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Structure and veining in the Devonian-aged Mathinna–Alberton Gold Lineament, northeast Tasmania

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Abstract

The Mathinna-Alberton Gold Lineament experienced three major periods of movement from late-Early Devonian times onwards. These included:

- low-angle east-directed thrusting in the Mathinna Group during the main phase of the Tabberabberan Orogeny (D1);
- wrench faulting on northwest to NNW-trending faults (D₂); and
- reactivation of the wrench faults as dip-slip high-angle reverse faults (D₃), in a return to the far-field palaeo-stress conditions of the first phase.

Veining in the lodes is associated with D_2 dextral wrench faulting and occurs in dilational sites filled by quartz veins. The forms of the veins include laminated, brecciated, folded, boudinaged and laddered types. Overprinting relationships are common and at least three generations of quartz veins may be present. Regionally, the quartz veins comprise at least two sets of early to syn-tectonic extensional fibre veins (V₁ and V₂) which are overprinted by late ENE-trending V₃ quartz veins related to late granite emplacement. In the lode environment, laminated quartz is sulphidic and generally fine-grained due to the impurities impeding grain growth. A stylolitic cleavage developed in the laminae supports a tectonic emplacement for the mineralised veins (Mathinna). Early grey quartz veins, which may have a strong shape fabric due to cataclasis, are cut by later white quartz-carbonate veins (Golden Gate); similar relationships are to be found in the northern part of the lineament where late-tectonic quartz-sericite veins (Mt Victoria) and sulphidic extension veins (Ringarooma United) overprint at least two sets of earlier grey and buck quartz veins.

A northeast-trending transfer fault zone, inferred to lie directly beneath the township of Mathinna, causes a gross mismatch of geology on either side of this structure which requires the northwestern block to have moved six kilometres to the southwest. This structure, which also passes through the Aberfoyle tin deposit, pre-dated the gold mineralisation and was later reactivated as a zone of sinistral faulting and mega-kinking. The implications for exploration are that a transfer fault of this magnitude would be capable of:

- tapping deeper parts of the crust, thereby acting as a short-circuit escape mechanism for any gold-bearing fluids generated in that region, and
- (2) juxtaposing grossly different parts of the stratigraphy up against each other.

Prime exploration targets should be sought where D_1 transfer faults cross the gold lineament. The mudstone-siltstone host sequence at Mathinna, considered to be the equivalent to the Ordovician or Silurian-aged Turquoise Bluff Slates, may be a third ingredient required to make a major deposit.

INTRODUCTION

Regional structural studies in the Mathinna Group (McClenaghan et al. 1982; McClenaghan et al., 1993; Goscombe and Findlay, 1989; Powell and Baillie, 1992; Taylor, 1992) have shed considerable light on the structural and tectonic evolution of the Mathinna Group. Early studies on the gold-bearing structures (Twelvetrees, 1907a, b; Finucane, 1935; Threader, 1967), and more recent studies (Taheri, 1992; Roach, 1992) have highlighted some important aspects of the structural controls to mineralisation; for example, the role played by faulting in the mineralising process, the timing of mineralisation with respect to the regional folding, the dextral wrench nature of the Mathinna-Alberton 'gold corridor', and the role played by the granodiorites in providing the heat which drove the hydrothermal system. Threader (1967) described two periods of faulting related to mineralisation: an early fold-related northwest-trending set of faults and a later ENE-trending set of faults developed sub-perpendicular to the regional fold axes.

This study introduces new data on the kinematics and timing of fault movements in the 'gold corridor' and incorporates recent ideas on the structural evolution of northeast Tasmania. It is acknowledged that a study of this kind will encounter difficulties arising out of the need to reconcile fault history and fold history, the two not necessarily coinciding with each other. Whilst accepting, and corroborating to a large degree the results of the study of Powell and Baillie (1992) regarding the presence of a crenulation cleavage (S₂), difficulties arise when fitting this event into the overall scheme of folding and faulting in the region. As a consequence, D₂ has an early compression and late wrench phase attributed to it here, even though no thrusts of this age were positively identified. The results of two studies in particular, one on mega-kinking in northeast Tasmania (Goscombe and Findlay, 1989) and the other on the Devonian-aged St Marys Porphyrite (Turner et al., 1986), form the basis for the D₂ and D₃ events used here. Recent kinematic studies in the Melbourne Zone (Gray and Willman, 1991; Morand and Gray, 1991) - the most likely continuation of the Mathinna Group to the north of Bass Strait (Powell et al., 1993) — were also helpful in erecting the sequence of faulting in the Mathinna Group.

The main aims of this study were to:

- (1) establish the timing of the veining with respect to the sequence of structural and tectonic events in the district,
- (2) set up a history of quartz veining on both a regional and local scale,
- (3) determine the significance of the Mathinna-Alberton Gold Lineament, which is defined here as the linear zone that contains all the gold occurrences between Mangana in the south and Forester in the north (fig. 1).



Figure 1. Map of the Mathinna–Alberton Gold Lineament with the principal gold mining centres and prospects mentioned in this report. The inset is an enlargement of the Mathinna district.

5 cm

(4) discuss the implications for further exploration in the region.

The principal method of data collection adopted in this study was to measure fault striae, veins, bedding, cleavage, bedding-cleavage intersections, fold axes and lineations from underground workings and surface exposures. Techniques used to analyse the data include:

stereonet plotting (with a qualitative estimate of the palaeo-stresses), the drawing up of a semi-regional structural cross-section across the largest gold producing mine in the region (the Golden Gate at Mathinna, 1/4 m oz Au), and

thin-section examination of micro-structural relationships of veins from some of the more important areas of mineralisation.

At least 20 adits were visited in the course of the study, from Mangana in the south to Forester in the north and, in all, 95 surface locations were inspected, the majority of these being in the Mathinna-Mangana region. The structural data are appended at the back of the report.

FOLDING

The region is dominated by northwest to NNW-trending first generation folds that sub-parallel the gold lineament over much of its length (McClenaghan et al., 1982; McClenaghan et al., 1993). The Mathinna-Mangana region is dominated by folds that vary in wavelength from several hundreds of metres to several kilometres; these folds plunge shallowly to the northwest and to the southeast as indicated by bedding-cleavage intersections, rare minor folds (in both quartz veins and Mathinna Beds) and mineral lineations (fig. 2a, b and d). Outcrop-scale folds are rare around the Mathinna lodes; however, abundant mesoscopic folds are found in the vicinity of the Mangana lodes. These folds are generally upright, although the stereo plot of bedding poles does suggest a small tilt (i.e. 80°) towards the northeast. At the northern end of the lineament the folds plunge steeply to the northwest and have a consistent sense of easterly vergence (McClenaghan et al., 1982).

Small-scale second generation folds, with a well-developed north to northeast-trending axial plane fracture cleavage (S₂), occur around the Mangana lodes; here they are open in style and plunge moderately to steeply towards the south, also folding an early set of quartz veins. The generally steep plunge of the F₂ folds (>65°), reflects the dips of the limbs of the F₁ fold, the plunge direction being dependent on which limb these structure developed. Elsewhere, the existence of large-scale F₂ folds may be inferred from the spread of bedding and S₁ cleavage poles along girdles that define the refolded limbs of the F₁ folds (fig. 2).

Open folds in bedding-parallel quartz lodes at Mathinna (e.g. North Eldorado) represent a possible third generation of post-lode folding that locally trends NNW.

