PART 2 - MINERALISATION

CHAPTER 6
STRATIGRAPHY OF THE TELFER GOLD DEPOSITS AND CHARACTERISTICS OF THE OXIDISED ORES

6.1 INTRODUCTION

Econonomic gold mineralisation at Telfer occurs at both Main Dome and West Dome (Fig. 5.2), as thin concordant (or stratiform) layers in the very fine grained sedimentary rocks of the Middle Vale Siltstone and Outer Siltstone Members (Fig. 3.3 and Table 3.2). The bulk of the gold mineralisation occurs in the weathered zone, which extends to depths of about 95 m. Above the limit of oxidation the ores are dominated by auriferous iron oxides and quartz. Below the limit of oxidation a few cores of the concordant mineralisation have been recovered, which consist dominantly of auriferous pyrite and generally non-auriferous quartz, set in kaolinitic siltstone. The oxidised and friable nature of the near surface ore, combined with the shallow dips of the concordant layers, enables mining by a relatively straightforward open cut method (Plate 6.1A). Some of the ore exposures described below have been removed during these mining operations, but sulphide ore from the deeper levels has not been mined.

The major ore body at Telfer, the Middle Vale Reef* (or MVR), occurs near the base of the Middle Vale Siltstone Member, and the E Reefs (so called due to their prominence on the northeast flank of Main Dome) occur in the lower part of the Outer Siltstone Member. In addition to these economic ore bodies, mineralised veins occur in drill cores throughout the sedimentary sequence, from the lower limit of drilling in the Malu Formation (about 400m stratigraphically beneath the MVR - PR397, Fig. 5.2) to the upper part of the Outer Siltstone Member (PR518, Fig. 5.2). A concentration of such veins occurs in the upper few metres of the Footwall Sandstone Member, directly beneath the MVR. In places these footwall veins are sufficiently numerous to provide ore grade material. Other concordant, but non-economic, pyritic layers occur beneath the Rim

*The term reef was used initially at Telfer in the mining sense of a gold-bearing quartz vein, and the major quartz-rich concordant mineralised layers were named accordingly. However, in this study the word reef is only used for nomenclature, and has no genetic connotations.

Sandstone Member in borehole PR548, and in the Malu Formation in PR397 (Fig. 6.1).

The stratigraphic relationships between the mineralisation and the sedimentary rocks are described first below. These descriptions are followed by accounts of the various forms of the oxidised ores. The sulphide mineralisation in the MVR, the lateral equivalents of this MVR mineralisation, other sulphide mineralisation at Telfer, and the occurrence and morphology of gold in the various mineralisation types are all discussed in Chapter 7.

Throughout the discussion of the ores more attention is given to the MVR than to the E Reefs, for the following reasons.

1. The MVR is a single ore body, which can generally be accurately defined in terms of its stratigraphic position and thickness, whereas several E Reefs exist, whose exact stratigraphic positions are less certain than the MVR, due to the absence of a marker horizon close to the ores.

2. There are many more drill core intersections of the MVR than of the E Reefs, which facilitate study of the lower ore body.

3. Unoxidised pyritic intersections of the MVR have been drilled at several localities, whereas no unoxidised E Reefs have been recorded, due to their less extensive down dip continuation compared with the MVR.

4. Mining at Telfer began with the MVR, and good pit exposures were available for examination early in the study, but exposures of the E Reefs became available only during the latter stages of the field work.

In addition to this bias towards the MVR, more attention is given in this study to the texture, mineralogy and chemistry of sulphide bearing mineralised intervals, than to the characteristics of oxidised ore. This is due to the fact that prior to oxidation the

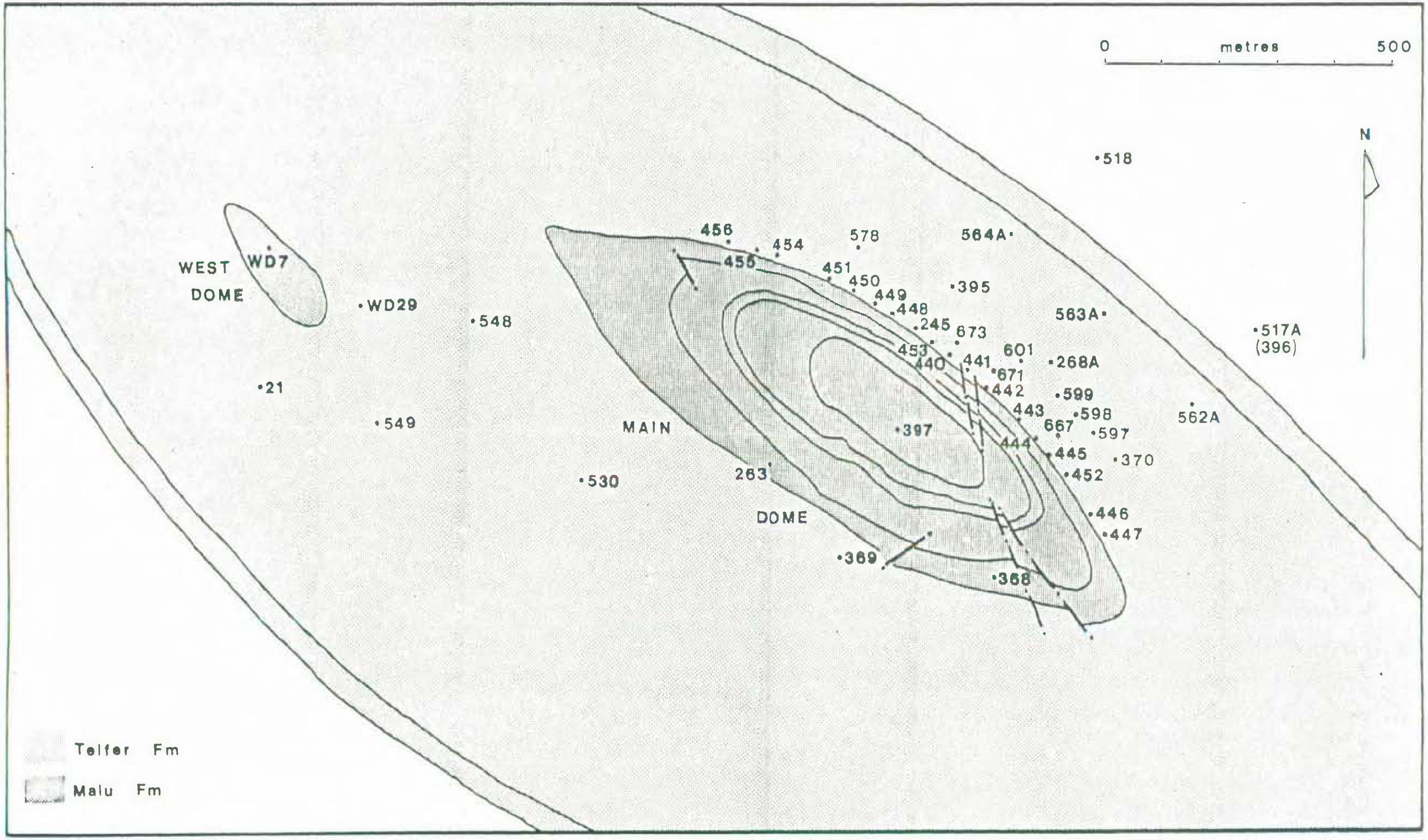

Figure 6.1 - Location of major bore holes at Telfer. Geology as on Figure 5.2. In the text, bore holes have the prefix PR (Paterson Range), except WD7 and WD29 from West Dome.

protores consisted dominantly of pyrite and quartz, with gold occurring preferentially as inclusions in the pyrite (see Chapter 7). Both gold and pyrite therefore have a common genesis, which can best be established by a detailed study of the pyritic mineralisation. Weathered ore and surface gossan samples are currently being studied petrographically and chemically by Dr. J. Wilmshurst, CSIRO, North Ryde, N.S.W.

