

HORDERN HILLS (EL 2366)

APPENDIX

MAPPING REPORT

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THE GEOLOGY OF HORDERN HILLS, EL 2366,
THE GRANITES REGION, N.T.

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SUMMARY

Geological mapping of the Hordern Hills has resulted in the identification of the main volcano-sedimentary beds found elsewhere in The Granites - Tanami area. All lithologies have been broadly folded then sheared to varying degrees.

Two phases of shearing have been identified:-

- (1) Regional D_2 dextral strike slip shearing has affected the Hordern Hills area in a compressional sense, with the corresponding development of NE striking folds.
- (2) Regional D_3 strike slip shearing along essentially the same planes resulted in dilational shearing in the Hordern Hills area.

Amphibolites and gabbros intruded into dilational zones subsequent to the D_3 event.

Peak metamorphic conditions are interpreted to have occurred during the compressional D_2 event, with the development of chlorite, sericite, andalusite and garnet schists. Andalusites retrograded to quartz-sericite masses during the dilational D_3 event.

Gold mineralisation is weak and patchy where it has been identified, and is suspected to have been introduced during D_2 and modified by D_3 . The Davidson and Blake Beds have been tested with no success, and rock-chip sampling indicates that the Madigan Beds (greywackes) are the only prospective units.

A modest exploration program is suggested, based on testing a probable D_2 dilation zone under scattered cover, immediately north of Hordern Hills.

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PLANS IN BACK POCKET

Hordern Hills Geology 1:5 000 Scale
(with Cross Section and Schematic Structural Interpretation)

Hordern Hills Interpreted Geology 1:25 000 Scale

1.0 INTRODUCTION

1.1 Location and Access

The Hordern Hills are located some 15 kilometres south of The Granites Gold Mine. Access is gained by either the Tanami Highway to the Hordern Hills turn-off at 15 kilometres from the Ivy Camp, or alternatively via the Grimwade Ridge road (Chad Street).

A grid has been established with the base-line at 061°04'29" (AMG), centred on the Trig Station at 638 061E, 7 716 253N (AMG) being local grid co-ordinates 30 000E / 10 000N.

1.2 Previous Work

The first work by NFM was a reconnaissance soil and magnetic survey of 5 traverses over the eastern main ridge of Hordern Hills. Discrete units within the Davidson Beds gave anomalous gold values in the range 10 to 40 ppb, over backgrounds of less than 2 ppb.

The area has been gridded with cross lines at 400 metre spacing, and RAB drilled to bedrock on 25m centres on these lines. Anomalous areas thus defined were angle RAB drilled to an average depth of 52 metres, on 25 metre centres along lines 100 metres apart. The area has also been extensively rock chip sampled, and regional vacuum drilling has been undertaken on broad sampling centres surrounding the hills. A number of costeans were also dug, now backfilled, mapped and sampled.

1.3 Historical Workings

Small dry-blowing mounds are scattered throughout the area, indicating testing by early prospectors. Some more significant workings can be found on the north-west flank of the prominent quartz strike ridge, at line 29 200E. Here two small pits have been gouged immediately downslope of a northwest striking, narrow (smoky) quartz vein.

2.0 GEOLOGY

2.1 Methods used

The area was mapped at 1:5000 scale using the existing 400 x 50 metre grid - extra pegs were surveyed into the baseline at 100 metre intervals between 26 400E and 31 200E, and selected other lines extended to cover outlying outcrops. RAB chips were also re-logged, as well as spoil from the costeans.

Air photographs from the Grimwade-Hordern Hills series, runs 1 & 2 were interpreted at 1:25 000 scale.

2.2 Lithologies

The stratigraphically lowermost unit exposed at Hordern Hills incorporates a series of very fine grained sericite+andalusite+garnet schists of the **Blake Beds**. Andalusite (or possibly staurolite) has retrogressed to sericitic masses, and fine grained magnetite is present in varying amounts. These schists are typically very clean metasediments with minor mafic interbeds (possible basalts and fine grained tuffs) and rarely outcrop.

