APPENDIX 4

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THE GEOLOGY OF MADAM PELE RIDGE, THE GRANITES REGION, N.T.

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SUMMARY

The ridge north of Madam Pele Hills was mapped at 1:5 000 scale and selected rock chip and dump samples taken. Units of the Davidson and Madigan Beds have been recognised, and large elongate amphibolite bodies have been intruded. An interpretation of the structural data shows that the area suffered at least 4 deformations, being:

D_1 Regional scale broad folding about a north-east striking axis.

D_2 Regional dextral strike-slip shearing, with the development of compressive splay shears and associated folds and joints.

D_3 Regional sinistral strike slip shearing with the redevelopment of existing shear planes in a dilational sense, and crenulation of some F_2 fabrics.

D_4 Large scale regional sinistral strike-slip shearing and development of splay shears along different planes and associated F_4 folds.

Much of the outcrop shows no gold mineralisation, but some anomalous gold values have been obtained in the north-east. However, extensive colluvial workings attest to the presence of gold which was probably shed from an eroding Tertiary river channel. The source of the gold is postulated to have been to the north-east, located in a favourable D_4 structural trap involving Davidson Beds and a magnetic granite.

A vacuum soil sampling program is proposed to test this theory.

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1.0 INTRODUCTION

1.1 Location and Access

Madam Pele Ridge, located just north of the Madam Pele Hills, is 54 kilometres by road south west of The Granites Gold Mine. Access is readily attained via the Mount Neverest exploration track to its junction with the old Tanami Downs Stock Route, then east to the Madam Pele base-line - a distance of 21 kilometres from the DBS haul road.

The Madam Pele Ridge is a low north-east striking ridge of quartz-rich scree material, reaching heights of no more than 2 metres above the surrounding sandy plain. The area is covered in light to dense mulga scrub.

The base-line along the ridge has a direction of 076°25'02" (AMG), with the local grid co-ordinates of 16 600E / 10 000N being at 593 088E, 7 714 859N (AMG).

1.2 Extractive History

The area has been tested fairly thoroughly by early prospectors, as testified by the prevalence of dry blowing gravel mounds throughout the area. Significant encouragement was generated in the area between 17 500E & 18 400E to warrant the digging for apparent colluvial/alluvial gold shedding from a weathering Tertiary river channel, and for the digging of pits and shafts estimated to be at least 2 metres deep within quartz veined chlorite schists and sheared amphibolitic rock.

A circular area 15 metres in diameter has been intensely worked by dry blowing methods at approximately 15 650E / 10 100N.

1.3 Previous Work

A diamond hole was drilled by Geopeko on one of the "Pioneer" prospects at 15 300E / 9 970N. The hole was angled at 55° towards 331° (M).

A number of regional RAB and ground magnetic traverses were made in 1986, two of these crossed the present base-line on the western end of the outcrop.

During 1990, further RAB drilling was undertaken at 25 metre spacings on cross-lines approximately 1 kilometre apart, giving valuable bedrock information over most of the strike length of the ridge.

A grid has been established, with the base-line surveyed at 200 metre intervals, and cross-lines surveyed at 1 kilometre intervals. The start and finish holes on each of the RAB lines have also been surveyed.

2.0 GEOLOGY

2.1 Methods used

The gridded area was mapped at 1:5 000 scale, and maps draughted at this and 1:25 000 scale. Air photographs at 1:25 000 scale (Madam Pele Hills I/R Runs 1, 2 & 3, 1989) were used for photo-interpretation. Although there is abundant white quartz and cherty quartz scree on the ridge and surrounding sandy flats, outcrop is strictly limited. The geology has been interpreted on structural readings of available outcrop, and on the logging of the RAB cuttings. Unfortunately, due to extensive slumping of the finer grained chloritic schists, structural readings of these units are unreliable, and provide a spread of data.

2.2 Layered Succession

Two groups of lithologies can be readily identified, being:

(1) *Clean, micaceous schists interbedded with siltstones, arenites and greywackes.* The inferred base of these sediments is dominated by the finer grained quartz-sericite schists and meta-siltstones, which outcrop as silica replacement rocks loosely grouped as cherts. Arkoses, arenites and greywackes appear higher in the sequence.

(2) *Chloritic schists, being* ***meta-volcanics*** *and fine grained laminated* ***argillaceous sediments****, with dark grey to graphitic shales and schists.* The volcanic component grades from basic to intermediate in composition (fine grained tuffs grading to felsic tuffs) with a very thin acid tuff component (distal facies?) near the top of the group. Fine grained metasediments (chlorite-sericite shales and schists with minor graphitic shales or schists) are interlayered with the volcanics, and become more prevalent near the top of the sequence. Chlorite-garnet and chlorite-andalusite schists are also present.

