THE GEOLOGY OF THE ESMERALDA PROJECT AREA

PINE CREEK, NORTHERN TERRITORY

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Introduction

At the request of Mark Edwards of Crocodile Gold Corporation, six weeks from 15th April 2014 to 25th May 2014 were spent mapping the Esmeralda area 8km to the NE of Pine Creek, Northern Territory, Australia. The area mapped covered sq. km.

The Esmeralda Area has three main areas of gold mineralization, Esmeralda A, B and C, together with a single known base metal occurrence, Caroline.

The aims of the mapping exercise were to establish the distribution and geometry of the mineralization in areas A, B and C (Caroline South).

Regional Setting

The Esmeralda and Caroline Project tenements are located in the Central Domain of the NNW-striking Pine Creek Belt, which comprises a >4km thick sequence of folded and metamorphosed Lower Proterozoic clastic, carbonate and carbonaceous sediments and volcanic rocks in the Northern Territory of Australia. These rocks unconformably overlie a Neo-Archaean granite-gneiss basement and intruded by dolerites and granitoids. The Pine Creek Belt has been subdivided into three regions, each characterized by stratigraphy, structural style and magmatism; the western amphibolite to granulite-facies Litchfield Province, the greenschist-facies Central Domain and the eastern amphibolite-facies Nimbuwah Domain. The sediments in the Central Domain have been dated at 2025 Ma for the earliest Mount Partridge Group to 1863 Ma for the South Alligator and Finnis River Groups. The post-tectonic I-type Cullen batholith was intruded 1835Ma to 1820 Ma (Glass et al, 2010).

Local Geology & Stratigraphy

The local geology of the Esmeralda and Caroline areas comprises an NNW-striking tightly folded inlier of Mount Bonnie Formation slates, greywackes and cherts conformably overlain to the west by the younger Burrell River slates that host the Union Reefs Mine and to the east by the Allamber Springs Lobe of the Cullen Batholith (Fig. 1).

The stratigraphy of the Adelaide River-Pine Creek Area (Fig. 2) comprises Lower Proterozoic sedimentary and volcanic rocks of the South Alligator Group and the Finnis River Group. Locally underlying the South Alligator Group are the conglomerates, arkoses, siltstones and graphitic shales of the Mount Partridge Group. The South Alligator Group consists of the basal Koolpin Formation overlain by the Gerowie Formation and capped by the Mount Bonnie Formation. The overlying Finnis River Group in the area comprises the Burrell Creek Formation. The entire sequence is intruded by the Zamu dolerites and the Cullen batholith granites (Glass et al, 2010).

Sedimentology & Palaeovolcanology

Five basic lithofacies (Lithofacies A to E) have been identified in the Mount Bonnie Formation in the Esmeralda area; slates, greywackes, cherts & massive and banded siliceous rocks.

Lithofacies A: Slates (Photo 1)

Description: The slates comprise fine grained, strongly and pervasively cleaved phyllosilicate-rich (mostly chlorite and muscovite) rocks in beds up to 20m thick. They occasionally show grading into greywackes. Certain beds are graphitic and also show rounded and oval siliceous nodules (“boudins”) similar to those seen in the Koolpin Formation at Cosmo and the Mount Bonnie Formation at Enterprise.

These slates have been hornfelsed in a belt roughly 200m wide around the granite intrusion to the east.

Interpretation: These slates represent regionally metamorphosed muds deposited in a marine shelf environment. The rounded and oval chert nodules have been interpreted as chert nodules and beds originally precipitated in an alkaline playa lake or diagenetic nodules and beds that grew after deposition or as siliceous nodules associated with shallow water emplacement of high temperature pyroclastic tuffs.

Economic Implications: The presence of the “boudins” in the mineralized areas is similar to the Cosmo and Enterprise deposits. These may be used as an indicator of mineralization. The graphitic nature of some of the slates could interfere with the ore processing.

Lithofacies B: Greywackes (Photo 2)

Description: The greywackes comprise graded to ungraded coarse to very coarse grained metamorphosed lithic wackes with significant amounts of volcaniclastic material. They are usually massive but can occasionally show wave rippled tops. They can grade vertically into the slates and laterally into the laminated cherts and siliceous rocks. Beds vary in thickness between 0.1 and 5m in thickness.

Interpretation: The massive greywackes are interpreted as debris flows or turbidites deposited as hyperconcentrated grain flows in a marine environment. Their high volcaniclastic content and their lateral relationships suggest that they were strongly influenced by nearby seafloor volcanic activity.

Economic Implications: The greywackes provide a more brittle lithofacies in the more ductile slate and as such provide a suitable site for mineralized bodies to form. In both Esmeralda A and B, the greywacke beds have undergone brittle deformation resulting in the opening of mineralized lodes and veins especially along bedding plane contacts. In Esmeralda C, a thick greywacke bed has undergone sinistral shearing and brecciation resulting in extensive pyrite/sericite alteration and a stockwork of fine quartz veins

Lithofacies C: Cherts (Photo 3)

Description: The chert beds are typically up to 1m thick and have sharp, conformable contacts with underlying and overlying beds. They generally show mm- to cm-scale white to reddish brown, parallel lamination and bands of micro-crystalline silica. No brecciated horizons or intra-bed fold structures have been seen unlike Lithofacies D and E.

Interpretation: The cherts are interpreted as siliceous exhalatives that accumulated in a marine environment influenced by nearby hydrothermal and volcanic activity.

Economic Implications: Combined with Lithofacies D and E these cherts suggest contemporaneous seafloor hydrothermal activity.

Lithofacies D: Massive/Brecciated Siliceous Rocks (Photo 4)

Description: These siliceous rocks are composed of fine to coarse silica cemented in a fine grained silica matrix and display massive or brecciated fabrics. Beds vary in thickness between 0.2m and 15m showing sharp, usually “conformable” relationships with the enclosing rocks with often planar to occasionally lobate contacts. Occasionally, however, as in the ridge between Esmeralda A and Esmeralda B, these beds of these siliceous rocks can show cross-cutting en-echelon geometries. The brecciated siliceous beds comprise angular to flattened and streaked, light coloured, silica fragments up to 10cm across in a darker siliceous matrix.

Interpretation: Although these siliceous rocks have previously been referred to as cherts and/or brecciated quartz veins they are too coarse grained to be described as cherts and display unusual fabrics for brecciated quartz veins (flattened/streaked out clasts and lobate footwall relationships). Quartz veins proper are present in the area but their textures are either massive anhedral and coarsely crystalline or composed of angular, equant breccia fragments. These rocks are provisionally interpreted as silicified felsitic volcanic rocks (“rhyolites”) originally formed as submarine domes or cryptodomes (intrusive domes) in a marine environment.

Economic Implications: Combined with presence of Lithofacies C and E, this lithofacies suggests contemporaneous acid seafloor volcanism. If there was contemporaneous basic volcanism, then the possibility of VMS cannot be ruled out.

Lithofacies E: Banded Siliceous Rocks (Photo 5)

Description: The banded siliceous beds are generally alternating greenish grey and light grey, medium to coarse grained and show cm-scale coarse parallel banding. Beds are up to 2m thick and appear to be conformable with the enclosing slates. Locally the banding can be folded into dm-scale, isoclinal, recumbent folds, these folds being confined to the banded siliceous rocks, having random orientations and not extending into the enclosing country rocks. The banding also shows local brecciation, with both jigsaw fit and rotated fabrics. Clasts are generally angular and monomictic comprising fragments of the light grey bands in a matrix of dark greenish grey material. Small spherical nodules can also be present.

Interpretation: These Banded Siliceous Rocks are provisionally interpreted as felsic lava flows (“rhyolites”) displaying flow banding, flow brecciation and flow folds. The spherical nodules may represent devitrification sphaerulites. They grade laterally into more proximal Massive/Brecciated Siliceous submarine dome lithofacies and more distal hyper-concentrated Greywacke lithofacies.

Economic Implications: Again these rhyolitic flows imply the possibility of VMS. Any VMS bodies are more likely to be found nearer the Lithofacies D lenses.

Summary

The combination of lithofacies identified in the Esmeralda area is thought to represent a shallow muddy marine environment influenced by occasional submarine felsic volcanic eruptions (Fig. 3). These felsic volcanic systems may have produced VMS which could have had low-grade gold mineralization (~0.1g/t) that was remobilized during regional and/or thermal metamorphism and concentrated in suitable sites. This mechanism appears to be quite common elsewhere in the world.