Overlying, and grading into these schists, is a thick sequence of coarse to medium grained mafic tuffs, basalts (dolerites?) grading to intermediate volcanics, and chloritic shales. Andalusite schists and garnet schists can also be found. Graphitic shales grading to graphite schists are present in this mixed shallow marine/volcanic sequence usually identified as the **Davidson Beds**. The chloritic lithologies generally outcrop as limonitic masses, and finely laminated silica-limonite structures can be well preserved representing laminated chlorite-sericite schists. Often, the more graphitic schists are silicified to form bold outcrops of black, amorphous quartz bodies.

These beds grade into a deeper marine sedimentary sequence of greywackes, siltstone and shales of the **Madigan Beds**. The coarser units are typically composed of grains of quartz, feldspars and detrital micas in a siliceous cemented matrix, while the finer grained beds are variably laminated quartz-sericite schists or fine grained quartzites. These schists often outcrop as siliceous, structureless cherts, particularly when close to, or within zones of shearing. The inter-relationships between these three units is schematically shown in the interpreted cross section on the 1:5 000 geology map - back pocket. ?

The silicification of the meta-sediments and meta-volcanics is a surface weathering feature, and does not necessarily indicate hydrothermal alteration of these beds.

Only exposed by RAB cuttings is a group of intrusive rocks loosely termed gabbros, but in fact grade from fine grained hornblende dolerite to coarse grained actinolite-tremolite gabbro. The grain size variation may be due to boundary crystallisation effects within large intrusive bodies, or due to different phases of intrusion, forming discrete, but proximal bodies.

Parallel quartz strike ridges form prominent outcrops in the Hordern Hills area, varying in thickness up to 15 metres across. Two types of quartz are present, viz;

- ✓ smoky quartz in discrete cross-cutting veins, and

- ✓ white milky quartz in veins or "reefs" parallel to the regional schistosity.

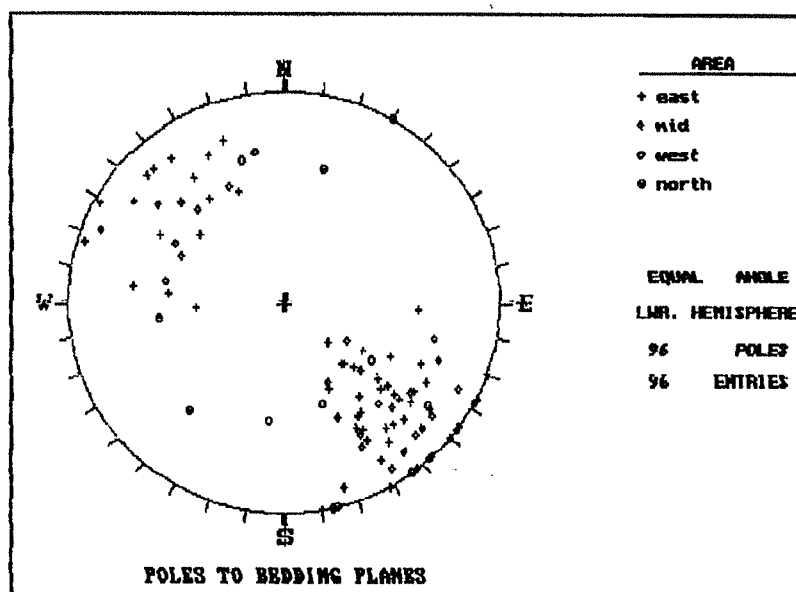
The latter type can be massive, crystalline (with radiating masses of quartz needles), or replacement (e.g. of cumingtonite needles). The former only occurs as massive quartz.

2.3 Structure

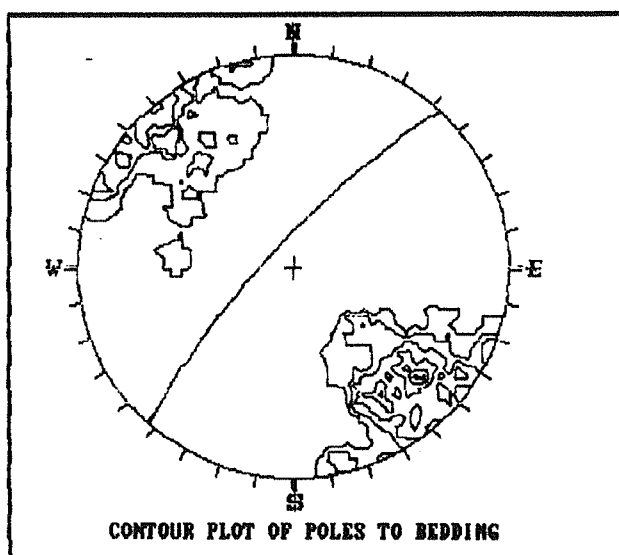
2.3.1 Folds

The metasedimentary and metavolcanic sequence has an overall north-easterly strike, and north-westerly dip. There is an apparent anticlinal fold closure north-east of Hordern Hills