6.2 STRATIGRAPHY OF THE GOLD DEPOSITS

6.2.1 STRATIGRAPHIC SETTING AND DIVERSITY OF THE MVR

The Middle Vale Reef was initially discovered as a discontinuous line of thin auriferous iron oxide - quartz gossan (section 6.3.1), which could be traced around Main Dome in the stratigraphic position that was mapped as the base of the Middle Vale Siltstone Member (Fig. 5.2). Exploration drilling subsequently showed that a variably auriferous layer extended in down-dip directions around the entire circumference of Main Dome. The thickest and highest grade intersections were found on the northeast flank of the structure. Gold was also found in thin veins stratigraphically beneath the MVR. The distribution of gold in drill intersections of the MVR and its footwall sediments has been plotted by the writer (Fig. 6.2). Before erosion of the crest of Main Dome the ore would have covered an elliptical area of 1.5 - 2 sq km. As a general rule, the higher the concentration of gold the thicker the MVR, the thickest intersection being about 1.5 m.

The exact stratigraphic position of the MVR is best determined by the examination of drill cores, some of which intersect the ore below the limit of oxidation. Careful graphical logging of the sedimentary and mineralogical features of seventeen drill cores, which intersect the MVR at depths between 90 m and 120 m along the northeast flank of Main Dome (Fig. 6.1) has revealed that the MVR is essentially a concordant, or stratiform, ore body (Figs. 6.3 and 6.4; gold values in these figures are Newmont assay data). The upper part of the MVR is considered to be truly concordant, whereas the lower part of the ore body consists of vein-type mineralisation or massive quartz which in places transects the bedding.

In these drill cores the distinctive natures of the Footwall

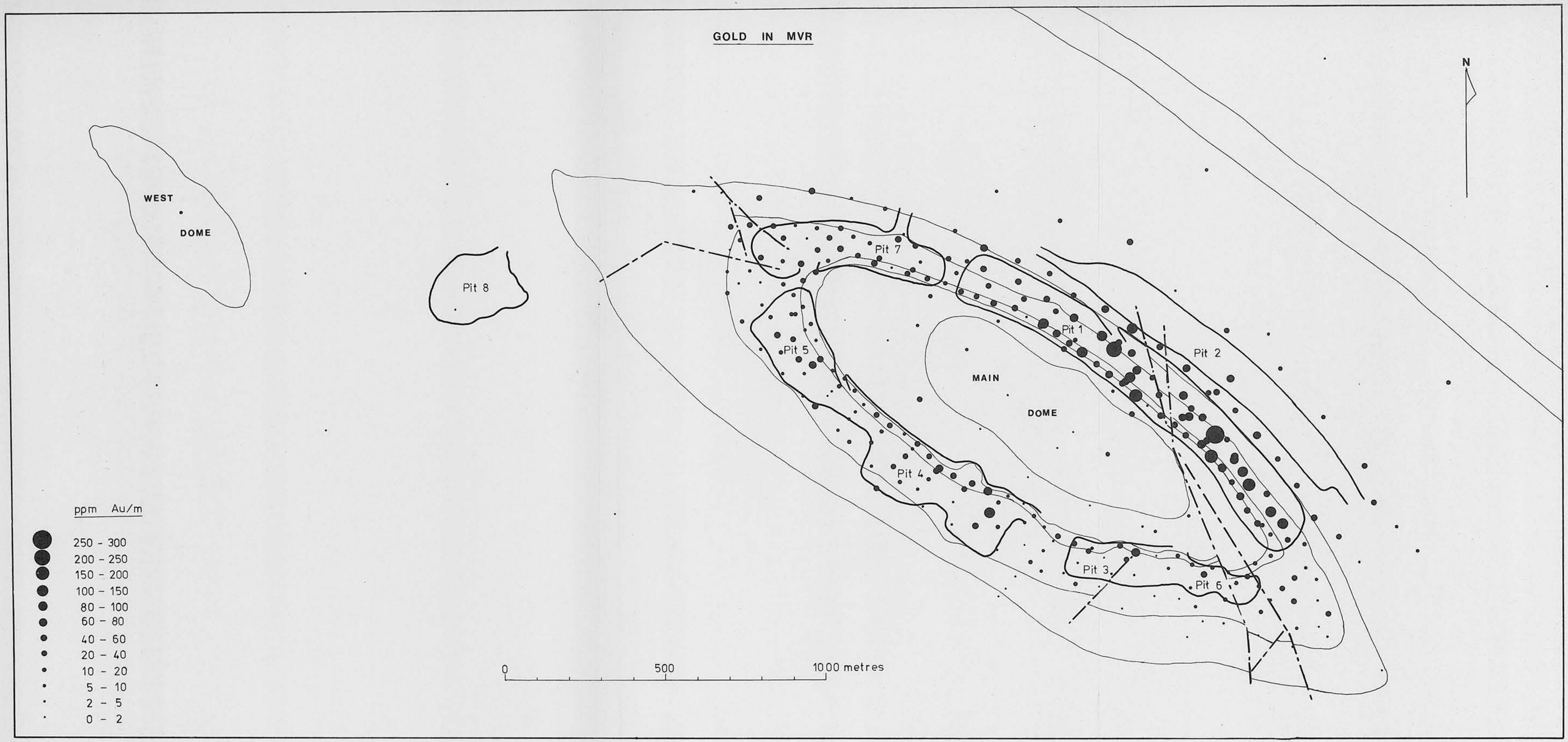

Figure 6.2 - Distribution of gold in the MVR and upper Footwall Sandstone. The total gold value was calculated by summing the products of assay values and assay intervals to give the equivalent gold content of a 1 m thick interval. Geology as in Figure 5.2.

Figure 6.3 - Core logs through the auriferous pyritic MVR from Main Dome (PR451, PR450 and PR449 - Fig. 6.1) and the non-auriferous pyritic MVR from West Dome (PR21). See Figure 6.4 for key to symbols (rear pocket).

Sandstone and Middle Vale Siltstone Members (Facies S3 and S1 respectively - Chapter 3) are clearly seen. The contact between these two conformable sedimentary units is fairly abrupt, and is a valuable marker horizon, being taken as the top of the highest prominent sandstone bed beneath the siltstone and claystone of the Middle Vale Siltstone Member. The top of the MVR is in all places very sharply defined (section 6.3 and Chapter 7), and has not been observed to transgress the bedding; it occurs within the Middle Vale Siltstone Member at a height of 1 - 2.5 m above the base of the unit (in fact, in most intersections this distance is 1.5 - 2 m). The thickness and form of the MVR is variable (Fig. 6.4, and section 6.3) but there is commonly a thin interval of siltstone between the base of the ore body and the top of the Footwall Sandstone Member; that is, the ore does not generally occur at the contact of the two sedimentary units, but within the basal portion of the siltstone member.

An extension of this logging technique to cores obtained farther from the crest of Main Dome, and at West Dome, led to the characterisation of the MVR stratigraphic interval elsewhere (Fig. 6.5). Of particular interest was the discovery of a pyritic unit 1.2 m thick in drill core PR21 from the southwest flank of West Dome. This unit was found to lie in exactly the same stratigraphic interval as the auriferous MVR at Main Dome (Fig. 6.3). However, there are important textural differences between the PR21 mineralisation and the pyritic MVR at Main Dome (Chapter 7). Although the mineralised interval in PR21 contains very little gold (Fig. 6.3) a further intersection (which is very poorly preserved) of the same unit in drill core WD7 on the crest of West Dome (Fig. 6.5) does contain low gold values (10 ppm over a 1 m interval), indicating the possibility of more widespread gold mineralisation in the MVR stratigraphic position beneath West Dome.