Strongly chloritic schists outcrop as limonite rock, and sericite rich schists outcrop as cherty rocks. Laminated chlorite-sericite schists outcrop as banded or laminated iron-chert units.

The first group can be identified with the Madigan Beds recognised elsewhere; the second equate with the Davidson Beds.

2.3 Intrusive Units

The oldest intrusive rock (based on structural history) is a medium to coarse grained granite. Outcrops of this are rare, being confined to narrow zones within the body of granite at Madam Pele Hills. Here the main (younger) granitic body is a weakly biotite granite, grading to granodiorite. Quartz often has a graphic habit.

Horneblende and actinolite-horneblende amphibolites, varying in grain size from dolerite to gabbro, intrude as lensoid or linear bodies parallel to the main structure. These bodies vary in width from a few metres to over 200 metres, are rare in outcrop, and often have a strong shear fabric. Some bodies may show chlorite alteration, particularly when in sheared contact with chloritic rocks.

Two types of quartz veins can be recognised, being;

- smoky blue-grey quartz in discrete cross-cutting and parallel veins, and
- white milky quartz in veins or "reefs" parallel to the local schistosity.

The latter type can be massive, or rarely crystalline (with radiating masses of quartz needles). The former only occurs as massive quartz.

2.4 Metamorphism and Alteration

All lithologies have suffered metamorphism to at least Lower Greenschist Facies with the development of chlorite schists in iron rich (mafic & intermediate) units, and sericite schists in the pelitic units. Garnet schists are common within certain chlorite schists of the Davidson Beds, but andalusite schists were not observed.

Locally, higher metamorphic grades are seen with the development of biotite schists within suitable units of the Madigan Beds, and with the recrystallisation of horneblende (+actinolite) along shear planes within certain amphibolite bodies.

Locally, muscovite schists within the Madigan Beds and chlorite-mica schists within the Davidson Beds show a crenulation lineation - rarely some show 2 such lineations (e.g. RAB cuttings of chlorite-biotite schist at 17 750E/9 875N).

There is no evidence of a hydrothermal alteration mineral assemblage such as local silicification, or regional sericitisation and chloritisation with random mineral orientation.

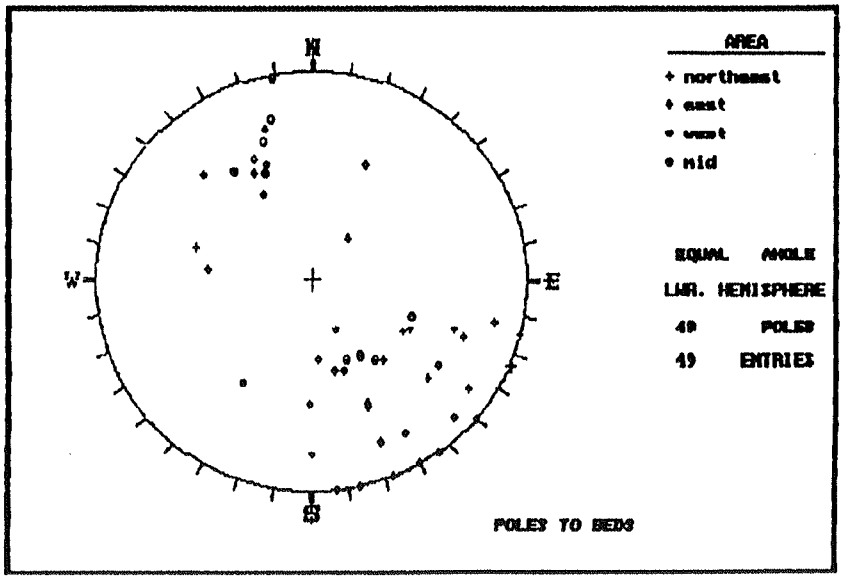
2.5 Structural Geology

All lithologies have suffered shearing or the effects of regional shearing to various degrees, with the development of a schistose fabric parallel to the local shear plane in strongly sheared rocks, and a weak fabric±joints±folds in weakly sheared rocks.