CLEAVAGE

The main cleavage is a pervasive penetrative slaty to spaced cleavage developed in silty to sandy beds of the Mathinna Group. The slaty cleavage is particularly well developed in the southern area, but in the north the main cleavage is a spaced cleavage. This cleavage may transect the regional-scale folds with a consistent sense (of clockwise) rotation, the amount varying from 0-15°. This effect is most pronounced in the folded strata west of Dans Rivulet (see McClenaghan et al., 1993). A close inspection of fold hinges in the field reveals that the slaty cleavage transects the folds at a low angle and a second fracture cleavage is the true axial plane cleavage (R. H. Findlay, pers. comm., 1993). This feature suggests either cleavage development during rotation of the stress field or sinistral transpression along the fold belt. However, at the eastern end of the Mathinna traverse, a pair of 200-400 m wavelength folds have a cleavage which is quite symmetrical with respect to their northerly-trending fold axes, suggesting that the degree of transection is variable.

A second, spaced fracture cleavage or crenulation cleavage (S_2) , trending in a north to northeast direction, is locally developed throughout the district and may be related either to compression or to wrench faulting. It is particularly well represented immediately adjacent to the lodes at Mangana, where individual cleavage planes, spaced 5–20 mm apart, transect, offset and fold early quartz veins (fig. 3*a*, *b*). This cleavage also refracts strongly across the altered selvedges of cleavage-parallel veins. Small-scale movements along the individual cleavage planes suggest that the cleavage is related to an episode of faulting, i.e. the main slaty cleavage forms lazy 's' sygmoidal domains that lie at an angle of 35° to the spaced cleavage. This can be interpreted two ways; either it is due to:

- (1) superimposition of one fabric upon another (i.e., S₂ on S₁), or it is due to
- (2) dextral shear movements along the north-trending faults (i.e. they are C-S fabrics).

A similar tectonic fabric, developed immediately adjacent to the lodes at Mathinna, parallels the nearby north-trending sinistral shears that post-date the quartz lodes. The timing of this cleavage in relation to other events is difficult to assess, however, it may be early-D₃, rather than D₂, in age.

The main cleavage in the northern part of the lineament is a spaced domainal cleavage. At the Mt Victoria mine, for example, the cleavage is defined by an alignment of sericite \pm chlorite-rich domains which are separated by 2–3 mm wide quartz-rich bands (fig. 9*h*). Evidence that this may be a crenulation cleavage comes from:

- (1) early deformed quartz veins which preserve a fibre direction lying at a high angle to the main extension direction, and
- (2) the main cleavage trending in a northerly direction, which is sub-parallel to the spaced cleavage in the south.

FAULTING

The principal mineralised structures in the gold lineament were initially developed as wrench faults, although most have been later reactivated as reverse faults. On some faults



Structural data from the Mathinna-Mangana region plotted as equal area stereographic projections: (a) poles to bedding showing the broad, partial NE-SW trending girdle defining the regional F1 fold axis; the minor F2 axes, represented by a spread of poles along the NE-dipping and SW-dipping limbs respectively, are also shown; (b) poles to cleavage; S1 is the slaty cleavage and S2 is the spaced fracture cleavage or crenulation cleavage; note that a few S1 have E to NE trends suggesting that they are either a folded cleavage or a S2 slaty cleavage; (c) plot of bedding-cleavage intersection lineations and quartz lode-cleavage intersections. Although not marked separately, the latter tend to have steeper plunges than the others; (d) minor folds in quartz veins and mineral lineations.





DEVELOPMENT AND RESOURCES

more than one reactivation has been observed (e.g. Golden Mara fault, Warrentinna); here, dextral and sinistral strike-slip, as well as dip-slip reverse movements, have been recorded. Regionally, the mineralised structures comprise two sets of dextral strike-slip faults (D₂), trending either WNW to northwest or NNW to north (fig. 4). The former trend is dominant in the Mangana–Mathinna region, whereas the latter is the dominant trend at Warrentinna. The Main Slide at Mathinna has a northwester to NNW strike which may have been the main displacement shear direction (D-shear) in the Tchalenko wrench model; if this so, then the northerly trending structures are R-shears, whilst the WNW faults are P-shears, lending some support to the wrench model put forward by Taheri (1992).

Thrusts (D1)

A number of east-directed, low-angle thrusts, belonging to the early deformation, occur at the Mt Victoria and Linton mines (fig. 4a). In the Linton open pit, a single thrust is truncated by a vertical northeast-trending quartz lode. In the Mt Victoria adit, a number of small thrust faults with moderate westerly dips are seen cutting sandy beds of the Mathinna Group. The absence of low-angle thrusts at the southern end of the gold lineament indicates that there are some differences in structural style along the length of the corridor; such differences may be due to lithological factors alone, i.e. the stratigraphy contains more quartz-rich sandstone in the north hence the deformation was more brittle, and more siltstone-mudstone in the south hence the deformation was more ductile; or it may simply be due to the level of crust now exposed at the surface.

Dextral Strike-Slip Faults (D2)

The northwest-trending dextral wrench faults (fig. 6a) occur in the southern part of the Alberton-Mathinna lineament (fig. 4b). A number have been identified in the Mangana area (Brennans adit, Argyle mine and Miami West), as well as at Mathinna (Gladstone adit, Old Derby adit) where they strike 120-135° and dip between 75°NE and 80°SW. At Mangana, the faults are inferred to range from 1.5-3 km in length and are spaced up to 1.75 km apart. They are hard to identify on the surface because they contain black puggy clays which weather easily, most having been reactivated later on (i.e. during D₃) as dip-slip reverse faults. Their relationship to the regional folds is not known in detail; however, they generally parallel the trend of the F1 folds and lie close to, if not on, the hinges of one of these structures (fig. 5). The steep dips of these faults and an absence of striae or quartz veining that was related to an early thrusting event suggests that these faults were not D1 structures and that they were generated after the regional folding as wrench faults (Threader, 1967).

The main fault plane can usually be identified as a carbonaceous zone, between 300 mm and 1–2 m wide, sitting on the hangingwall side of the lode (e.g. Argyle adit); in this locality, the fine-grained sandstone and siltstone interbeds in the footwall carry oblique (i.e. north-trending) 10–40 mm thick tension gash veins arranged in an *en echelon* fashion due to the dextral wrenching. Elsewhere, easterly-trending folds, with a 'z' sense of vergence, may occur locally in the footwall (e.g. near the entrance to Argyle No.1 adit). The bedding plane is generally discordant to the fault in the footwall and parallel to it in the hangingwall, indicating that

the rotations were often confined to the lower sides of the fault. The thickest quartz lodes are invariably associated with the widest carbonaceous zones.

At Mathinna, the wrench faults range in strike from $095-150^{\circ}$ (magnetic) and they also show a greater range of structural style than elsewhere. At the Victoria Golden Gate, for example, the host sediment is a strongly cleaved siltstone with no visible carbon; the hangingwall comprises a 4 m wide zone of schistose sediments, whilst the lode itself is a 6 m wide quartz stockwork set in strongly sheared sediment. The sharp contact between the lode and the hangingwall sediment, along which much of the movement has been concentrated, is marked by a 50-100 mm wide pyrite-bearing, weakly vuggy, laminated quartz vein.

A brittle-ductile shear zone, in which a rotated cleavage and a slightly later generation of quartz veining is seen cross-cutting earlier folded veins (Old Derby), illustrates that when the faults do not contain carbonaceous material the movement tends to be more widely distributed (fig. 6b). Local shortening across this zone is implied by folding in the veins.