Three core intersections of the Middle Vale Siltstone and Footwall Sandstone Members have been drilled in the area between Main Dome and West Dome (WD29, PR548 and PR549 - Fig. 6.5). These did not encounter an auriferous or pyritic interval in the MVR stratigraphic position, but instead found a similarly thick unit of interbedded grey

FIGURE 6.4

STRATIGRAPHIC SETTING OF THE MIDDLE VALE REEF IN BOREHOLES ON THE NORTH EAST FLANK OF MAIN DOME, TELFER.

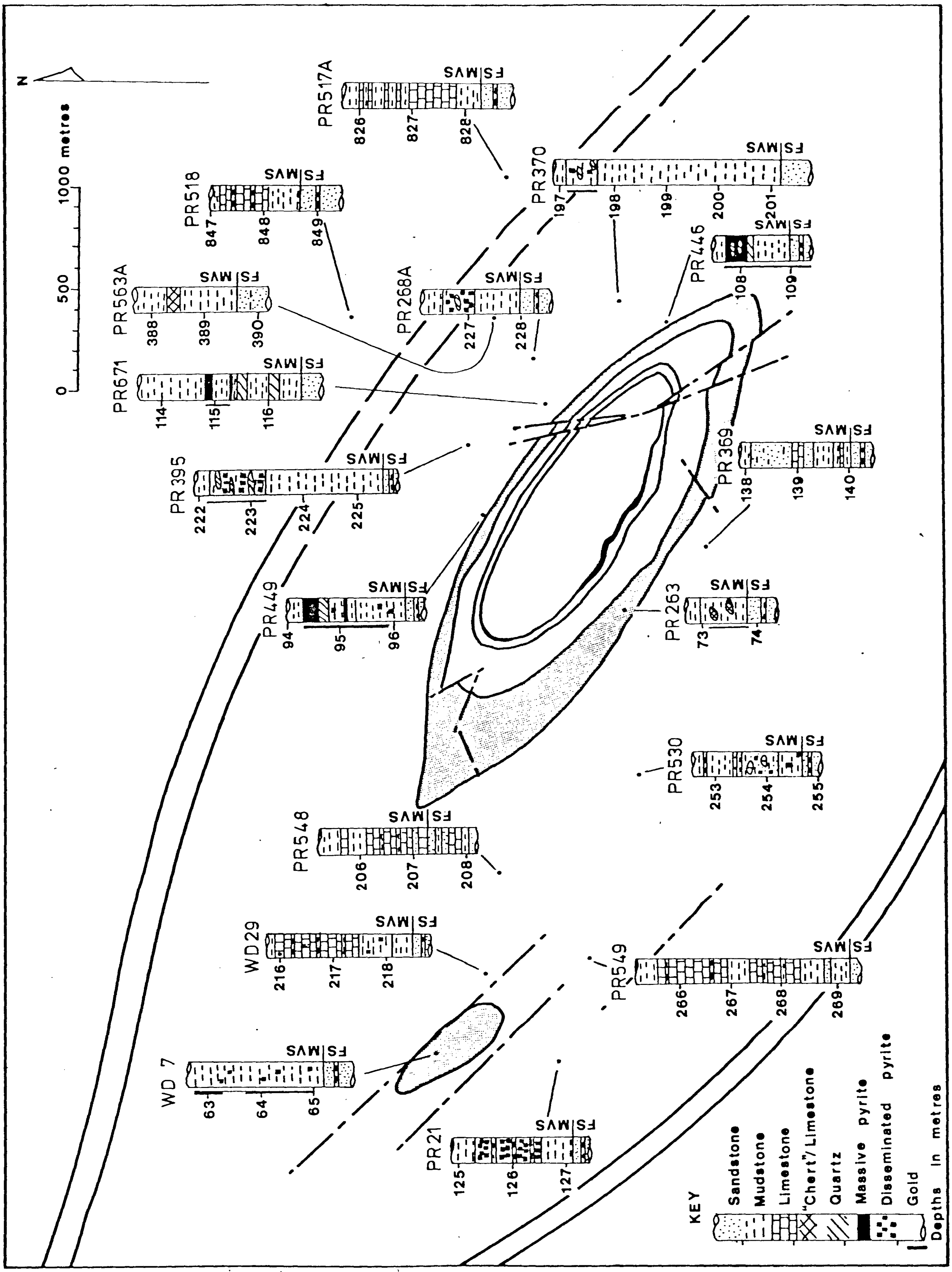

Figure 6.5 - Characteristics of the lower Middle Vale Siltstone Member (MVS) and the upper Footwall Sandstone Member (FS) at Telfer. The geology is as shown in Figure 5.2, the shaded unit being the Rim Sandstone Member.

crystalline limestone and subordinate pale greenish grey mudstone. A similar carbonate lithology occurs in cores PR517A and PR518 on the northeast flank of Main Dome (Fig. 6.5), and carbonate also occurs in this stratigraphic interval in cores PR369 and PR530 on the southwest flank of the structure. This lithology is described in detail in Chapter 7. It is clear that the carbonate interval is a lateral equivalent of the pyritic and auriferous MVR, and is therefore of great importance in considerations of the ore genesis (Chapter 10). A further variation in the lithology of the MVR stratigraphic interval is found in boreholes PR263 and PR563A (Fig. 6.5), where thin "chert" layers occur (Chapter 7).

6.2.2 STRATIGRAPHIC SETTING OF THE E REEFS

Mineralisation in the lower part of the Outer Siltstone Member is commonly not as clearly defined as the Middle Vale Reef. However, an indication of the areal extent of mineralisation is given by Figure 6.6. There are three main areas of E Reef type mineralisation - the northeast flank of Main Dome, to the west of the northwestern end of Main Dome (the "West Reefs" area) and West Dome.

On the northeast flank of Main Dome economic mineralisation is confined to the lowest 45 m of the Outer Siltstone Member, and occurs in two main intervals, the E1 and E2 reefs. The highest reef (E2) is about 12 m stratigraphically above E1, which is about 30 m above the top of the Rim Sandstone Member. In places there is also a reef (E0) at a slightly lower stratigraphic position, and another (E3) a few metres above E2. There are few cores through the E Reefs, which would more accurately establish their stratigraphic positions, and unlike the MVR there is no closely associated stratigraphic boundary or marker horizon to use as a datum. In the subsurface the reefs have usually been mapped by using assays of drill cuttings, a method which cannot distinguish vein type mineralisation from concordant units.

Mapping by Newmont geologists during mining in Pit 2 (Fig. 6.6) has suggested that the E Reefs are less continuous along strike than was originally mapped (Fig. 5.2), and pinch out and swell to form lens-like ore bodies. However, at places where the reefs are well