; the south-eastern limb of this fold has apparently been consumed by a magnetically noisy granite.

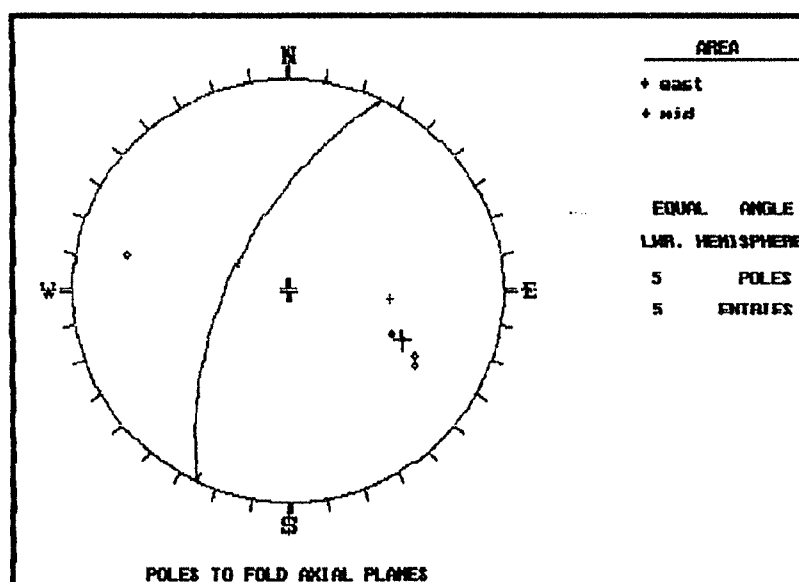


This stereonet shows poles to bedding planes, with different symbols denoting different areas within the Hordern Hills outcrop. The poles plot into 2 main groups, striking to the north-east, with steep dips to the south-east and north-west. Bedding planes near the northern quartz ridge however strike in a north-easterly direction, almost at right angles to the majority trend.

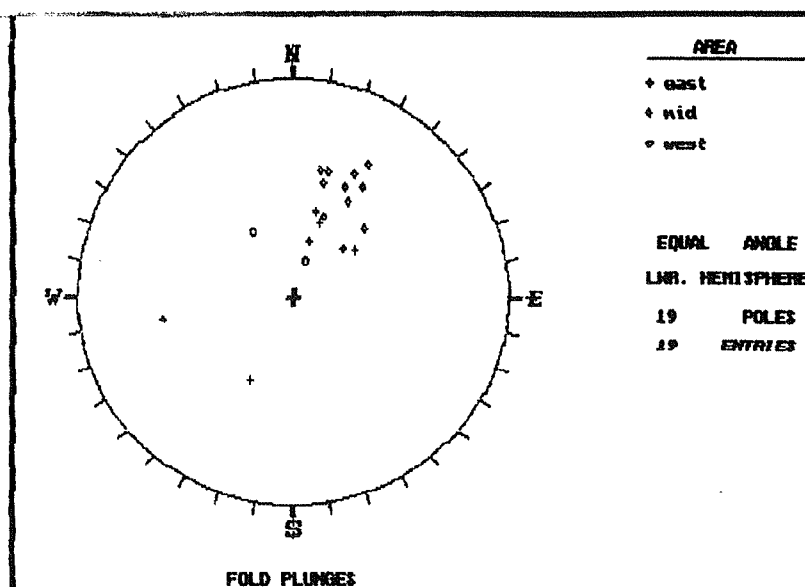


When contoured, an average bedding trend can be plotted striking at 042° , dip 75° to the north-west.