2.5.1 Folds and Bedding

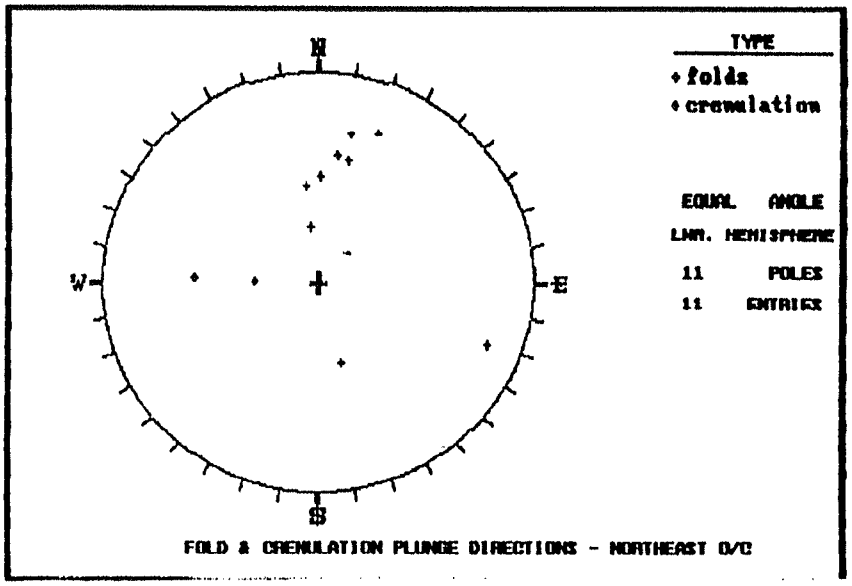
Outcrop along Madam Pele Ridge forms a narrow anticlinal structure, plunging gently to the south-west. Davidson Beds form the core of this anticline, with micaceous schists of the Madigan Beds on the limbs.

The quartzites, meta-siltstones and greywackes dip mainly to the north-west, with local variations. The following stereoplot of poles to bedding planes shows a broad scatter of bedding attitudes, but bedding is more consistent in the north-east (21 300E to 21 600E) outcrop. This area is separate from the main ridge which has suffered extensive shearing, so a clearer picture of fold relationships is obtained.



Most bedding strike directions are to the north-east, either dipping at shallow to moderate angles to the north-west, or at moderate to steep angles to the south-east.

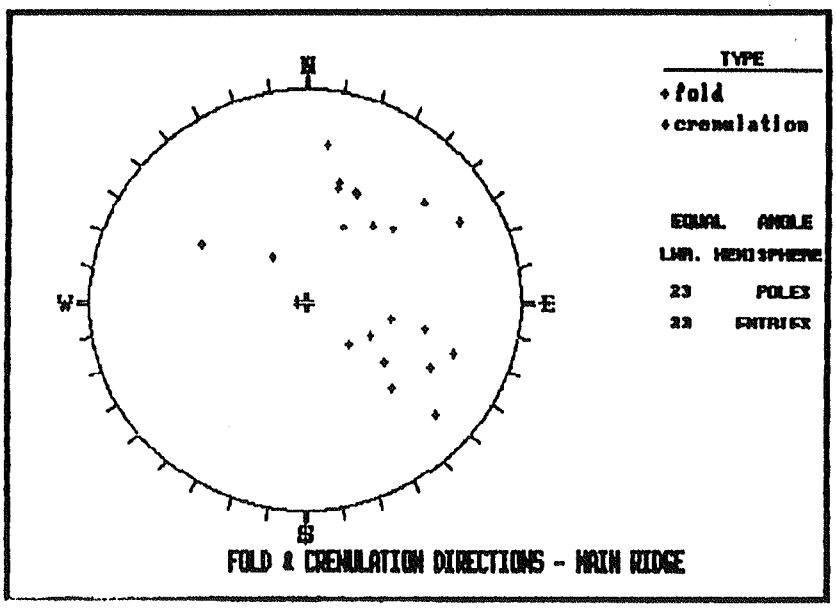
Broad, open folds (no plunge direction measured, but appear to be to the north-east) can be seen within fine grained units of the Madigan Beds in costeans across the main ridge. In the north-east outcrop area the greywackes have been (open) folded about a north-south axis, plunging 10° to 50° to the north. Locally, these folds are overprinted by a crenulating fold, plunging 40° to 60° to the west.