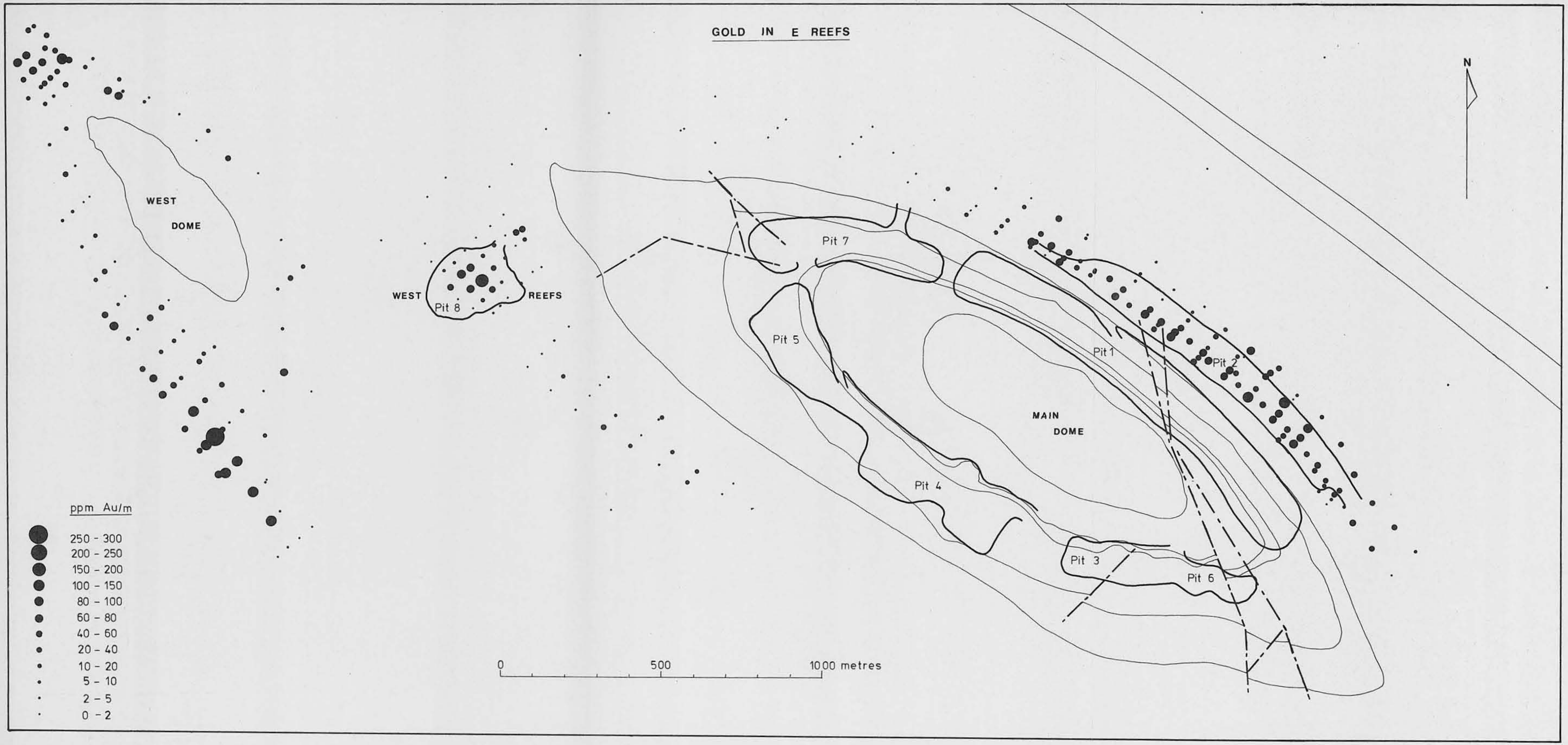

Figure 6.6 - Distribution of gold in the E Reefs and the lower part of the Outer Siltstone Member. Calculated in a similar manner to values for the MVR (Fig. 6.2). Geology as in Figure 5.2.

exposed in Pit 2 a concordant relationship with the bedding is apparent. Mineralised veins are visible in places, occurring both at high angles to the bedding and along bedding surfaces. The bedding plane veins differ from the concordant reefs by being parallel-sided with sharp planar boundaries, and by being thinner, generally less than 10 cm thick.

In the West Reefs area the ore bodies are even less well defined, and occur as diffuse bands of ferruginous siltstone. Two mineralised intervals are again apparent, but here they are at slightly higher stratigraphic elevations above the base of the Outer Siltstone Member (J. Kalnejais, pers. comm. 1980). This is consistent with the thicker sedimentary sequence in this area compared with that on the northeast flank of Main Dome (see Chapter 5), and suggests that the reefs do in fact occur in the same stratigraphic positions as on the northeast flank of Main Dome.

At West Dome extensive areas of surface mineralisation were mapped by Newmont geologists (Fig. 5.2). However, subsequent mapping by Newmont has shown that not all of these areas represent concordant mineralisation, as some are related to faults and shear zones. Mining of this area had not begun during the period of the writer's visits to Telfer, and stratigraphic control during drilling was poor, few of the holes being drilled to the Rim Sandstone Member, which would have acted as a datum. The accurate stratigraphic configuration of the E Reefs at West Dome, and their correlation with the E Reefs at Main Dome, therefore remain uncertain. However, three more or less stratiform reefs occur, which are probably equivalent to the E1, E2 and E3 reefs at Main Dome.

6.2.3 OTHER CONCORDANT MINERALISATION

In addition to the economic Middle Vale Reef and the E Reefs, a mineralised interval occurs in places within the uppermost 2 m of the Median Sandstone Member, directly beneath the Rim Sandstone. This is much less continuous than the MVR or E Reefs, but it occurs in several areas, the best development being in borehole PR548, where layers of massive pyrite are interbedded with mudstone and sandstone

(Chapter 7). The mineralisation was not encountered in the nearby boreholes PR549, WD29 and PR530 (Fig. 6.5), but small patches of oxide mineralisation occur in this stratigraphic position in some of the pits on the southwest side of Main Dome. Also, irregular patches, veins and disseminations of sulphide, accompanied by quartz and carbonates, occur in this position in some of the boreholes on the northeast side of Main Dome (e.g. PR562, PR563A, PR564A and PR578 - Fig. 6.1).

In borehole PR397 in the centre of Main Dome (Fig. 5.2) two pyritic layers, 40 cm and 1.30 m thick, occur in the Malu Formation at depths of 359 m and 372 m (Fig. 3.6). Although there are no other drill intersections or exposures of these intervals, the thickness of the mineralisation and its similarity to the mineralisation in PR548 (Chapter 7) suggests that these intervals may be concordant layers of limited lateral extent.

6.3 OXIDISED ORE

6.3.1 SURFACE EXPRESSION OF THE ORES

The Middle Vale Reef

When the Telfer gold deposits were discovered, exposures of the Middle Vale Reef were found intermittently around Main Dome as gossan consisting of gold-bearing iron oxides and quartz. Unfortunately most of this gossan has been removed subsequently during mining. However, all of the exposures occurred near the stratigraphic base of the Middle Vale Siltstone Member, which occupied a shallow valley around the dome. Erosion by ephemeral streams in this valley had removed much of this gossan, leaving only small patches of the rock.

The best exposures of gossan occurred at the northwest nose of the dome, and were examined by the writer. Here, a 35 cm thick bed of gossan was enclosed in the lowest 1 m of the Middle Vale Siltstone Member (Plates 6.1B and 6.1C), which dipped at 21° to the northwest. The outcrop was well exposed along a 5 m strike length in the bank of a small dry creek, and could be traced as a less well exposed bed for a distance of about 100 m. The MVR here consisted of massive brownish black haematite, reddish brown goethite and earthy limonite, together with irregularly shaped nodular patches of white or grey quartz up to about 5 cm across. The ore bed was concordant with the enclosing sedimentary rock, and both the top and bottom of the bed were sharply defined (Plate 6.1C). Crude layering parallel to the bedding could be seen in places in the gossan.

Beneath the gossan occurred 20 cm of thinly bedded weathered brown siltstone, similar to the overlying rocks. Thicker slightly coarser grained beds of the Footwall Sandstone Member underlay the siltstone. Bedding plane exposures of the Footwall Sandstone a few metres up dip from the gossan outcrop were cut by sparse iron oxide - quartz veins about 1 cm thick. At a few other localities around Main Dome the MVR gossan was exposed only as isolated eroded blocks resting on the footwall sediments.

Boxwork textures of iron oxides after pyrite are ubiquitous in gossan samples, most boxwork cavities being less than about 2 mm across. Visible gold flakes, usually less than about 0.5 mm across, could be found in most gossan exposures. The gold occurred most commonly in the iron oxide boxworks, but could also be found within the irregular quartz nodules (section 7.6). Before mining began gold could be panned from gravel in the dry creek beds draining the areas of gossan exposure, small nuggets 1 mm - 2 mm in diameter being recovered.

