THE GEOLOGY AND EVALUATION OF THE "A"-REEF AT No.3 SHAFT, WESTERN HOLDINGS MINE, WELKOM GOLDFIELD

BY

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DECLARATION:

I, Nigel John Frederick Blamey, certify that this thesis has not been submitted at any other university and that it is my original work, except where otherwise acknowledged, referenced or annotated.

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ABSTRACT

The "A"-Reef occurs within the Aandenk Formation of the Central Rand Group, Witwatersrand Supergroup, in the Welkom Goldfield. It comprises the the Witpan and Uitsig Reefs which are both oligomictic conglomerates, and are exploited for their gold content by Anglo American Corporation.

The main Witpan channel complex is orientated in a NW-SE direction and occurs close to No.3 Shaft of Western Holdings Mine where it is currently being mined. The Witpan Reef varies in thickness from 7-220cm, with lateral facies changes controlling the thickness. Within the reef, gold is associated with degradation surfaces, carbonaceous material, increase in pebble sphericity, and channel edges. Two channel edges have yielded the best gold values on No.3 Shaft although the potential for further payable gold lies in the recognition of sieve conditions. The potential also exists for extensions of the "carbon"-bearing Uitsig channel currently being mined on President Steyn Mine. The palaeo-environment proposed for formation of the Witpan Reef is a braidplain that was partly reworked by a brief transgression.

Ore evaluation using geostatistics was considered a valid technique as the dataset is sufficiently well structured. Semi-variograms in the channel and across-channel directions differ markedly. It was found that variograms of gold in cmg/t lacked sufficient structure for modelling, however, log semi-variogram modelling followed by simple log-kriging and back-transformation, proved to be the most successful method.

Owing to the morphology and distribution of gold within the reef, a geologically based geostatistical valuation method is proposed. The potential for further exploration of "A"-Reef depends on a substantially higher gold price. In this event, exploration of Uitsig Reef to the southwest of the current mining area is recommended as well as a new exploration strategy for Witpan Reef.

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CHAPTER 1

1.1 INTRODUCTION

The Witwatersrand is the richest known gold depository in the world, outcropping and suboutcropping within the Kaapvaal Craton of South Africa (Fig. 1.1). Discovered by George Walker and George Harrison in 1886 on the farm Langlaagte (Whiteside et al., 1976), at what is now the city Johannesburg, this exceptional basin has, up until 1990, produced 42107 tonnes of gold from 4619 million tonnes of ore at an average grade of 9.12g/t. The Orange Free State Goldfields alone have produced 8942 tonnes of gold from 879 million tonnes of ore at an average grade of 10.17g/t (Chamber of Mines Statistics, by courtesy of Venmyn Rand). From 1952 to 1987 the basin yielded 145389 tonnes of U_3O_8 (D.A. Pretorius, pers. com., 1989). One may ask why is it that so much gold has accumulated within the Witwatersrand Basin? Is it the tectonic setting which is important, or is it that the basin is coeval with the rest of the world's Archaean rocks?

1.2 AIMS OF RESEARCH

This thesis examines the "A"-Reef, one of the less important gold-bearing placer deposits in the Welkom goldfield of the Witwatersrand Basin. By doing so, the writer aims to identify pertinent sedimentological and morphological characteristics of the orebody which will be shown to be important from an exploration and mine valuation view point.

1.3 METHODOLOGY

The Witpan Placer, a prominent mineralised unit of the "A"-Reef is examined geologically and statistically in order to establish the controls of gold mineralisation. The geology of the Welkom goldfield will be reviewed along with other reefs showing similarities to the "A"-Reef in an attempt to derive a depositional model. Univariate statistics and geostatistics are used as an integral part of valuation of the "A"-Reef. Sedimentological features are examined in conjunction with statistical signatures of gold distribution as a means of defining viable mining parameters. Proposals for the future exploitation of the "A"-Reef include recommendations on a valuation system for determining an exploration strategy for this reef type.

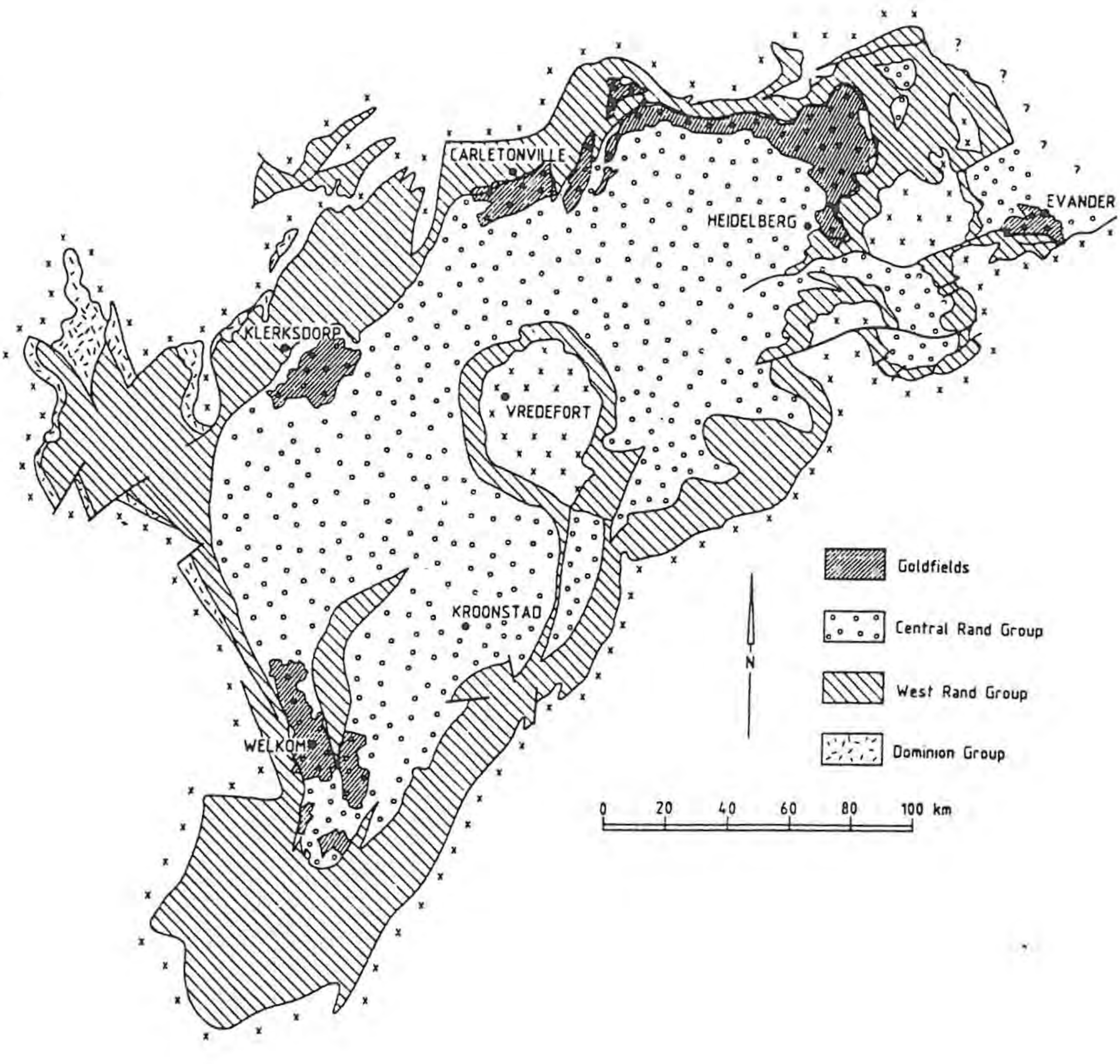


Figure 1.1 Sub-Transvaal Sequence outcrop of the Witwatersrand Basin showing the distribution of the Witwatersrand Supergroup and the major goldfields. (After Myers *et al.*, 1990).

CHAPTER 2

2.1 THE TECTONIC SETTING OF THE WITWATERSRAND BASIN

The Witwatersrand Basin is an Archaean, ENE-trending intracratonic basin, older than 2700 Ma (Armstrong et al., 1986) occupying an area of about $42000km^2$ (Fig. 2.1). The bulk of the Witwatersrand Basin underlies younger Proterozoic and Phanerozoic rocks of the Ventersdorp, Transvaal and Karoo Sequences. It suboutcrops in the southern part of the Transvaal Province as well as the northern and eastern Orange Free State (Fig. 1.1). The southern limits of the Witwatersrand Basin are yet to be determined but published maps show it terminating as far south as Brandfort. The upper stratigraphy (Central Rand Group) comprises sandstones and conglomerates, and it is within these arenaceous and rudaceous rocks that the gold-bearing reefs occur.

No less than four tectonic models have been proposed to explain the formation of the Witwatersrand Basin. The **taphrogenic** model, developed by Pretorius (1981), supports the development of basin-and-dome structures resulting from the superimposition of folds. The southeastern side of the basin is downwarped while the northwestern side is fault-bound, thereby producing higher-energy sediments along that margin. The goldfields occur in fan-deltas of major river systems which drained the hinterland to the west and north. Their positions were controlled by domal features caused by regional fold interference patterns.

The **intracratonic, alluvial-plain / lacustrine** model is a refinement of the **taphrogenic** model, introducing the tectono-stratigraphic concept of reworking of sedimentary cycles during basin shrinkage, contemporaneous with marginal uplift and basin-subsidence (Vos, 1975).

A **plate-tectonic** model was proposed by van Biljon (1980), who concluded that the Witwatersrand Basin could represent an embayment preserved along the margin of a suture-zone between two Archaean continents (Fig. 2.2). Burke et al (1986) view the Witwatersrand as a foreland basin, the Central Rand Group being the product of collision between the Kaapvaal and Rhodesia cratons.

The **cratonic foreland** model proposed by Winter (1987), places the Witwatersrand Basin in an Andean subduction setting (Fig. 2.3). A foreland basin is visualised along with an active fold-thrust belt in its hinterland, similar to the north American Cordillera. Adjacent to the thrust front with its syntectonic sediments, a foredeep developed which

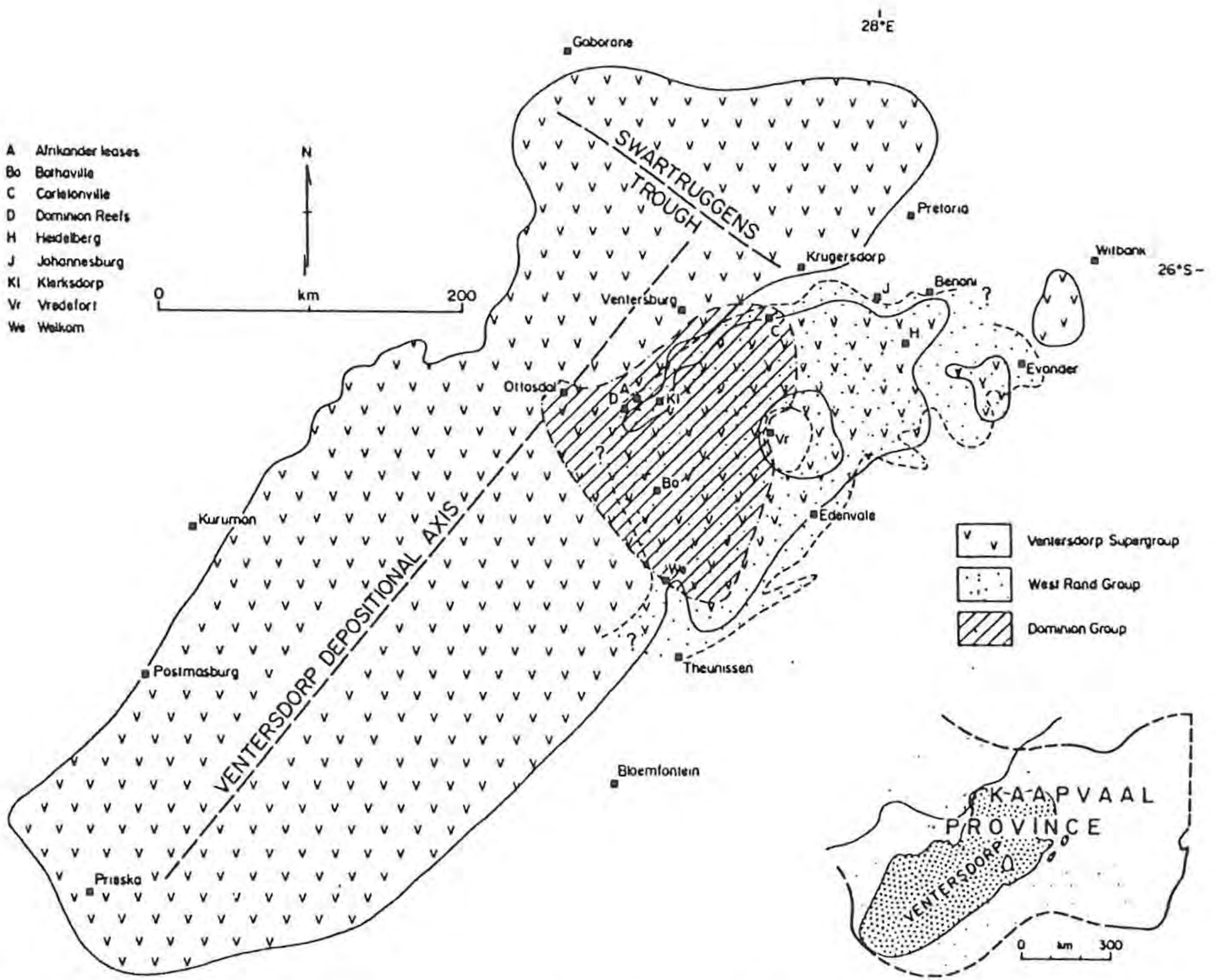


Figure 2.1 Map showing the distribution of the Dominion, West Rand, and Ventersdorp sequences. [Adapted from Hutchison (1975), Tyler (1979a), M. Strydom (personal communication, 1981).]

(after Tankard et al., 1982)

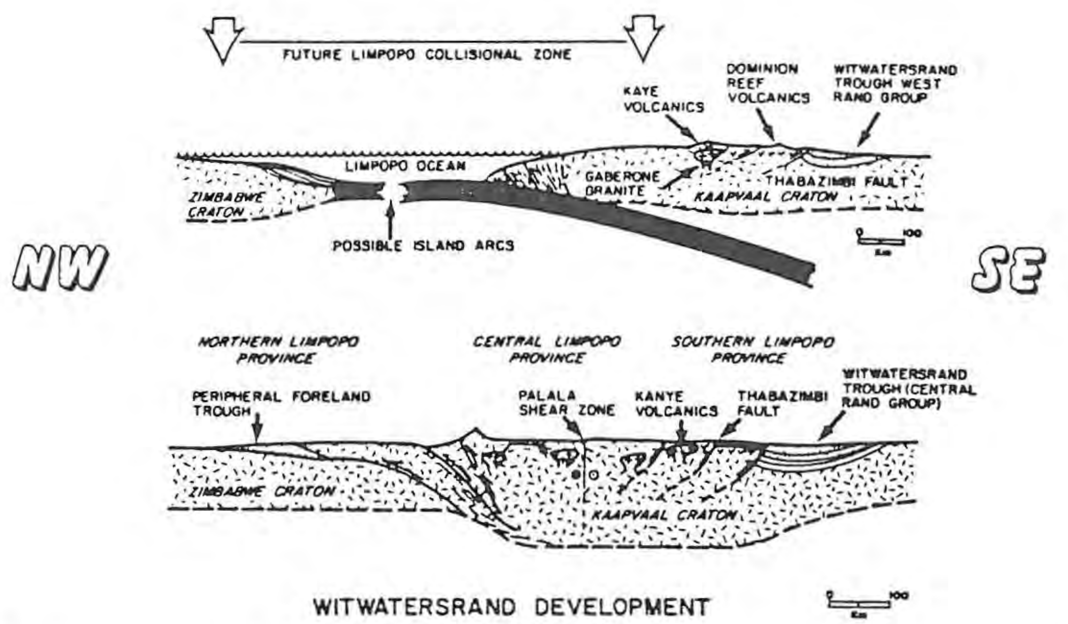


Figure 2.2 Interpretation by Burke, Kidd & Kusky (1986) of possible plate-tectonic events: (above) the West Rand Group as a retro-arc basin; (below) the Central Rand Group as the product of continent-continent collision.

(after Winter, 1987)

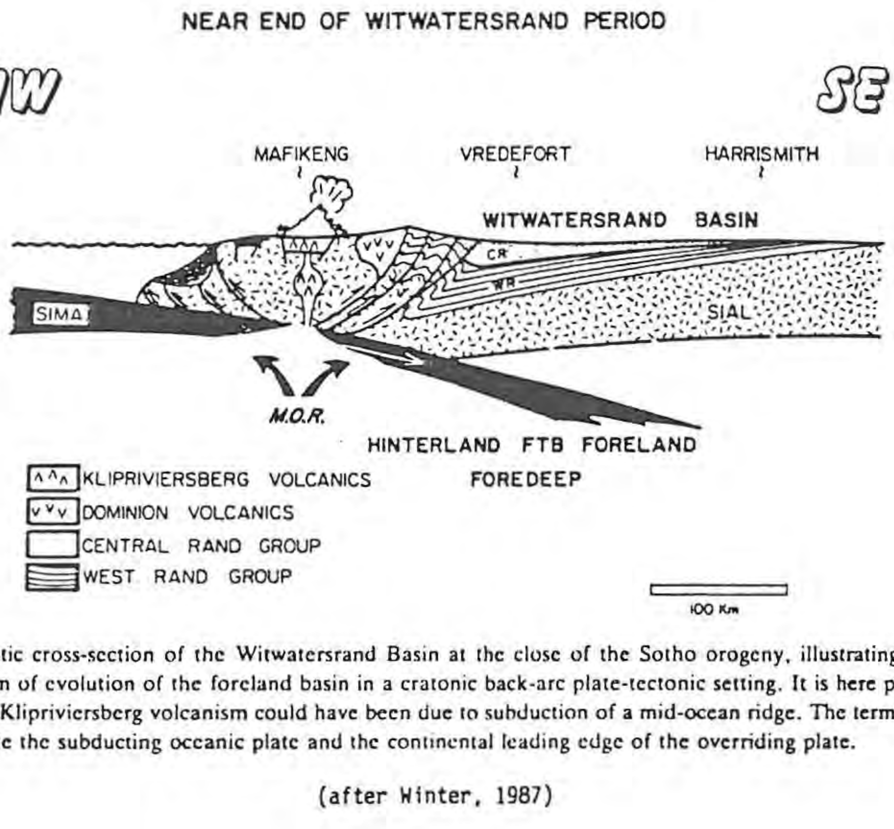


Figure 2.3 Schematic cross-section of the Witwatersrand Basin at the close of the Sotho orogeny, illustrating the concept and possible mechanism of evolution of the foreland basin in a cratonic back-arc plate-tectonic setting. It is here postulated that the rapid transition to Klipriviersberg volcanism could have been due to subduction of a mid-ocean ridge. The terms 'sima' and 'sial', respectively, denote the subducting oceanic plate and the continental leading edge of the overriding plate.

(after Winter, 1987)

tapered distally to a foreland basin. A post-orogenic molasse cycle of deposition in the form of the Ventersport Formation covered the foreland basin, thereby preserving the last Witwatersrand basin cycle together with previously-deposited auriferous units.

The most recent attempt to resolve the tectonic framework of the Witwatersrand Triad traces the evolution of the triad within a Wilson Cycle (Stanistreet and McCarthy, 1991). The time constraints for these stages are discussed by Robb et al (1991).

2.2 THE WELKOM GOLDFIELD

Several points of sedimentary influx into the Witwatersrand Basin with associated goldfield development have been recognised (Fig. 2.4). The most south-westerly known goldfield occurs in the Welkom area and extends from Allanridge in the north to some 10km south of Welkom (Fig. 2.5). Anglo American Corporation (hereafter AAC) is responsible for the majority of gold production within the area, this coming from several mines:- Freddies, Free State Geduld, Western Holdings, President Brand, President Steyn, and Saaiplaas. These mines are situated at the main sediment entry point for the Welkom Goldfield. Additional mines such as St. Helena, Oryx, Loraine, Joel and Beatrix Mines are managed by other mining companies that operate in the Welkom Goldfield.

2.3 THE STRATIGRAPHY OF THE WELKOM GOLDFIELD

The stratigraphy of the Welkom Goldfield is well documented by SACS (1980) and is described in greater detail by each mine's Geology Department. The Welkom Goldfield occurs within the Central Rand Group and can be correlated, in broad terms, with the Klerksdorp and Central Rand Goldfields of the Transvaal (Fig. 2.6). On Western Holdings Mine, the stratigraphic subdivisions differ slightly from that of SACS (1980) and are outlined in Figure 2.7. The subdivisions of the Central Rand Group are currently under review by SACS.

Recent chronostratigraphic investigations by the Basin Analysis Team of AAC has led to reclassification of the Central Rand Group in terms of unconformity bounded sequences (hereafter UBS). This is an internal AAC convention only, which has not yet been adopted by SACS. In this classification, the interval from the Basal Reef to below the "B"-Reef is referred to as the Bird UBS and is overlain by the Kimberley UBS, in which the "A"-Reef occurs.

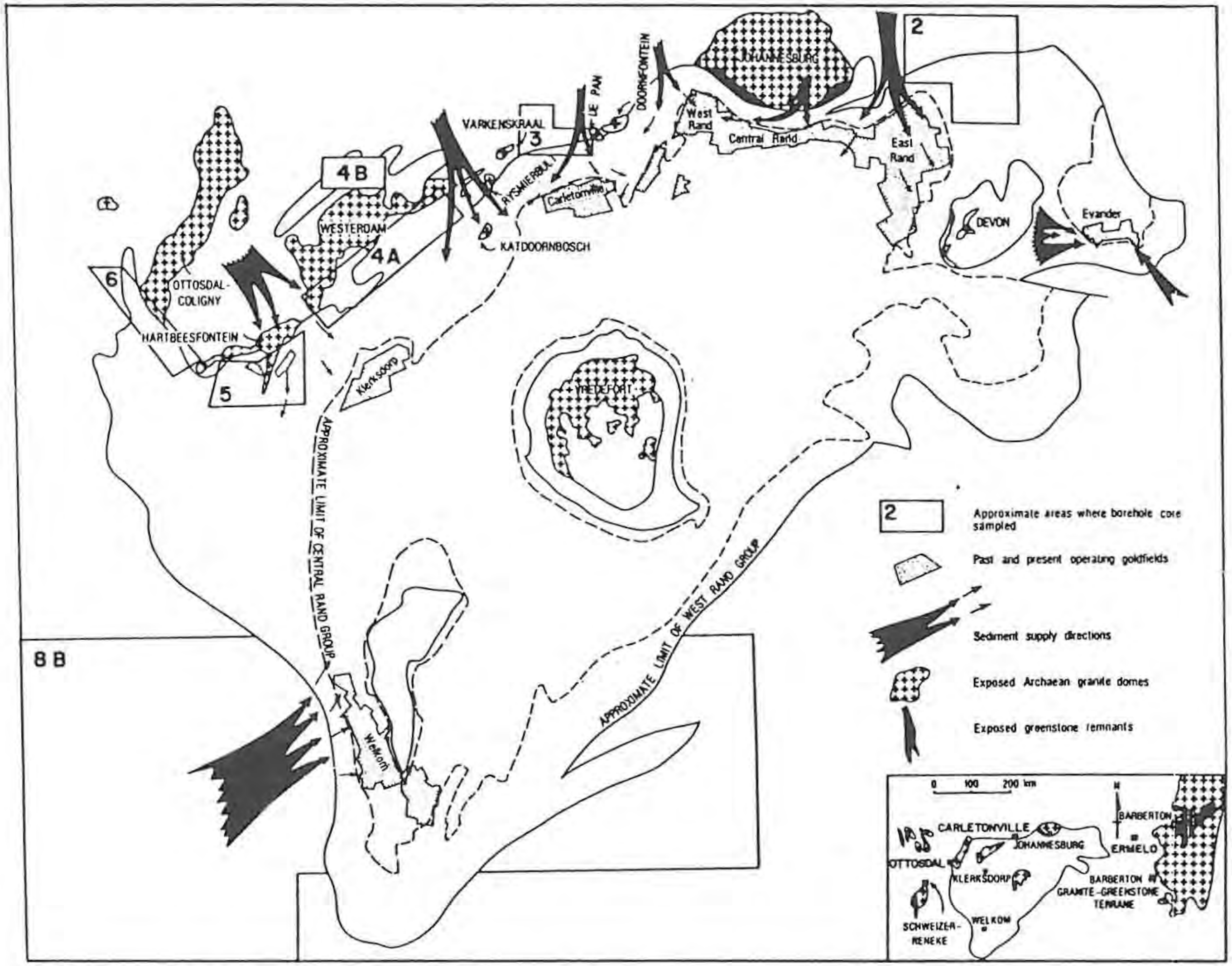


Figure 2.4 Schematic map of the Witwatersrand basin showing approximate sediment supply directions. (after Robb et al., 1990)

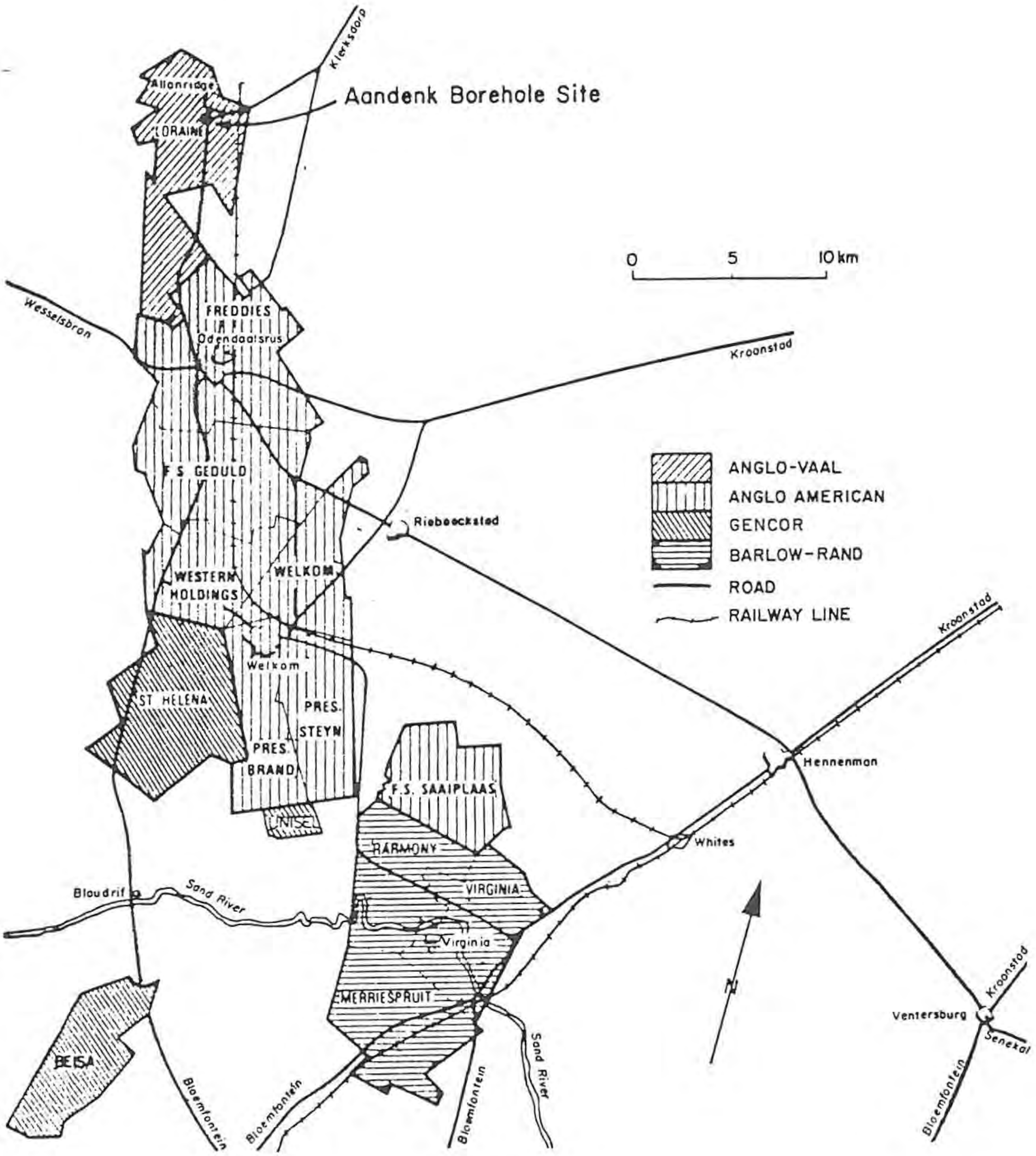


Figure 2.5 General locality map of the Welkom Goldfield showing relative positions of the mines and suburban areas. (from Minter et al., 1986).

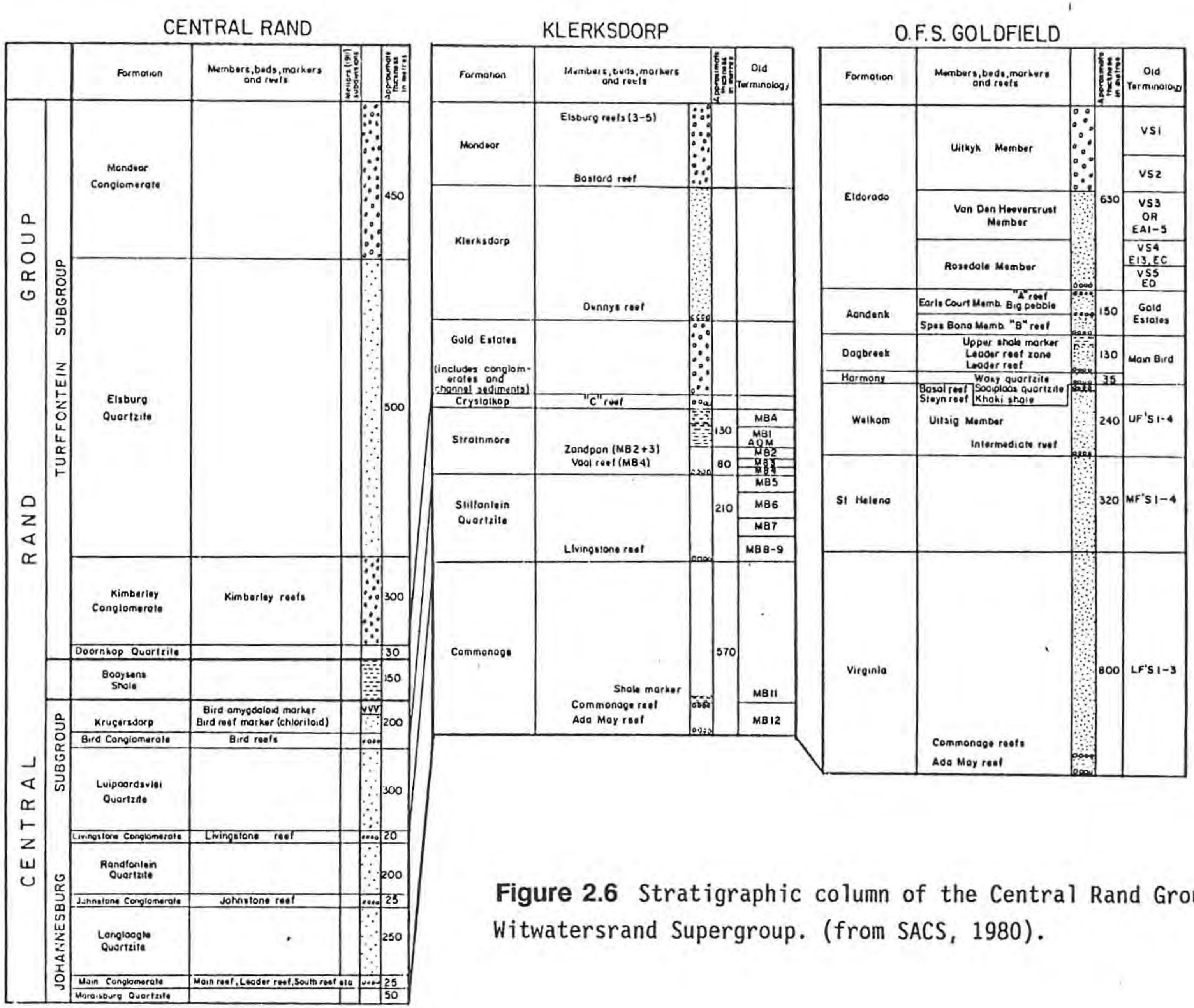


Figure 2.6 Stratigraphic column of the Central Rand Group, Witwatersrand Supergroup. (from SACS, 1980).

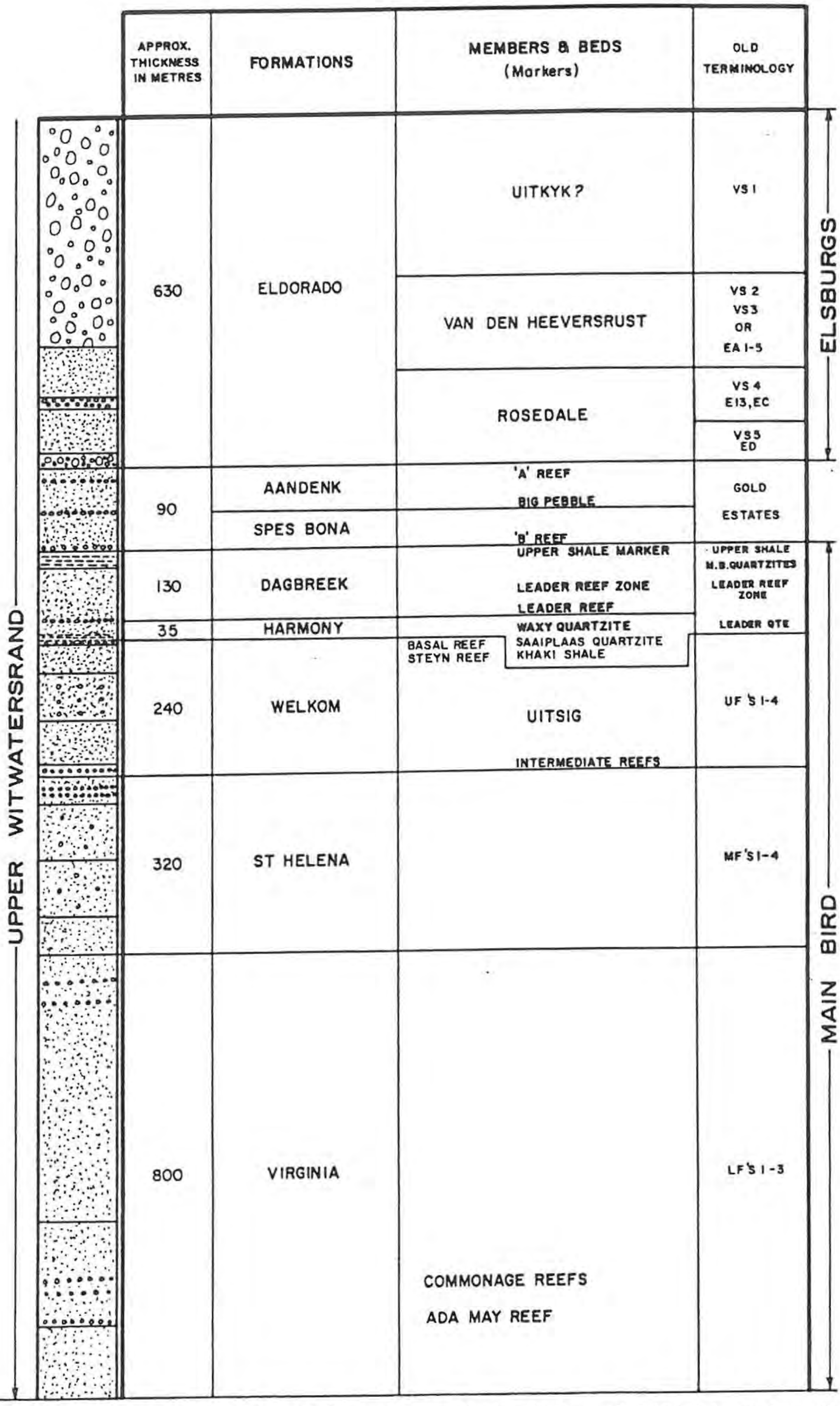


Figure 2.7 Local stratigraphic column of the Welkom Goldfield, using the terminology accepted by Anglo American geologists. (courtesy of Western Holdings Mine).

2.4 THE STRUCTURE OF THE WELKOM GOLDFIELD

The Welkom Goldfield is dominated by north-south striking normal faults, several of which are known to have a component of right lateral displacement (Fig. 2.8). Minter et al (1986) have determined that these faults were active in middle Ventersdorp times, and subsequent to this. The De Bron horst to the east of Welkom formed a prominent feature during the Middle Ventersdorp (Buck, 1980) but as will be shown later, had commenced uplift during the time of the Aandenk Formation. Major reverse faults and monoclinal folds are key features of the Welkom Goldfield but are unimportant to the structure of the "A"-Reef on Western Holdings. Myers et al (1990) recognise parallels between the tectonic styles of the Orange Free State Goldfield and that of the northern parts of the Witwatersrand Basin and apply a **block fault** model to the northern and western margins of the basin.

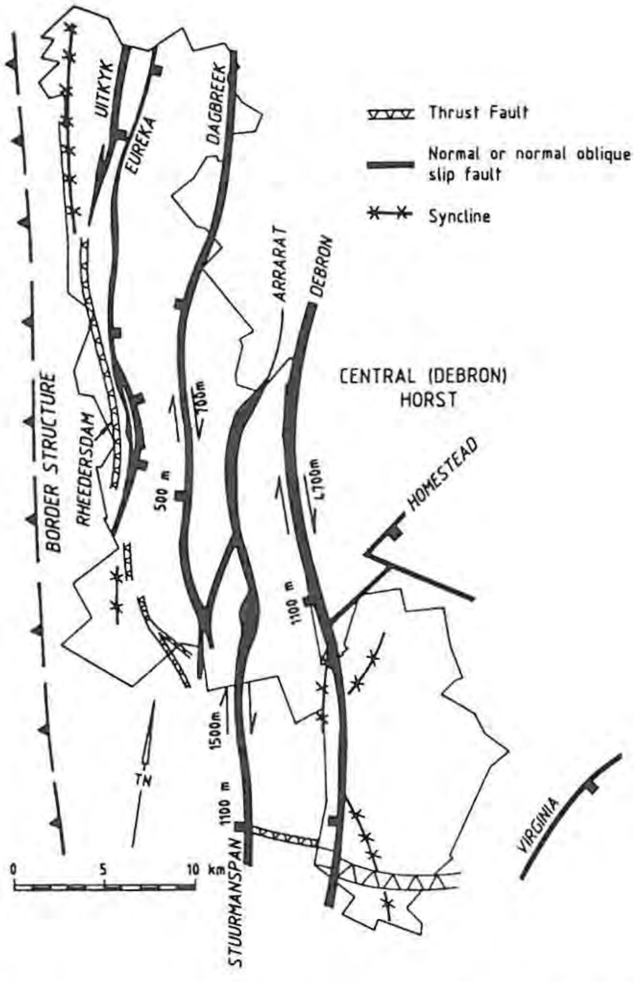


Figure 2.8 Simplified structural map of the Welkom Goldfield. (After Minter et al., 1986).

2.5 REGIONAL SEDIMENTATION PATTERNS IN THE WELKOM GOLDFIELD

Several reef horizons occur in the Welkom Goldfield, of which the most important economically are the Basal Reef and Leader Reef. Each reef is characterised by a number of prominent features, interpreted to be a function of the palaeoenvironment. These are summarised in Table 1.

The Basal Reef, first of the economic horizons to be exploited in the Welkom goldfield, is a sheet-like palaeoplacer. It has been the major gold producing reef in the Welkom Goldfield. It occurs at the top of the Welkom Formation but would form the base of the Bird UBS in terms of the AAC basin analysis model. The exact environment of deposition for the Basal Reef is not clear but was most likely formed in a fan-like environment that was close to base level, where winnowing rather than degradation occurred. The regional sedimentological patterns which affected Basal Reef deposition appear to be repeated in overlying reefs, including the "A"-Reef. A major gold geochemical anomaly accompanied by large pebble conglomerates would indicate that the entry point for the Basal Reef was located near the present No.4 Shaft on Free State Geduld Mine, a few kilometres northwest of No.3 Shaft of Western Holdings (C. Herbert, pers. com., 1991) (Fig. 2.9). Gold distribution patterns within the Basal Reef on No.3 Shaft have a preferred northwest-southeast orientation. The Basal Reef on Western Holdings Mine was subsequently scoured and eroded by northerly-flowing currents which deposited a more distal, polymictic placer known as the Steyn Reef. The Steyn Reef is an alluvial fan deposit, whose entry into the basin lay well to the south, southwest of No.3 Shaft (Minter and Loen, 1991) (Fig. 2.9). Although occurring on the same palaeosurface as the Basal Reef, the morphology, sedimentology, depositional environment, and gold content of the Steyn Reef differs greatly from the Basal Reef (Table 1).

