as before, with more gabbroic portions in places. Small carbonate - rich fractures in places. Mixed zone of granitic intrusive material, altered gabbro - norite and carbonate fractures at 196.17 - 199.90m. Gradational lower contact.	215.63		200.00 210.00
215.63 to 226.85 m: Medium grained GABBRO, with minor small carbonate - fractures and sericitization in places. Gabbro - noritic unit at 24.67 - 225.00m. Pyroxenes amphibolitised in places. Gradational contacts.	226.85		220.00
226.85 to 236.43 m:			

LOGGED BY: SP CROUS	APPENDIX E	Page 2 of 5.

PROJECT: MINERAL RANGE	BOREHOLE NO: RF2	Date: 29-03-1995
FARM: RIETFONTEIN 70JS	230.00 to 345.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m
Medium grained GABBRO-NORITE with gabbroic unit at 228.87 - 229.20 m. 2cm steep (75 deg.) quartz-carbonate fracture. Gradational contact.	236.43
236.43 to 245.96 m: Medium grained GABBRO. Feldspars extremely altered in places. Very distinct lower contact.	245.96
245.96 to 254.85 m: Medium-grained peridotite (harzburgite ?). Pyroxenes partially altered to amphiboles, olivine altered throughout. Serpentinization evident in places. Carbonate veining common. Minor sulphide speckling in places. Well defined lower contact.	254.85
254.85 to 259.60 m: Spotted NORITE, with minor chromite blebs and disseminated sulphides in places. Sharp bottom contact.	259.60
259.6 to 261.46 m: Peridotite (Harzburgite), as before. Serpentinized with sharp lower contact.	261.46
261.46 to 278.97 m: Spotted NORITE. Pegmatites at 269,19 - 269,33m; 271,63 - 272,20m; 273,53 - 273, 94m. Pyroxenitic units at 276,84 - 277,12 m; 277,45 - 277,72 m. Norite becomes anorthositic and altered from 275,22 - 276,00 m. Disseminated sulphides (chalcopyrite & pyrrhotite) associated with pegmatite/pyroxenitic zones.	278.97
278.97 to 302.45 m: Medium-grained FELDSPATHIC PYROXENITE. Pegmatitic zones at 278,56-278,66 m; 279,46-279,84m. Chromite rich horizon at 281,59-281,80m. Less feldspathic below 281,80m,with pegmatitic zones(+minor diss.sulphides).Cr blebs at 285,90 & 288,84 Micaceous granitic intrusion at 285,70-288,84m; 298,40-299,80m; 302,24-302,45m.	302.45
302.45 to 318.64 m: Spotted NORITE with small pegmatitic zones in places. Granitic veining at 309,30 - 309,73m. Angular metasedimentary fragment at 318,45 - 318,64 m. 3cm carbonate- rich fracture at 307,07m (app.dip = 40 deg.). Minor disseminated sulphides in places. Distinct lower contact.	318.64
318.64 to 325.04 m: Fine to medium grained FELDSPATHIC PYROXENITE (highly altered in places), often pegmatitic. Hornfels xenolith at 323,07-323,55m. Pegmatite at 324,41-325,04m. Minor disseminated sulphide mineralization associated with xenolith. Sharp lower contact.	325.04
325.04 to 484.80 m: Fine grained (mafic?) HORNFELS with metadsediment fragments (bedding often preserved and contorted) in places. Pegmatitic patch at 351,68 - 352,49 m.	

Depth Metres: 230.00, 240.00, 250.00, 260.00, 270.00, 280.00, 290.00, 300.00, 310.00, 320.00, 330.00, 340.00

LOGGED BY: SP CROUS	APPENDIX E	Page 3 of 5.

PROJECT: MINERAL RANGE	BOREHOLE NO: RF2	Date: 29-03-1995
FARM: RIETFONTEIN 70JS	345.00 to 460.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

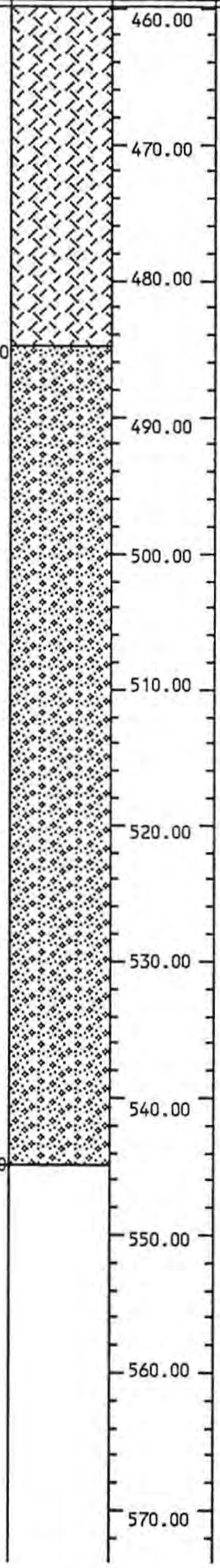
Geological Description	Depth m	Legend	Depth Metres
			350.00
			360.00
			370.00
			380.00
			390.00
			400.00
			410.00
			420.00
			430.00
			440.00
			450.00

LOGGED BY: SP CROUS

APPENDIX E

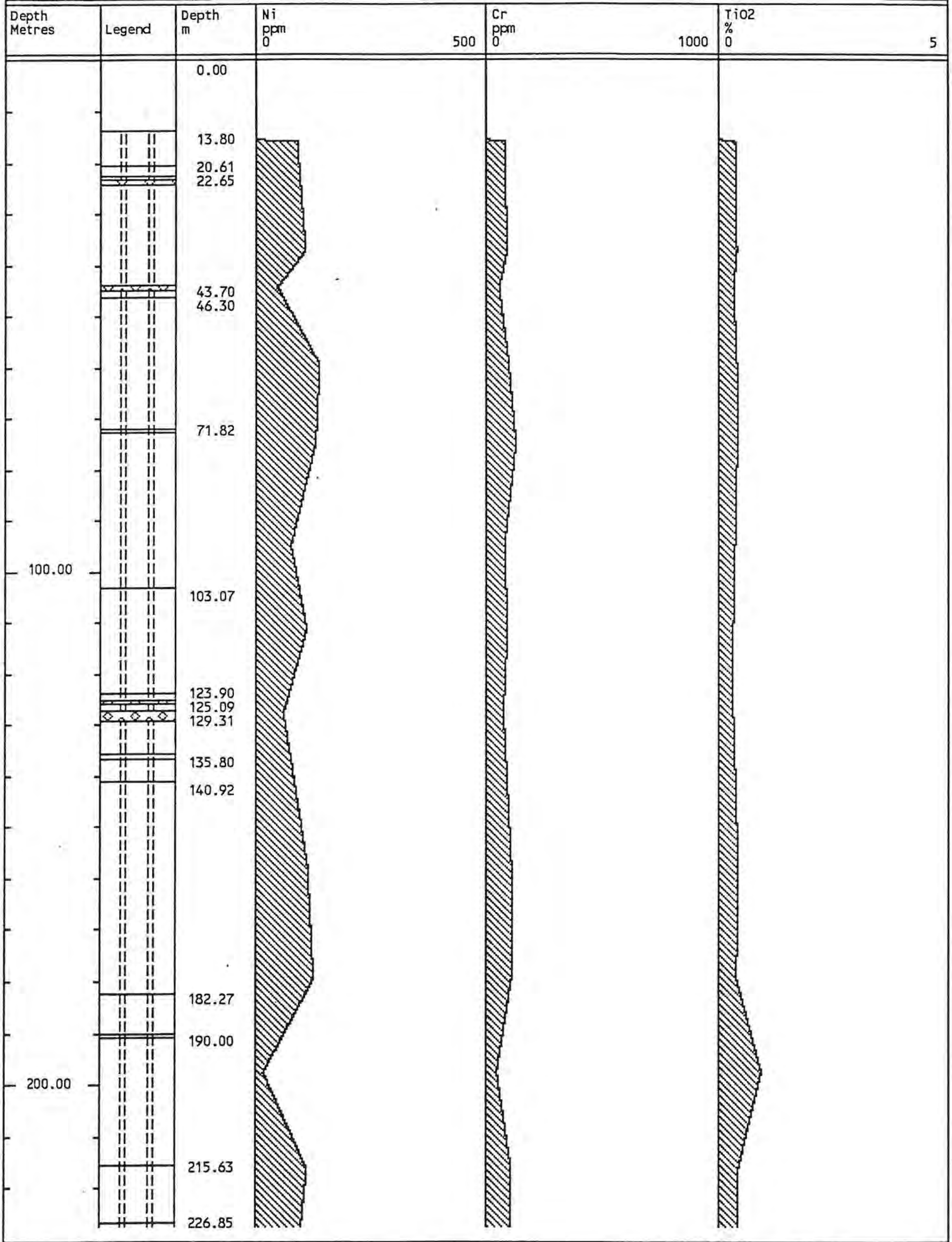
PROJECT: MINERAL RANGE	BOREHOLE NO: RF2	Date: 29-03-1995
FARM: RIETFONTEIN 70JS	460.00 to 545.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
	484.80		
484.8 to 545.00 m: Medium grained white META-QUARTZITE. Apparent dip = 44 degrees. E.O.H.= 545,00m.			
End of hole at 545.00 metres.	545.00		



PROJECT: MINERAL RANGE	BOREHOLE NO: RF-2	Date: 03-04-1995
FARM: RIETFONTEIN	0.00 to 230.00 metres	Scale: 1:1000

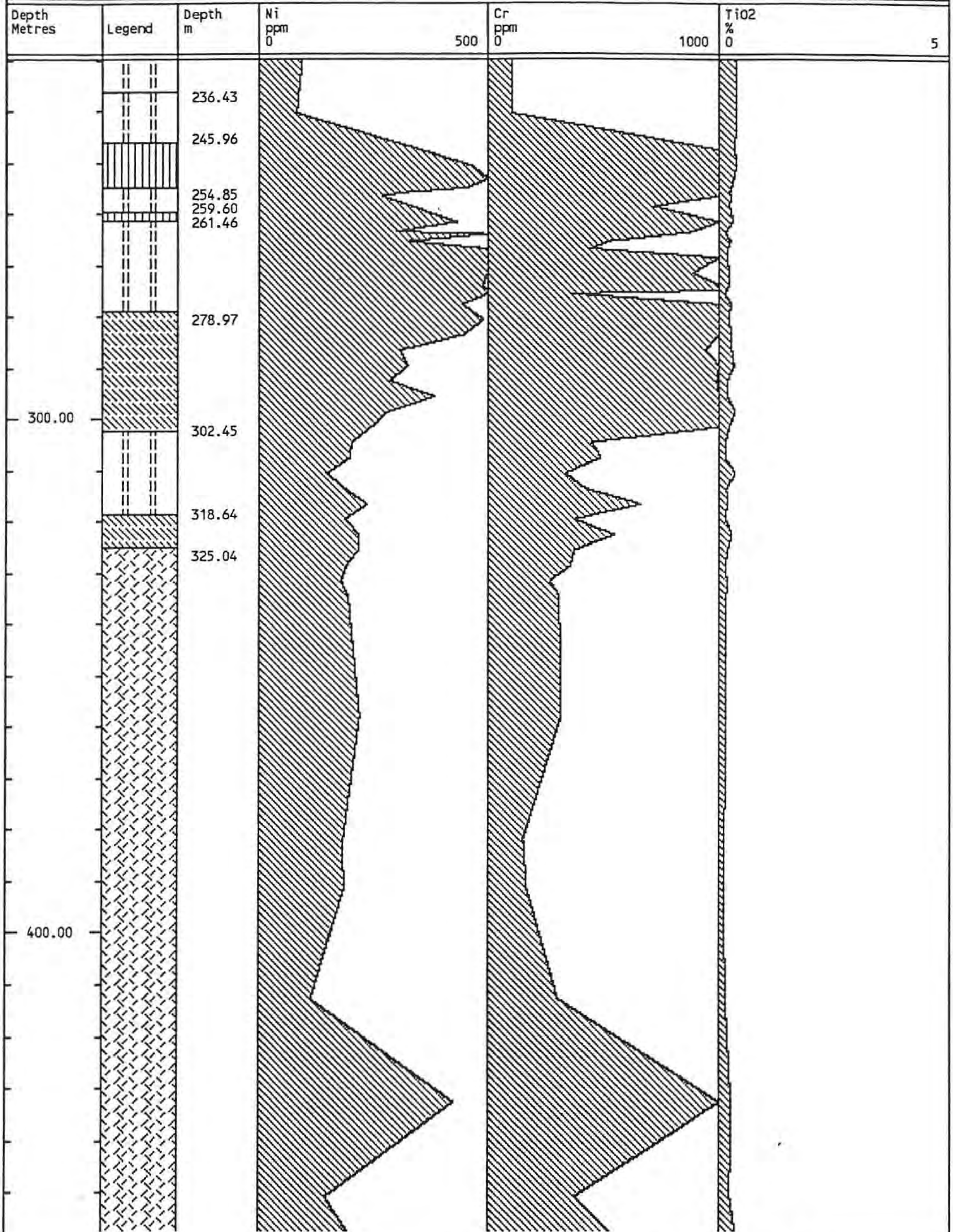
ROUTINE GEOCHEMICAL PROFILES



APPENDIX F

PROJECT: MINERAL RANGE	BOREHOLE NO: RF-2	Date: 03-04-1995
FARM: RIETFONTEIN	230.00 to 460.00 metres	Scale: 1:1000

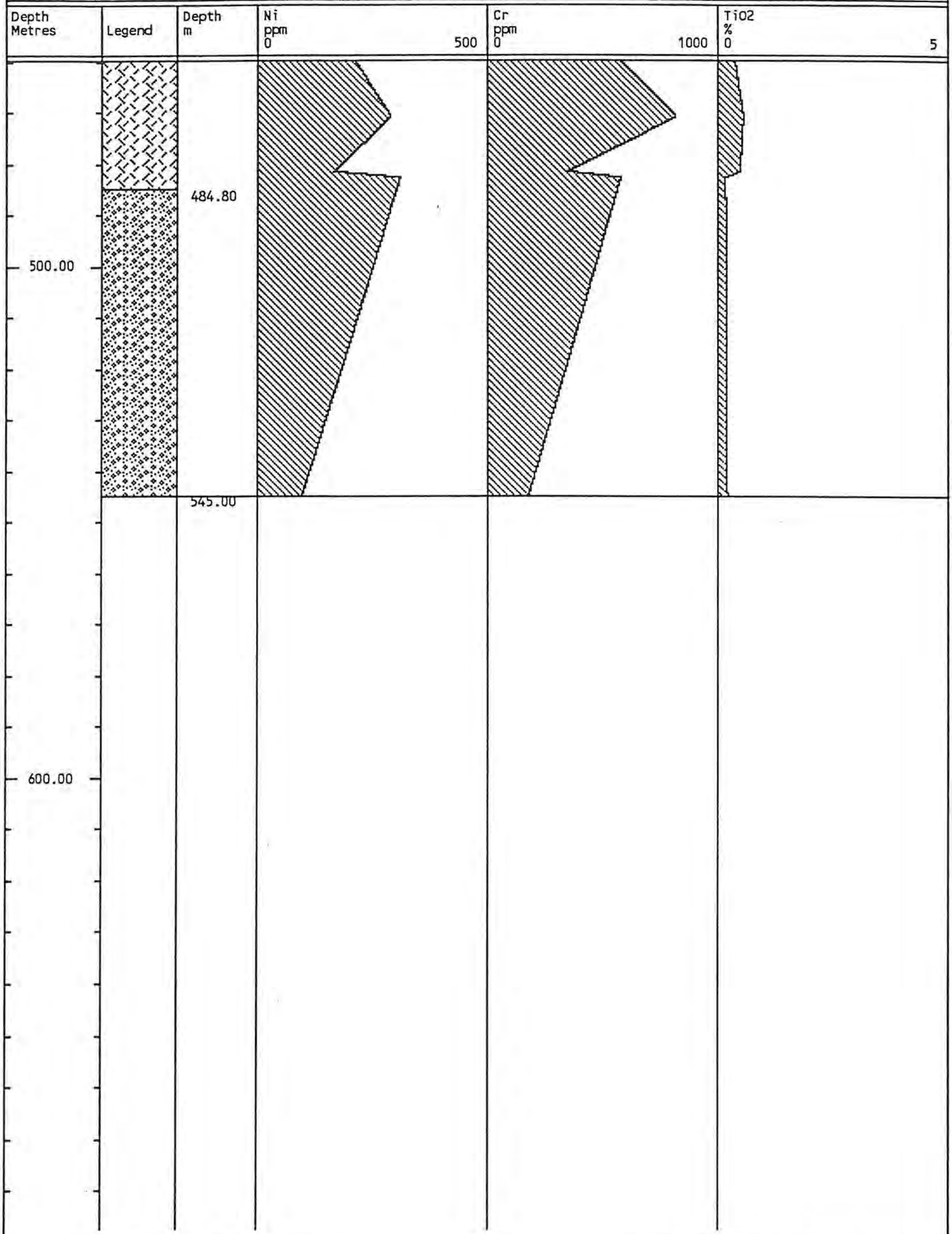
R O U T I N E   G E O C H E M I C A L   P R O F I L E S



PROJECT: MINERAL RANGE | BOREHOLE NO: RF-2 | Date: 03-04-1995

FARM: RIETFONTEIN | 460.00 to 545.00 metres | Scale: 1:1000

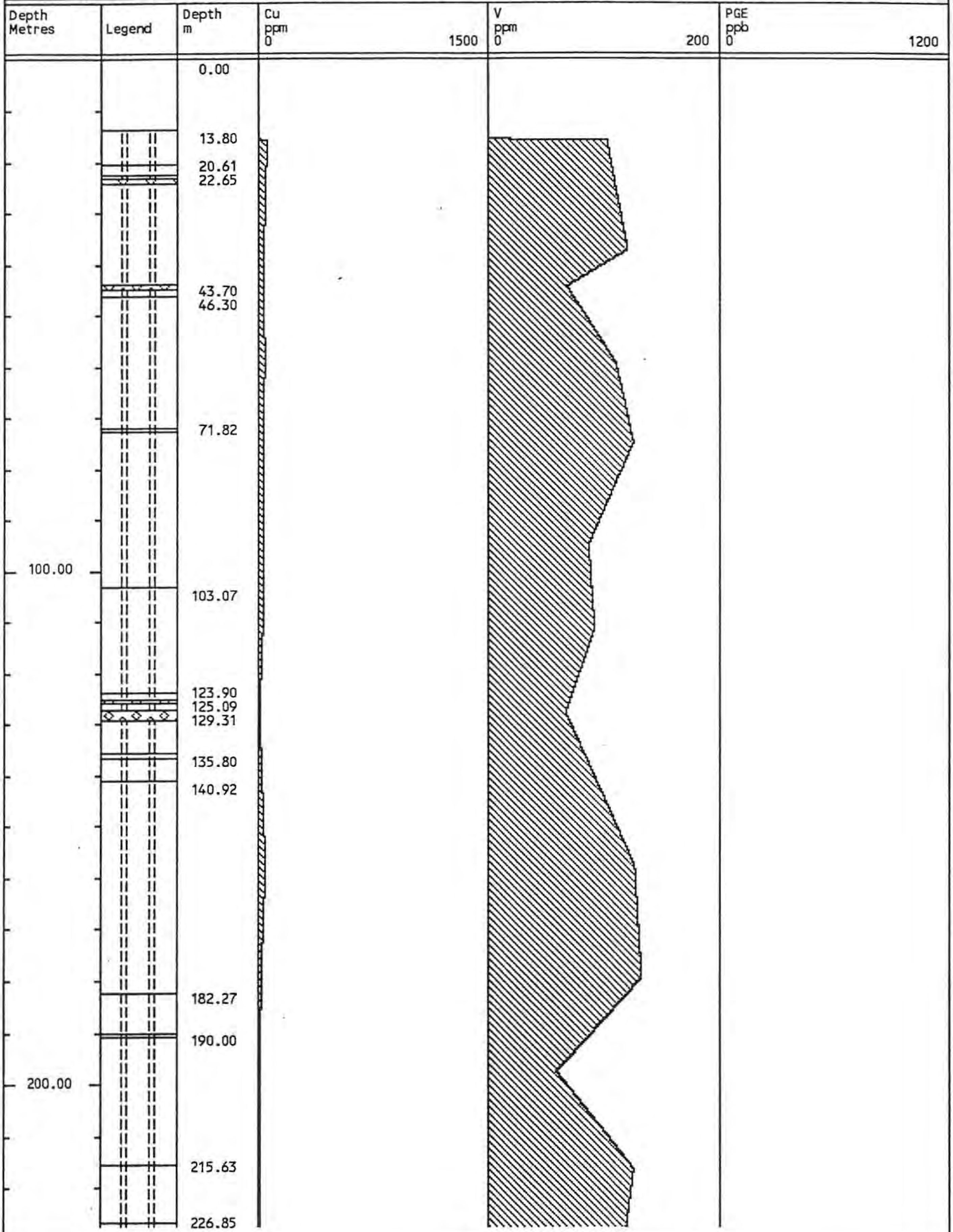
R O U T I N E   G E O C H E M I C A L   P R O F I L E S



APPENDIX F

PROJECT: MINERAL RANGE	BOREHOLE NO: RF-2	Date: 06-04-1995
FARM: RIETFONTEIN	0.00 to 230.00 metres	Scale: 1:1000