Within this general north-easterly strike direction can be seen open (in greywackes) to tight (in tuffs & graphitic schists) folds with a fairly consistent plunge direction of 53° towards 025° (M), and average fold axial plane striking 025° , dipping 60° to the north-west.



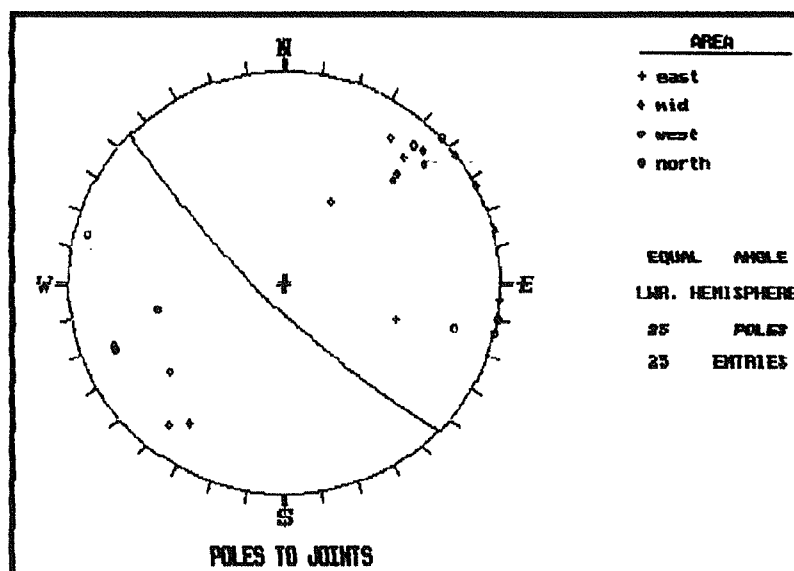
The earlier folds have been refolded in this direction:- an excellent example of a refolded fold can be seen at $30\ 110E / 9\ 970N$.



In the eastern part of the Hordern Hills outcrop area, the folds have a fairly consistent plunge of around 53° towards 026° . On moving to the south-west, the fold plunges become shallower (average 32°), then change direction such that the beds more often strike north-westerly. Fold closures are less well exposed in this area however.

The greywackes adjacent to the prominent quartz strike ridge north-east of the main hill contain refolded quartz veins, the latest fold axis plunging at a shallow to medium angle to the south east. These folds are parallel to the folds found in the west end of the Hordern Hills (see bedding planes in the north area, in the Poles To Bedding Planes plot).

Joint planes generally strike to the north-west (steep), i.e. at 90° to the most common fold direction, however, due to the nature of the lithologies and the joint style, a large spread of readings was obtained. In the following plot an average joint plane trend has been calculated at 314° , dip 77° to the south-west.

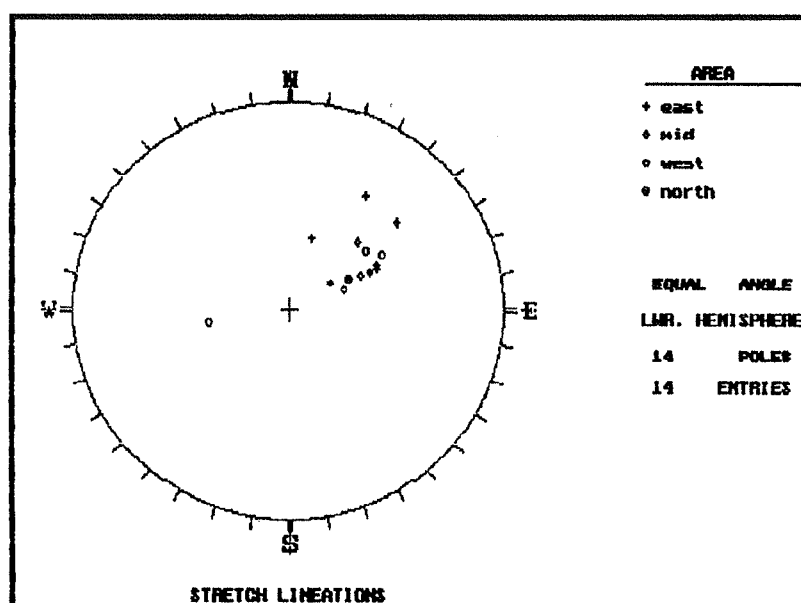
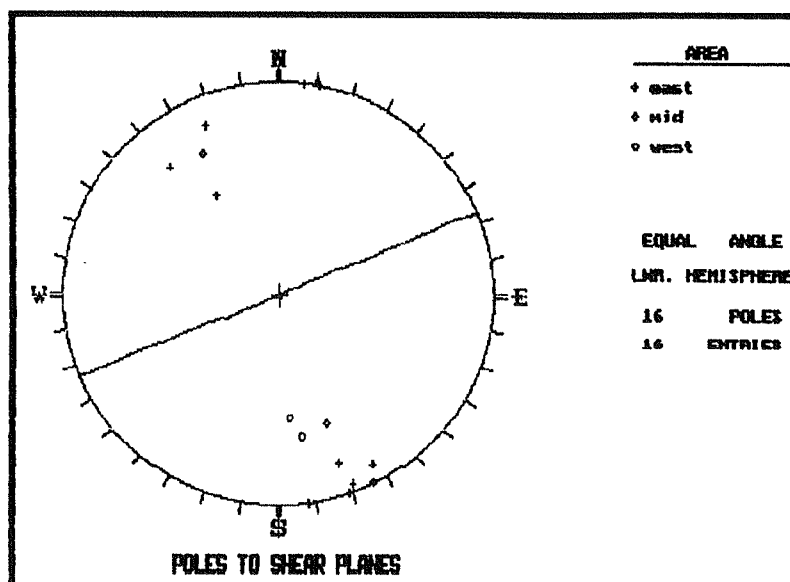