The overlying Harmony Formation is represented by an overall transgression followed by regression. At its base is the Khaki Shale which is overlain by the Leader Quartzite, interpreted to be a debris-flow unit. This was followed by the Leader Reef, comprising a lower unit, known as the Alma Reef, and an upper unit termed the Bedelia Reef. These placers form the base of the Dagbreek Formation. The oligomictic Alma Reef shows northwest-southeast channel directions, formed within a longitudinal braidplain environment. The polymictic Bedelia Reef is an alluvial fan deposit, overlapping the Alma Reef with a slight unconformity and has channel directions varying from west to southwest on No.3 Shaft. It would

Parameter	Basal Reef	Steyn Reef	Alma Reef	Bedelia Reef	Witpan Reef
Aggr./Degradation	Equilibrium	?	Degradation	Aggradation	?
Clast size trend downslope	Very Slight	Moderate	Slight	Moderate	Hardly discernable
Sedimentary Environment	Equilibrium Surface	Alluvial fan	Braidplain	Alluvial fan	Braidplain reworked
Pebble type	Oligomictic	Polymictic	Oligomictic	Polymictic	Oligomictic
Sediment Maturity	Very High	Moderate	High	Moderate to poor	High
Presence of carbon	40mm to flyspeck	20mm to absent	4mm to absent	Not common	Not common
Percentage mineable on Western Holdings	Nearly All	Nearly All	20-30%	20-30%	<2%
Relative gold tennor	Rich	Rich to moderate	Moderate	Moderate	Poor
Payzone Association	Carbon seams	Carbon seams	Carbon,pyrite	Carbon,pyrite	Channel-edges,pyrite,carbon
Gold Variance	High	High	Medium	Medium	Low
CH.W Variance	Low	Low	Medium	Medium	High
Anisotropy of Semivariograms	Low	Low	Medium	Medium	High

Table 1. Comparison between different reef types on Western Holdings Mine.

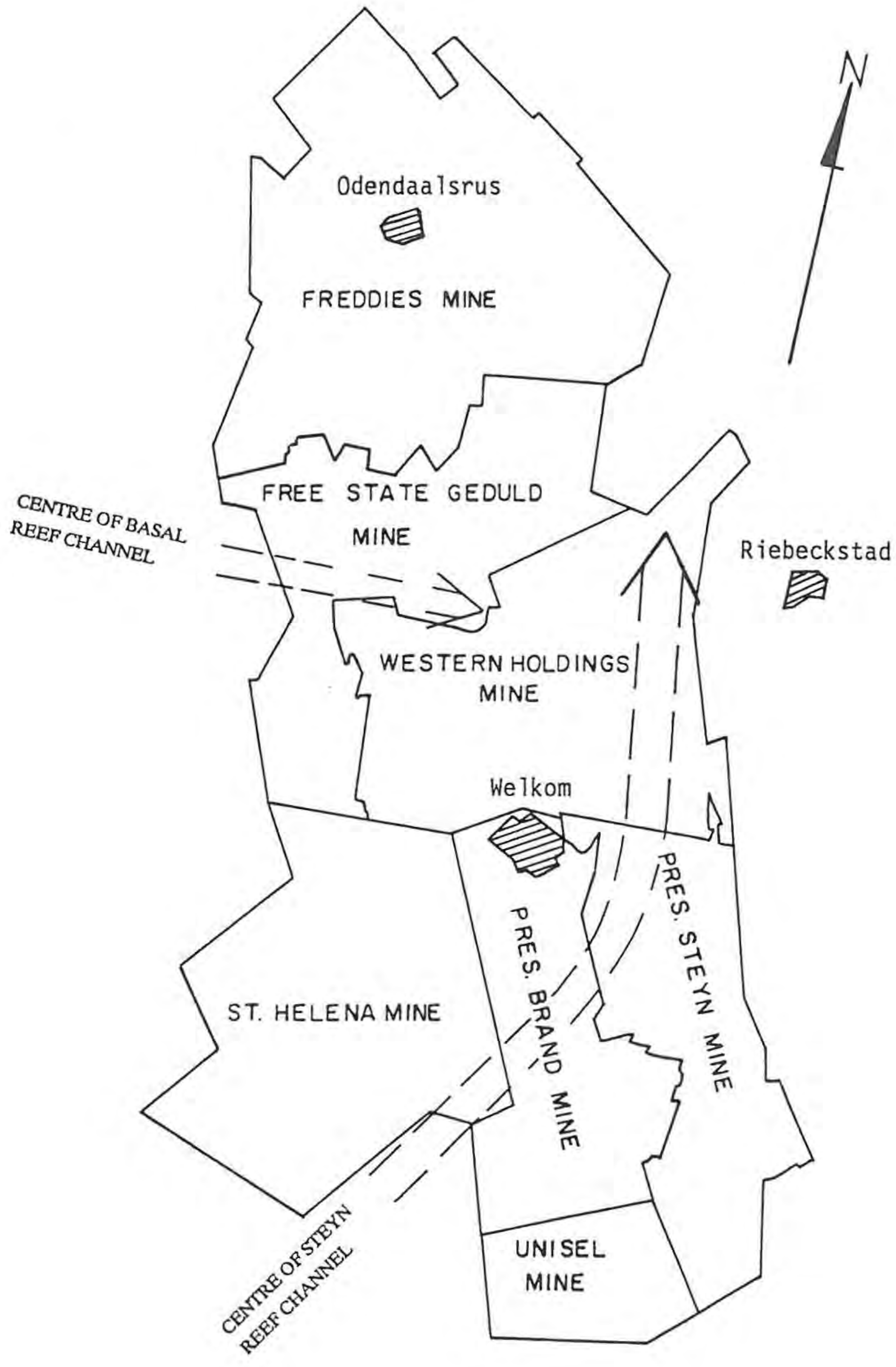


Figure 2.9 Map showing the relative positions of mines to the Basal Reef and Steyn Reef flow directions in the Welkom Goldfield.

appear, therefore, that polymictic conglomeratic units of lower gold tenor were derived from alluvial fans in the southwest, while a richer source area and/or sedimentary environments conducive to greater reworking and enrichment of gold in the oligomictic units occurred in the northwest. A basin-wide marine transgression followed deposition of the Leader Reef Zone.

Regression of the sequence is marked by deposition of the "B"-Reef which is interpreted to be a delta front deposit (J. Victor, pers. com, 1990). This is followed by arenaceous sediments of the Spes Bona and Aandenk formations which are also referred to as the Kimberley UBS by the AAC basin analysis team. Similar patterns recognised for the Basal and Leader Reefs occur in the Aandenk Formation. The channelised features in the polymictic footwall conglomerates underlying the "A"-Reef are orientated southwest to northeast. The main channel complex of the "A"-Reef across the Welkom Goldfield is orientated northwest to southeast (Jordaan, van Berkel, Caulkin, and Bradley, pers. com.; Weir, 1988; Kingsley, 1984). Channel-edge directions measured by the writer and previous workers (Rogers, pers. com., 1989) portray the same NW-SE orientation.

Tectonic processes active during the deposition of the Aandenk Formation can be traced as far back as the "B"-Reef of the Spes Bona Formation and upwards to the VS5 at the base of the Eldorado Formation. The thickest channel development for the "B"-Reef, Big Pebble Marker, "A"-Reef and VS5 are all orientated in a northwest to southeast direction. The writer has recognised a progressive shift of these depo-axes from east to west as the the stratigraphy is ascended (Fig. 2.10). The "B"-Reef is thickest at No.1 Shaft on Western Holdings and the Big Pebble Marker is thickest at No.2 Shaft. The "A"-Reef channel is best developed at No.3 Shaft on Western Holdings while the VS5 attains maximum thickness near No.5 Shaft. This shift in the thickest channel development is attributed to the initiation of structural activity which preceded the formation of the De Bron horst which occurs to the east of Western Holdings Mine. This implies activity of the De Bron horst prior to the Ventersdorp-age movements for the De Bron reported by Buck (1980).

2.6 THE STRATIGRAPHY AND SEDIMENTOLOGY OF THE AANDENK FORMATION

The "A"-Reef zone comprises conglomerates and arenites, and is situated within the Aandenk Formation. On Western Holdings Mine it has a stratigraphic separation above the Basal Reef that increases eastwards. At No.6 Shaft in the west the separation is ±150m and increases to ±200m to

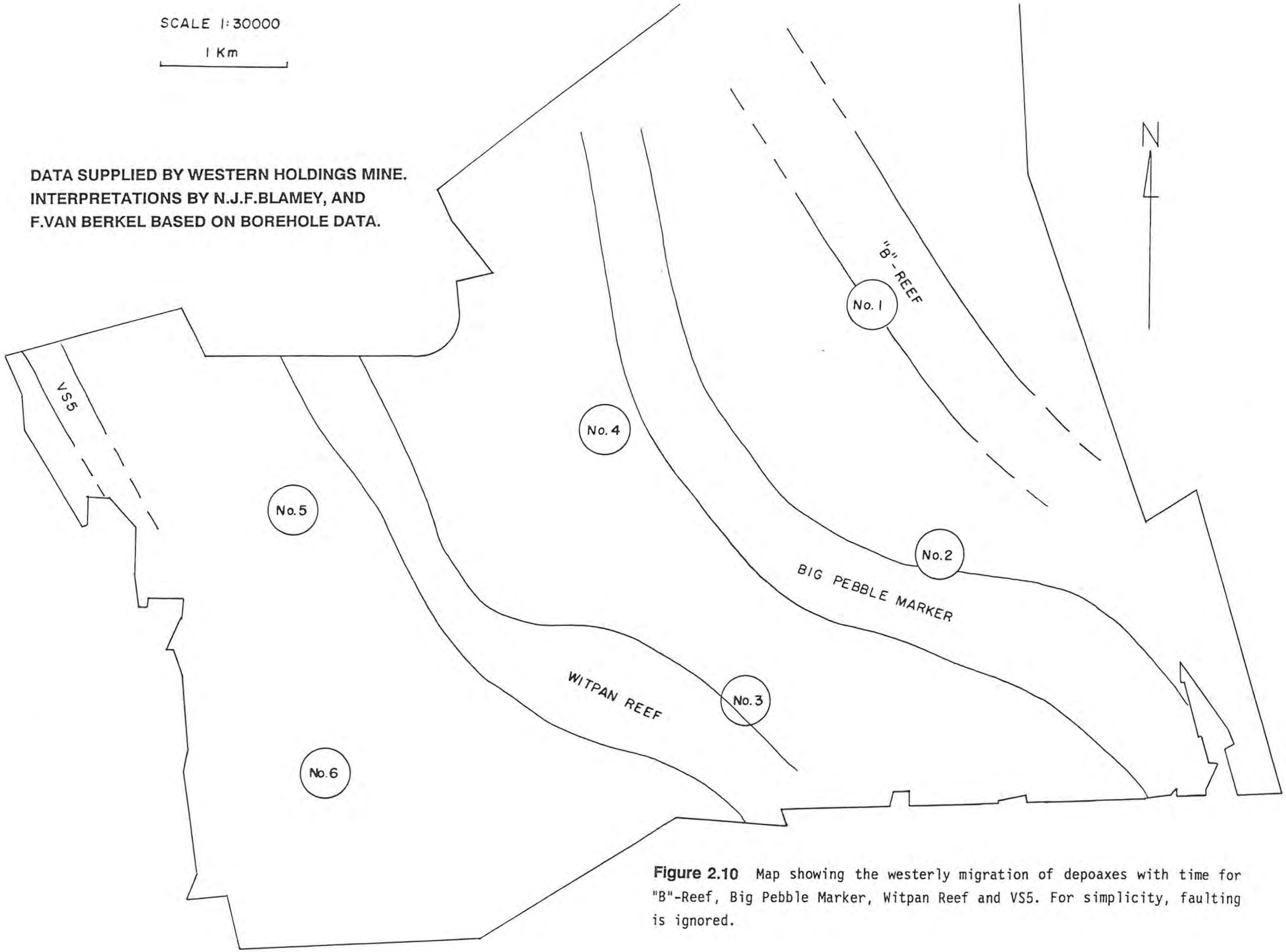


Figure 2.10 Map showing the westerly migration of depoaxes with time for "B"-Reef, Big Pebble Marker, Witpan Reef and VS5. For simplicity, faulting is ignored.

the south of No.2 Shaft. At No.3 Shaft the separation is ±180m. The "A"-Reef zone at No.3 Shaft occurs ±20m below the base of the Eldorado Formation and also ±20m above the base of the Aandenk Formation (Fig. 2.11). The Aandenk Formation is unconformably overlain by the VS5, the basal unit of the Eldorado Formation.

2.6.1 THE FOOTWALL SUCCESSION

The Aandenk Formation is dominated by a series of polymictic, poorly sorted, matrix-supported, large pebble to cobble conglomerates, with pebbly quartzwackes or lithic arenites overlying erosional surfaces. The conglomerates are separated by yellowish quartzwackes which cap each conglomerate unit. Clasts are predominantly of rounded to well-rounded quartz or chert with subangular shale fragments. The conglomerate matrix, as well as the interbedded quartzwackes, is yellowish, argillaceous, medium to coarse-grained lithic arenites which commonly becomes gritty in nature. Gold mineralisation in these conglomerates is invariably poor with values generally less than 1 g/t over a sampled 20cm vertical section through the unit.

The Big Pebble Marker

The Big Pebble Marker is currently accepted as the basal unit of the Aandenk Formation which unconformably overlies the Spes Bona Formation. It is a polymictic, matrix-supported, large cobble conglomerate to cobbly lithic arenite with clasts up to 300mm in diameter. The durable clasts are predominantly well-rounded white vein quartz with subordinate black chert, while the nondurable component consists of subangular to subrounded light-brown shale fragments of up to 100mm in diameter. The matrix comprises yellowish, argillaceous, medium to coarse-grained quartzite with scattered 1-3mm yellow shale fragments. The Big Pebble Marker is persistent over the entire Welkom Gold Field and attains a maximum isopach thickness of 12m in the No.1 Shaft area (Fig. 2.10). The unit is thought to be a high energy fan deposit with the main channel being a fan head trench (Jordaan, 1986). This explains the co-existence of very large cobbles in an argillaceous matrix. Ongoing discussion is attempting to determine as to whether the BPM occurs at the top of the Spes Bona Formation or at the base of the Aandenk Formation.

The Immediate Footwall Sequence to the "A"-Reef

The alternating quartzwackes and conglomerates that directly underlie

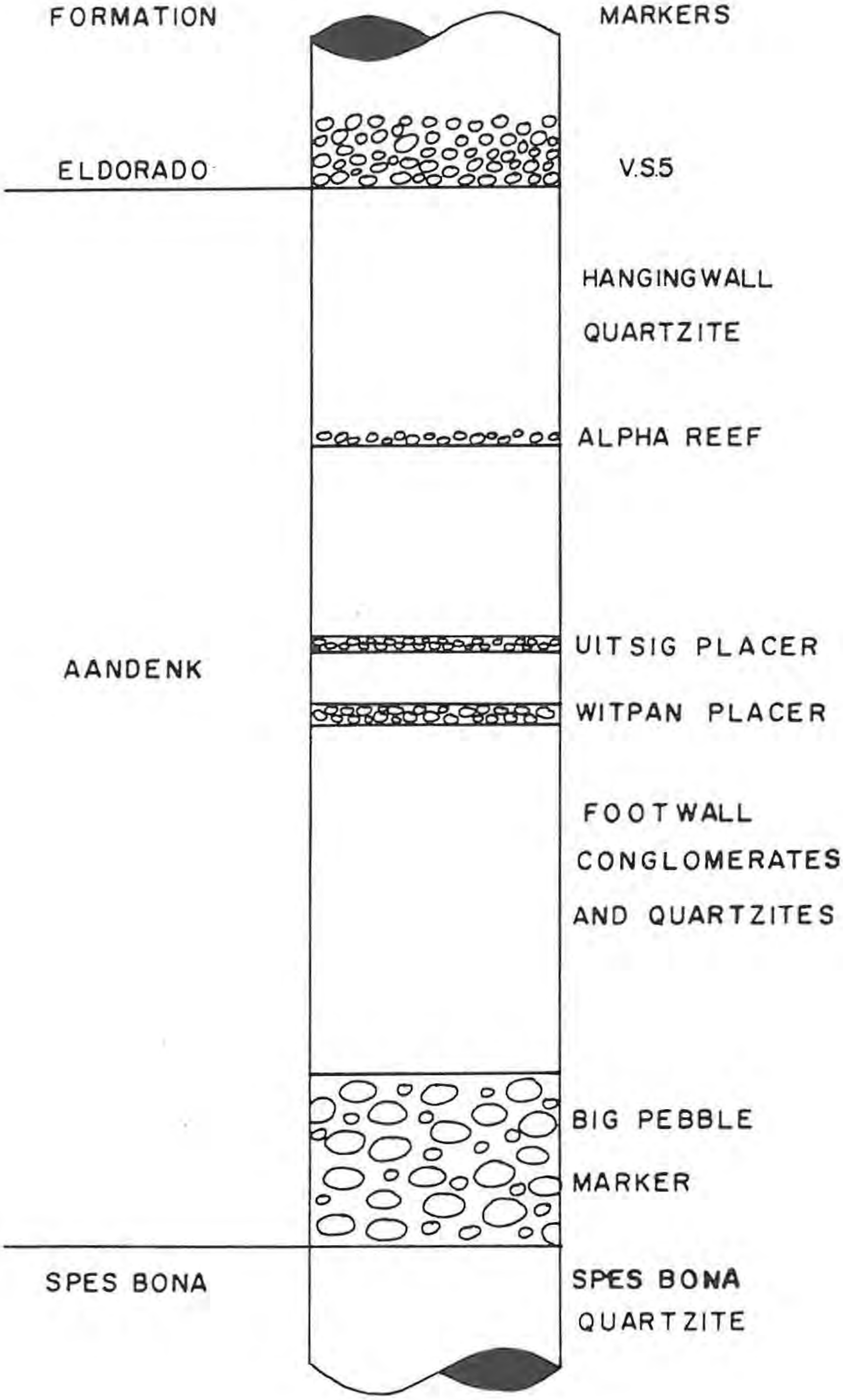


Figure 2.11 Idealised section of the Aandenk Formation.

the "A"-Reef package are termed the immediate footwall. The quartzwackes are light yellowish-brown, argillaceous, medium-grained with or without scattered, well-rounded, medium-sized pebbles of white vein quartz and dark chert. The conglomerates are polymictic, medium to large pebble (some clasts exceed 100mm in diameter), matrix-supported, poorly sorted with a yellowish-grey subwacke matrix. The pebbles and cobbles consist of well-rounded white vein quartz and dark or banded chert, with subangular to angular yellowish-brown shale fragments up to 70mm across. Armitage (1986) reports a current direction towards the east for these sediments on the basis of channel-edge measurements and pebble imbrication.

2.6.2 THE HANGINGWALL SUCCESSION

Overlying the "A"-Reef couplet is a ±20m sequence of quartzites. They are light yellowish-brown, medium to fine-grained wackes and subwackes with scattered fine yellow shale fragments. Scattered medium or smaller sized, subangular clasts occur. Distinctive of these sediments are occasional to rare fragments of red jasper. In this part of the sequence there is the development of further placers north of Western Holdings, on Free State Geduld and Freddies Mines.

The sediments are truncated by the VS5 unconformity, signifying the base of the Eldorado Formation.

CHAPTER 3

THE "A"-REEF ZONE

3.1 HISTORY OF THE "A"-REEF MINING

There is a scarcity of published literature on the "A"-reef. In-house reports from other AAC mines have been available to the writer but little has been forthcoming from other companies. The first report referring solely to "A"-Reef, was written by Spinks (1979) who outlined the potential of a mineralised unit on President Steyn Mine. Later work by Karpeta (1984) has addressed not only the "A"-Reef but the Aandenk stratigraphy. On Western Holdings Mine, the first report by Armitage (1986) noted two placers with mining potential within the Aandenk Formation. These were called the Witpan and Uitsig placers. The most recent report is by van As (1990) who was supervised by the writer during a sedimentological investigation of the Witpan Placer.

Although "A"-Reef was first exploited on President Steyn and Free State Geduld mines, a number of mines have mined "A"-Reef (Fig. 3.1). Exploration of the "A"-Reef on Western Holdings Mine was initiated during 1980 when the gold price was over $600 per oz.. The prevailing economic climate at the time meant that low grade reefs could be explored as a source of gold reserves to fill the mill, thereby increasing the life of the mine. The first boreholes exploring "A"-Reef commenced in 1986 (Armitage, 1986) and initially 33 holes were planned on No.1, 2, 3 and 6 Shafts in an effort to:

(1) locate new "A"-Reef channel complexes,
(2) prove/disprove continuations to the channel complex located on No. 3 Shaft, and
(3) evaluate the south-eastern extension located on No.3 Shaft.

The most encouraging values were first intersected on No.2 Shaft, west of the shaft pillar. Access to the reef was made by a reef-drive but unexpected faulting made this area unsatisfactory from a mining view-point. At the same time that development was taking place on No.2 Shaft, the first boreholes of the programme were drilled at No.3 Shaft. The first intersection, from borehole 3/999, produced poor results (ie. 10 cmg/t with channel width of 13cm). The fifth borehole, 3/1233, intersected 906 cmg/t over a channel width of 154cm and was followed by further encouraging values (Kieck, pers. com., 1990).

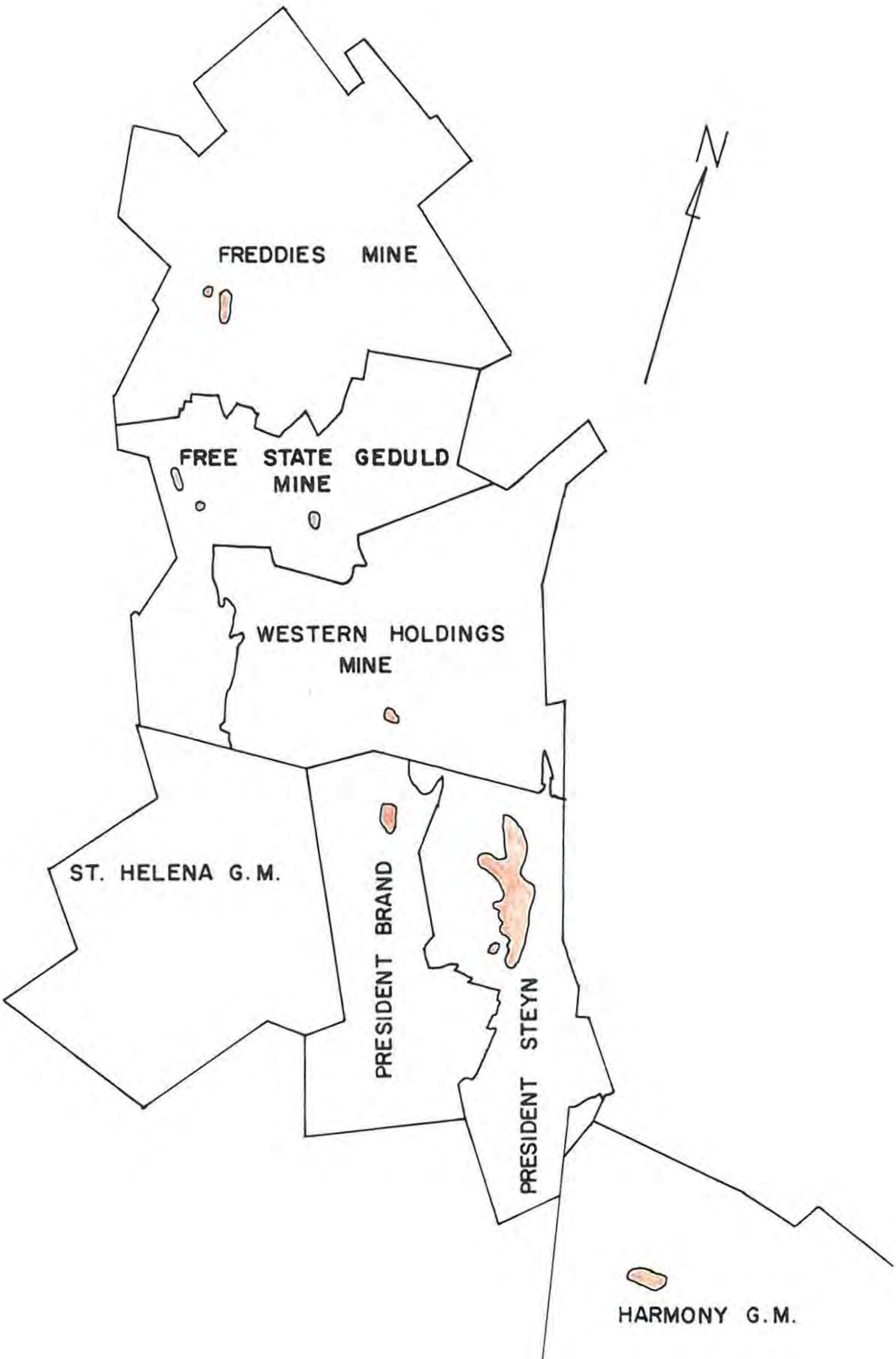


Figure 3.1 Locality map showing areas in which "A"-Reef has been mined in the Welkom Goldfield. The areas are coloured in red.

Following those favourable borehole intersections and the anticipation of a relatively unfaulted reef horizon close to the shaft pillar, the decision was made to develop a raise to explore the Witpan Placer (Fig. 3.2). The intersection of zones of payable gold values by this raise were encouraging. As a result, the decision was taken to exploit the Witpan Placer on No.3 Shaft as a low-cost mining exercise. Mechanical mining equipment (front-end loaders) was acquired and development of an inclined access (known as the "Ramp") was initiated (Fig. 3.2). At various intervals, on-reef prospects were developed in both north and south directions to expose and evaluate the reef horizon and if good values were located, serve as a starting point for raising or stoping.

3.2 INTRODUCTION

The "A"-Reef Zone refers to the package of placer conglomerates and arenites found between the immediate footwall and hangingwall sequences (terminology by Karpeta, 1984). The zone is not continuous throughout the Welkom Goldfields. Towards the north in the thicker part of the Aandenk sedimentary wedge, the appearance of additional placers has resulted in informal subdivisions for the various reefs, frequently obscuring intermine stratigraphic correlation. For Western Holdings Mine, the sequence exposed in the 37"A"-Reef area is considered within the mine to be the "type area" for "A"-Reef. This corresponds to the reef couplet exposed in the "South Region" and termed the Witpan and Uitsig Placers by Karpeta (1984).

3.3 THE WITPAN PLACER

The Witpan Placer forms the lowermost part of the "A"-Reef package and has an erosional contact with the underlying Immediate Footwall Sequence. The placer is a channelised, oligomictic, medium to large pebble, matrix-supported conglomerate with a grey, siliceous and pyritic matrix (Plate 1). Clasts tend to be ellipsoid and rounded, and are dominated by quartz, with the chert component commonly in the small-pebble range. Locally, pebble sphericity is very high. Flow directions are from the northwest to southeast, corresponding to channel-edge measurements and isopach maps for the Witpan Reef on Western Holdings (Fig. 3.3).

Three distinct components are recognised within the Witpan Placer although all three are not always developed (Fig. 3.4 and Plate 2). Firstly, the basal scour unit, which attains a thickness of up to 1.2m, has an erosional, irregular to undulatory contact with the Immediate Footwall Sequence. The unit generally comprises an oligomictic, grey, siliceous pebbly quartzite, with bimodal medium and large pebbles, with or

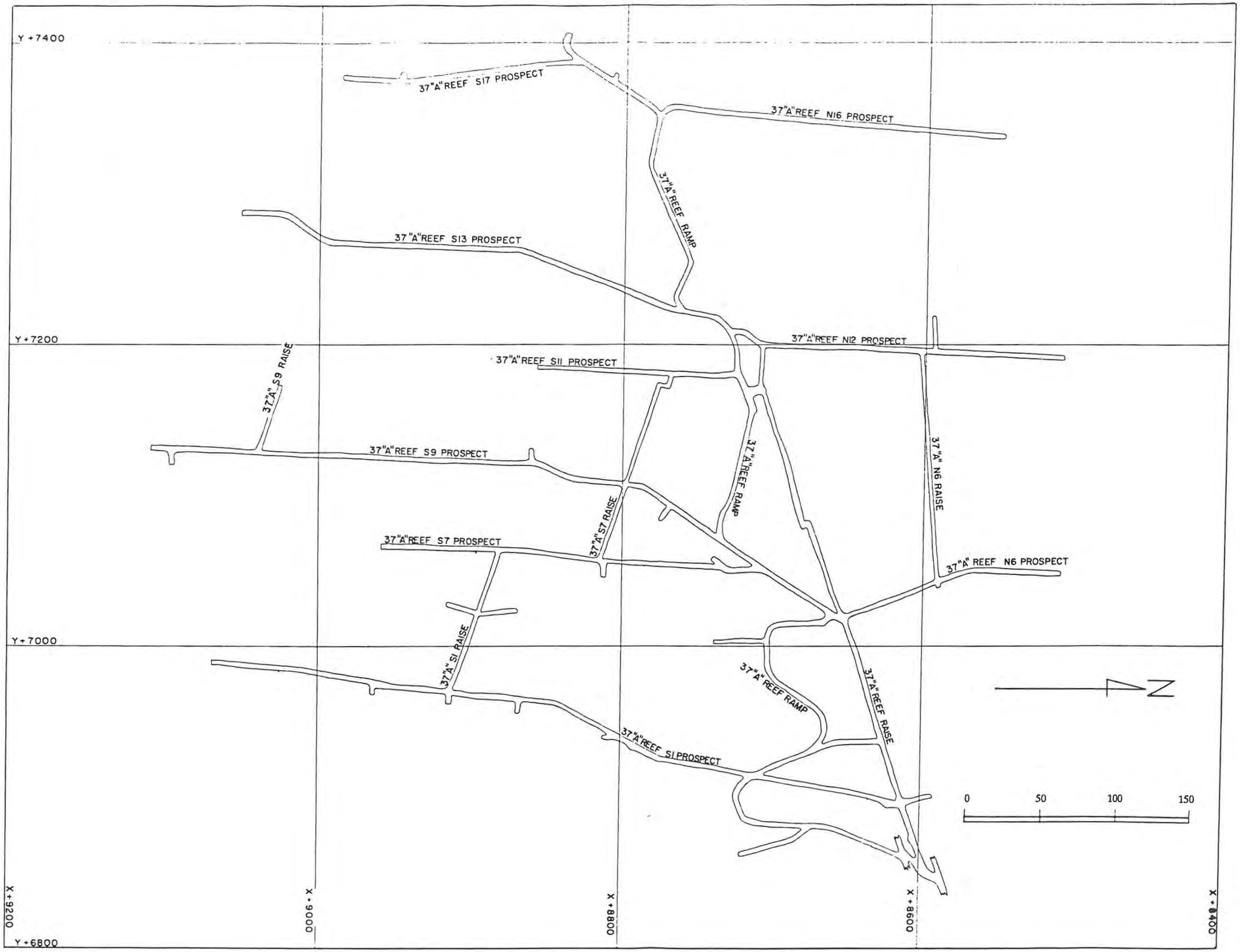


Figure 3.2 The No.3 Shaft "A"-Reef mining area showing the currently exposed development ends, ie. all prospects, raises and the "Ramp".

Plate 1 Witpan Reef exposed in the S1 Prospect of the No.3 Shaft mining area. A ±20cm zone rich in pyrite is developed near the base.

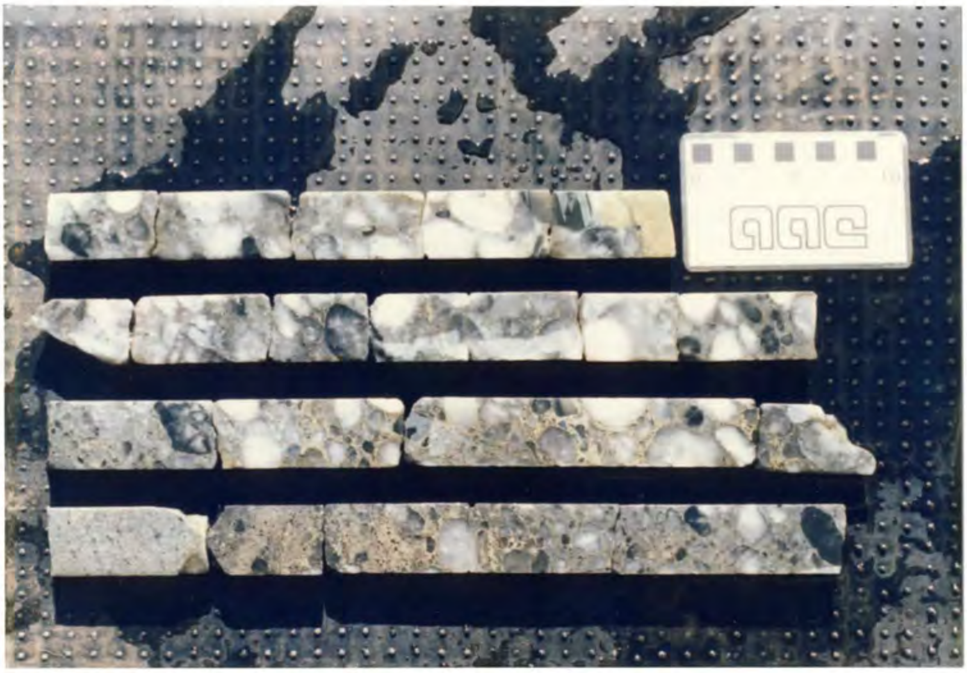


Plate 2 Drill core of Witpan Reef showing the basal scour unit, the reef zone, and pyritic zone.

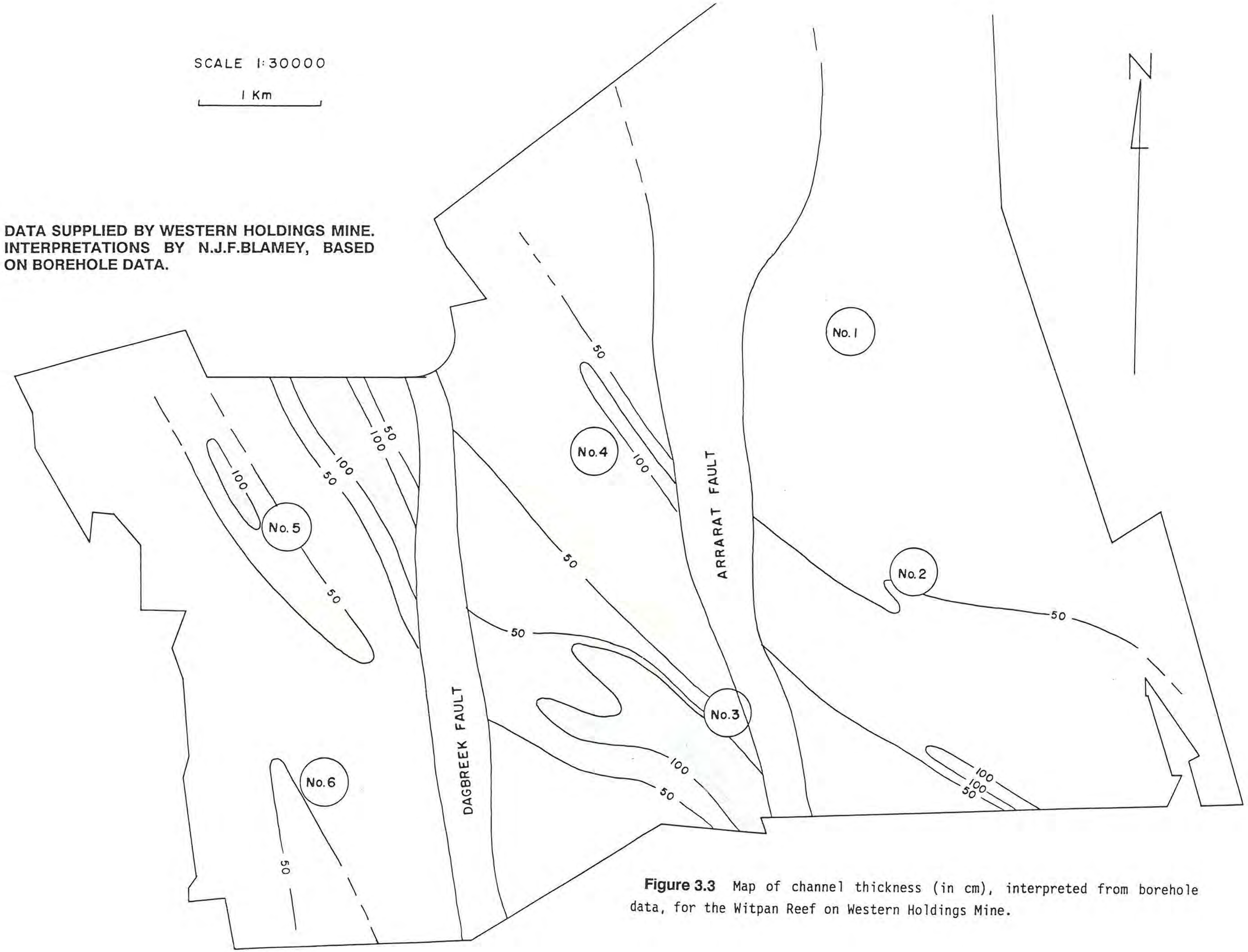


Figure 3.3 Map of channel thickness (in cm), interpreted from borehole data, for the Witpan Reef on Western Holdings Mine.

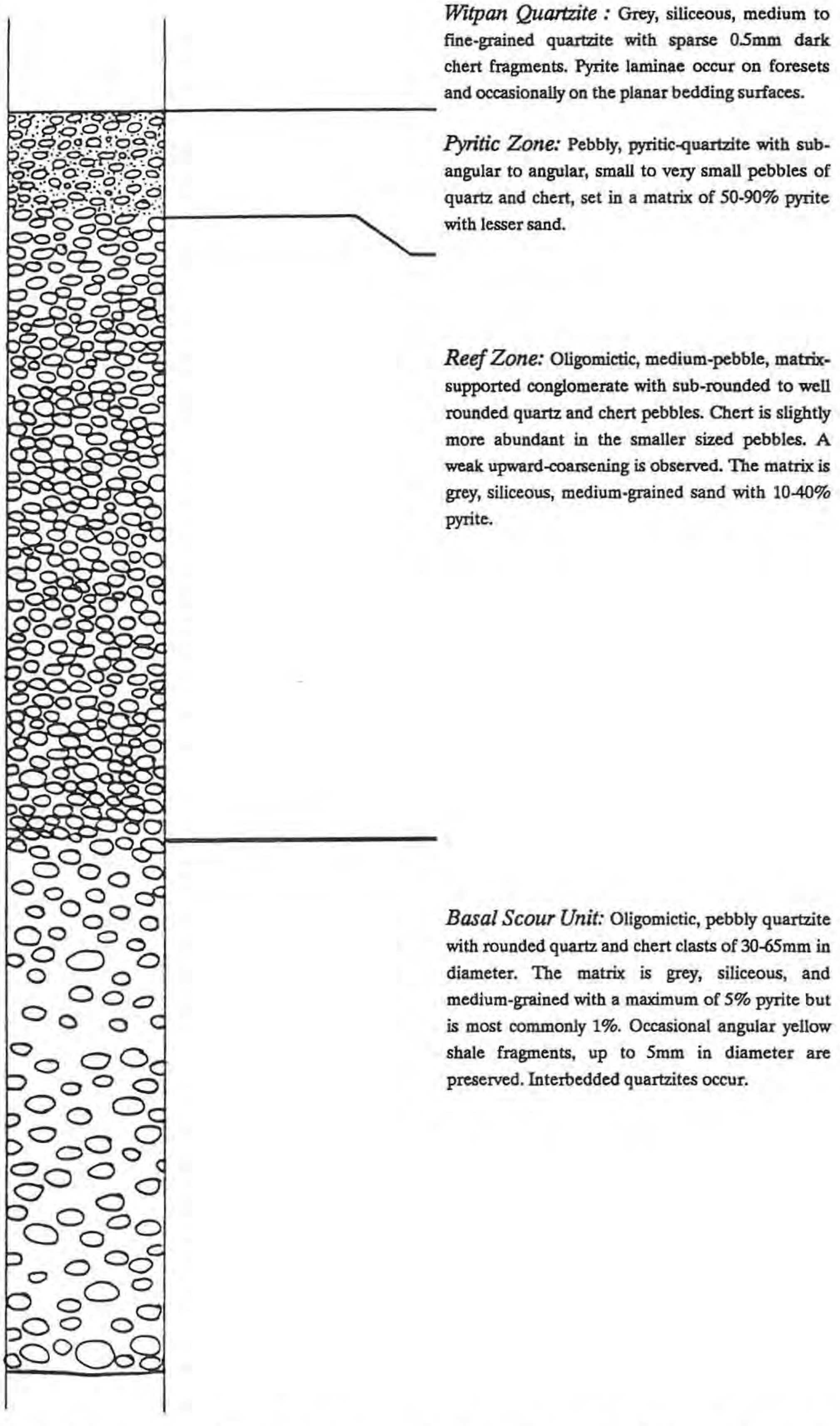


Figure 3.4 Generalised section of "in-channel" Witpan Reef showing the Basal Scour Unit, the Reef Zone, the Pyritic Zone and Witpan Quartzite. (Scale 1:10).

without intercalated placer quartzites. Pebbles are rounded, with the larger clasts having been cannibalised from the underlying sediments. Visible pyrite makes up an estimated 1% of the matrix on average, with a maximum of about 5%. Occasional non-durable, angular, yellow shale fragments of up to 5mm in diameter are preserved but are confined to this scour unit only.