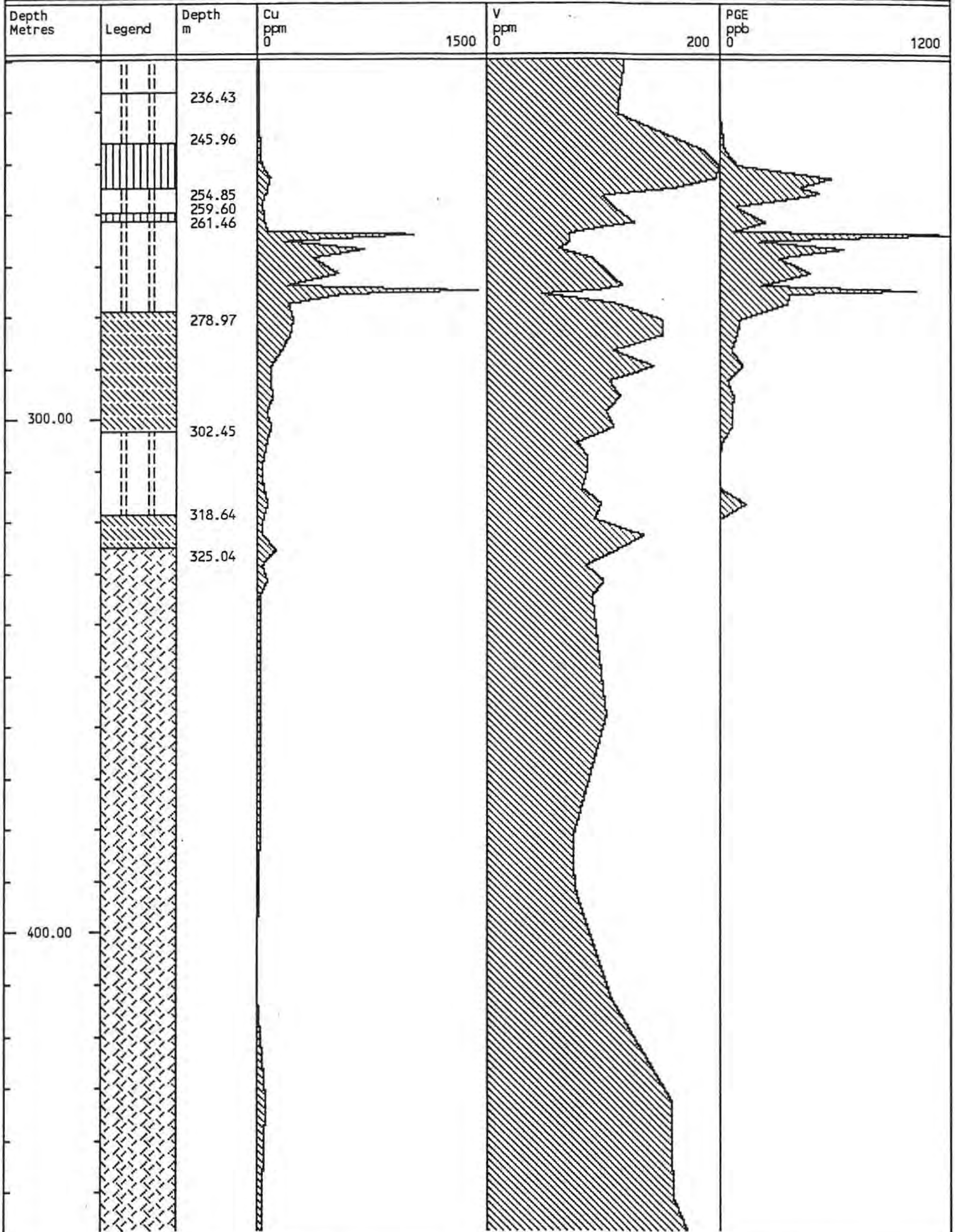
R O U T I N E G E O C H E M I C A L P R O F I L E S



APPENDIX G

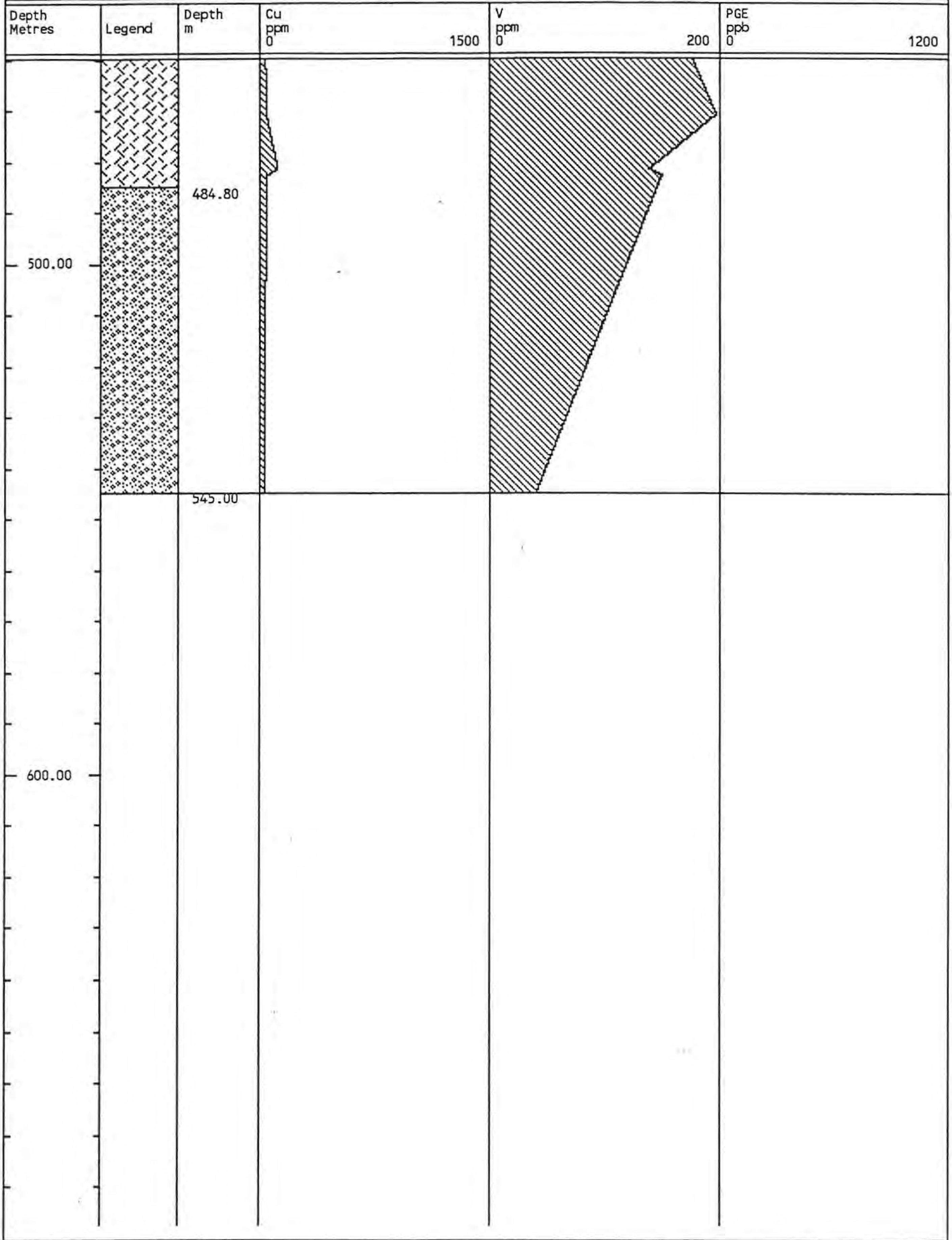
PROJECT: MINERAL RANGE	BOREHOLE NO: RF-2	Date: 06-04-1995
FARM: RIETFONTEIN	230.00 to 460.00 metres	Scale: 1:1000

ROUTINE GEOCHEMICAL PROFILES



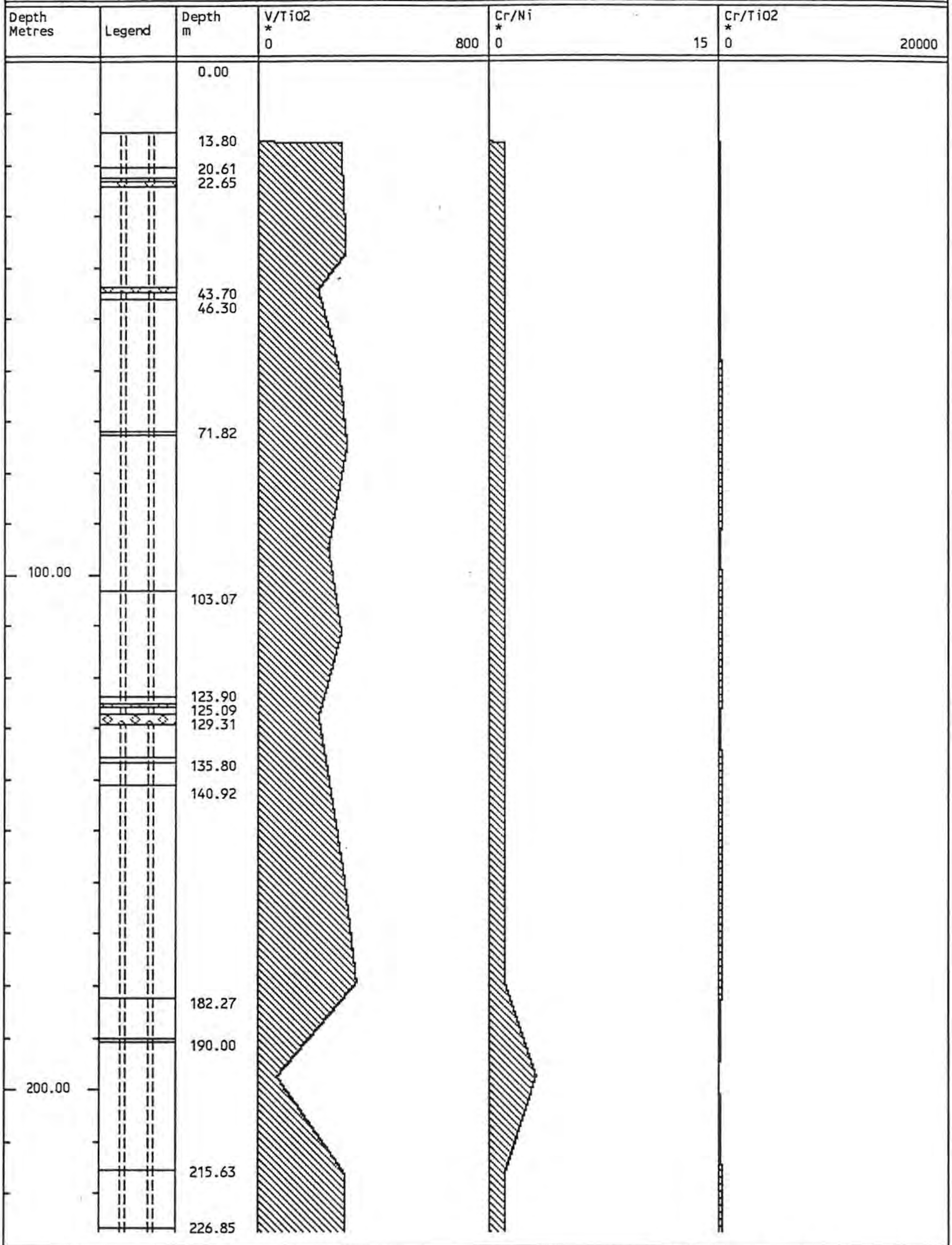
PROJECT: MINERAL RANGE	BOREHOLE NO: RF-2	Date: 06-04-1995
FARM: RIETFONTEIN	460.00 to 545.00 metres	Scale: 1:1000

R O U T I N E   G E O C H E M I C A L   P R O F I L E S



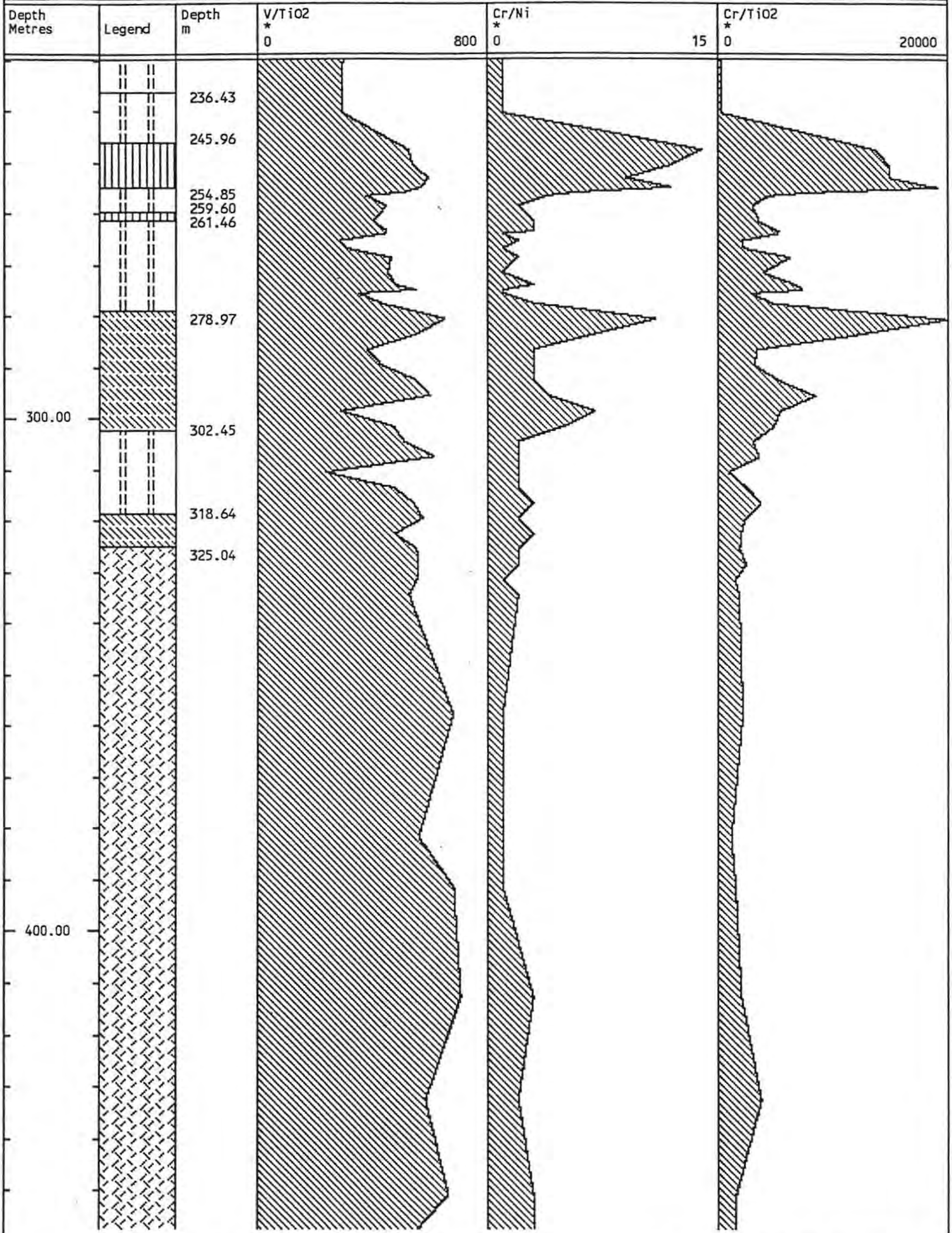
PROJECT: MINERAL RANGE	BOREHOLE NO: RF-2	Date: 06-04-1995
FARM: RIETFONTEIN	0.00 to 230.00 metres	Scale: 1:1000

R O U T I N E   G E O C H E M I C A L   P R O F I L E S



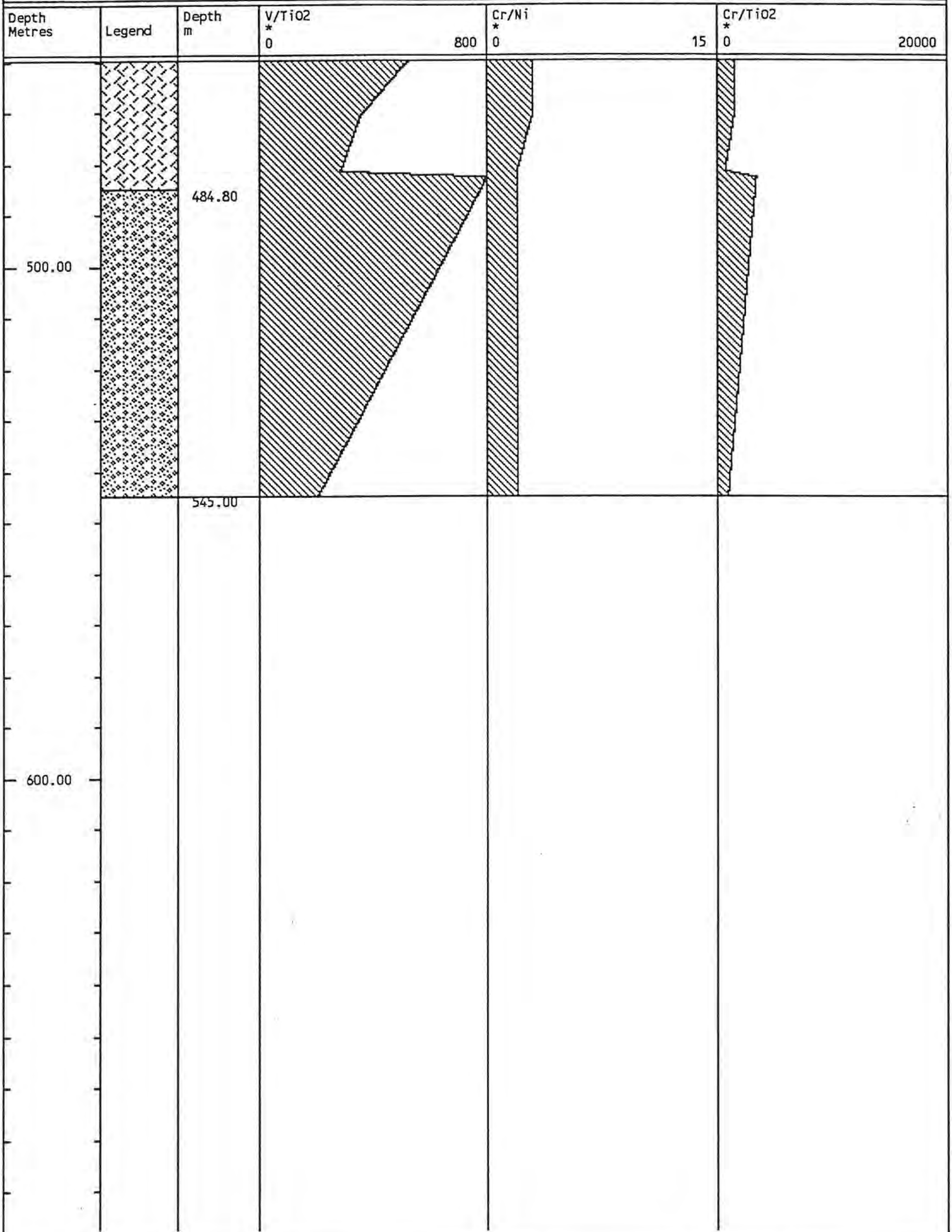
PROJECT: MINERAL RANGE	BOREHOLE NO: RF-2	Date: 06-04-1995
FARM: RIETFONTEIN	230.00 to 460.00 metres	Scale: 1:1000

R O U T I N E   G E O C H E M I C A L   P R O F I L E S



PROJECT: MINERAL RANGE	BOREHOLE NO: RF-2	Date: 06-04-1995
FARM: RIETFONTEIN	460.00 to 545.00 metres	Scale: 1:1000

ROUTINE GEOCHEMICAL PROFILES



PROJECT: MINERAL RANGE	BOREHOLE NO: RF3	Date: 27-03-1995
FARM: RIETFONTEIN 70JS	0.00 to 46.00 metres	Scale: 1:200
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
0.00 to 21.15 m: Highly weathered GABBRO-NORITE. (NQ-size core from 15,00m.)	0.00		10.00 20.00
21.15 to 31.53 m: Fine-grained NORITE. Becomes more pyroxenitic in places.	21.15		30.00
31.53 to 64.44 m: Fine-grained FELDSPATHIC ORTHOPYROXENITE. Zone of chloritized hairline fractures (70 degr.) at 32,28-36,60m. Increase in degree of chloritization from 36,31m. Chloritized fracture (1-2cm) (app.dip = 70 degr.) at 36,61m. Feldspar-rich (+ minor biotite) pegmatitic zones at 45,17-45,20m; 46,28-46,46m; 46,55-46,66m. Alternating, relatively thin pyroxenitic layers in parts. Igneous layering (20 degr.) evident in places. Feldspar/Qz-infilled fracture (2cm) at 51,66m, displaying granophyric texture with minor chalcopyrite and mica (app.dip = 70). Highly serpentinized unit at 57,27-57,67m, with minor sulphides (pyrrhotite) and mica on upper and lower contacts (app.dip = 34 degr.). 7cm Qz/feldspar/mica vein at 59,53m (70 degr.) 2cm Qz/feldspar/mica vein, as before at 63,88m.	31.53		40.00

LOGGED BY: S.P.CROUS	APPENDIX I	

PROJECT: MINERAL RANGE	BOREHOLE NO: RF3	Date: 27-03-1995
FARM: RIETFONTEIN 70JS	46.00 to 92.00 metres	Scale: 1:200
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
			50.00
			60.00
64.44 to 70.88 m: Medium-grained GABBRO-NORITE. (High angle, irregular contact).	64.44		
			70.00
70.88 to 73.34 m: Fine-grained NORITE. Minor presence of clinopyroxenes in certain patches.	70.88		
73.34 to 86.89 m: Medium-grained GABBRO-NORITE, as before. Relatively small angular fragments of pyroxenite present in parts. Coarse-grained, feldspar-rich patches at base of unit.	73.34		
			80.00
86.89 to 108.35 m: Medium-grained NORITE, with more gabbroic patches in places. Highly serpentinized zone at 91,17-91,43m. Slickensides on contacts (34 deg). 10cm Angular pyroxenite fragment at 92,65m.	86.89		
			90.00