Intrusives

Felsic Intrusives

A single example of an aplitic sill, 5cm thick, was seen in the Esmeralda A area in a greywacke/slate sequence approximately 100m away from the granite/sediment contact. There should be other aplitic intrusives present in the area around the granite. Sampling of this sill gave no gold suggesting that the granite was not responsible for the gold mineralization.

Mafic Intrusives

A deeply weathered, NW-SE striking 5m thick dolerite (?) dyke was seen in the road cut in the southern part of Esmeralda and another deeply weathered NW-SE striking

2m thick dolerite (?) dyke was seen in an old trench just north of Caroline. These may represent strike continuations of the same intrusive and can be traced from geophysics. They may represent Zamu type dolerites.

Two other thin (<1m) NW-SE striking lamprophyric dykes were seen in the Esmeralda A area and south of Caroline Hill.

Granitoids (Photo 6)

The large irregular intrusive body of the Allamber Springs Lobe of the Cullen Batholith marks the eastern boundary of the Esmeralda area. This granitoid comprises an earlier porphyritic, hornblende-biotite, metaluminous, coarse grained monzogranodiorite and a later equigranular, biotite, peraluminous coarse grained monzogranite. Both phases were seen in the east of Esmeralda area. These granitoids are cut by later aplite dykes and sericite-epidote-rich griesens. Its intrusion has hornfelsed the sediments in contact with it in a zone up to 300m wide.

Structure

Bedding

Bedding in the Esmeralda area shows the dominance of steep dips (>70°) towards the NE and SW, related to the tight to isoclinal NW-SE striking folding. Younging directions marked by graded bedding and ripple marks were also observed on bedding planes enabling the fold facing to be ascertained and indicating that the eastern limbs of the major anticlines are overturned (Fig. 4a).

Foliation

At least three foliations/cleavages have been observed, an earlier axial planar cleavage steeply SW-dipping associated with the tight NW-SE striking folds, a NW-SE zonal anastomosing shear foliation and a later cross-cutting moderately eastward dipping fracture cleavage (Fig. 4b).

Folding

At least three phases of folding were seen in the Esmeralda area, an early steeply plunging, asymmetric set of folds confined to Lithofacies E, a subsequent upright, shallow plunging tight fold set and a later set of tight steeply plunging small scale folds.

The F0 folds are confined to Lithofacies E and show highly variable axial plane and plunge orientations. They can also show brittle fracturing of their limbs and are interpreted as flow folds in felsitic lava flows (Fig. 4c, Photo 8).

The F2 fold set (Photo 9) includes the first and second order upright, NW-SE striking tight to isoclinal folding which shows mostly steeply west dipping axial planes and variable plunges. This folding shows shallow (~5°) NW plunges in the north of

Esmeralda (north of 8476500) changing to shallow (~12°) SE plunges in the middle (8476500 to 8477000) and back to NW plunges in the south (south of 8477000) suggesting shallow NE-SW striking cross-folding. Fold wavelengths vary between metres and 100's of metres (Fig. 4d, e, f).

Later small-scale F3 folds are asymmetric with wavelengths of less than 1m and show sub-vertical SW-dipping axial planes but steep plunges (>80°) to the SW. They generally show "S" shaped geometries and are associated with the anastomosing shear foliation suggesting sinistral vergence. Occasionally "Z" geometries are seen suggesting limited subsequent dextral shear movements.

Thrusts

Evidence for bedding plane parallel thrusting can be seen in the Esmeralda area as small duplexes with north-eastwards vergences suggesting an early SW-over-NE thrusting event. This early thrusting has been overprinted by the variable flexural slip movement on the bedding planes on the limbs of the folds. Further thrusting has resulted in the local displacement of fold axes to the NE as at Esmeralda A.

Shear Zones

Dominant NW-SE and subordinate NE-SW striking shear zones are found in the Esmeralda area marked by shear foliation, asymmetrical, steeply plunging folds and sulphide-mineralized brecciation in greywackes (Photo 10). These shear zones show mainly sinistral structures (folds and S-C structures) but locally show a dextral fabric suggesting subsequent reactivation.

Quartz Veins

Several generations of quartz veins have been encountered comprising early barren, massive, white quartz veins, subsequent barren, sheared white quartz veins and finally late massive and brecciated auriferous grey quartz(-tourmaline) veins. The early massive white quartz veins appear to represent saddle reefs on the culminations of second order upright folds (F2) of the D2 deformational event. The sheared quartz veins occur in the sinistral shear zones of the D3 deformational event. The late massive quartz tourmaline veins are found along bedding planes between the second order strike slip fault splays.

Despite their differing parageneses, all these quartz vein generations appear to be parallel to bedding (Fig. 4g).

Summary of Structural Evolution (Fig. 5a-f)

The structural evolution of the Esmeralda area is as follows:

1. Early bedding plane parallel SW-over-NE thrusting, which may locally have produced imbricate fans of fault bend folds where the thrusts stepped up through the stratigraphy (D1).

2. SW-NE oriented compression tightened the D1folds and producing new folding such as second order parasitic folds on the SW limbs of the first order folds (D2).
3. Clockwise rotation of the shortening to W-E orientation resulting in sinistral strike-slip faulting often reactivating the now-subvertical thrust planes (D3).
4. Further clockwise rotation of the shortening direction to NW-SE producing resulting in subtle cross-folding and the doubly plunging axial planes of the D2 folds (D4).
5. Local reactivation of the strike slip faults as dextral faults (D5).
6. Intrusion of the Allamber Springs Lobe of the Cullen Batholith resulting in the uplift of the Mount Bonnie Formation and the formation of the late fracture cleavage (D6).

This model for the structural evolution of the Esmeralda area resembles that proposed for the Union Reefs area with the exception of the early bedding plane parallel thrusting D1, which is probably present at Union Reefs but was not recognized.

Alteration

Alteration

Five alteration zones were noted during mapping comprising silica, epidote, chlorite, tourmaline, and sericite alteration.

Silica

Silica alteration involves the silicification of the massive and banded siliceous lithologies (Lithofacies D and E) and the country rocks around the quartz veins. The former is probably due to seafloor early diagenetic alteration/remobilization of silica in felsic volcanic rocks. The latter may be related to the remobilization/migration of silica-rich fluids during both regional and thermal metamorphism.

Pyrite

Pyrite alteration occurs in two settings: as randomly distributed euhedral-subhedral cubes up to 20mm across in the massive and banded siliceous lithologies (Lithofacies D and E) and as disseminated anhedral aggregates around quartz veins and in altered/sheared greywackes. The former may be due to early propylitic alteration and the latter due to alteration by regional and/or thermal metamorphic fluids.

Epidote

Epidote alteration comprising irregular fine grained patches of epidote was noted in the massive and banded siliceous lithologies (Lithofacies D and E) especially near the thicker developments of these lithologies. This alteration is possibly related to propylitic alteration associated with the migration of Fe- and S-bearing hydrothermal fluids and associated with the chlorite and pyrite alteration. Epidote was also noted associated with quartz veins and shear zones in the granites.

Chlorite

Chlorite alteration was again noted in the massive and banded siliceous lithologies (Lithofacies D and E) associated with epidote-pyrite alteration. It also occurs as a regional metamorphic mineral in the country rocks.

Tourmaline

Fine needles and rosettes of black tourmaline are found in the auriferous quartz veins at Esmeralda A but are rarer elsewhere in the meta-sedimentary rocks at Esmeralda. Tourmaline is also found in late-stage alteration around veins cutting the Allamber granite.

Sericite

Sericite alteration comprising irregular disseminated books of sericite is found mainly around shears and quartz veins associated with pyrite and tourmaline alteration especially in greywackes.

Metamorphism

The rocks in the Esmeralda area have undergone two types of metamorphic alteration, an earlier regional metamorphism and a later thermal metamorphism. The regional metamorphism is generally Upper Greenschist with the formation of biotite, chlorite, andalusite and garnet in the shales. The garnets are often retrogressed to chlorite. The Zamu dolerites also show Upper Greenschist metamorphism with the formation of amphibole, chlorite, sericite, biotite and albite.

The thermal metamorphism was produced by the intrusion of the Cullen Granite, which has resulted in the formation of garnet, amphibolite and cordierite in sillimanite to hornblende- hornfels in a 300m wide aureole around the granite. It is interesting to note that no auriferous quartz veins appear to occur in the hornfels suggesting that the veins are syn- to post- the Allamber granite intrusion.

Mineralization

Gold mineralization was detected in four areas, the already drilled Esmeralda A and B areas, an area of shearing south of Caroline (Esmeralda C) indicated by geochemical anomalies and rock chip samples and an area to the NW of Esmeralda A and the NE of Esmeralda B (here termed Esmeralda D). Base metal mineralization has been noted at Caroline.