Secondly, the reef zone proper is an oligomictic, medium-pebble, matrix-supported conglomerate that overlies the basal scour unit or the Immediate Footwall Sequence. This horizon is more wide-spread than the basal scour unit. The average thickness for the fully-developed reef zone is about 100cm, but a maximum of 120cm is recorded. Pebbles are sub-rounded to well-rounded and there is a tendency for chert to be more abundant in the smaller size fraction (Plate 3). The unit is crudely coarsening-upward and locally, very small angular clasts can occur towards the top. Shale fragments are absent and the unit is noticeably richer in pyrite (10-40% of the matrix). Locally, there is a direct correlation between an increase in pebble sphericity, detrital pyrite and elevated gold tenor.

Thirdly, the uppermost facies of the reef is pyrite-rich and is 10-25cm in thickness. It is a pebbly pyritic-quartzite with medium to small, oligomictic pebbles set in a matrix of 50-90% pyrite with lesser amounts of quartz grains and very small subangular to angular clasts. The unit is more sheet-like than the underlying Witpan components. Pyrite is usually rounded (detrital?), up to 0,3mm in diameter. This pyritic zone has also been recognised on President Steyn Mine (Grobler, pers. com., 1991). Carbon seams commonly occur on top of the zone and occasionally at the base. This has resulted in exceptionally good gold values with stope values varying from 10-65 g/t.

The Witpan Reef is commonly capped by the Witpan Placer Quartzite, a light-grey, medium-grained quartzarenite that contains scattered to sparse dark chert fragments and thin pyrite laminations on foresets. The thickness of this placer quartzite is variable across the existing "A"-Reef mining area. In places it may not be developed but in the 37"A"N6 area it attains a thickness of up to 60cm.

Three subenvironments of the Witpan Reef are recognisable in the No.3 Shaft area and are now recognised across the goldfield (Karpeta, 1984; and Armitage, 1986). They represent in-channel, terrace, and channel-edge deposits (Fig. 3.5). The basal scour unit is only developed within the "in-channel" facies and is overlain by the "reef zone" and the pyritic zone. Pebbles within this basal facies are generally larger near the base being derived from the larger pebble footwall succession. The "in-channel" facies

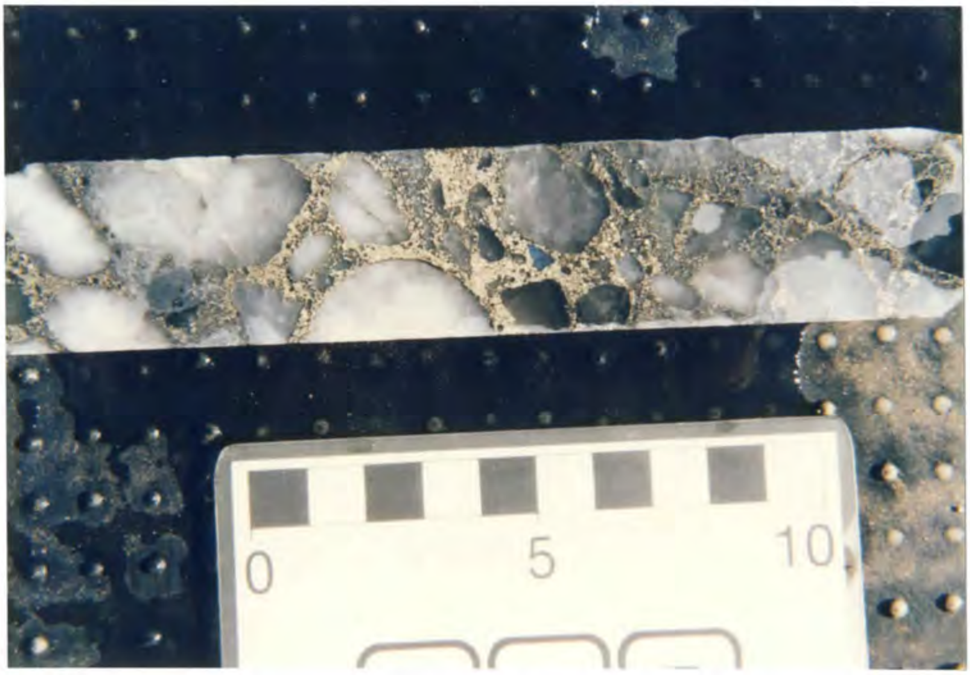


Plate 3 Witpan Reef from drill core showing medium to large, well-rounded pebbles with smaller subangular quartz and chert pebbles.

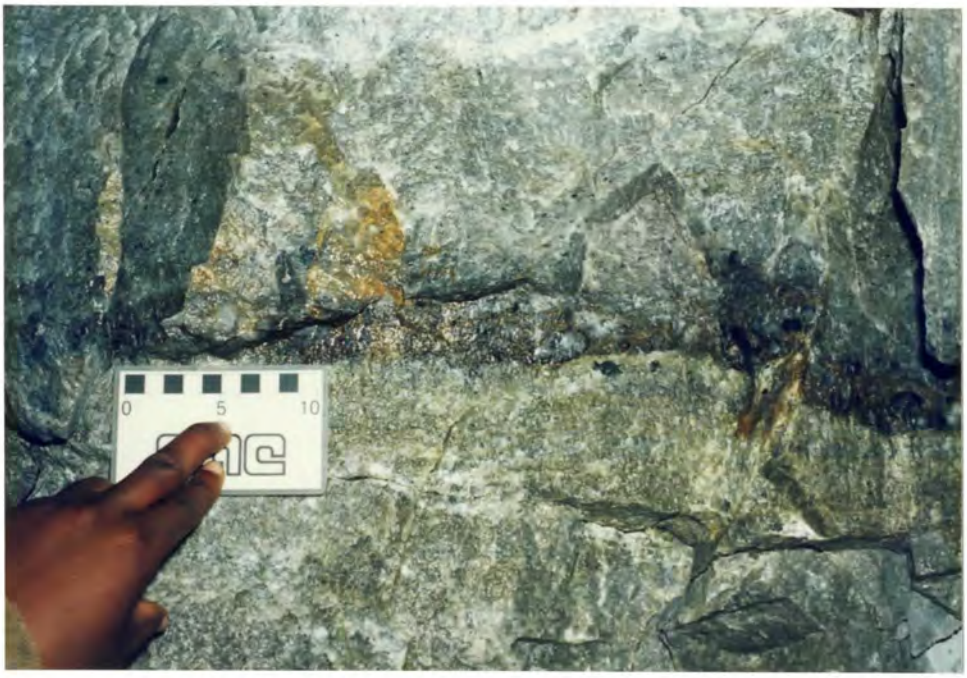


Plate 4 Uitsig Placer exposed on the eastern side of the mining area on No.3 Shaft, Western Holdings. In this area the reef is little more than a pebble lag, overlain by siliceous quartzite.

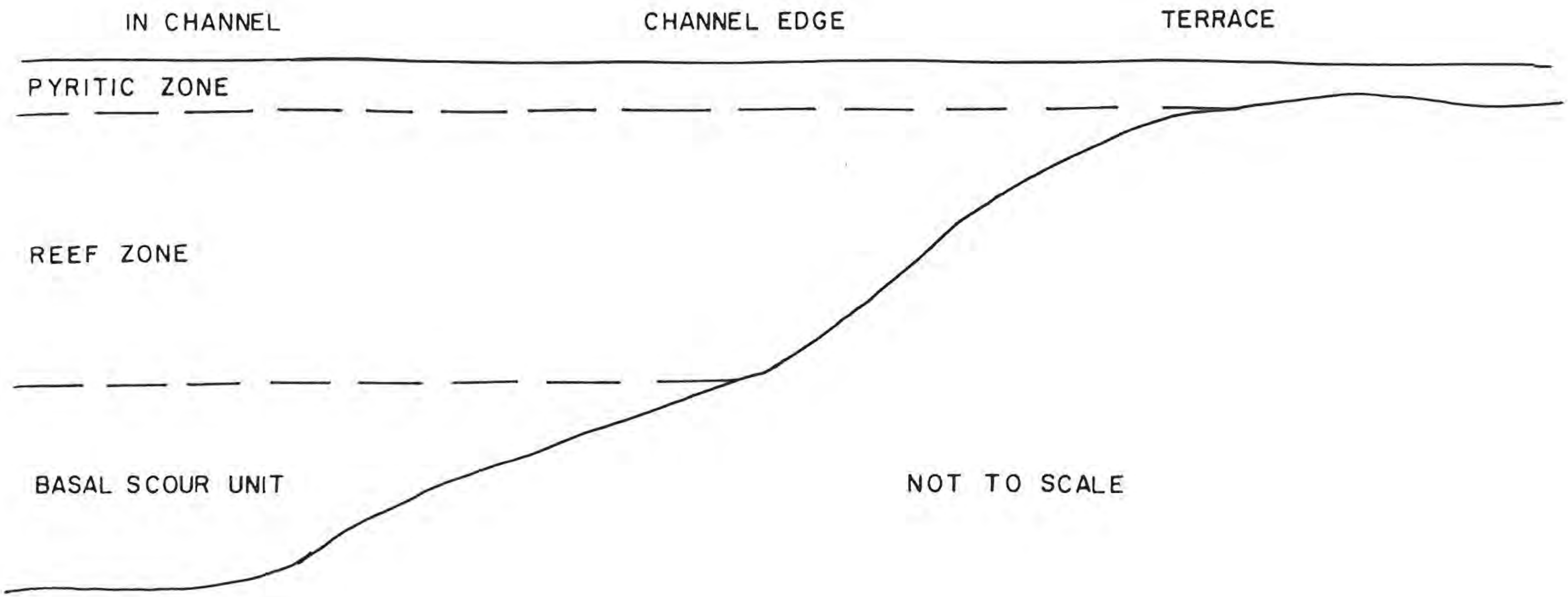


Figure 3.5 Idealised sketch showing the three subenvironments recognised in the main channel complex on No.3 Shaft.

is the most commonly occurring facies in the No.3 Shaft mining area because of mining activities being confined to the main Witpan channel complex. Within the facies, the channel thickness of the rudaceous sediments of the Witpan unit varies from ±110cm to a maximum of ±230cm.

The terrace facies is less common, the channel thickness of the facies varying from 5-50cm. Two terraces are recognised, one in the 37"A"S9 prospect and the other in the 37"A"N6 prospect and 37"A"Raise areas. Pebble sizes within the facies are small, boardering on medium with a slight increase of quartz pebble:chert pebble ratio. Poor sorting of the reef occurs along with a decrease in the pyrite content of the matrix (10-40%). This is the only facies where "flyspeck carbon" is present, occurring as 0.3-1mm black specks on the lower contact of the reef.

The channel-edge facies separates the in-channel from the terrace facies. Although the pyritic zone is fully developed, the reef zone is only partially so; the basal scour unit is always absent. Pebble sizes are generally medium with occasional pebbles of noticeably increased sphericity occurring. Pyrite is enriched within the matrix (30-50%). Gold content shows a positive correlation with pyrite. Channel-edges are consequently the target from an exploitation aspect, not only for the increased gold values but they offer the optimum stope width with full reef extraction.

Overlying the Witpan placer is a light yellowish-brown, medium-grained quartzwacke containing abundant yellow shale fragments. The unit separates the Witpan and Uitsig placers and varies in thickness from 1.3m to 3m across the No.3 Shaft mining area.

3.4 THE UITSIG PLACER

The Uitsig Placer is locally developed on No.3 Shaft of Western Holdings Mine. Within the 37"A" Reef "Ramp" area the placer thickens towards the southwest up to as much as 40cm and grades laterally into a pebble lag. The scour surface, upon which it sits, may be completely absent towards the northeast. Generally the Uitsig Placer on No.3 Shaft comprises a lower conglomeratic unit of up to 15cm, overlain by placer quartzite (Plate 4). The conglomerate is an oligomictic, matrix-supported, small pebble conglomerate that contains 1-20% pyrite in the matrix. The overlying placer quartzite is a light-grey, medium-grained quartzarenite with scattered to sparse, fine dark chert fragments. Up to 60cm of quartzarenite can be preserved although 20cm is the modal thickness. The placer quartzites are sometimes capped by shale elsewhere on the mine but on No.3 Shaft the shale is not preserved.

On President Steyn Mine, the Uitsig Reef has a carbonaceous facies which is significant in terms of gold tenor (Bradley and Fraser, pers. com., 1990). Flyspeck carbon occurs on the lower contact as well as within the matrix of the reef. This facies offers a potential gold source if it exists on Western Holdings Mine. Its anticipated location is to the southwest of the present Ramp area on No.3 Shaft. Thickening of the Uitsig placer has already been recognised in this direction, thereby increasing the potential for existence of this facies.

3.5 STRUCTURAL GEOLOGY AND INTRUSIVE ROCKS

Similar to the regional structural patterns, the "Ramp" area is dominated by north-south-striking normal faults (Fig. 3.6). Two faults of 10-15m displacement occur along with minor 0.5m to 2m sympathetic faults. Although it is suspected that a degree of lateral movement has occurred on these faults it cannot be proven at this stage. Right-lateral movement has been determined on the Arrarat and Dagbreek faults, so it is realistic to consider sympathetic movement on the minor faults. Interpretations based on two boreholes drilled in the S9 Raise near the end of the S9 prospect, support right-lateral movement along the fault.

The intrusive rocks of the area have not been examined in detail but as they affect the mining activities they are therefore discussed. They comprise dark green, fine-grained dolerite dykes, commonly bearing thin white anastomosing quartz and calcite veins. Two dykes of about 10-15m in width have been regarded by the mining department as the mining limits of the "A"-Reef on No.3 Shaft. Both dykes displace the strata vertically by several metres. No lateral movements along the dykes have been proven yet. These would affect the valuation of the "A"-Reef because pay channels would be displaced. For this reason it is recommended that further investigation be done by the Geology Department on Western Holdings Mine.

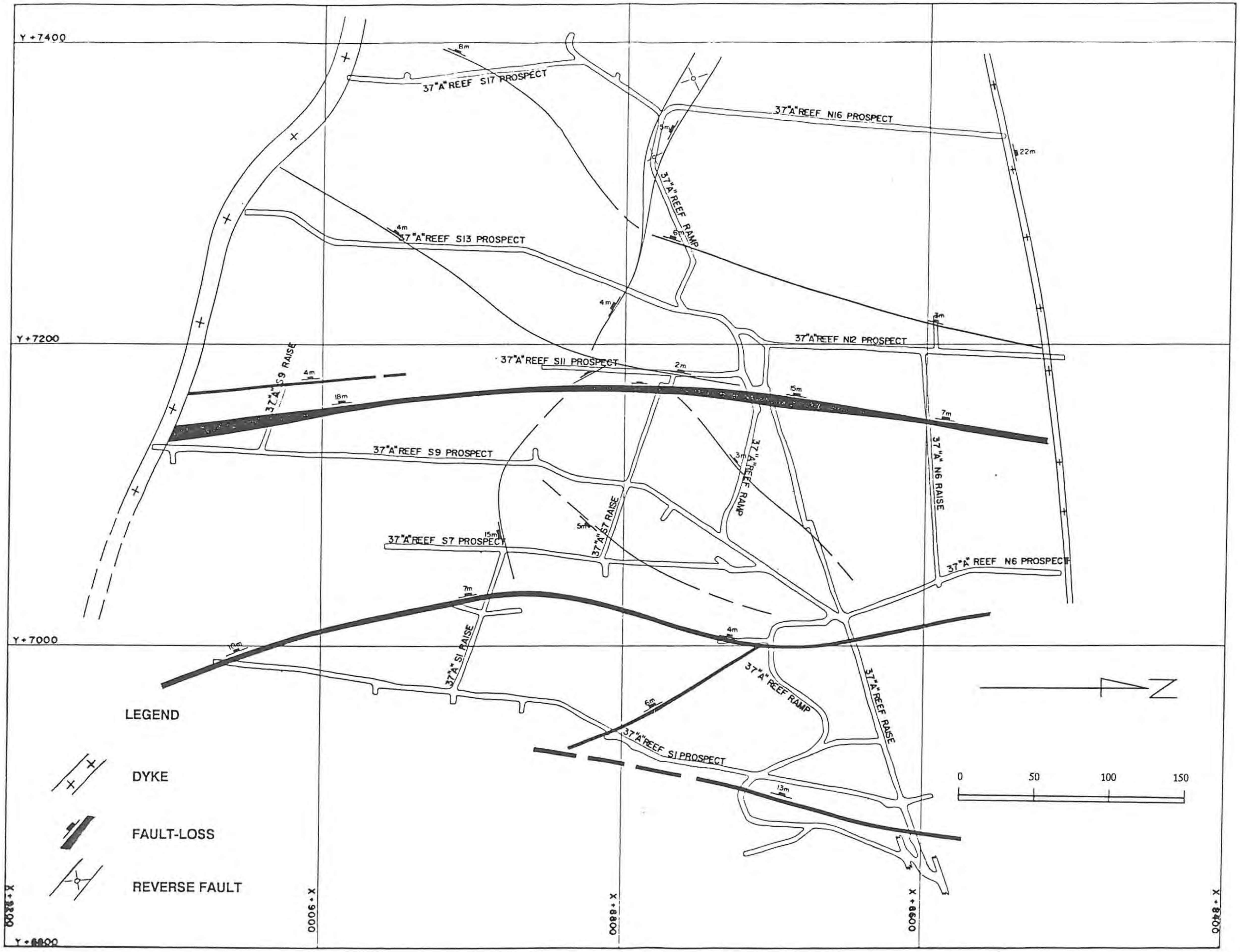


Figure 3.6 The structure of the No.3 Shaft "A"-Reef mining area.

CHAPTER 4

4.1 GOLD MINERALISATION

It is widely accepted by geologists in the Welkom Goldfield that conglomeratic placers, and in particular oligomictic conglomerates, resting on degradational surfaces, are the most suitable sites for gold accumulation. At the base, or within these conglomerates, gold is found in association with "carbon" or pyrite. The existence of "carbon" usually means that the gold tenor is high, and is one of the criteria used to keep the mining operations on reef. The existence of pyrite can be misleading within some of the reefs.

Within the Witpan placer, gold is not evenly distributed (Fig. 4.1 in pouch). The most common sites for gold are the degradation surfaces within the reef horizon. The first of these is the contact with the Footwall sequence. The basal scour unit is generally poor in gold. The next significant gold values occur in the "reef zone". Degradation surfaces within the "reef zone" invariably carry gold (Fig. 4.1). Although in some cases it may not be possible to identify each individual surface, enrichment of gold is thought to indicate these surfaces. The pyritic zone at the top of the "reef zone" is also enriched in gold with values of 5-20 g/t occurring over the entire pyritic zone. The Witpan quartzite generally has poor to trace gold values. The generalised trends of gold enrichment upward within the Witpan Reef are summarised in Figure 4.2.

The presence of "carbon" on terrace areas is reflected by dramatic increases in gold tenor. "Carbon" associated with the Aandenk reefs on Western Holdings Mine is not well documented and is only recorded in the S9 Prospect on No.3 Shaft. Gold values of 1632 cmg/t over a channel width of 37cm are reported. A similar increase of gold tenor in association with "flyspeck carbon" is reported by Weir (1988) from President Steyn Mine, where "seam-carbon" is known to occur.

Channel edges show the greatest potential for the enrichment of gold in the Witpan package. The channel edges at the S9 and N6 Prospects are currently the most important "A"-Reef areas on No.3 Shaft. Stope values of these areas exceed not only the cut-off grade for low-cost mining exercises but the high cut-off grade normally accepted for Basal Reef. It is peculiar however that the best values occur on the southwest side of these channel edges. This may be important, not only from an exploration target aspect but also from a palaeoenvironmental viewpoint.

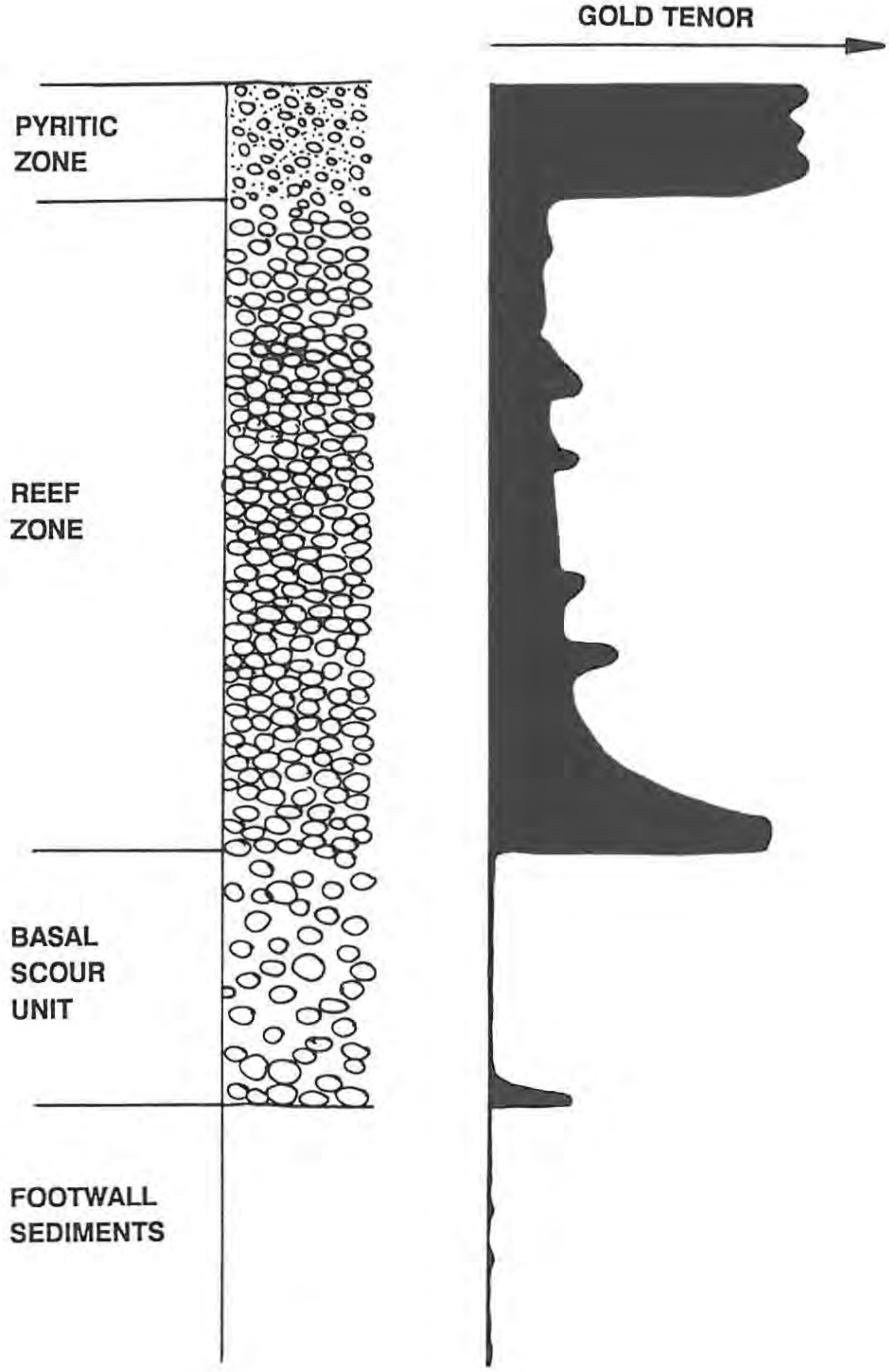


Figure 4.2 Idealised section through the Witpan Reef showing the typical positions of gold enrichment. In this case the channel width is 114cm although the sampling ensures overbreak. (SCALE 1:10)

In three areas, an increase in pebble sphericity is evident. Two of these cases corresponded to the channel edges of the N6 and S9 Prospects while the other occurrence was at the end of the S1 Prospect. At these sites, pyrite mineralisation and gold tenor increase.

At No.3 Shaft of Western Holdings there are a few places where the Witpan Reef cuts into the polymictic footwall conglomerates, but such areas are unfortunately no longer accessible. On President Steyn Mine, similar areas have proved valuable in terms of gold enrichment. Where the Witpan Reef immediately overlies the polymictic footwall conglomerates without a quartzite middling, greatly elevated gold tenor has been recorded (Fig. 4.3). It seems likely that the condition acted like a sieve deposit. Gold within the streams was initially enriched by bed roughness but was also able to filter down and be trapped between the pore-space offered by the porous footwall conglomerates. This condition is regarded as an important target for future gold reserves within the "A"-Reef package.

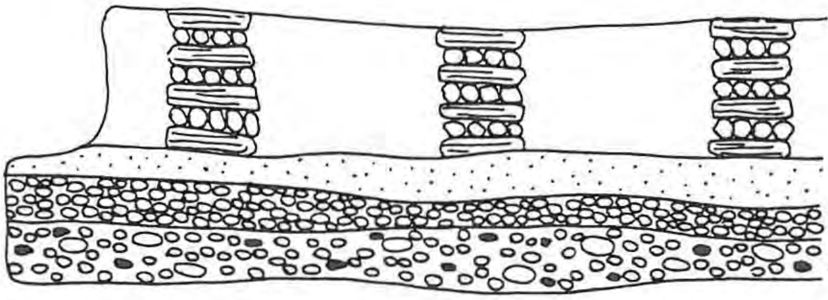
The poor development of the Uitsig Reef on the No.3 Shaft of Western Holdings Mine has detracted attention from it in favour of the Witpan Reef. It is noted that the average channel thickness for the Uitsig Reef increases towards the southwest where the potential exists for a profitable reef unit. It was observed on President Steyn Mine (Bradley and Grobler, pers. com., 1990) that a "carbon"-bearing Uitsig Reef occurs to the southwest of the main Witpan channel complex. Gold values of 1000 to 1500 cmg/t over a channel thickness of 5-20 cm for this unit are the norm. Insufficient borehole data on Western Holdings Mine have hindered the evaluation of this potential gold reserve but it remains a target for future exploration.

4.2 GENESIS OF GOLD MINERALISATION

The origin of gold in the Witwatersrand Basin has been a heatedly debated issue amongst geologists for the last 100 years. Many proposals have been put forward in an effort to explain the genesis of gold. The Witwatersrand however, does not comply with experiences in other well-known non-stratiform gold deposits. What then was the origin of gold in the Witwatersrand, the biggest known gold depository?

A number of popular models regarding the origin of gold are summarised:

(1) The **syngenetic** model suggests that placer/alluvial gold was derived from erosion of greenstone belts bordering the basin to the west and northwest.



32.5				WITPAN
12.6	0.8	Tr	15.7	
27.6	3.4	1.1	0.8	
25.1	0.5	2.9	1.1	
31.2	8.4	6.3	5.1	
56.3	9.7	2.1	5.8	FOOTWALL
18.7	20.0	2.1	2.4	
30.9	31.3	Tr	5.1	
18.7	47.2	4.8	14.7	
16.0	7.4	2.4	12.3	
1.8	53.1	Tr		

Figure 4.3 Sampling report for Witpan and Footwall conglomerates in 30/29 S4 ASG on President Steyn Mine. (Values are in g/t for each sample). (Data supplied courtesy of Bradley and Fraser, pers. com., 1990).

(2) The **epigenetic** model sees the gold being of hydrothermal origin, coming from fluids from an unspecified magmatic source.
These two models have major flaws as outlined in Table 2.

(3) The **compromise** or **modified placer** model has gold dissolved in thermal fluids and being captured in alluvial sediments.

(4) The **Davidson model** suggested that ground water percolating through the Ventersdorp Supergroup transported Au and U into the uppermost units of the Witwatersrand.

(5) The **metamorphic dehydration** model (Phillips, et al., 1990) envisages transportation of the gold by fluid and emplacement thereof into more permeable horizons (reef horizons) during regional metamorphism (±350°C).

There are a number of features which cannot be ignored in attempting to understand the controls of gold mineralisation in the Witwatersrand sediments.

1. There is an overwhelming correlation between sedimentological features and gold mineralisation. The Witwatersrand is after all a sedimentary basin although it is within the upper 12% of the stratigraphic column that conglomerates hosting mineable gold concentrations occur. It is widely recognised that gold occurs at the base of conglomerates and in particularly the oligomictic placers (eg. Basal, Alma, Witpan and Uitsig Reefs). The writer has already mentioned the link between channel edges and high gold tenor. The proposed model of deposition (Chapter 5) can also account for the confinement of payshoots to one side of terraces as a result of sedimentary processes. This is certainly strong evidence to support the **modified placer** or **syngenetic** models.

2. The Witwatersrand Supergroup was deposited during a gold metallogenic epoch. The richest and largest deposits of gold are hosted by late Archaean rocks. The Archaean gold deposits elsewhere in the world are related to hydrothermal mineralisation in granite-greenstone terranes such as the Yilgarn in Australia and Abitibi in Canada. It is therefore significant that the Witwatersrand placer-hosted gold is coeval with late Archaean greenstone gold deposits.

3. Geologists on Witwatersrand mines regard the depository as a pile of sediments that have been subjected to greenschist facies of metamorphism. Original macroscopic sedimentary features are well preserved, however, petrographic studies reveal the presence of sericite and chlorite. At these metamorphic grades it is very easy to destroy microscopic evidence in the reef horizon that could settle the dispute of the origin of Witwatersrand gold and as to how it was captured within the basin.

Table 2.

POINTS AGAINST THE PLACER MODEL FOR SOURCE OF GOLD IN WITWATERSRAND

1. Source of such a large volume of gold.
2. Absence of gold nuggets.
3. Small particle size compared to recent placers.
4. Secondary crystalline and hackley habit of Au.
5. Low fineness of gold.
6. Association of Au, Fe, As, S and Au carbon is epigenetic, not syngenetic.
7. Abundance of idiomorphic pyrite.
8. Gold in end-member electrum is epigenetic.

POINTS AGAINST THE HYDROTHERMAL MODEL FOR SOURCE OF GOLD IN WITWATERSRAND

1. No evidence of fluid channelways.
2. Absence of hydrothermal zoning.
3. Association of low permeability pyritic quartzites.
4. Blocks of isolated mineralised conglomerate in barren quartzites.
5. High spatial correlation of Au, U and detrital zircon.
6. Relation between heavy mineralization and sedimentary structures.
7. Rich accumulation on unconformities.
8. Zircon, chromite, uraninite and pyrite in hydraulic equilibrium.

4. The mutual co-existance of gold with "carbon" and uranium as well as gold with Fe-sulphides must be explained. The presence of carbon commonly indicates elevated gold tenor, such as is found in the S9 Prospect. The mutual co-existance of gold and carbon occurs in Carlin-hosted gold deposits as well as biological gold in blue-green algae and in biogenic material in New Zealand sinter deposits (Pirajno, pers. com., 1987). The co-existance of gold with hydrothermal sulphides is widely reported (Groves et al., 1984). Those in favour of the **hydrothermal model** argue that the reef horizons would have been the most porous and permeable sites for movement of fluids within the sequence (Phillips, et al.,1990).

CHAPTER 5

5. INTERPRETATIONS AND DISCUSSION

5.1 PALAEO-ENVIRONMENTAL RECONSTRUCTION

The major sedimentological features of the Aandenk Formation that require interpretation are:

(1) a predominantly wacke and subwacke succession with polymictic pebbles and cobbles with channel edge directions that are orientated SW-NE,

(2) two palaeoplacers (Witpan and Uitsig) within the succession whose payshoots and channel edge directions are both NW-SE,

(3) a slight angular discordance between the Witpan Reef and the footwall succession,

(4) the Witpan Reef containing a lower channelised unit and upper sheet-like unit with overlying placer arenite,

(5) why the Uitsig Reef is a sheet-like placer capped by placer arenite,

(6) the three vertical zones of the Witpan Reef and their distribution,

(7) the difference in character of the pyritic zone from the underlying zones to a sheet-like pyrite-rich unit,

(8) the distribution and enrichment of gold in the pyritic zone, and

(9) the occurrence of payshoots on the south side of terraces and not the north.

Sediment influx in the Welkom Goldfield during Aandenk times was dominated by a source area to the southwest with abundant short-lived pulses of sediment into the subsiding basin. These introduced argillaceous sediments interbedded with polymictic conglomerate from an alluvial fan whose channel edges are orientated in a SW-NE direction. A period of quiescence ensued prior to initiation of the Witpan event. During this time, preferential compaction of the sediments occurred. This produced an uneven palaeosurface as is observed in a slight angular disconformity in parts of the study area and in Figure 4.1.

Deposition of the Witpan Placer commenced from the northwest introducing an oligomictic detritus from a braided-type pediment placer. The initial channels eroded as much as 2.5m into the underlying Footwall

Sequence, thereby cannibalising pebbles and introducing them into the basal scour unit. Most of the argillaceous material in the Footwall Sequence was broken down by mechanical processes during sediment transport. Some shale fragments did survive and are found scattered in the matrix of the basal scour unit.

The "reef zone" formed after the initial channeling event but, with a decrease in flow strength, less downward erosion occurred. Enrichment of Fe-rich detritus occurred, partly due to a lower stream power than during the basal scour event. Fe-rich minerals settled between the interstices of pebbles along with other heavy minerals. Reworking by anastomosing braided streams caused the numerous scour and degradation surfaces that occur within the "reef zone".

The event was followed by transgression. Reworking of upper portions of the reef zone occurred resulting in enrichment of heavy minerals, increasing the pyrite concentration. It is also within this zone that the richest gold values occur. The pyritic zone is interpreted as a high-energy nearshore zone whereas the overlying arenitic facies represents a shelf sand offshore zone.

Regression followed with influx of argillaceous sediments from the alluvial fan to the southwest. Warping of the sedimentary pile due to small movement on the de Bron horst is inferred prior to the Uitsig event. This resulted in gently undulatory pre-Uitsig topography which shifted the Uitsig depoaxis towards the southwest.

The Uitsig Reef is also interpreted as originating in the form of a braided type of deposit that was totally reworked by transgression. Once again the placer comprises a sheet-like conglomerate to pebble lag whose pebble size remains relatively constant on a 10km scale. The reef is also overlain by arenites and the entire unit is rarely thicker than 1m. Preferential entrapment of carbonaceous material occurred in the President Steyn Mine area. Extensions of the carbonaceous unit are likely to exist on Western Holdings Mine although further exploration is required to confirm this.

After the Uitsig event, sedimentary influx into the goldfield was once again dominated by the southwest entry point. Argillaceous quartzites were re-introduced although the rate of influx was reduced. This resulted in smaller-sized and more widely dispersed pebbles. Similarly, the non-durable component of the quartzites was affected, producing quartzwackes, a product of the lack of durability of some of the shale fragments.

The influence of beach processes on fluvial sediments has already been recognised within the Witwatersrand for the Vaal Reef palaeoplacer

(Verrezen, 1987). Comparing with other reefs in the Welkom Goldfield, the Basal Reef may well have formed in such an environment for it is overlain by shales. This is clear evidence for marine transgression. The Alma Reef is also a sheet-like palaeoplacer with overlying quartzarenite.

Although this model is tentative, a beach interaction can explain, by swash action, the preferential enrichment of gold on only one side of the terraces. In a fluvial environment gold is concentrated on both sides of the terraces. The more widespread distribution of the pyritic zone and capping by siliceous quartzarenite have also been explained in terms of reworking and shifting of material in a beach environment.

CHAPTER 6

6. ORE EVALUATION AND GEOSTATISTICS

6.1 INTRODUCTION

During the last few decades, the gold grades on South African mines have steadily declined due to exploitation of the richest gold-bearing horizons and depletion of the highest-grade reserves. With rising mining and labour costs, and a gold price that does not keep pace with inflation, it has become imperative to utilise gold reserves in the Witwatersrand to the full. Mines are becoming progressively more marginal and the future of Witwatersrand mining lies with complex reefs where selective mining of the payable zones takes place. As a result, there is an increasing demand for effective valuation techniques with a view to selective mining and this topic has been the focus of several theses (Stear, 1987).

The remainder of this thesis will concentrate on data collected by the writer and previous geologists in the 37 "A"-Reef area, and examine the distributions of gold, channel width, and grades. Features about these distributions will be discussed and their significance linked to sedimentary/morphological features. The modelling of semi-variograms derived from the dataset will be discussed with a view to kriging the area for channel width and gold tenor in cmg/t. This will then be used to construct a grade/tonnage curve.

To date there has been no recorded attempt to valuate the "A"-Reef using the above mentioned techniques. The only documented evaluation studies within the Welkom Goldfield have been in a dissertation by Ainslie (1981) and a thesis by Clay (1987), however in-house geostatistics have been applied by Snowden and Thurston (pers. com., 1990).

At this point attention is drawn to a change of terminology. Sedimentologically it is acceptable to refer to the vertical thickness of the reef as "channel thickness". However, for the purposes of ore-evaluation, the South African mining industry makes use of the term "channel width" (Storrar, 1977) and the term will be used in this context for the remainder of this chapter.

6.2 THE METHODOLOGY AT WESTERN HOLDINGS MINE

6.2.1 DATA COLLECTION

The dataset used in this thesis were collected by the writer between May 1989 and October 1990, as well as prior to this by previous geologists. It is a standard on Western Holdings Mine that the geologist is responsible for the mapping and marking off of the reef horizon before it is sampled. All development is plotted on a 1:200 scale with detailed sedimentological reef descriptions (reef profiles) on a scale of 1:50 or 1:20 at approximately 20m intervals. The sampler will sample a 10cm wide section perpendicular to bedding in 7, 10 or 15cm intervals (Figure 6.1). A 2cm footwall and hangingwall overbreak is included to ensure that all the gold on the reef contacts is sampled. Strict control of these sampling procedures is essential and samplers are well-trained and carefully monitored.

Reef chip samples are sent to the laboratory and are analysed for gold by "fire-assay". Uranium is determined by a scintillometer. A constant Au:Ag ratio is assumed for each reef type during analysis and results are corrected for Ag. In addition, it is estimated that the level of detection is ±0.3 g/t gold (values <0.3 g/t are reported as trace values) whereas the reported values have an error of 0.2 g/t (Havenga, pers. com., 1989). The values are relayed to the sampler who calculates the channel width and cmg/t for the sections sampled.

Not all the sample positions reported in Appendix A are from sampled sections. Borehole reef intersections have also been used. Core-loss was usually <1% and was treated as negligible. Drill core has a major advantage over channel sampling in that it provides a "balanced" sample by virtue of its uniform shape. The cmg/t values and channel widths are corrected for intersection angle. Although it is not normally desirable to mix different sample types due to change of support problems, this will not matter with channel width values. Ideally, gold values from two differing sample types should not be mixed. However, the borehole values constitute <1% of the total data set and this effect on the validity of interpolation is negligible. Nevertheless, adding these data points increases the information in areas of low density.

The values of cmg/t and channel width (hereafter Ch.W.) were transferred from the sampling ledgers onto 1:200 and 1:1000 geological sheets. Boreholes that have been drilled were also plotted together with the corrected cmg/t and Ch.W. values. All of the development sheets in the study area were captured digitally (Figure 6.2).