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PROJECT: MINERAL RANGE	BOREHOLE NO: RF3	Date: 27-03-1995
FARM: RIETFONTEIN 70JS	92.00 to 138.00 metres	Scale: 1:200
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
			100.00
108.35 to 109.09 m: Coarse-grained PYROXENITE, with thin Qz/feldspar mica veins in places. Unit becomes more fine-grained towards base.	108.35		
109.09 to 125.14 m: NORITE, as before with some gabbroic patches in places, and thin, serpentinized hairline fractures throughout.	109.09		110.00
			120.00
125.14 to 126.82 m: Fine-grained, FELDSPATHIC PYROXENITE.	125.14		
126.82 to 135.34 m: Norite, as before.	126.82		130.00
135.34 to 140.66 m: Fine-grained FELDSPATHIC ORTHOPYROXENITE, with numerous chloritized hairline fractures. Gradational top contact. Feldspar content increase in certain places throughout unit.	135.34		

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PROJECT: MINERAL RANGE	BOREHOLE NO: RF3	Date: 27-03-1995
FARM: RIETFONTEIN 70JS	138.00 to 184.00 metres	Scale: 1:200
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m
	140.66
140.66 to 145.04 m: Fine-grained NORITE.	145.04
145.04 to 149.64 m: Fine-grained FELDSPATHIC ORTHOPYROXENITE, as before. Magnetite (secondary)-rich veinlets in parts.	149.64
149.64 to 153.43 m: Coarse-grained OLIVINE-PYROXENITE (often pegmatoidal). Magnetite-rich veinlets at 149,64-151,11m with associated chloritization. Feldspar-rich pegmatitic units at 151,50-151,63m; 151,76-151,86m; 153,11-153,14m.	153.43
153.43 to 153.63 m: Coarse-grained to pegmatitic HARZBURGITE.	
153.63 to 153.86 m: Pegmatitic PYROXENITE.	153.86
153.86 to 155.52 m: Fine-grained OLIVINE-PYROXENITE, as before. Decrease in olivine content in certain parts.	155.52
155.52 to 155.84 m: GABBRO-NORITE, with distinct quench textures at base of unit.	
155.84 to 175.51 m: Fine-grained FELDSPATHIC PYROXENITE. Unit becomes more feldspathic from 158m. Hornfels (mafic?) xenoliths at 157.49-157.85m; 158.99-160,03m. Intensely altered (serpentinized) meta-sediment xenolith (contorted bedding preserved in places) at 161,41-162,00m. Mafic hornfels xenolith at 162,93-164,06m (sharp contacts).	175.51
175.51 to 178.11 m: Medium-grained GABBRO-NORITE.	178.11
178.11 to 181.27 m: Fine-grained PYROXENITE. Pegmatitic patch at 178,20-178,40m. Relatively thin, steep (60-70 deg) chloritized fracture at 181,00m.	181.27
181.27 to 183.49 m: Medium-grained GABBRO-NORITE. Unit becomes slightly more noritic in places.	183.49

Depth Metres: 140.00, 150.00, 160.00, 170.00, 180.00

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APPENDIX I

PROJECT: MINERAL RANGE	BOREHOLE N0: RF3	Date: 27-03-1995
FARM: RIETFONTEIN 70JS	184.00 to 230.00 metres	Scale: 1:200
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

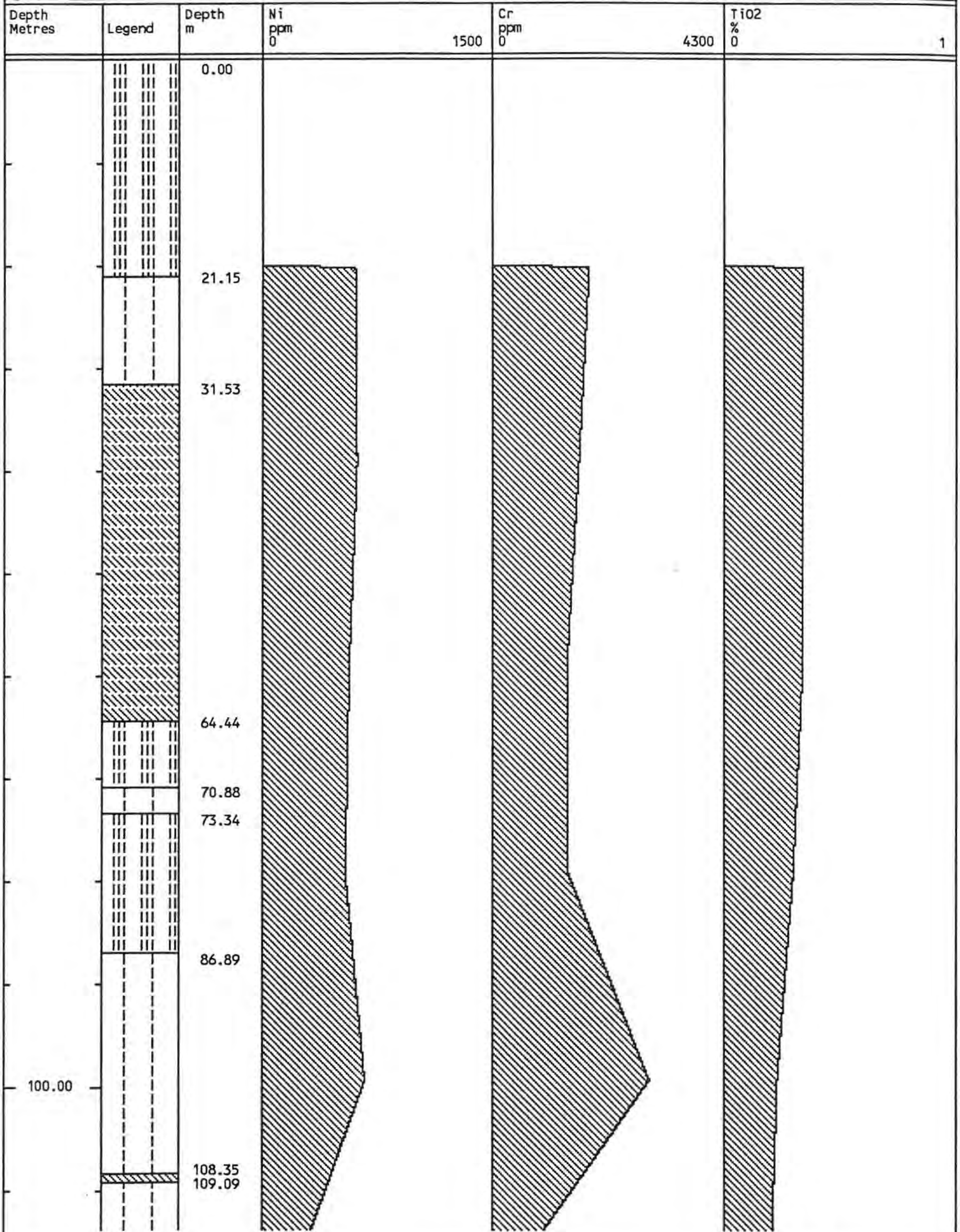
Geological Description	Depth m	Legend	Depth Metres
183.49 to 194.98 m: Medium-grained NORITE.			190.00
194.98 to 199.83 m: Fine-grained FELDSPATHIC PYROXENITE.	194.98		
199.83 to 200.85 m: Medium-grained GABBRO-NORITE.	199.83		200.00
200.85 to 250.48 m: FELDSPATHIC PYROXENITE, as before. Unit fairly homogeneous with minor disseminated sulphides throughout. E.O.H = 250,85m.	200.85		210.00 220.00

PROJECT: MINERAL RANGE	BOREHOLE NO: RF3	Date: 27-03-1995
FARM: RIETFONTEIN 70JS	230.00 to 250.48 metres	Scale: 1:200
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
			230.00
			240.00
End of hole at 250.48 metres.	250.48		250.00
			260.00
			270.00

PROJECT: MINERAL RANGE	BOREHOLE NO: RF3(-90)	Date: 30-11-1995
FARM: RIETFONTEIN 70JS	0.00 to 115.00 metres	Scale: 1:500

R O U T I N E   G E O C H E M I C A L   P R O F I L E S

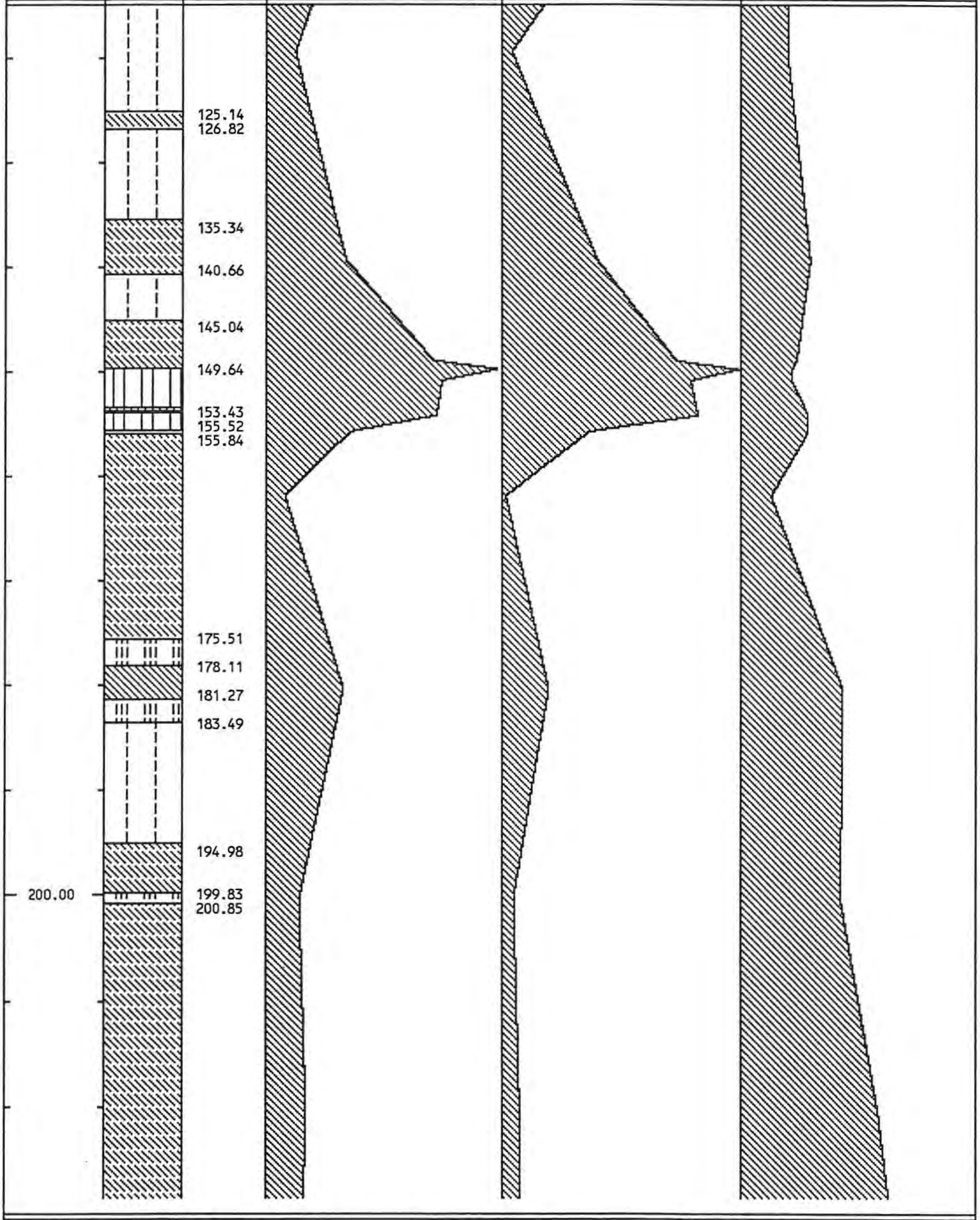


APPENDIX J

PROJECT: MINERAL RANGE	BOREHOLE NO: RF3(-90)	Date: 30-11-1995
FARM: RIETFONTEIN 70JS	115.00 to 230.00 metres	Scale: 1:500

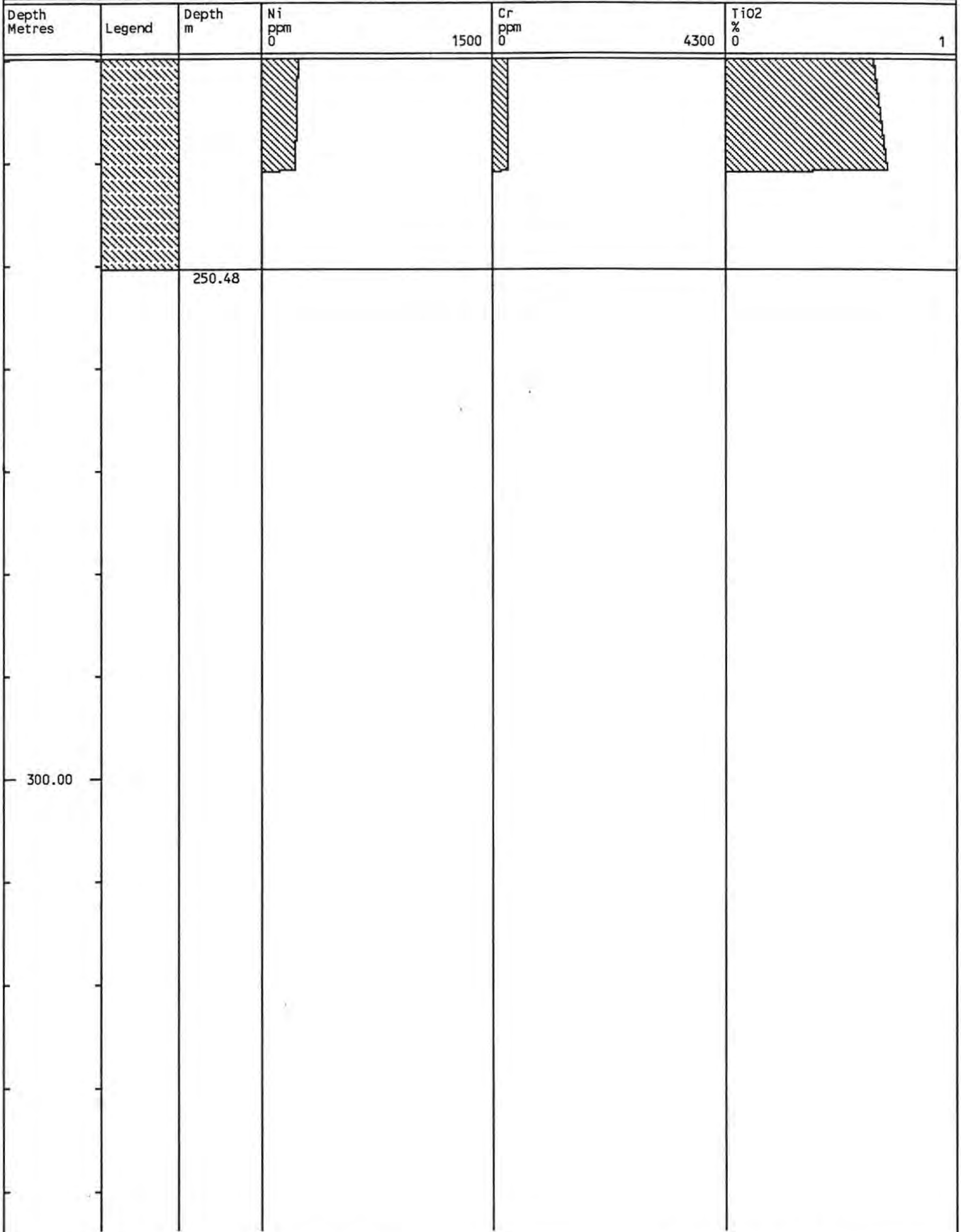
R O U T I N E   G E O C H E M I C A L   P R O F I L E S

Depth Metres	Legend	Depth m	Ni ppm 0 – 1500	Cr ppm 0 – 4300	TiO2 % 0 – 1



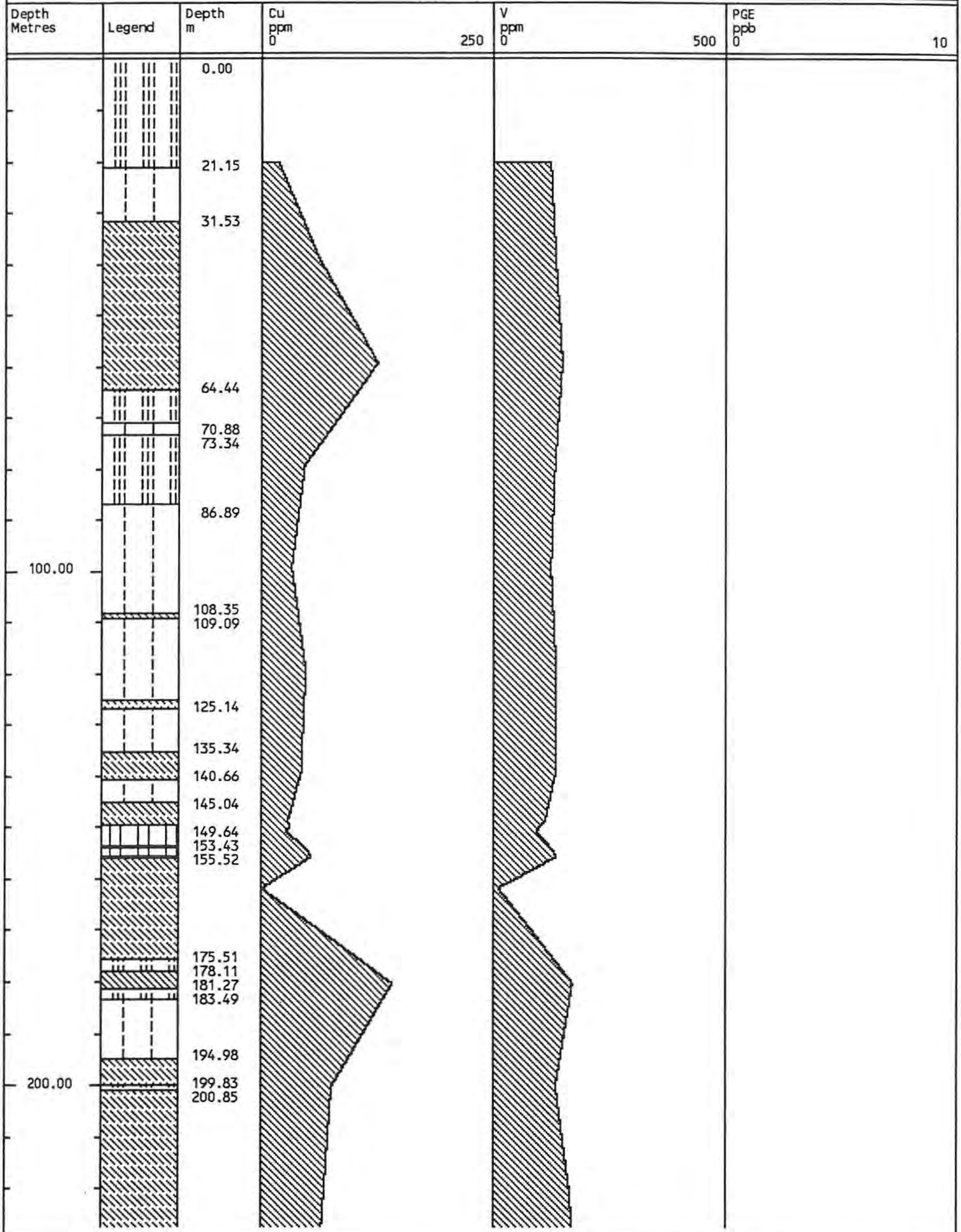
PROJECT: MINERAL RANGE	BOREHOLE NO: RF3(-90)	Date: 30-11-1995
FARM: RIETFONTEIN 70JS	230.00 to 250.48 metres	Scale: 1:500

ROUTINE GEOCHEMICAL PROFILES



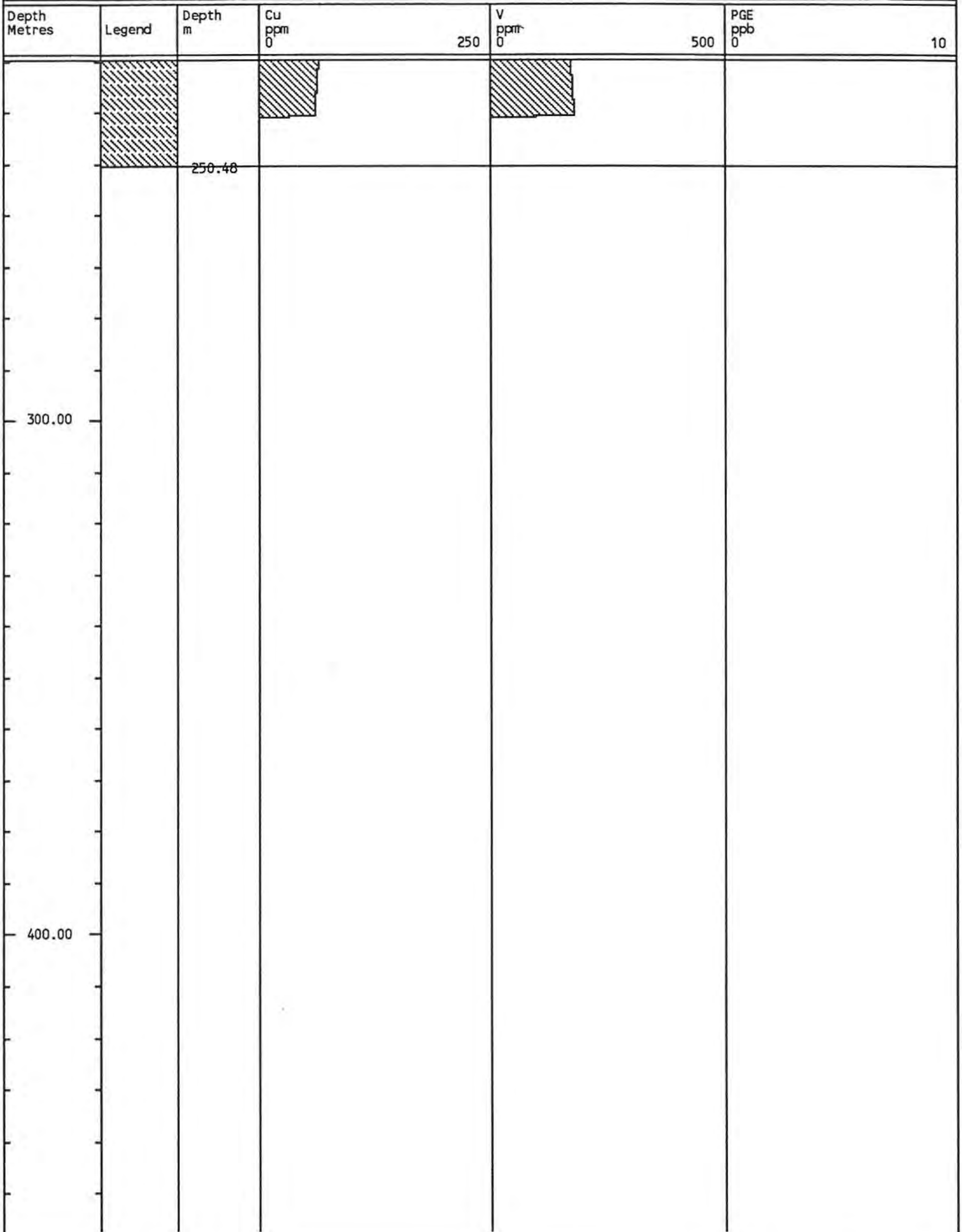
PROJECT: MINERAL RANGE	BOREHOLE NO: RF3(-90)	Date: 30-11-1995
FARM: RIETFONTEIN 70JS	0.00 to 230.00 metres	Scale: 1:1000