The E Reefs

Surface exposures of the stratigraphically higher E Reefs around Main Dome were found mostly along the northeastern flank of the dome, but small patches also occurred elsewhere, in particular to the west of the northwestern nose of the structure (the area termed West Reefs - Fig. 5.2). On the northeastern flank the exposure consisted of a massive white quartz "blow" about 1.5 m thick, which extended about 300 m along strike (Plate 6.1D). This outcrop was conformable with the sedimentary strata and was displaced in the small graben shown on Figure 5.2. Little ferruginous material was associated with the quartz, and to the writer's knowledge no visible gold was found in the outcrop. Drilling and subsequent mining revealed that the quartz died out within a short distance in the subsurface, where a more typical iron oxide-rich reef occurred.

At West Dome the oldest stratigraphic unit exposed is the Rim Sandstone Member (Fig. 5.2). The stratigraphic position of the MVR therefore occurs in the subsurface, where the development of the mineralisation is less spectacular than at Main Dome (Chapter 7). However, surface mineralisation in the form of gossan is found at numerous localities within the Outer Siltstone Member at West Dome. Some of this mineralisation is stratiform and represents the E Reefs, and some is developed along shear zones or as veins. The West Dome gossans are similar to the MVR gossan at Main Dome, being composed dominantly of dark brown iron oxides and quartz. However, they are less well defined stratigraphically, due to a combination of the more complex structure of West Dome compared with Main Dome, the absence of good marker horizons, and the fact that bedding planes are commonly difficult to distinguish from joints, which hampers recognition of the relationship between bedding and mineralisation.

6.3.2 ORE EXPOSURES IN THE TELFER PITS

Mining at Telfer is by an open cut method, the overburden of the conformable ore layers being removed first and the ore then being bulldozed off the dip slope (Plate 6.1A). Mining of the MVR began on the northeastern flank of Main Dome (Pit 1) and progressed almost all the way round the structure (Fig. 6.2). Mining of the E Reefs began later than that of the MVR but also commenced on the northeast flank of Main Dome (Pit 2 - Fig. 6.6). Another pit for the removal of the E Reefs has been developed in the West Reefs area (Pit 8 - Fig. 6.6), and at the end of the writer's field work plans were being made for mining the E Reefs at West Dome. The mining method has at times provided good exposures of the ores, but accurate mapping of the various textural types was not possible during the present study. However, representative examples of exposures of the oxidised ore types are described below.

Pit 1

A typical exposure of the MVR in the central part of Pit 1 is shown in Plate 6.1E. The ore here is similar in character to the surface gossan (Plates 6.1B and 6.1C), being a massive conformable bed about 70 cm thick, composed of dark brown auriferous iron oxides and nodular quartz. Other important features are the sharp planar top of the ore bed, and the absence of mineralisation in the hanging wall kaolinitic siltstone. At this locality the ore is truncated at a fault (Plate 6.1E), and is in fact downthrown in the small graben shown in Plate 3.7D and Figure 5.2.

Where exposed in Pit 1 the base of the massive MVR is also generally sharply defined. However, unlike the sharp top of the ore, which is a ubiquitous feature of the MVR, the base is in places more diffuse, with patchy mineralisation and veins occurring in the underlying siltstone. Footwall veins, which are similar in composition to the stratiform ore, are exposed in places in the pit (Plate 6.1F), and range in width from a few millimetres to about 40 cm. Some veins clearly transgress the strata, but many are parallel to the bedding, although they commonly bifurcate, and apparently do not extend for more than about 20 m along strike (exposures are inadequate to map the full extent of veins).

The MVR in Pit 1 is not everywhere a single massive bed; in places, thinly laminated kaolinitic and ferrguinous siltstone layers occur between massive ore layers. These are the weathered equivalents of delicately laminated pyritic siltstone found in some cores of the MVR at deeper levels (Type B mineralisation - Chapter 7). This laminated type of ore forms part of the MVR exposed in a short horizontal adit which was excavated along the reef at a depth of 45 m beneath the surface at the southeast end of Pit 1. Two beds of ore occur here (Plate 6.2A, Fig. 6.7), separated by 40 cm of partially iron stained siltstone. The upper ore bed consists of the thinly laminated ferruginous siltstone ore, while the lower bed comprises two types of massive ore. The upper half of the lower bed is massive iron oxide - quartz reef, while the lower half of the bed is dominantly iron stained coarsely crystalline quartz. The tops and bases of both ferruginous beds are sharp and conformable.

Samples were taken through the ore at this location and were

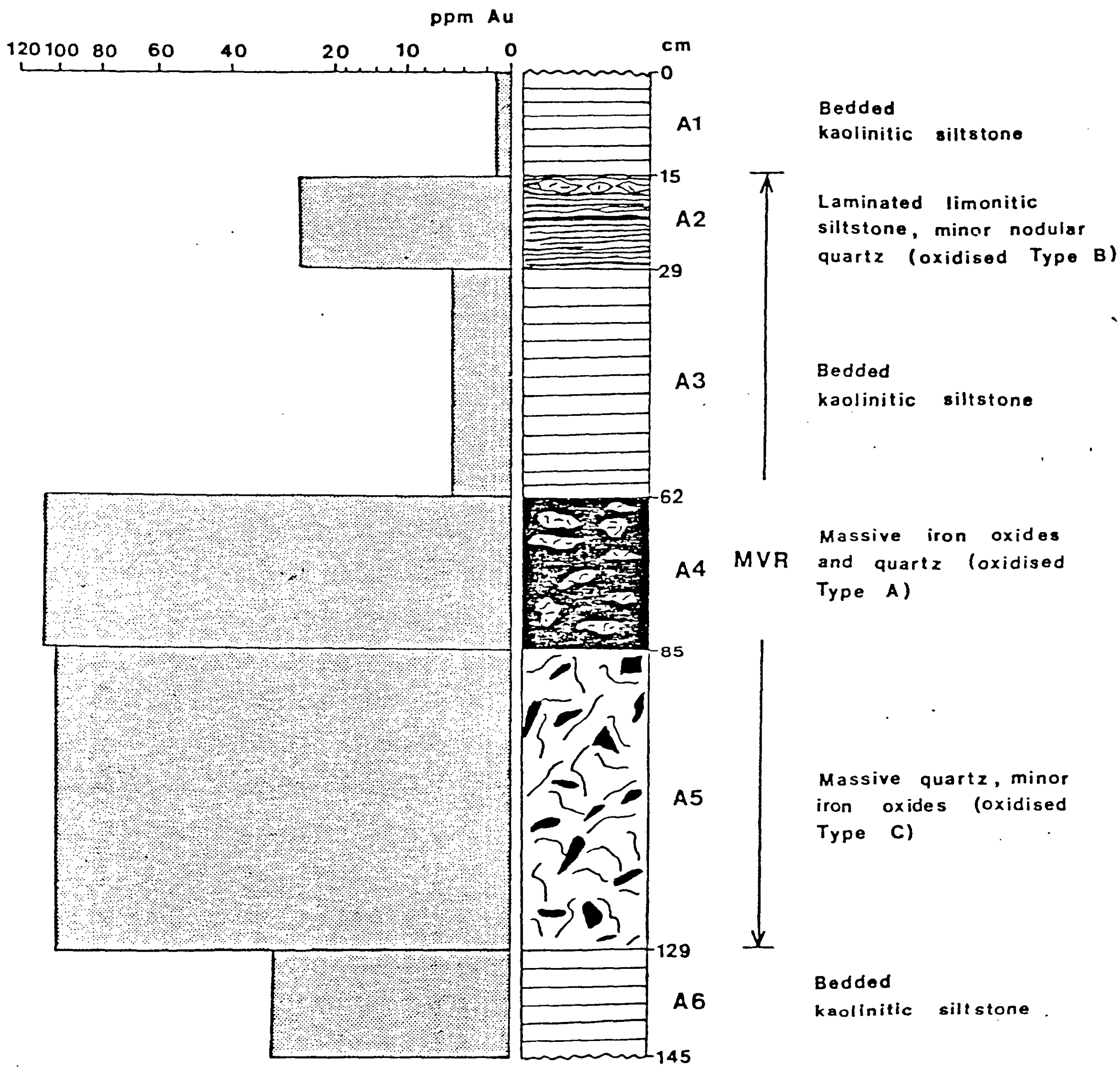

Figure 6.7 - Lithology and gold content (Table 9.1) of the oxidised MVR exposed in an adit at the southeast end of Pit 1. Same locality as Plate 6.2A.