Neither the amphibolites nor the major quartz veins have been folded, being linear in form, and parallel to the overall strike direction.

2.3.2 Shears

The metasedimentary and metavolcanic lithologies have been sheared, with a dominant steeply dipping shear plane striking at around 67°; stretching lineations appear to pitch at around 30 to 60° in this plane (average 43° towards 058°), and gross movement indicators such as bedding / shear relationships indicate a gross dextral sense of movement. (A convincing movement indicator can be seen at 28 900E / 10 200N).

Apart from C-S fabrics developed within finer grained lithologies in regions of strong shearing, flattening of various lithologies can also be seen, e.g., flattening of particles in tuff beds, and the development of lozenges in silica rich units (resistant units within fine grained more ductile beds).



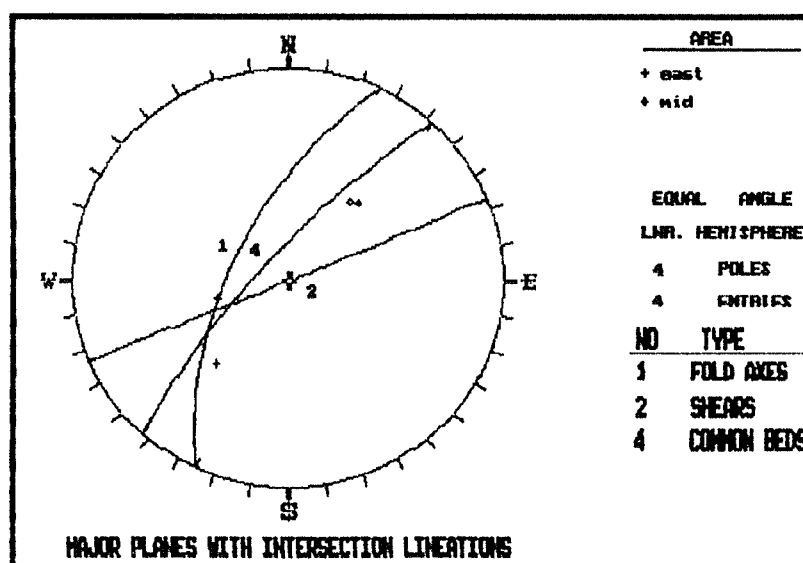
Bedding / shear relationships between 26 700E & 28 400E indicate a gross sinistral sense of movement along this shear plane.

Minor, narrow shear zones strike at 040° and 100°. These are splay shears from the main shear direction.

Neither the intrusive amphibolites (gabbros) nor the large, white quartz bodies have been subject to shearing. This implies that these are post-tectonic (or at least very late-stage tectonic), and their strike direction also indicates that they occupy areas of dilation within shear zones.