R O U T I N E   G E O C H E M I C A L   P R O F I L E S



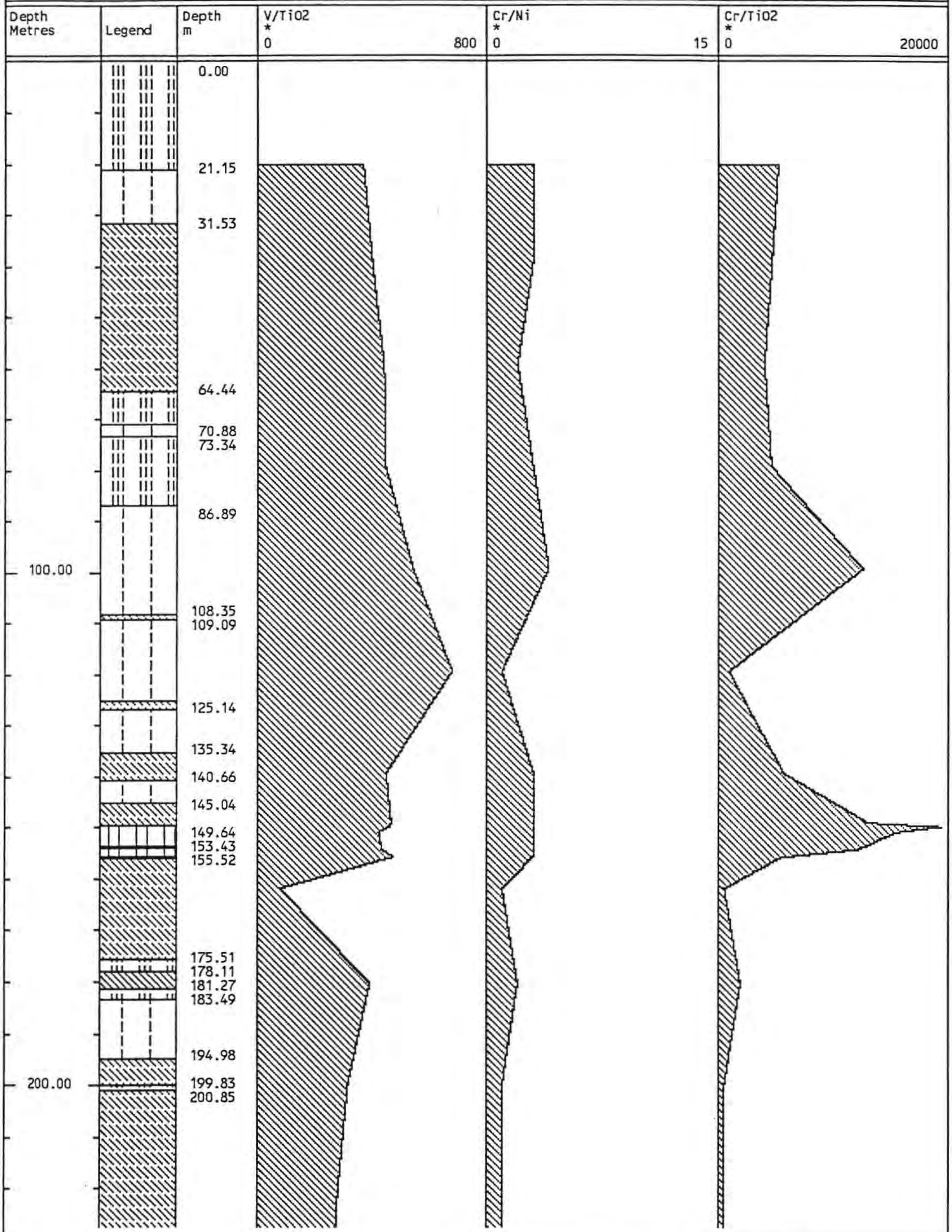
PROJECT: MINERAL RANGE	BOREHOLE NO: RF3(-90)	Date: 30-11-1995
FARM: RIETFONTEIN 70JS	230.00 to 250.48 metres	Scale: 1:1000

R O U T I N E   G E O C H E M I C A L   P R O F I L E S



PROJECT: MINERAL RANGE	BOREHOLE NO: RF3(-90)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	0.00 to 230.00 metres	Scale: 1:1000

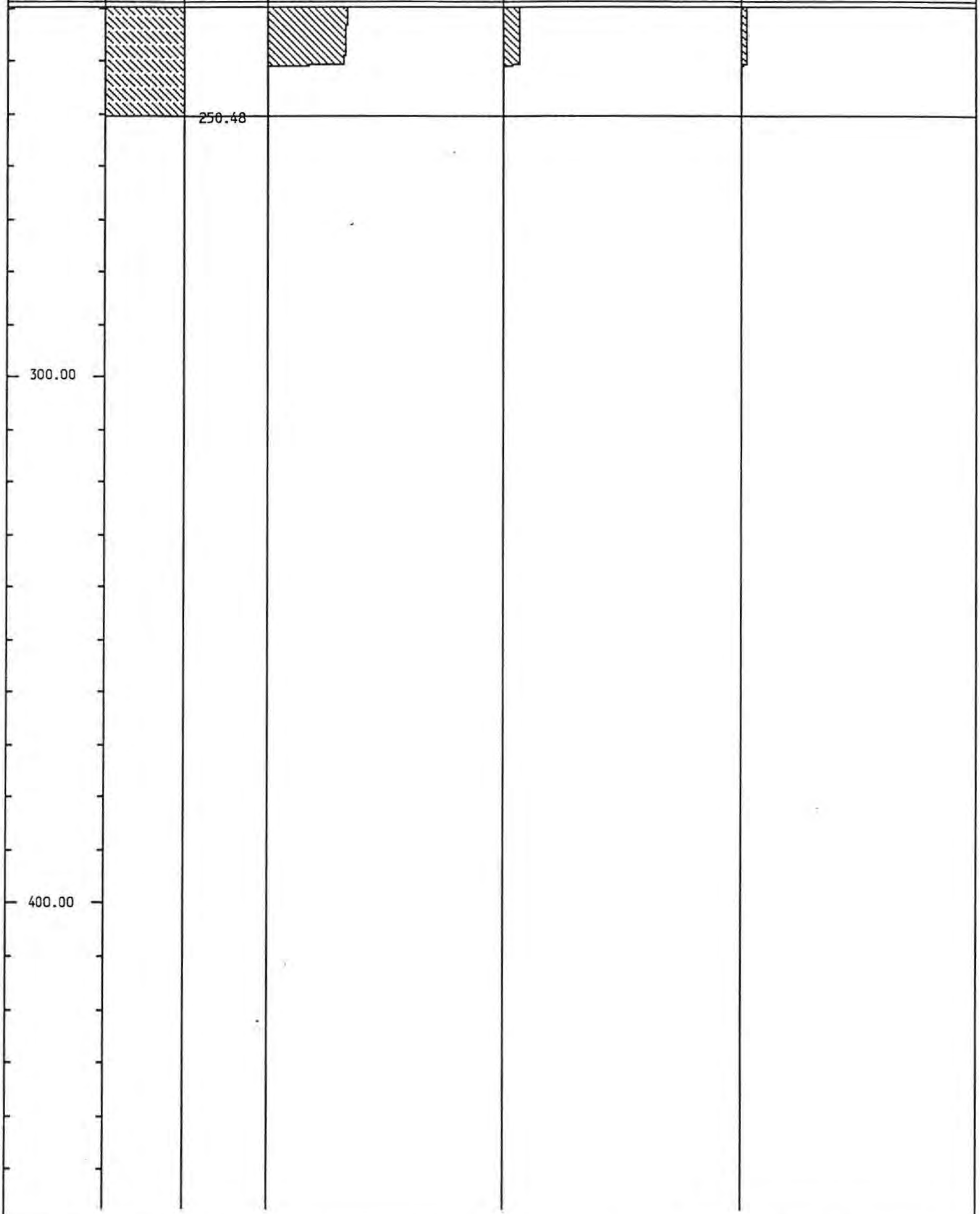
R O U T I N E   G E O C H E M I C A L   P R O F I L E S



PROJECT: MINERAL RANGE	BOREHOLE NO: RF3 (-90)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	230.00 to 250.48 metres	Scale: 1:1000

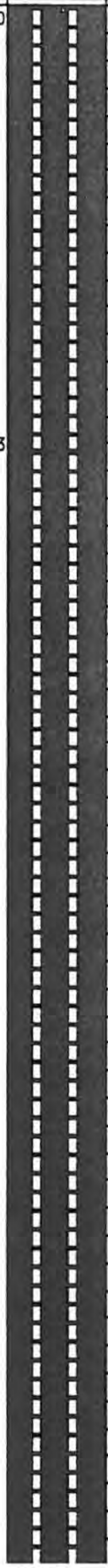
ROUTINE GEOCHEMICAL PROFILES

Depth Metres	Legend	Depth m	V/TiO2 * 0 – 800	Cr/Ni * 0 – 15	Cr/TiO2 * 0 – 20000



PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 07-04-1995
FARM: RIETFONTEIN 70JS	0.00 to 115.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
0.00 to 32.43 m: Highly weathered MAGNETITE-GABBRO. NQ-size core from 33,04m.	0.00		10.00 20.00 30.00
32.43 to 159.19 m: Coarse-grained MAGNETITE-GABBRO. (cumulus magnetite)(BC Upper Zone?) with disseminated pyrrhotite in places. Significant decrease in feldspar content at 59,81-60,87m. Numerous chloritized hairline fractures throughout. Pegmatitic patch (granitic in composition) at 122,10-122,83m (late intrusion).	32.43		40.00 50.00 60.00 70.00 80.00 90.00 100.00 110.00



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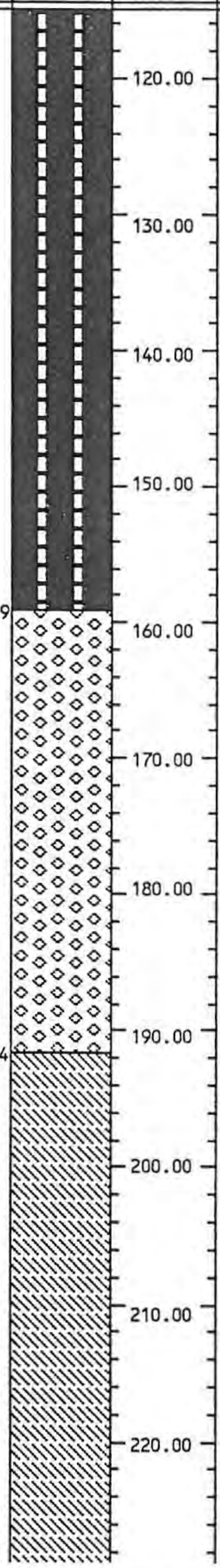
APPENDIX M

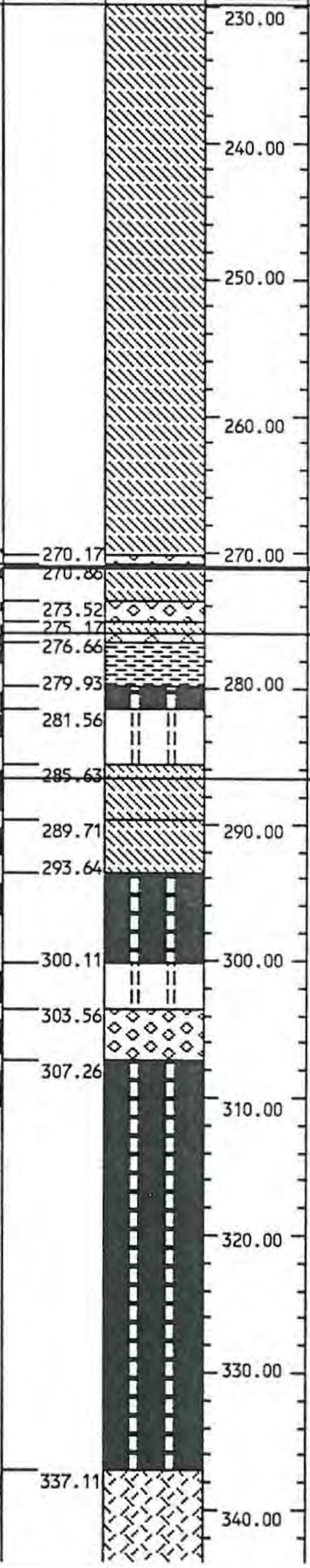
PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 07-04-1995
FARM: RIETFONTEIN 70JS	115.00 to 230.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
159.19 to 191.64 m: Spotted ANORTHOSITE with pyroxene oikocrysts (+/- 1cm diam.) and interstitial magnetite in places. Minor disseminated pyrrhotite and chalcopyrite present. Sulphide blebs (pyrr & chpy) from 183,92-185,48m. Pyroxenes amphibolitized (with associated sericitization) at 184,90-185,48m. Concentration of (1mm) magnetite grains (+ minor pyrrhotite and chalcopyrite speckling) at 185,89-186,30m; 186, 83 -187,36m. Granitic intrusions at 194,17-194,18m; 197,33-197,39m; 200,98-201, 19m; 203,48-203,63m; 204,76-204,94m; 206,36-206,70m; 212,43-212,76m. Amphiboles in radial orientation evident adjacent to intrusive material in certain places.	159.19		
191.64 to 270.17 m: Magnetite-bearing, FELDSPATHIC PYROXENITE, with minor disseminated pyrrhotite and chalcopyrite. Unit becomes gabbroic in places. Highly altered zone at 226,83 -227,35m with pyrrhotite blebs from 227,00-227,19m.	191.64		



PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 07-04-1995
FARM: RIETFONTEIN 70JS	230.00 to 345.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres



270.17 to 270.86 m:
Spotted ANORTHOSITE with magnetite blebs in places

270.86 to 271.05 m:
Medium-grained FELDSPATHIC PYROXENITE with minor disseminated pyrrhotite and magnetite. Irregular contacts.

271.05 to 271.25 m:
Spotted ANORTHOSITE, as before.

271.25 to 273.52 m:
Highly magnetic FELDSPATHIC PYROXENITE.

273.52 to 275.17 m:
Spotted ANORTHOSITE, as before (gabbroic appearance in some instances.

275.17 to 275.91 m:
Extremely magnetite-rich FELDSPATHIC PYROXENITE, with disseminated sulphide mineralization.

275.91 to 276.66 m:
ANORTHOSITE, as before.

276.66 to 279.93 m:
Pyroxenitic PEGMATOID, with minor disseminated sulphide (predominantly pyrrhotite & subordinate chalcopyrite) mineralization. Anorthositic xenolith at 277,80-277,94m.

279.93 to 281.56 m:
Medium-grained MAGNETITE GABBRO

281.56 to 285.63 m:
Coarse-grained, non-magnetic GABBRO, with pegmatitic pyroxenite (+ minor secondary magnetite blebs) patches at 282,04-282,21m; 282,63-283,25m; 283,67- 283,82m, 284,38-284,45m.

285.63 to 286.66 m:
Medium-grained FELDSPATHIC PYROXENITE.

286.66 to 289.71 m:
Medium-grained FELDSPATHIC ORTHOPYROXENITE (spotted, noritic appearance in places). Minor disseminated chromite present.

289.71 to 293.64 m:
Coarse-grained FELDSPATHIC PYROXENITE, with pegmatitic (often feldspar-rich) in parts. Pegmatitic pyroxenite with distinct chromite grains at 291,06-291,89m. Magnetite vein at 291,68-291,79m. Magnetite-rich unit (with slight decrease in feldspar content) at 292,11-292,82m.

293.64 to 300.11 m:
Medium-grained MAGNETITE-GABBRO. Fragments of coarse-grained gabbro at 298,19- 298,39m; 299,16-299,22m.

300.11 to 303.56 m:
Coarse-grained GABBRO (BC Main Zone?). Minor molybdenum in altered

LOGGED BY: S.P.CROUS	APPENDIX M	Page 3 of 4.

PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 07-04-1995
FARM: RIETFONTEIN 70JS	345.00 to 389.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
fracture at 301,45m. Pegmatitic Pyroxenite at base of unit from 303,38m.			
303.56 to 307.26 m: Spotted ANORTHOSITE. Magnetite-bearing, pegmatitic patches at 304,38-304,46m; 305,29-305,60m; 305,87-306,33m.			350.00
307.26 to 337.11 m: Medium-grained MAGNETITE-GABBRO. Sharp irregular upper contact. Abundant disseminated pyrrhotite & chalcopyrite near upper contact. Fine-grained feldspathic pyroxenite xenolith at 308,88-309,38m.			360.00
337.11 to 389,84 m: Micaceous HORNFELS (green, glassy appearance) with minor small fragments of fine-grained meta-sediments in places. E.O.H.= 389,84M.			370.00 380.00
End of hole at 389.00 metres.	389.00		390.00
			400.00 410.00 420.00 430.00 440.00 450.00

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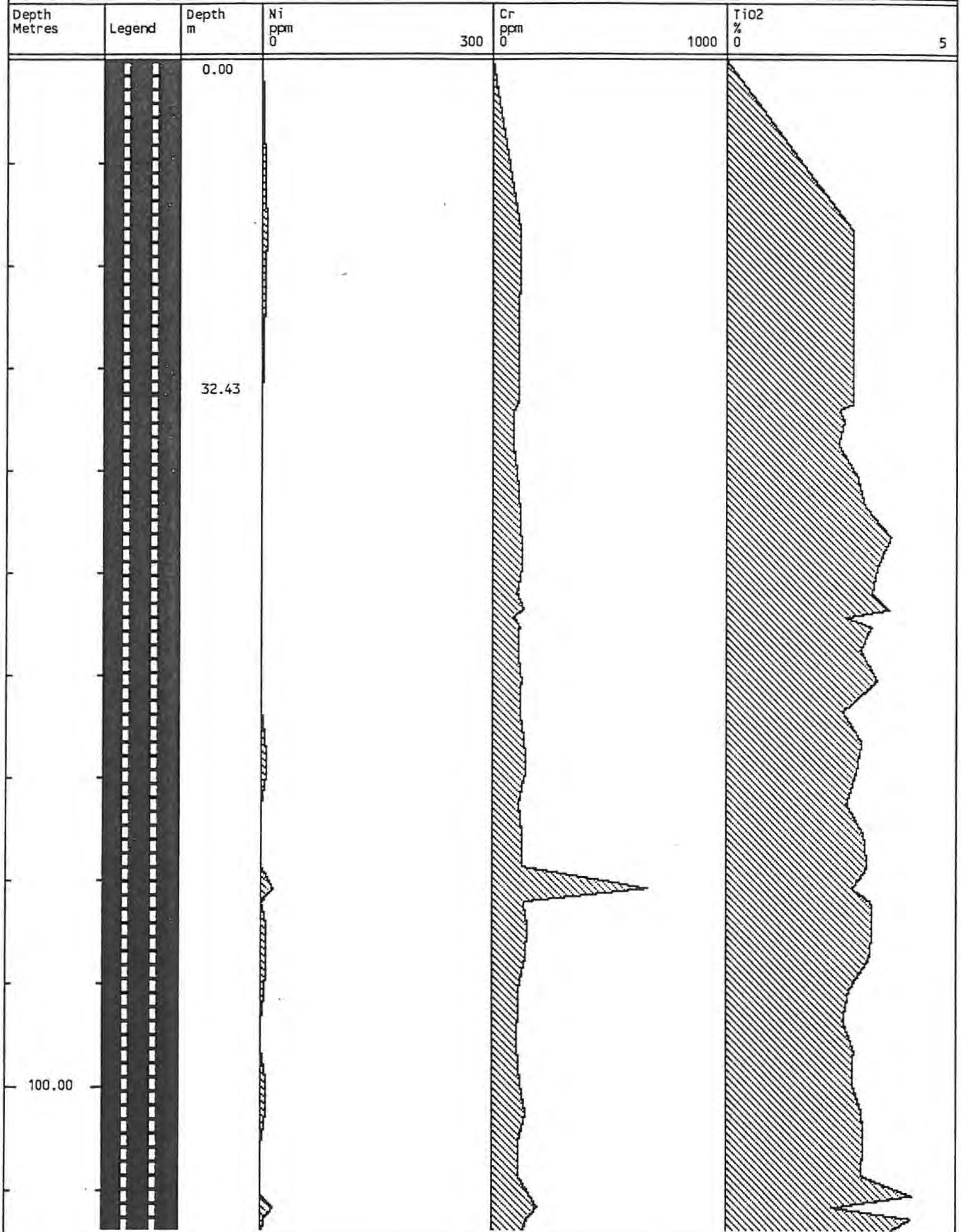
PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 04-04-1995
FARM: RIETFONTEIN 70JS	0.00 to 115.00 metres	Scale: 1:500