Sinistral Wrench Faults (late-D₂ or early D₃)

North-trending faults or shears (fig. 4d), with small sinistral displacements of <2 m, cross-cut and offset the lodes in a number of places (e.g. Miners Dream underlay shaft and section 359-G adit). The local drag of the cleavage into the fault and the presence of conjugate kink bands immediately adjacent to these structures testify to their generally brittle nature and their late-stage of formation (fig. 6c). This faulting parallels the S₂ spaced cleavage which suggests that it is related to a relatively late stage in the D₂ event; the inferred NW–SE compressive stress field responsible for sinistral wrenching along north-trending structures also supports this.

Sinistral (-normal) Faults (?early-D3)

A small number of ESE-trending faults with sinistral-normal or sinistral strike-slip movements (fig. 4e) occur in the northern part of the gold lineament (Linton mine) and around the Mathinna lodes; this set has been observed in non-magnetic granodiorite (Kapai Road). Although no cross-cutting relationships with other faults have been observed it is believed that these faults formed during D₃ and have been tentatively assigned to the early part of that event.

Dip-Slip Reverse Faults (D3)

The wrench faults have been reactivated as dip-slip reverse faults (fig. 4f, 5; Miami West, Argyle, Brennans adit); or they may show little evidence for any reactivation (Victoria Golden Gate); or they were reverse faults throughout much of their history, perhaps showing evidence for limited sinistral movement prior to the dip-slip movements (section 359-G adit). In the last example, tightly-folded quartz veins with little or no consistent sense of vergence are contained within a 300–500 mm wide cataclastic zone comprising carbonaceous shale and broken clasts of quartz vein material (fig. 6d). The main fault surface contains anastomosing black carbonaceous seams enclosing domains of grey shale; the quartz veins contained within the latter are tightly folded, indicating considerable local shortening across the fault zone. The cataclasite is separated from an underlying

MATHINNA-ALBERTON GOLD LINEAMENT



D3 SINISTRAL WRENCH

D₃ REVERSE FAULTS

Figure 4. Equal-area stereographic projections of fault striae data from the Gold Lineament (i.e. from Mangana to the Linton mine). (a) E-directed thrusts of unknown, but possibly, D₁ age; (b) the main mineralised dextral wrench faults due to N-S compression during D₂; note these faults range in strike from E to NNW; (c) dextral wrenching on N-S faults; these structures are shown separately because they may be secondary riedel shears; (d) D₂/D₃ sinistral wrench faults; these offset the mineralised structures; (e) E-W sinistral wrench faults formed in the D₃ stress field, i.e. the return to the NE-SW far field stress; (f) late-stage D₃ reactivation on the D₂ wrench faults. Maximum palaeo-stress directions are shown as arrows outside the stereonet. If no movement direction was measured, the direction of movement is shown by arrow or U and D.





Figure 5. Structures at Miami West. The mineralised structures lie close to the hinge of a sub-horizontally plunging anticline in the Mathinna Group sediments. Insets show: relationship between the wrench and dip-slip striae (note the ledges hang downwards because the view is from the footwall side), and a lode which is developed parallel to cleavage in the folded strata (note the relict bedding in the lode).

laminated quartz vein by a 50 mm puggy fault zone. The hanging wall shales are markedly discordant to the fault, indicating that movement was concentrated in the footwall of the lode (fig. 6d).

QUARTZ VEINS

Regional quartz veins

The east Mathinna structural traverse contains several generations of barren quartz veins, at least two of which are associated with hematitic staining; a third contains abundant orange staining and was probably related to a sulphidic fluid. In contrast, few quartz veins were observed on the west Mathinna traverse. Localities where cross-cutting vein relationships have been observed are shown in Figure 10. A total of three vein generations are inferred from overprinting relationships.

The earliest quartz veins (V₁, so-called because one of the set lies in the extension direction of the presumed D₁ palaeo-stress field) formed early in the development of the regional cleavage. They form two sets of veins: one lies close to, or within, the plane of the regional cleavage, is irregular, discontinuous, boudinaged and generally thin (<3 mm) comprising a mosaic of variably-sized quartz grains which show little effects of an accumulated strain; the other comprises translucent, pale grey to white fibrous quartz veins that trend northeast to east and are gently folded. These veins are overprinted by NNW-trending fibre veins (V₂, because



Figure 6. Structures associated with faulting (a) drag of cleavage and sulphidic lode quartz into dextral fault zone (Miami West); (b) brittle-ductile shear zone showing dextral sense of movement from the drag of cleavage into the shear on left and the offset of later cross-cutting vein on right (Old Derby adit); (c) minor sinistral offset of lode along north-trending shear; the kink band in the cleaved sediments gives the same stress field that would be required for sinistral movement on the shear (Miners Dream incline shaft); (d) crumpled and folded quartz veining in reverse fault (looking up); note the lack of sense of vergence in the folds which is due to most of the movement being dip-slip plus with shortening across the fault zone, i.e. there is a lack of the early wrench movement here; the matrix is strongly graphitic shales (section 359-G adit). Sketches are from slides taken underground which are reversed to give a view looking *down* on the structure, except (d).

E/Z

they lie in the plane of extension associated with the D₂ stress field) that sub-parallel the regional S₁ cleavage and are weakly deformed by it. The youngest veins consist of sulphide-bearing veins (V₃) which trend in an ENE direction; they are sulphidic and have an azimuth of 80–90°, dipping towards the south. This set is restricted to the folding at the extreme eastern end of the section (i.e. the cliff section exposed on the Fingal–Mathinna road at Mathinna Rocks) and lies sub-perpendicular to the axis of regional folding. They are possibly equivalents of the mineralised extension veins of the Scamander Field, which are related to granite (Groves, 1972).

Inspection of the map makes it clear that two of these vein sets, V_1 and V_3 , are related to a NE-SW compression. The conditions for this stress field were present during D₁ (i.e. during the initial tectonic event) and during D₃ (i.e. during a return to the far-field stress). These V₃ veins, therefore, may represent a possible later introduction of gold into the lode system at Mathinna. Their presence at Mt Victoria and Ringarooma has already been documented.

Paragenesis

The overprinting of quartz veins is relatively common within the goldfields, and paragenetically at least three broad generations of quartz \pm carbonate \pm sulphide veins can be defined:

- (1) early veins include the barren fibre veins and the economically important, grey, laminated and/or brecciated veins. Silicified wallrocks units are probably also early in paragenesis.
- (2) intermediate veins are white in colour and display buck, comb, breccia and ladder textures. However the paragenesis of ladder veins is not well established.
- (3) late veins include spider quartz veinlets and narrow veinlets of sulphides or carbonates \pm quartz. In addition, white quartz is rarely brecciated and infilled by grey quartz (Golden Gate, Mangana Gold Reef). It is not certain whether this grey quartz is of the early generation (making the one generation of white quartz very early), or is a later phase.

It must be emphasised, however, that detailed relationships are complex and not always clear, and up to five vein generations have been distinguished in one small sample (e.g. Mt Victoria, sample No. C103855B).

Fibre veins

These veins are characterised by an aggregate of parallel quartz fibres at a high angle to the vein wall, and multiple growth increments without euhedral terminations. This has been interpreted as a product of crack-seal incremental growth (Ramsay, 1980; Cox and Etheridge, 1983; Dowling and Morrison, 1989).

Some quartz veins in the lode environment may be fibrous in texture (fig. 7a, c). Where they are associated with carbonate alteration (i.e. where the fluids had been highly reactive) the veins have crack-seal micro-textures; if not, they have continuous growth fibres. These veins are unmineralised, narrow (usually <5 mm) and volumetrically insignificant, and there is no evidence for any direct relationship to gold mineralisation.