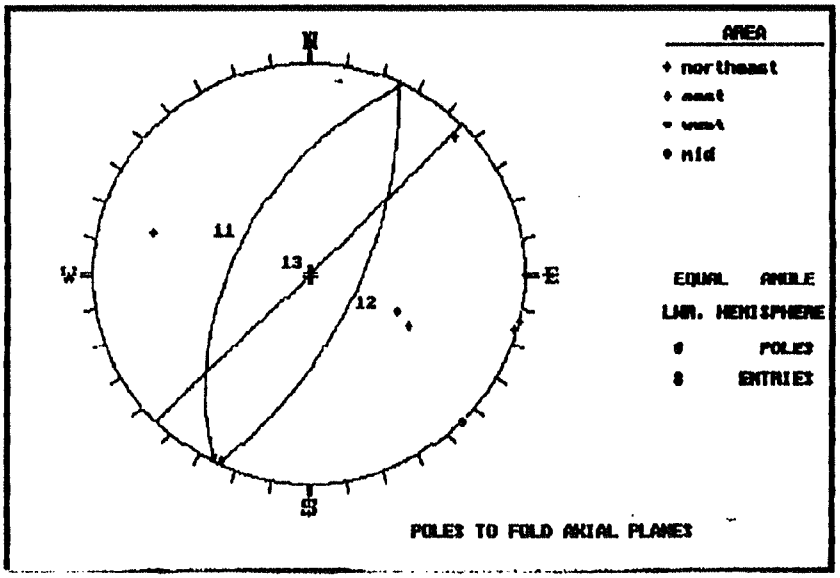
Along the main ridge fold plunges, as measured on narrow to tight folds principally in chert outcrops, plot into four distinct groups, being:

(a) 35° towards 024° (m)
(b) 34° towards 043° (m)
(c) 23° towards 114° (m)
(d) 36° towards 131° (m)

This distribution can be seen in the following stereoplot. Note that the differentiation between the last two plunge groupings are tenuous, and another interpretation may include only a third grouping of 30° towards 120°.



Attitudes of fold axial planes were difficult to measure due to the nature of the exposures, but of the 11 planes measured, 3 groups can be averaged as shown in the next plot.



The measured planes are:

(11) strike 026°, dip 51° NW

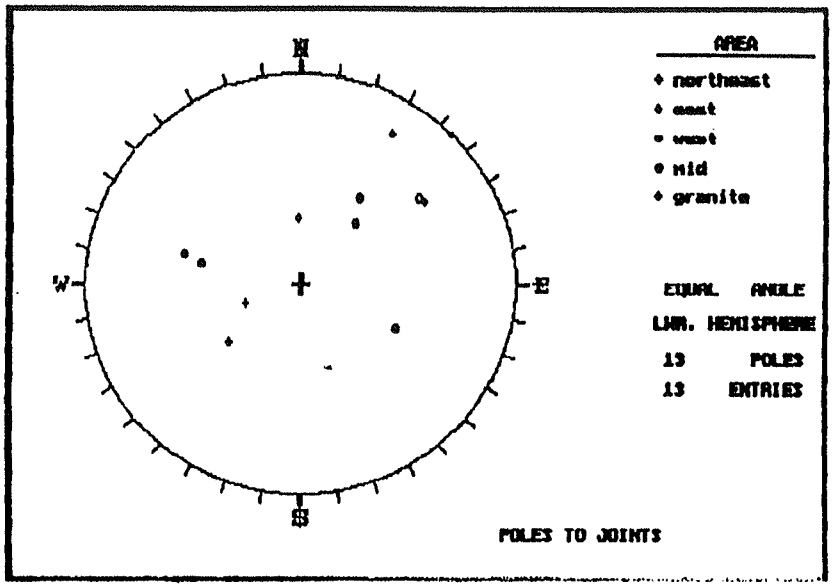
(12) strike 025°, dip 64° SE

(13) strike 045°, vertical.

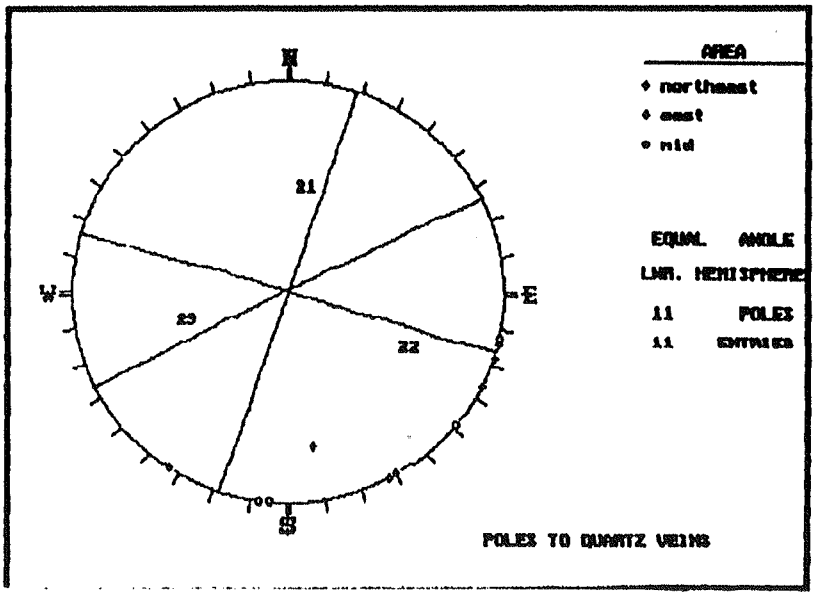
Obviously, planes 11 & 12 are the same fold axial plane, with errors in measuring the dip accounting for the different attitudes.