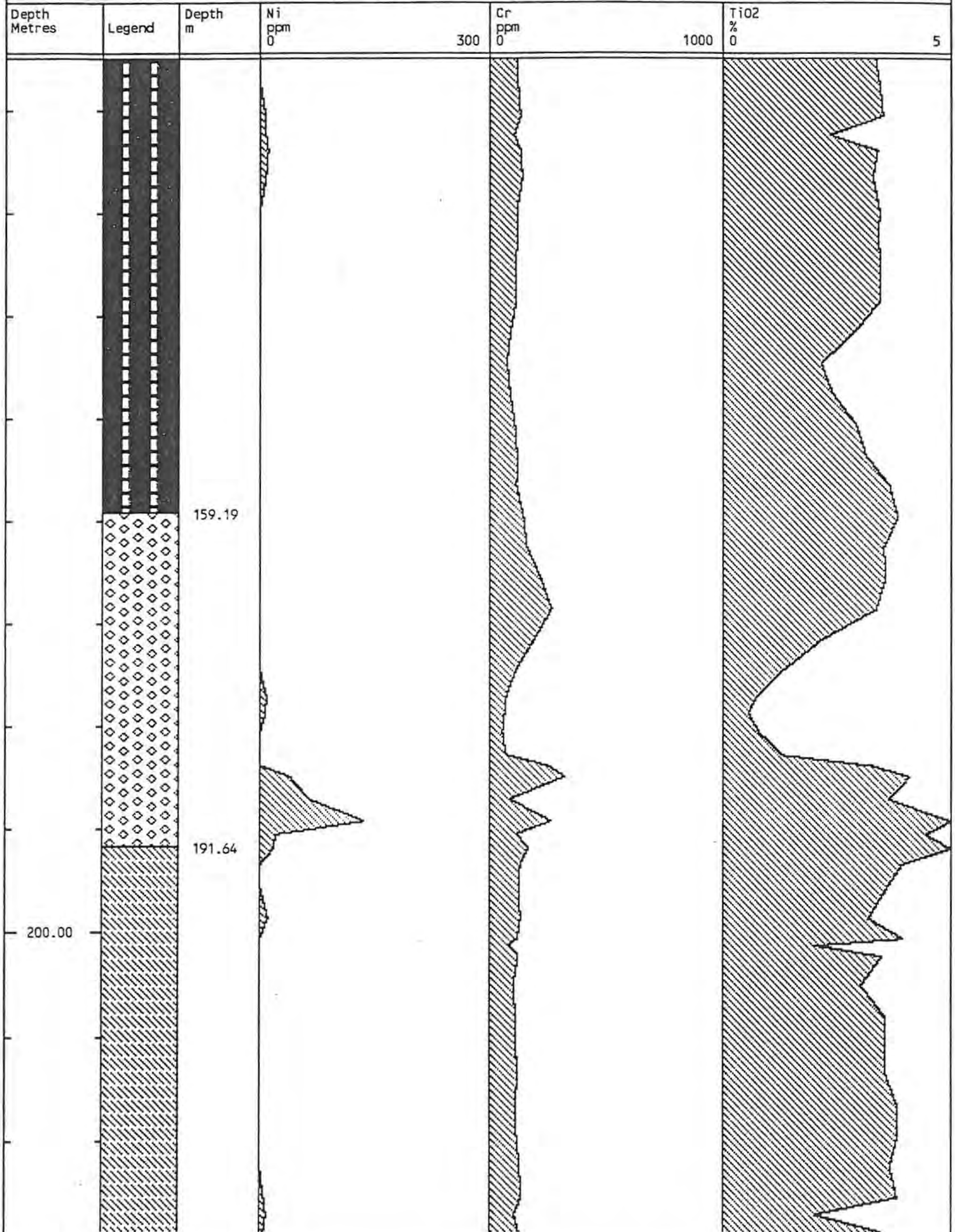
ROUTINE GEOCHEMICAL PROFILES



APPENDIX N

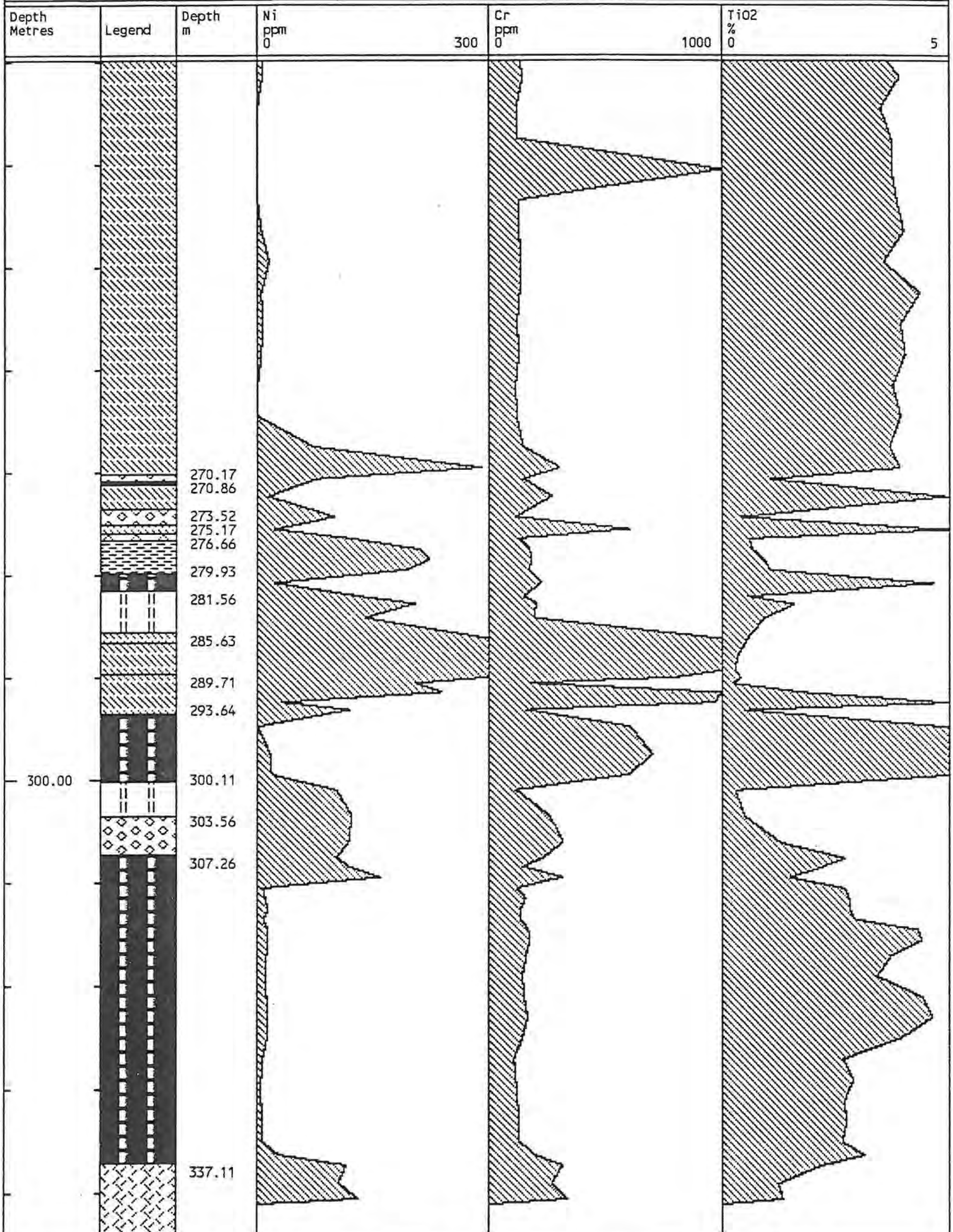
PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 04-04-1995
FARM: RIETFONTEIN 70JS	115.00 to 230.00 metres	Scale: 1:500

ROUTINE GEOCHEMICAL PROFILES



PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 04-04-1995
FARM: RIETFONTEIN 70JS	230.00 to 345.00 metres	Scale: 1:500

R O U T I N E   G E O C H E M I C A L   P R O F I L E S



APPENDIX N

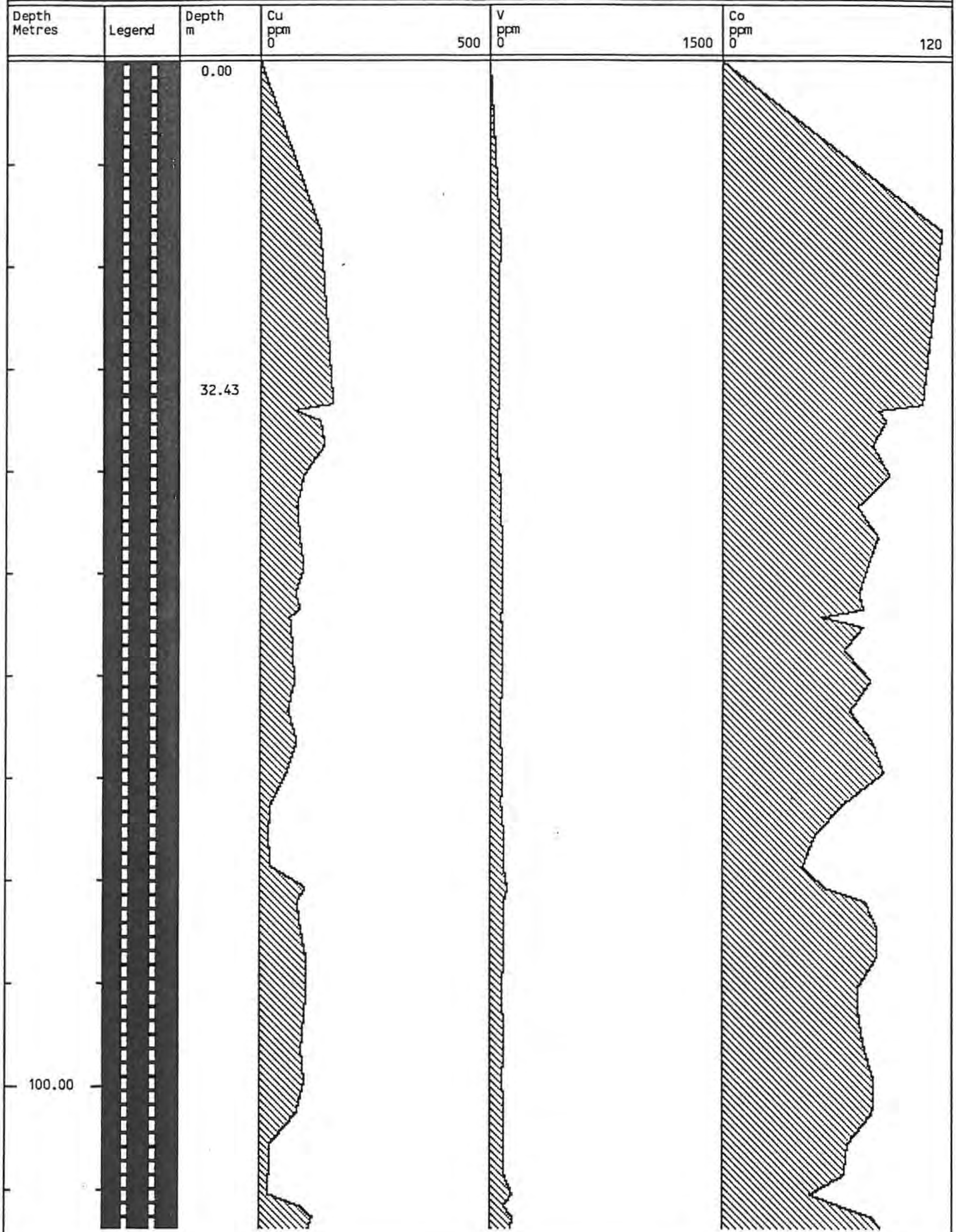
PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 04-04-1995
FARM: RIETFONTEIN 70JS	345.00 to 389.00 metres	Scale: 1:500

ROUTINE GEOCHEMICAL PROFILES

Depth Metres	Legend	Depth m	Ni ppm 0 – 300	Cr ppm 0 – 1000	TiO2 % 0 – 5
		389.00			
400.00					

PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	0.00 to 115.00 metres	Scale: 1:500

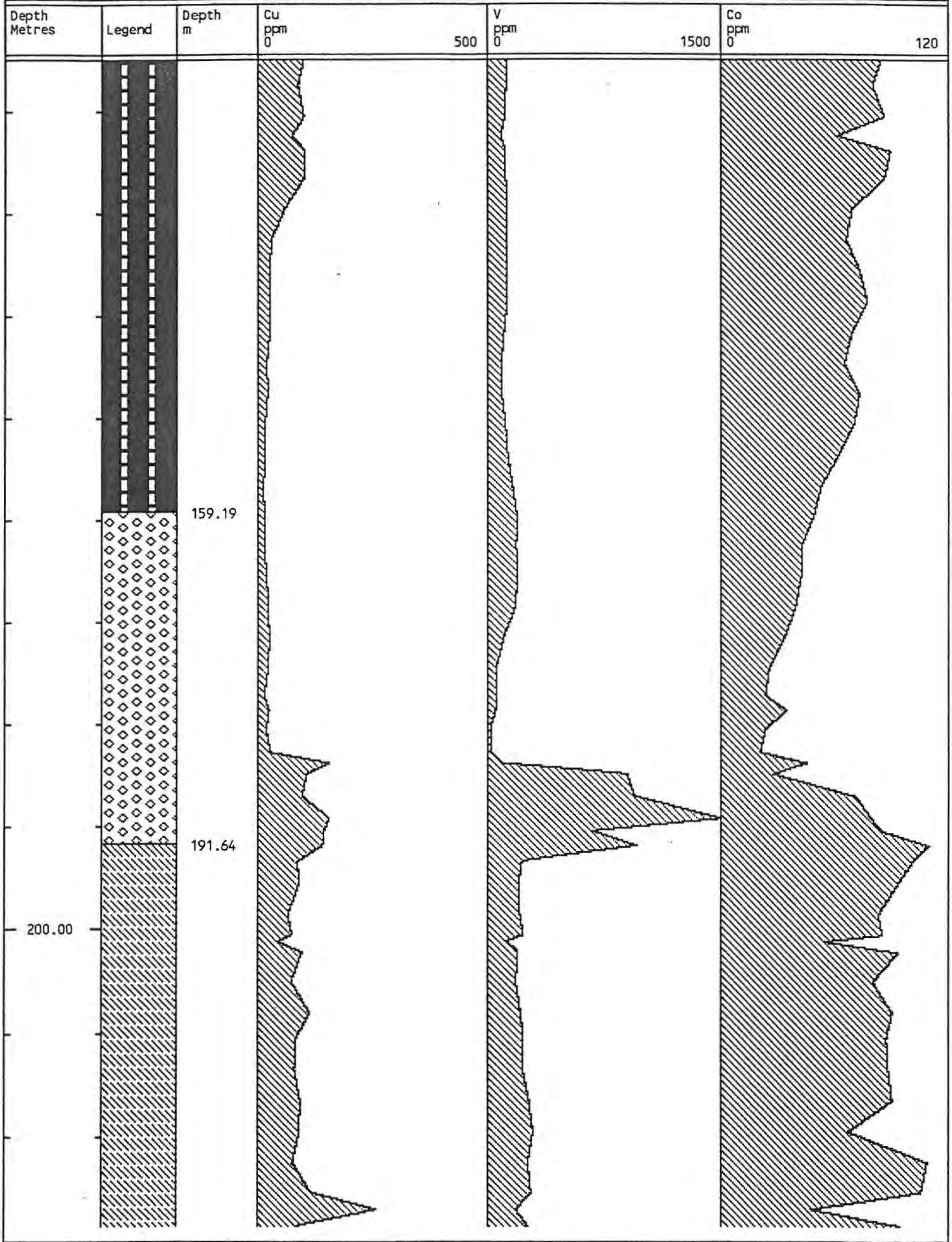
R O U T I N E   G E O C H E M I C A L   P R O F I L E S



APPENDIX O

PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	115.00 to 230.00 metres	Scale: 1:500

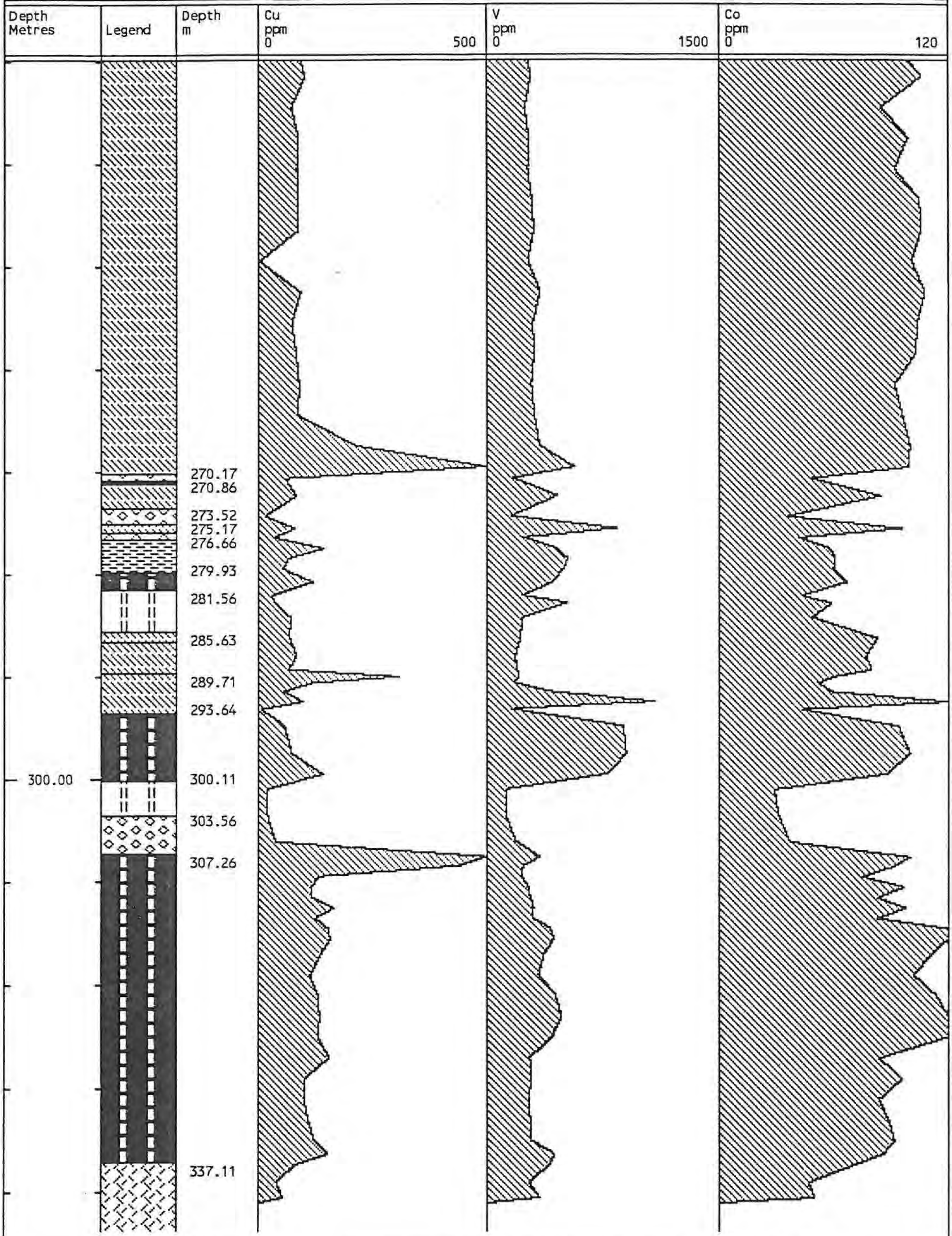
R O U T I N E   G E O C H E M I C A L   P R O F I L E S



APPENDIX O

PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	230.00 to 345.00 metres	Scale: 1:500

ROUTINE GEOCHEMICAL PROFILES



APPENDIX O

PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	345.00 to 389.00 metres	Scale: 1:500