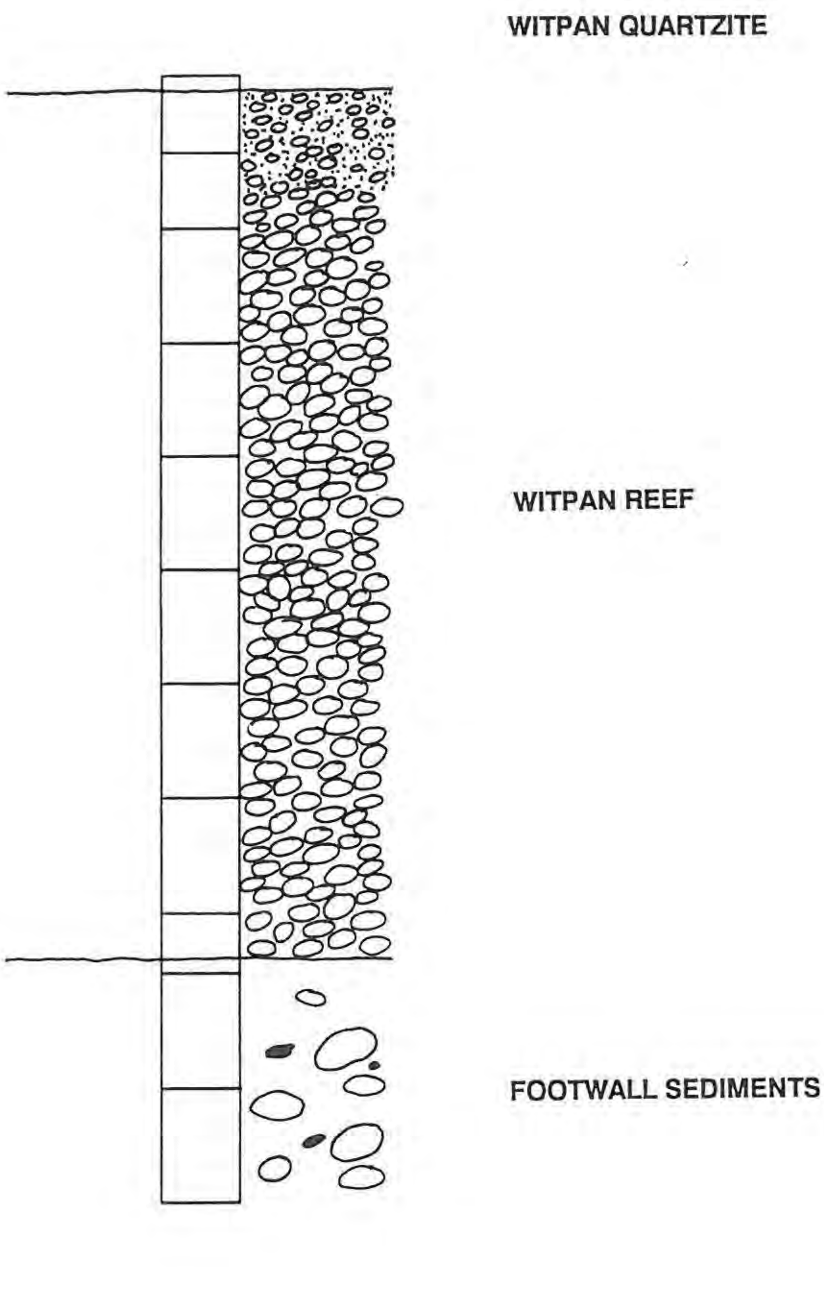


Figure 6.1 Example of a sampled section showing the vertical sample intervals, as well as the sampling overbreak. Samples taken from the footwall only serve to check for gold below the Witpan Reef. (SCALE 1:10)

X block dimension :	20.00	Number of blocks for X :	40
Y block dimension :	20.00	Number of blocks for Y :	35
Network minimum X :	8400.00	Number of samples :	932
Network minimum Y :	6800.00		

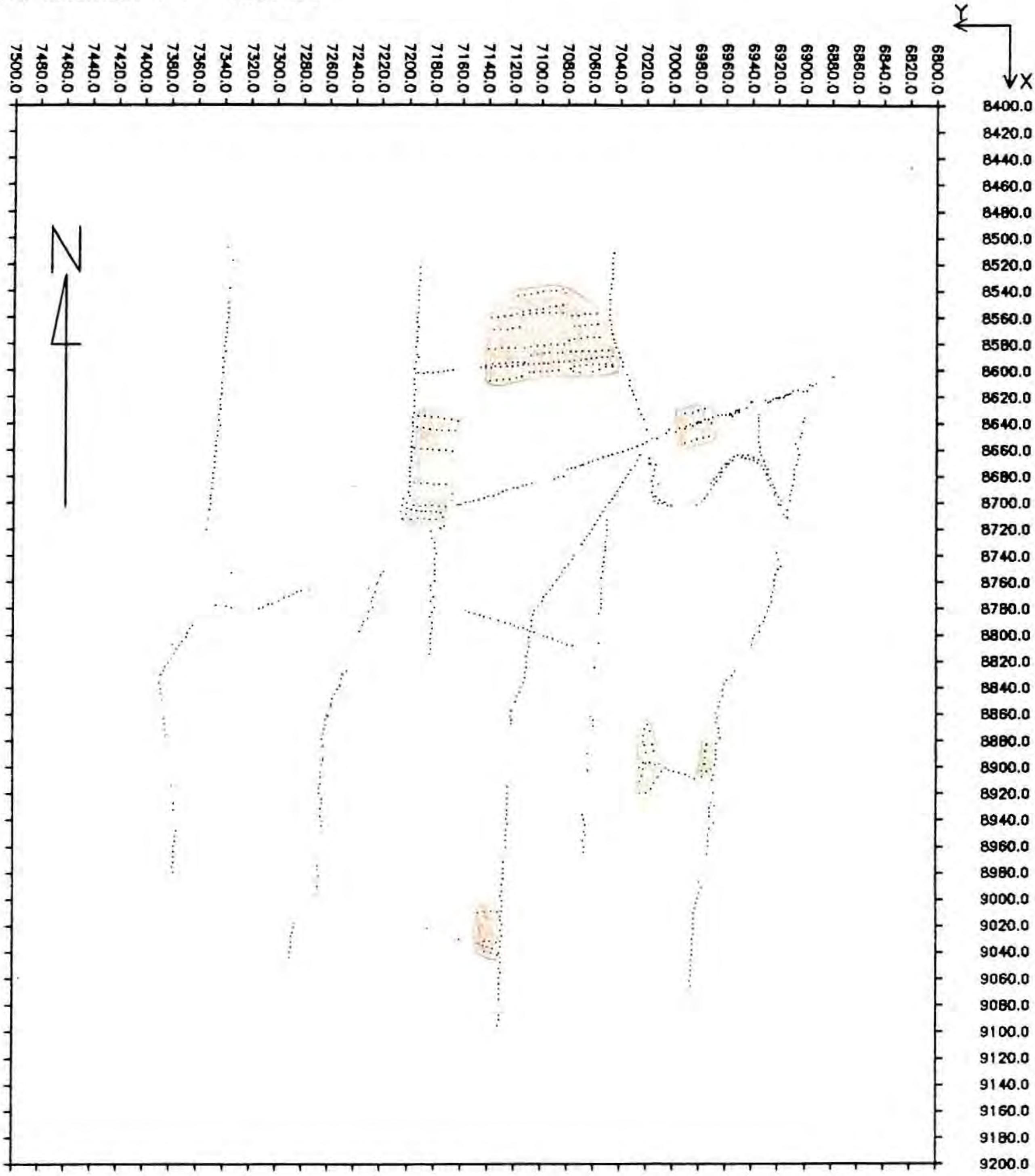


Figure 6.2 Location plot of all the digitised data points, both for development and stoping (coloured), for the No.3 Shaft mining area.

6.2.2 DATA PROCESSING

For data storage and processing an IBM compatible personnel computer was used. Two geostatistical packages have been used: the public domain **GEOEAS** (Geostatistical Environmental Assessment Software) package developed by the United States Environmental Protection Agency, and an in-house **GEOSTATS** package developed by De Beers and Anglo American Corporation. The **GEOEAS** package was found to produce better histograms but a bug in the kriging calculation favoured the use of the **GEOSTATS** package for geostatistical analysis. For the determination of the direction of anisotropy for variography, a program called **SEMI** was obtained from the Geostatistics Department of Genmin.

6.3 UNIVARIATE STATISTICS

Histograms, log-probability plots and classical statistics are all meaningful for examining geological data population distributions and can sometimes be linked to the genesis of orebodies. Unless otherwise stated, data used will be from development samples only. The limited stope data that are available are on a much closer-spaced grid, as well as being in areas of best values, and would thus bias the global statistics of the Witpan Reef.

6.3.1 CHANNEL WIDTH

The histogram of channel width (CH.W.) values for the Witpan Reef is almost symmetrical with slightly more values in the left tail of the distribution (Fig. 6.3). A normal probability plot of channel width values indicates a bimodal distribution (Fig. 6.4). Ignoring the outermost parts of the tails, two straight lines with an inflection point at about 35% of cumulative percentage occur and at approximately 110cm of channel width, implying two normal distributions. Geologically, the two populations reflect two separate events. The population with a >110cm channel width contains the basal scour and the main reef zone and constitutes ±65% of the dataset. The other population where the basal scour unit is absent comprises ±35% of the dataset. The population representing the pyritic zone cannot be separated from the rest due to this zone being so thin and widespread.

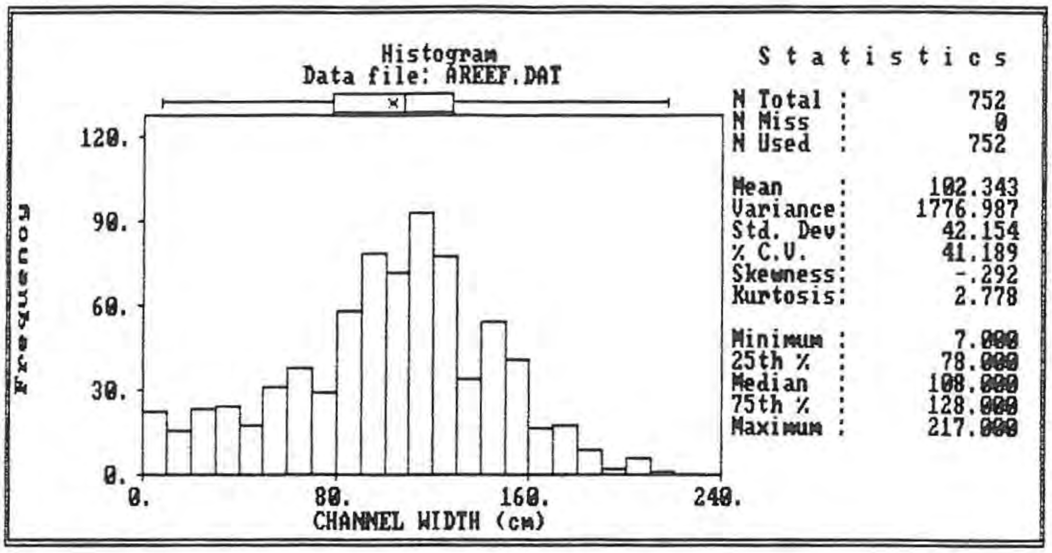


Figure 6.3 Histogram of channel width data.

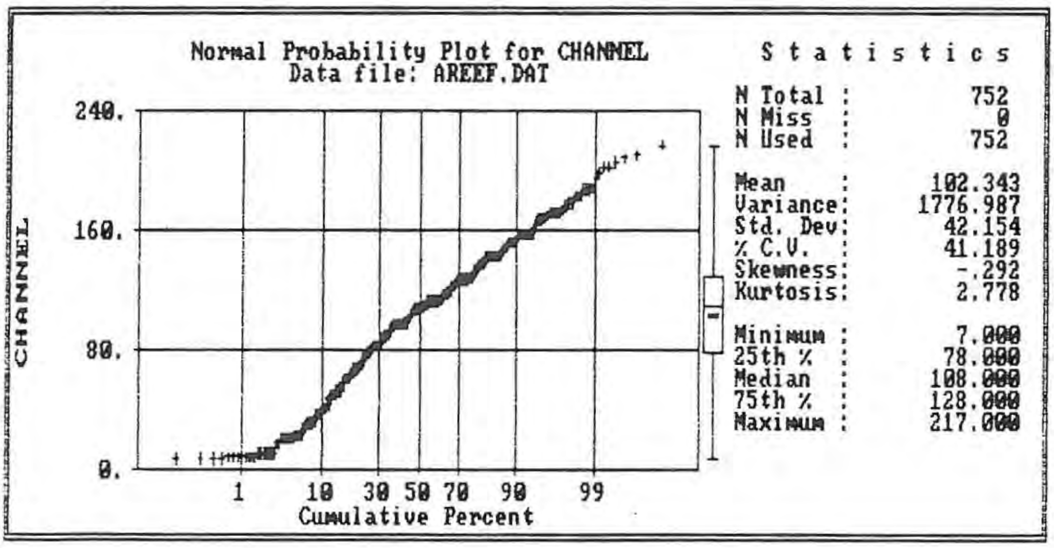


Figure 6.4 Normal probability plot of channel width data.

6.3.2 GOLD VALUES IN cmg/t

A distinctly asymmetrical distribution for gold is portrayed (Fig. 6.5). However, the distribution for log values of gold in cmg/t approaches symmetry (Fig. 6.6). The distribution for gold values is therefore approximately log-normal, but as is the case with the channel width distribution, a noticeable tail of low gold values occurs (Fig. 6.6). The distribution appears to be bimodal. This is confirmed by examining the probability plot for the log of gold values where an inflection point at ±15 cumulative percent occurs (Fig. 6.7). This indicates at least two gold mineralising controls or processes which may be attributed to the "in-channel" and terrace areas (the latter could result in a lower cmg/t value).

6.3.3 GRADE IN g/t

It is sometimes misleading to view gold values solely in cmg/t since channel width differences are usually masked. It was decided therefore to examine the grade distribution in g/t (cmg/t / Ch.W.). Like the cmg/t value for gold, the distribution of grade value is asymmetrical (Fig. 6.8). The log of grade however approximates to a normal distribution but once again a tail of low values occurs (Fig. 6.9). The probability plot for log of grade is not quite unimodal (Fig. 6.10). Two distinct deviations occur within the tails.

6.4 GEOSTATISTICS

It has already been pointed out in the description of the Witpan Reef, that the basal scour unit is not always present. Ideally more confidence could be placed in the results of the geostatistical treatment of this area if the basal scour unit had been identified in previous geological mapping, permitting a better subdivision of the area into geologically homogeneous zones. Previous geologists did not recognise the internal subdivisions described in Chapter 3 and as such, the basal scour unit has not been recorded. As a result, the writer has had no option but to treat all the data together.

6.4.1 VARIOGRAPHY

The semi-variogram is a useful tool in ore evaluation, allowing the user to quantify the variance of a variable at a given distance and direction from an arbitrary position. For the construction of semi-variograms, all the available data from development and stope sampling have

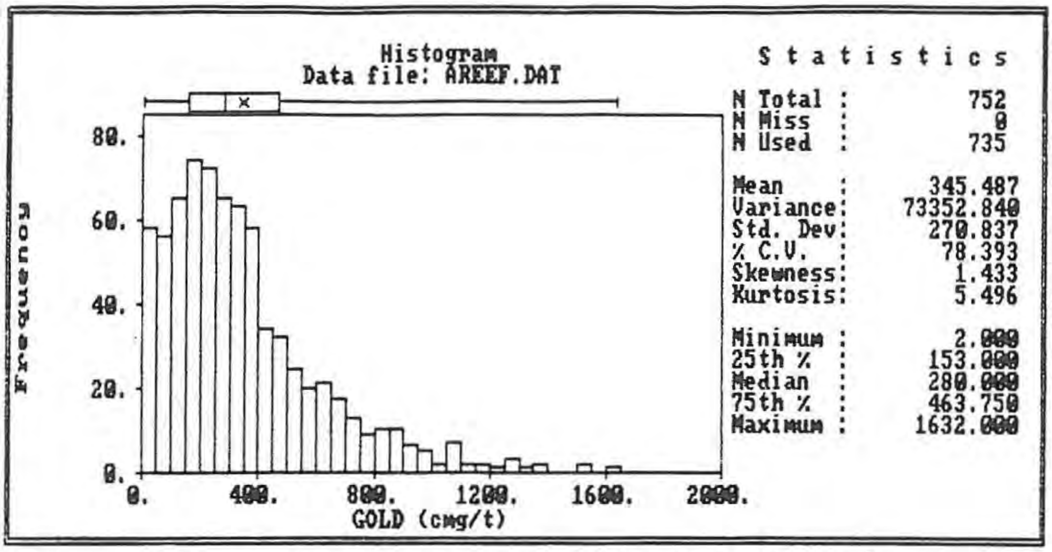


Figure 6.5 Histogram of gold values in cmg/t.

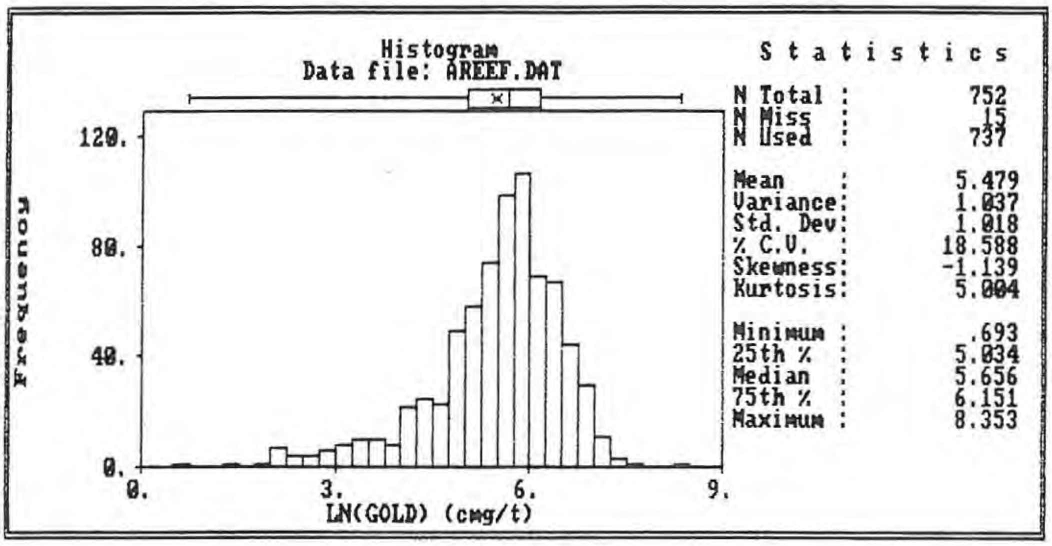


Figure 6.6 Histogram of logged gold values ie. Ln(cmg/t).

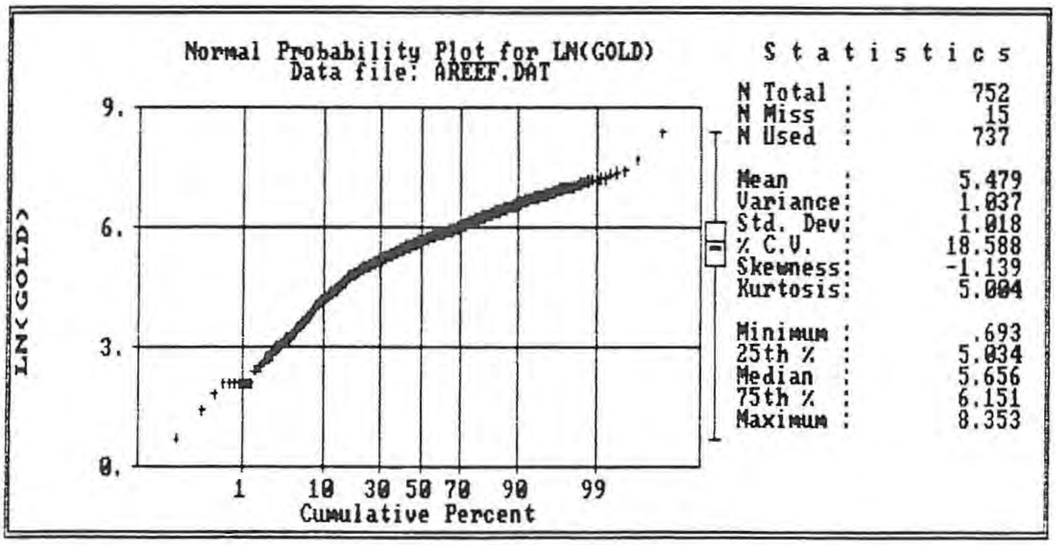


Figure 6.7 Log-normal probability plot of gold in cmg/t.

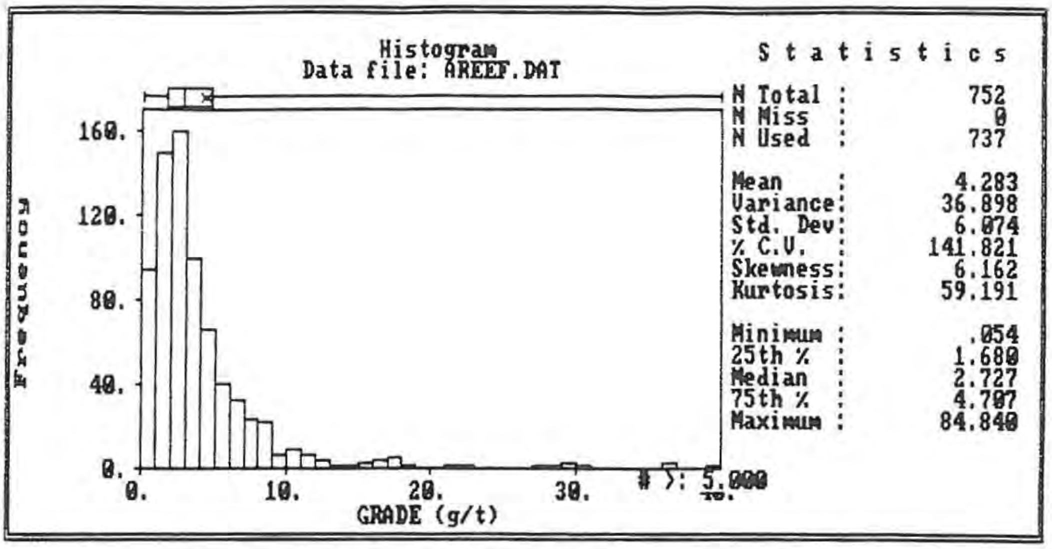


Figure 6.8 Histogram of grade of each section in g/t.

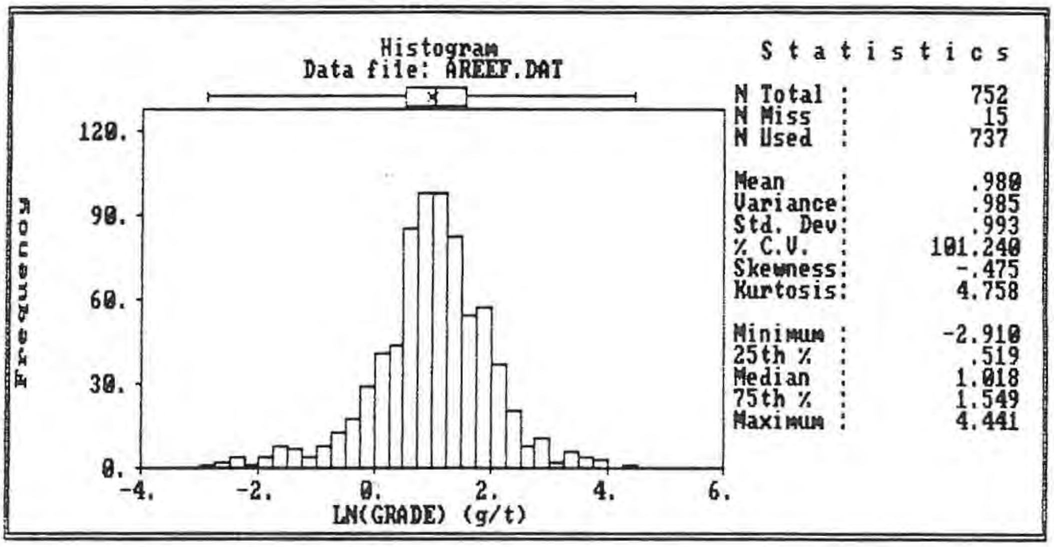


Figure 6.9 Histogram of the log of grade values.

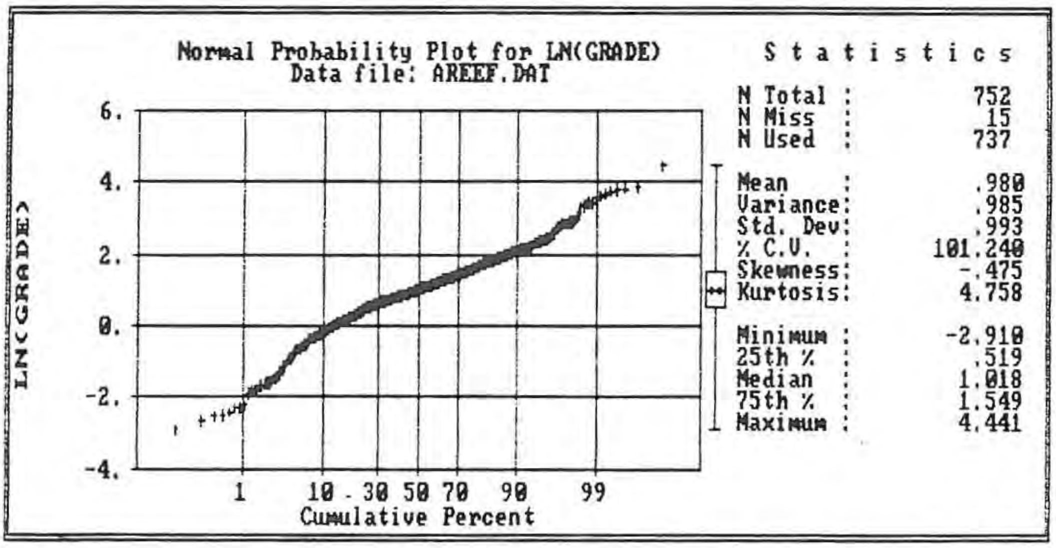


Figure 6.10 Log probability plot of grade values.

been used in order to get better spatial representation in orientations other than the N-S prospect directions. Stope sampling is carried out to the same standards and by the same samplers who sample development. The data is therefore of the same "type" and of equal support.

6.4.2 Orientation of Anisotropy Ellipse

It is generally accepted by inexperienced geologists that the palaeoflow direction corresponds to the direction of payshoots and hence the direction of elongation of the log axis of the anisotropy ellipse. This is not necessarily true. The writer has therefore had to test the hypothesis as to whether the long axis of elongation variography for the Witpan Reef is in the same direction as the mapped channel-edges.

For this example, a program provided by the Geostatistics Department of Genmin was used. Firstly the data were regularised into 10m square blocks for both gold in cmg/t and channel width, using a minimum of two points per block. The package effectively compares block pairs in the same relative position to each other and calculates the variance for each combination of position. The data support for each pair is presented in Figure 6.11.

For gold in cmg/t, an indicator semi-variogram based on a 451cmg/t (the payability cutoff in section 6.6) was calculated. The Genmin program was run to calculate the variance of pairs with the same relative position. The results are shown in Figure 6.12, the colour yellow representing the highest variance. This indicator semi-variogram diagram enhances trends in the dataset. Two directions are apparent, a prominent NW-SE trend and minor SW-NE trend. The dominant NW-SE trend corresponds to the channel-edge direction reported in this investigation and by others (Rogers, pers. com., 1989; van Berkel, pers. com., 1990; Grobler, pers. com., 1991; Armitage, 1986). The weaker SW-NE direction may correspond to gold accumulation on the leading edges of transverse bars. This style of mineralisation is well developed at Free State Geduld Mine several kilometres upstream from the No.3 Shaft (Western Holdings Mine) channel complex. SW-NE trending payshoots are arranged *en echelon* fashion down the main NW-SE trending channel (van Berkel, pers. com., 1991).

Semi-variogram calculation of channel width confirms the same NW-SE trend. In the indicator semi-variogram for gold, a prominent NW-SE trend occurs which corresponds to the channel-edge directions recorded during geological development mapping. As a result, the direction of greatest correlation and long axis of the anisotropy ellipse for kriging is orientated in the same direction. These will be termed the "in-channel"

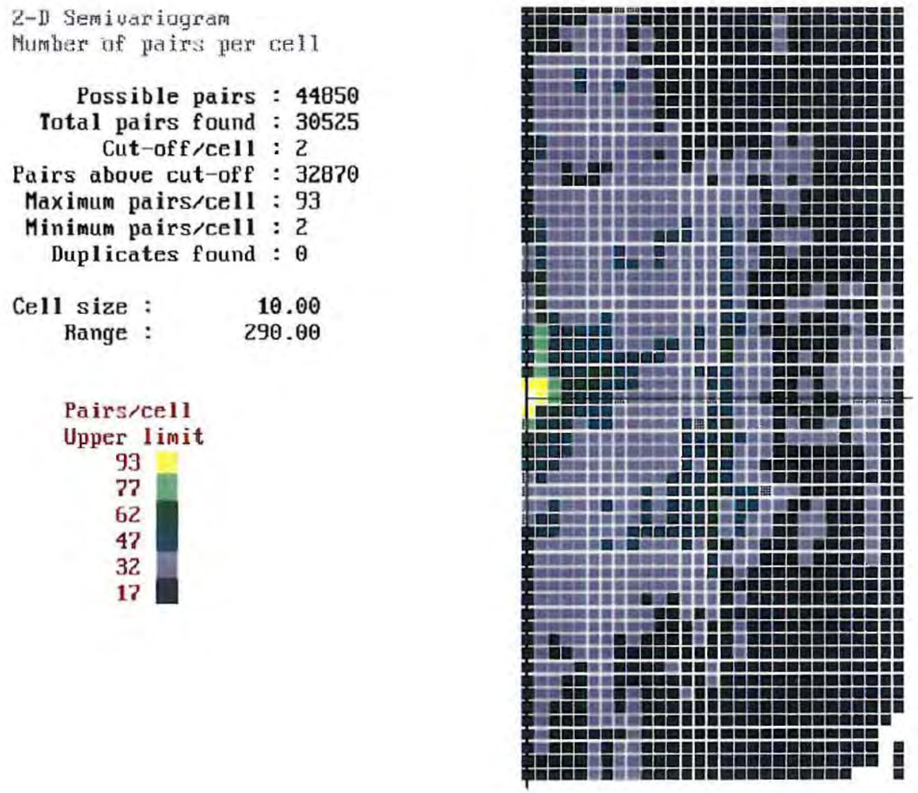


Figure 6.11 Data support for pairs in relative positions to each other. Each block is 10mx10m.

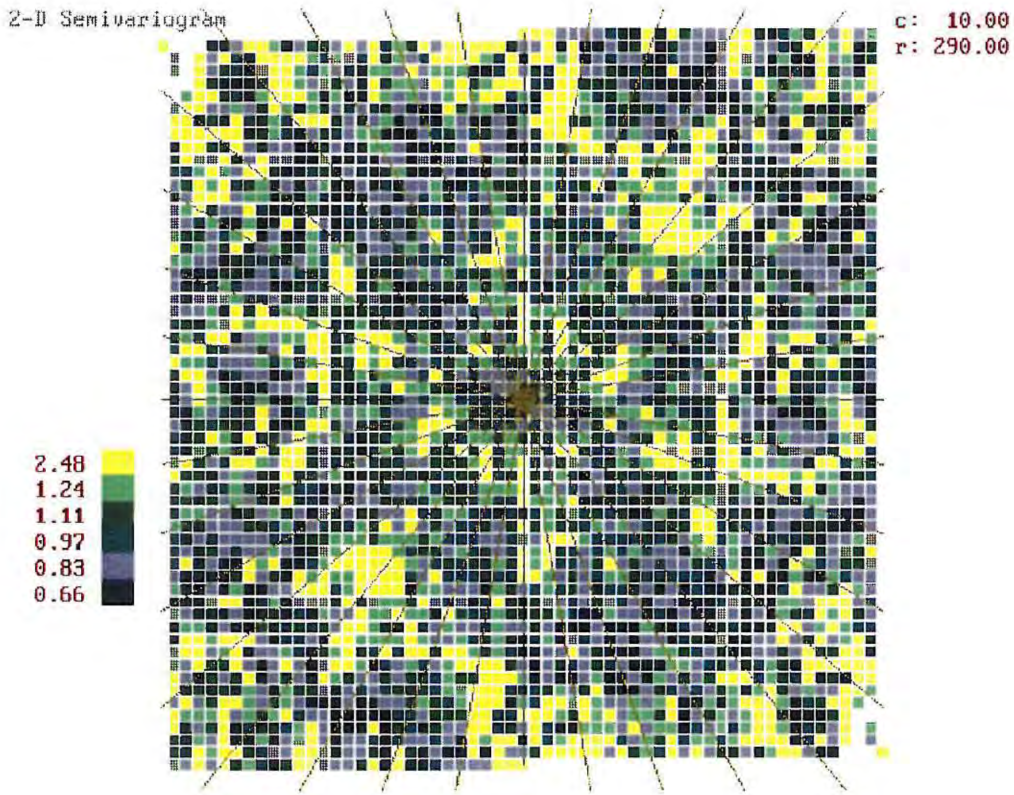


Figure 6.12 2-Dimensional indicator semi-variogram for gold based on 45lcmg/t cutoff. The trends of equal colour (such as yellow) correspond to the measured NW-SE channel-edge directions.

(NW-SE) and "across-channel" (SW-NE) directions.

The **GEOSTATS** package from De Beers and AAC calculates semi-variograms in the classical method as outlined by Armstrong (1986) and Clark (1979). The closest fitting semi-variogram models were found to have elements of geometric and zonal anisotropism. Owing to closer approximation of the semi-variograms to geometric models rather than zonal models, the writer has decided to model and krige the data for geometric anisotropism. During the modelling routine, an attempt was made to obtain the best fit for the first 60m. This is considered adequate since the furthest distance a kriged block can be from any data point is 40-60m.

Channel Width

Channel width is spatially correlated and structurally well defined as shown by the semi-variograms in Figures 6.13 and 6.14. Although it may be argued that a more accurate fit could be achieved for the nugget effect for different directions, geometric anisotropy requires a common nugget effect for all directions. A nugget effect of 225 cm^2 is a compromise between the NW-SE (in-channel) direction and the SW-NE (across-channel) direction (Fig. 6.13 and 6.14). Both semi-variograms exhibit two structures with separate sills and ranges; as such they are said to portray elements of geometric and zonal anisotropy. The initial 25m of each semi-variogram approaches geometric anisotropy. However, thereafter a marked difference in range and sill occurs. The final sill for the NW-SE semi-variogram remains below the variance of all the data. This is not surprising for one would expect least variability in the channel direction. The SW-NE semi-variogram has the higher sill and shorter range; one might expect greater variability in the across-channel direction. Interestingly, the across-channel direction semi-variogram has a hole-effect at about 100m, corresponding to a subtle wavelength developed between channels within the greater channel complex as exposed at No.3 Shaft. The semi-variograms have been modelled for geometric anisotropy.

Gold values in cmg/t.

Semi-variograms of Witwatersrand ores tend to deviate from the standard shapes, largely due to the high variability of gold values. A number of techniques that can be used to cope with this include:-

(1) regularising of values,

(2) removal of the outliers which cause extreme variability,

(3) semi-variogram modelling on the natural log value.

Although the Witpan Reef is regarded as a relatively low grade reef, the

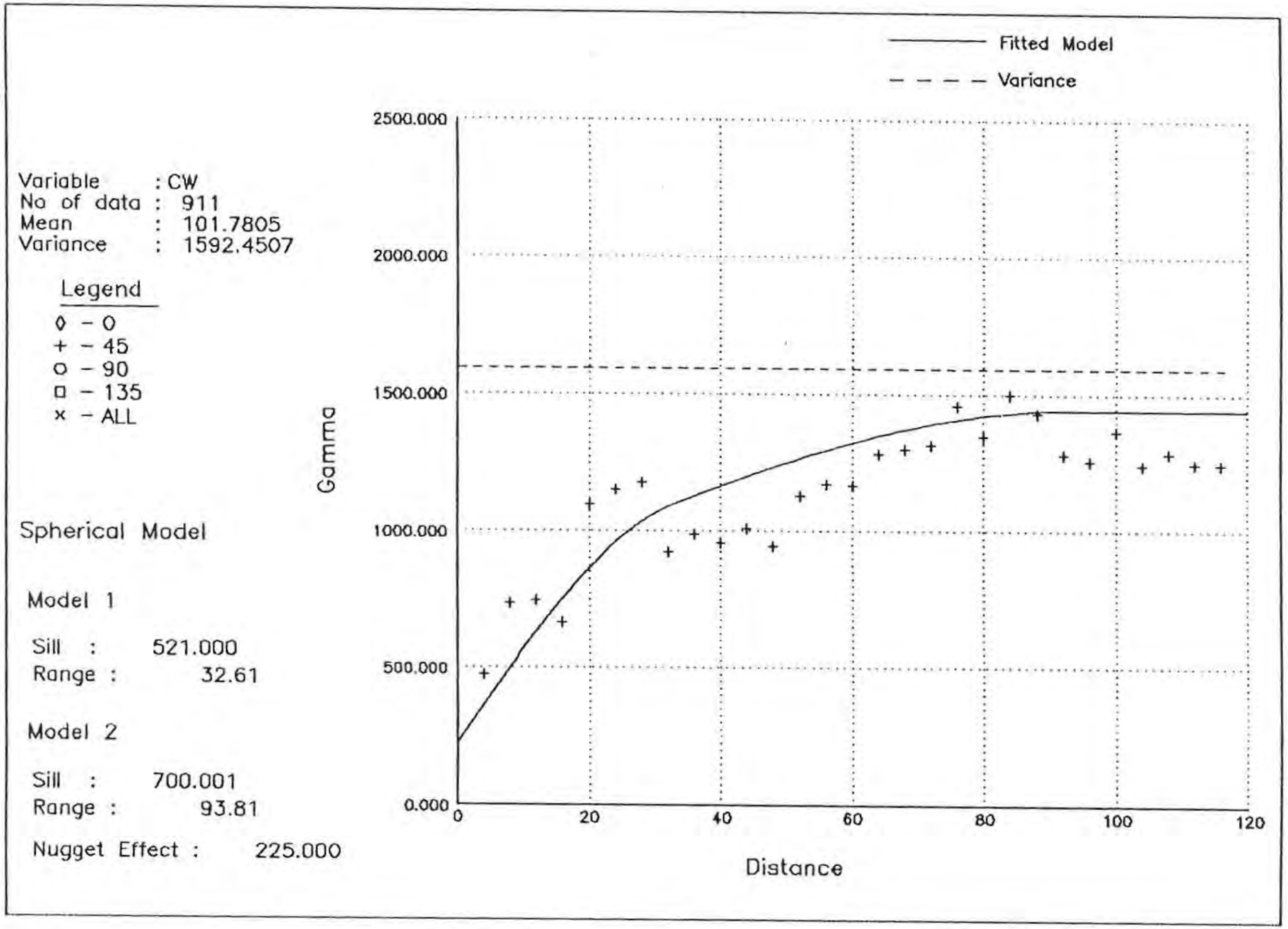


Figure 6.13 Semi-variogram for channel width (cm) in the NW-SE (in-channel) direction.

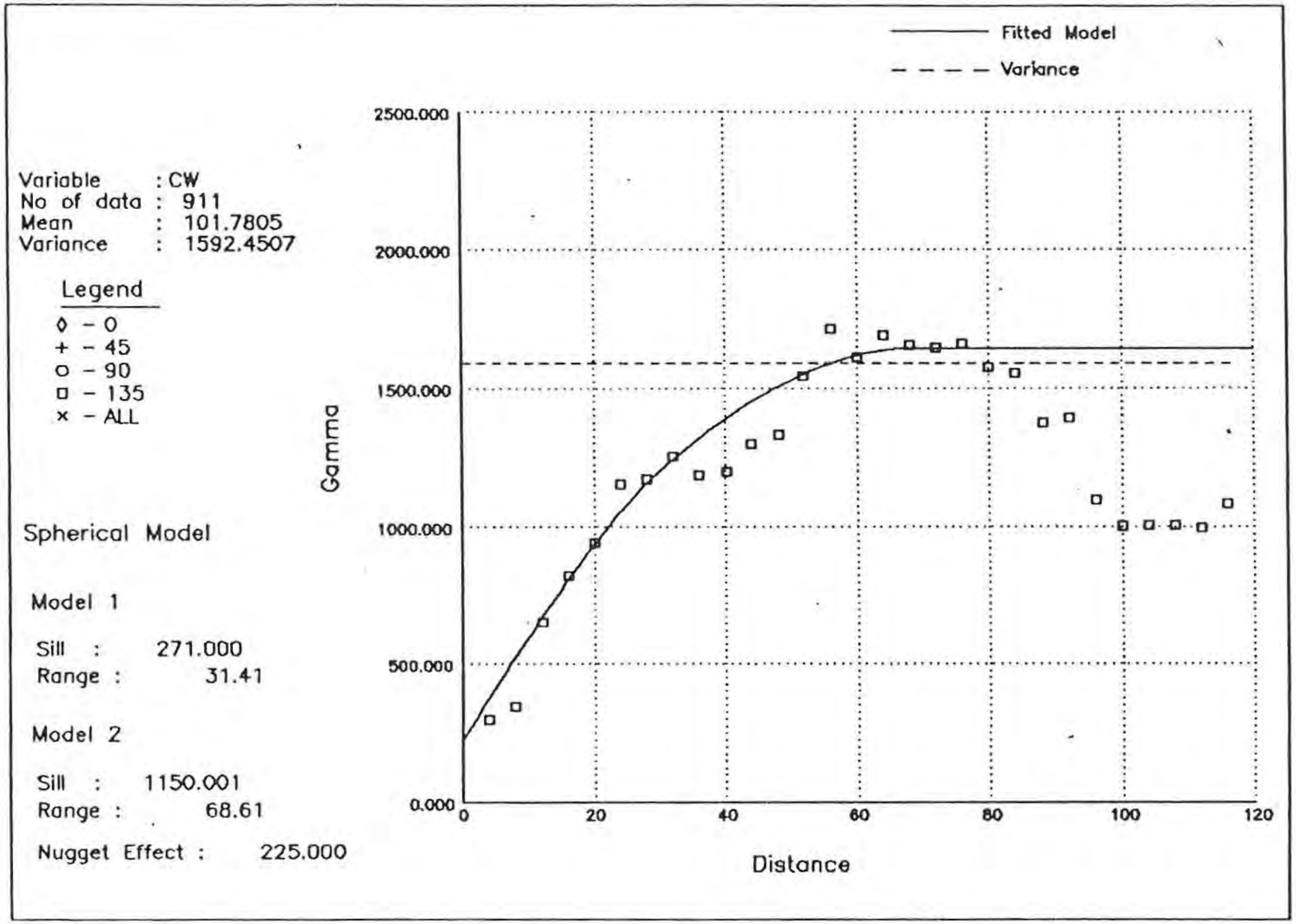


Figure 6.14 Semi-variogram for channel width (cm) in the SW-NE (across-channel) direction.

semi-variograms for gold in cmg/t are not "well behaved". They have short ranges with sills that exceed the variance, as well as prominent hole effects (Fig. 6.15). To undertake kriging based on the modelling of such a semi-variogram is not meaningful in that adjacent kriged blocks may vary in value by more than the variance of the whole area. The variance within blocks too will be unacceptably high. To overcome this log transformation was carried out before statistical modelling.