The crack-seal fibre veins may show considerable variation in alteration from one side of the vein to the other; for example, in a sample from Mathinna, the wall rock on one side has strong sericite-carbonate alteration, whereas the other side has chlorite-alteration (this shows up on the weathered surface as contrasting red and green colourations). The fibres in this sample show zones due to repeated cracking during growth, which is typical of the crack-seal process (fig. 7b). The quartz fibres taper to one side (a more typical feature of quartz comb structures), indicating that they clearly nucleated on the side which contains the more abundant carbonate spotting; such asymmetry may be useful in indicating a direction of palaeo-fluid flow.

Continuous fibre veins occur in the more competent host rocks (i.e. sandstone) which have generally suffered little or no wallrock alteration (fig. 7*a*). Although they may contain planar 'tuttle lamellae', which cut across several grains simultaneously in the coarse-grained centres of the veins, they represent a process of continuous rather than incremental dilation of the rock. Invariably, the fibre veins are cut (and offset) by later veins with coarser grain sizes. The fibres may show evidence of grain boundary movement during recrystallisation, indicating their syn-tectonic nature. The fibrous texture appears to be a remarkably stable one, enabling these veins to remain unaffected by later deformation, with the principal exception being where they occur in the gold-bearing parts of laminated quartz.

Grey quartz

Grey quartz, as its name suggests, is a light to dark grey or bluish form of quartz, usually greasy in lustre. It is generally fine grained and massive or laminated, usually without open space filling or visible crystals.

Finely dispersed rutile, organic material and fine-grained sulphides (mostly arsenopyrite) give the quartz its characteristic grey colour and suggests that the quartz is probably largely a result of silicification of wallrocks. They are invariably sulphidic and fine-grained (fig. 7c). This could be partly due to the impurities which had the effect of impeding grain growth, or may indicate rapid deposition as cherty silica. The massive varieties appear to be the earliest gold-bearing veins, and statistically have the highest grades in this field. The grey quartz may occur as selvages and clasts in white quartz, typified by the Una and Golden Mara mines.

Laminated veins

Laminated quartz veins are characterised by vitreous quartz with banding or laminations parallel to the vein walls. They may contain thin lamellae of wallrock material and/or sulphides, separating quartz domains of varying grain size. This definition includes the ribbon and stylolite textures of Dowling and Morrison (1989).

These veins are present in a number of localities (e.g. Argyle adits, 359-G adit, Brennans adit, City of Hobart); they generally, but not necessarily, occur where the slates are black and probably carbonaceous. The slates are incorporated as thin planar or crenulated laminae of dark



In the Argyle, the quartz septae, and to a lesser extent the black laminae, are partially replaced by slightly irregular veins or segregations of a more pure white quartz which is developed perpendicular to the walls (fig. 9c). At the Argyle and 359-G adits, the laminated veins are from 50–100 mm thick; they occur on the footwall side of the black (?)carbonaceous zone representing a conduit for fluid that opened up several times during lode formation. Dark green to grey sericitic laminae, of a similar morphology to the carbonaceous layers described above, are present at the City of Hobart. Here, the laminae tend to be developed at the edges of a vein whose centre comprises 30 mm wide massive, fractured grey to white quartz septae.

A stylolitic cleavage in the laminae may be composed of dark residues of sericitic mica, rutile, possibly carbonaceous material, and usually fine-grained arsenopyrite (fig. 9b, c). This cleavage is strongly crenulated where the fill is sericite, otherwise it tends to be wavy in form; often the stylolites separate areas of coarser-grained quartz from finer-grained quartz, indicating active solution transfer during, and as a result of, vein formation. Where fibre veins are present in the laminated quartz, the dark inclusion trails may be traced along the edges of individual quartz fibres, indicating that the fibres and the stylolites were formed during a period of tectonic extension parallel to the vein walls (note the difference between the other fibre veins where the extension is perpendicular to the walls) (fig. 7c). In one specimen, the laminated grey quartz has a grain-size banding, possibly due to the effect of impurities restricting grain growth, or variation in rates of precipitation.

Macroscopically visible gold occurs along the grey to greenish quartz bands within laminated quartz (City of Hobart). Although the gold is often intimately related to the arsenopyrite, occurring in the centres of the grains, it may also occur as free grains in quartz.

Folded and boudinaged veins

This type of vein structure is common in lodes which have no clearly identifiable fault surface (fig. 8c). The faults invariably lack graphite or carbonaceous material and, therefore, can be classified as brittle-ductile faults or shear zones. Good examples of these come from the Miners Dream underlay, North Eldorado, Old Derby and the Mangana Gold reefs (lower adit). The thin veins are generally ptygmatically folded by the cleavage; at Miners Dream the cleavage consistently dips flatter than the vein, suggesting the possibility of local structural overturning; or else the vein may be 'folded' in the sense that the cleavage is superimposed on an existing non-linear vein geometry (Old Derby). Where the deformation is intense around the lodes, as at Mangana, the veins may be both contorted and boudinaged within the confines of a single lode shear.

Silicified lode

Selected sandstone units within the Mathinna Beds have been locally replaced by silica to form silicified or quartzitic bodies (Linton, North Eldorado, Long Struggle, Mangana Gold Reef and Mt Victoria mines). These quartzites appear to be more common hosts to gold veins at Alberton than are the slates, which may be the reason why there are numerous rather relatively short, discontinuous veins of rather variable orientations in this field, reflecting the competency and brittle nature of the host rocks in this area.

Some silicified units contain euhedral or subhedral quartz crystals in a matrix of micaceous, lithic material and chert (Linton mine). This style of alteration often appears to have disaggregated some arenites, suggesting that the sediments were poorly consolidated at the time of deformation. The timing of silicification is uncertain.

Ladder veins

Ladder veining may occur in the steeper sections of silicified sandstone beds or in vertical shear zones (fig. 8a, d, 9e, f). In the North Eldorado adit, steeply-dipping grey silicified beds contain sub-horizontal white quartz veins.

Brecciated quartz veins

Slivers and fragments of wall rock may form as a result of hydraulic brecciation. The breccias have a wide range of clast types (slate, sandstone, quartz and rarely porphyry and feldspars, usually kaolinised) and sizes. The matrix is also variable from white to grey in colour, and may be carbonate and sulphide-bearing. They occur in most of the gold deposits and may be highly mineralised and gold bearing, but are quite variable in grade. This is a volumetrically important vein type.

At the Golden Gate mine, a 40 mm wide vein contains tabular inclusions of wallrock material which sub-parallels vein walls (fig. 9a). These inclusions are set in a matrix of coarse-grained white buck quartz. The local jigsaw fit of the breccia indicates its essentially autonomous nature, as well as the very high fluid pressures (above lithostatic) that were locally attained during its formation. These veins are not usually highly mineralised, although they may contain relicts of grey laminated quartz.

Buck quartz

Buck quartz veins have an aggregate of coarse-grained, anhedral quartz grains, white to milky in colour and a

Figure 8

Quartz lode textures. (a) silicified lode with sub-horizontal ladder veins in Mathinna Group sediments (North Eldorado); (b) cataclastic textures in quartz set in matrix of deformed graphitic shale; note the indented and serrated contacts between the quartz and its matrix (Argyle adit); (c) 'folded' quartz vein with boudinaged limb; the quartz veins probably started life as an orthogonal array which was subsequently deformed by shearing, note the intense cleavage on upper side of right-hand limb only (Old Derby adit); (d) about zone with lodder veining (Pingarooma United)

(d) shear zone with ladder veining (Ringarooma United).