Esmeralda A: The gold mineralization in Esmeralda A occurs in a series of NNW-SSE striking, bedding plane parallel quartz-tourmaline veins associated with pyrite-sericite alteration in a sequence of alternating slates and greywackes. These veins are thought to have formed during an episode of dextral strike-slip movement between a series of right-lateral stepovers. However evidence of sinistral movement was seen also seen on these faults and the mineralization could instead have been formed during left-lateral movement similar to Esmeralda B (Fig. 7). The extent of this gold mineralized vein system is governed by a WNW-ESE striking cross fault to the north and the hornfelsed aureole of the Allamber granite to the south.

Esmeralda B: The gold mineralization at Esmeralda B again occurs in a series of NNW-SSE striking, bedding-plane parallel quartz veins in an alternating slate-greywacke sequence. Gold mineralization also occurs in NE-SW striking sinistral cross fractures and in the culminations of parasitic folds as pyrite-sericite alteration. Little or no tourmaline appears to be present. This mineralization appears to have formed during an episode of sinistral strike-slip movement between a series of left-lateral stepovers (Fig. 7). The extent of this mineralization appears to be cut off to the north by the same WNW-ESE striking cross fault as Esmeralda A. The southern end of Esmeralda B is not constrained but disappears under a cover of siliceous rubble towards Caroline Hill.

Esmeralda C: The gold mineralization at Esmeralda C occurs in a NNW-SSE striking sinistral 5m wide shear zone cutting through a 20m thick greywacke and is associated with pyrite-sericite alteration and was picked up by geochemistry and chip sampling. This mineralization appears to be limited by cross-faulting to the north but is unconstrained to the south but covered by siliceous rubble.

Esmeralda D: The gold mineralization at Esmeralda D was located by chip sampling (up to 0.3 g/t) and comprises pyrite-sericite alteration in the culmination of a major NNW-SSE striking anticline. It is cut off to the south by the same WNW-ESE striking cross fault as Esmeralda A but is unconstrained to the north.

Caroline: The base metal prospect at Caroline has been looked at in the field and comprises massive sulphides in an epidote-chlorite altered brecciated siliceous bed (Lithofacies D). It is thought to represent a poorly developed VMS and may indicate other better developed VMS bodies in the area. Some gold mineralization also appears to be present.

Conclusions

Sedimentology & Palaeovolcanology

Five lithofacies (Lithofacies A to E) have been identified in the Mount Bonnie Formation in the Esmeralda area; slates, greywackes, cherts & massive and banded siliceous rocks and are thought to represent a shallow mostly muddy marine shelf environment (slates and greywackes) influenced by occasional submarine felsic volcanic eruptions (cherts, massive and banded siliceous rocks). These felsic volcanic systems may have produced VMS which could have had low-grade gold mineralization (~0.1g/t) that was remobilized during regional and/or thermal metamorphism and concentrated in suitable sites. The mechanism appears to be quite common elsewhere in the world.

Intrusives

A single example of an aplitic sill, 5cm thick, was seen in the Esmeralda A area in a greywacke/slate sequence approximately 100m away from the granite/sediment contact. This may be associated with the Allamber Springs granite.

A deeply weathered, NW-SE striking 5m thick dolerite (?) dyke was seen in the road cut in the southern part of Esmeralda and another deeply weathered NW-SE striking 2m thick dolerite (?) dyke was seen in an old trench just north of Caroline. These may represent strike continuations of the same intrusive and can be traced from geophysics. They may represent Zamu type dolerites. Two other thin (<1m) NW-SE striking lamprophyric dykes were seen in the Esmeralda A area and south of Caroline Hill.

The large irregular intrusive body of the Allamber Springs Lobe of the Cullen Batholith marks the eastern boundary of the Esmeralda area. Its intrusion has hornfelsed the sediments in contact with it.

Structure

Bedding in the Esmeralda area is dominated by steep dips (>70°) towards the NE and SW, related to the tight to isoclinal NW-SE striking folding. Younging directions marked by graded bedding and ripple marks were observed on bedding planes enabling the fold facing to be ascertained and indicating that the western limbs of the major anticlines are mostly the right way up and the eastern limbs are overturned.

At least three foliations/cleavages have been observed, an earlier axial planar cleavage dipping steeply SW associated with the tight NW-SE striking folds, a NW-SE zonal anastomosing shear foliation associated with the strike-slip faulting and a later cross-cutting moderately eastward dipping fracture cleavage possibly associated with the Allamber Springs granite intrusion.

Three phases of folding were seen in the Esmeralda area, an early steeply plunging, asymmetric set of folds confined to Lithofacies E interpreted as flow folds in felsitic lava flows, a subsequent upright, shallow plunging tight fold set formed under NE-SW compression and a later set of tight steeply plunging small scale folds associated with sinistral and occasionally dextral shear zones.

Early bedding plane parallel thrusting can be seen in the Esmeralda area marked by small duplexes with north-eastwards vergences suggesting an early SW-over-NE thrusting event. This early thrusting may have been responsible for the initial folding of the rocks whereas later thrusting resulted in the displacement of fold axes to the NE as at Esmeralda A.

NW-SE and NE-SW striking shear zones are found in the Esmeralda area marked by shear foliation, asymmetrical, steeply plunging folds and sulphide-mineralized brecciation in greywackes. A dominant early sinistral but subordinate later dextral sense of movement is indicated.

Several generations of quartz veins have been encountered: early barren, massive, white quartz veins, then subsequent barren, sheared white quartz veins and finally late massive and brecciated auriferous grey quartz (-tourmaline) veins. The early massive white quartz veins appear to represent saddle reefs on the culminations of second order upright folds (F2) of the D2 deformational event. The sheared quartz veins occur within and between the sinistral shear zones of the D3 deformational event. The late massive gold bearing quartz tourmaline veins are also found within and between the sinistral shear zones of the D3 deformational event but closer to the granite. Despite their differing parageneses, all these quartz vein generations appear to be parallel to bedding.

Mineralization and Alteration

Five alteration types were noted during mapping comprising silica, epidote, chlorite, tourmaline, and sericite alteration.

Silica alteration involves the silicification of the massive and banded siliceous lithologies (Lithofacies D and E) and the country rocks around the quartz veins. The former is probably due to seafloor early diagenetic alteration/remobilization of silica in felsic volcanic rocks.

Pyrite alteration occurs in two settings: as randomly distributed euhedral-subhedral cubes up to 20mm across in the massive and banded siliceous lithologies (Lithofacies D and E) and as disseminated anhedral aggregates around quartz veins and in altered/sheared greywackes. The former may be due to early propylitic alteration and the latter due to alteration by regional and/or thermal metamorphic fluids.

Epidote alteration comprising irregular fine grained patches of epidote was noted in the massive and banded siliceous lithologies (Lithofacies D and E) especially near the thicker developments of these lithologies. This alteration is possibly related to propylitic alteration produced by the migration of Fe- and S-bearing hydrothermal fluids.

Chlorite alteration was again noted in the massive and banded siliceous lithologies (Lithofacies D and E) associated with epidote-pyrite alteration.

Fine needles and rosettes of black tourmaline are found in the auriferous quartz veins at Esmeralda A but are rarer elsewhere in the meta-sedimentary rocks at Esmeralda.

Sericite alteration comprising irregular disseminated books of sericite is found mainly around shears and quartz veins associated with pyrite and tourmaline alteration especially in greywackes.

Metamorphism of the rocks in the Esmeralda area has resulted in two types of metamorphic alteration, an earlier regional metamorphism and a later thermal metamorphism. The regional metamorphism is generally Upper Greenschist with the formation of biotite, chlorite, andalusite and garnet in the shales. The Zamu dolerites also show Upper Greenschist metamorphism with the formation of amphibole, chlorite, sericite, biotite and albite. The thermal metamorphism associated with the intrusion of the Allamber Springs Granite has resulted in the formation of garnet, amphibolite and cordierite in a sillimanite to hornblende- hornfels 300m wide around the granite.