Gold values (in cmg/t) approximate to a lognormal distribution and hence semi-variograms of the log of gold were calculated. This will be followed by the utilisation of lognormal kriging. By this no outliers are excluded and their presence is then meaningful and contributes to the semi-variogram.

The semi-variograms of the log of gold (cmg/t) are more meaningful when compared to absolute gold values. A low nugget effect of ±15% of the variance (Fig. 6.16 and 6.17), together with a final sill that is close to the variance as well as a range of 77m, makes this a practical semi-variogram. As in the channel width semi-variogram, the log of gold semi-variogram also portrays both geometric and zonal anisotropy. For kriging purposes, geometric anisotropy has been applied. Hole effects also occur at around 100m and appear to be more pronounced in the NW-SE semi-variogram. This may be linked to the length of pay-shoots which occur on the edges of terraces.

The exclusion of outliers in the data removed approximately 1% of the data (ie. values above 1300cmg/t). The resulting semi-variograms are an improvement on Figure 6.15 as can be seen in Figures 6.18 and 6.19. In both cases the sill corresponds to the variance of the sample population and only the ranges vary. The semi-variograms are therefore modelled for geometric anisotropism.

6.4.3 BLOCK KRIGING

Kriging provides a means to estimate values by taking cognisance of actual values nearby and the change of variance with distance, modelled in the semi-variogram. Progressively more sophisticated mathematical techniques have evolved in the last decade but for this thesis, only ordinary and simple kriging are considered. Ordinary kriging was the first type of kriging developed and in the past was the most widely used. Simple kriging is a modification of the former and during estimation of values away from existing data, weights the estimation towards the mean value. This is an advantage in areas of geological homogeneity as it decreases the chance of over-valuation in high grade areas as well as over-valuation in

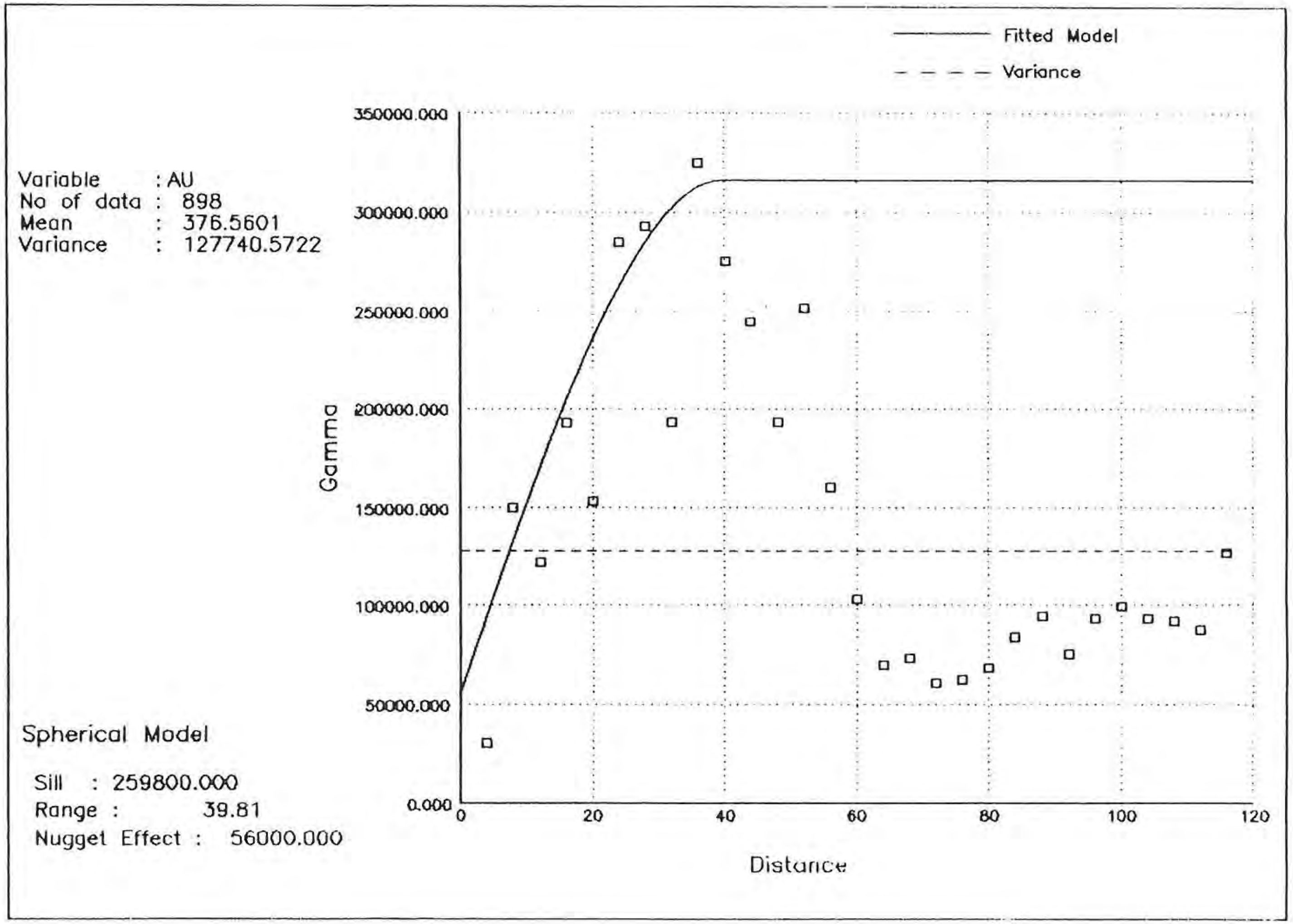


Figure 6.15 Semi-variogram for gold (cmg/t).

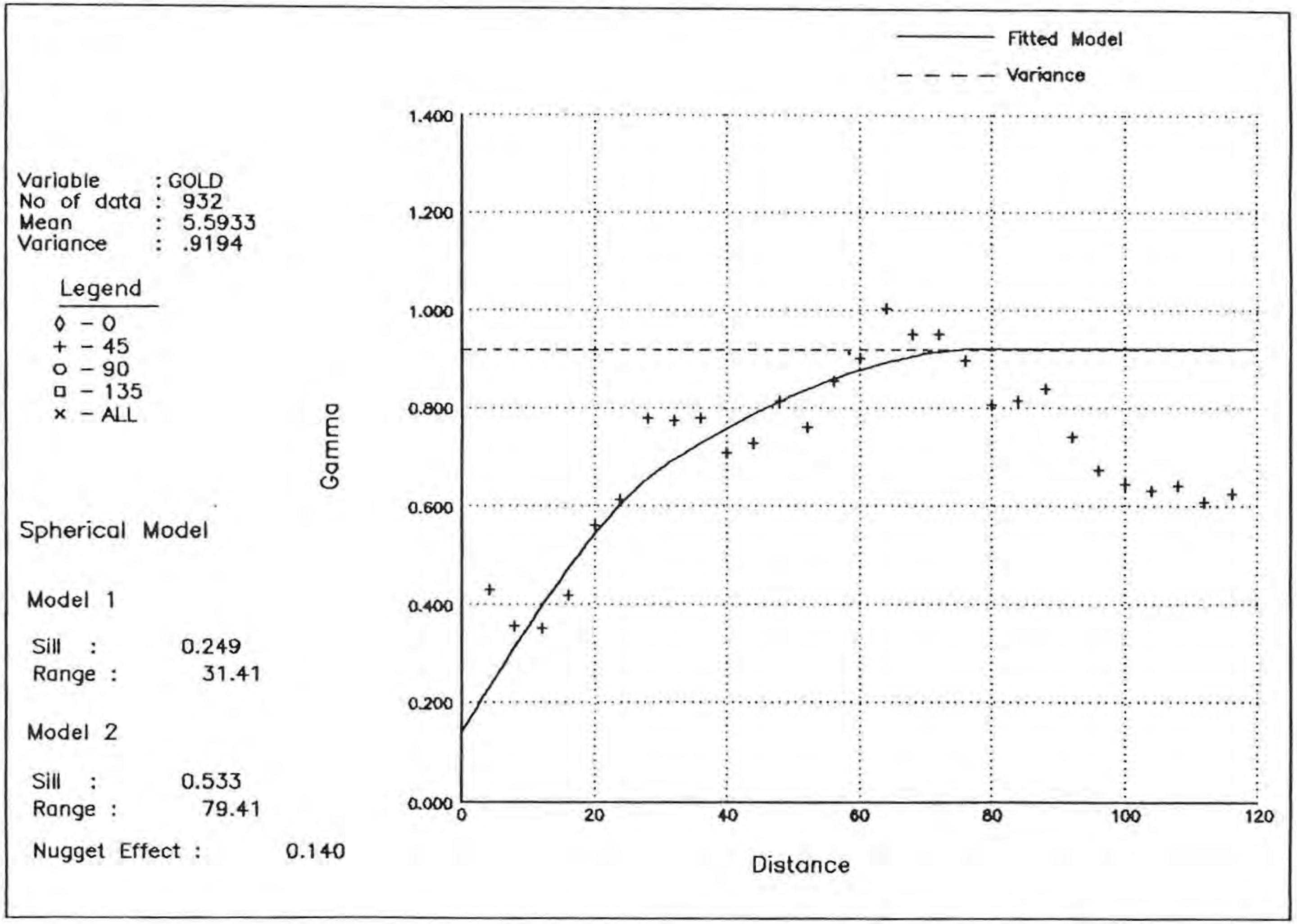


Figure 6.16 Semi-variogram for the natural log of gold (ie. Ln(cmg/t)), taken in the NW-SE direction.

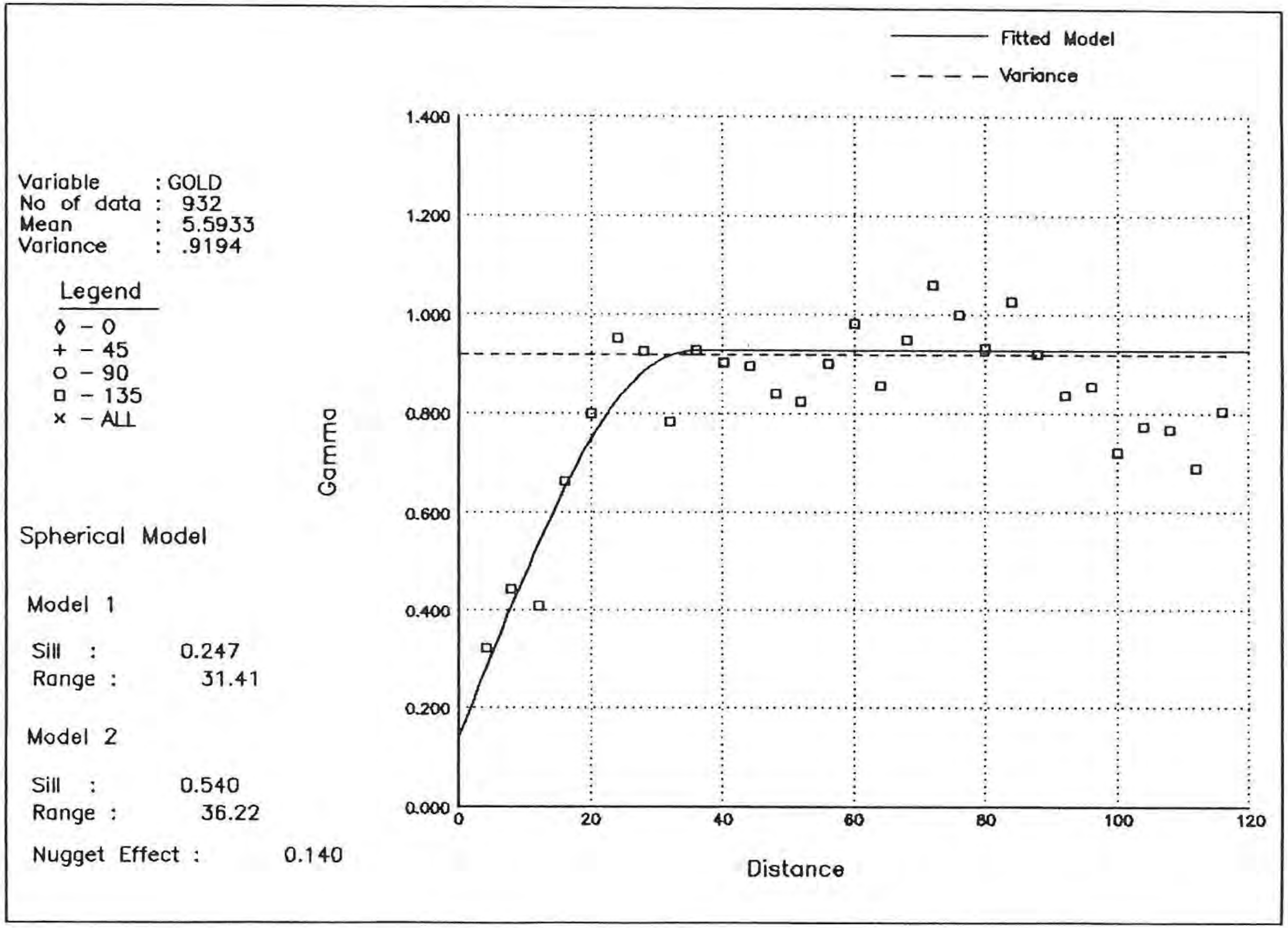


Figure 6.17 Semi-variogram for the natural log of gold (ie. Ln(cmg/t)), taken in the SW-NE direction.

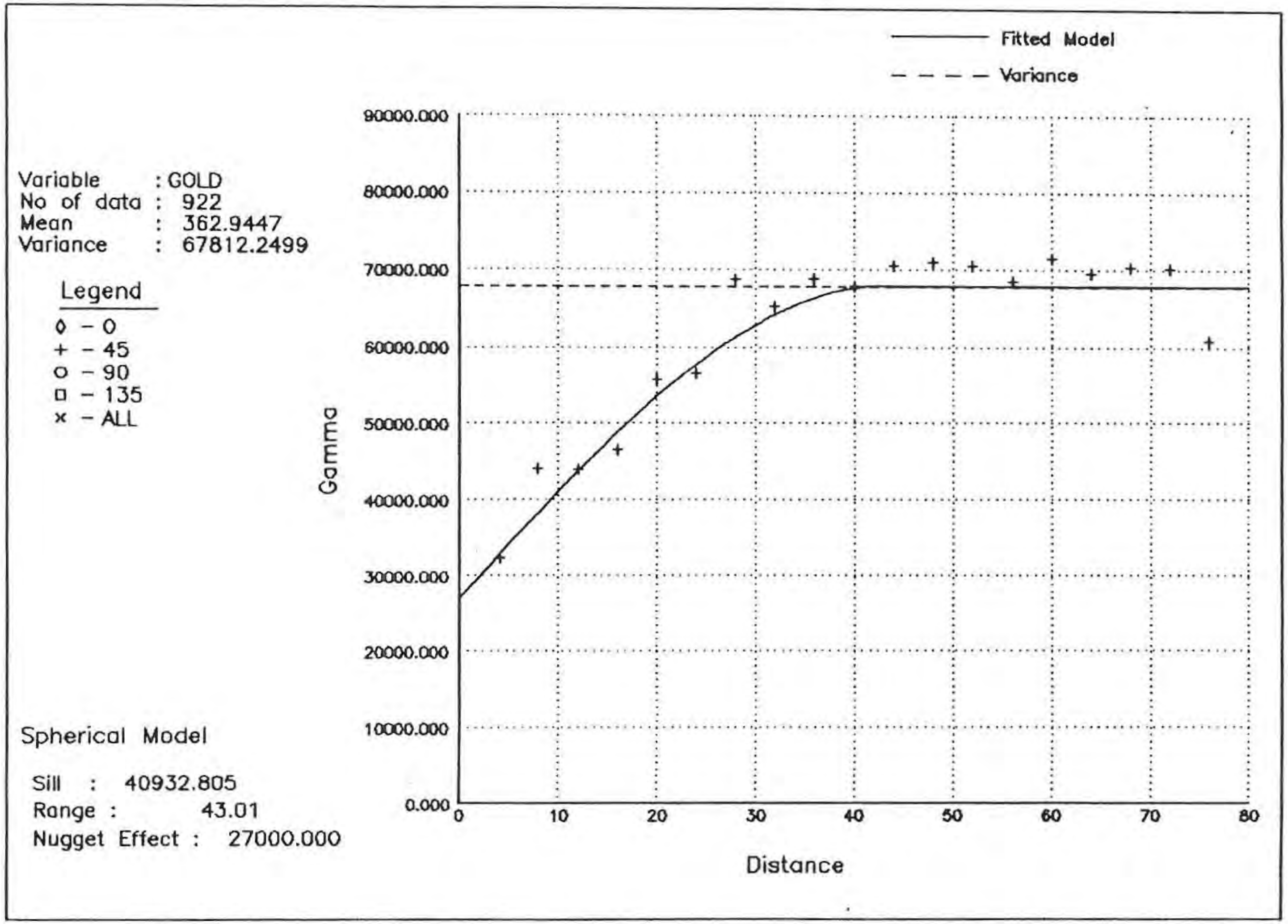


Figure 6.18 Semi-variogram for gold values (ie. cmg/t) taken in the NW-SE (in-channel) direction.

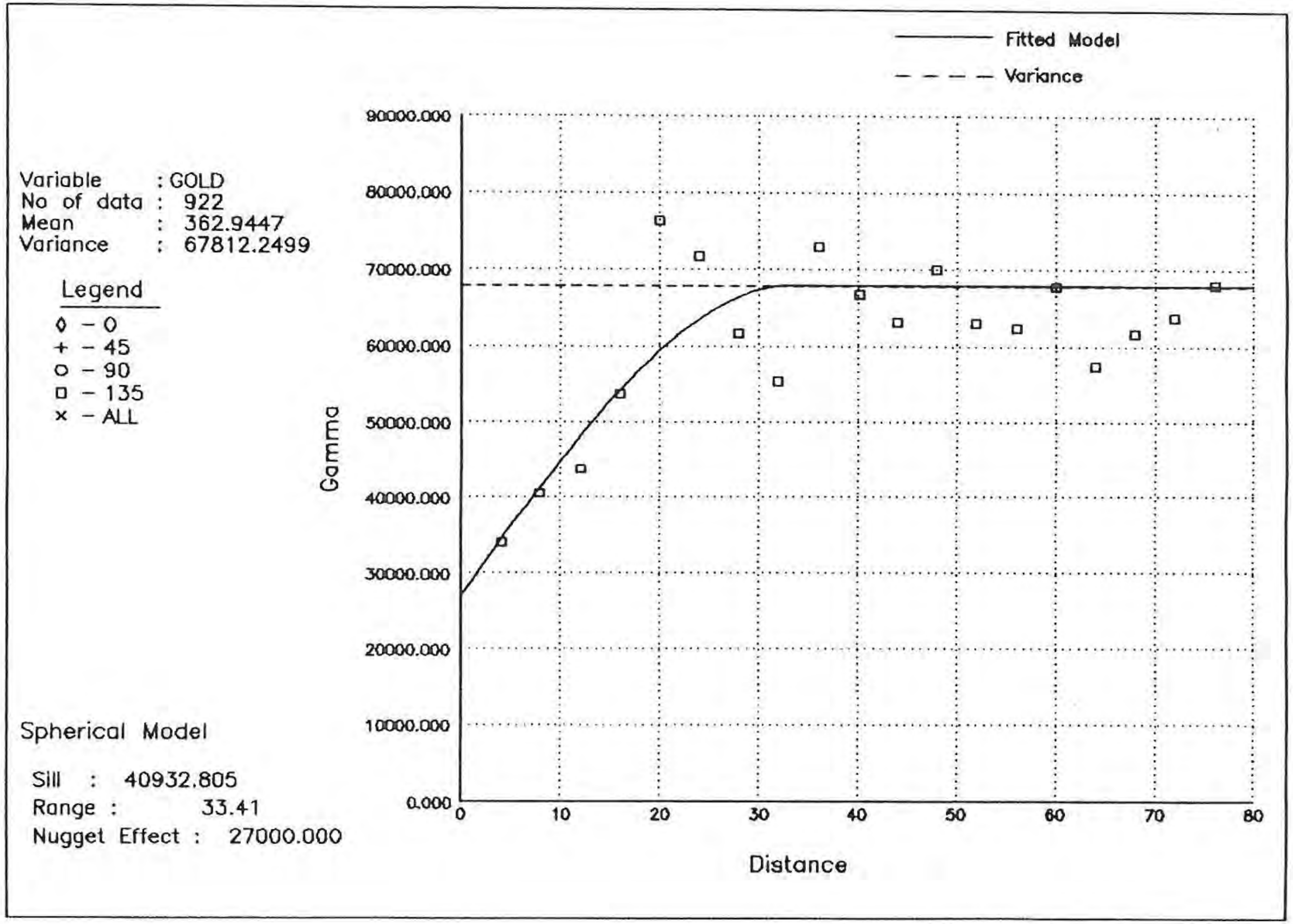


Figure 6.19 Semi-variogram for gold values (ie. cmg/t) taken in the SW-NE (across-channel) direction.

low grade areas.

The block size selected for kriging takes cognisance of panel lengths, monthly face advances, and the choice of the mining department to mine breast or up-dip panels. Face advances are commonly 10m between sampling intervals. Panels mined vary in width from 20m to 30m. To select rectangular blocks of, for example 30x10m, may not be wise as there are both breast and up- or down-dip panels. For this reason 20mx20m square blocks were selected.

Channel Width

Ordinary block kriging has been used to estimate values from an almost normal distribution for channel widths. Ordinary kriging will be influenced by variations or trends within the data such as terraces and centre of channels. Simple kriging would have the effect of under-estimating the deeper channels while giving excessive thickness to terrace areas.

Gold Values

The semi-variogram for gold values in cmg/t, based on all the data, is regarded as unacceptable. It is unwise to use kriging based on a semi-variogram model where the sill is double the variance. To overcome this, the gold values were subjected to log-normal kriging. One flaw of ordinary log-normal kriging is the gross over-estimation or under-estimation of predicted log values. As a result, the writer has chosen to use simple log-normal kriging to prevent such over or under-estimation, thereby weighting distant blocks by the mean gold value. Owing to a skewness in the log distribution of gold, it is common practice to add a constant before taking log values. For the Witpan on No.3 Shaft, this constant was found to be 120cmg/t. Simple lognormal kriging was performed in 5x5 blocks and the values transformed back to gold in cmg/t for each block using the formula in Appendix B.

The weaknesses of the semi-variograms in Figures 6.18 and 6.19 for gold in cmg/t, are the shorter ranges and weaker anisotropism. As a result of the short ranges, kriging in 3x3 blocks was performed.

6.5 RESULTS

The output from the **GEOSTAT** package is reported in Appendix D, the gold values having been calculated from log-normal kriging. Using these block values, contour plans have been compiled to graphically represent the data for both channel width (cm) and gold (cmg/t) (Fig. 6.20 and 6.21). The terrace areas are coincident with channel width in the order of ±50cm in

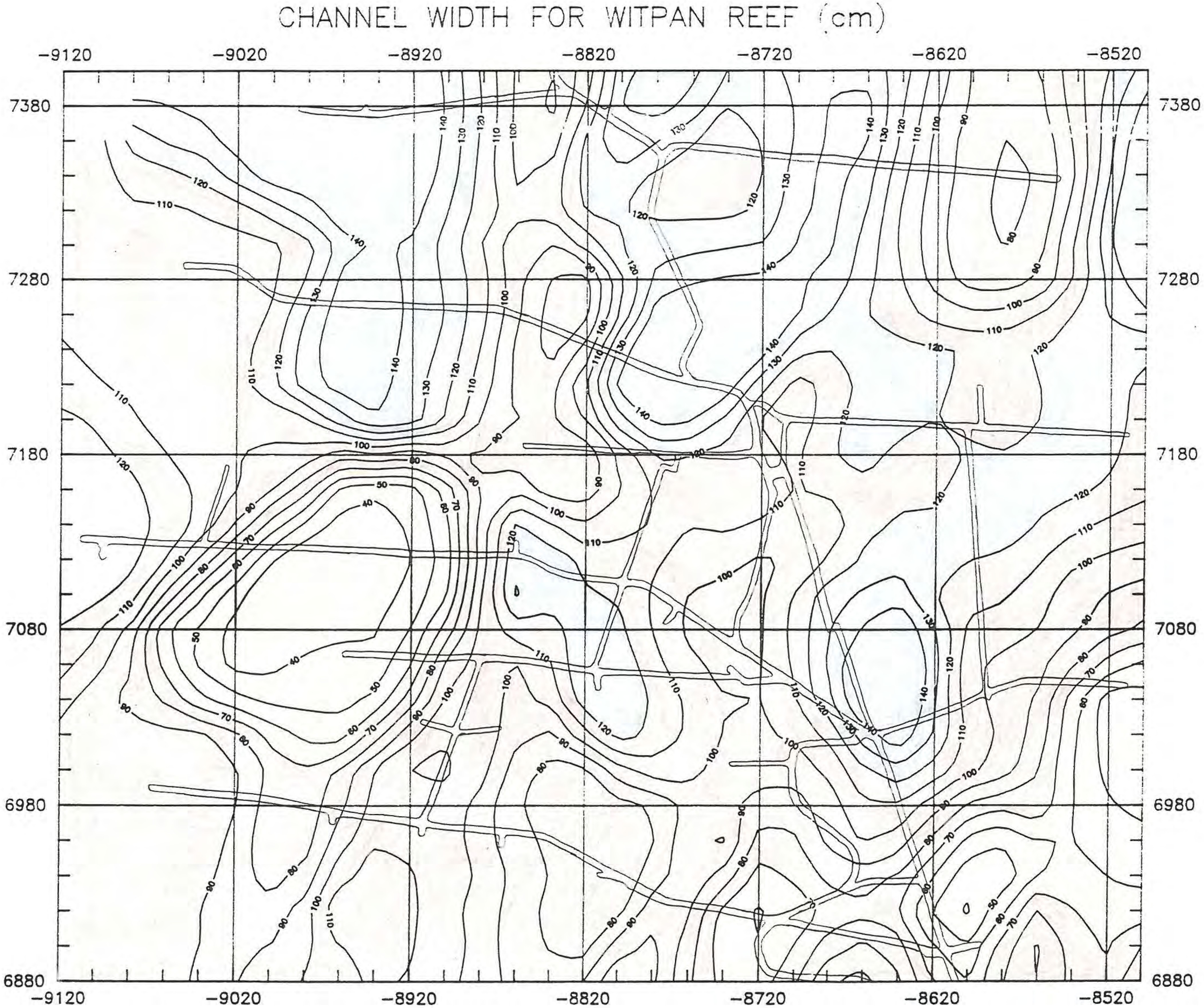


Figure 6.20 Contour map of channel width (cm), compiled from the kriged output (see Appendix D).

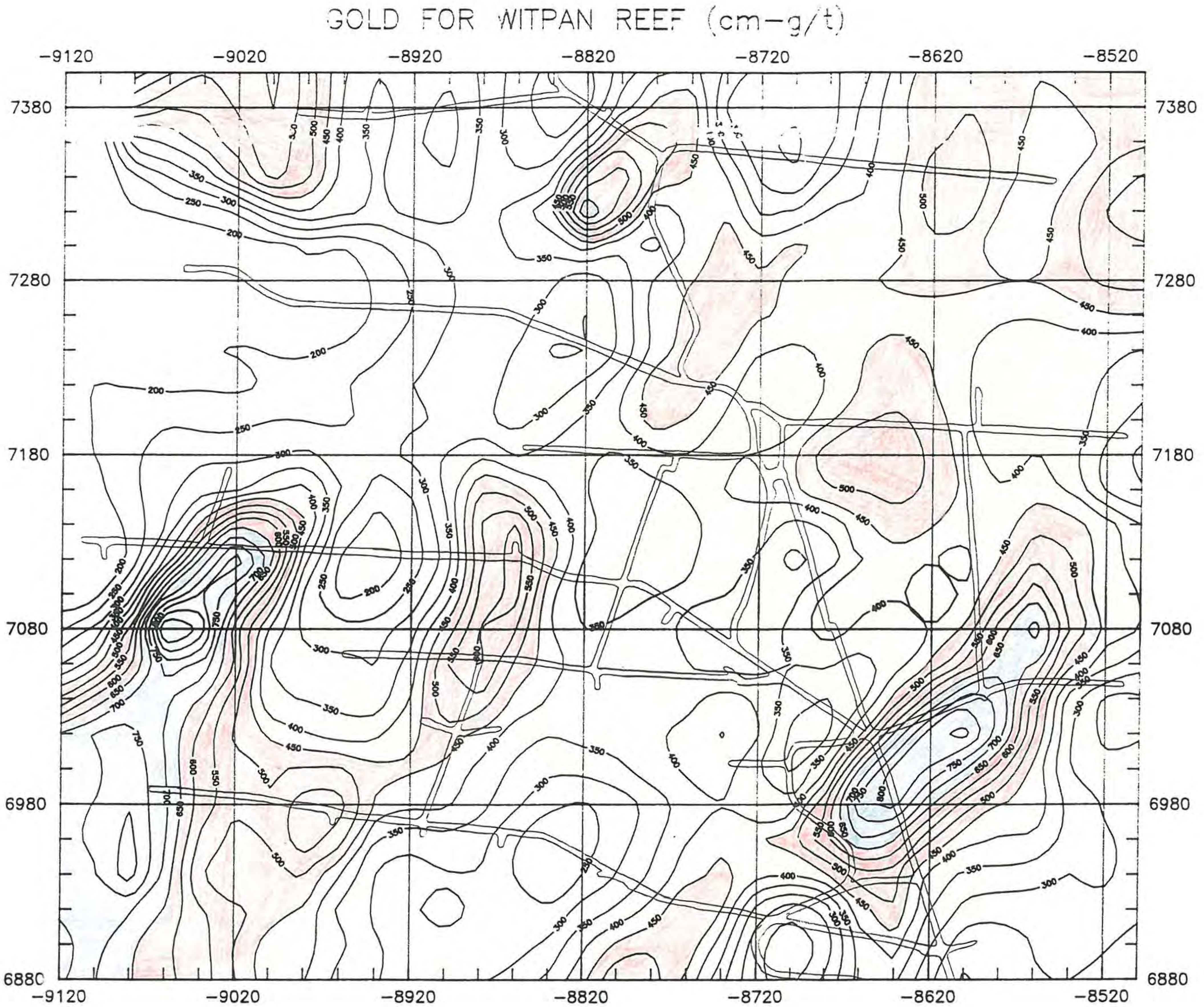


Figure 6.21 Contour map of gold (cmg/t), compiled from the back-transformed kriged output (see Appendix D).

Figure 6.20 and areas of channel width in excess of 120cm contain all three zones (ie. basal scour unit, reef zone, and pyritic zone). In Figure 6.21, the two most important payshoots of the No.3 Shaft mining area are indicated by high grade. The block estimates from the two methods are compared in Figure 6.22.

6.6 ESTIMATION OF PAY-LIMIT

The "A"-Reef on Western Holdings is regarded by management as a marginal reef under the 1990 gold price of approximately R33000/kg. Considerable capital has been invested in development ie. ramp, prospects, and raises in order to exploit the reef. It is fortunate however, that most of the development has been on-reef and has had a financial return by virtue of its gold content. It is estimated that values exceeding 456cmg/t enable on-reef development to cover all its costs (Rautenbach, pers. com. 1990). For the purposes of a pay-limit estimation, it has been decided that the cost of development be ignored and cutoff grades be determined from the values estimated by the kriging routine for 20mx20m blocks.

It is essential on any mine to determine the cutoff grade. On AAC gold mines there are a number of cutoff grades, depending on whether a stope is to pay for its own costs, or if the stope is to make a contribution to shaft, mine, or regional costs. For the purposes of this thesis, the cost of a stope paying for itself, along with a minor profit, will be referred to as the cutoff grade. This is referred to as COST I by AAC. The formula for a 20mx20m block making a profit is given in Appendix B and takes cognisance of the stope width (S.W.). Rearranging the formula provides a means of determining a cutoff grade at any given stope width. Based on the costs in Appendix C, the cutoff grade for 100cm stope width is 384cmg/t while at 144cm the cutoff grade is 451cmg/t.

6.7 GRADE/TONNAGE CURVE

One of the most important geostatistical tools, yet whose derivation is least understood, is the grade/tonnage curve. Many a mine has commenced operation, only to find itself mining a higher or lower tonnage (which their plant cannot handle) at a different mill grade to that anticipated. This is an effect of the volume variance relationship, expressed by authors such as Clark (1979), as well as incorrect approaches to the calculation of a grade/tonnage curve. It is common practice to determine the grade/tonnage curve from the sample distribution, however, David (1972) indicates this to

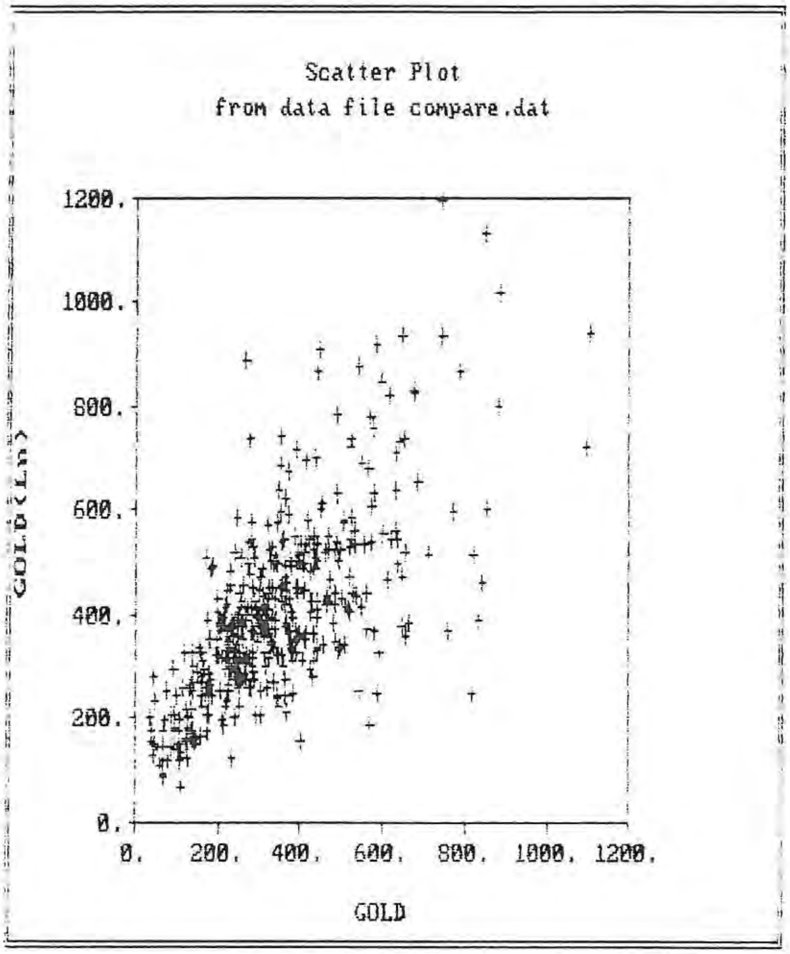


Figure 6.22 Comparison between the block estimates from the kriging routine. Gold refers to the 3x3 block search to which ordinary kriging was applied. The gold(Ln) refers to the simple log-normal kriging block estimates.

be incorrect. Instead he shows that grade/tonnage curves based on estimated block values is the correct method. During this section, both methods will be used to serve as an example and the results compared.

It is inaccurate to base a grade/tonnage curve on the sample distribution of a deposit. Instead, there are a number of variables that must be quantified in order to produce a grade/tonnage curve. These include the block size, the semi-variograms constraining the metal's spatial distribution, the block variance, and the distribution of the sample data. The spatial relationship of payable to unpay blocks is also important. To access a pay block, an unpay block may have to be extracted, increasing the tonnage and decreasing the mean grade. These are all variables that will change the shape of a grade/tonnage curve but are beyond the scope of this thesis.

The block size selected is the same as the kriging block size, 20mx20m. The sample distribution on which the grade/tonnage curve has been based is the development data, **AREEF.DAT** in Appendix A. The block variance calculated by the **GEOSTAT** program is 24403 (output from the block kriging based on Figures 6.18 and 6.19) using 15 Hermite polynomials, resulting in the grade/tonnage curve shown in Figure 6.23. This shows that at a cutoff grade of 451cmg/t, approximately 28% of the area is mineable using a block size of 20mx20m, and that ±43% of the metal in the mining area can be extracted. The valuation department has set a cutoff stope value of 5g/t which at 144cm is 720cmg/t. This would mean that at AAC's COST III, only 3% of the Witpan on No.3 Shaft is contributing to mine costs and at this cutoff, only 6% of the metal would be extracted. One note of caution of this grade/tonnage curve is that it does not show where these blocks above cutoff are located, nor indicate the boundaries between pay and unpay blocks.

The alternative method of grade/tonnage curve calculation, as recommended by David (1972), is based on estimated block values. In this case, the results of log-kriging are used (from Appendix D). The resultant grade/tonnage curve is compared to the curve based on sample data, and shown in Figure 6.24. The curves are very similar although slightly more tonnage is determined from the curve based on block estimates, indicating that the correct methodology was employed.

6.8 VALUATION OF THE WITPAN REEF

The responsibility of monthly gold call from stopes on Western Holdings Mine is carried out by the valuation and survey departments. Estimation methods of gold called for, vary from averaging the previous

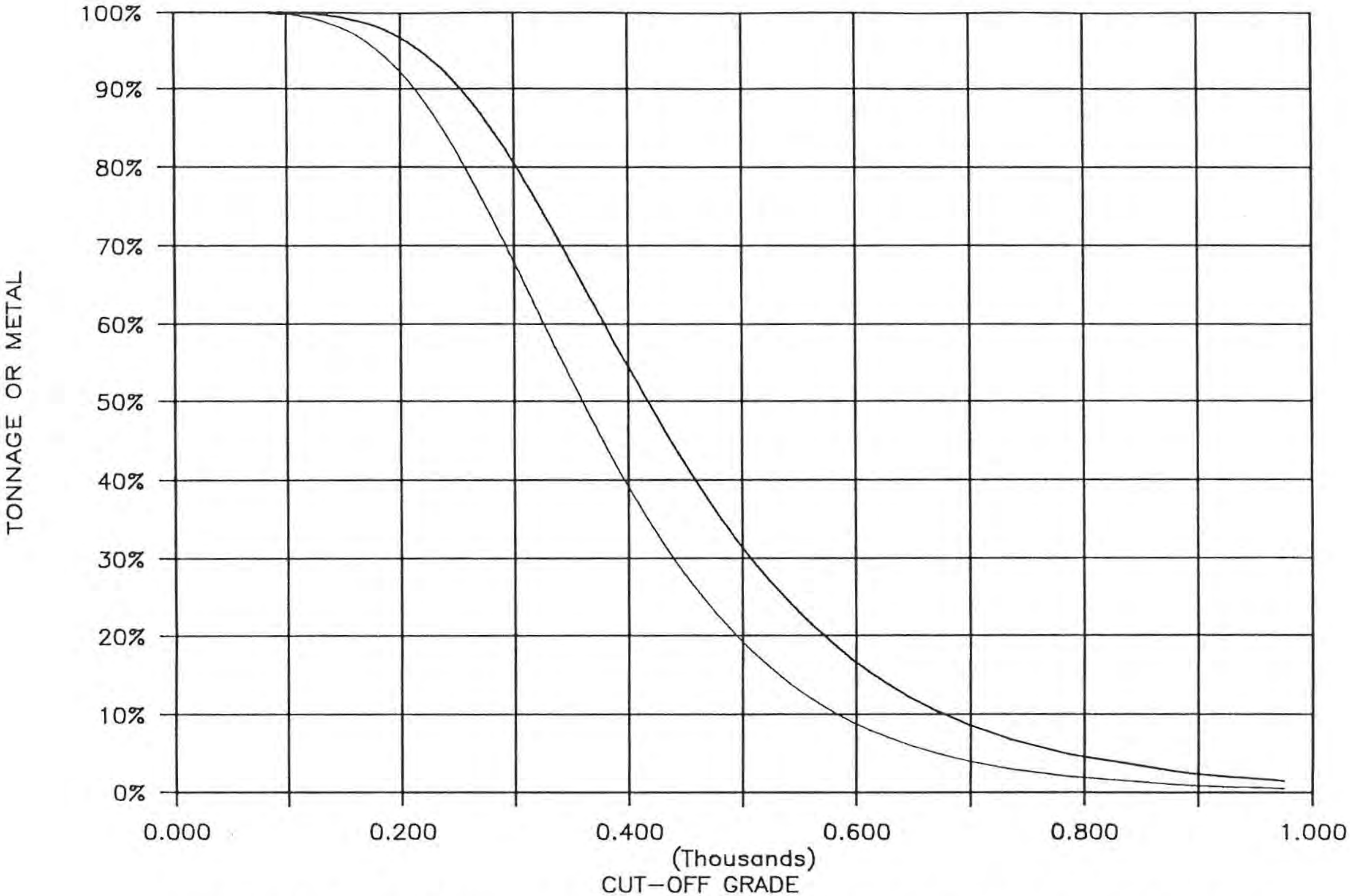


Figure 6.23 Grade/tonnage curve for the Witpan Reef, based on the distribution of sample data. The lower line represents the cut-off grade against tonnage whereas the upper line is cut-off grade against metal recovered.