chemically analysed (Chapter 9); gold values are shown in Figure 6.7. The association of gold mineralisation with ferruginous and quartz-rich horizons is clear, and the unmineralised nature of the hanging wall siltstone is also evident. The assays also demonstrate the higher quantity of gold in massive iron oxide - quartz ore compared with that in laminated ore, a feature which is also evident elsewhere in cores (see Chapter 7).

Pits 4 and 5

On the southwest side of Main Dome the MVR is well exposed in the southeastern wall of Pit 4 (Fig. 6.2). Here the MVR forms a concordant layer 40 - 60 cm thick, the base of which is 80 cm above the top of the Footwall Sandstone Member (Plate 6.2B). The character of the MVR at this location is quite different from that described above from the northeastern flank of the dome.

The ore consists of anastomosing veins of limonite (Plate 6.2C), most of which are less than 5 cm thick, although a few are up to 10 cm thick. The veins lie parallel or at low angles to the bedding, and are enclosed in kaolinitic siltstone. Quartz composes only a small percentage of the mineralised veins, and occurs in coarsely crystalline fractured nodular form (Plate 6.2C). The kaolinitic siltstone between the veins is unmineralised, and is identical to the overlying sediment of the Middle Vale Siltstone. Ferruginous footwall mineralisation in this area is sparse or absent, but numerous veins of white kaolinite, mostly less than 5 cm thick, occur in the siltstone below the reef. Similar veins also occur within the lowest 50 cm of the hangingwall siltstone.

Another exposure of the MVR was examined in Pit 5, near its connection with Pit 4 (Fig. 6.2). Here the mineralisation is only weakly developed, and occurs as two layers in the kaolinitic sandstone. The top of the reef is sharply defined and planar, and the upper 10 cm comprises laminated gritty quartz and limonite with small siltstone lenses. About 60 cm beneath this layer is a 10 cm thick layer of massive iron oxides and nodular quartz, which in turn is underlain by 50 cm of siltstone and then sandstone of the Footwall

Sandstone Member. This exposure resembles the MVR in the adit in Pit 1 (see above), apart from the lower mineralised interval being thinner in the Pit 5 exposure.

Pit 2

The E Reefs in Pit 2 are basically similar to the MVR in Pit 1, being composed of auriferous iron oxides and quartz set in kaolinitic siltstone. However, bench mapping by Newmont geologists during mining suggests that the mineralisation thickens and thins along strike to a greater degree than the MVR (Q. Amos, pers. comm., 1980). Well exposed outcrops of the typical E Reefs were only occasionally produced during mining, and the writer was able to examine only a few of these.

Near the centre of Pit 2, at a depth of about 15 m below the ground surface, the E1 reef was conformable, and about 80 cm thick (Plate 6.2D). Both the base and top were sharply defined, but the top was more undulose than the planar top of the MVR. The lower half of the reef was composed of nodular quartz and a gossanous boxwork of iron oxides, while the upper half included ferruginous siltstone lenses as well as quartz and iron oxides. A few ferruginous quartz veins up to 10 cm thick cut the underlying siltstone nearby. Elsewhere in Pit 2, similar crosscutting veins beneath the E1 reef reached 40 cm in width (Plate 6.2E).

At the southeast end of Pit 2 another well developed exposure of the E1 reef was examined. The reef here was thicker than in the centre of the pit, but the visible mineralisation was more diffuse. Three conformable layers of gritty ferruginous quartz and siltstone up to 30 cm thick occurred in a 2.6 m thick unit of iron stained siltstone. The top of the mineralised interval was again a sharply defined bedding plane. Small faults with displacements of a few tens of centimetres cut one of the concordant mineralised layers at this locality. The effect of this faulting was to cause thinning of the layer over a distance of about 50 cm. Similar small faults may account for much of the thickening and thinning of the E Reefs along the length of Pit 2. Such faults at low angles to the bedding are also found elsewhere in the Telfer pits, cutting unmineralised sediments. They were probably formed during the main period of folding, indicating that the E Reefs pre-date this deformation.

Pit 8

A single exposure of the E2 reef in Pit 8 to the west of Main Dome (Fig. 6.6) was available for study. Here the mineralisation was a poorly defined unit of iron stained siltstone 2 - 3 m thick. Little quartz was associated with the reef, but in places hard dark silicified concretions up to 30 cm in diameter occurred. This exposure represents the most diffuse economic mineralisation examined, and constrasts strongly with the well defined massive MVR of Pit 1.

6.3.3 OXIDISED ORE IN CORES

Cores of oxidised ores from beneath the present depth limit of mining are most numerous on the northeast flank of Main Dome. The oxidised ores are generally very friable, which commonly results in poor core recovery, and thus during the present study these cores have not been examined in as much detail as cores of pyritic ores. However, descriptions of the major features of the oxidised cores are given below.

MVR

Most of the cores from the line of drill holes along the northeast flank of Main Dome (Figs. 6.4 and 6.1) intersect oxidised Middle Vale Reef. Only three of these cores (PR449, PR450 and PR451) contain relatively unoxidised pyritic mineralisation (Chapter 7), and in one of these (PR450) the upper part of the MVR is almost completely oxidised, while only the lowest 20 cm is dominated by incipiently oxidised pyrite. There is a transitional zone of about 20 cm between the oxidised and pyritic ore in this core, with irregular patches of pyrite being surrounded by iron oxides. This core demonstrates two facts, firstly that the oxidised ore is a weathering product of the pyritic mineralisation, and secondly that the base of oxidisation is, at least in some instances, very abrupt.

In all of the cores of oxidised MVR examined, the top of the ore is represented by a sharp downward transition from unmineralised kaolinitic siltstone to highly ferruginous, and in places quartz-rich, sediment. The actual contact is broken in most cores, but in PR450 the top of the oxidised ore can be seen to follow a bedding plane, with only a few centimetres of brown iron staining in the siltstone above the contact.

Four main textural types of oxidised mineralisation occur in the cores, which correspond both to those types found in surface and pit exposures, and also to the four types of pyritic ore described in Chapter 7. In the upper 10 – 40 cm of many cores crudely laminated brown to reddish brown ferruginous sediment with minor authigenic quartz occurs, resulting in a gritty texture (e.g. in the cores between PR441 and PR446 in Fig. 6.4). This is the same type of ore as the upper mineralised bed of the MVR shown in Plate 6.2A.

Massive dark reddish brown iron oxide – quartz ore is also common. In PR450 sparse visible gold blebs up to about 1 mm in diameter occur in the massive iron oxide of the upper MVR, in addition to microscopic inclusions of gold in iron oxide boxworks (Plate 6.2F). In the same core, this type of mineralisation passes downward into massive pyrite – quartz mineralisation.