<u>Gold Mineralization</u>

Gold mineralization was detected in four areas, the already drilled Esmeralda A and B areas, an area of shearing south of Caroline (Esmeralda C) indicated by geochemical anomalies and rock chip samples and an area to the NW of Esmeralda A and the NE of Esmeralda B (here termed Esmeralda D). Base metal mineralization has been noted at Caroline. The gold mineralization in Esmeralda A occurs in a series of NNW-SSE striking, bedding plane parallel quartz-tourmaline veins associated with pyrite-sericite alteration in a sequence of alternating slates and greywackes. The extent of this gold mineralized vein system is governed by a WNW-ESE striking cross fault to the north and the hornfelsed aureole of the Allamber granite to the south.The gold mineralization at Esmeralda B again occurs in a series of NNW-SSE striking, bedding-plane parallel quartz veins in an alternating slate-greywacke sequence. This mineralization appears to be cut off to the north by the same WNW-ESE striking cross fault. The southern end of Esmeralda B is not constrained but disappears under a cover of siliceous rubble towards Caroline Hill. The gold mineralization at Esmeralda C occurs in a NNW-SSE striking sinistral 5m wide shear zone cutting through a 20m thick greywacke and is limited by cross-faulting to the north but is unconstrained to the south. The gold mineralization at Esmeralda D was located by chip sampling (up to 0.3 g/t) and comprises alteration in the culmination of a major NNW-SSE striking anticline. It is cut off to the south by the same WNW-ESE striking cross fault as Esmeralda A but is unconstrained to the north.

The base metal prospect at Caroline has been looked at in the field and comprises massive sulphides in an epidote-chlorite altered brecciated siliceous bed (Lithofacies D). It is thought to represent a poorly developed VMS body and may indicate other better developed VMS bodies in the area. Some gold mineralization is also present.

<u>**Recommendations**</u>

The following recommendations can be made:

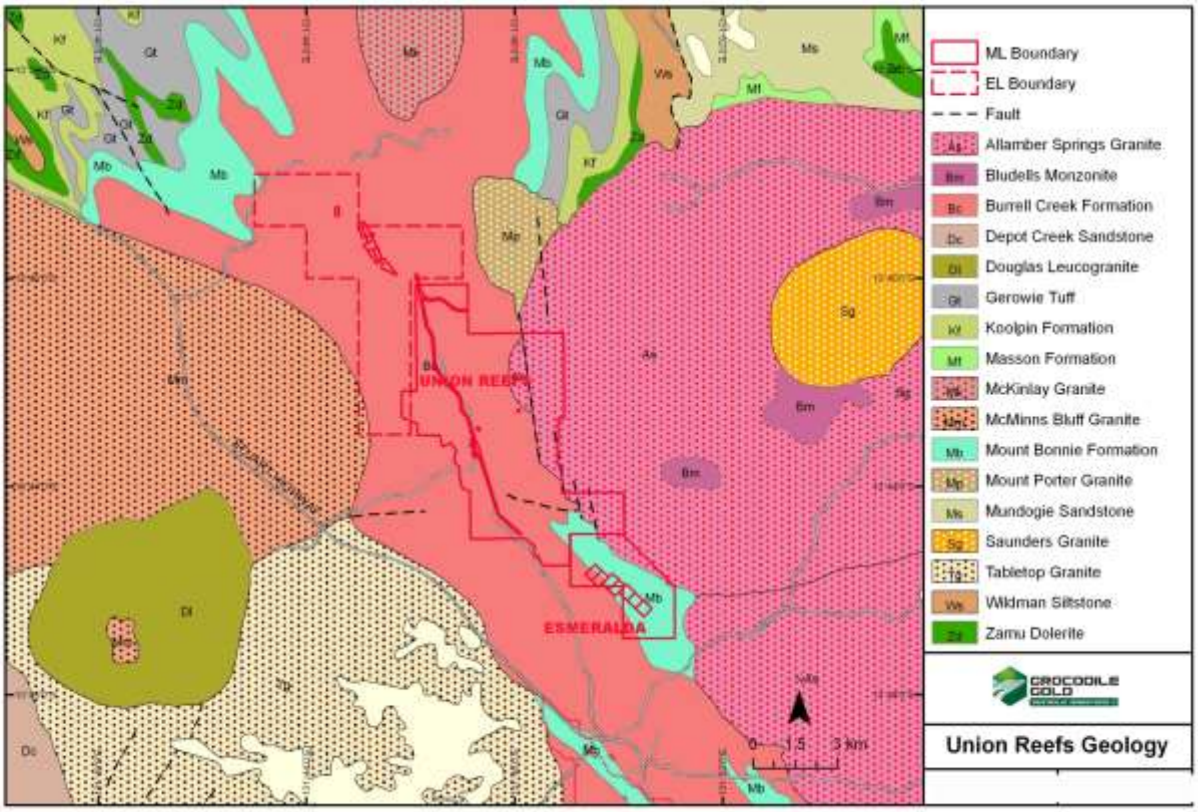
- At Esmeralda A, the mineralization is confined to the north by the cross fault, to the east and south by the hornfels and to the west by a shear and drilling has established its full extent. Moving the gas pipeline further to the east by at least 300m appears possible and would possibly make this area mineable.
- At Esmeralda B, the mineralization has been constrained to the north by the cross fault, to the east and west by two shears and to the south by a cover of siliceous rubble. The drilling only covers the central area of B and should be extended to the north to the cross fault and south under the siliceous rubble possibly after costeaning and sampling.
- At Esmeralda C the mineralization has been constrained to the north by a cross fault and to the east and west by the limits of the shear. This area should be drilled and its southern limit established by costeaning.
- At Esmeralda D, only the southern limit has been established at a cross-fault, the other limits being unconstrained. This area needs a soil geochemical survey, costeaning and drilling.
- At Caroline, a ground geophysical survey may locate larger blind VMS-type orebodies.

ADDENDUM:

BONS RUSH

Three days were spent in the Bons Rush area looking at the known mineralization and comparing it to Cosmo Howley Mine. From initial mapping, the Bons Rush proper mineralization is mainly in or just below the Zamu dolerite and associated with a series ("fan") of NW-SE striking folds similar to Howley. However the presence of "boudins" and a stratigraphic and structural deformation history similar to the Cosmo Howley area suggests that other mineralization will almost certainly be present in the area in the equivalent of the Koolpin Formation similar to Cosmo Mine. It is recommended that mapping, chip sampling and a geochemical survey be carried out in the area especially over the possible intersection of the Koolpin Formation with the fold fan to the NW of Bons Rush itself.