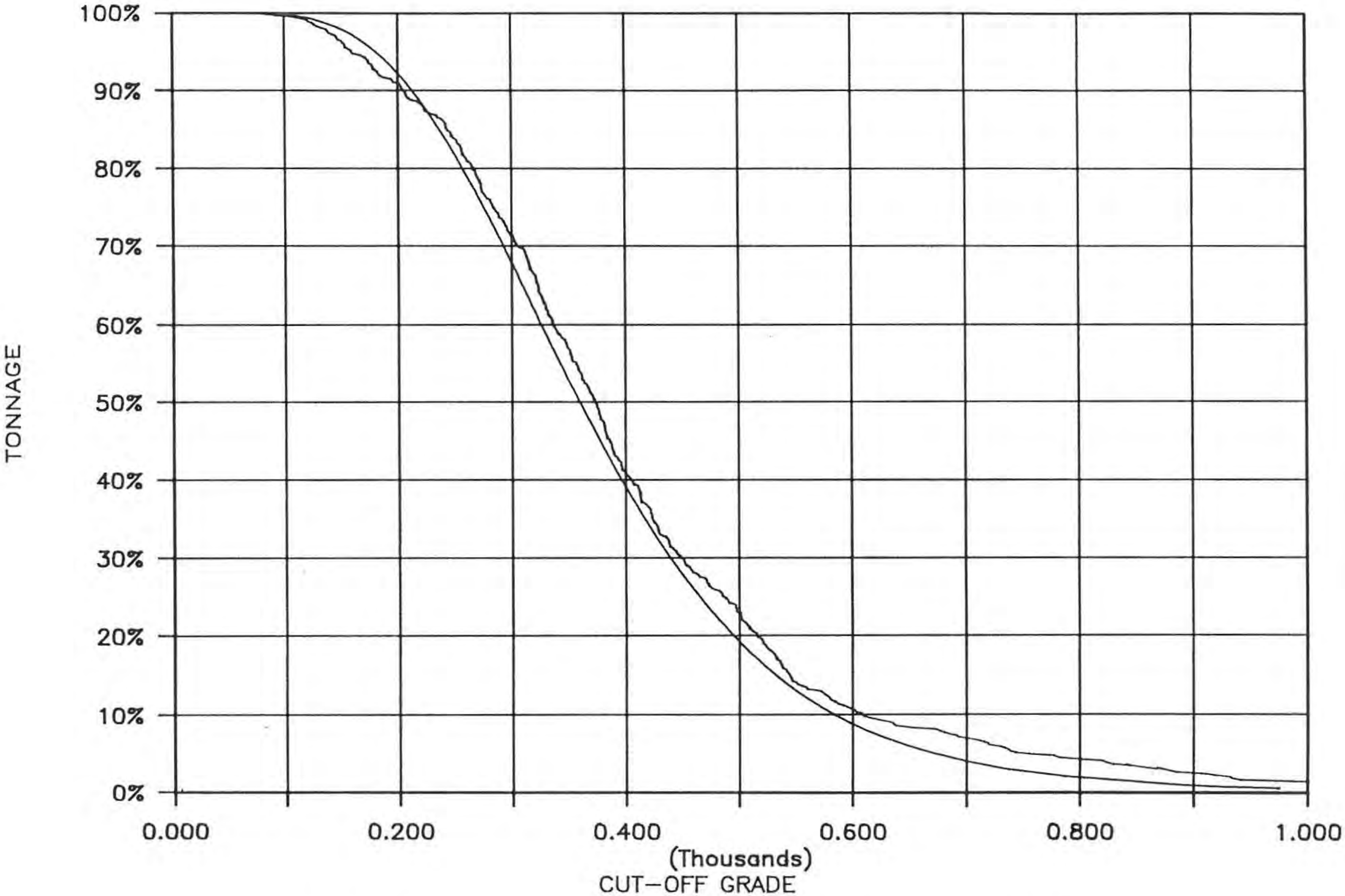


Figure 6.24 Comparison of grade/tonnage curves determined by sample data (smooth line) and block estimates (ragged line).

three samplings, or weighting the sampling in order of proximity to the current face positions, or even selecting the mean of all samples within a radius of 40-50m. These methods have no application to valuation of channelised reef.

The valuation department on the mine regard the Basal Reef values on a stope scale to be random with very high variance (D.C. Jones, pers. com., 1991). The practised method of valuation for homogeneous zones of Basal or Steyn Reef is to include data within a 40-50m radius of a stope and take the arithmetic mean. The current technique of valuating the "A"-Reef and Alma Reef on No.3 Shaft differs owing to the channelised nature of these reefs. Pay-shoots are blocked by the valuation department after consultation with the geologist who has determined the direction and limits of the pay-shoot. Valuation of these payshoots is done using several methods which include:

(1) an arithmetic mean,
(2) an area weighted mean, and
(3) a geometric mean.

The cmg/t value given depends on which technique is closest to the median or mode. During development ledging, the values in the payshoot closest to the ledging are used to determine the cmg/t for the panel. With periodic sampling the cmg/t value is determined by weighting the last three samplings in a 3:2:1 ratio with increasing distance from the face (Fig. 6.25). By this method there is the tendency to slightly undervalue high grade panels and overvalue low grade panels as the stope advances across the geochemical gradient. The overall grade will nevertheless approximate to the mean of the sample population.

6.8.1 Need for a Computerised Valuation Technique

With the advances in personal computers, programming packages, speed of computing, and decrease in price of such computers, it has become attractive from an economical viewpoint to introduce a computerised reef valuation system. Witpan grade data are digitised and the database updated regularly. It is stressed that the "geo" in geostatistics is vital to a meaningful valuation system. Recognition of the three zones of the Witpan becomes important. Recognition of channel edges where the cmg/t values are high (Chapter 4) is obviously desirable at an early stage and it is the geologist's expertise and input that is vital for identifying such payshoots.

Several mines emphasise the "geo" in geostatistics to estimate areas of reasonably assured reserves; Joel Mine is one such example (D. Young,

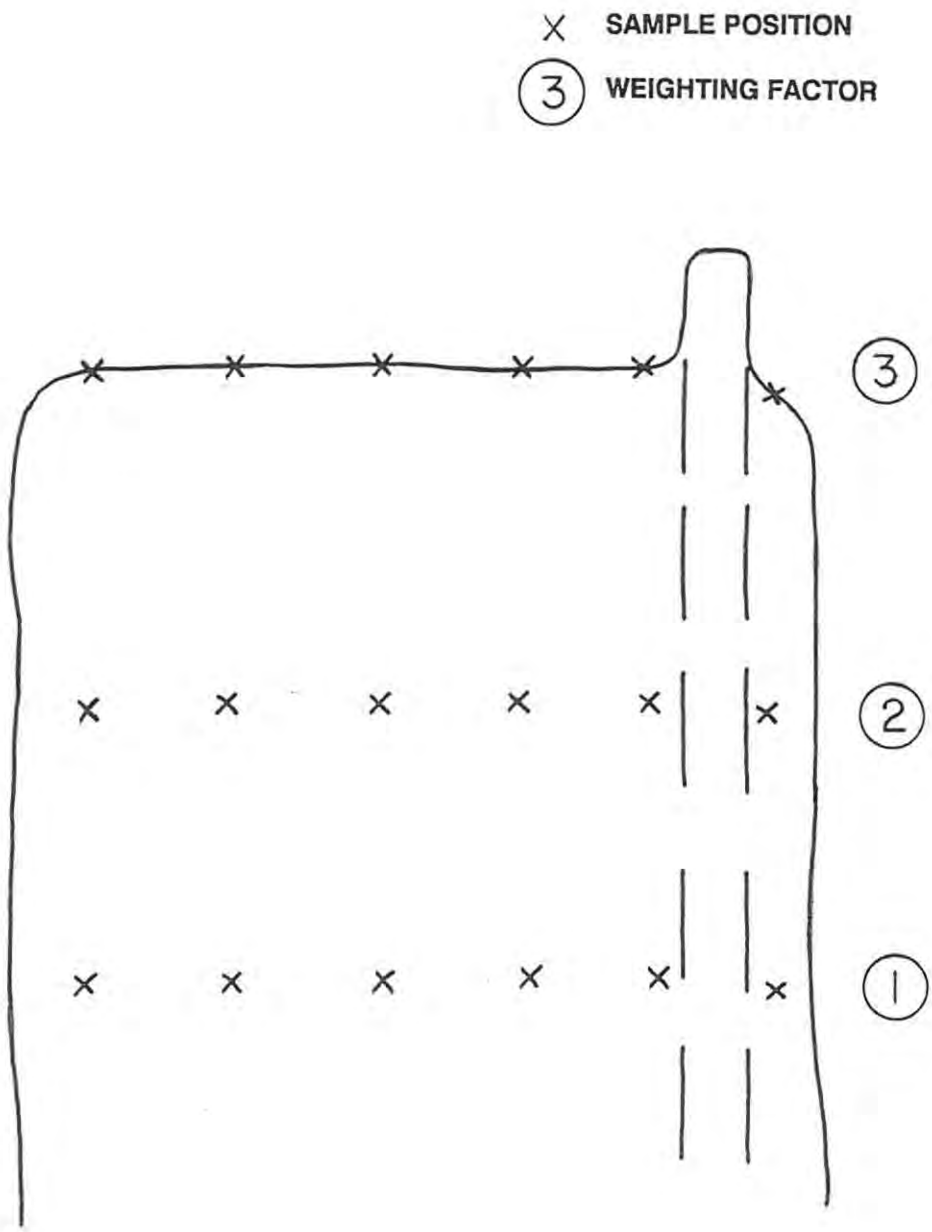


Figure 6.25 Example of a stope plan showing the sampling positions. The samples closest to the current face are weighted by three, the second closest by two and the furthest by one to obtain the panel valuation.

(NOT TO SCALE)

pers. com., 1991). The reef is classified into three facies, each facies having differing mean cmg/t and channel width. These factors are applied during simple kriging to estimate the values in blocks adjacent to current development. It is the input from the geologists which determines which facies is to be expected beyond current development, and thereby emphasising the "geo" in geostatistics as applied on Joel Mine.

Facies or zonal subdivision can be based either on a lateral subdivision into "in-channel" and combination of channel-edge and terrace or a vertical subdivision on the basis of basal scour, reef zone and pyritic zone. Since these three zones differ considerably in gold tenor, this is a logical choice. The drawback however is that routine development sampling takes no cognisance of zone boundaries.

To test the feasibility of subdividing the zones laterally, two sets based on a 115cm cutoff were selected from the data set. Channel width values of less than 115cm were called the reefzone set and channel width values of 115cm and greater called the scour set. The statistics of each are tabularised in Table 3.

STATISTIC	SCOUR SET	REEFZONE SET
MEAN	377,5	337,9
VARIANCE	58866	122453
SKEWNESS	1,497	4,116
MEDIAN	331	234

Table 3. Comparison of datasets separated on basis of 115cm CH.W for gold values in cmg/t.

Although the mean cmg/t values are not vastly different, the variance and median statistics differ significantly. To weight the zones with their respective cmg/t values during kriging would therefore make little change to any mean grade of a block. The confidence in the value of the blocks will differ due to the variance being significantly different.

6.8.2 Proposed Valuation Technique

The technique proposed requires the demarcation of the basal scour, reef zone and pyritic zone by the geologist, and that the sampler chip the sample section according to the subdivisions. Channel width can be determined using the existing CH.W semi-variogram. The dataset is updated with each visit by the geologist to a panel. It is also important to ignore cmg/t values from the basal scour unit on channel edges where this zone is not developed. To solve this, estimated channel width values in the unknown can be used to predict if the basal scour unit is present as the zone is usually developed once the channel width exceeds 115cm.

For gold values, each zone is initially treated as a discrete entity. Since it has been shown that the pyritic zone has a different palaeo-environment to the lower parts of the Witpan Reef. Classical statistics would initially be applied to each zone to determine mean cmg/t values and variances. Thereafter semi-variograms for gold in cmg/t and Ln(cmg/t) would be modelled. Here the writer is not in a position to select if normal or log semi-variograms for the zones should be used for the method needs to be tested. Kriging can then be undertaken for each zone independently but the results are added to determine a total cmg/t value.

At this stage, the modelled semi-variograms and kriging routines can be applied on a monthly basis. The database must first be kept up to date with regular sampling. Selective kriging, using a package which allows for single and irregularly shaped areas is essential; **Play-Krige** is such a package. The area stoped is digitised and entered into a computer and that area alone is kriged. This decreases the calculation time since the entire mining area is not recalculated. In less than one minute the cmg/t and channel width for the area stoped during the month is available. This method offers a geologically based valuation system and can be applied not only to the Witpan Reef but also to other channelised reefs such as the Alma Reef.

6.9 BOREHOLE COMPARISON

Exploration of Witwatersrand reefs is expensive and siting of underground boreholes is limited by available access haulages, crosscuts and stopes. The economic optimisation of boreholes is dependent on a number of factors which include:

(1) accessibility for drilling,

(2) statistical characteristics of the reef,

(3) morphological information, and

(4) information on faulting.

To explore a reef horizon by means of boreholes, in order to estimate the mean grade and variability of values, may require as little as ten borehole intersections. Magri (1987) proposes a method of evaluating reefs from surface boreholes with multiple deflections, however the technique has restricted application on "A"-Reef exploration on Western Holdings Mine.

For a selective mining operation, it may be more important to minimise access development costs to higher grade areas. In this case fifty boreholes may be needed. Comparison of borehole data of the Witpan Reef to the development data may help to identify the most economical method for future exploration of Witpan Reef on Western Holdings Mine.

The original borehole data from the underground exploration drilling is available and the writer has had the opportunity to analyse this data and compare results with an anaylsis of development data. Well in excess of 100 boreholes intersected "A"-Reef during the "A"-Reef exploration programme on Western Holdings Mine, of which about 55 intersections are in the No.3 Shaft area. Forty of these are on the downthrown side of the Arrarat fault and the remainder on the upthrown side. For this examination, only the boreholes on the downthrown side are used as their location is within the same channel complex as the current mining area. This way there is certainty that the information is spatially correlated. The data are tabulated in Appendix E.

The results of the boreholes are compared with the development data. The arithmetic mean of cmg/t for the borehole data of 357.9 is very close to the mean of 353.2 cmg/t for the development data. Similarly, the median for the boreholes is 310.0 cmg/t whereas the median for the development data is 280.0 cmg/t. In terms of determining the cmg/t for the channel complex on No.3 Shaft, the exploration programme would appear to have been a success.

The exploration programme did however have limitations. The borehole spacing has been compared to the semi-variogram models and found to exceed the range for gold of the semi-variogram model. As a result, the borehole data for gold can be treated as being independent and classical statistics applied as an evaluation technique. It has already been shown that the gold cmg/t distribution approximates to a lognormal distribution (Section 6.3.2) and hence Sichel's t estimation method must be applied to determine confidence limits. Based on the methodology and Ψ tables outlined by Clark (1987), it was found that the Sichel's t estimator for mean grade is 419 cmg/t with central 90% confidence limits of 323 and 601 cmg/t. Using lower and upper confidence limits of 90% the mean grade falls between 342 and 553 cmg/t. This is confirmed with the mean grade of the development samples being 353 cmg/t. Using Krige's t'' estimate (Krige, 1984), a mean grade of 416 cmg/t is calculated, an answer very similar to the Sichel's t estimate.

The exploration programme has therefore proved to be successful in determining the mean cmg/t value on No.3 Shaft. Only one of the two major payshoots in the "A"-Reef mining area was intersected in boreholes during the original drilling programme. An exploration strategy needs to be formulated to optimise resources for future exploration of the Witpan Reef or similar reef-type. This takes cognisance of the direction of payshoots, the width and length of payshoots, accessibility for drilling, the information gained by drilling in comparison to on-reef development, and the anisotropy of semi-variograms for both channel width and cmg/t gold values.

6.9.1 Proposal for future "A"-Reef exploration

Future exploration on the "A"-Reef on Western Holdings Mine can be subdivided into Witpan and Uitsig exploration. The choice to undertake further exploration is strongly linked to the gold price in Rand terms. Such a decision will be a mine management responsibility, but it is worth devising a strategy should the need arise.

The Uitsig Reef on No.3 Shaft of Western Holdings Mine is only worth investigating in certain areas of the mining area. The potential exists for locating extensions to the payshoots that are being mined on President Steyn Mine. Already established in the "A"-Reef mining area is the increase in channel width and cmg/t gold values for the Uitsig Reef in a southwesterly direction. This is also normal to the direction of the pay trends. A diagonal raise is proposed on the Uitsig Reef from the 37"A"S17 Prospect and in a southwest direction (Figure 6.26). This has the following advantages:

(1) On-reef development has a financial return in that gold is mined from it. If the cmg/t exceeds 456cmg/t then it will pay for itself,

(2) Much information with respect to sedimentology, mineralisation, channel widths and especially gold values is forthcoming,

(3) Structural information regarding faults is gained, and

(4) Down-thrown faults can be negotiated by developing flat or by footwall-lifting.

It is imperative for close geological control of any development within the Aandenk Formation. Experience has shown that the similarities between the footwall and hangingwall sediments to the "A"-Reef are too close for the mining staff to distinguish between the two. Similarly, the mining staff could easily mistake the Witpan for the Uitsig Reef, resulting in the incorrect horizon being followed. Good geological input is therefore required to reduce off-reef mining and to maintain a diagonal raise on the correct reef horizon.

The major potential for Witpan Reef exploration lies in location of

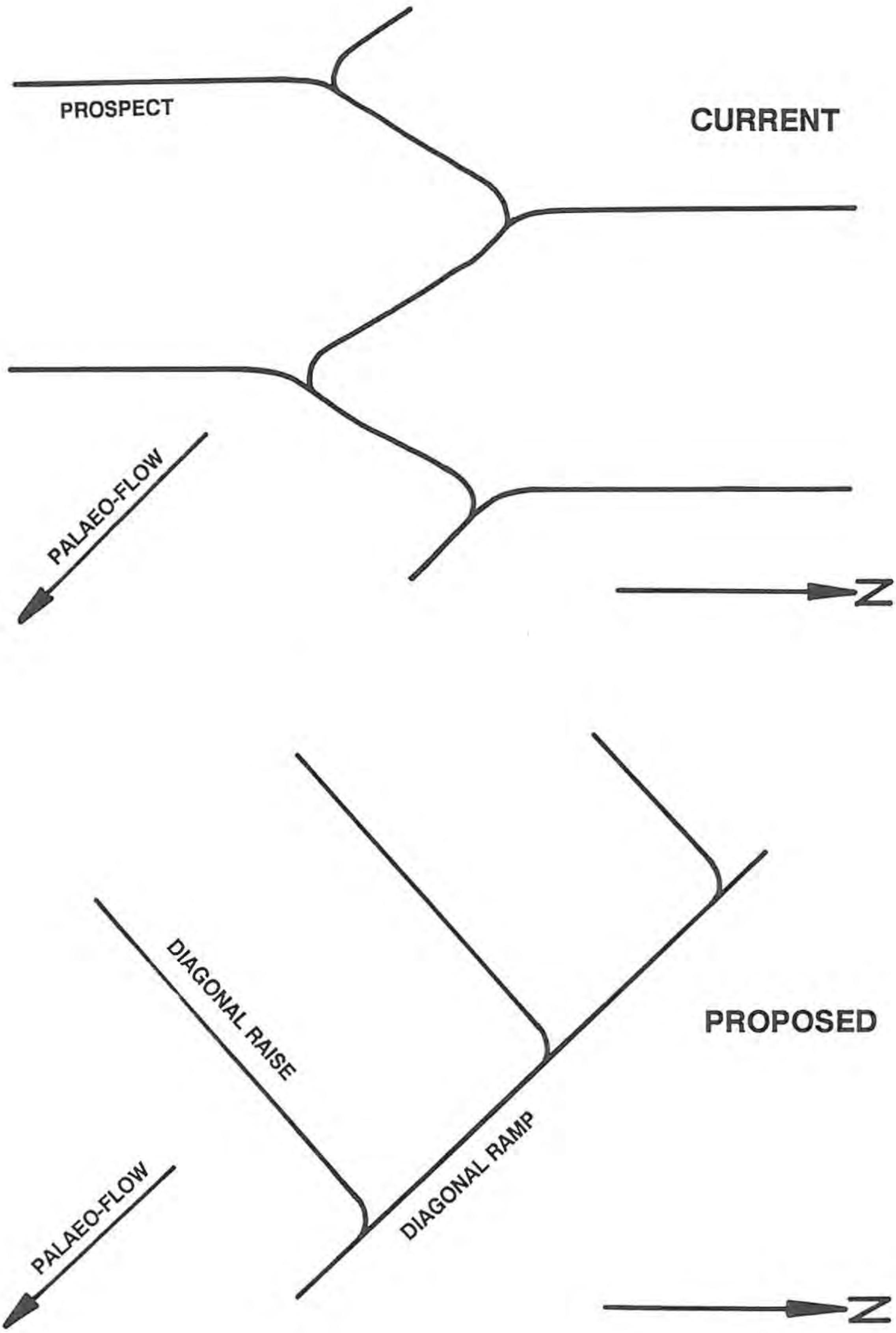


Figure 6.26 Proposed orientation of development relative to the channel directions. Diagonal raises are favoured in preference to prospects and up-dip raises. (NOT TO SCALE)

payshoots on the southwest side of terraces. For this, geological input is crucial. In the past, recommendations from the geology department have not been adhered to and have resulted in the payshoot in 37"A"S9 Prospect being only partially exploited. Diagonal raises in a southwest direction are recommended, replacing the on-strike prospects. The spacing of these diagonal raises needs to be changed to correspond to information provided by the semi-variograms. To space diagonal raises at distances equivalent to the range will be over-kill of expensive development. Alternatively, a spacing of double the range will result in low confidence of information between raises. In consequence, a spacing of not greater than 100m is recommended. Targets for such raises are terraces and payshoots, requiring the collection of both channel width and gold in cmg/t. Since the relationship of the highest gold cmg/t occurring on the southwest side of terraces has been established, geological interpretation of the data is crucial to the exploration programme.

6.10 SUMMARY

This thesis has proved that sufficient structure exists in the "A"-Reef data such that geostatistics can be applied to the valuation of channelised reef in the Welkom Goldfield. It has also brought to attention the necessity of understanding the sedimentological factors influencing gold distribution within a channelised reef. Semi-variograms can be constructed for reefs with high variance, provided that those semi-variograms are applied with the correct kriging routine. Ordinary and simple log-normal kriging were applied and showed that further investigation into block estimation is required.

Geostatistics when applied to channelised reefs, offers a more scientific approach than the present valuation methods. On a routine basis, it offers improvement in block valuation which can be updated as additional sampling reports provide new data. This will assist the survey department in the estimation of gold called for in current stopes. The application is valid not only for the Witpan Reef but also for reefs such as the Alma, Bedelia and Uitsig.

A comparison between the original borehole exploration of the "A"-Reef on No.3 Shaft and the development data was made. The mean grade of the boreholes was found to be approximately 10 cmg/t different from the development data. The 40 boreholes drilled were therefore successful in estimating the mean grade of the reef.

Future exploration of the "A"-Reef on No.3 Shaft is recommended for the Uitsig Reef with a diagonal raise from the 37"A"S17 Prospect, across the main channel direction (ie. to the southwest). Any further exploration of the Witpan Reef is also recommended to take the form of southwest diagonal raises. Such raises are recommended to be spaced at not greater than 100m intervals to correspond to the ranges provided by the semi-variogram modelling. Payshoots intersected can then be raised in the "in-channel" direction (ie. to the northwest) with holing into the adjacent diagonal raise.

CHAPTER 7

7.1 CONCLUSION

This thesis is an example of a geological and geostatistical investigation into a channelised reef within the Witwatersrand Supergroup and in particular, the Welkom Goldfield. The regional sedimentary patterns are reflected in the stratigraphy, from the St Helena to Spes Bona Formations, influencing the sedimentation in the "A"-Reef. The reported NW-SE channel directions have been confirmed by both the writer's observations and those of his colleagues, and by variography during the ore evaluation exercise. Although it was already known that the "A"-Reef comprised a couplet containing the Witpan and Uitsig Reefs, the internal subdivisions of the Witpan placer have been recognised, as well as the lateral facies changes in the cross-channel direction.

Gold distribution has been investigated in association with certain sedimentological features and target areas have been identified for future potential. These include:-

(1) Channel edges, where increased gold tenor occurs,
(2) Areas bearing "carbon" have been associated with payable gold values,
(3) Increased sphericity of pebbles is not only associated with increased pyrite mineralisation, but also increased gold tenor,
(4) Sieve conditions, whereby the Witpan Reef is in contact with the underlying footwall conglomerates, have been proven to contain the highest gold values on Pres. Steyn Mine. This has been overlooked on Western Holdings Mine.
(5) The Uitsig Reef offers potential for payable gold values. The carbonaceous Uitsig channel recognised on Pres. Steyn Mine is interpreted to occur to the southwest of the current mining area on No.3 Shaft.

A palaeo-environment model is proposed. The Aandenk Formation is dominated by sediment from an alluvial fan to the southwest of the study area. The Witpan Reef began as a braided river deposit but was "drowned" by transgression. This transgression reworked the Witpan Reef to form a sheet-like pyritic zone, capped by quartzarenite. The Uitsig Reef was not studied in detail during this investigation but may have also originated as a braided river deposit that was reworked during a transgression.

The ore evaluation exercise has highlighted some of the problems associated with the evaluation of Witwatersrand reefs. The distribution of the gold data is strongly asymmetrical. This asymmetry may well be the reason why variography with gold values in cmg/t is unsuccessful. As a result, semi-variograms have very short ranges with pronounced hole effects, as well as a sill that can be up to twice the variance of gold. The choice to solve the problem by using log-kriging for gold was successful, however, it was essential to add a constant before doing simple log-kriging followed by a back transformation to gold in cmg/t.

Based on geological input, a new valuation method is proposed requiring the recognition of the three vertical subdivisions of the Witpan Reef. The method is computer based, using geostatistics to value stoped areas on a monthly basis.

Comparisons between the channel width and gold (cmg/t) values sampled from the original boreholes drilled and in development ends, shows a close correlation. This has supported the concept that a few borehole intersections may give an idea of the mean grade of a reef, however, many more intersections are required to indicate where the best values occur. An exploration strategy for "A"-Reef on Western Holdings Mine is proposed, recommending investigation by a diagonal raise on the Uitsig Reef to the southwest of the current mining area. Future Witpan Reef exploration is recommended to take the form of diagonal raises at approximately 100m spacing.

7.2 ACKNOWLEDGEMENTS

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APPENDIX A

AREEF.DAT - "A" REEF DEVELOPMENT DATA FOR JUNE 1990

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8517.42	7334.29	710.0	176.0	4.0341	1.3948
8538.47	7336.37	470.0	126.0	3.7302	1.3165
8549.49	7336.95	390.0	97.0	4.0206	1.3914
8553.43	7337.31	457.0	67.0	6.8209	1.9200
8557.41	7337.59	299.0	87.0	3.4368	1.2345
8560.69	7337.81	601.0	82.0	7.3293	1.9919
8564.50	7338.00	326.0	89.0	3.6629	1.2983
8568.13	7338.30	174.0	65.0	2.6769	0.9847
8571.84	7338.50	223.0	57.0	3.9123	1.3641
8575.55	7338.99	342.0	61.0	5.6066	1.7239
8578.87	7339.13	437.0	72.0	6.0694	1.8033
8582.38	7339.50	106.0	70.0	1.5143	0.4149
8586.13	7339.87	268.0	104.0	2.5769	0.9466
8590.18	7340.41	332.0	77.0	4.3117	1.4613
8594.03	7340.71	349.0	52.0	6.7115	1.9038
8598.02	7341.23	766.0	67.0	11.4328	2.4365
8602.06	7341.55	762.0	89.0	8.5618	2.1473
8609.85	7341.86	233.0	82.0	2.8415	1.0443
8614.35	7342.06	910.0	122.0	7.4590	2.0094
8617.98	7342.29	730.0	82.0	8.9024	2.1863
8622.22	7342.67	351.0	89.0	3.9438	1.3721
8626.28	7343.28	473.0	92.0	5.1413	1.6373
8629.58	7343.43	604.0	97.0	6.2268	1.8289
8633.85	7343.58	435.0	97.0	4.4845	1.5006
8637.91	7344.32	473.0	107.0	4.4206	1.4863
8642.05	7343.48	256.0	96.0	2.6667	0.9808
8646.17	7344.70	649.0	87.0	7.4598	2.0095
8649.52	7344.83	216.0	52.0	4.1538	1.4240
8653.68	7345.37	234.0	101.0	2.3168	0.8402
8657.59	7345.61	246.0	134.0	1.8358	0.6075
8661.38	7345.92	293.0	145.0	2.0207	0.7034
8665.39	7346.66	292.0	163.0	1.7914	0.5830
8669.73	7347.39	319.0	117.0	2.7265	1.0030
8673.82	7347.54	344.0	147.0	2.3401	0.8502
8677.68	7347.85	327.0	137.0	2.3869	0.8700
8681.54	7348.28	560.0	157.0	3.5669	1.2717
8685.20	7348.92	233.0	157.0	1.4841	0.3948
8689.59	7349.79	374.0	152.0	2.4605	0.9004
8694.31	7350.03	30.0	149.0	0.2013	-1.6027
8697.11	7350.16	519.0	157.0	3.3057	1.1957
8701.30	7350.16	219.0	157.0	1.3949	0.3328
8705.67	7350.95	62.0	157.0	0.3949	-0.9291
8712.93	7351.58	79.0	139.0	0.5683	-0.5650
8720.67	7352.57	68.0	92.0	0.7391	-0.3023
8522.67	7191.17	60.0	109.0	0.5505	-0.5970

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8527.35	7191.57	76.0	107.0	0.7103	-0.3421
8532.17	7191.70	234.0	114.0	2.0526	0.7191
8536.51	7192.09	175.0	157.0	1.1146	0.1085
8540.15	7192.27	146.0	136.0	1.0735	0.0710
8543.47	7192.41	441.0	143.0	3.0839	1.1262
8547.79	7192.81	675.0	138.0	4.8913	1.5875
8552.56	7192.99	495.0	136.0	3.6397	1.2919
8556.53	7193.11	268.0	123.0	2.1789	0.7788
8560.33	7193.50	283.0	146.0	1.9384	0.6618
8563.99	7193.83	349.0	114.0	3.0614	1.1189
8567.88	7193.74	304.0	117.0	2.5983	0.9549
8571.10	7193.90	225.0	112.0	2.0089	0.6976
8575.39	7194.01	250.0	132.0	1.8939	0.6387
8578.24	7194.10	342.0	117.0	2.9231	1.0726
8582.94	7194.19	192.0	102.0	1.8824	0.6325
8588.12	7193.66	744.0	102.0	7.2941	1.9871
8590.48	7193.46	255.0	97.0	2.6289	0.9666
8593.98	7194.37	192.0	142.0	1.3521	0.3017
8599.42	7195.36	207.0	112.0	1.8482	0.6142
8602.74	7194.72	126.0	107.0	1.1776	0.1635
8607.31	7195.26	144.0	92.0	1.5652	0.4480
8611.07	7195.15	331.0	112.0	2.9554	1.0836
8614.53	7195.52	273.0	122.0	2.2377	0.8055
8618.92	7195.71	473.0	127.0	3.7244	1.3149
8623.01	7195.74	586.0	127.0	4.6142	1.5291
8627.38	7195.68	495.0	127.0	3.8976	1.3604
8632.43	7195.89	344.0	117.0	2.9402	1.0785
8635.93	7196.35	209.0	117.0	1.7863	0.5802
8639.62	7196.42	327.0	127.0	2.5748	0.9458
8642.33	7196.86	477.0	127.0	3.7559	1.3233
8646.47	7196.88	635.0	97.0	6.5464	1.8789
8650.48	7196.95	670.0	112.0	5.9821	1.7888
8654.37	7197.41	357.0	112.0	3.1875	1.1592
8658.25	7197.39	415.0	109.0	3.8073	1.3369
8662.11	7197.24	298.0	142.0	2.0986	0.7413
8665.62	7197.46	833.0	142.0	5.8662	1.7692
8668.72	7198.00	940.0	157.0	5.9873	1.7896
8674.00	7198.23	596.0	142.0	4.1972	1.4344
8676.84	7198.48	783.0	172.0	4.5523	1.5156
8679.89	7198.18	346.0	142.0	2.4366	0.8906
8684.61	7198.30	483.0	142.0	3.4014	1.2242
8687.94	7198.63	423.0	142.0	2.9789	1.0915
8692.28	7199.09	367.0	152.0	2.4145	0.8815
8694.87	7199.23	323.0	142.0	2.2746	0.8218
8700.79	7200.54	227.0	137.0	1.6569	0.5050
8704.29	7200.26	207.0	97.0	2.1340	0.7580
8709.09	7201.50	182.0	77.0	2.3636	0.8602

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8712.57	7203.18	125.0	64.0	1.9531	0.6694
8602.26	7192.54	102.0	112.0	0.9107	-0.0935
8602.54	7188.65	153.0	112.0	1.3661	0.3119
8601.60	7185.43	293.0	97.0	3.0206	1.1055
8602.13	7181.95	654.0	157.0	4.1656	1.4269
8601.63	7177.81	339.0	142.0	2.3873	0.8702
8601.12	7173.92	209.0	172.0	1.2151	0.1948
8600.41	7170.80	249.0	142.0	1.7535	0.5616
8599.62	7167.04	312.0	127.0	2.4567	0.8988
8589.23	7045.96	383.0	97.0	3.9485	1.3733
8589.92	7049.87	1152.0	107.0	10.7664	2.3764
8590.10	7053.71	292.0	101.0	2.8911	1.0616
8590.25	7057.90	1111.0	112.0	9.9196	2.2945
8590.86	7061.61	896.0	112.0	8.0000	2.0794
8591.62	7065.62	996.0	126.0	7.9048	2.0675
8592.41	7070.44	626.0	107.0	5.8505	1.7665
8592.61	7074.84	553.0	97.0	5.7010	1.7406
8592.99	7078.85	1142.0	112.0	10.1964	2.3220
8593.35	7082.99	354.0	97.0	3.6495	1.2946
8593.91	7086.57	255.0	142.0	1.7958	0.5854
8594.01	7091.11	315.0	127.0	2.4803	0.9084
8594.62	7094.75	261.0	112.0	2.3304	0.8460
8595.02	7098.17	451.0	115.0	3.9217	1.3665
8595.17	7102.14	398.0	131.0	3.0382	1.1113
8595.40	7106.27	371.0	127.0	2.9213	1.0720
8595.48	7110.29	153.0	112.0	1.3661	0.3119
8595.91	7113.94	373.0	128.0	2.9141	1.0695
8596.39	7118.29	344.0	116.0	2.9655	1.0871
8597.00	7122.20	572.0	114.0	5.0175	1.6129
8597.33	7126.01	228.0	118.0	1.9322	0.6587
8597.87	7130.32	144.0	144.0	1.0000	0.0000
8597.33	7134.28	170.0	106.0	1.6038	0.4724
8597.97	7138.22	363.0	142.0	2.5563	0.9386
8598.27	7141.65	683.0	187.0	3.6524	1.2954
8598.17	7145.76	606.0	187.0	3.2406	1.1758
8644.82	7020.29	882.0	148.0	5.9595	1.7850
8637.20	7022.40	538.0	152.0	3.5395	1.2640
8632.89	7024.12	1051.0	139.0	7.5612	2.0230
8629.15	7025.67	907.0	142.0	6.3873	1.8543
8621.89	7028.49	663.0	142.0	4.6690	1.5409
8618.21	7030.02	988.0	112.0	8.8214	2.1772
8615.54	7030.78	1068.0	112.0	9.5357	2.2550
8611.30	7032.73	1267.0	109.0	11.6239	2.4531
8607.77	7033.55	2145.0	97.0	22.1134	3.0962
8603.33	7035.35	790.0	98.0	8.0612	2.0871
8597.31	7037.61	1071.0	94.0	11.3936	2.4331
8593.88	7038.22	606.0	83.0	7.3012	1.9880

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8590.33	7040.22	812.0	82.0	9.9024	2.2928
8586.77	7041.06	744.0	82.0	9.0732	2.2053
8582.81	7042.76	832.0	82.0	10.1463	2.3171
8579.28	7044.36	657.0	82.0	8.0122	2.0810
8576.38	7045.02	1358.0	152.0	8.9342	2.1899
8572.75	7046.50	784.0	142.0	5.5211	1.7086
8569.35	7047.33	627.0	152.0	4.1250	1.4171
8565.51	7047.36	694.0	112.0	6.1964	1.8240
8562.04	7048.00	407.0	107.0	3.8037	1.3360
8558.18	7048.07	447.0	107.0	4.1776	1.4297
8554.29	7048.17	228.0	62.0	3.6774	1.3022
8550.05	7048.17	152.0	67.0	2.2687	0.8192
8546.44	7047.87	98.0	17.0	5.7647	1.7518
8542.63	7047.69	30.0	7.0	4.2857	1.4553
8538.52	7047.33	81.0	17.0	4.7647	1.5612
8535.07	7046.90	64.0	21.0	3.0476	1.1144
8531.16	7046.42	204.0	31.0	6.5806	1.8841
8527.58	7046.55	46.0	32.0	1.4375	0.3629
8523.77	7046.09	441.0	52.0	8.4808	2.1378
8519.65	7045.79	44.0	52.0	0.8462	-0.1671
8515.89	7045.68	59.0	36.0	1.6389	0.4940
8511.68	7045.30	92.0	49.0	1.8776	0.6300
8721.79	7182.48	76.0	129.0	0.5891	-0.5291
8719.40	7175.98	23.0	118.0	0.1949	-1.6352
8717.98	7172.32	527.0	112.0	4.7054	1.5487
8705.51	7197.62	259.0	127.0	2.0394	0.7126
8706.22	7193.88	750.0	152.0	4.9342	1.5962
8706.73	7189.97	252.0	127.0	1.9843	0.6852
8706.68	7186.44	687.0	112.0	6.1339	1.8138
8706.63	7182.33	442.0	105.0	4.2095	1.4373
8707.47	7178.85	421.0	117.0	3.5983	1.2805
8707.65	7175.24	374.0	128.0	2.9219	1.0722
8701.91	7163.16	344.0	78.0	4.4103	1.4839
8701.78	7160.47	451.0	88.0	5.1250	1.6341
8700.23	7156.43	386.0	108.0	3.5741	1.2737
8699.62	7153.25	288.0	98.0	2.9388	1.0780
8698.86	7150.33	96.0	130.0	0.7385	-0.3032
8697.67	7146.45	216.0	68.0	3.1765	1.1558
8696.96	7142.89	185.0	58.0	3.1897	1.1599
8695.89	7139.31	104.0	58.0	1.7931	0.5839
8694.82	7136.24	22.0	97.0	0.2268	-1.4837
8693.17	7132.15	35.0	108.0	0.3241	-1.1268
8691.70	7128.77	172.0	104.0	1.6538	0.5031
8690.63	7125.57	231.0	135.0	1.7111	0.5371
8689.01	7120.67	176.0	132.0	1.3333	0.2877
8689.08	7117.40	146.0	141.0	1.0355	0.0348
8687.51	7114.20	352.0	134.0	2.6269	0.9658