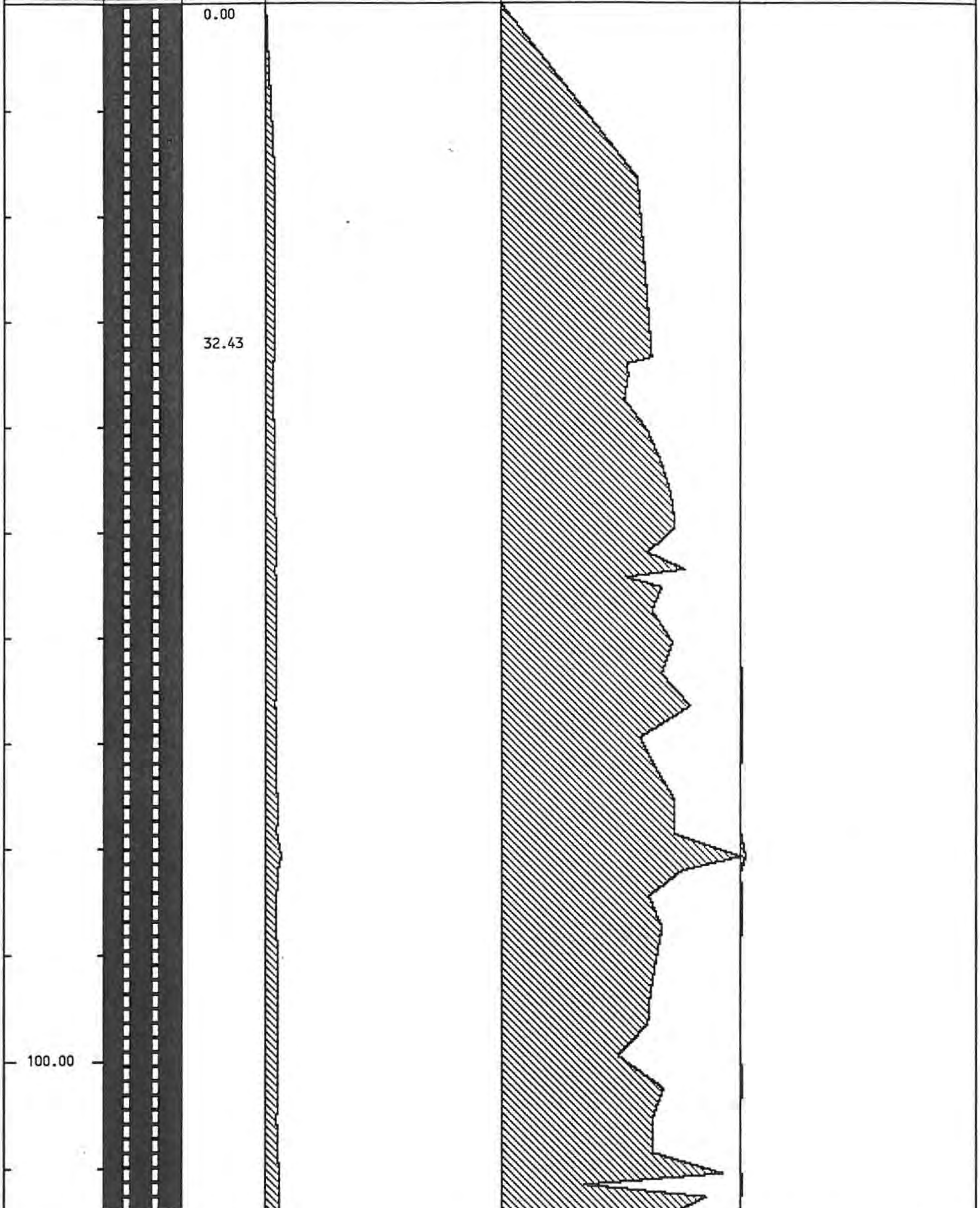
R O U T I N E   G E O C H E M I C A L   P R O F I L E S

Depth Metres	Legend	Depth m	Cu ppm 0 – 500	V ppm 0 – 1500	Co ppm 0 – 120
		389.00			
400.00					

PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 07-04-1995
FARM: RIETFONTEIN 70JS	0.00 to 115.00 metres	Scale: 1:500

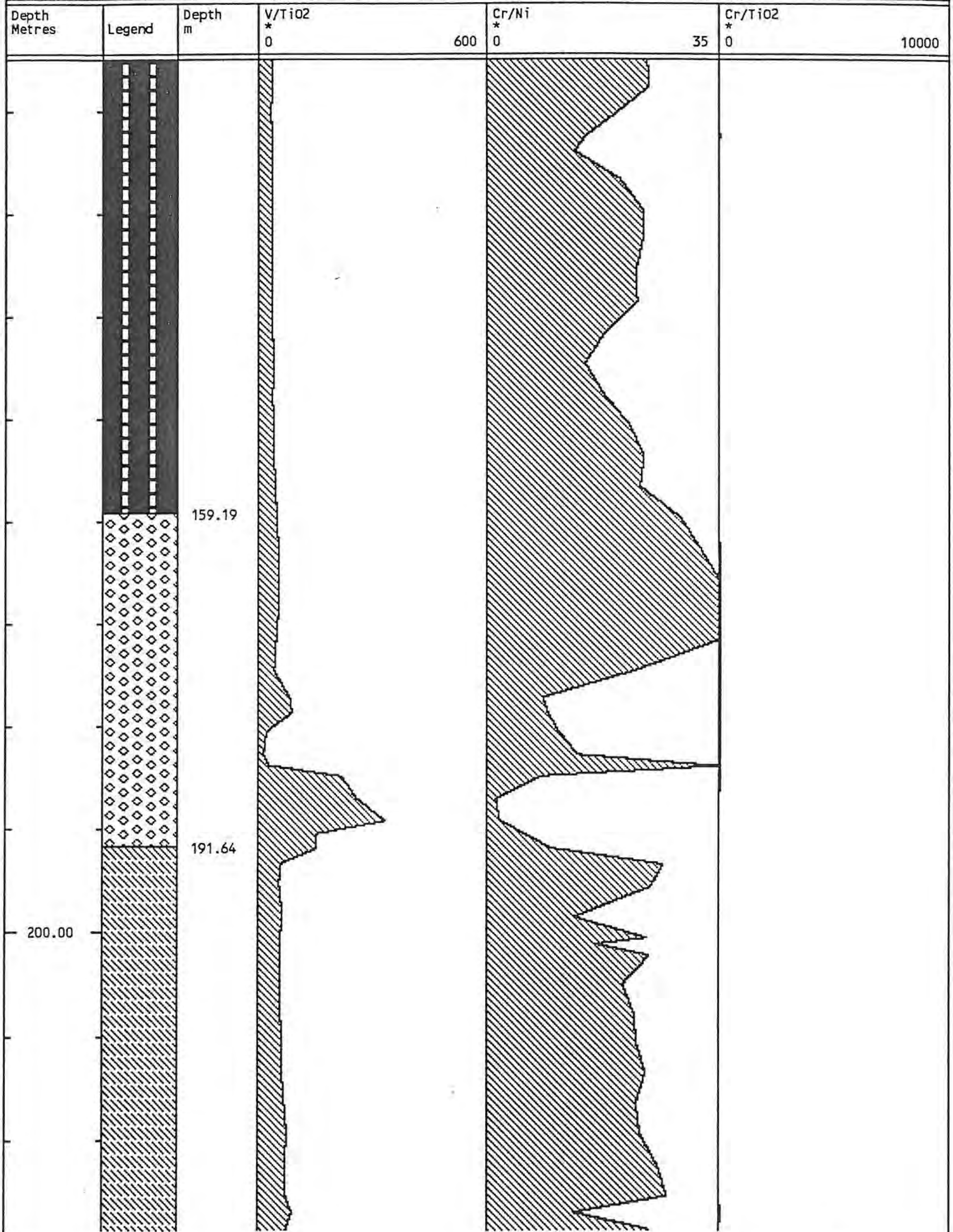
R O U T I N E   G E O C H E M I C A L   P R O F I L E S

Depth Metres	Legend	Depth m	V/TiO2 * 0 600	Cr/Ni * 0 35	Cr/TiO2 * 0 10000



PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 07-04-1995
FARM: RIETFONTEIN 70JS	115.00 to 230.00 metres	Scale: 1:500

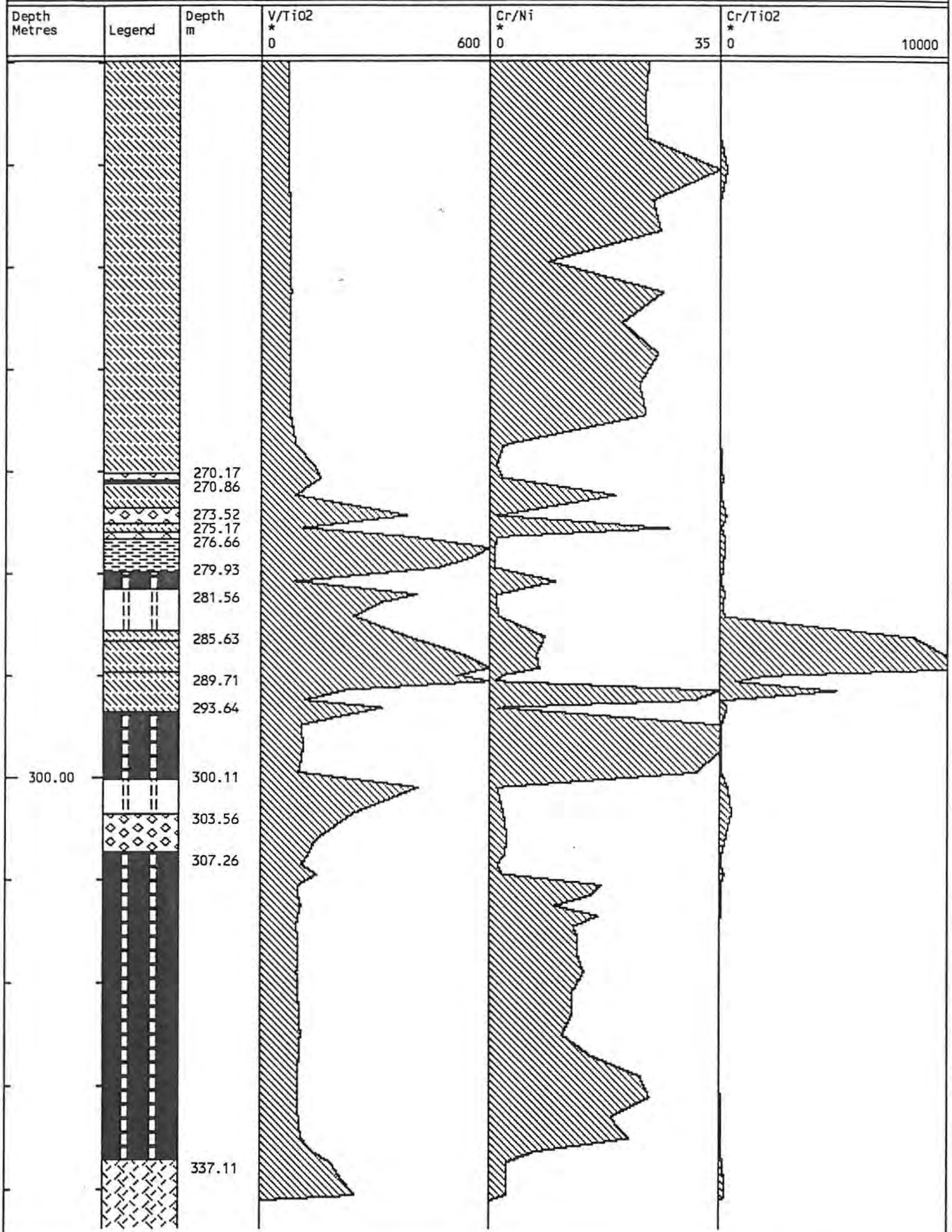
ROUTINE GEOCHEMICAL PROFILES



APPENDIX P

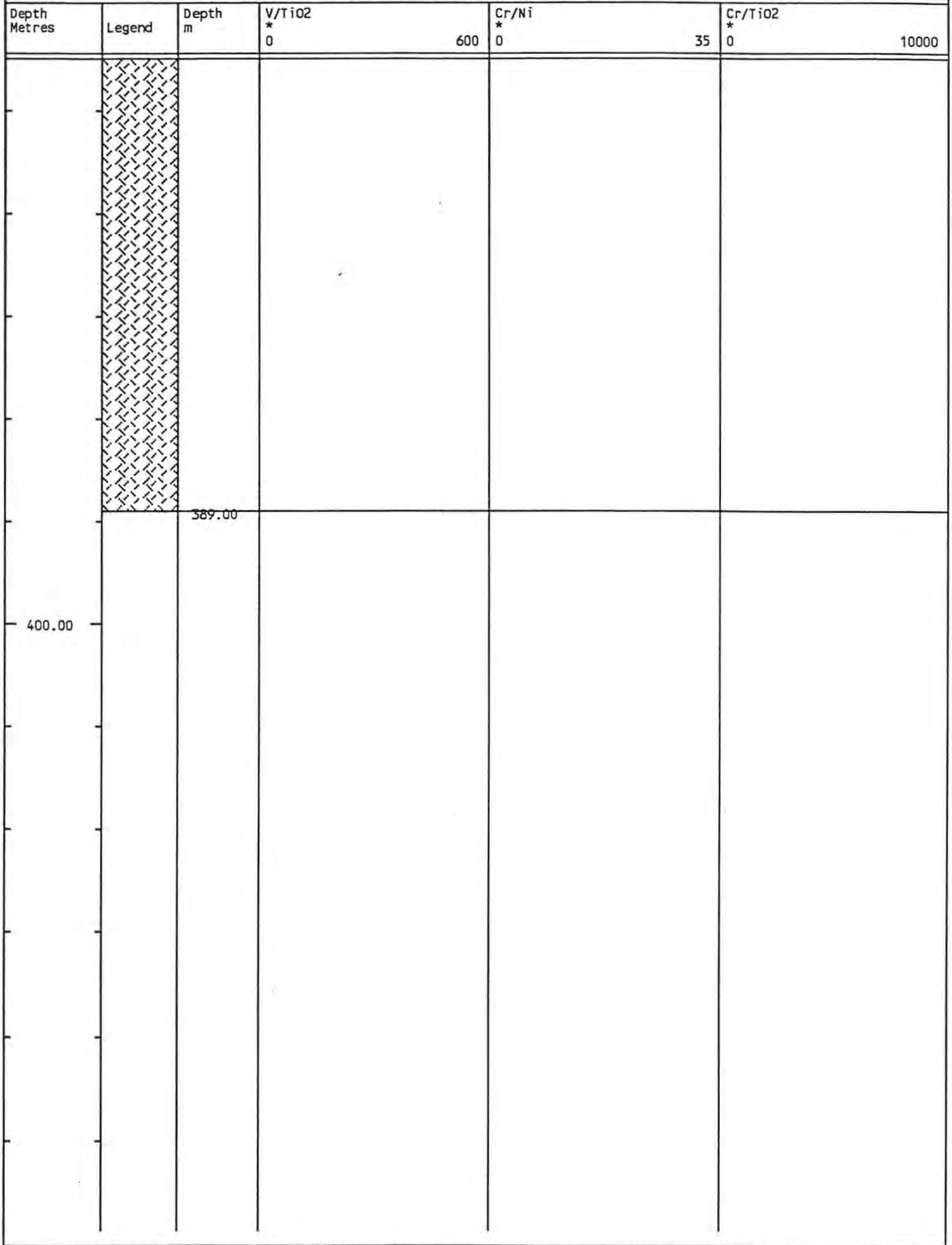
PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 07-04-1995
FARM: RIETFONTEIN 70JS	230.00 to 345.00 metres	Scale: 1:500

R O U T I N E   G E O C H E M I C A L   P R O F I L E S



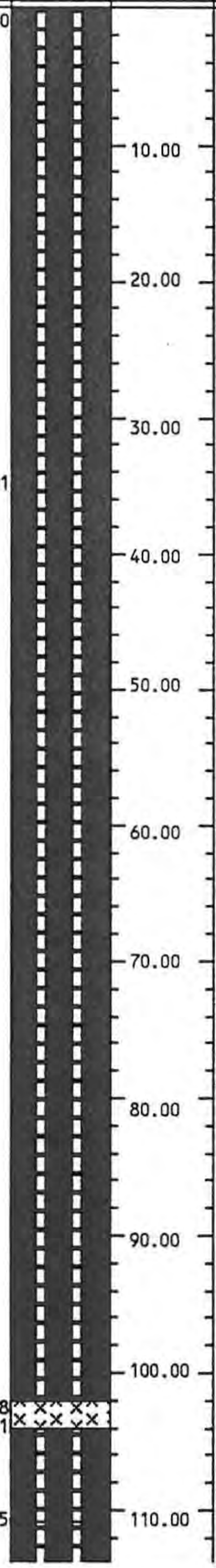
PROJECT: MINERAL RANGE	BOREHOLE NO: RF4(-90)	Date: 07-04-1995
FARM: RIETFONTEIN 70JS	345.00 to 389.00 metres	Scale: 1:500

R O U T I N E   G E O C H E M I C A L   P R O F I L E S



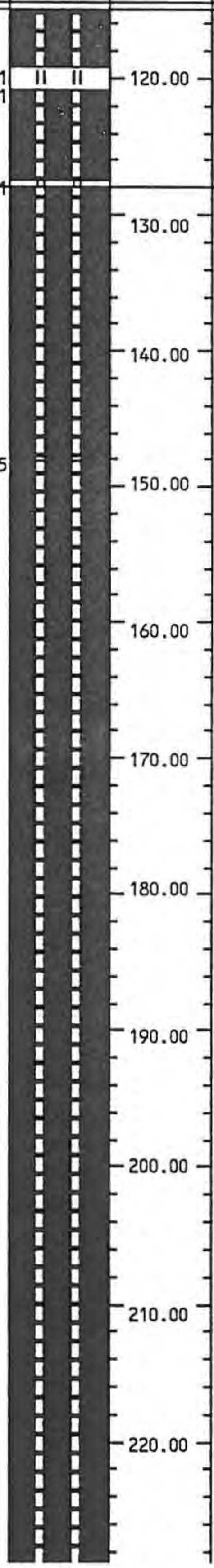
PROJECT: MINERAL RANGE	BOREHOLE NO: RF5	Date: 03-04-1995
FARM: RIETFONTEIN 70JS	0.00 to 115.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
0.00 to 33.91 m: Weathered MAGNETITE-GABBRO. NQ-size core starts from 34,12m.	0.00		
33.91 to 102.08 m: Coarse-grained MAGNETITE-GABBRO (BC Upper Zone). Unit often micaceous with minor disseminated sulphides (pyrrhotite & chalcopyrite). Granitic intrusion (displaying granophyric intergrowth) at 69,63-70,23m. Unit becomes medium- grained with associated decrease in feldspar content at 77,60-83,79m. Massive magnetite units (layers?) with disseminated sulphide mineralization at 89,84-89, 94m; 91,64-91,71m; 92,86-92,95m; 99,17-100,24m; 100,49-100,64m.	33.91		
102.08 to 104.01 m: Granitic INTRUSION. Very conspicuous contacts (app.dip = 60 deg). No chill margin evident.	102.08		
104.01 to 110.75 m: Medium-grained MAGNETITE-GABBRO, as before. 4cm Steep (75 deg) Qz/feldspar vein at 108,29m. Magnetite layer with disseminated sulphides (pyrr & chpy) at 110,38- 110,75m (arbitrary contacts).	104.01		
110.75 to 119.21 m: Medium-grained MAGNETITE-GABBRO, with magnetite- and sulphide-bearing	110.75		



PROJECT: MINERAL RANGE	BOREHOLE NO: RF5	Date: 03-04-1995
FARM: RIETFONTEIN 70JS	115.00 to 230.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
pegmatiticunits at 115,26-115,51m; 118,27-118,59m. 10cm Granitic intrusion at 115,59m (60 deg).			
119.21 to 120.81 m: Coarse-grained to pegmatitic GABBRO, with minor coarse sulphides near base of unit. Sharp bottom contact.	119.21 120.81		
120.81 to 127.41 m: Medium-grained MAGNETITE-GABBRO.	127.41		
127.41 to 127.98 m: Coarse-grained to pegmatitic GABBRO, as before. Sharp irregular contacts.			
127.98 to 148.05 m: Fine to medium-grained MAGNETITE-GABBRO, with pegmatite at 129,61-129,94m. Unit becomes coarser-grained with disseminated sulphides in places. Fine-grained granitic intrusions at 146,59-147,08m; 148,03-148,75m.	148.05		
148.05 to 311.21 m: Coarse-grained MAGNETITE-GABBRO, with abundant disseminated sulphides in places. Granitic intrusions at 165,80-165,89m; 168,92-168,99m.			



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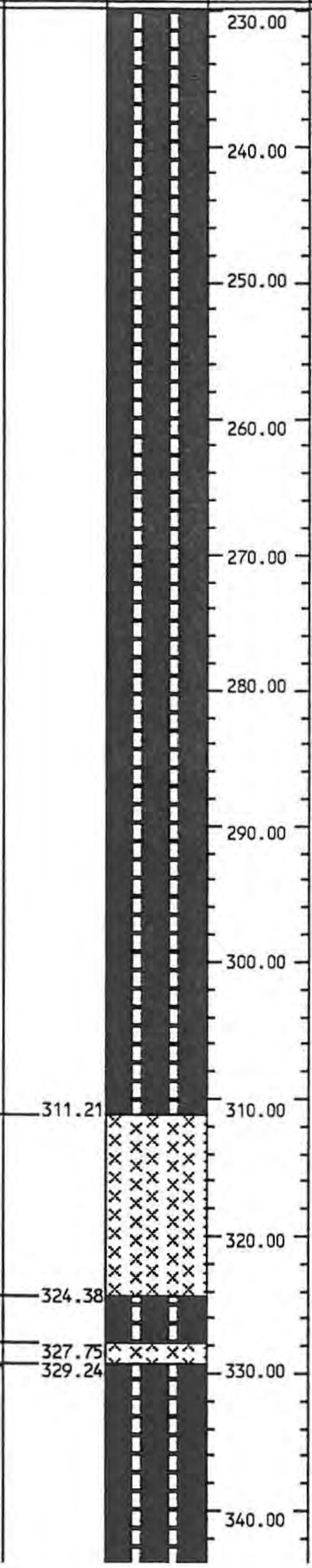
APPENDIX Q

PROJECT: MINERAL RANGE	BOREHOLE NO: RF5	Date: 03-04-1995
FARM: RIETFONTEIN 70JS	230.00 to 345.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres



311.21 to 324.38 m:
INTRUSION of granitic composition (medium-grained to pegmatitic). Top and bottom contacts app.dip = 55 degrees. Pink appearance due to K-feldspar. Fragments of Fe-gabbro at 317,04-317,24m; 322,12-322,75m.

324.38 to 327.75 m:
Coarse-grained MAGNETITE-GABBRO, as before.

327.75 to 329.24 m:
Granitic INTRUSION, as before. Contacts gradational but appears steep.

329.24 to 369.94 m:
MAGNETITE-GABBRO, as before. Concentrations of magnetite (layers?) from 359,74- 360,40m; 361,67-361,84m. Unit becomes altered and more finer-grained from 364, 34m.