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vitreous lustre (Dowling and Morrison, 1989). They are commonly barren but may contain some gold. Buck quartz is volumetrically the most important vein type in the field, and normally forms later than, but may grade into, grey quartz.

Comb veins

Comb veins are coarser grained than fibre veins, with crystals identifiable at hand specimen scale, perpendicular to vein walls and partly euhedral. They commonly terminate in cavities and are tapered at their base (Dowling and Morrison, 1989).

In the gold belt these veins are usually wider and volumetrically more important than fibre veins, especially at the Golden Gate mine. They are commonly vuggy, carbonate-bearing, and are typically white in colour. The grain size varies widely and is usually coarser in the centre of the veins. The veins may also be multiple in form, containing small amounts of sideritic carbonate fill in the outer parts of the vein and ankeritic in the core; occasionally, a later quartz-carbonate vein, showing a non-fibrous texture, may form on one side of the vein. The quartz in these veins tends to display the effects of later strains (e.g. lattice bending, deformation lamellae etc.) because of their coarse size. Small amounts of coarse-grained sulphides may be present, but the gold content is usually low (e.g. the Golden Gate mine).

Spider veinlets

These form a random network of fine glassy quartz veinlets, millimetrically sized, which crosscut host quartz (Dowling and Morrison, 1989). They appear to be partly related to recrystallisation of the highly stressed earlier quartz veins and are essentially unmineralised (fig. 9b).

Sulphide veinlets

These rare veinlets are narrow, to about 2 mm thick, and are very sulphide rich. They clearly crosscut all other veins (e.g. Ringarooma United).

Carbonate-rich veinlets

These rare veinlets are narrow, to about 2 mm thick, and are very siderite rich. They clearly crosscut all other veins (e.g. Golden Gate). They may also form along margins or cores of comb quartz at this location.

Illustrations of vein relationships

At the Golden Gate mine the veins may form networks of orthogonal to oblique cross-cutting sets. The earliest veins are 2–10 mm wide grey fibrous extensional quartz veins containing occasional vuggy patches. An intermediate set of 2–5 mm wide grey to white, non-fibrous veins may also occur. These are both overprinted by a later set of white, coarse-grained, 10–20 mm wide quartz-carbonate veins (fig. 9d). These early veins may either form low-angle (30°) intersecting sets (New Eldorado), or random parallel arrays (Golden Gate). Where a cleavage is present in the metasediments the early grey to blue quartz veins may be ptygmatically folded and may display micro-thrusts, indicating their early to syn-cleavage age. In contrast, the later cross-cutting veins are generally unaffected by the cleavage, being late-tectonic in age (fig. 9h). In strongly deformed rocks (?Main Slide, Golden Gate), the white quartz veins overprint fault-related grey-quartz breccias that contain a strong shape fabric due to cataclasis (fig. 9g).

At the Mt Victoria mine pre-cleavage to early cleavage quartz veins (V_1) are deformed by a spaced cleavage which is defined by an alignment of sericite and/or chlorite laths. These early veins are grey to blue in colour and the individual quartz grains weakly fibrous in nature (fig. 9*h*). A later set of ESE-trending white, boudinaged quartz veins (V_2) , with minor sulphides, are cut by a set of northeast-trending, composite, fibrous quartz-sericite veins (V_3) ; the latter veins cross-cut the cleavage and their formation coincided with a change in the nature and/or composition of the fluid during a phase of late- to post-cleavage extension in the lode. The two extension directions at right angles to each other, the first being preserved in the early veins only, suggest that the main cleavage might be a strong crenulation of an earlier cleavage.

In the contact zone between a quartz porphyry dyke and Mathinna Group sediments at Ringarooma United, a one metre wide north-trending shear zone contains three distinct generations of quartz veins (fig. 8d);

deformed vein clasts due to cataclastic deformation (fig. 9e, f); these form narrow (200 mm) high strain zones which are overprinted by;

Figure 9

Quartz vein textures:

(a) breccia vein with fragments of wallrock set in a matrix of white quartz; a relict of grey laminated quartz can be seen at the base of the specimen (Golden Gate dump specimen);

(b) auriferous laminated quartz vein with gold (not visible) that comes from the dark grey laminated upper part of the specimen (city of Hobart dump specimen);

(c) laminated quartz showing progressive replacement by white quartz which cuts across and obliterates the crenulated carbonaceous bands; the disruptions to the laminae may also be due to "pull-apart" parallel with the vein walls (Argyle adit);

(d) early orthogonal fibrous quartz-(carbonate) veins overprinted by later white quartz (New Eldorado);

(e) and (f) shear zone with ladder veins; at least three generations of quartz are visible here: early cataclastically deformed quartz, white ladder quartz veins and late sulphidic quartz veins (Ringarooma United adit);

(g) early cataclastic quartz (grey) overprinted by veins of quartz (white) and carbonate (brown) (Golden Gate dump specimen);

(h) three generations of quartz veins in cleaved Mathinna Group: early deformed grey quartz (arrowed), white quartz-(carbonate) veins and late quartz sericite vein; the gold is presumed to be related to the first vein set (Mount Victoria 4L adit).



- (2) a set of white ladder veins (up to 10 mm thick) whose geometry is largely controlled by the competency contrasts between the sand and silt layers in the rock; finally
- (3) a set of south-dipping grey to white sulphidic extension veins (<5 mm) which cross-cuts both the earlier quartz types.

This zone had clearly experienced an extended period of deformation during and after intrusion of the dyke. The dark crenulated bands in the more deformed part of the shear zone indicate that pressure solution was an active process during the deformation; the small offsets on all veins, including the latest set, suggest that this initial deformation may have been D_1 in age and was closely related to emplacement of the dyke; the subsequent deformations along its margins may have been D_2 or even D_3 in age. Although the third set of veins was derived from a sulphur-rich fluid there is little evidence that it was auriferous; a source for the sulphur in these veins, as well as the disseminated sulphides in the dyke, could be the subject of further study.

MATHINNA CROSS SECTION

The cross-section through the Mathinna mining district has been sub-divided into two parts (fig. 10, 11). The first, a 7 km long western section from Chinamens Hill to Sandhurst Road, follows the Griffin Road along the South Esk River; the second, a 6 km long eastern section which is made up of a number of smaller traverses east of Mathinna, includes a cross-section of the Golden Gate mine. A major discontinuity, or transfer zone, trending northeast through Mathinna separates the two sections, which consequently have been displayed separately.

West Mathinna Traverse (Section line A-A')

This part of the section comprises mostly fine-grained sandstone and siltstone, minor shale and occasional greywacke (McClenaghan *et al.*, 1993). Broadly, the section is sub-divided into a western sequence of greywacke, sandstone and shale which is part of an upward-fining cycle of sedimentation; and an eastern sequence of mostly siltstone and minor fine-grained sandstone. These are separated by an east-trending fault (fig. 10).

The western sequence lies on the southwestern limb of a F₁ syncline in which the greywacke occurs in the lowest part of the exposed sequence and the shale in the highest part in the core of the syncline (fig. 11). The shale is pale green in colour and is slate-like in places; these rocks have slightly enhanced apparent magnetic susceptibilities (0.19 and 0.28), putting them at the high end of the range of k' values for the Mathinna Group rocks. An interpreted southwest-directed high-angle reverse fault located mid-way through the western sequence has been inferred to explain the dip variations in the beds and a repetition of a sandstone unit; such a structure is entirely reasonable given the slight northeastward tilt of the F1 folds in the district. The thickness of exposed stratigraphy inferred from the cross-section is 1500 m; however, since the section is oblique with respect to F₁, a range of 1200-1500 m is a more realistic figure. This sequence is construed to be relatively high up in the stratigraphy and may correlate with

either the Bellingham Formation or the 'Sidling sandstone' (Powell et al., 1993).