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8686.77	7110.92	415.0	125.0	3.3200	1.2000
8685.71	7106.60	653.0	138.0	4.7319	1.5543
8682.28	7089.72	252.0	118.0	2.1356	0.7587
8680.58	7086.47	320.0	123.0	2.6016	0.9561
8679.97	7083.04	426.0	68.0	6.2647	1.8349
8675.22	7080.32	88.0	76.0	1.1579	0.1466
8674.02	7076.59	81.0	173.0	0.4682	-0.7588
8673.24	7073.74	122.0	205.0	0.5951	-0.5190
8671.89	7070.27	408.0	178.0	2.2921	0.8295
8671.23	7067.80	204.0	210.0	0.9714	-0.0290
8669.83	7064.15	150.0	188.0	0.7979	-0.2258
8668.51	7060.84	318.0	183.0	1.7377	0.5526
8667.14	7056.55	172.0	178.0	0.9663	-0.0343
8665.97	7052.82	384.0	158.0	2.4304	0.8880
8664.88	7048.99	446.0	168.0	2.6548	0.9764
8663.36	7045.68	48.0	208.0	0.2308	-1.4663
8662.37	7041.82	202.0	198.0	1.0202	0.0200
8661.12	7038.29	478.0	173.0	2.7630	1.0163
8659.65	7034.41	513.0	178.0	2.8820	1.0585
8658.84	7030.63	268.0	163.0	1.6442	0.4972
8657.16	7026.97	370.0	168.0	2.2024	0.7895
8655.94	7022.96	645.0	108.0	5.9722	1.7871
8654.09	7019.88	406.0	148.0	2.7432	1.0091
8651.60	7015.82	607.0	138.0	4.3986	1.4813
8651.19	7012.29	389.0	168.0	2.3155	0.8396
8647.61	7005.46	804.0	138.0	5.8261	1.7623
8644.79	7003.00	634.0	138.0	4.5942	1.5248
8646.22	6998.68	370.0	60.0	6.1667	1.8192
8643.47	6995.68	862.0	108.0	7.9815	2.0771
8642.41	6989.89	641.0	108.0	5.9352	1.7809
8640.63	6987.15	630.0	128.0	4.9219	1.5937
8639.82	6982.12	602.0	58.0	10.3793	2.3398
8638.98	6979.08	1506.0	118.0	12.7627	2.5465
8636.87	6976.10	1071.0	108.0	9.9167	2.2942
8636.80	6973.11	677.0	109.0	6.2110	1.8263
8635.22	6970.42	525.0	98.0	5.3571	1.6784
8634.05	6966.12	446.0	90.0	4.9556	1.6005
8633.44	6962.87	486.0	110.0	4.4182	1.4857
8632.99	6958.86	-9.0	100.0	-9.0000	-9.0000
8630.35	6952.26	260.0	30.0	8.6667	2.1595
8629.71	6950.56	208.0	40.0	5.2000	1.6487
8628.16	6944.21	216.0	40.0	5.4000	1.6864
8624.17	6941.16	188.0	40.0	4.7000	1.5476
8625.90	6939.94	161.0	40.0	4.0250	1.3925
8622.42	6930.90	600.0	20.0	30.0000	3.4012
8624.12	6928.36	524.0	30.0	17.4667	2.8603
8623.03	6926.56	60.0	20.0	3.0000	1.0986

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8621.41	6924.55	36.0	30.0	1.2000	0.1823
8621.00	6922.80	224.0	40.0	5.6000	1.7228
8620.92	6920.95	134.0	20.0	6.7000	1.9021
8620.39	6919.81	363.0	10.0	36.3000	3.5918
8620.16	6916.63	360.0	20.0	18.0000	2.8904
8618.74	6915.92	300.0	10.0	30.0000	3.4012
8618.28	6913.30	148.0	10.0	14.8000	2.6946
8617.70	6911.25	176.0	10.0	17.6000	2.8679
8615.16	6909.04	84.0	10.0	8.4000	2.1282
8615.41	6907.97	-9.0	10.0	-9.0000	-9.0000
8614.70	6905.48	54.0	20.0	2.7000	0.9933
8616.51	6903.68	-9.0	10.0	-9.0000	-9.0000
8616.05	6901.34	8.0	10.0	0.8000	-0.2231
8615.21	6898.12	52.0	10.0	5.2000	1.6487
8611.66	6894.84	92.0	60.0	1.5333	0.4274
8610.74	6896.70	20.0	70.0	0.2857	-1.2528
8610.26	6893.17	-9.0	20.0	-9.0000	-9.0000
8609.70	6891.41	80.0	110.0	0.7273	-0.3185
8604.75	6878.13	92.0	110.0	0.8364	-0.1787
8635.86	6900.38	408.0	119.0	3.4286	1.2321
8638.83	6901.17	396.0	124.0	3.1935	1.1611
8647.28	6902.13	68.0	100.0	0.6800	-0.3857
8650.10	6903.50	318.0	100.0	3.1800	1.1569
8655.26	6907.11	484.0	125.0	3.8720	1.3538
8659.02	6905.36	160.0	125.0	1.2800	0.2469
8663.46	6904.47	384.0	90.0	4.2667	1.4508
8667.09	6905.13	642.0	80.0	8.0250	2.0826
8671.10	6906.88	474.0	170.0	2.7882	1.0254
8674.56	6908.61	462.0	159.0	2.9057	1.0667
8678.26	6908.53	138.0	156.0	0.8846	-0.1226
8682.28	6908.71	64.0	100.0	0.6400	-0.4463
8686.49	6909.72	6.0	110.0	0.0545	-2.9087
8690.84	6910.71	74.0	144.0	0.5139	-0.6657
8694.14	6911.50	92.0	128.0	0.7188	-0.3302
8698.38	6911.88	40.0	170.0	0.2353	-1.4469
8702.34	6912.87	-9.0	158.0	-9.0000	-9.0000
8705.34	6913.08	11.0	68.0	0.1618	-1.8216
8710.95	6913.58	8.0	78.0	0.1026	-2.2773
8807.67	6940.48	80.0	70.0	1.1429	0.1335
8802.70	6939.18	264.0	70.0	3.7714	1.3275
8800.13	6938.22	480.0	60.0	8.0000	2.0794
8797.52	6934.48	162.0	50.0	3.2400	1.1756
8792.84	6934.20	414.0	40.0	10.3500	2.3370
8789.67	6931.61	312.0	133.0	2.3459	0.8527
8786.19	6930.93	151.0	134.0	1.1269	0.1194
8781.87	6928.13	898.0	148.0	6.0676	1.8030
8778.52	6927.73	308.0	128.0	2.4063	0.8781

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8774.89	6925.62	530.0	148.0	3.5811	1.2757
8771.13	6925.77	150.0	118.0	1.2712	0.2400
8767.60	6924.58	276.0	90.0	3.0667	1.1206
8762.80	6923.28	618.0	70.0	8.8286	2.1780
8758.59	6923.44	730.0	40.0	18.2500	2.9042
8754.52	6922.78	790.0	60.0	13.1667	2.5777
8750.66	6920.87	946.0	20.0	47.3000	3.8565
8748.28	6918.05	306.0	40.0	7.6500	2.0347
8742.82	6920.26	158.0	50.0	3.1600	1.1506
8737.61	6921.18	138.0	50.0	2.7600	1.0152
8733.65	6918.15	16.0	148.0	0.1081	-2.2246
8827.28	6953.05	144.0	74.0	1.9459	0.6657
8830.78	6955.53	177.0	67.0	2.6418	0.9715
8834.21	6959.19	189.0	97.0	1.9485	0.6670
8837.54	6960.99	126.0	82.0	1.5366	0.4296
8841.85	6962.31	109.0	82.0	1.3293	0.2846
8846.35	6962.75	12.0	79.0	0.1519	-1.8845
8850.54	6963.86	15.0	79.0	0.1899	-1.6614
8854.68	6965.46	195.0	97.0	2.0103	0.6983
8858.92	6966.86	35.0	82.0	0.4268	-0.8514
8862.96	6966.15	172.0	62.0	2.7742	1.0204
8866.18	6966.91	105.0	82.0	1.2805	0.2472
8870.40	6965.08	364.0	82.0	4.4390	1.4904
8874.10	6965.21	126.0	52.0	2.4231	0.8850
8877.79	6964.80	212.0	97.0	2.1856	0.7819
8881.95	6966.86	248.0	112.0	2.2143	0.7949
8886.95	6967.01	231.0	106.0	2.1792	0.7790
8890.76	6967.04	131.0	111.0	1.1802	0.1657
8894.09	6967.06	374.0	127.0	2.9449	1.0801
8898.30	6968.05	221.0	114.0	1.9386	0.6620
8901.83	6971.76	332.0	110.0	3.0182	1.1047
8906.20	6969.58	274.0	119.0	2.3025	0.8340
8909.73	6970.26	219.0	118.0	1.8559	0.6184
8929.29	6968.31	156.0	112.0	1.3929	0.3314
8919.13	6969.76	101.0	77.0	1.3117	0.2713
8926.75	6971.61	318.0	127.0	2.5039	0.9179
8930.84	6972.40	359.0	97.0	3.7010	1.3086
8933.40	6972.12	116.0	98.0	1.1837	0.1686
8937.18	6972.09	192.0	97.0	1.9794	0.6828
8941.83	6969.45	130.0	137.0	0.9489	-0.0524
8946.22	6972.47	479.0	112.0	4.2768	1.4532
8950.95	6972.93	263.0	127.0	2.0709	0.7280
8956.03	6973.26	348.0	127.0	2.7402	1.0080
8959.43	6973.69	296.0	97.0	3.0515	1.1156
8633.17	6935.65	273.0	76.0	3.5921	1.2787
8635.65	6935.27	171.0	58.0	2.9483	1.0812
8638.22	6935.30	196.0	38.0	5.1579	1.6405

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8641.70	6935.58	236.0	38.0	6.2105	1.8262
8645.53	6935.35	1382.0	33.0	41.8788	3.7348
8650.23	6935.50	556.0	50.0	11.1200	2.4087
8654.12	6935.27	195.0	48.0	4.0625	1.4018
8657.87	6934.79	626.0	83.0	7.5422	2.0205
8661.43	6934.31	433.0	100.0	4.3300	1.4656
8664.27	6933.21	332.0	90.0	3.6889	1.3053
8668.51	6931.28	292.0	70.0	4.1714	1.4283
8671.59	6930.34	662.0	43.0	15.3953	2.7341
8674.86	6928.67	222.0	53.0	4.1887	1.4324
8678.24	6928.01	24.0	8.0	3.0000	1.0986
8681.62	6926.46	27.0	8.0	3.3750	1.2164
8686.04	6924.35	19.0	8.0	2.3750	0.8650
8688.29	6923.69	16.0	8.0	2.0000	0.6931
8692.13	6922.01	38.0	8.0	4.7500	1.5581
8695.56	6920.36	11.0	8.0	1.3750	0.3185
8698.43	6918.59	50.0	8.0	6.2500	1.8326
8701.73	6918.00	70.0	8.0	8.7500	2.1691
8713.89	6914.57	-9.0	68.0	-9.0000	-9.0000
8708.64	6916.76	20.0	30.0	0.6667	-0.4055
8704.24	6918.92	-9.0	30.0	-9.0000	-9.0000
8701.20	6920.49	12.0	60.0	0.2000	-1.6094
8697.69	6922.19	-9.0	47.0	-9.0000	-9.0000
8693.96	6923.26	4.0	20.0	0.2000	-1.6094
8690.48	6924.61	-9.0	29.0	-9.0000	-9.0000
8686.95	6926.46	8.0	20.0	0.4000	-0.9163
8682.73	6928.21	20.0	20.0	1.0000	0.0000
8678.54	6929.46	8.0	10.0	0.8000	-0.2231
8674.58	6931.00	32.0	30.0	1.0667	0.0645
8671.97	6933.21	438.0	60.0	7.3000	1.9879
8669.73	6936.06	250.0	60.0	4.1667	1.4271
8668.13	6939.16	420.0	60.0	7.0000	1.9459
8666.74	6942.76	1230.0	70.0	17.5714	2.8663
8666.18	6945.68	268.0	60.0	4.4667	1.4966
8665.85	6948.75	144.0	110.0	1.3091	0.2693
8701.63	6982.38	285.0	28.0	10.1786	2.3203
8698.94	6978.64	306.0	68.0	4.5000	1.5041
8696.93	6976.76	457.0	86.0	5.3140	1.6703
8693.83	6974.40	534.0	78.0	6.8462	1.9237
8689.84	6971.79	742.0	110.0	6.7455	1.9089
8686.26	6968.97	426.0	110.0	3.8727	1.3540
8683.93	6966.99	210.0	138.0	1.5217	0.4199
8679.94	6964.45	852.0	138.0	6.1739	1.8203
8676.67	6962.90	828.0	138.0	6.0000	1.7918
8673.16	6960.13	335.0	118.0	2.8390	1.0434
8670.47	6957.87	472.0	118.0	4.0000	1.3863
8668.01	6955.23	168.0	100.0	1.6800	0.5188

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8685.04	6971.48	668.0	78.0	8.5641	2.1476
8682.13	6968.97	543.0	108.0	5.0278	1.6150
8680.02	6967.37	234.0	103.0	2.2718	0.8206
8677.10	6965.69	779.0	138.0	5.6449	1.7308
8673.85	6963.25	839.0	108.0	7.7685	2.0501
8670.82	6960.13	592.0	108.0	5.4815	1.7014
8667.42	6957.62	463.0	112.0	4.1339	1.4192
8665.26	6954.77	150.0	78.0	1.9231	0.6539
8664.12	6951.42	1260.0	78.0	16.1538	2.7822
8663.99	6947.38	306.0	68.0	4.5000	1.5041
8664.02	6943.47	4242.0	50.0	84.8400	4.4408
8665.62	6939.16	220.0	68.0	3.2353	1.1741
8667.42	6935.60	488.0	68.0	7.1765	1.9708
8644.03	6991.19	556.0	125.0	4.4480	1.4925
8641.72	6984.79	376.0	128.0	2.9375	1.0776
8638.98	6981.23	871.0	108.0	8.0648	2.0875
8639.49	6971.30	564.0	108.0	5.2222	1.6529
8633.72	6957.06	673.0	121.0	5.5620	1.7160
8632.38	6957.69	268.0	217.0	1.2350	0.2111
8633.83	6959.93	246.0	170.0	1.4471	0.3695
8633.06	6956.30	8.0	100.0	0.0800	-2.5257
8631.79	6953.53	14.0	88.0	0.1591	-1.8383
8631.31	6950.79	25.0	64.0	0.3906	-0.9400
8671.43	7012.93	244.0	98.0	2.4898	0.9122
8685.78	7011.61	165.0	113.0	1.4602	0.3786
8694.95	7012.72	103.0	133.0	0.7744	-0.2556
8697.82	7010.16	270.0	128.0	2.1094	0.7464
8699.37	7005.97	203.0	143.0	1.4196	0.3504
8702.24	7001.29	56.0	90.0	0.6222	-0.4745
8702.01	7004.06	248.0	90.0	2.7556	1.0136
8700.43	7008.23	126.0	90.0	1.4000	0.3365
8700.54	7011.30	32.0	60.0	0.5333	-0.6286
8698.78	7014.07	84.0	80.0	1.0500	0.0488
8695.74	7015.08	146.0	80.0	1.8250	0.6016
8687.10	7015.16	56.0	80.0	0.7000	-0.3567
8687.15	7015.21	118.0	90.0	1.3111	0.2709
8683.32	7016.56	792.0	90.0	8.8000	2.1748
8679.36	7015.57	354.0	130.0	2.7231	1.0018
8675.01	7014.09	290.0	130.0	2.2308	0.8023
8670.90	7017.01	292.0	150.0	1.9467	0.6661
8670.77	7018.44	510.0	120.0	4.2500	1.4469
8666.30	7018.16	516.0	130.0	3.9692	1.3786
8908.92	6982.99	512.0	112.0	4.5714	1.5198
8906.91	6986.90	372.0	112.0	3.3214	1.2004
8905.29	6990.53	396.0	112.0	3.5357	1.2629
8904.17	6995.20	629.0	107.0	5.8785	1.7713
8903.33	6998.81	543.0	112.0	4.8482	1.5786

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8902.32	7002.97	320.0	127.0	2.5197	0.9241
8900.46	7005.28	405.0	122.0	3.3197	1.1999
8897.77	7010.54	299.0	109.0	2.7431	1.0091
8898.00	7013.15	317.0	127.0	2.4961	0.9147
8896.55	7017.45	301.0	127.0	2.3701	0.8629
8871.03	7021.53	195.0	137.0	1.4234	0.3530
8876.01	7022.14	220.0	128.0	1.7188	0.5416
8880.33	7021.97	387.0	127.0	3.0472	1.1142
8883.47	7021.46	344.0	127.0	2.7087	0.9965
8888.73	7020.19	263.0	113.0	2.3274	0.8448
8896.58	7021.81	294.0	127.0	2.3150	0.8394
8900.46	7025.11	258.0	127.0	2.0315	0.7088
8964.18	7066.63	160.0	23.0	6.9565	1.9397
8960.17	7066.89	335.0	47.0	7.1277	1.9640
8955.34	7067.73	164.0	52.0	3.1538	1.1486
8951.25	7066.30	248.0	67.0	3.7015	1.3087
8948.36	7066.63	197.0	52.0	3.7885	1.3320
8943.61	7065.80	155.0	22.0	7.0455	1.9524
8939.98	7066.86	73.0	17.0	4.2941	1.4572
8935.76	7067.90	374.0	42.0	8.9048	2.1866
8902.80	7064.27	360.0	96.0	3.7500	1.3218
8890.10	7063.54	676.0	132.0	5.1212	1.6334
8868.87	7059.73	114.0	67.0	1.7015	0.5315
8864.68	7060.01	393.0	127.0	3.0945	1.1296
8861.89	7062.11	476.0	67.0	7.1045	1.9607
8806.43	7055.82	348.0	136.0	2.5588	0.9395
8824.66	7059.30	248.0	149.0	1.6644	0.5095
8784.26	7055.97	213.0	97.0	2.1959	0.7866
8779.99	7054.24	391.0	90.0	4.3444	1.4689
8776.18	7054.06	374.0	127.0	2.9449	1.0801
8772.91	7054.19	111.0	112.0	0.9911	-0.0090
8768.59	7054.37	173.0	117.0	1.4786	0.3911
8764.88	7053.91	520.0	127.0	4.0945	1.4096
8757.29	7054.06	340.0	111.0	3.0631	1.1194
8752.36	7053.48	293.0	88.0	3.3295	1.2028
8748.10	7052.59	693.0	87.0	7.9655	2.0751
8745.13	7051.88	844.0	77.0	10.9610	2.3943
8740.99	7052.21	210.0	98.0	2.1429	0.7621
8736.14	7051.30	445.0	113.0	3.9381	1.3707
8733.07	7050.81	253.0	98.0	2.5816	0.9484
8729.59	7050.76	152.0	103.0	1.4757	0.3892
8725.07	7050.15	144.0	98.0	1.4694	0.3848
8720.80	7049.98	294.0	98.0	3.0000	1.0986
8716.96	7049.77	296.0	90.0	3.2889	1.1905
8712.75	7050.36	299.0	128.0	2.3359	0.8484
8808.16	7075.47	303.0	157.0	1.9299	0.6575
8807.55	7079.79	280.0	112.0	2.5000	0.9163

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8805.72	7083.67	309.0	122.0	2.5328	0.9293
8804.78	7087.41	163.0	97.0	1.6804	0.5190
8803.20	7090.99	248.0	112.0	2.2143	0.7949
8801.76	7094.57	134.0	112.0	1.1964	0.1793
8801.07	7097.79	71.0	157.0	0.4522	-0.7936
8799.47	7101.42	284.0	142.0	2.0000	0.6931
8798.05	7104.40	180.0	142.0	1.2676	0.2371
8796.60	7109.68	479.0	112.0	4.2768	1.4532
8794.92	7113.08	197.0	112.0	1.7589	0.5647
8794.67	7116.43	286.0	97.0	2.9485	1.0813
8792.82	7120.24	340.0	97.0	3.5052	1.2542
8791.62	7123.11	251.0	112.0	2.2411	0.8070
8790.66	7127.10	245.0	112.0	2.1875	0.7828
8789.24	7131.29	249.0	97.0	2.5670	0.9427
8787.99	7134.94	-9.0	115.0	-9.0000	-9.0000
8787.54	7138.12	193.0	117.0	1.6496	0.5005
8786.57	7142.49	82.0	107.0	0.7664	-0.2661
8785.28	7146.14	183.0	127.0	1.4409	0.3653
8784.21	7149.47	555.0	137.0	4.0511	1.3990
8782.96	7153.94	268.0	112.0	2.3929	0.8725
8781.62	7157.14	78.0	97.0	0.8041	-0.2180
9098.97	7130.88	-9.0	97.0	-9.0000	-9.0000
9095.26	7131.49	36.0	112.0	0.3214	-1.1350
9090.89	7131.24	27.0	142.0	0.1901	-1.6600
9087.44	7130.83	138.0	122.0	1.1311	0.1232
9075.61	7130.83	384.0	127.0	3.0236	1.1065
9071.59	7130.93	120.0	127.0	0.9449	-0.0567
9067.46	7131.11	310.0	107.0	2.8972	1.0637
9063.95	7130.98	95.0	92.0	1.0326	0.0321
9059.35	7130.73	543.0	97.0	5.5979	1.7224
9055.67	7130.20	169.0	107.0	1.5794	0.4571
9051.91	7130.65	607.0	122.0	4.9754	1.6045
9047.75	7130.20	573.0	120.0	4.7750	1.5634
9043.86	7130.22	728.0	113.0	6.4425	1.8629
9040.33	7130.42	932.0	128.0	7.2813	1.9853
9037.16	7135.81	705.0	97.0	7.2680	1.9835
9036.04	7139.34	747.0	97.0	7.7010	2.0414
9034.92	7142.66	1182.0	94.0	12.5745	2.5317
9033.43	7146.96	879.0	106.0	8.2925	2.1153
9036.02	7129.43	1050.0	49.0	21.4286	3.0647
9031.57	7129.84	882.0	31.0	28.4516	3.3482
9027.64	7129.18	990.0	36.0	27.5000	3.3142
9023.50	7129.54	1632.0	37.0	44.1081	3.7866
9019.08	7128.77	1298.0	36.0	36.0556	3.5851
9015.70	7129.38	1068.0	27.0	39.5556	3.6777
9012.76	7129.41	961.0	21.0	45.7619	3.8235
9009.15	7128.62	389.0	23.0	16.9130	2.8281

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
9004.86	7128.54	522.0	17.0	30.7059	3.4245
9001.35	7128.98	363.0	22.0	16.5000	2.8034
8997.32	7129.28	422.0	37.0	11.4054	2.4341
8994.14	7129.18	487.0	32.0	15.2188	2.7225
8989.04	7128.29	209.0	22.0	9.5000	2.2513
8984.57	7127.94	119.0	7.0	17.0000	2.8332
8979.92	7128.09	15.0	7.0	2.1429	0.7621
8976.67	7127.88	130.0	22.0	5.9091	1.7765
8972.02	7127.35	24.0	22.0	1.0909	0.0870
8967.45	7127.22	-9.0	44.0	-9.0000	-9.0000
8964.33	7127.02	-9.0	59.0	-9.0000	-9.0000
8960.11	7126.08	42.0	62.0	0.6774	-0.3895
8955.39	7125.73	65.0	52.0	1.2500	0.2231
8951.63	7125.50	56.0	31.0	1.8065	0.5914
8947.62	7125.37	88.0	29.0	3.0345	1.1100
8943.35	7124.94	24.0	7.0	3.4286	1.2321
8939.39	7125.83	84.0	22.0	3.8182	1.3398
8935.71	7125.22	40.0	20.0	2.0000	0.6931
8932.71	7125.12	26.0	27.0	0.9630	-0.0377
8927.61	7124.74	234.0	62.0	3.7742	1.3282
8923.75	7124.69	220.0	52.0	4.2308	1.4424
8919.59	7124.84	190.0	50.0	3.8000	1.3350
8915.06	7124.38	161.0	49.0	3.2857	1.1896
8867.45	7121.64	619.0	167.0	3.7066	1.3101
8864.66	7121.87	750.0	136.0	5.5147	1.7074
8861.94	7122.50	522.0	115.0	4.5391	1.5127
8857.27	7121.51	443.0	130.0	3.4077	1.2260
8850.82	7119.12	492.0	142.0	3.4648	1.2427
8846.86	7117.73	314.0	127.0	2.4724	0.9052
8843.68	7116.03	144.0	105.0	1.3714	0.3159
8839.44	7114.53	184.0	110.0	1.6727	0.5145
8836.27	7112.67	280.0	117.0	2.3932	0.8726
8828.62	7111.71	58.0	102.0	0.5686	-0.5645
8824.46	7111.02	328.0	117.0	2.8034	1.0308
8820.65	7110.59	253.0	112.0	2.2589	0.8149
8664.02	7025.32	882.0	110.0	8.0182	2.0817
8667.83	7027.45	404.0	110.0	3.6727	1.3009
8671.54	7029.38	380.0	120.0	3.1667	1.1527
8675.19	7031.69	90.0	110.0	0.8182	-0.2007
8678.42	7033.65	118.0	100.0	1.1800	0.1655
8681.36	7035.91	186.0	90.0	2.0667	0.7259
8684.79	7038.27	156.0	100.0	1.5600	0.4447
8688.02	7040.27	127.0	108.0	1.1759	0.1621
8691.39	7042.46	140.0	143.0	0.9790	-0.0212
8694.52	7044.52	210.0	103.0	2.0388	0.7124
8697.23	7046.47	194.0	103.0	1.8835	0.6331
8700.28	7048.07	260.0	118.0	2.2034	0.7900

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8816.51	7110.41	196.0	132.0	1.4848	0.3953
8813.23	7109.78	357.0	157.0	2.2739	0.8215
8809.20	7109.04	170.0	87.0	1.9540	0.6699
8805.49	7108.92	146.0	142.0	1.0282	0.0278
8801.65	7108.51	325.0	122.0	2.6639	0.9798
8797.31	7107.85	552.0	82.0	6.7317	1.9068
8793.76	7107.32	332.0	107.0	3.1028	1.1323
8789.39	7106.68	587.0	87.0	6.7471	1.9091
8784.92	7106.20	247.0	113.0	2.1858	0.7820
8782.00	7104.57	364.0	98.0	3.7143	1.3122
8778.77	7102.19	252.0	113.0	2.2301	0.8020
8774.84	7099.32	147.0	83.0	1.7711	0.5716
8771.69	7097.44	165.0	83.0	1.9880	0.6871
8769.23	7095.56	267.0	98.0	2.7245	1.0023
8765.92	7092.97	445.0	97.0	4.5876	1.5234
8762.40	7090.76	167.0	92.0	1.8152	0.5962
8758.79	7088.32	194.0	84.0	2.3095	0.8370
8755.84	7085.81	192.0	83.0	2.3133	0.8387
8752.59	7083.93	147.0	88.0	1.6705	0.5131
8749.22	7081.59	196.0	108.0	1.8148	0.5960
8746.45	7079.13	81.0	71.0	1.1408	0.1318
8742.71	7076.23	117.0	53.0	2.2075	0.7919
8739.64	7074.63	133.0	113.0	1.1770	0.1630
8731.64	7069.43	345.0	108.0	3.1944	1.1614
8728.42	7067.32	186.0	88.0	2.1136	0.7484
8725.57	7065.31	162.0	88.0	1.8409	0.6103
8723.03	7063.41	176.0	108.0	1.6296	0.4884
8719.94	7061.10	222.0	109.0	2.0367	0.7113
8716.74	7059.14	203.0	108.0	1.8796	0.6311
8713.33	7057.26	250.0	108.0	2.3148	0.8393
8710.13	7054.83	834.0	98.0	8.5102	2.1413
8706.93	7052.54	309.0	108.0	2.8611	1.0512
8703.28	7050.59	346.0	118.0	2.9322	1.0758
8727.45	7181.72	371.0	122.0	3.0410	1.1122
8730.65	7179.36	442.0	127.0	3.4803	1.2471
8734.46	7179.23	533.0	148.0	3.6014	1.2813
8738.91	7179.10	306.0	152.0	2.0132	0.6997
8742.79	7179.74	291.0	142.0	2.0493	0.7175
8746.91	7179.43	599.0	139.0	4.3094	1.4608
8751.40	7179.21	596.0	97.0	6.1443	1.8155
8754.09	7179.36	84.0	51.0	1.6471	0.4990
8759.17	7179.99	102.0	52.0	1.9615	0.6737
8763.00	7182.48	399.0	124.0	3.2177	1.1687
8766.46	7182.56	232.0	82.0	2.8293	1.0400
8771.41	7180.17	525.0	82.0	6.4024	1.8567
8774.64	7182.36	116.0	97.0	1.1959	0.1789
8778.98	7179.94	340.0	167.0	2.0359	0.7110

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8783.14	7182.10	351.0	157.0	2.2357	0.8045
8786.52	7183.14	524.0	150.0	3.4933	1.2509
8790.66	7181.44	267.0	157.0	1.7006	0.5310
8795.00	7181.24	173.0	97.0	1.7835	0.5786
8764.73	7229.11	418.0	172.0	2.4302	0.8880
8775.04	7227.71	433.0	152.0	2.8487	1.0469
8779.08	7226.92	396.0	167.0	2.3713	0.8634
8782.76	7229.94	496.0	162.0	3.0617	1.1190
8787.33	7230.07	1549.0	152.0	10.1908	2.3215
8789.57	7232.94	537.0	202.0	2.6584	0.9777
8792.61	7234.49	344.0	182.0	1.8901	0.6366
8797.64	7236.17	159.0	181.0	0.8785	-0.1296
8771.49	7226.08	651.0	147.0	4.4286	1.4881
8767.80	7224.79	675.0	202.0	3.3416	1.2064
8761.51	7222.99	360.0	172.0	2.0930	0.7386
8760.14	7222.55	321.0	172.0	1.8663	0.6239
8755.03	7220.37	138.0	172.0	0.8023	-0.2202
8752.09	7218.31	138.0	142.0	0.9718	-0.0286
8827.58	7246.42	207.0	97.0	2.1340	0.7580
8830.12	7248.99	105.0	92.0	1.1413	0.1322
8833.22	7250.36	64.0	27.0	2.3704	0.8630
8838.20	7251.83	127.0	82.0	1.5488	0.4375
8841.17	7253.59	192.0	82.0	2.3415	0.8508
8844.67	7255.67	93.0	47.0	1.9787	0.6825
8848.58	7257.47	63.0	37.0	1.7027	0.5322
8852.04	7258.51	177.0	67.0	2.6418	0.9715
8854.25	7258.77	303.0	77.0	3.9351	1.3699
8861.27	7260.54	247.0	79.0	3.1266	1.1399
8864.00	7261.89	473.0	97.0	4.8763	1.5844
8868.31	7262.73	45.0	82.0	0.5488	-0.6001
8871.34	7263.16	119.0	97.0	1.2268	0.2044
8874.82	7264.30	385.0	79.0	4.8734	1.5838
8878.93	7265.29	192.0	92.0	2.0870	0.7357
8883.58	7264.33	488.0	117.0	4.1709	1.4281
8893.15	7264.81	280.0	122.0	2.2951	0.8308
8895.00	7264.61	355.0	127.0	2.7953	1.0279
8898.48	7265.01	117.0	97.0	1.2062	0.1875
8903.64	7266.54	281.0	142.0	1.9789	0.6825
8907.62	7266.69	192.0	142.0	1.3521	0.3017
8912.75	7266.23	250.0	142.0	1.7606	0.5656
8915.72	7266.87	244.0	142.0	1.7183	0.5413
8919.97	7266.97	77.0	152.0	0.5066	-0.6801
8923.52	7265.47	241.0	127.0	1.8976	0.6406
8927.23	7265.39	155.0	142.0	1.0915	0.0876
8931.55	7266.21	207.0	157.0	1.3185	0.2765
8936.73	7266.41	156.0	142.0	1.0986	0.0940
8940.94	7265.55	156.0	142.0	1.0986	0.0940

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8944.24	7265.19	36.0	107.0	0.3364	-1.0893
8949.07	7265.52	8.0	77.0	0.1039	-2.2644
8970.55	7264.61	-9.0	106.0	-9.0000	-9.0000
8974.67	7267.96	44.0	177.0	0.2486	-1.3920
8978.14	7268.49	15.0	166.0	0.0904	-2.4039
8982.31	7266.99	27.0	167.0	0.1617	-1.8222
8990.23	7268.64	69.0	98.0	0.7041	-0.3509
9017.66	7286.57	8.0	97.0	0.0825	-2.4953
9021.09	7286.22	23.0	110.0	0.2091	-1.5650
9025.28	7287.46	123.0	110.0	1.1182	0.1117
9027.81	7288.05	69.0	106.0	0.6509	-0.4293
9032.03	7288.27	42.0	119.0	0.3529	-1.0415
9036.25	7288.71	63.0	131.0	0.4809	-0.7321
9040.08	7289.34	240.0	112.0	2.1429	0.7621
9043.71	7288.98	21.0	82.0	0.2561	-1.3622
8765.75	7275.58	393.0	142.0	2.7676	1.0180
8767.12	7281.52	321.0	145.0	2.2138	0.7947
8767.47	7284.11	284.0	142.0	2.0000	0.6931
8769.18	7287.44	595.0	156.0	3.8141	1.3387
8771.00	7290.33	1050.0	187.0	5.6150	1.7254
8772.04	7294.32	270.0	112.0	2.4107	0.8799
8774.51	7298.71	176.0	129.0	1.3643	0.3107
8776.34	7302.72	466.0	127.0	3.6693	1.3000
8777.10	7306.48	237.0	122.0	1.9426	0.6640
8779.05	7309.94	274.0	97.0	2.8247	1.0384
8780.40	7313.11	101.0	127.0	0.7953	-0.2291
8777.71	7346.38	316.0	97.0	3.2577	1.1810
8778.90	7337.84	400.0	120.0	3.3333	1.2040
8778.90	7337.84	361.0	112.0	3.2232	1.1704
8979.57	7377.05	397.0	132.0	3.0076	1.1011
8975.33	7377.86	939.0	157.0	5.9809	1.7886
8971.74	7377.31	199.0	154.0	1.2922	0.2564
8967.30	7376.92	131.0	152.0	0.8618	-0.1487
8963.34	7377.13	87.0	157.0	0.5541	-0.5903
8959.84	7376.72	138.0	152.0	0.9079	-0.0966
8955.57	7376.16	373.0	152.0	2.4539	0.8977
8951.96	7375.96	212.0	142.0	1.4930	0.4008
8947.90	7374.84	377.0	172.0	2.1919	0.7848
8931.77	7376.65	78.0	152.0	0.5132	-0.6672
8927.20	7377.03	177.0	194.0	0.9124	-0.0917
8914.00	7378.80	1089.0	93.0	11.7097	2.4604
8883.53	7381.90	33.0	82.0	0.4024	-0.9102
8878.70	7382.69	-9.0	152.0	-9.0000	-9.0000
8875.58	7383.35	96.0	117.0	0.8205	-0.1978
8871.69	7384.11	210.0	107.0	1.9626	0.6743
8867.15	7384.37	230.0	87.0	2.6437	0.9722
8863.54	7384.31	333.0	97.0	3.4330	1.2334

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8849.17	7385.94	2.0	29.0	0.0690	-2.6741
8844.70	7386.70	33.0	37.0	0.8919	-0.1144
8840.51	7387.03	55.0	67.0	0.8209	-0.1974
8836.29	7387.64	61.0	57.0	1.0702	0.0678
8830.25	7386.98	72.0	97.0	0.7423	-0.2980
8827.07	7385.15	238.0	182.0	1.3077	0.2683
8823.92	7383.50	127.0	172.0	0.7384	-0.3033
8820.90	7381.17	136.0	167.0	0.8144	-0.2053
8817.83	7379.16	352.0	157.0	2.2420	0.8074
8814.33	7377.08	331.0	172.0	1.9244	0.6546
8810.97	7375.27	540.0	172.0	3.1395	1.1441
8807.44	7378.27	398.0	157.0	2.5350	0.9302
8808.05	7372.79	739.0	157.0	4.7070	1.5491
8805.01	7370.93	250.0	142.0	1.7606	0.5656
8801.98	7368.34	531.0	127.0	4.1811	1.4306
8798.86	7366.51	406.0	127.0	3.1969	1.1622
8795.51	7364.56	805.0	124.0	6.4919	1.8706
8792.82	7363.42	1301.0	106.0	12.2736	2.5074
8799.12	7182.51	255.0	127.0	2.0079	0.6971
8802.85	7182.51	130.0	71.0	1.8310	0.6049
8806.33	7182.79	161.0	81.0	1.9877	0.6870
8810.87	7183.07	164.0	74.0	2.2162	0.7958
8814.63	7183.14	341.0	72.0	4.7361	1.5552
8986.7	6980.1	1058.0	62.0	17.0645	2.8370
8991.2	6978.6	323.0	47.0	6.8723	1.9275
8995.2	6979.8	357.0	62.0	5.7581	1.7506
8998.9	6981.1	312.0	67.0	4.6567	1.5383
9002.8	6982.2	497.0	62.0	8.0161	2.0814
9006.6	6983.3	537.0	67.0	8.0149	2.0813
9010.7	6984.1	290.0	52.0	5.5769	1.7186
9014.5	6984.1	206.0	37.0	5.5676	1.7170
9018.2	6984.2	571.0	74.0	7.7162	2.0433
9022.1	6984.6	404.0	82.0	4.9268	1.5947
9026.1	6984.6	715.0	112.0	6.3839	1.8538
9030.1	6984.8	278.0	112.0	2.4821	0.9091
9034.1	6984.9	288.0	112.0	2.5714	0.9445
9038.1	6985.0	402.0	127.0	3.1653	1.1523
9042.0	6985.1	275.0	112.0	2.4553	0.8983
9046.0	6985.9	813.0	97.0	8.3814	2.1260
9049.9	6986.4	887.0	127.0	6.9842	1.9437
9053.9	6986.4	979.0	92.0	10.6413	2.3647
9057.8	6986.6	569.0	82.0	6.9390	1.9372
9061.6	6986.9	382.0	82.0	4.6585	1.5387
9065.5	6985.8	648.0	112.0	5.7857	1.7554
9029.8	7160.3	130.0	112.0	1.1607	0.1490
9021.5	7184.9	104.0	98.0	1.0612	0.0594
8738.7	7267.5	477.0	166.0	2.9444	1.0799

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8753.2	7334.5	583.0	114.0	5.1140	1.6320
8784.2	7371.2	790.0	120.0	6.5833	1.8845

ARSTOPE.DAT - "A" REEF STOPE DATA FOR OCTOBER 1990

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8569.55	7135.50	441.0	105.0	4.2000	1.4351
8569.45	7130.78	627.0	135.0	4.6444	1.5357
8569.25	7126.17	470.0	79.0	5.9494	1.7833
8568.08	7121.58	651.0	97.0	6.7113	1.9038
8567.73	7116.86	802.0	97.0	8.2680	2.1124
8560.51	7137.84	595.0	109.0	5.4587	1.6972
8559.97	7132.88	271.0	109.0	2.4862	0.9108
8559.40	7128.00	708.0	122.0	5.8033	1.7584
8558.85	7123.14	728.0	92.0	7.9130	2.0685
8557.86	7119.28	415.0	67.0	6.1940	1.8236
8584.30	7139.68	362.0	100.0	3.6200	1.2865
8584.09	7134.73	529.0	154.0	3.4351	1.2340
8583.37	7130.02	441.0	127.0	3.4724	1.2449
8583.35	7125.13	354.0	150.0	2.3600	0.8587
8583.36	7120.23	95.0	112.0	0.8482	-0.1646
8596.40	7141.38	346.0	97.0	3.5670	1.2717
8595.59	7136.55	93.0	72.0	1.2917	0.2559
8595.00	7131.59	227.0	112.0	2.0268	0.7065
8594.60	7126.86	409.0	112.0	3.6518	1.2952
8594.34	7122.22	726.0	92.0	7.8913	2.0658
8594.39	7117.45	637.0	112.0	5.6875	1.7383
8594.21	7112.70	642.0	135.0	4.7556	1.5593
8588.86	7107.61	405.0	112.0	3.6161	1.2854
8587.55	7102.70	348.0	127.0	2.7402	1.0080
8587.19	7097.95	375.0	82.0	4.5732	1.5202
8586.79	7093.42	986.0	112.0	8.8036	2.1752
8586.96	7088.25	2263.0	97.0	23.3299	3.1497
8586.64	7083.62	895.0	82.0	10.9146	2.3901
8582.98	7112.40	390.0	97.0	4.0206	1.3914
8582.33	7107.52	291.0	112.0	2.5982	0.9548
8581.78	7102.49	518.0	127.0	4.0787	1.4058
8581.51	7097.81	1263.0	122.0	10.3525	2.3372
8580.72	7093.04	587.0	97.0	6.0515	1.8003
8580.77	7088.05	295.0	82.0	3.5976	1.2803
8580.60	7083.31	386.0	82.0	4.7073	1.5491
8558.94	7077.09	150.0	87.0	1.7241	0.5447
8558.66	7072.29	353.0	87.0	4.0575	1.4006
8558.01	7067.36	358.0	124.0	2.8871	1.0603
8557.69	7062.53	198.0	90.0	2.2000	0.7885
8557.07	7057.89	185.0	64.0	2.8906	1.0615