There is no evidence at Hordern Hills of a pervasive shear fabric parallel to bedding (as produced by an early (D_1) horizontal shear event - Ding, 1990, 1991). Where bedding is conclusively identified, it is at an angle to the shear fabric and intersection lineations can be readily identified.

The following plot of some intersection lineations, for the eastern and middle portions of the Hordern Hills outcrop, shows two distinct groupings. Superimposed on this plot are the average fold axial plane (1), average shear plane (2), and most common bedding orientation (4). The intersection of these 3 planes is approximately 50° towards 243° , the same as the intersection lineation group in the eastern part of the area. The angle between the two groups of intersection lineations is approximately 90° , the angle between the bedding-shear intersection and the stretch lineation is also 90° .



2.3.3 Faults

Minor late stage cross faulting has affected all of the lithologies, with displacements of only tens of metres. The direction of this faulting is generally north-south, with apparent movement in either direction.

2.4 Mineralisation and Alteration

The RAB drilling shows that all lithologies have been metamorphosed to at least lower greenschist facies with the development of sericite within the fine grained silica rich facies, and chlorite within the iron rich facies (mafic units of the Davidson Beds).

The alignment of these minerals is generally parallel to the shearing, however in the fine grained lithologies there is a pervasive bedding-parallel metamorphic fabric (even in weakly- or non-sheared rocks). Similar bedding parallel fabrics are common in mid-Proterozoic and earlier rocks throughout Australia, and are probably due to dewatering and/or lithostatic loading effects. This layer-parallel fabric is poorly developed in coarser grained units.

While rocks may be silicified at the surface, costean and drill cuttings did not indicate any lithologies to have undergone any hydrothermal silicification.

No gossans that could be directly attributed to oxidised sulphides were recognised in either drill cuttings, or in surface rocks.

Samples taken from the costeans gave a best value of 17 metres at 0.02 ppm gold from laminated and graphitic metasediments (costean 29 190E). An anomalous result of 3 metres at 0.04 ppm gold was also found within a similar lithology in costean 29 000E.

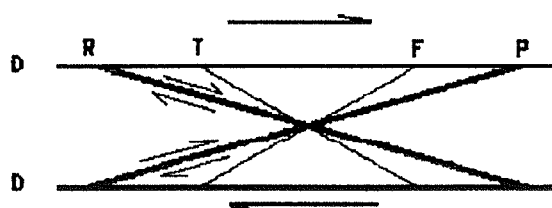
RAB and angle RAB drilling gave a maximum gold value of 180 ppb from a hole collared at 9965N, on line 29 200E, in chloritic mafic schist. Other scattered values not exceeding 67 ppb gold were obtained in drill lines between 29 000E and 29 600E, within mixed mafics and chloritic metasediments.

All angle RAB holes were drilled towards grid south, at an oblique angle to both local bedding, and shearing.

2.5 Interpretation

The Hordern Hills area has suffered 3 deformations - the first of which (D_1) was due to regional compression which developed extensive open folds, probably striking about an east-west axis.

Subsequent regional dextral shearing (D_2), locally along a plane striking at 067° (M) produced local folds (F_2) at 45° to this shear, i.e. at 025° . Conjugate joints striking at 295° to 315° also developed, following the Reidel Array 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 $+45^\circ$ to the D direction respectively).

Refer to the Schematic Structural Interpretation on the Hordern Hills Geology Plan in back pocket.

As the strong development of these folds indicates that this local shear zone is one of compression, i.e. a 'P shear' in a Reidel Shear Array, the regional shear zone or principal shear components strike at 280° (M), and would also have a dextral sense of movement. At The Granites Gold Mine, The Granites Shear Zone strikes at 280 to 285° ; and near Grimwade Ridge two shear zones also strike at 280° (Grimwade Shear, and possible DBS Shear).

A second phase of shearing (D_3) along the same planes, but with a sinistral sense of movement (i.e. a reversal of the D_2 event), resulted in a sinistral & dilational shear zone ('R shear' of a Reidel Array) along the Hordern Hills Shear, with associated weak development of folds with a north-west axial plane (F_3), and conjugate NE joint sets.