2.5.2 Joints and Quartz Veins

Joint surfaces could only be measured in the more brittle outcrops of laminated cherts (after sericitic and quartzitic schists), which proved to give a fairly broad spread of readings. Nevertheless, a rough trend is evident in the following plot of poles to joint planes to suggest a common north-westerly joint strike i.e. at right angles to the most common fold axial planes.



Similarly, a tight pattern of poles to quartz veins was not obtained, and the averages of attitudes are not conclusive. The following average planes are calculated using contoured density plots, however only 11 readings were taken, so the data set is small.



The measured planes are:

(21) strike 019°, vertical

(22) strike 106°, vertical

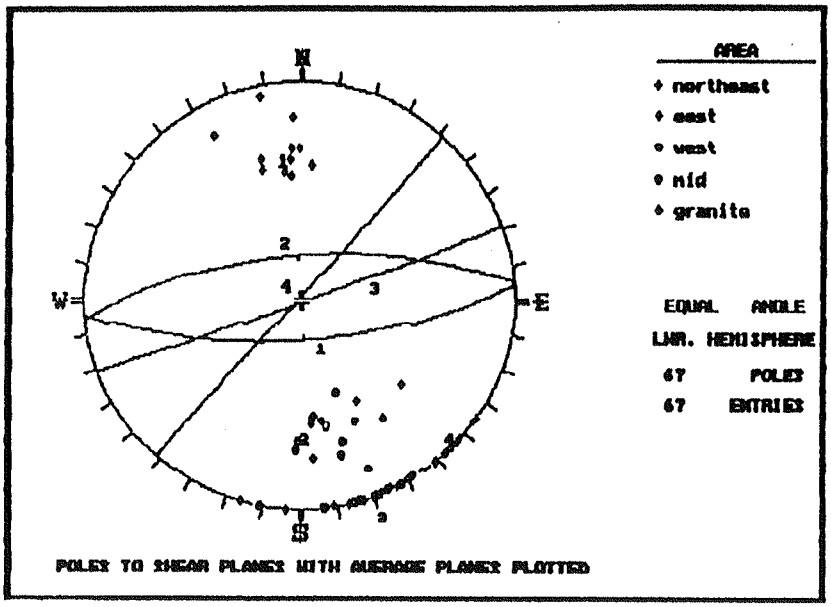
(23) strike 064°, dip 88° to the north-west

Note that planes 21 & 22 form a conjugate set.

2.5.3 Shears

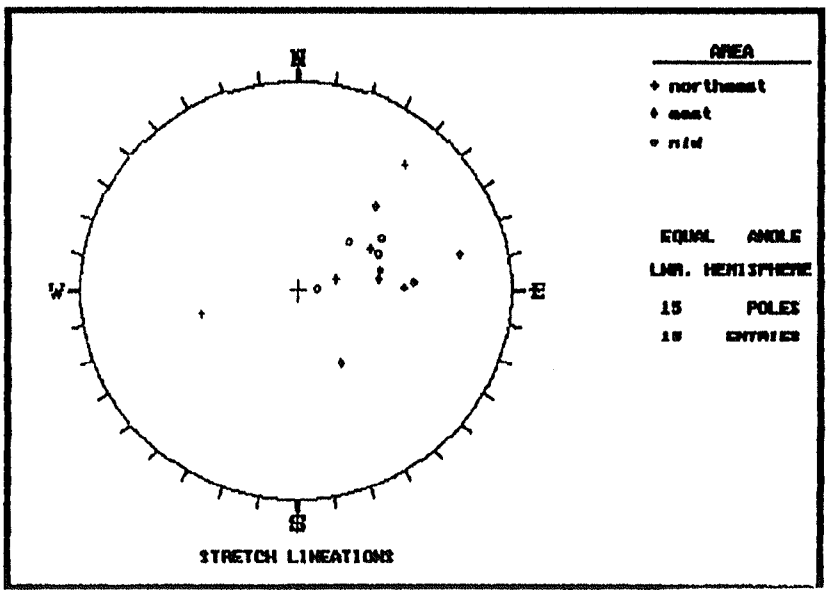
The dominant shear direction is 069° mag. (249°) which controls the extent of the outcropping lithologies. The shear plane is essentially vertical, but variations both in strike and dip occur. (Plane 3 in the following stereoplot.)