The eastern part of this traverse is much more complicated in its structure than the western end because of the involvement of brittle-style D₂ faulting and folding. A prominent feature at the eastern end of the section is the high strain zone which trends NNW following the course of Dans Rivulet. The major fault structure (azimuth 290°), separating the western and eastern domains, has been involved in overturning of the west-dipping mixed sandstone-siltstone sequence on its eastern side, suggesting it may have originated as a D₁ thrust. The north-block-up movement is a late reactivation.

A dextral strike-slip fault zone (azimuth 330°) separates an indeterminate sequence of mixed sandstone and siltstone to the west, from a sequence of siltstone only to the east; it is noted that these structures are developed in the siltstone-only sequence. A minimum stratigraphic thickness of 1500 m for the siltstone-only sequence can be inferred from the section.

East Mathinna Traverse (Section line B-B')

This part of the traverse stretches from a syncline-anticline pair at Mathinna Rocks as far as the regional F1 anticlinal hinge immediately west of the Mathinna lodes (fig. 11). The lithologies on this section comprise siltstone-mudstone sequences interbedded with quartzwacke turbidite sandstone, the latter including quartz-rich fine-grained sandstone and greywacke and minor siltstone (McClenaghan et al., 1993). Given the relatively straightforward nature of the structure on this section, at least a 5-6 km thickness of stratigraphy can be inferred. The basal sequence (>500 m) consists of sandstone with minor siltstone; the next sequence (0.8-1 km) comprises thick sequences of dominantly mudstone-siltstone lithologies with a number of graphitic shale beds. This is followed by a sequence (2.5 km) that comprises 500-600 m thick large-scale interbeds of dominantly fine-grained and coarse-grained sediments which pass up into a sequence (1.5 km) of dominantly fine-grained sandstone with minor siltstone and shale. These sequences are tentatively correlated with the upper part of the Turquoise Bluff Slate, Bellingham Formation and 'Sidling sandstone' respectively, which are to be found in the Lefroy area (Powell et al., 1993). A recent description of a Silurian graptolite locality, (Rickards et al., 1993) from the Golden Ridge Anticline — a similar structural and stratigraphic setting to Mathinna --- suggests that the Turquoise Bluff Slate may, in part, be Silurian in age. The anticline-syncline pair, with a half wavelength of 600 m may, from its position in the regional anticline and its general lack of cleavage, correlate with the Devonian 'Sidling sandstone'.

Structural and stratigraphic setting of the Mathinna deposits

The regional cross-section demonstrates that the Mathinna lodes lie on the eastern limb of a regional F_1 antiform whose half-wavelength is approximately six kilometres. Mapping by Finucane (1935) has shown that the hinge zone lies at the extreme end of the section line B-B' (fig. 11); thus the mineralisation lies near the base of the Mathinna Group in a sequence tentatively correlated with the upper part of the



Figure 10. Structural map of the Mathinna mining district. The Mathinna traverse has been divided into a western and eastern section. A lack of correlation between the two sections suggests that a major D1 transfer zone separates a northwestern structural domain from a southeastern domain; the mega-kink zone (Goscombe and Findlay, 1989), which passes through the township, is the most likely site of such a transfer zone. Localities mentioned in the text are marked, as also are the positions of individual structural stations which appear in Appendix 1 at the back of this report. For further explanation, see text.

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Figure 11. Structural traverse through the Mathinna goldfield. The section line A-A' follows the north bank of the South Esk River as far as the Main Slide, whilst the section line B-B' passes directly through the main mineralised area, including a projected cross-section through the Golden Gate mine. The western end of this section includes data from Finucane (1935).



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Early Ordovician-?Silurian Turquoise Bluff Slate. The Main Slide at Golden Gate (Twelvetrees, 1907b) occurs towards the top of this unit and exploits a number of graphitic shale bands which acted as lubricants during faulting. The fault in the 359-G adit is one such graphitic fault zone which may represent the easternmost limit of this structure. The fault is D_2 in age, having been initiated as a wrench fault and subsequently re-activated as a reverse fault during D₃. The abundance of quartz veining indicates that this structure was a major conduit for fluids during this period; brittle-style deformation features, including late-stage quartz veining, small-scale sinistral wrench faults, kinks and the spaced S₂ cleavage, all suggest that this structure continued to be an important pathway for fluids during D3. The amount of displacement on the Main Slide is not known; if the western option for its northward continuation on Figure 11 is accepted, then it may be considerable.

A wide zone (250–400 m) of close to tight folding which passes through the centre of the goldfield (Finucane, 1935; and Figures 10 and 11) is of importance to the mineralisation; firstly, as an an expression of the high strains developed around the fault and secondly, as a facilitator of secondary fluid pathways branching off the main fault. The zone is concave towards the northeast, with a bend that is reflected in the arcuate traces of bedding and cleavage in the area. The southern continuation of the Main Slide has been located in the eastern tributaries of Long Gully Creek (field locality 1; see Appendix 1 for AMG co-ordinates) and Finucane (1935) walked the length of Coxs Creek, further to the southeast, and found its continuation as a zone of open-style folding in the sediments.

Faulting in the vicinity of the lodes indicates that the Main Slide had experienced the following movements:

- dextral wrench (early-D₂); faults showing this movement parallel the strike of the Main Slide and are considered fundamental structures;
- (2) sinistral wrench (late-D₂/early-D₃); faults showing this movement lie oblique to the main deformation zone and are, therefore, considered to be secondary structures;
- (3) reverse movements (D₃); these movements are due to a NE-SW compression which, although comparatively late in the sequence of events (i.e. they occur after the wrenching) are probably the ultimate cause of the zone of close folding and NNW-trending open-style folding of the quartz lodes. The bending probably relates to this event.

A gross mismatch of geology between section lines A-A' and B-B' is demonstrated by the lack of correspondence of structure and stratigraphy between the two sections. For example, the syncline in the northwest part of Figure 2 is juxtaposed against the anticline in the southeast part of the map. Similarly, the mudstone-siltstone host sequence to the Mathinna lodes has failed to be located on section A-A'. It should be noted, however, that the Main Slide continues through from one section to the other, although its exact position on section A-A' is uncertain.

DISCUSSION

D₁ transfer faults

The gross mismatch of geology between Mathinna sections A-A' and B-B' leads to the conclusion that a major structural discontinuity lies beneath the town. The most likely position and orientation of such a structure is the late-stage mega-kink axis of Goscombe and Findlay (1989). The age of such a structure would have to be pre-D2, because the Main Slide passes through it without significant displacement (the greatest displacement that can be inferred is a 1 km sinistral offset, see Figure 10); the most likely origin is a transfer zone developed during crustal extension or crustal compression. By projecting the F₁ synclinal closures onto the discontinuity, a 6 km sinistral offset can be inferred, with the northwest block moving towards the southwest (fig. 12). If this zone had been active during the folding (i.e. as a lateral ramp or detachment structure), then the offset would be considerably less than this. As a consequence of this, the mega-kinks can be seen to have exploited a pre-existing crustal weakness.

Figure 12 clearly shows that there is a structure that can be traced for at least 50 km from the Aberfoyle tin deposit in the southwest to a position well inside the Blue Tier Batholith. Although some of the faults that define this structure are as young as post-Permian in age, many occur in the Mathinna Group, and the conclusion that this represents a fundamental deep (mantle-tapping?) structure seems justified.