FIGURES



<u>Fig 1:</u> Location of the Esmeralda relative to Union Reefs

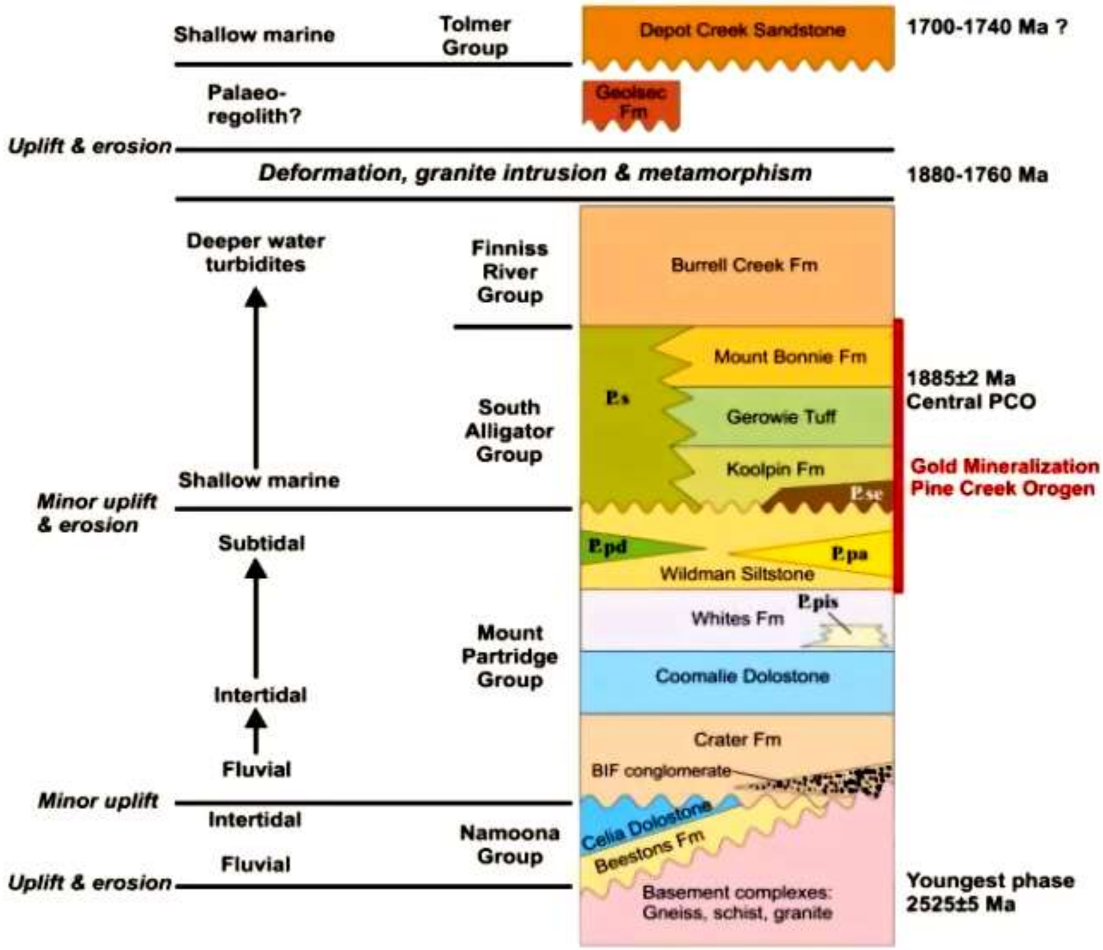
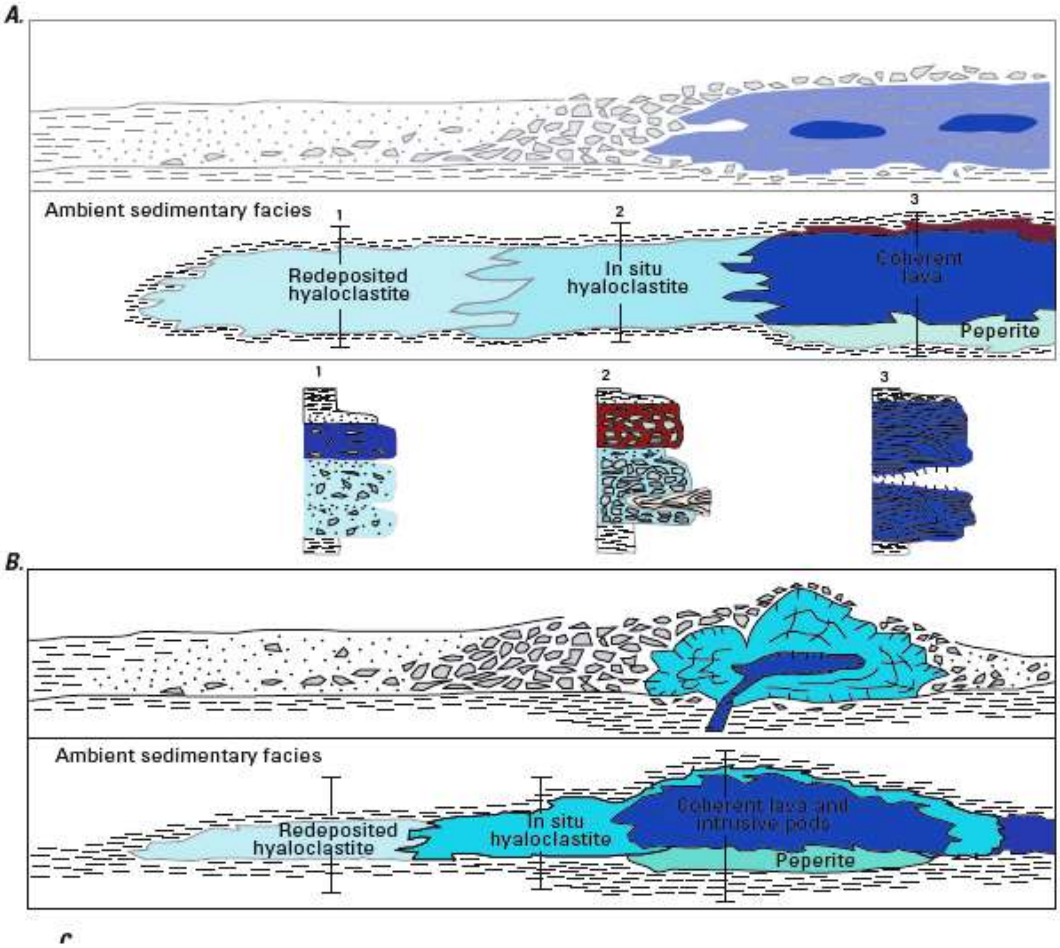
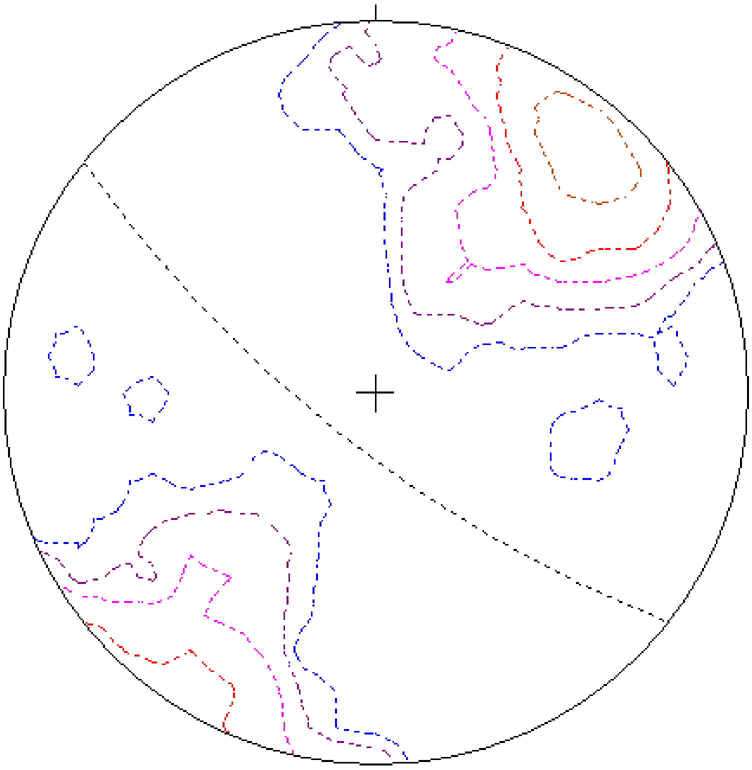


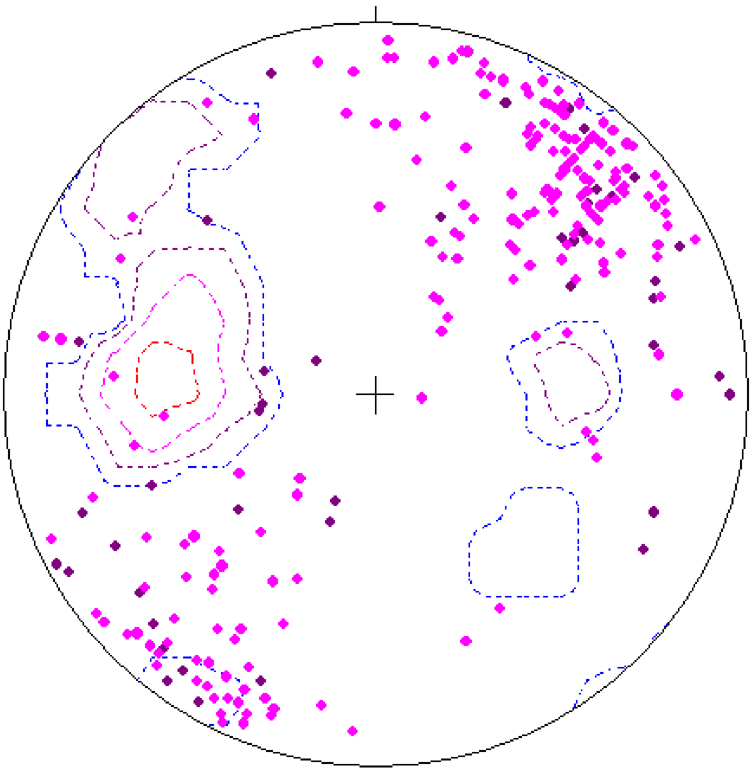
Fig. 2: **Stratigraphy of the Adelaide River-Pine Creek area**



<u>Fig. 3:</u> Typical lithofacies variations for A, a submarine felsic lava, and B, a submarine felsic dome.