In the north-east outcrop area (21 300E to 21 600E) the common shear direction is 041° (221°), or approximately at 30° to the major shear direction. (Plane 4 on the following stereoplot). Gross movement indicators (such as gross bedding/shear relationships, indicate an overall dextral strike-slip sense of movement.



Planes 1 & 2 represent variations in dip of an essentially vertical or steeply dipping shear plane striking at 085°. This shear direction is readily observed in the granite outcrops of Madam Pele Hills, and overprints the 069° shear which is only seen (in this area) in a much coarser grained granite phase.

That the 085° shear is later than the 069° shear is also seen by its displacement of the sheared chlorite schists along the main Madam Pele Ridge, in a dextral sense.

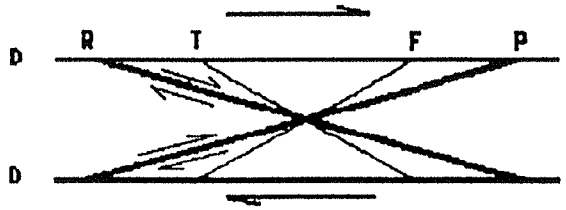


Stretch lineations are consistently to the east, or north-east within the relevant shear plane.

2.6 Interpretation

The broad north-easterly folds as seen in the greywackes north of the main ridge, and the overall shallow NW dipping beds are the result of an early D_1 fold event, developed through regional compression about a NW - SE axis. An example of this fold style can be seen on the small ridge just west of the Mt. Neverest-Madam Pele road, where the top of the ridge is formed by a shallow (10-40°) ENE plunging open anticlinally folded greywacke. A late D_1 or early D_2 intrusive event introduced small coarse granite bodies locally.

Subsequent regional dextral shearing D_2, locally along a plane striking at 069° m (plane 3) produced the major cleavage direction parallel to the main ridge. Associated F_2 folds plunge at 35° to 024°. Splay shears at 30° to this main direction developed as seen in the north-east outcrop (strike 041° m - plane 4), with local north plunging folds at 45° to this splay direction. Joints and vein quartz developed at right angles to the local fold direction. This interpretation is shown schematically on the 1:25 000 Interpreted Geology Plan, and the shear, fold and joint relationships can easily be interpreted in the Reidel Dextral Strike-slip Shear Array, as below:



Reidel Array for Dextral Shear Zone

Only relevant planes are shown, where D is the bounding shear plane, R is the dilational splay direction, P the compressional splay direction (at 30° and -30° to the D direction respectively), F is the plane of pure flattening (folds) and T is the extensional plane (at -45° and 45° to the D direction respectively).

The relation between the folds and shear direction show the shear regime to be dextral, and compressive, suggesting that the main shear direction is a P splay shear from a regional dextral shear regime striking at 099° (279°). Major shear zones at Grimwade Ridge strike in this direction, and another bounding shear with a similar strike probably exists between Officer Hill and Madam Pele Ridge beneath extensive cover.

Later reversal of this shear sense during D_3 resulted in crenulating folds overprinting the earlier F_2 folds in the north-east, and minor sinistral movement along existing shear planes. Joint sets at right angles to earlier joints and localised folds F_3 plunging 23° towards 114° also developed. Being a sinistral strike-slip shear, the shear planes were in a dilational sense, being in the R direction of a Reidel Array.

The effects of D_1, D_2, and D_3 can be observed at Hordern Hills with the same directions and sense of movements.

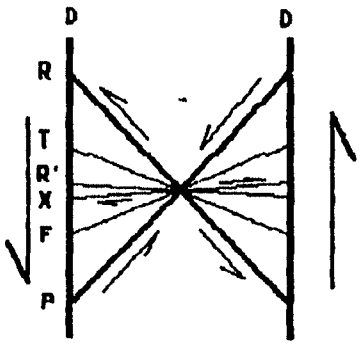
A major intrusive event resulted in the emplacement of much of the Madam Pele granite body during or subsequent to D_3, and the emplacement of amphibolitic material along dilational shear zones, i.e. parallel to the main shear direction. Cover lithologies, in particular the Muriel Range Sandstone, were deposited.