A stratigraphic or lithologic control to gold mineralisation?

As the section line B-B' comprises a relatively intact northeastern limb of a regional F₁ anticline, it is reasonable to attempt a correlation of the units on this section with the stratigraphy of Powell et al. (1993), west of the Scottsdale Batholith. The broad grain-size classification used in this study indicates that all four major lithological sub-divisions may be present on this section. At least six kilometres of stratigraphy is implied (fig. 11), a figure which compares favourably with a total thickness of seven kilometres for the Lefroy area. The lower units may correlate with the upper parts of the Turquoise Bluff Slate, whilst the remaining part of the cross-section may correlate with the Bellingham Formation and the 'Sidling sandstone' (fig. 11). This information could be crucial to the understanding of mineralisation at Mathinna because the majority of the lodes would appear to lie in the lower part of the sequence. Twelvetrees (1904) noted that the mineralised lodes tended to occur in sequences rich in grey to black slate bands. It is reasonable, therefore, to argue that the bulk of the gold lies in the carbonaceous mudstone-siltstone sequences of the Turquoise Bluff Slate member, with the remainder lying in the higher units that were unfavourable for the occurrence of large deposits. The reason may be the insufficient quantity of carbonaceous material in the upper sequences to act as a reductant; also the gold is most likely to be deposited in the first available structural trap site encountered by the migrating fluids, which means that the upper sequences will be effectively starved of gold.

A stratigraphic control to Early Palaeozoic turbidite-hosted gold deposits has already been put forward by Graves and

MATHINNA-ALBERTON GOLD LINEAMENT



Figure 12. The Mathinna–Alberton Gold Lineament. The 70 by 6 km corridor contains the majority of the gold occurrences in the region. Bedding trends range from being parallel to the lineament to being markedly oblique to it. The main feature of this diagram is the NE-trending transfer fault zone which passes north of Mathinna. It has been extended to show how it appears also to control the position of the major Aberfoyle tin deposit, southwest of Mathinna. Sinistral offsets of about 500-600 m are apparent on this structure in the granites of the Blue Tier Batholith.



Zentilli (1980) who state that the gold veins in the Meguma district of Nova Scotia "... favour a specific position in the stratigraphic section as measured by slate to metawacke ratio"; despite this the authors do not actually state where this position might be.

A two-stage process, whereby C-O-H fluids were formed by mixing of a metamorphic fluid with carbonaceous material below the level of the Ordovician strata to produce a modified metamorphic fluid, has been put forward by Cox et al. (1987, 1991) for the Lachlan Fold Belt. A similar model is proposed for northeast Tasmania by Taheri and Bottrill (1994). This kind of model may explain why the stratigraphic control could be important, because it pre-supposes a deep crustal source for the gold (?Cambrian volcanic rocks), as well as a source of the carbon from the base of the sedimentary pile (?Lower Ordovician black shale). Clearly both these factors, including the presence of permeability barriers and suitable structural traps in the lutite association (Banks and Baillie, 1989; Cox et al., 1987), will tend to favour the gold mineralisation in the Ordovician-Silurian, rather than the Devonian, strata. More specifically, the presence of carbonaceous bands is considered important in localising mineralisation.

There is little available data at the mine or regional scale to support a stratigraphic control on gold deposits in northeast Tasmania, and in the absence of extensive wallrock alteration around the lodes (Taheri and Bottrill, 1994), this association has to be speculative. This is an area where further regional mapping might be warranted.

Gold distribution

If the D₁ transfer zone exists, and the stratigraphic control to the gold deposits has validity, then these two factors provide a good reason for there being high concentrations of gold in some parts of the lineament and low concentrations in other parts. For example, there is little significant mineralisation known to date along Dans Rivulet, where despite the continuation of the favourable D₂ structure north of Mathinna, no major deposits have been found within a 15 km stretch between Mathinna and Mt Victoria. The reason may simply be that the right stratigraphy is not present. The northeast-trending structural discontinuity has juxtaposed much higher parts of the stratigraphy against lower parts, and one of the critical ingredients for a major deposit is lacking. A similar reasoning can be used to explain the abrupt cut-off to mineralisation east of Mathinna; the Bellingham Formation would be considered too high in the stratigraphy and contains insufficient reductants (i.e. organic carbon) to precipitate much gold from solution. It is interesting to note that the barren veins found east of Mathinna are associated with hematite staining, implying that the fluids may have been oxidising and, in the absence of suitable reductants, the gold merely passed on in solution to higher crustal levels. It should be stressed, however, that much potentially prospective groundalong the rivulet lies under recent cover and the geology is poorly known.

Tectonic significance of the gold lineament

The gold lineament lies between two granite masses, the Scottsdale and Blue Tier Batholiths (Williams *et al.*, 1989). Although its overall trend is NNW (fig. 12), it actually

comprises a number of faults of different trends (i.e. WNW to NNW, E-W, N-S and NE-SW) and of different ages (D₁-D₃). Recent research has shown that the pressures of formation of the granodiorites east of the lineament are considerably greater than those west of it; for example, the central granodiorites were formed at depths of up to 10-11 km (3 kb), whereas the western granodiorites were formed at comparatively shallow crustal depths of 1-3 km (R. Varne, pers. comm., 1993). This implies a considerable amount of uplift of the Blue Tier Batholith relative to the Scottsdale Batholith after D_1 — the generally agreed timing of emplacement of the syn-tectonic granodiorites (McClenaghan et al., 1993). The only structures able to accommodate this amount of uplift would either be D2 thrusts (not proven) or D₃ high-angle dip-slip reverse faults which have demonstrated east-block-up movements. The wrench faults, therefore, may have provided the zones of weakness in the crust that aided this late- to post-orogenic uplift. However, the preliminary findings of a crystallinity index (CI) study by Taheri and Bottrill (1994) indicate that the relationship between the depths of granite and metamorphic grade in the Mathinna Beds is a complex one, and that the lineament need not necessarily be the edge of a zone of regional uplift as suggested here.

Implications for exploration

The implications for exploration are that a sound knowledge of structure and stratigraphy is essential to effectively target for gold deposits in northeast Tasmania. The prime targets may lie at the intersections of the northeast-trending D1 transfer faults with the gold lineament. Transfer faults of this magnitude would be capable of:

- (1) tapping deeper parts of the crust, thereby acting as a short-circuit escape route for gold-bearing fluids generated in that region, and
- (2) juxtaposing more, favourable parts of the stratigraphy against less favourable parts.

These transfer faults should find expression in the regional geology and magnetic data sets; for example, they should be either visible as subtle changes in the magnetic basement, or they should be detectable by the concentration of younger fault systems and mega-kink axes on the geological maps, and so on. Leaman (1992) has drawn attention to subtle ENE-trending magnetic features in the Mathinna area which may well be part of this structure; however, more obvious in his Figure 8, although not specifically related to mineralisation, is a strong northeast-trending cut-off in the regional magnetics passing through Tower Hill.

Tectonic targeting may also be an appropriate method for exploring in the Mathinna Beds. For example, the left-hand deflection of beds at the intersection of a WNW-trending structural corridor is one of the important targeting criteria used in exploring for major deposits in Australia (O'Driscoll, 1990). The existence of anomalous WNW-trends in bedding and structure around Mathinna (fig. 12) raises the possibility that such corridors may exist in northeast Tasmania, in which case the confluence of NNW, WNW and northeast-trending lineaments could provide a sound basis for conducting local and regional exploration programmes. Finally, if it could be shown that lower and more favourable parts of the stratigraphy (i.e. Turquoise Bluff Slate or equivalents) were present at shallow, drillable depths beneath known gold occurrences in the vicinity of the right structures, then this knowledge could be used to form the basis of a successful deep exploration programme in the future.