<u>Fig. 4a:</u> Stereonet of bedding in the Esmeralda area (220 data points)



<u>Fig. 4b:</u> Stereonet of earlier axial planar (D2) foliation in pink and later (D6) fracture cleavage (contoured)

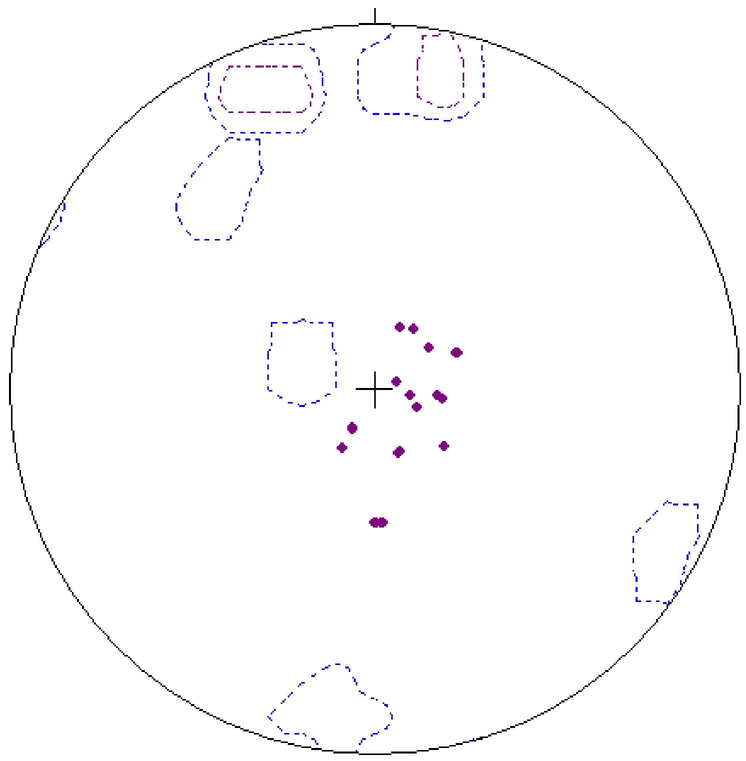


Fig. 4c: **Axial planes (contoured) and plunges (purple diamonds) of F0 flow folds.**

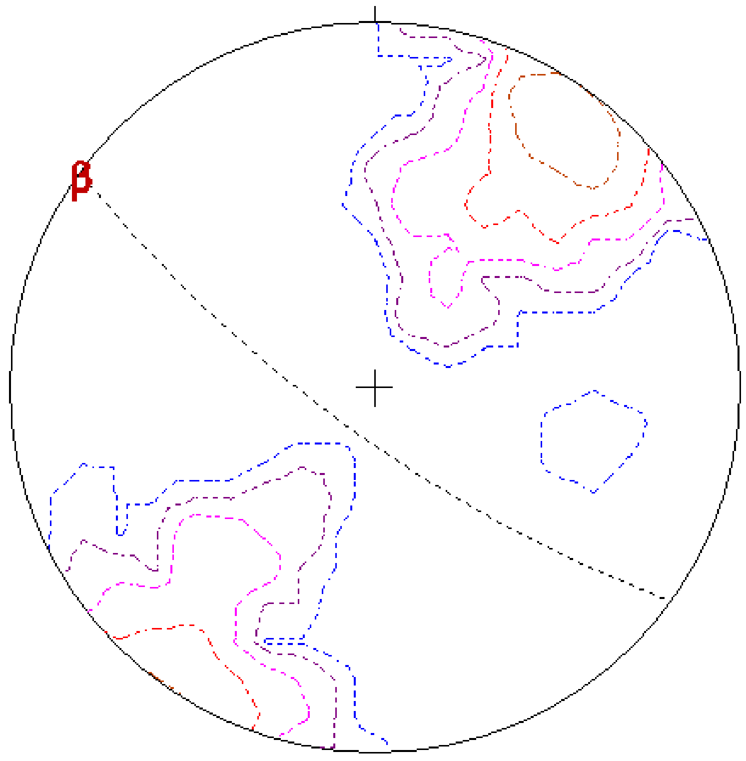
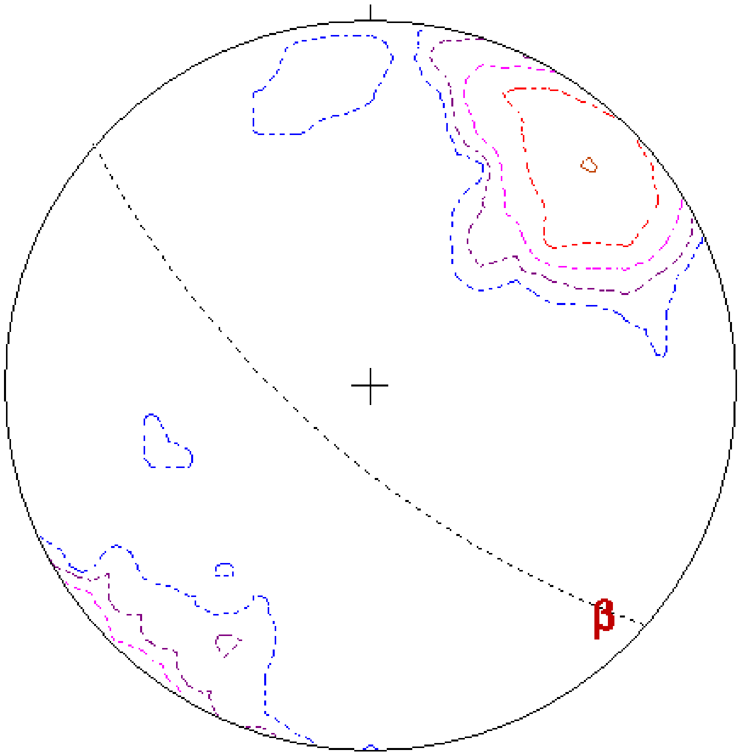
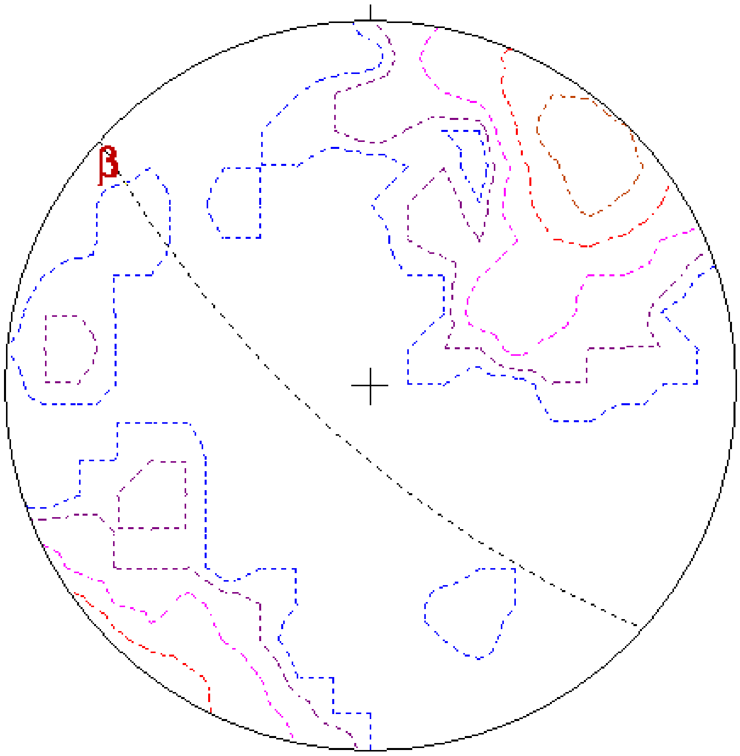


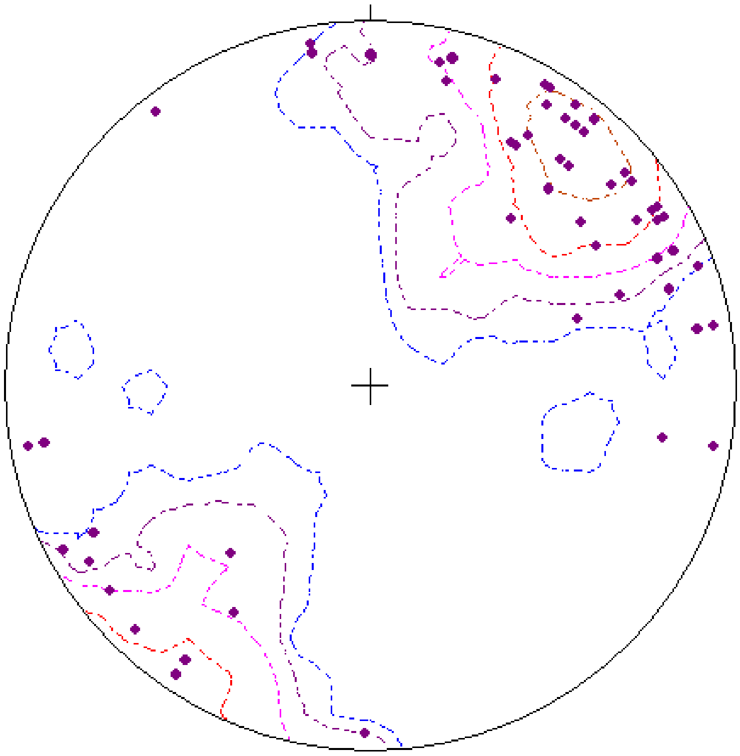
Fig. 4d: **Mean axial plane (dashed line) and plunge (β) of F2 folds in northern Esmeralda.**