A strong, locally compressional shear event D_4 resulted in dextral strike-slip shearing along a different strike direction, 085° m (shear planes 1 & 2) and in discrete shear zones. F_4 folds associated with this direction plunge 34° towards 043°, but joints and quartz filling veins did not develop. This event affected the amphibolite and granite bodies, with the corresponding recrystallisation of horneblende within the amphibolites.

Regional photo-interpretation south of Madam Pele Hills shows bedding of the Muriel Range Sandstone to have been rotated and displaced along a north-south striking plane, in a sinistral strike-slip sense (see 1:25 000 scale interpreted geology map). This shear plane is visible in the infra-red photographs as a narrow line, and on the ground is delineated as a low rise of greenish lateritic pisolite material mixed with aeolian sand.

Epidote alteration is associated with this structure where it truncates the outcropping Davidson Beds at 15 700E/10 100N; epidote is also seen in an early RAB hole south of this location.

A strong sinistral shear zone striking north-south would produce a compressional dextral cross shear striking at 086°, as shown in the following Reidel Shear Array.



REIDEL SHEAR ARRAY FOR SINISTRAL STRIKE-SLIP MOVEMENT

D is the bounding shear plane, R is the dilational splay direction, P the compressional splay direction (at 30° and -30° to the D direction respectively), F is the plane of pure flattening (folds) and T is the extensional plane (at -45° and 45° to the D direction respectively). X and R' shears are conjugate shears to P and R at -86° and 86° respectively with an opposite sense of movement.

This shear direction can be incorporated into the regional north-west striking shear zone if it is considered as a splay from a 330° striking sinistral strike-slip shear direction. The regional C. Giles mapping of The Granites and Tanami sheets show structures with this direction, and recent mapping in the McFarlanes area also shows sinistral strike-slip shearing with considerable movement to have been the last major event (post Pargee Sandstone).

3.0 GEOCHEMISTRY

3.1 Regional Rock Chip Sampling

Of sixteen rock chip samples taken from selected outcrops, 4 returned gold values of 0.02 ppm or greater. These were taken from a brecciated chlorite ± sericite ± graphite schist at a sheared contact between Davidson Beds and Madigan Beds, near the eastern outcrop of the main Madam Pele Ridge. The samples are:

No	EASTING	NORTHING	GOLD	ARSENIC
320	21190	10220	0.15	310
321	20800	10090	0.32	35
322	20810	10100	0.053	120
323	20780	10100	0.020	95

Samples are prefixed 313***, gold and arsenic values in ppm.

Samples No. 313320 and 321 came from chlorite schist sheared with a strike direction of 053° to 059°. This direction is interpreted to be a first order splay at 30° from the local 085° striking D_4 shear direction.

The remaining samples returned gold values in the range 1 to 7 ppb, and arsenic ranging 5 to 35 ppm.

3.2 Historical Workings

The whole of the mapped area shows evidence of having been tested by dry-blowing methods for alluvial or colluvial gold deposits - small scattered dry-blowing dumps can be found mainly on the north-west side of the ridge. These dumps are quite numerous on the quartz gravel flat between 18 000E and 18 500E, while south of the ridge extensive colluvial dryblow workings can be seen in this area following the contact between sheared chloritic tuff (chert-limonite schist), and graphite-chlorite schist.

Other intense but shallow colluvial workings can be seen along the same lithological horizon between 17 400E & 17 550E.

Trenches or pits probably up to 1 metre deep were dug into chlorite schists, often on the sheared contact with narrow amphibolite bodies, at 18 350E, 18 175E, 18 050E, 17 520E, and 17 200E. Apart from chlorite schist and amphibolite, calcrete is a common mineral on the dumps (except for the pit at 17 200E, where chlorite schist and vein quartz are the common rock type).

A thin, eroded calcrete capping rests on graphite-chlorite schists, forming a narrow (up to 10 metres wide) and linear but broken ridge of low relief. In areas where dryblowing operations have been extensive, this calcrete cap is well exposed - the colluvial diggings are always immediately downslope of this cap.