CONCLUSIONS

- 1. The following history of faulting has been recorded in the Mathinna–Alberton Gold Lineament:
 - (a) low-angle east-directed thrusting in the Mathinna Group during the main phase of the Tabberabberan Orogeny (D₁);
 - (b) dextral wrench faulting on northwest- to NNW-trending faults during a period of north-south tectonic compression (D₂); and
 - (c) reactivation of the wrench faults as dip-slip high-angle reverse faults in a return to the far-field palaeo-stress conditions of the first phase (D₃).
- 2. Gold mineralisation is associated with D₂ wrench structures and occurs in quartz veins.
- 3. Overprinting of veins is common. At least three generations of quartz veins are generally present in the region (V_1-V_3) and as many, if not more, are present in the lodes.
- 4. A northeast-trending D₁ transfer fault zone at Mathinna causes a gross mismatch of geology. This structure pre-dated the gold mineralisation but was later reactivated as a zone of sinistral wrenching and mega-kinking during D₂.
- 5. A stratigraphic control to the large Mathinna lodes may exist. The carbonaceous mudstone-siltstone host sequences, which are tentatively correlated with the upper parts of the Ordovician to Silurian-aged Turquoise Bluff Slate equivalents, may have provided the right physical and chemical conditions to precipitate sufficient quantities of gold to form major deposits.
- 6. Prime exploration targets should be sought where D₁ transfer zones cross the gold lineament.

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APPENDIX 1

Structural data from the Mathinna traverse

Uniq No.	Field No.	Mag Sus	Rock Type	Easting (m)	Northing (m)	Bedding Dip	Dip az.	Cleavage Dip	Dip az.	S0–S1 Plu.	Int. Lin Az.
1	1	0.23	mdst	575115	5405525			90	235		
2	2	0.16	slst	575195	5405480			55	180		
3	3	0.33	mdst	575240	5405425			75	45		÷
4	4	0.33		575280	5405400			54	85		
5	5	0.16	sl st/mds t	575360	5405405	52	55	65	65		
6	6	0.34		575380	5405340			60	25		
7	7	0.31	mdst	575410	5405290	28	133	54	35		
8	8	0.23	mdst	575460	5405260			42	50		
9	9	0.22	mdst	575575	5405150			63	45		
10	10	0.33	mdst	575600	5405075			67	38		
11	11	0.32	mdst	575680	5405050			72	50		
12	12	0.27	mdst	575750	5405045			86	45		
13	13	0.23	slst	575830	5405045	45	30	68	32		
14	14	0.43	mdst	575905	5405050	52	52	76	58		
15	15	0.37	slst	576035	5405100			76	70		
1 6	16	0.22	mdst	576325	5404920			81	242		
17	17			574360	5406700	12	252	75	245		
18	20A	0.07		573970	5409300	55	235				
1 9	20B	0.14		573970	5409330	50	1 92	64	208		
20	21	0.09		573805	5409860	55	1 95	28	215		
21	22	0.07	sst	573760	5410020						
22	23	0.09	slst/sst	573685	5410195	20	210	20	210		
23	24	0.08	slst/mdst	573500	5410450			66	218		
24	25	0.08	slst/sst	573470	5410600	49	220	52	228		
25	26	0.12	slst/fgsst	573400	5410700	83	212	83	212		
26	27	0.08		573280	5410750						
27	28	0.17		572240	5409830						
28	38	0.21	fgsst	574210	5404740			86	220		
29	39	0.19		574370	5405090			67	60		
30	40	0.17		574850	5406440			85	245		
31	4 1	0.17		574930	5406450			87	55		
32	42	0.19	fgsst/slst	574980	5406450	86	52	88	65		
33	43	0.28		575030	5406465			90	225		
34	44	2,4		575115	5406480			84	236		
35	49	0.18	slst	572820	5410250			85	216		
36	50	0.15	slst	572550	5409955			80	45		
37	51	0.1	slst/fgsst	572350	5409870						
38	52	0.2	slst	572090	5409820	68	233	85	40		
39	53	0.06	sst	571995	5409760			90	185		
40	54	0.15	slst	571990	5409580						
41	55	0.08	sst(slst)	571960	5409475	27	1 42				
42	56	0.07	sst	571925	5409405			90	236		
43	57	0.17	sst/slst	571900	5409380	30	160				
44	58	0.12		571830	5409370	26	67	61	22		
45	59	0.16	slst(sst)	571495	5409320			30	155		
46	60	0.14		571390	5409230		-	68	220		
47	61	0.08	sst	571275	5409145	60	6	75	23		
48	62	0.08		571190	5409100	67	185	63	195		
49	63	0.14		571130	5409070	75	220	59	218		

MATHINNA-ALBERTON GOLD LINEAMENT

Uniq No.	Field No.	Mag Sus	Rock Type	Easting (m)	Northing (m)	Bedding Dip	Dip az.	Cleavage Dip	Dip az.	S0–S1 Plu.	Int. Lin Az.
50	64.4	0.08	-57-	579750	5407150	80	238	<u>F</u>			
50 51	64B	0.00		579700	5407270	55	256				
52	64C	0.02		579650	5407330	64	30	75	55	7	319
53	64D	0.00		579560	5407400	61	240	15	55	,	517
54	64E	0.12		579470	5407475	56	265	80	50		
55	65	0.1		578980	5407630	50	255	85	247		
56	66	0.13		578685	5407680	32	25	55	58	20	325
57	67	0.09		578570	5407700			87	250	-•	
58	68	0.1	fgsst/mdst	578180	5407750	75	42	88	227		
59	69	0.12	schist	574860	5407340			82	35		
60	70	0.14	schist	574970	5407600			76	235		
61	71	0.09	fgsst	575060	5407900			85	225		
62	72	0.14	sst/grwack	575380	5407975			78	40		
63	73	1.13	U	575865	5407425	75	98	86	244		
64	74	0.46	slst	576265	5407300			80	65		
65	75	0.59	slst	576460	5407490			90	235		
66	76	0.55	fgsst	577120	5407050			85	218		
67	77	0.18	fgsst	577880	5406900			77	227		
68	78	0.16	slst(fgsst)	575150	5404750	47	35	80	60	26	306
69	79	0.12	slat/fgsst	576020	5409840	70	340	87	220		
70	80	0.11	fgsst	571045	5409045	33	158				
71	81	0.28	grnschist	570730	5408750			90	205		
72	82	0.19	fgsst/mdst/slst	570550	5408650	73	25	88	205		
73	83	0.15	fgsst/mdst	569850	5408720	81	14	84	1 95		
74	84	0.12	slst/mdst/fgsst	569800	5408900	60	360	85	30		
75	85	0.14	fgsst	569640	5408935	62	10	65	210	45	312
76	86	0.11	fgsst	569440	5408870	54	9	84	20		
77	87	0.21	sst/grwack	569195	5408785	77	20				
78	88	0.11	sst	56901 0	5408730	55	5	64	210		
79	89	0.09	sst	568800	5408700	38	17	56	200		
80	91	0.17	sist	567100	5409955			45	30	6 1	45
81	92	0.18	fgsst	567400	5409745	77	25	77	40		
82	93	0.14	slst/mdst	567565	5409710			78	36		
83	94	0.12	sst	568310	5408970	67	175	85	185	30	82
84	95	0.14	mdst/fgsst	568385	5408870	64	15				

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