PROJECT: MINERAL RANGE	BOREHOLE NO: RF5	Date: 03-04-1995
FARM: RIETFONTEIN 70JS	345.00 to 460.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres

369.94 to 370.36 m:
Medium- to coarse-grained OLIVINE-PYROXENITE.

370.36 to 371.75 m:
Highly altered GABBRO.

371.75 to 373.44 m:
Medium-grained PYROXENITE.

373.44 to 406.32 m:
Fine-grained mafic INTRUSION, with fragments of altered, coarse-grained gabbro in places.

406.32 to 416.38 m:
Fine-grained, slightly altered PYROXENITE, with minor disseminated sulphides. Pyroxenitic pegmatites (+minor, coarse chalcopyrite & pyrrhotite mineralization in parts) at 410,40-411,16m; 412,03-414,98m.

416.38 to 418.16 m:
Medium-grained, sulphide-bearing HARZBURGITE. Olivines highly altered in parts

418.16 to 420.54 m:
Coarse-grained GABBRO.

420.54 to 422.47 m:
HARZBURGITE, as before. Distinct lower contact at apparent dip of 35 degrees.

422.47 to 426.10 m:
Coarse-grained MAGNETITE-GABBRO, with 11cm sulphide-bearing magnetite layer at base of unit.

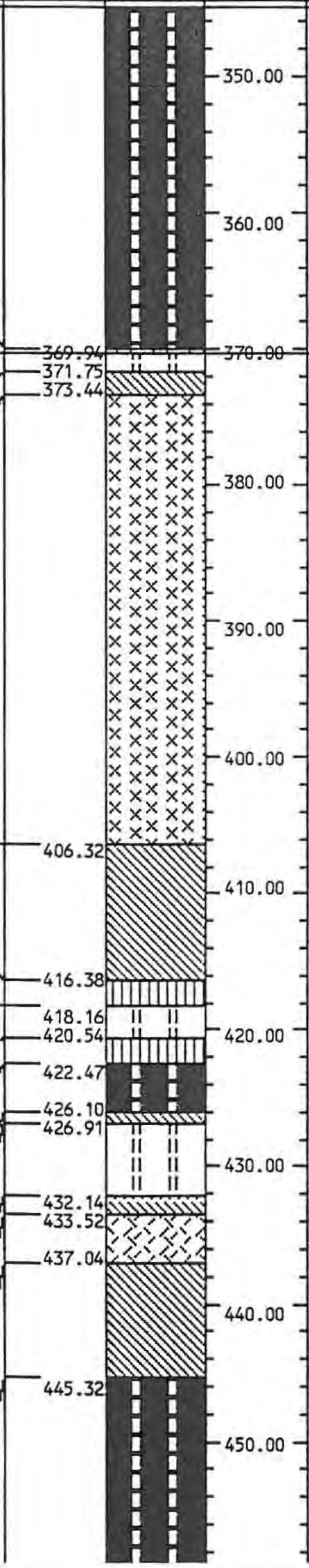
426.1 to 426.91 m:
Fine-grained PYROXENITE, with sharp, irregular bottom contact.

426.91 to 432.14 m:
Coarse-grained MAGNETITE-GABBRO. Granitic vein at 432,66-432,80m.

432.14 to 433.52 m:
Coarse-grained, highly altered, magnetite-bearing FELDSPATHIC-PYROXENITE.

433.52 to 437.04 m:
Mafic HORNFELS (xenolith?).

437.04 to 445.32 m:
Coarse-grained PYROXENITE, containing xenolith of hornfels at 438,09-438,74m, and fragments of gabbroic material at 439,76-439,98m; 441,21-441,56m; 442,28- 442,49m. Well defined bottom contact (app.dip = 35deg).



LOGGED BY: S.P.CROUS	APPENDIX Q	Page 4 of 6.

PROJECT: MINERAL RANGE	BOREHOLE NO: RF5	Date: 03-04-1995
FARM: RIETFONTEIN 70JS	460.00 to 575.00 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
445.32 to 464.98 m: Coarse-grained, MAGNETITE-GABBRO. Granitic vein at 456,53-456,66m. Unit becomes medium-grained in places.	464.98		460.00
464.98 to 466.90 m: Medium-grained, altered FELDSPATHIC PYROXENITE.	466.90		
466.9 to 470.89 m: Coarse-grained MAGNETITE-GABBRO, as before. Fine-grained pyroxenitic fragments at 459,71-460,10m. Concentration of magnetite with minor disseminated sulphides at 470,60m.	470.89		470.00
470.89 to 471.58 m: Granitic INTRUSION.			
471.58 to 485.25 m: Coarse-grained MAGNETITE-GABBRO with massive magnetite units (layers) with associated, disseminated sulphide muineralization at 472,18-472,49m; 475,77- 476m. Meta-sediment xenoliths at 476,67-477,04; 478,20-479,85m; 482,63-484,25m. Fine-grained pyroxenite xenolith at 477,41-478,10m. Pegmatite with minor sulphides at 484,25-485,25m.	485.25		480.00
485.25 to 494.87 m: Fine-grained FELDSPATHIC PYROXENITE, with pegmatitic zones (often sulphide- bearing) at 487,11-487,33m; 487,76-488,53m; 489,25-490,48m. Granitic intrusion (with granophyric texture) at 488,87-489,25m (steep contacts). Bottom contact at 25 degrees.	494.87		490.00
494.87 to 508.37 m: Medium- to coarse-grained MAGNETITE-GABBRO with minor disseminated sulphides in places. Magnetite-rich units (layers?) at 496,91-497,02m; 497,85-498,10m; 498, 84-498,86m; 498,89-498,94m. Anorthositic appearance to gabbro at 506 - 508m.	508.37		500.00
508.37 to 520.84 m: Fine-grained FELDSPATHIC PYROXENITE. Pegmatitic patches with minor sulphides (often feldspathic) at 510,91-512,66m; 514,27-514,41m; 516,12-516,51m; 516,87- 517,26m; 517,56-517,62m. Granitic intrusion at 515,19-515,42m.	520.84		510.00
520.84 to 530.19 m: Granitic INTRUSION, with angular fragments of fine-grained pyroxenite, gabbro, pegmatite and meta-sediment. Pyroxenite adjacent to intrusion altered, and chill margin evident.	530.19		520.00
530.19 to 556.46 m: Fine-grained FELDSPATHIC PYROXENITE, as before with pegmatitic patches (+associated sulphides) at 537,51-537,92m; 541,88-542,03m; 543,26-543,52m; 543, 80-544,62m; 546,99-547,16m; 547,37-547,57m; 550,34-550,68m; 551,60-552,41m; 552, 92-553,03m; 553,21-553,71m; 554,03-554,17m; 554,53-555,39m.	556.46		530.00 540.00 550.00
556.46 to 567.98 m: Pyroxenitic PEGMATOID, often feldspathic, with disseminated and coarse sulphide (predominantly pyrrhotite & chalcopyrite) mineralization in places. Top contact at apparent dip of 35 degrees.	567.98		560.00
567.98 to 674.87 m: Medium- to coarse-grained (sometimes pegmatitic) MAGNETITE-GABBRO. Fragment of fine-grained pyroxenite at 569,56-572,23m. Magnetite-rich zones (+ associated sulphide mineralization) at 616,11-617,83m;			570.00

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PROJECT: MINERAL RANGE	BOREHOLE NO: RF5	Date: 03-04-1995
FARM: RIETFONTEIN 70JS	575.00 to 680.30 metres	Scale: 1:500
CONTRACTOR: MOWVILLE EXPL.	MACHINE: LONGYEAR 44	

Geological Description	Depth m	Legend	Depth Metres
618,02-618,92m; 625,44-62569m; 626, 81-626,93m. Pegmatitic pyroxenite xenoliths at 626,94-630,34m. Magnetite-rich zone (layer?) with disseminated chalcopyrite and pyrrhotite at 639,81-641,91m. Unit becomes mica-rich in places.			580.00 590.00 600.00 610.00 620.00 630.00 640.00 650.00 660.00 670.00
674.87 to 680.30 m: Fine-grained FELDSPATHIC PYROXENITE, with pegmatitic patches in places. Unit becomes extremely altered in certain parts. E.O.H. = 680,30m.	674.87		
End of hole at 680.30 metres.	680.30		680.00

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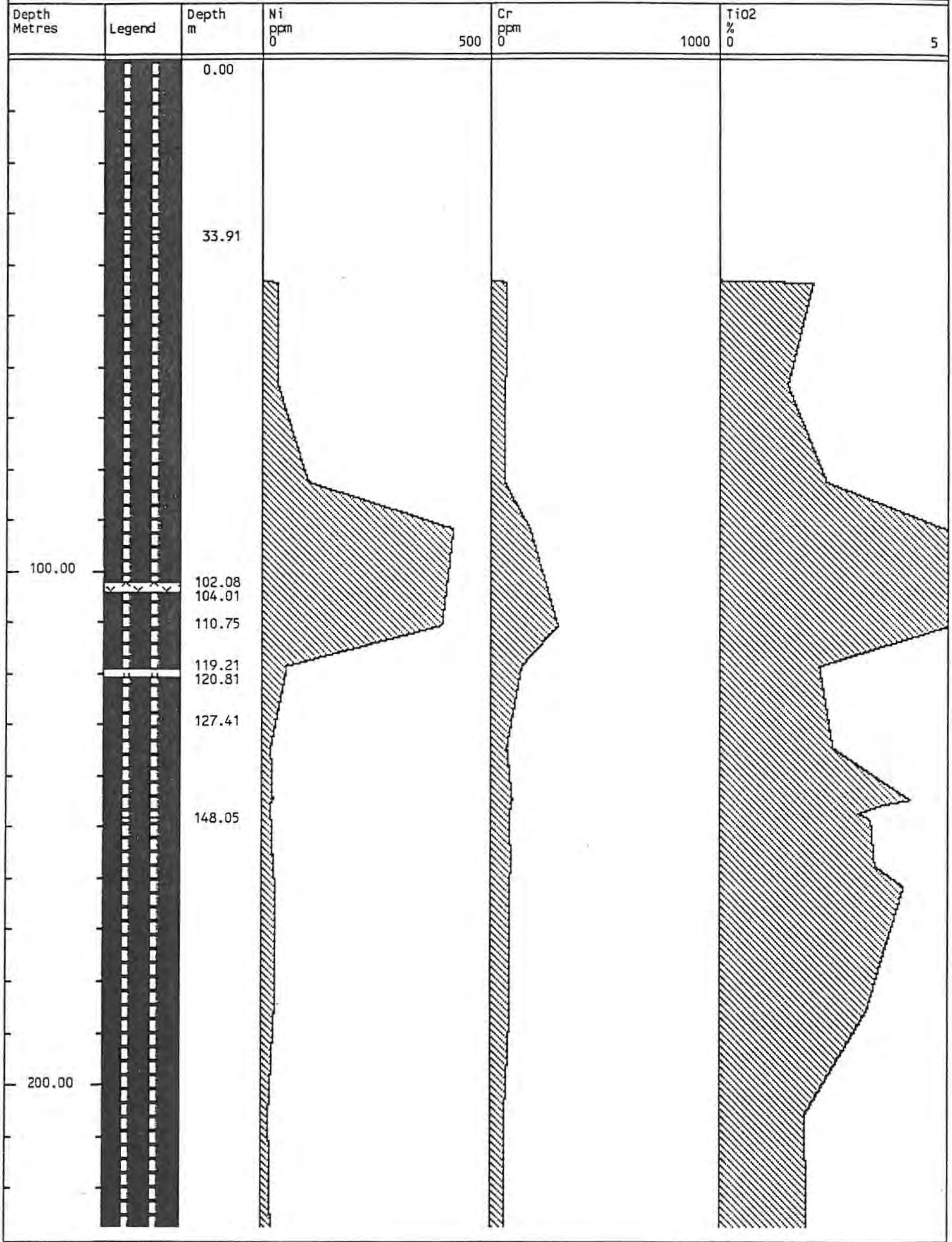
PROJECT: MINERAL RANGE	BOREHOLE NO: RF5(-90)	Date: 03-04-1995
FARM: RIETFONTEIN 70JS	0.00 to 230.00 metres	Scale: 1:1000

ROUTINE GEOCHEMICAL PROFILES

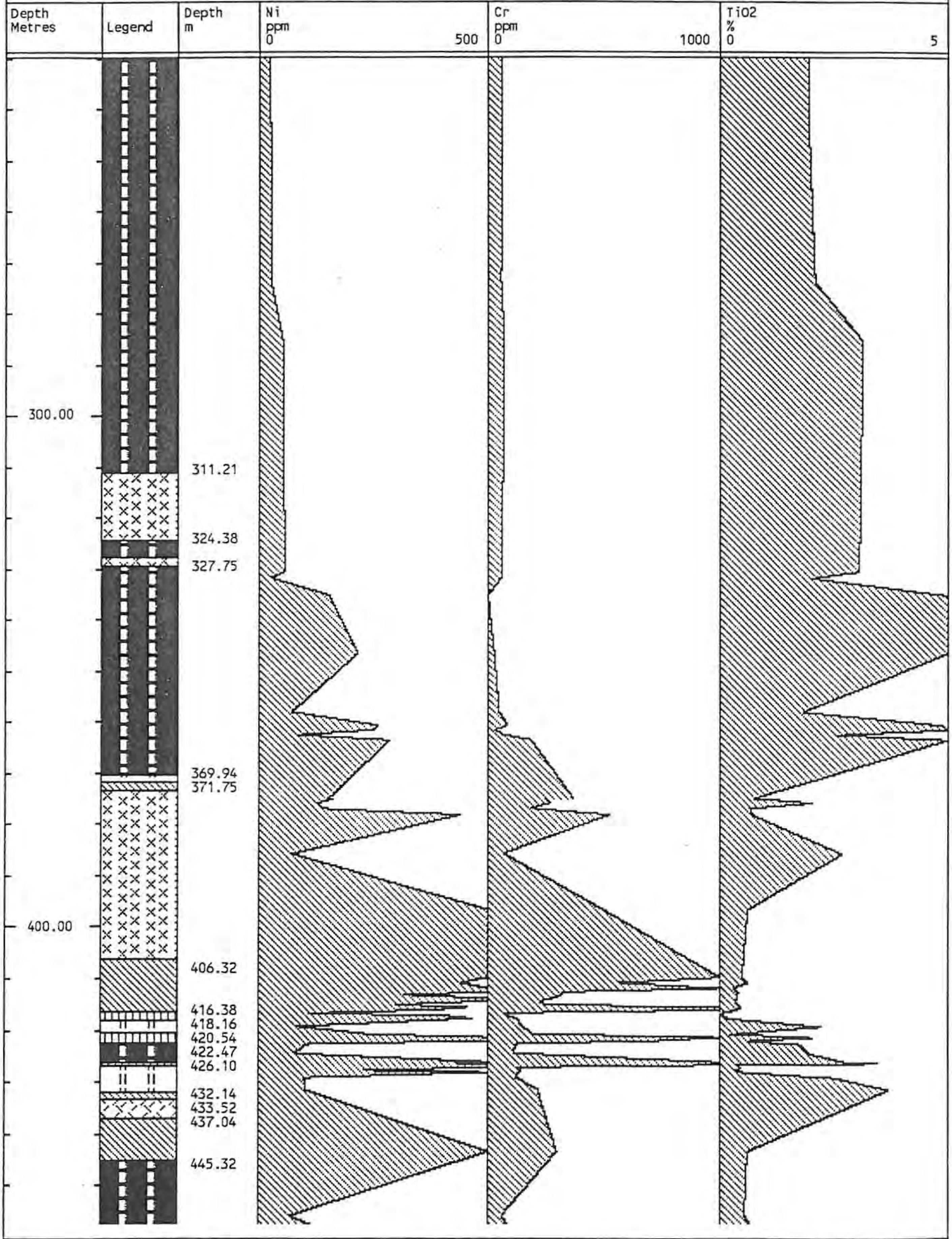


APPENDIX R

PROJECT: MINERAL RANGE | BOREHOLE NO: RF5(-90) | Date: 03-04-1995

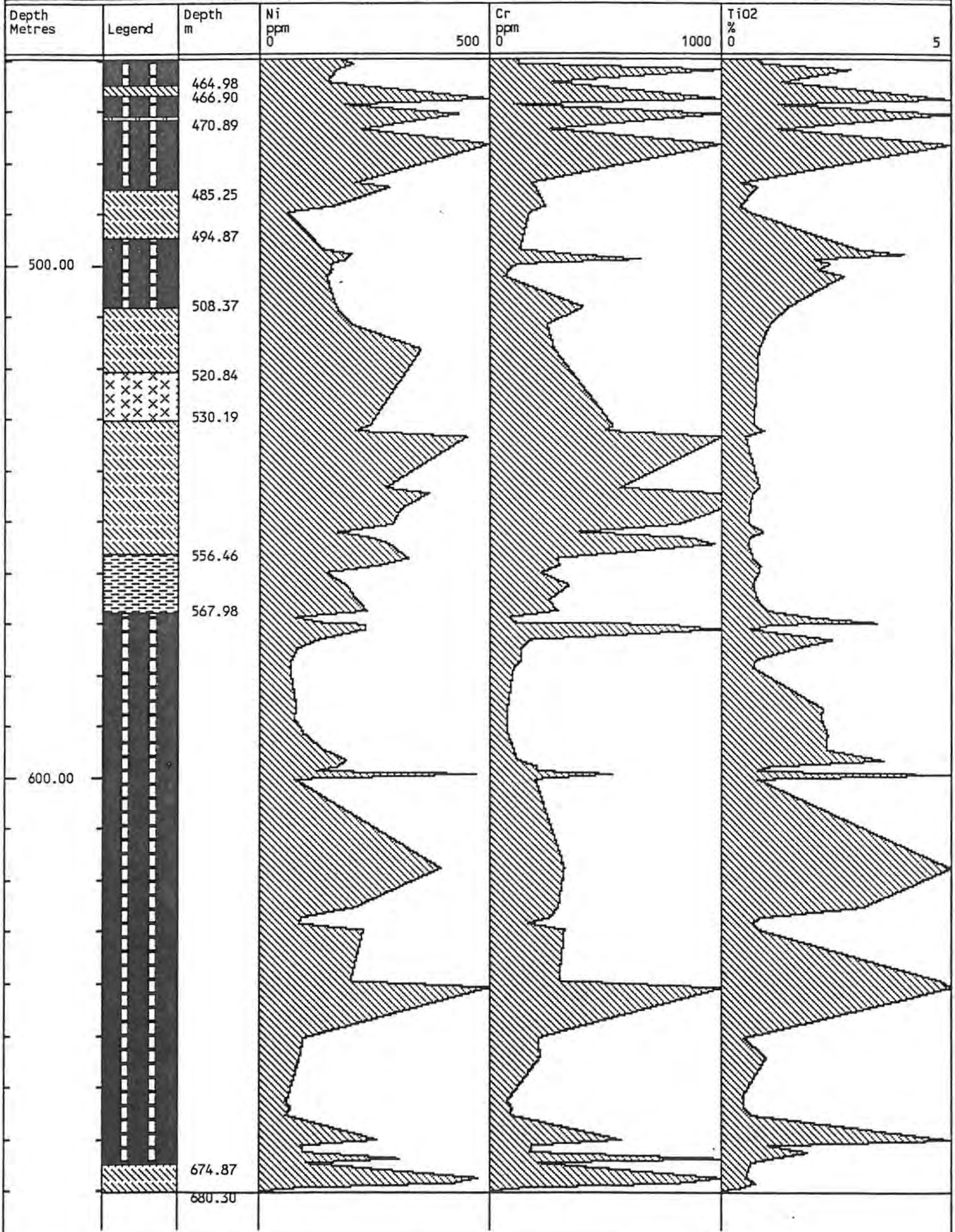
FARM: RIETFONTEIN 70JS | 230.00 to 460.00 metres | Scale: 1:1000

ROUTINE GEOCHEMICAL PROFILES



PROJECT: MINERAL RANGE	BOREHOLE NO: RF5(-90)	Date: 03-04-1995
FARM: RIETFONTEIN 70JS	460.00 to 680.30 metres	Scale: 1:1000