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8566.84	7074.98	507.0	97.0	5.2268	1.6538
8566.65	7071.46	561.0	82.0	6.8415	1.9230
8565.99	7067.29	269.0	82.0	3.2805	1.1880
8565.70	7062.25	326.0	97.0	3.3608	1.2122
8565.06	7056.77	583.0	82.0	7.1098	1.9615
8577.49	7079.37	534.0	105.0	5.0857	1.6264
8576.47	7074.62	581.0	97.0	5.9897	1.7900
8575.96	7069.84	250.0	97.0	2.5773	0.9467
8574.84	7064.99	460.0	92.0	5.0000	1.6094
8574.93	7060.31	504.0	77.0	6.5455	1.8788
8574.81	7055.53	330.0	64.0	5.1563	1.6402
8585.82	7078.14	1478.0	97.0	15.2371	2.7237
8585.85	7073.54	602.0	97.0	6.2062	1.8255
8585.51	7069.25	795.0	97.0	8.1959	2.1036
8585.42	7064.31	504.0	92.0	5.4783	1.7008
8585.48	7059.37	659.0	97.0	6.7938	1.9160
8584.80	7054.45	397.0	82.0	4.8415	1.5772
8584.70	7049.33	439.0	97.0	4.5258	1.5098
8608.08	7138.34	246.0	105.0	2.3429	0.8514
8607.44	7133.46	297.0	105.0	2.8286	1.0398
8607.22	7128.40	246.0	120.0	2.0500	0.7178
8607.04	7123.86	50.0	67.0	0.7463	-0.2927
8606.11	7119.29	201.0	115.0	1.7478	0.5584
8604.83	7114.44	86.0	115.0	0.7478	-0.2906
8601.25	7109.28	152.0	97.0	1.5670	0.4492
8601.36	7105.99	224.0	97.0	2.3093	0.8369
8600.75	7101.16	300.0	120.0	2.5000	0.9163
8600.74	7096.17	186.0	105.0	1.7714	0.5718
8600.48	7091.44	585.0	135.0	4.3333	1.4663
8599.91	7086.75	144.0	120.0	1.2000	0.1823
8599.00	7078.23	307.0	67.0	4.5821	1.5222
8596.81	7075.36	866.0	97.0	8.9278	2.1892
8600.77	7075.62	407.0	82.0	4.9634	1.6021
8596.43	7070.65	666.0	82.0	8.1220	2.0946
8601.53	7070.74	605.0	67.0	9.0299	2.2005
8596.07	7065.62	490.0	112.0	4.3750	1.4759
8595.66	7061.11	646.0	99.0	6.5253	1.8757
8600.81	7061.09	372.0	97.0	3.8351	1.3442
8595.43	7056.00	739.0	97.0	7.6186	2.0306
8599.51	7056.08	296.0	67.0	4.4179	1.4857
8597.26	7051.44	440.0	82.0	5.3659	1.6801
8595.07	7051.29	375.0	89.0	4.2135	1.4383
8595.66	7046.26	1517.0	84.0	18.0595	2.8937
8596.91	7046.27	537.0	82.0	6.5488	1.8793
8638.52	7163.12	348.0	120.0	2.9000	1.0647
8637.75	7168.07	597.0	135.0	4.4222	1.4866
8637.19	7172.85	606.0	135.0	4.4889	1.5016

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8636.07	7177.60	301.0	112.0	2.6875	0.9886
8635.13	7182.46	248.0	62.0	4.0000	1.3863
8634.93	7187.28	220.0	67.0	3.2836	1.1889
8635.00	7192.40	438.0	142.0	3.0845	1.1264
8645.66	7164.56	471.0	120.0	3.9250	1.3674
8645.90	7169.36	795.0	115.0	6.9130	1.9334
8645.67	7174.19	497.0	112.0	4.4375	1.4901
8645.18	7179.10	108.0	97.0	1.1134	0.1074
8644.76	7183.73	403.0	62.0	6.5000	1.8718
8643.71	7188.53	435.0	77.0	5.6494	1.7315
8642.83	7193.33	708.0	111.0	6.3784	1.8529
8661.23	7166.70	411.0	120.0	3.4250	1.2311
8660.99	7171.56	547.0	122.0	4.4836	1.5004
8660.49	7176.46	663.0	120.0	5.5250	1.7093
8659.99	7181.27	204.0	132.0	1.5455	0.4353
8659.64	7185.92	231.0	135.0	1.7111	0.5371
8659.38	7190.59	314.0	115.0	2.7304	1.0045
8659.09	7195.60	582.0	107.0	5.4393	1.6936
8686.04	7171.42	314.0	127.0	2.4724	0.9052
8686.46	7176.25	911.0	112.0	8.1339	2.0960
8686.00	7181.00	330.0	75.0	4.4000	1.4816
8685.68	7185.80	387.0	135.0	2.8667	1.0531
8685.62	7190.44	370.0	97.0	3.8144	1.3388
8685.12	7195.37	247.0	125.0	1.9760	0.6811
8693.18	7166.85	217.0	127.0	1.7087	0.5357
8698.46	7166.91	449.0	112.0	4.0089	1.3885
8703.53	7171.66	552.0	108.0	5.1111	1.6314
8702.75	7176.39	520.0	97.0	5.3608	1.6791
8702.23	7181.30	793.0	112.0	7.0804	1.9573
8702.52	7186.17	1130.0	97.0	11.6495	2.4553
8702.67	7191.01	217.0	97.0	2.2371	0.8052
8702.52	7195.82	330.0	97.0	3.4021	1.2244
8711.15	7173.88	212.0	119.0	1.7815	0.5775
8712.62	7178.69	293.0	105.0	2.7905	1.0262
8712.64	7183.47	303.0	122.0	2.4836	0.9097
8712.14	7188.08	734.0	87.0	8.4368	2.1326
8712.38	7192.97	482.0	78.0	6.1795	1.8212
8712.84	7197.77	151.0	67.0	2.2537	0.8126
8697.38	7204.03	265.0	82.0	3.2317	1.1730
8702.34	7204.50	423.0	97.0	4.3608	1.4727
8706.80	7205.18	249.0	97.0	2.5670	0.9427
8712.02	7204.65	300.0	82.0	3.6585	1.2971
8903.47	7008.19	405.0	112.0	3.6161	1.2854
8907.58	7011.33	683.0	127.0	5.3780	1.6823
8911.96	7013.91	283.0	112.0	2.5268	0.9269
8916.30	7016.05	463.0	127.0	3.6457	1.2935
8919.22	7020.28	390.0	122.0	3.1967	1.1621

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8911.03	7024.99	453.0	120.0	3.7750	1.3284
8906.34	7023.29	211.0	109.0	1.9358	0.6605
8901.62	7021.67	306.0	127.0	2.4094	0.8794
8896.88	7020.23	379.0	97.0	3.9072	1.3628
8887.64	7014.24	231.0	82.0	2.8171	1.0357
8882.69	7015.17	222.0	67.0	3.3134	1.1980
8872.78	7017.01	283.0	82.0	3.4512	1.2387
8867.83	7018.71	214.0	67.0	3.1940	1.1613
8907.26	6978.25	164.0	97.0	1.6907	0.5252
8902.48	6977.79	393.0	112.0	3.5089	1.2553
8897.57	6976.26	410.0	112.0	3.6607	1.2977
8892.55	6975.74	270.0	110.0	2.4545	0.8979
8887.84	6975.26	229.0	97.0	2.3608	0.8590
8882.93	6974.29	259.0	97.0	2.6701	0.9821
8883.21	6974.78	128.0	67.0	1.9104	0.6473
8888.21	6975.18	392.0	74.0	5.2973	1.6672
8892.86	6975.37	192.0	97.0	1.9794	0.6828
8897.72	6975.34	159.0	82.0	1.9390	0.6622
8903.21	6974.41	236.0	97.0	2.4330	0.8891
9032.55	7132.51	343.0	82.0	4.1829	1.4310
9031.76	7137.33	1062.0	102.0	10.4118	2.3429
9031.49	7141.95	991.0	84.0	11.7976	2.4679
9042.45	7132.04	1141.0	109.0	10.4679	2.3483
9040.67	7136.72	990.0	97.0	10.2062	2.3230
9039.55	7141.34	985.0	104.0	9.4712	2.2483
9039.55	7141.34	985.0	104.0	9.4712	2.2483
9010.00	7146.40	748.0	67.0	11.1642	2.4127
9009.70	7141.50	1451.0	67.0	21.6567	3.0753
9009.20	7137.20	349.0	35.0	9.9714	2.2997
9009.40	7132.00	807.0	17.0	47.4706	3.8601
8538.80	7084.10	509.0	82.0	6.2073	1.8257
8540.10	7088.70	489.0	89.0	5.4944	1.7037
8540.20	7093.20	334.0	82.0	4.0732	1.4044
8540.80	7098.60	160.0	82.0	1.9512	0.6685
8541.80	7103.10	162.0	67.0	2.4179	0.8829
8542.60	7108.10	259.0	74.0	3.5000	1.2528
8543.40	7113.10	319.0	97.0	3.2887	1.1905
8544.50	7118.00	253.0	105.0	2.4095	0.8794
8551.10	7083.90	889.0	142.0	6.2606	1.8343
8551.70	7089.00	705.0	142.0	4.9648	1.6024
8552.50	7094.00	691.0	137.0	5.0438	1.6182
8553.70	7099.00	549.0	122.0	4.5000	1.5041
8554.20	7103.90	465.0	95.0	4.8947	1.5882
8555.00	7108.80	292.0	82.0	3.5610	1.2700
8556.20	7113.80	403.0	67.0	6.0149	1.7942
8556.70	7084.20	846.0	95.0	8.9053	2.1866
8556.50	7089.20	829.0	91.0	9.1099	2.2094

X-COORD	Y-COORD	GOLD	CH.W.	GRADE	LnGRADE
8556.50	7094.00	981.0	137.0	7.1606	1.9686
8556.50	7099.00	603.0	90.0	6.7000	1.9021
8557.20	7104.00	363.0	85.0	4.2706	1.4518
8557.90	7108.90	319.0	80.0	3.9875	1.3832
8558.40	7113.80	319.0	86.0	3.7093	1.3108
8632.60	6990.90	535.0	94.0	5.6915	1.7390
8631.90	6985.20	745.0	97.0	7.6804	2.0387
8630.10	6980.80	488.0	62.0	7.8710	2.0632
8629.40	6976.20	546.0	49.0	11.1429	2.4108
8649.50	6973.00	595.0	67.0	8.8806	2.1839
8650.80	6977.60	694.0	99.0	7.0101	1.9474
8652.00	6982.00	376.0	111.0	3.3874	1.2201
8653.40	6986.60	892.0	89.0	10.0225	2.3048
8654.40	6991.70	1258.0	113.0	11.1327	2.4099

APPENDIX B

FORMULAE:

- Kg GOLD PER BLOCK= m^2 x cmg/t x 0.0000278

PROFIT PER BLOCK = (A x B x C x D) - (E x F x G x H)

A = GOLD PRICE IN RAND TERMS PER Kg

B = RECOVERY FACTOR

C = MINE CALL FACTOR

D = Kg GOLD PER BLOCK

E = SIZE OF BLOCK (m^2)

F = MINING COST PER m^2 ie. ((STOPE WIDTH x 0.8714) - 134.48)

G = INFLATION FACTOR (IN THIS CASE 15%)

H = PROFIT FACTOR (10% PROFIT IS USED; A SMALL PROFIT MUST BE PLANNED TO SATISFY SHAREHOLDERS AND COVER THE RISK OF PREDICTING GRADE IN A BLOCK THAT AFTER MINING WAS FOUND TO BE LOWER)

$$Z(V) = \exp[L(V)_{SK} + (\sigma^2_{SK} + \sigma^2 - \sigma(V,V))/2] - \text{constant}$$

(from Rivoirard, 1987)

APPENDIX C

DESCRIPTION	@S.W.=144cm R/centare	@S.W.=100cm R/centare
LABOUR	45.30	45.30
SUPPORT	15.80	15.80
STORES	14.61	14.61
EXPLOSIVES	11.21	11.21
COMPRESSED AIR	16.20	16.20
WINCH OVERHAULS	0.92	0.92
TRAMMING	29.98	22.15
HOISTING	17.44	12.88
METALLURGICAL TREATMENT	47.19	34.86
TOTAL DIRECT COSTS	198.65	173.93
PUMPING	6.39	4.72
SHAFT ENGINEERING	15.94	11.78
VENTILATION	6.54	4.83
HOSTELS & MED. STN.	9.15	9.15
SUPERVISION	23.29	17.21
TOTAL STOPING COSTS	259.96	221.62
INFLATION	15.00%	
RECOVERY	93.56%	
MINE CALL FACTOR	85.00%	

Note: These costs are based on 1989 costs. It is estimated that during 1990, stoping costs have increased by 15%.

The costs that cover all the stoping costs with no profit is refered to by AAC as COST 1. This means that the stope is paying for itself but makes no contribution to shaft costs. To make a contribution to shaft and mine costs (eg. Administration etc.) the cutoff grade must increase by 30-50%. The cutoff grade in this thesis refers to COST 1 plus a minor profit of 10% above COST 1.

APPENDIX D

This is a combination of the output files from the kriging routines and gives the LO co-ordinates, followed by channel width (CH.W. in cm), gold in cmg/t (transformed using the formula in Appendix C) and the stope value (S.V. in g/t). The stope value is determined by adding 10cm to the channel width (for optimum mining) and assumes a minimum practical stope width of 100cm. Due to a problem in log-normal kriging, the block variance is given as -9.000 for blocks very far from data. As a result, the transformation back to cmg/t cannot compute this and therefore a default value of -9 is reported for gold and stope value.

X-COORD	Y-COORD	CH.W.	GOLD	S.V.
8490	7350	176	-9	-9
8490	7330	176	-9	-9
8490	7310	176	-9	-9
8490	7210	108	-9	-9
8490	7190	108	-9	-9
8490	7170	108	-9	-9
8490	7050	44	-9	-9
8490	7030	44	-9	-9
8490	7010	44	-9	-9
8510	7350	139	465	3.13
8510	7330	156	710	4.26
8510	7310	155	555	3.36
8510	7210	126	328	2.42
8510	7190	116	178	1.42
8510	7170	115	171	1.37
8510	7130	101	-9	-9
8510	7110	87	341	3.41
8510	7090	86	413	4.13
8510	7070	82	420	4.20
8510	7050	45	208	2.08
8510	7030	42	178	1.78
8510	7010	37	283	2.83
8530	7350	111	411	3.40
8530	7330	118	533	4.16
8530	7310	130	546	3.89
8530	7210	126	384	2.83
8530	7190	134	406	2.83
8530	7170	128	291	2.11
8530	7150	114	-9	-9
8530	7130	105	488	4.25
8530	7110	98	362	3.34
8530	7090	80	336	3.36
8530	7070	90	571	5.71
8530	7050	50	270	2.70
8530	7030	32	159	1.59
8530	7010	54	252	2.52
8550	7350	84	369	3.69
8550	7330	81	439	4.39
8550	7310	92	452	4.45
8550	7210	123	372	2.80
8550	7190	126	423	3.12
8550	7170	129	413	2.98
8550	7150	120	441	3.40
8550	7130	114	536	4.31
8550	7110	92	674	6.59
8550	7090	104	730	6.38

X-COORD	Y-COORD	CH.W.	GOLD	S.V.
8550	7070	103	734	6.51
8550	7050	90	412	4.10
8550	7030	89	419	4.19
8550	7010	64	288	2.88
8570	7350	74	422	4.22
8570	7330	73	362	3.62
8570	7310	75	377	3.77
8570	7210	115	316	2.53
8570	7190	113	358	2.91
8570	7170	122	459	3.48
8570	7150	126	422	3.11
8570	7130	125	530	3.92
8570	7110	114	435	3.51
8570	7090	108	759	6.46
8570	7070	92	907	8.85
8570	7050	90	608	6.08
8570	7030	104	777	6.83
8570	7010	97	462	4.30
8570	6910	110	-9	-9
8570	6890	110	259	2.16
8590	7350	82	543	5.43
8590	7330	75	550	5.50
8590	7310	78	401	4.01
8590	7210	117	377	2.96
8590	7190	111	255	2.10
8590	7170	133	384	2.68
8590	7150	127	382	2.78
8590	7130	126	361	2.65
8590	7110	113	396	3.23
8590	7090	116	380	3.01
8590	7070	101	515	4.64
8590	7050	101	638	5.77
8590	7030	91	1132	11.25
8590	7010	104	719	6.29
8590	6990	90	394	3.93
8590	6970	45	390	3.90
8590	6950	40	352	3.52
8590	6930	28	324	3.24
8590	6910	36	206	2.06
8590	6890	69	146	1.46
8610	7350	89	537	5.37
8610	7330	93	691	6.74
8610	7310	84	491	4.91
8610	7210	119	437	3.40
8610	7190	122	527	3.99
8610	7170	120	529	4.08
8610	7150	126	490	3.59
8610	7130	124	387	2.89
8610	7110	118	378	2.94
8610	7090	111	378	3.12
8610	7070	107	405	3.45
8610	7050	101	511	4.61
8610	7030	119	940	7.31
8610	7010	123	1019	7.69
8610	6990	104	651	5.72
8610	6970	64	521	5.21
8610	6950	60	324	3.24
8610	6930	36	330	3.30
8610	6910	26	268	2.68
8610	6890	45	121	1.21

X-COORD	Y-COORD	CH.W.	GOLD	S.V.
8630	7350	104	421	3.68
8630	7330	90	525	5.25
8630	7310	102	478	4.28
8630	7210	123	458	3.45
8630	7190	122	541	4.09
8630	7170	94	444	4.27
8630	7150	123	575	4.32
8630	7130	122	382	2.90
8630	7070	177	423	2.27
8630	7050	162	367	2.13
8630	7030	155	603	3.65
8630	7010	139	933	6.25
8630	6990	113	739	6.01
8630	6970	100	844	7.64
8630	6950	100	389	3.53
8630	6930	55	435	4.35
8630	6910	67	473	4.73
8630	6890	102	312	2.78
8650	7350	131	386	2.74
8650	7330	123	382	2.88
8650	7310	113	390	3.17
8650	7210	129	464	3.33
8650	7190	125	610	4.52
8650	7170	122	505	3.82
8650	7150	120	538	4.15
8650	7130	126	473	3.47
8650	7110	135	425	2.93
8650	7090	135	371	2.56
8650	7070	157	305	1.83
8650	7050	174	348	1.90
8650	7030	175	373	2.01
8650	7010	133	635	4.44
8650	6990	118	1082	8.44
8650	6970	105	829	7.23
8650	6950	94	587	5.64
8650	6930	71	615	6.15
8650	6910	87	579	5.79
8650	6890	106	453	3.91
8670	7370	155	-9	-9
8670	7350	149	391	2.46
8670	7330	145	449	2.89
8670	7310	140	359	2.39
8670	7210	123	414	3.11
8670	7190	135	532	3.68
8670	7170	118	573	4.48
8670	7150	107	404	3.46
8670	7130	106	293	2.53
8670	7110	127	388	2.83
8670	7090	136	577	3.96
8670	7070	127	302	2.20
8670	7050	157	304	1.82
8670	7030	118	211	1.65
8670	7010	107	311	2.65
8670	6990	104	584	5.11
8670	6970	99	823	7.53
8670	6950	114	595	4.79
8670	6930	60	295	2.95
8670	6910	67	153	1.53
8670	6890	129	328	2.37
8690	7370	133	260	1.82

X-COORD	Y-COORD	CH.W.	GOLD	S.V.
8690	7350	143	207	1.35
8690	7330	149	302	1.91
8690	7310	150	609	3.81
8690	7210	103	344	3.05
8690	7190	116	407	3.22
8690	7170	113	702	5.70
8690	7150	106	397	3.43
8690	7130	84	178	1.78
8690	7110	115	269	2.16
8690	7090	133	471	3.30
8690	7070	116	438	3.47
8690	7050	118	383	2.99
8690	7030	111	252	2.09
8690	7010	94	201	1.93
8690	6990	95	261	2.47
8690	6970	72	427	4.27
8690	6950	84	602	6.02
8690	6930	78	261	2.61
8690	6910	55	67	0.67
8690	6890	94	194	1.86
8710	7370	128	273	1.97
8710	7350	119	160	1.24
8710	7330	126	187	1.37
8710	7210	85	307	3.07
8710	7190	86	335	3.35
8710	7170	116	332	2.64
8710	7150	112	393	3.23
8710	7130	100	322	2.94
8710	7110	92	266	2.61
8710	7090	104	289	2.55
8710	7070	98	304	2.80
8710	7050	103	299	2.64
8710	7030	98	396	3.66
8710	7010	101	312	2.82
8710	6990	88	273	2.73
8710	6970	81	357	3.57
8710	6950	65	584	5.84
8710	6930	55	281	2.81
8710	6910	64	147	1.47
8710	6890	64	139	1.39
8730	7370	114	183	1.48
8730	7350	114	376	3.03
8730	7330	114	417	3.36
8730	7310	114	-9	-9
8730	7290	146	-9	-9
8730	7270	146	-9	-9
8730	7250	146	-9	-9
8730	7230	155	-9	-9
8730	7210	129	377	2.71
8730	7190	114	411	3.31
8730	7170	132	498	3.51
8730	7150	119	428	3.33
8730	7110	96	485	4.59
8730	7090	91	286	2.83
8730	7070	93	209	2.03
8730	7050	98	451	4.17
8730	7030	97	509	4.76
8730	7010	94	509	4.90
8730	6930	56	456	4.56
8730	6910	50	243	2.43

X-COORD	Y-COORD	CH.W.	GOLD	S.V.
8730	6890	59	202	2.02
8750	7350	112	374	3.07
8750	7330	114	533	4.31
8750	7310	120	533	4.09
8750	7290	136	520	3.57
8750	7270	145	425	2.75
8750	7250	159	515	3.04
8750	7230	159	473	2.79
8750	7210	156	378	2.27
8750	7190	124	373	2.78
8750	7170	88	322	3.22
8750	7150	112	383	3.13
8750	7130	113	326	2.65
8750	7110	102	367	3.28
8750	7090	94	353	3.40
8750	7070	91	270	2.66
8750	7050	106	360	3.10
8750	7030	105	451	3.92
8750	6950	134	-9	-9
8750	6930	90	580	5.80
8750	6910	61	693	6.93
8750	6890	69	375	3.75
8770	7390	152	-9	-9
8770	7370	130	559	3.98
8770	7350	114	516	4.15
8770	7330	112	339	2.77
8770	7310	121	240	1.83
8770	7290	129	403	2.90
8770	7270	140	482	3.22
8770	7250	162	429	2.50
8770	7230	168	630	3.53
8770	7210	160	591	3.48
8770	7190	133	446	3.12
8770	7170	125	414	3.06
8770	7150	106	273	2.36
8770	7130	114	313	2.52
8770	7110	103	350	3.10
8770	7090	98	362	3.37
8770	7070	106	413	3.58
8770	7050	108	340	2.88
8770	7030	112	368	3.01
8770	6950	83	341	3.41
8770	6930	110	364	3.04
8770	6910	118	502	3.93
8770	6890	90	485	4.83
8790	7390	164	369	2.12
8790	7370	147	516	3.28
8790	7350	124	737	5.50
8790	7330	117	484	3.80
8790	7310	119	284	2.20
8790	7290	128	274	1.99
8790	7270	129	521	3.74
8790	7250	141	256	1.70
8790	7230	164	247	1.42
8790	7210	162	551	3.21
8790	7190	115	400	3.21
8790	7170	104	272	2.39
8790	7150	108	318	2.70
8790	7130	114	316	2.55
8790	7110	118	349	2.73

X-COORD	Y-COORD	CH.W.	GOLD	S.V.
8790	7090	117	327	2.57
8790	7070	119	376	2.92
8790	7050	127	424	3.09
8790	7030	124	390	2.92
8790	6970	74	-9	-9
8790	6950	69	321	3.21
8790	6930	61	324	3.24
8790	6910	98	352	3.27
8790	6890	136	676	4.65
8810	7390	114	221	1.78
8810	7370	162	333	1.93
8810	7350	137	498	3.39
8810	7330	121	1095	8.36
8810	7270	55	182	1.82
8810	7250	99	242	2.23
8810	7230	120	332	2.55
8810	7210	145	353	2.28
8810	7190	84	330	3.30
8810	7170	79	315	3.15
8810	7150	92	324	3.19
8810	7130	113	324	2.64
8810	7110	119	295	2.29
8810	7090	125	348	2.57
8810	7070	134	366	2.55
8810	7050	142	364	2.40
8810	7030	142	388	2.56
8810	6970	77	257	2.57
8810	6950	72	234	2.34
8810	6930	66	315	3.15
8810	6910	58	394	3.94
8830	7390	74	156	1.56
8830	7370	80	126	1.26
8830	7350	124	313	2.33
8830	7270	69	302	3.02
8830	7250	60	177	1.77
8830	7230	75	219	2.19
8830	7210	95	320	3.05
8830	7190	73	428	4.28
8830	7170	73	353	3.53
8830	7150	73	423	4.23
8830	7130	128	457	3.32
8830	7110	120	337	2.59
8830	7090	121	275	2.10
8830	7070	126	413	3.04
8830	7050	123	370	2.78
8830	7030	108	349	2.95
8830	7010	67	-9	-9
8830	6990	67	-9	-9
8830	6970	79	216	2.16
8830	6950	78	167	1.67
8830	6930	77	251	2.51
8850	7390	85	297	2.97
8850	7370	81	257	2.57
8850	7350	77	256	2.56
8850	7270	83	354	3.54
8850	7250	79	278	2.78
8850	7230	74	254	2.54
8850	7210	92	226	2.22
8850	7130	133	501	3.49
8850	7110	136	636	4.37

X-COORD	Y-COORD	CH.W.	GOLD	S.V.
8850	7090	126	413	3.03
8850	7070	87	502	5.02
8850	7050	87	475	4.75
8850	7030	88	375	3.75
8850	7010	78	289	2.89
8850	6990	75	328	3.28
8850	6970	79	242	2.42
8850	6950	82	159	1.59
8850	6930	81	247	2.47
8870	7390	107	264	2.26
8870	7370	110	223	1.86
8870	7350	103	319	2.82
8870	7270	107	357	3.07
8870	7250	99	347	3.20
8870	7230	96	336	3.17
8870	7130	138	878	5.93
8870	7110	138	720	4.86
8870	7090	138	868	5.86
8870	7070	104	497	4.35
8870	7050	100	523	4.73
8870	7030	104	445	3.89
8870	7010	107	331	2.83
8870	6990	93	384	3.71
8870	6970	76	323	3.23
8870	6950	95	293	2.80
8870	6930	92	282	2.75
8890	7390	132	430	3.02
8890	7370	131	438	3.09
8890	7350	128	336	2.43
8890	7270	127	315	2.30
8890	7250	123	322	2.42
8890	7230	116	351	2.79
8890	7130	53	352	3.52
8890	7110	53	277	2.77
8890	7090	53	347	3.47
8890	7070	114	781	6.29
8890	7050	114	715	5.76
8890	7030	115	546	4.38
8890	7010	118	407	3.17
8890	6990	113	429	3.50
8890	6970	103	388	3.43
8890	6950	114	296	2.38
8890	6930	99	337	3.09
8910	7390	152	381	2.35
8910	7370	145	542	3.49
8910	7350	149	470	2.96
8910	7270	137	266	1.80
8910	7250	138	272	1.84
8910	7230	133	330	2.31
8910	7130	41	244	2.44
8910	7110	51	288	2.88
8910	7090	43	338	3.38
8910	7070	66	343	3.43
8910	7050	77	444	4.44
8910	7030	97	498	4.64
8910	7010	112	453	3.70
8910	6990	111	491	4.06
8910	6970	107	397	3.40
8910	6950	102	203	1.82
8910	6930	114	325	2.61

X-COORD	Y-COORD	CH.W.	GOLD	S.V.
8930	7390	152	301	1.86
8930	7370	159	268	1.58
8930	7350	154	362	2.21
8930	7270	138	242	1.64
8930	7250	138	207	1.41
8930	7230	139	298	2.00
8930	7130	36	153	1.53
8930	7110	28	124	1.24
8930	7090	44	284	2.84
8930	7070	38	294	2.94
8930	7050	34	257	2.57
8930	7030	70	321	3.21
8930	7010	113	503	4.10
8930	6990	113	439	3.56
8930	6970	107	381	3.27
8930	6950	115	222	1.78
8930	6930	110	285	2.38
8950	7390	153	382	2.35
8950	7370	151	274	1.70
8950	7350	155	281	1.70
8950	7270	157	174	1.05
8950	7250	152	196	1.21
8950	7230	150	276	1.73
8950	7130	31	174	1.74
8950	7110	39	119	1.19
8950	7090	26	223	2.23
8950	7070	45	316	3.16
8950	7050	45	296	2.96
8950	7030	40	314	3.14
8950	6990	89	507	5.07
8950	6970	102	497	4.45
8950	6950	109	333	2.79
8950	6930	137	266	1.81
8970	7390	149	396	2.49
8970	7370	148	501	3.17
8970	7350	149	397	2.49
8970	7270	142	142	0.93
8970	7250	155	108	0.66
8970	7230	148	249	1.57
8970	7150	40	-9	-9
8970	7130	23	256	2.56
8970	7110	22	137	1.37
8970	7090	32	224	2.24
8970	7070	47	359	3.59
8970	7050	47	316	3.16
8970	7030	47	400	4.00
8970	6990	76	545	5.45
8970	6970	76	885	8.85
8970	6950	89	538	5.38
8990	7390	148	743	4.71
8990	7370	148	598	3.79
8990	7350	148	685	4.34
8990	7290	106	-9	-9
8990	7270	108	203	1.72
8990	7250	113	174	1.41
8990	7230	139	234	1.57
8990	7190	98	-9	-9
8990	7170	104	273	2.39
8990	7150	76	560	5.60
8990	7130	41	622	6.22

X-COORD	Y-COORD	CH.W.	GOLD	S.V.
8990	7110	24	372	3.72
8990	7090	22	272	2.72
8990	6990	66	438	4.38
8990	6970	62	501	5.01
8990	6950	64	520	5.20
9010	7290	106	153	1.32
9010	7270	104	129	1.13
9010	7250	103	235	2.09
9010	7230	98	171	1.58
9010	7190	98	-9	-9
9010	7170	102	184	1.65
9010	7150	98	387	3.58
9010	7130	65	1193	11.93
9010	7110	32	932	9.32
9010	7090	31	422	4.22
9010	6990	88	488	4.88
9010	6970	75	509	5.09
9010	6950	77	429	4.29
9030	7290	106	195	1.67
9030	7270	106	145	1.25
9030	7250	106	238	2.05
9030	7190	98	-9	-9
9030	7170	104	247	2.17
9030	7150	107	246	2.10
9030	7130	110	801	6.70
9030	7110	60	868	8.68
9030	7090	35	537	5.37
9030	6990	102	547	4.87
9030	6970	109	524	4.40
9030	6950	90	414	4.14
9050	7290	107	151	1.30
9050	7270	107	138	1.18
9050	7250	107	182	1.56
9050	7150	114	327	2.63
9050	7130	114	359	2.90
9050	7110	97	471	4.38
9050	7090	40	1551	15.51
9050	6990	97	544	5.08
9050	6970	97	680	6.36
9050	6950	105	448	3.90
9070	7150	120	242	1.87
9070	7130	124	206	1.54
9070	7110	121	310	2.37
9070	6990	92	918	9.00
9070	6970	92	820	8.04
9070	6950	92	1000	9.80
9090	7150	126	265	1.95
9090	7130	127	132	0.97
9090	7110	126	150	1.10
9110	7150	127	119	0.87
9110	7130	127	92	0.67
9110	7110	127	88	0.64

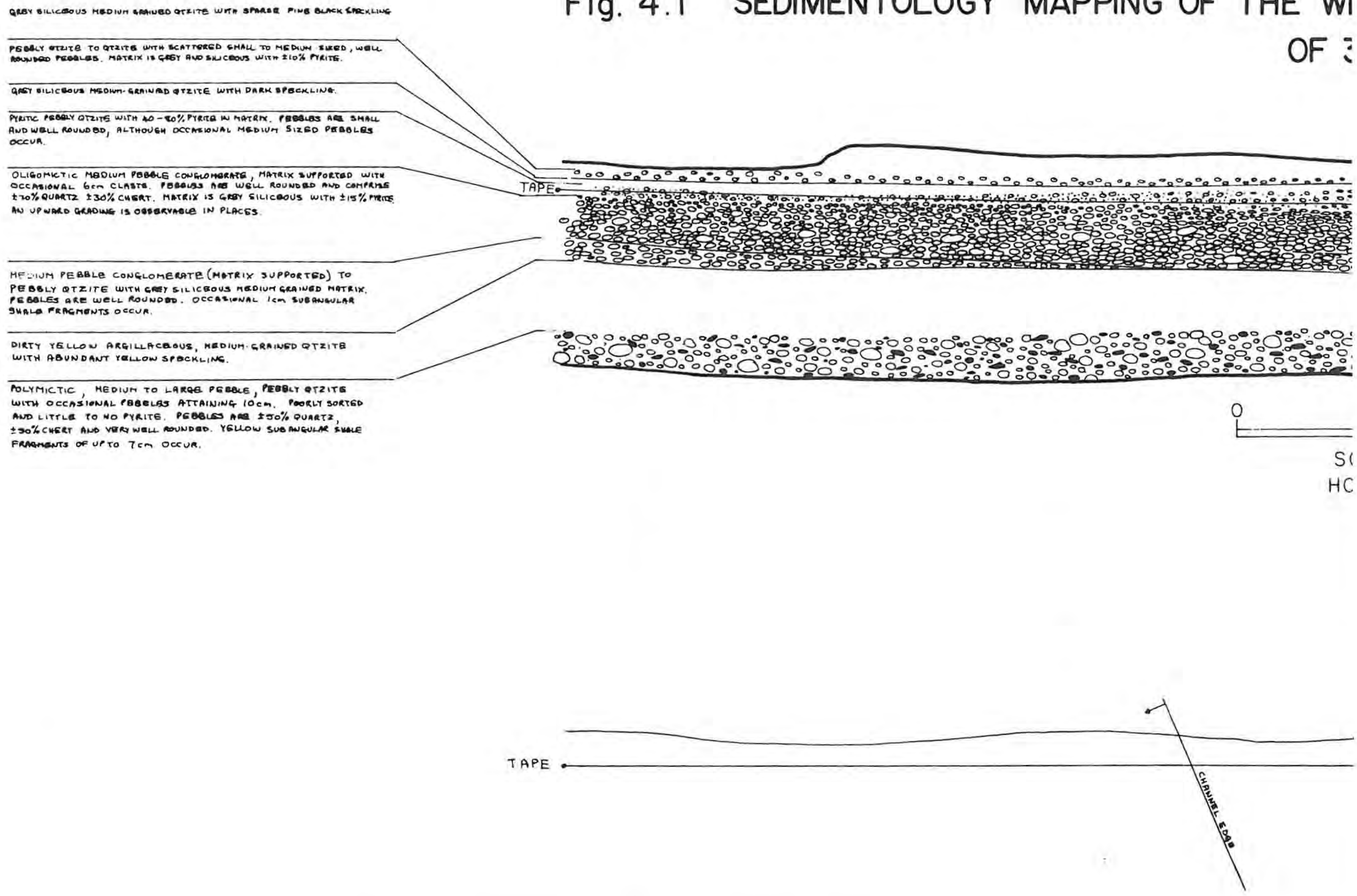
APPENDIX E

GBH.DAT - "A"-REEF BOREHOLES PRIOR TO DEVELOPMENT AND ONLY ON THE WEST OF THE ARRARAT FAULT

X-COORD	Y-COORD	GOLD(cmg/t)	CH.W.(cm)	BOREHOLE No.
8616	6845	10	13	999
8754	7334	583	114	1211
9210	7735	493	74	1218
8272	7423	349	52	1224
8655	7051	906	154	1233
8419	7069	265	75	1235
8644	7059	716	145	1236
6968	7870	167	90	1246
8651	6981	522	77	1250
8750	7298	392	180	1253
8744	7260	477	116	1281
8653	7015	870	169	1291
8900	7764	141	134	1301
7109	7293	268	81	1310
8708	7172	126	135	1330
6031	9179	279	32	3681
6725	9445	787	55	3923
8870	7613	332	135	31213
8806	7057	348	140	31400
8829	6954	205	74	31401
8723	7002	174	129	31408
8825	7058	248	2	31409
8787	7378	790	12	31418
8895	7084	446	220	31420
6977	8268	137	70	31421
8405	7400	441	113	31426
8860	7150	12	85	31427
8876	7064	180	110	31435
8905	7066	361	96	31437
8859	7132	654	106	31439
6801	7609	128	60	31447
8885	7665	232	210	31448
8864	7178	231	98	31457

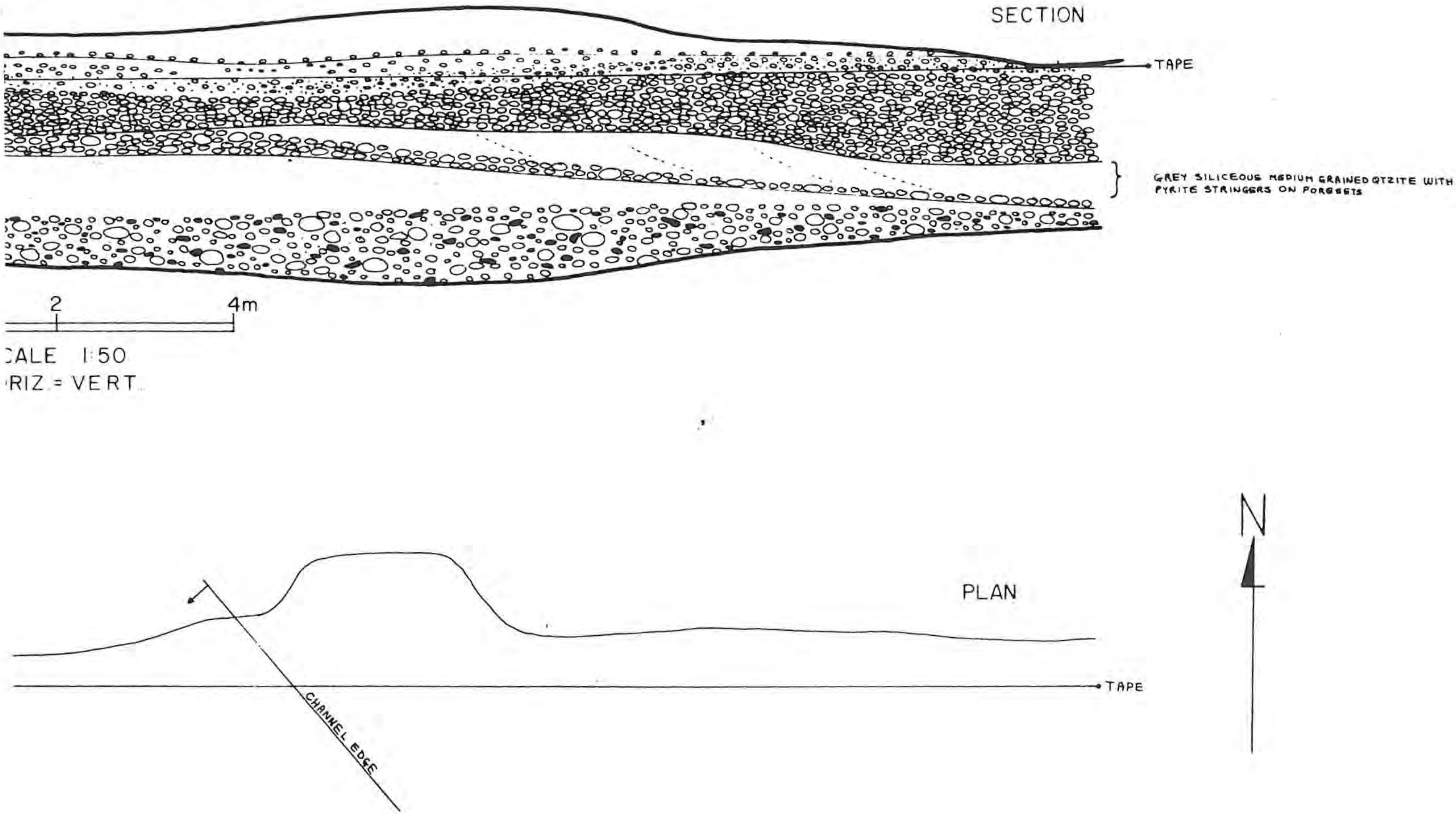
X-COORD	Y-COORD	GOLD(cmg/t)	CH.W.(cm)	BOREHOLE No.
8630	7183	217	102	31458
8810	7215	341	108	31470
8805	7240	322	185	31471
8445	7115	298	42	31474
9080	7131	154	66	31477

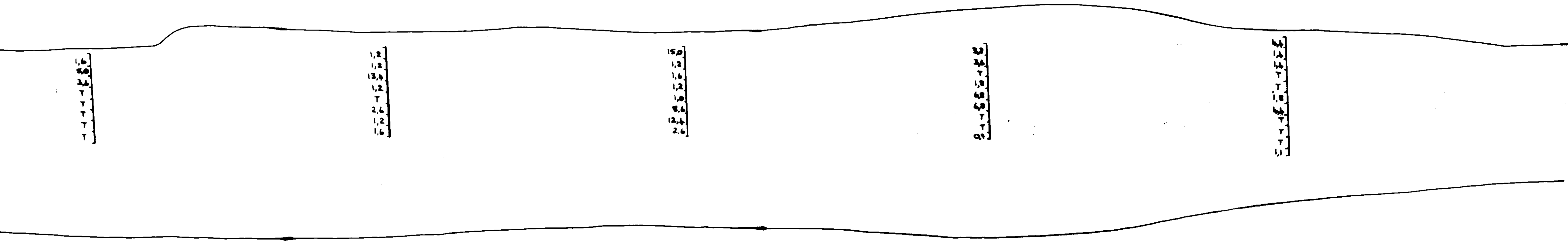
Fig. 4.1 SEDIMENTOLOGY MAPPING OF THE WI
OF 3



TPAN PLACER EXPOSED ON THE NORTH SIDEWALL
37 "A"-REEF N6 RAISE

MAPPED BY N.J.F. BLAMEY





VALUE OVERLAY FOR FIG. 4.1 WITH VALUES GIVEN IN g/t; TRACE VALUES ARE REPORTED AS T.

NOTE THE CORRELATION OF HIGHER GOLD TENNOR WITH DEGRADATION SURFACES, PARTICULARLY ON THE RIGHT.