A third type of mineralisation is massive grey or greyish white quartz, which occurs in the MVR beneath the more ferruginous mineralisation in several of the cores shown in Figure 6.4 (e.g. in PR441 and PR444). The quartz forms intervals up to 20 cm thick, and is commonly vuggy, probably due to the removal during weathering of patches of pyrite (see Chapter 7). Some of the vugs are lined with grey or white cryptocrystalline quartz formed during the weathering of the ore. In PR442 a speck of gold 0.5 mm across is visible within the massive quartz.

Veins form the fourth type of mineralisation, and are common in the Footwall Sandstone Member beneath the MVR in many of the cores (Fig. 6.4). These veins seldom exceed 2 cm in width, and are formed in quartz, pyrite and/or iron oxides and, in places, kaolinite.

E Reefs

Few cores of auriferous intervals in the lower Outer Siltstone Member were available for study by the writer, but examples of such cores are described below.

In core from borehole PR598 on the northeast flank of Main Dome (Fig. 6.1) the E1 reef was intersected at a depth of about 72 m beneath ground level (the top of the reef occurred at a core depth of 54.2 m, as the hole was drilled in the floor of Pit 2). The reef here has a sharp but broken top, the overlying sediment being unmineralised pale gray mudstone. The top 15 cm of the reef comprises massive dark reddish brown iron oxides, possessing a conspicuous boxwork texture after pyrite, within which microscopic gold inclusions occur (see Chapter 7 and Plate 7.7B). Beneath the massive iron oxide layer is a further mineralised interval 2.7 m thick. Most of this interval consists of pale brown iron stained siltstone, with patches containing slightly ferruginous quartz and kaolinite veinlets. The lowest 20 cm of the mineralised interval is massive grey quartz. This intersection of the E1 reef resembles the MVR by having a very sharp top, with overlying unmineralised sediment, and by having a zone of high grade mineralisation at the top of the reef. A rather similar intersection of the E1 reef occurs at a depth of about 73 m in PR597 (Fig. 6.1). This intersection contains a 30 cm thick unit of massive iron oxides, which is the main manifestation of the mineralisation.

Intersections of the stratigraphically higher E2 reef differ from those of the E1 reef by having more diffuse and less ferruginous mineralisation. In PR599 (Fig. 6.1) a 75 cm thick interval at a depth of about 75 m below ground level contains high gold values equivalent to 42 ppm/m (see scales on Fig. 6.6 for comparison). However, little visible mineralisation occurs in this interval, with most of the unit being kaolinitic siltstone which is slightly darker grey than the adjacent siltstone. A few very thin (about 1 mm) ferruginous quartz veins occur, and sparse patches of limonite after pyrite exist. In PR601 (Fig. 6.1) lower gold values occur in the E2 reef position between depths of 69 m and 73 m below ground level. Here the mineralisation is composed of numerous irregular features filled with nodular quartz, kaolinite and limonite cutting iron stained siltstone. The sparse mineralisation of these two core intersections of the E2 reef is similar to the texture of the E2 reef exposed in Pit 8 (section 6.3.2).

6.3.4 MINERALOGY OF THE OXIDISED ORES

Iron oxides in the surface gossans and subsurface weathered ores include goethite, haematite and limonite. Some of these minerals represent a replacement of pyrite during oxidation, resulting in boxwork texture. However, some of the iron oxides occur as massive nodular patches devoid of structures, and some are botryoidal in nature. These latter types are of "secondary" origin, being due to mobilisation and reprecipitation or iron within the mineralised intervals during weathering.

There is also more than one phase of quartz in the ores. The primary quartz is coarse grained and is commonly highly strained, but finer grained clearer quartz and microcrystalline botryoidal quartz also occur. These latter quartz types are of secondary origin, some being due to weathering processes, but some probably being due to recrystallisation during deformation of the ores (see Chapter 10).

In addition to quartz, iron oxides and associated gold, a few trace minerals have also been reported. Odekirk (1973) recorded minor ($<1\%$) xenotime (YPO_4) in coarse grained quartz from two surface gossan samples, one from West Dome and the other from the MVR on the southwest side of Main Dome. Monazite ((Ce, La, Th)PO_4) was recorded by Hausen (1974) in addition to xenotime, as trace minerals in quartz veins cutting the lower Middle Vale Siltstone Member. Monazite was also noted by Whittle (1977) in a sample of the oxidised MVR in PR446 at a depth of 107.95 m, and both monazite and xenotime were reported by Ahlrichs (1978) in crushed ore samples from the mine. Small amounts of magnetite, cuprite, covellite, chalcopyrite, rutile and zircon were also recorded in the heavy mineral fractions of these crushed ore samples. Goode (1974) found a single small grain (0.01 mm across) of gersdorrfite ((Ni,Fe)AsS) within quartz in a gossan sample from the MVR.

No copper minerals have been reported from surface gossans, but Goode (op. cit.) noted a few quadrangular boxworks after chalcopyrite in the MVR gossan. Odekirk (op. cit.) recorded that persistent trace copper values in gossan samples probably indicated copper minerals in the primary mineralisation, and Hausen (1974) stated that copper had been leached to a depth of 70 - 80 m, beneath which supergene enrichment of the element occurred (see Chapter 7). For example, in cores of the oxidised MVR malachite is abundant in a 5 cm interval in PR446, and native copper is found as small blebs in massive iron oxide boxworks in PR453 (Plate 6.2F). In addition, chrysocolla occurs in quartz-rich veins at a depth of 105.25 m in the Footwall Sandstone Member of PR444. However, chalcocite is the most common supergene copper mineral, extending down into the pyritic mineralisation.

PLATE 6.1 - LARGE SCALE FEATURES OF MINERALISATION AT MAIN DOME

A. Pit 1 (Fig. 6.1) from the northwest. MVR forms the unit being mined, which dips at about 30° to northeast. The top of the Footwall Sandstone Member forms the dip slope on the right.

B. Outcrops of the MVR in the anticlinal crest at the northwestern end of Main Dome.

C. Outcrop of the MVR at some locality as 6.1B. The sharp conformable top and base (arrows) of the unit are evident. Light grey patches are quartz, but most of bed consists of iron oxides. Hammer rests on lowest beds of the Middle Vale Siltstone Member.

D. Massive coarse grained quartz "blow" marking the surface position of the El reef on the northeastern side of Main Dome. View to the southeast.

E. MVR exposed in the floor of Pit 1. Dip is to right. Note sharp conformable top of the ore (base not exposed, but is at the level of the pit floor). MVR is absent beyond geologists, due to downfaulting in the graben shown in Plate 3.7D.