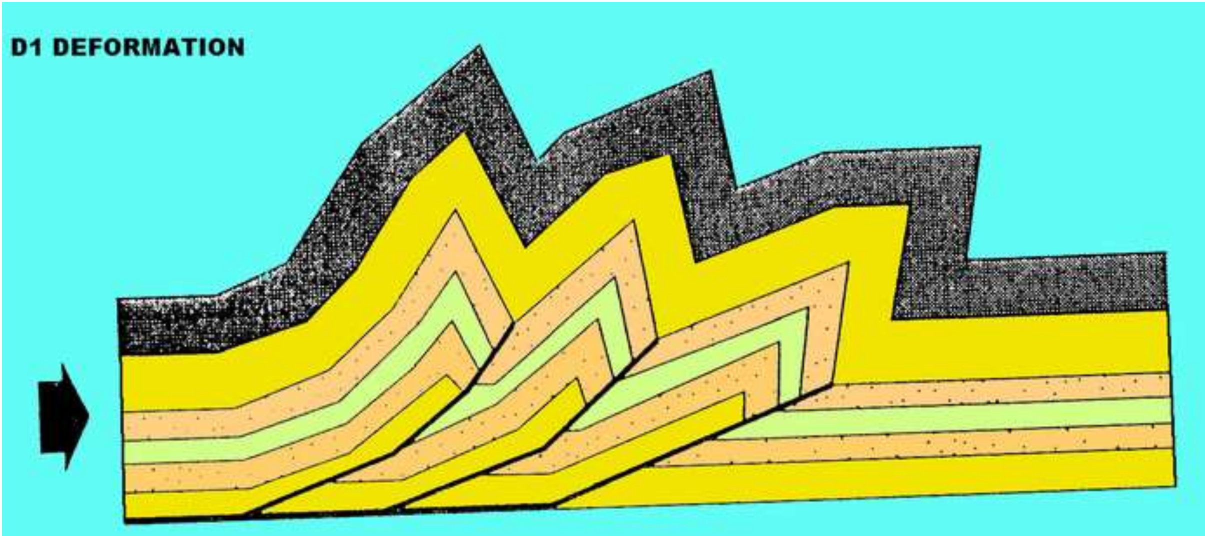
<u>Fig. 4e:</u> Mean axial plane (dashed) and plunge (β) of F2 folds in central Esmeralda



<u>Fig. 4f:</u> Mean axial plane (dashed) and plunge (β) of F2 folds in southern Esmeralda



<u>Fig. 4g:</u> Esmeralda quartz veins (purple diamonds) overlaid on bedding



<u>Fig. 5a:</u> D1 Deformation - Bedding plane parallel thrusting with the formation of imbricate fans