As linear calcrete ridges are recognised elsewhere in The Granites and Tanami region as being remnant Tertiary river channels, it is reasonable to assume that a drainage channel was along the ridge as well. During the Tertiary the graphite-sericite schists would have formed a topographic low compared with the quartz-sericite schists and quartzites of the Madigan Beds, and hence would be the bed of a Tertiary creek. Subsequent selective lateritisation and erosion of the Tertiary land surface would result in a topographic high formed by the calcrete channel.

It appears by the proximity of colluvial operations to the calcrete cap that gold is shedding from the calcrete (channel). The direction of flow would have been towards the south-west where large calcrete and salt pans exist today, implying that the source of the gold is from the north-east.

Samples were taken from these workings, from the dumps and from dry-blow areas, but none returned any gold values above background. The ANALABS method 334 uses a $HCl+HNO_3$ digestion which may not have liberated gold from an indurated clay+calcrete matrix, and fire assay methods would be more appropriate.

3.3 Costean Sampling

Costeans were dug across strike next to trenches and pits dug into chlorite schists, as listed in the following table.

LINE	FROM	TO	LENGTH
15 700E	10 110N	10 070N	33m
10 100N	15 700E	15 688E	12m
18 365E	10 020N	10 120N	100m
18 190E	10 060N	10 110N	50m
18 041E	10 117N	10 075N	62m
17 525E	10 074N	10 110N	36m
17 205E	10 195N	10 213N	18m

At 18 365E the amphibolite/chlorite schist contact showed little alteration, but significant calcrete cementation along cleavage planes.

Gold values were returned in the range <1 to 68 ppb, and arsenic values were in the range <5 to 65 ppm. The 68 ppb gold value came from costean 17 205E, 10 212N.

The costean sampling results confirm that the excavations were not after bedrock gold mineralisation.

4.0 SUMMARY AND RECOMMENDATIONS

The Madam Pele Ridge is a structural element within a major north-west trending shear zone, with an estimated width in excess of 50 kilometres, and strike length in excess of 700 kilometres.

Units of the Davidson Beds and Madigan Beds are exposed along the Madam Pele Ridge in a narrow (stretched out) D_1 anticlinal structure. These have suffered intense dextral strike-slip shearing along an east-north-east direction being a compressive splay direction from a regional ESE-WNW dextral shear D_2. Associated folds and joints developed, with local attitudes determined by the attitude of local splay shears. Units of the Davidson Beds suffered more intense shearing due to the nature of the original lithologies, being basic to intermediate tuffs (chlorite schists), and shallow marine chemical sediments (graphite-chlorite schists).

A relaxation along the shear planes D_3 produced dilational sinistral shearing and associated folds, with localised crenulating folds. Dilational shear zones allowed the introduction of amphibolitic material in elongate and parallel lenses, and the Madam Pele Hills main granite body intruded.

A major regional sinistral shear event D_4 caused dextral strike-slip shearing along an east-west axis, with north-east plunging folds.

Ding has suggested that gold mineralisation was introduced during the first shear event, and subsequent tectonic events have remobilised this mineralisation to form ore zones in selected localities. From an inspection of Dead Bullock Ridge and Callie ore bodies, it is apparent that gold mineralisation was introduced by the D_2 shear event, and remobilised by at least the D_4 shear event. *[If the amphibolite bodies were folded by the D_4 event, as at Dead Bullock Soak, large dilational structural traps would have formed with the consequent introduction of remobilised ore-bearing fluids.]*

Anomalous gold-arsenic mineralisation is present at the eastern end of the Madam Pele Ridge, within sheared, brecciated and quartz veined chlorite schists. Gold is assumed also to have been carried from the east by a Tertiary river channel from an unknown location beneath aeolian sand cover.

Shear Zone geometry predicts the existence of a dilational D_4 shear plane striking at 094° (m) which could provide the locus for remobilised gold mineralisation. The 053° shear direction should not be overlooked either, as this has been shown to be mineralised. Interpretation of the aeromagnetic data east of the main ridge suggests the presence of a number of magnetic bodies, one of which is a magnetically noisy granite, with a structural break in an approximately east-west direction. A sheared contact between magnetic Davidson Beds and this granite body would form an ideal structural inhomogeneity suitable for the injection of remobilised gold bearing fluids.

It is suggested that a close spaced vacuum soil sampling program be implemented over the area under sand cover to the north-east of the ridge, covering in particular the structural breaks identified by the aeromagnetic data. Records of previous vacuum drilling in this area should also be checked, as some holes may have bottomed in calcrete. It should also be noted that BLEG assays of calcareous and carbonaceous material are unreliable.

Further investigation of the rock-chip gold anomalies in the area 20 800E to 21 200E is also recommended.