That this shear was weaker in effect than the D_2 shear is shown by the relatively well preserved dextral movement indicators, and the poor development of the less common sinistral movement indicators. This second shear event could well be considered a relaxation of the ground subsequent to the first shear event.

Being a dilational shear zone locally, the ground was now prepared for the intrusion of amphibolitic material along the wider shear zones, as well as the later introduction of silica rich fluids to form quartz strike ridges.

The chlorite and sericite schists developed during one or both of the shear events, however the highest grade of metamorphism would have occurred during the compressional D_2 phase. Andalusite and garnet probably formed during this event, the andalusites retrogressing to sericitic masses during the dilational D_3 phase (except for isolated zones of intense D_3 shearing).

It can only be assumed that the weak and patchy gold mineralisation present at Hordern Hills was introduced during one of the shear events - either during the D_3 dilational phase; or during the D_2 compressional phase with subsequent remobilisation to (weakly) concentrate in favourable locations during the latter event. Many other shear-hosted gold deposits throughout Australia have been found to have been mineralised immediately after peak metamorphic conditions have been reached.

That the only area with any detectable mineralisation is around 29 000E is also coincident with both the SW striking (dilational D_2) quartz veins, and where quartz vein and intrusive amphibolite development is greatest (dilational D_3), suggests that gold deposition was introduced by the D_2 shear and modified by the dilational, sinistral D_3 event.

The graphite schists and graphitic shales may have originally been carbonate facies sediments - one would expect carbonates to develop at the end of sub-aerial to shallow marine volcanism as indicated by the top of the Davidson Beds, and before the development of deeper basin sedimentation or flysch facies of the Madigan Beds.

3.0 GEOCHEMISTRY

3.1 Methods Used

A recent rock-chip sampling program of 93 samples taken along the grid lines returned no anomalous gold values, being in the range to 5 ppb, apart from the first sample taken at 33 205E / 10 305N, which returned a value of 0.22 ppm gold. Being the first sample, laboratory contamination was suspected, so this area was resampled. Nineteen other rock chip samples have also been taken from selected sites during the course of mapping - numbered 313 301 to 313 319. The samples were submitted to ANALABS for assay for gold (method 334) and arsenic (method 115).

3.2 Results

The repeat sample at 33 205E / 10 305N returned a gold result of 0.033 ppm with associated 390 ppm arsenic. Other rock chips in this area returned gold values in the range 0.001 - 0.082 ppm with 6 of the 12 samples recording values greater than 0.02 ppm. Arsenic values were in the range 5 - 410 ppm, with 10 samples returning values greater than 100 ppm. All of the anomalous gold and arsenic values are in meta-siltstones and arkoses of the Madigan Beds.

The regional Horderern Hills rock chip sampling returned only gold values of less than 4 ppb, and associated low arsenic values.

4.0 GOLD POTENTIAL & EXPLORATION DIRECTION

Anomalous gold values have been found in the three main lithologies at Hordern Hills through RAB drilling, but only the Davidson Beds have been tested.

Gold mineralisation is likely to be found in areas of dilational shearing, and if the mineralisation was introduced during the dextral D_2 event, dilation zones would have formed at $+30^\circ$ to the Hordern Hills Shear, i.e. with a strike direction of $100 - 280^\circ(M)$.

Such a shear direction can readily be seen on air photographs, immediately north and east of the prominent quartz strike ridge, north of the main ridge (approximate grid co-ordinates of 29 600E / 10 700N). This trend is visible at surface as rare outcrops of sheared greywacke, but most of the area is under shallow aeolian sand cover. The only significant historical workings are in greywackes on the north side of this quartz ridge (at 29 200E / 10 600N), which, apart from limited rock-chip sampling, has not been investigated.

It is recommended that a soil sampling programme (using the vacuum rig) be initiated over the NW trending shear, covering the northern flank of the quartz strike ridge (more than one shear may be present), at a sample density of say, 50 x 200 metres. Such a program between 29 100E and 30 300E, from 10 500N to 11 000N would involve the collection of only 77 samples.

Any anomalies thus defined would be further refined by more soil sampling, costeaning if the bedrock is shallow enough, or RAB drilling.

Should no anomalous gold values be found, then the Hordern Hills area can be considered to be of low prospectivity.