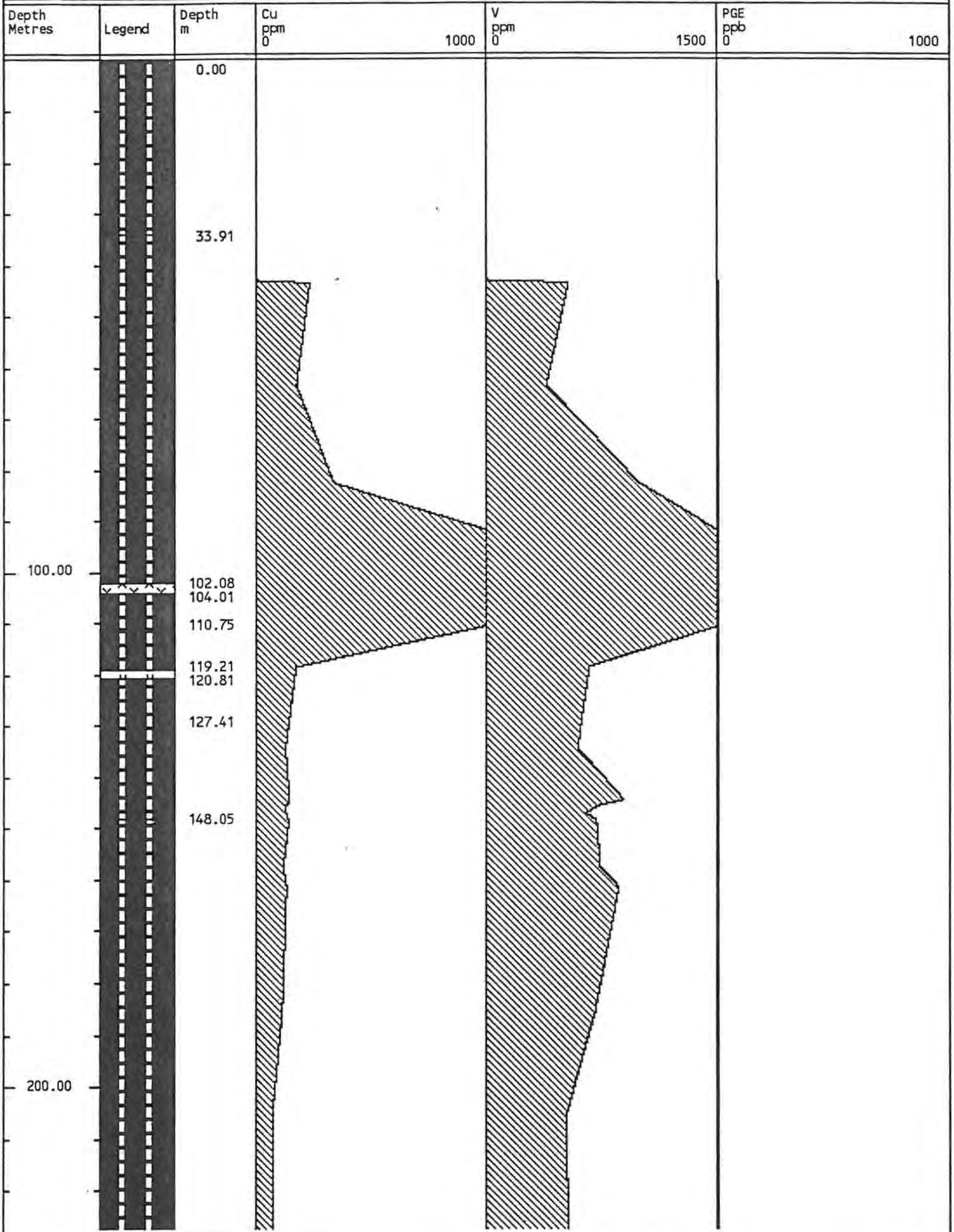
ROUTINE GEOCHEMICAL PROFILES



APPENDIX R

PROJECT: MINERAL RANGE	BOREHOLE NO: RF5(-90)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	0.00 to 230.00 metres	Scale: 1:1000

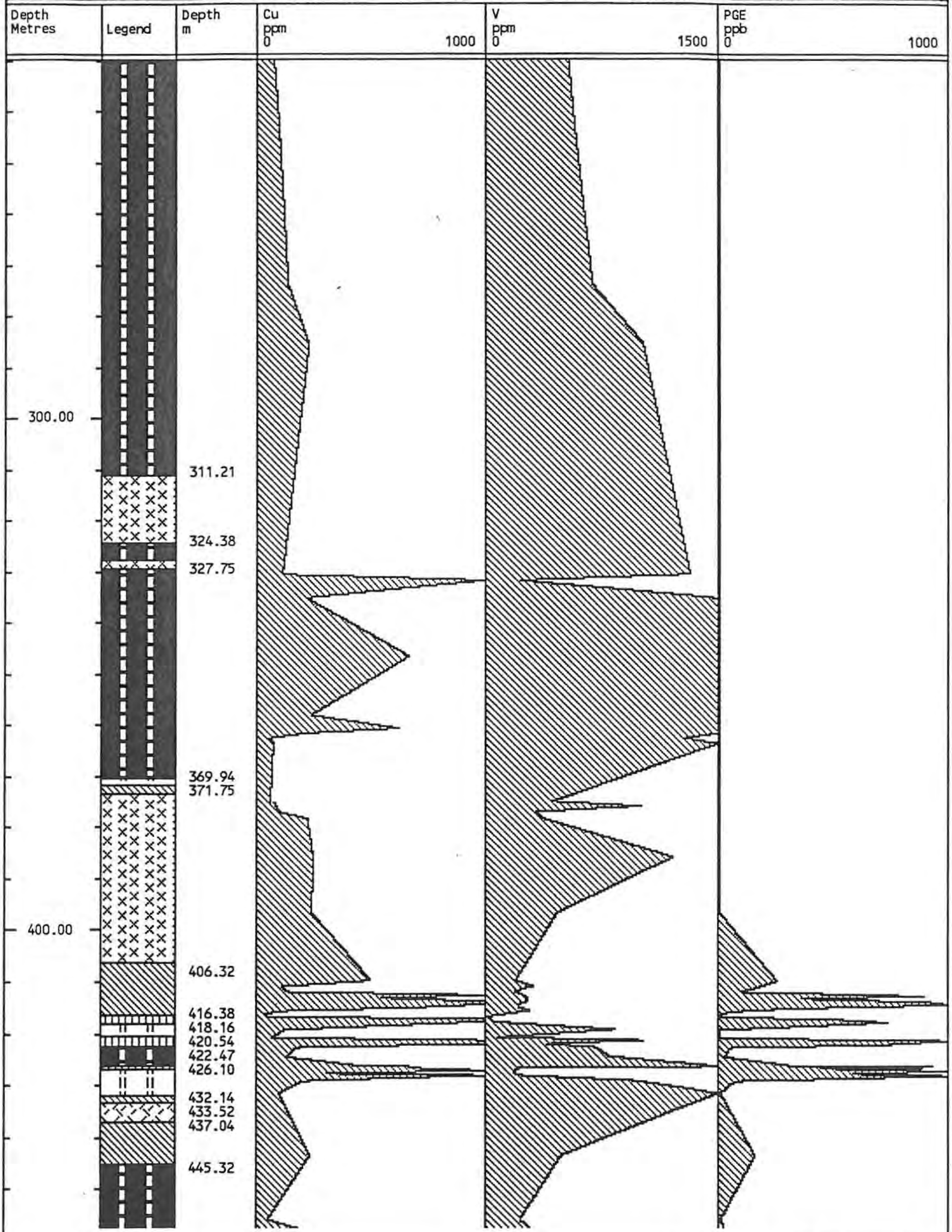
ROUTINE GEOCHEMICAL PROFILES



APPENDIX S

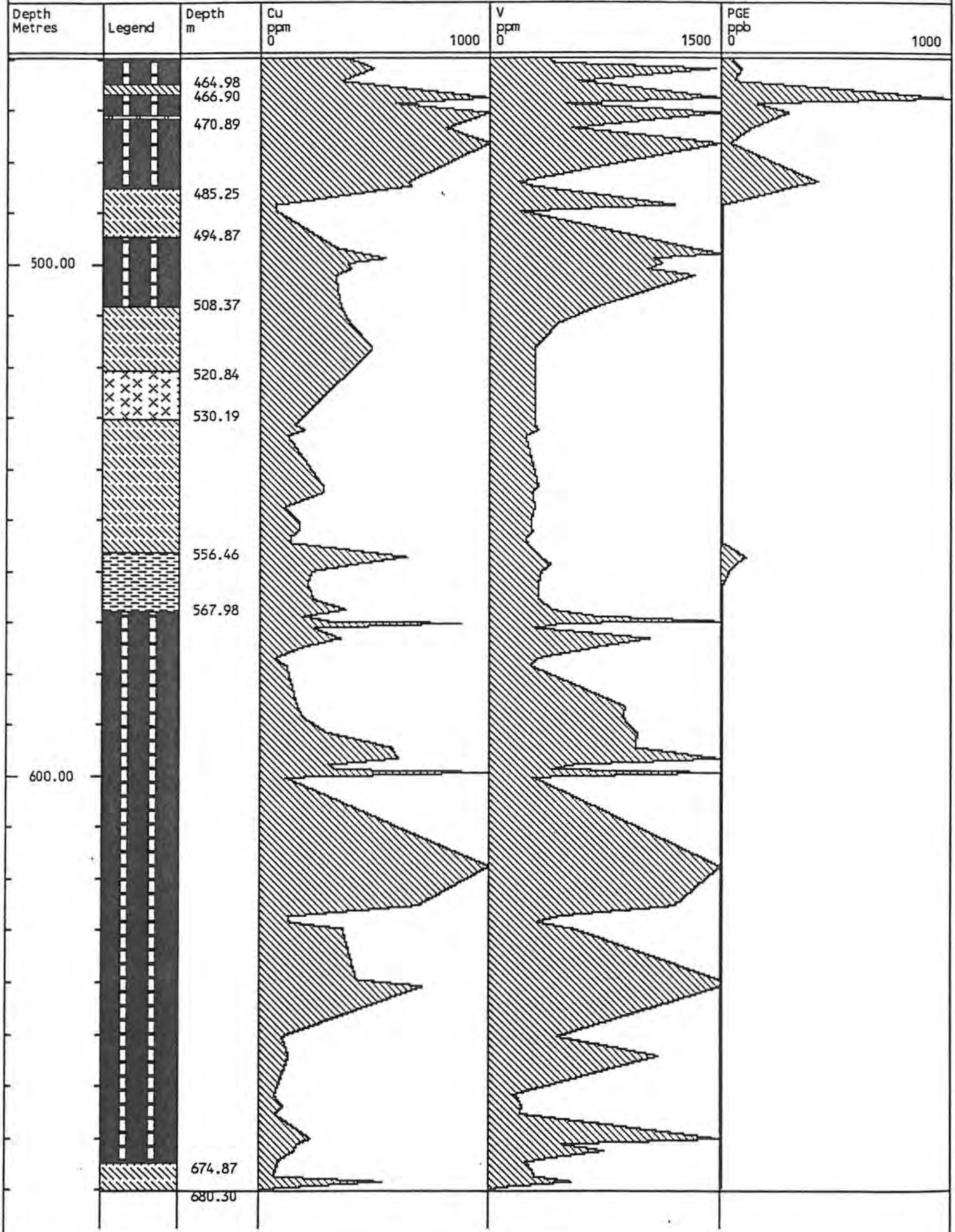
PROJECT: MINERAL RANGE	BOREHOLE NO: RF5(-90)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	230.00 to 460.00 metres	Scale: 1:1000

ROUTINE GEOCHEMICAL PROFILES



PROJECT: MINERAL RANGE	BOREHOLE NO: RF5(-90)	Date: 06-04-1995
FARM: RIETFONTEIN 70JS	460.00 to 680.30 metres	Scale: 1:1000

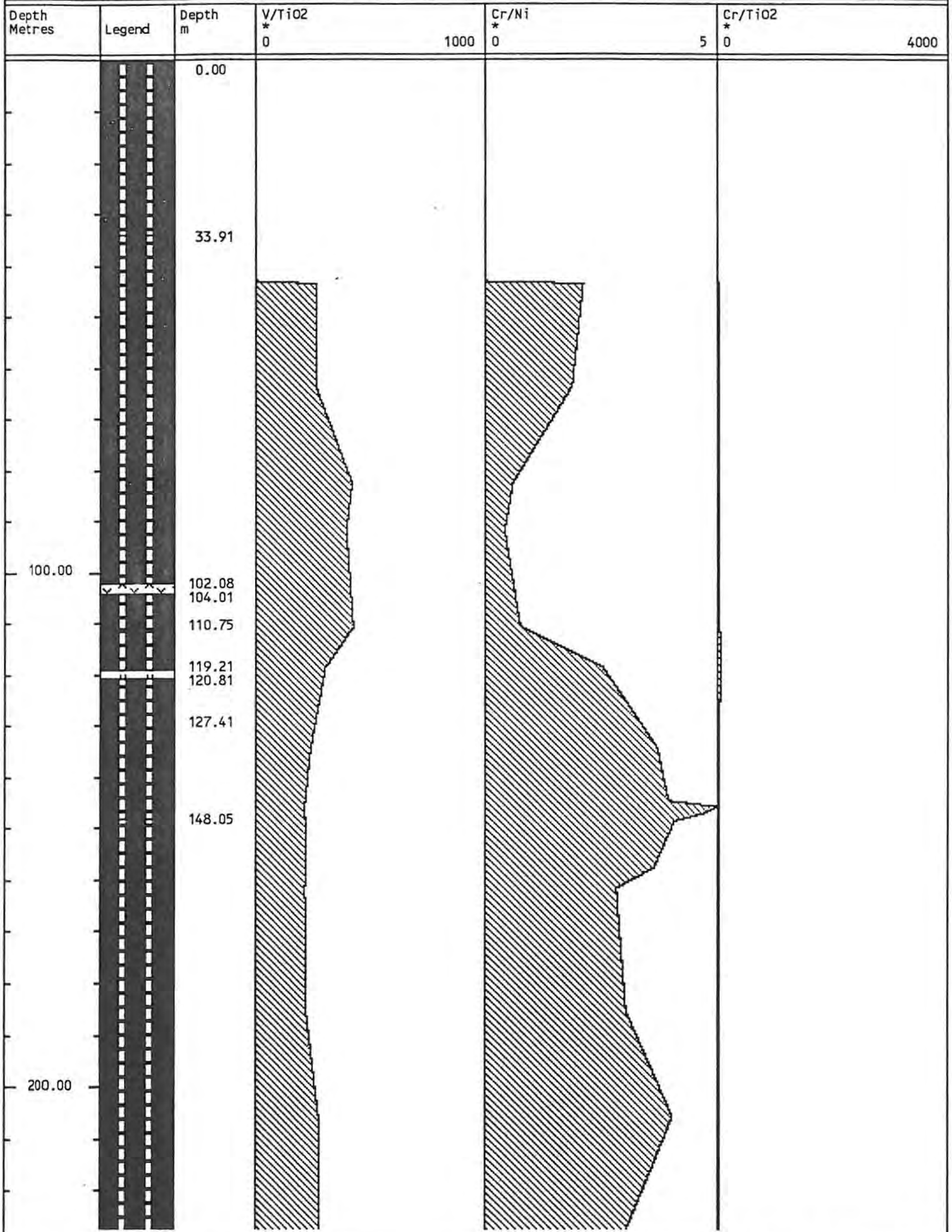
ROUTINE GEOCHEMICAL PROFILES



APPENDIX S

PROJECT: MINERAL RANGE	BOREHOLE NO: RF5(-90)	Date: 07-04-1995
FARM: RIETFONTEIN 70JS	0.00 to 230.00 metres	Scale: 1:1000

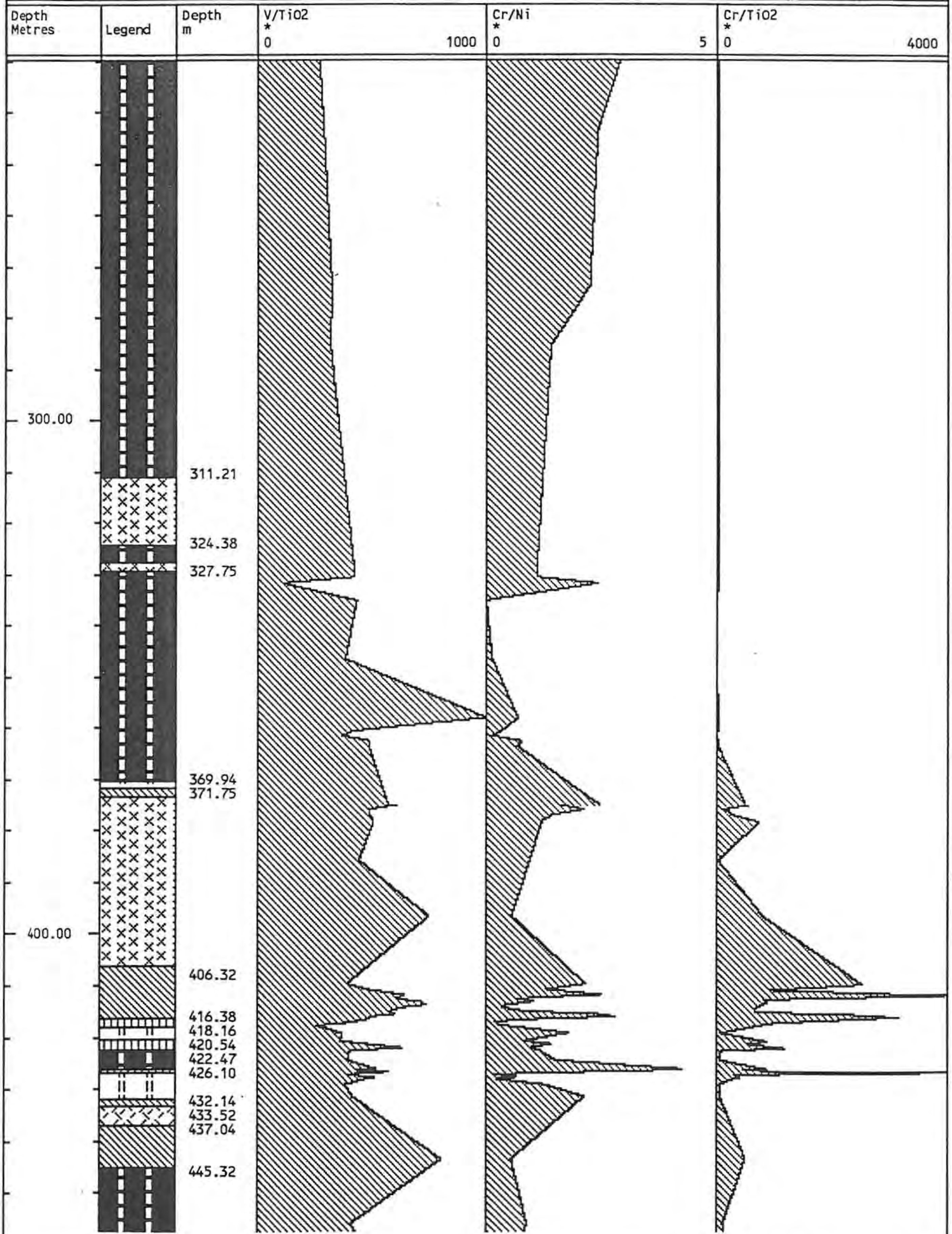
R O U T I N E   G E O C H E M I C A L   P R O F I L E S



APPENDIX T

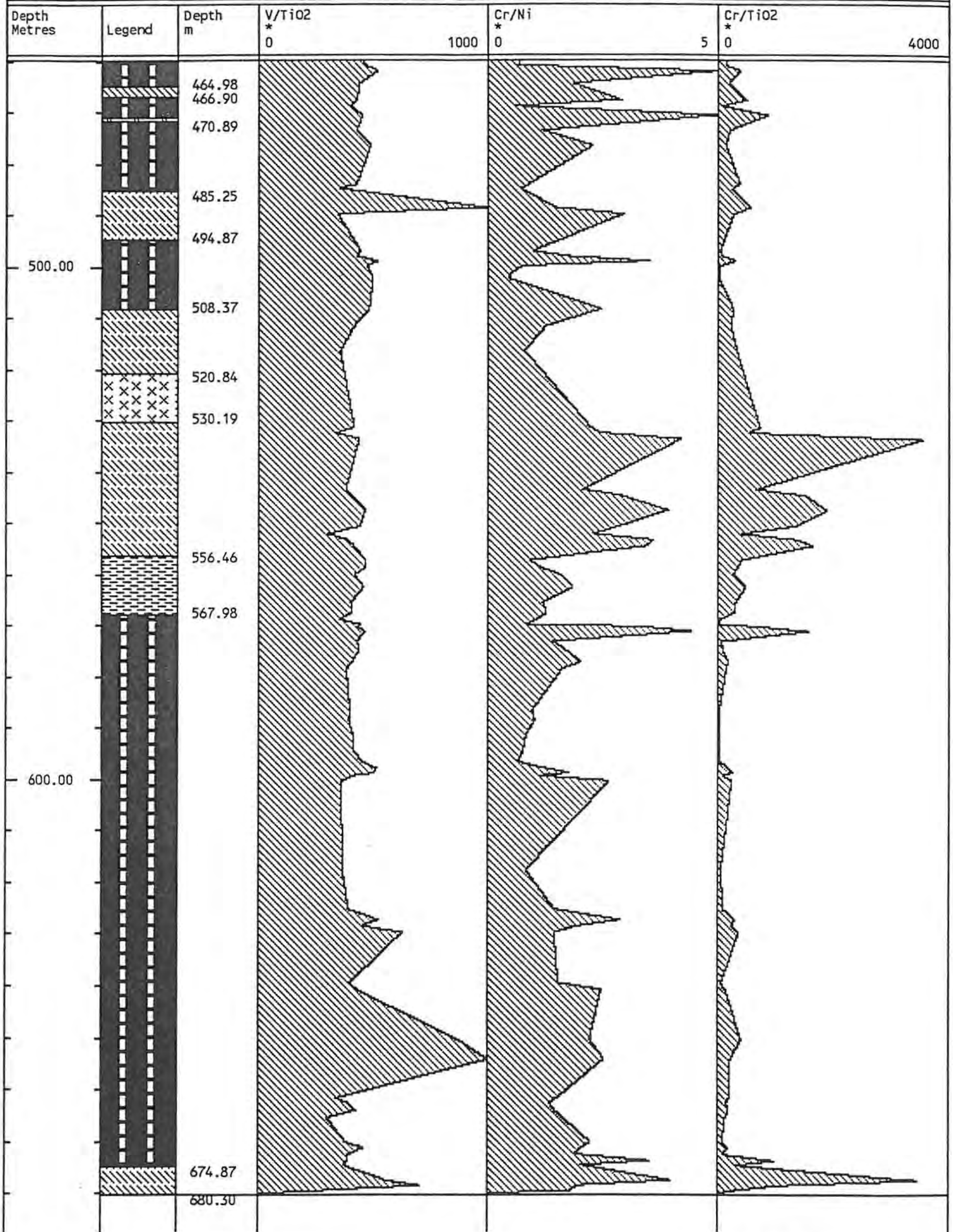
PROJECT: MINERAL RANGE	BOREHOLE NO: RF5(-90)	Date: 07-04-1995
FARM: RIETFONTEIN 70JS	230.00 to 460.00 metres	Scale: 1:1000

ROUTINE GEOCHEMICAL PROFILES



PROJECT: MINERAL RANGE	BOREHOLE NO: RF5(-90)	Date: 07-04-1995
FARM: RIETFONTEIN 70JS	460.00 to 680.30 metres	Scale: 1:1000

R O U T I N E   G E O C H E M I C A L   P R O F I L E S



APPENDIX T