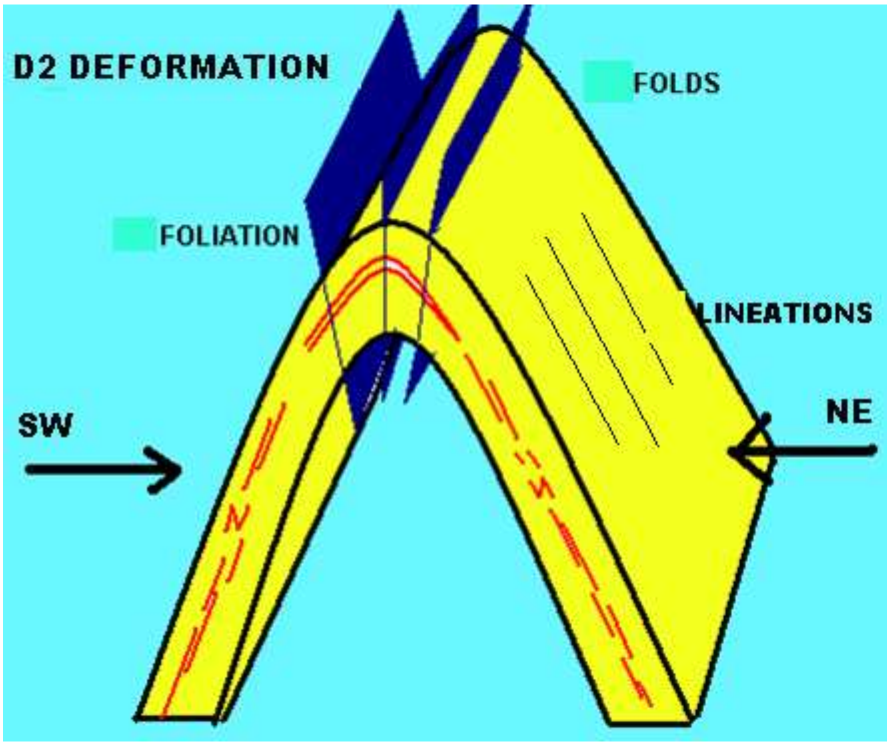


Fig. 5b: D2 tightening of folds by SW/NE compression

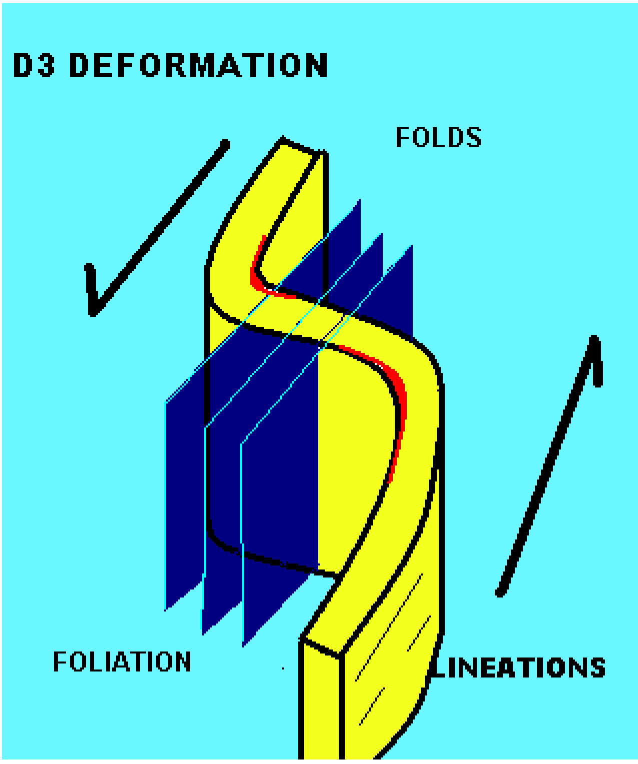


Fig. 5c: NW-SE striking sinistral strike slip faults

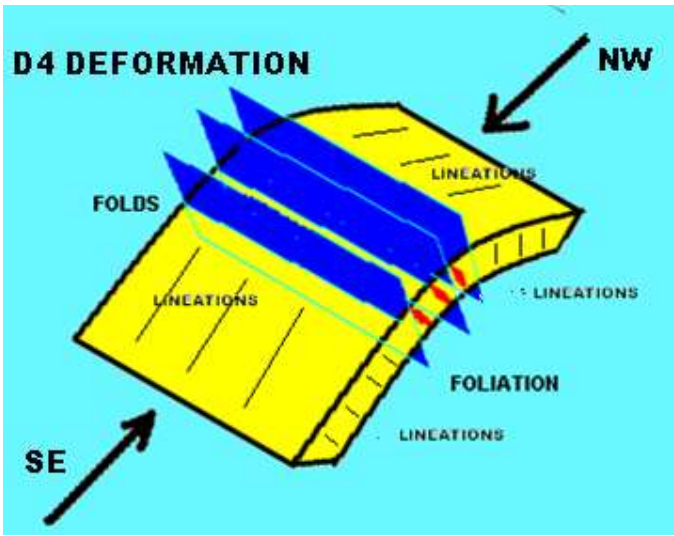


Fig. 5d: D4 deformation – NW/SE compression producing subtle cross folding

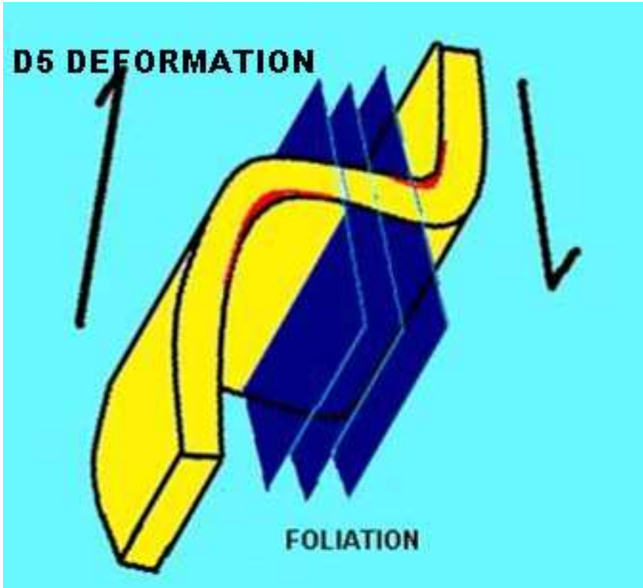
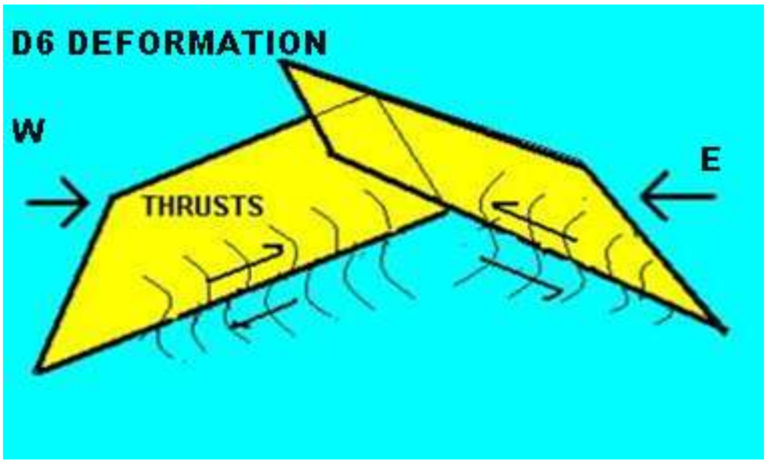
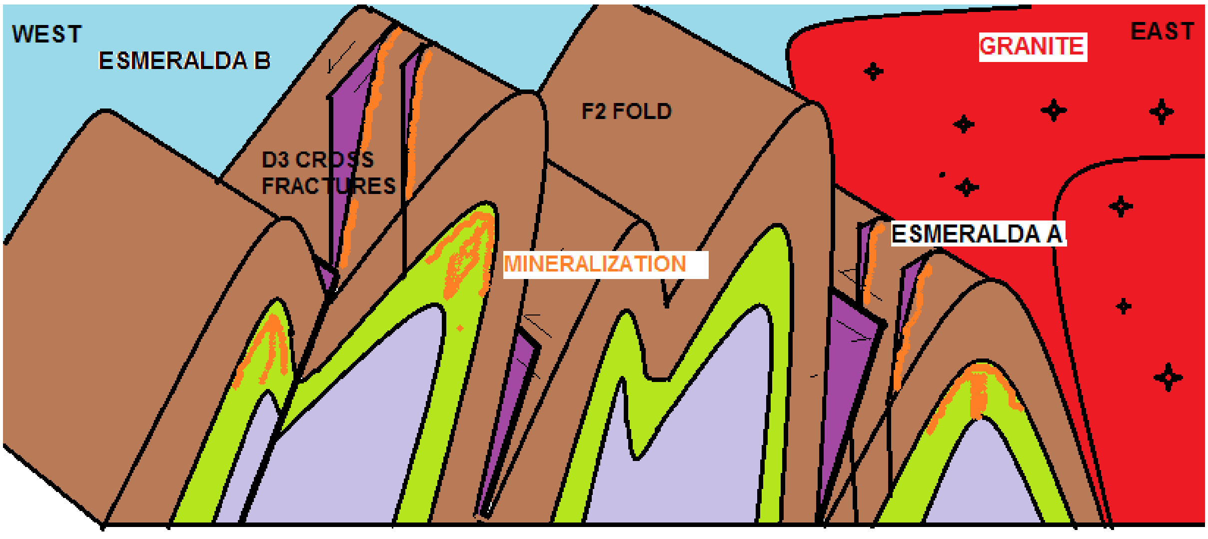


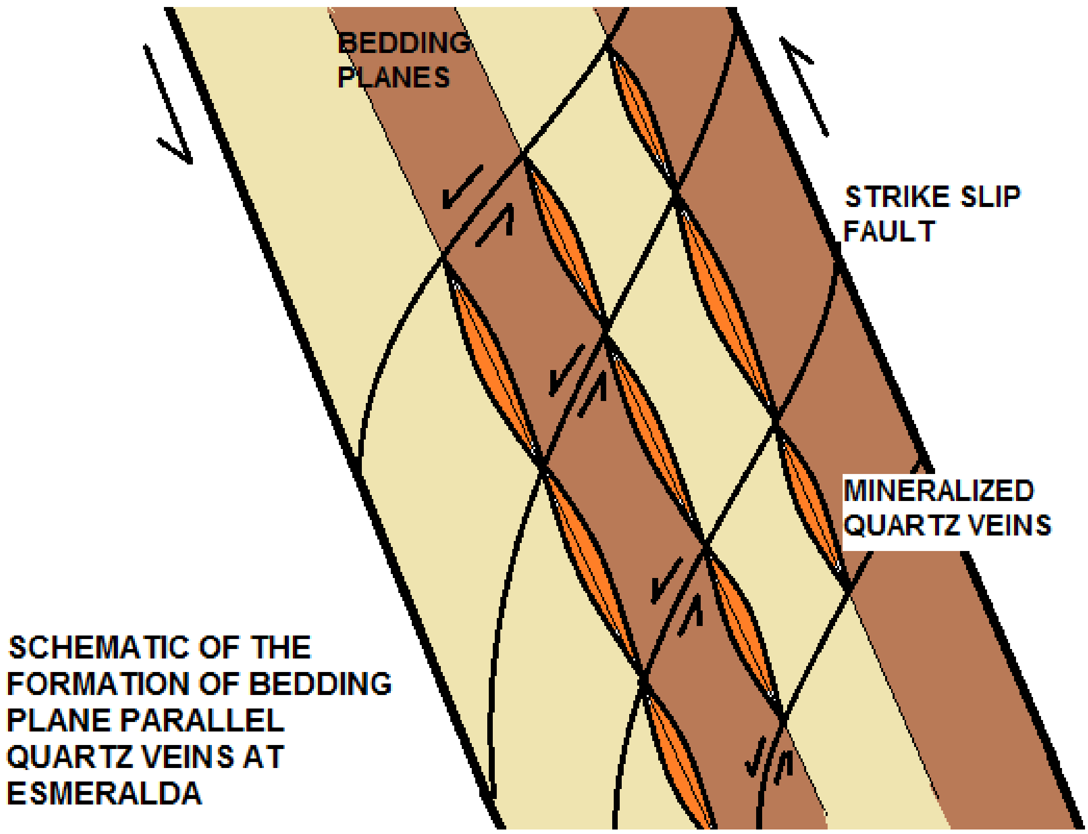
Fig. 5e: D5 deformation NW/SE striking dextral strike slip faulting



<u>Fig 5f:</u> East west compression, thrusting and fracture cleavage associated with granite intrusion



<u>Fig. 6:</u> Schematic east-west section through Esmeralda A and B with mineralization marked in orange.



<u>Fig. 7:</u> Schematic plan showing the formation of mineralized bedding plane parallel quartz veins during the F3 sinistral strike-slip deformation

<u>PHOTOGRAPHS</u>

<u>Photo 1:</u> Typical folded Mount Bonnie slate at Caroline

<u>Photo 2:</u> Ripple marked greywacke Esmeralda North

Photo 3: **Laminated chert horizon, Caroline**

Photo 4: **Massive and brecciated siliceous rock, Caroline**

<u>Photo 5: Typical banded siliceous rock</u>

<u>Photo 6:</u> Sphaerules in the banded siliceous rocks near Caroline

Photo 7: **Late stage epidote-chlorite greisen cutting granite, Eastern Esmeralda**

Photo 8: **F0 fold in banded siliceous rock**

<u>Photo 9:</u> Second order parasitic F2 fold Esmeralda B area

<u>Photo 10:</u> Second order sinistral shear zone cutting greywacke-slate sequence Esmeralda B