F. Bifurcating iron oxide-quartz veins in Footwall Sandstone Member about 3 m below MVR, in Pit 1. Dip is to left.

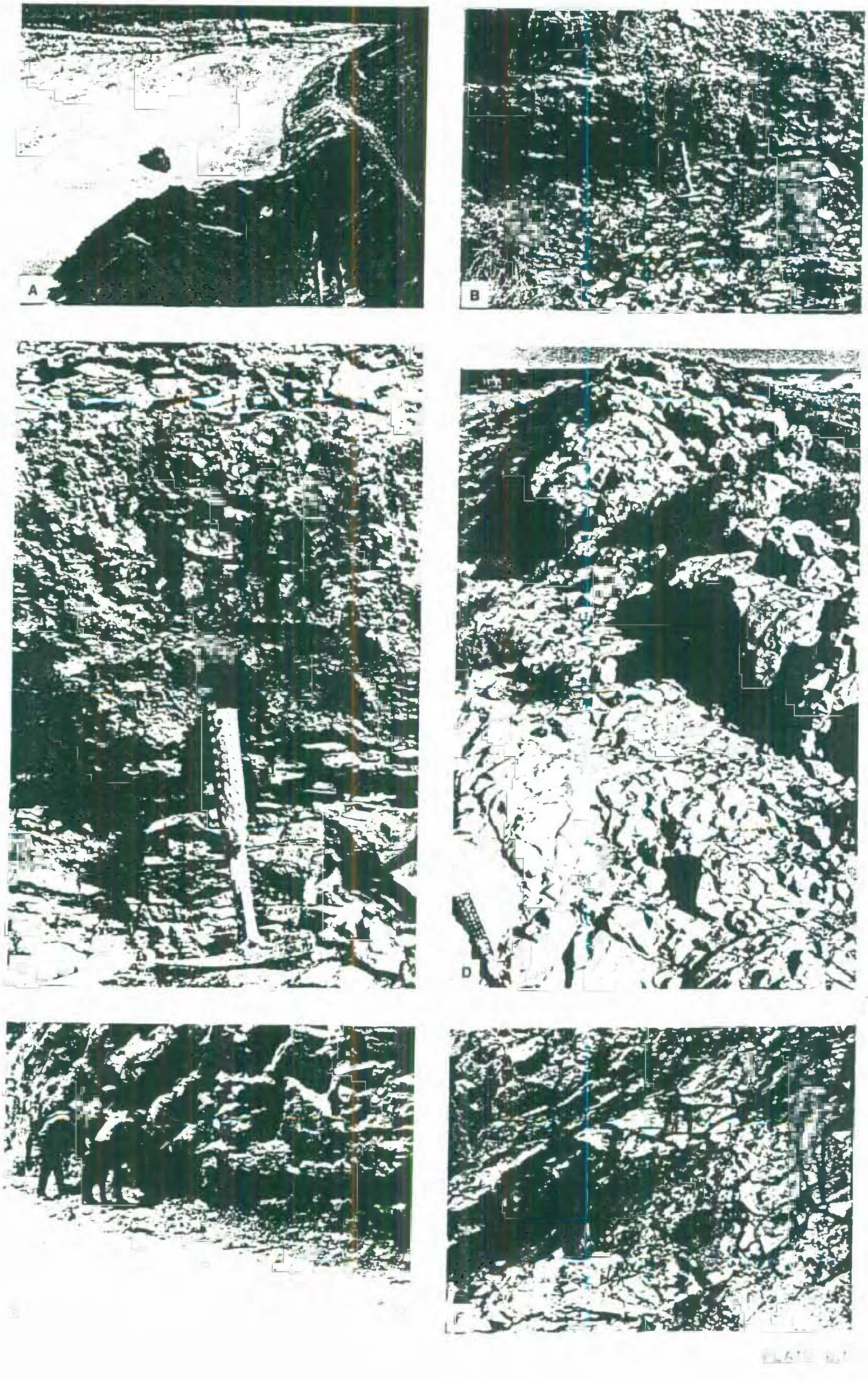

PLATE 6.1

PLATE 6.2 - LARGE SCALE AND MICROSCOPIC FEATURES OF MINERALISATION AT MAIN DOME

A. MVR exposed in adit at southeastern end of Pit 1. The ore occurs as two beds (see Figure 6.7). Top is marked by hammer, and base by arrow.

B. MVR (lower arrow) exposed in southeastern end of Pit 4. Foreground is the dip slope of the top of the Footwall Sandstone Member. Upper arrow marks contact between Middle Vale Siltstone and Median Sandstone Members.

C. Close-up of MVR at the southeastern end of Pit 4. Top of ore is uppermost dark limonite band, in which nodular quartz occurs at right. Host sediment is kaolinitic siltstone.

D. The E1 reef exposed in the central part of Pit 2 (Fig. 6.6). Hammer rests on upper surface, and dip slope in foreground marks the base of the iron oxide-quartz ore.

E. Iron oxide-quartz veins cutting well bedded sediments of the Outer Siltstone Member, below the E1 reef in Pit 2.

F. Polished thin section of oxidised MVR. Boxwork texture is after pyrite. Grey areas are haematite; dark areas are quartz and kaolinitic siltstone; bright arrowed patch is native copper. Core PR450, depth 91.6 m.

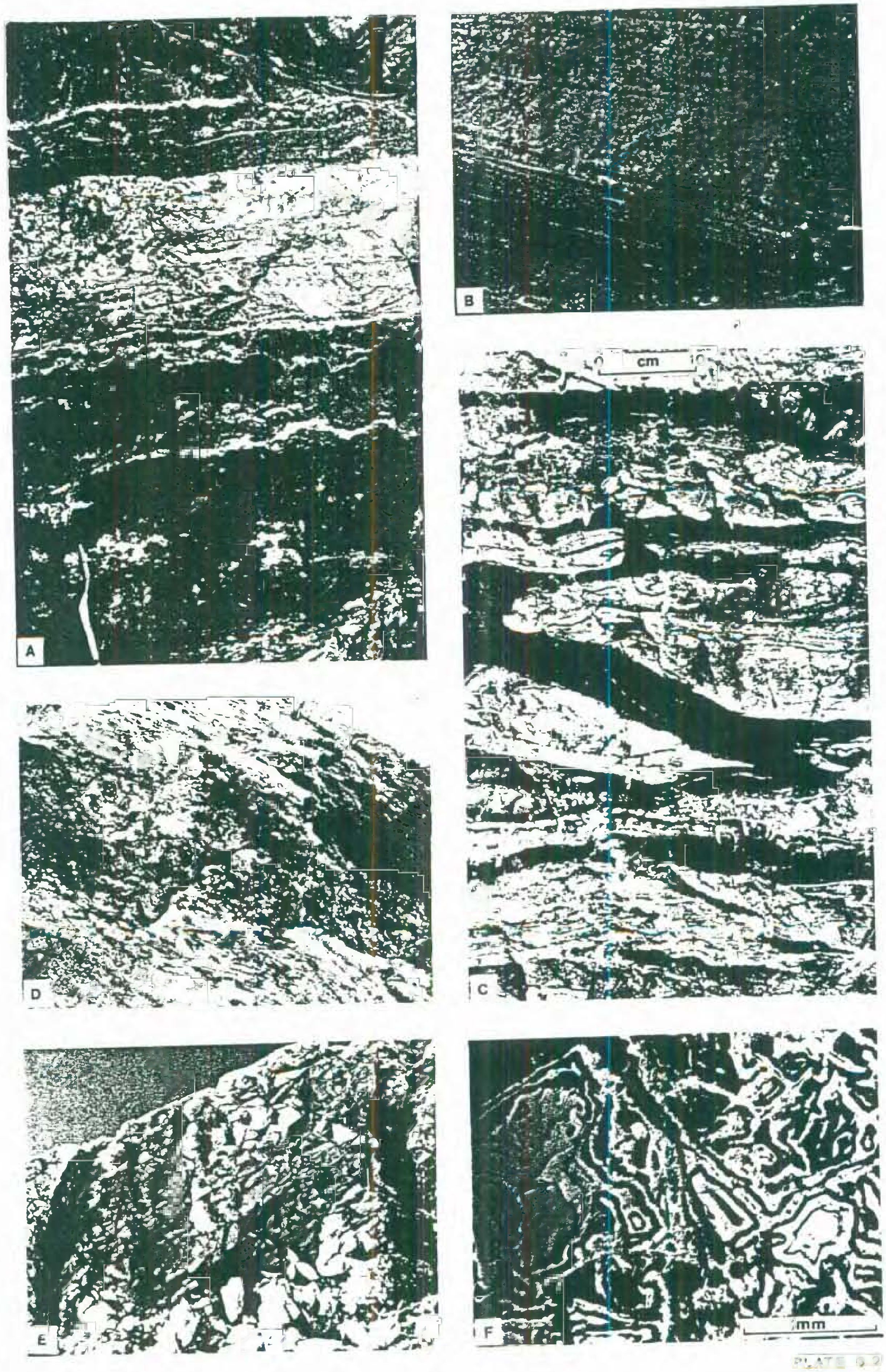

PLATE 9.2