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MINERALOGICAL REPORT.

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INTERPRETATIONS BASED ON DDH 5, 8, 12A, 12;

TENNANT CREEK.

(RC 23.5.73)

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NORTHERN TERRITORY
GEOLOGICAL SURVEY
INTERPRETATIONS BASED ON DDH 5, 8, 12A, 12;

TENNANT CREEK.

INTRODUCTION.

A suite of 23 samples was selected by Mr. R. Cambrell from those sections of the cores of DDH 5, 8, 12A, 12 which immediately embrace the mineralised zone. The section along 1140E, plan EL 357 of T.C. 8 Prospect, was supplied with the sampling sites plotted.

The object of microscopic examination was to attempt to establish the mineralogical criteria which are specific to both wall rock alteration, and to zonation within the mineralised rocks.

SUMMARY.

By and large, the observations which have already been made on the cores by the Resident Geologist, have established the major features of rock alteration and vertical zonation. This Report simply confirms these, with some additional data; and also draws some comparisons with orebodies such as Peko.

It should be recognised that the petrographic-mineralogic data may have some shortcomings because of inadequate sampling at certain critical contacts, but if necessary these can be eliminated by a supplementary sampling programme.

The country rocks. The cores include examples of slate, siltstone and tuffaceous sandstones, but only the one sample from DDH 12 at 904ft. can be regarded as entirely free from alteration. This has the separate peculiar feature of a content of disseminated chalcopyrite.

Using this unaltered rock as a reference, the initial and subsequent stages of wall rock alteration can be established in the following terms.
Gradations in rock alteration near, and within the mineralised zones.

Stage 1 - chloritic alteration-clinochlore.

In each of the four drill holes, outside of the mineralised zone, there are examples of sediments which consist predominantly of perfectly oriented clinochlore. This clinochlore is postulated to have replaced entirely, the randomly-oriented clastic sericite and chlorite components of the country rock sediments. This feature is especially well-manifest in those facies which contain silt or sand grade clastic components. This postulation implies magnesia metasomatism. In most examples of this type, there are several % small porphyroblasts of penninite which are forming in place, and which do not conform to the strongly established clinochlore cleavage structure.

Stage 2 - chloritic alteration - penninite.

In two drill holes viz., 5 and 12, but especially in 5, completely recrystallised, wholly penninitic schist, exists closer to the mineralised zone than does the clinochlore schist. This therefore indicates the extended growth and merging of the porphyroblasts of Stage 1; and the ultimate replacement of all clinochlore by penninite. It is furthermore significant that incipient mineralisation by magnetite, quartz and carbonates accompanied the formation of the penninite.

Stage 3 - talc-magnesite development.

This was not observed in the highest levels, i.e. in DDH 5, but it is present in all intersections below this. The textural intergrowth relationships in the relevant samples, clearly indicate that the talc formed from penninite schist which was contained within the mineralised areas, vide descriptive section. This simply implies more advanced magnesia metasomatism by the removal of Al,Fe from the silicate minerals. In general, large amounts of magnesian carbonates are associated with the talc, thus implying carbonatisation, as well as increased magnesia metasomatism.
Stage 4 - Amphibole Development.

The formation of a non-aluminous amphibole of the cummingtonite-grunerite series was noted only at one site within the talcose-magnesite zone in DDH 12A. This is interpreted to be the result of a localised higher temperature-stress condition in this part of the highly altered and mineralised zone, but it is important since it establishes a parallel with the incidence of anthophyllite at depths in excess of 900 ft. in the Peko orebody.

Stage 5 - Silicification.

The relative status of this type of alteration is not fully apparent from the present investigation. Only one example is included in this suite of cores, viz. from the hanging wall zone in DDH 12. Since this is sited on the country rock side of a Stage 2 alteration at this contact, it can be presently regarded as an outer zone of rock alteration. This postulation is in accord with observations at Peko, and elsewhere at Tennant Creek, where marginal silicic zones exist beyond the chloritised, and other silicate zones.

The Paragenesis of Mineralisation.

In generalised terms, the mineralising medium comprises the intergrowths of magnetite-hematite-quartz-carbonates-sulphides, but the proportions of these epigenetic components vary with depth.

In the higher levels (vide. DDH 5). The assemblage is essentially quartz-magnetite-specularite-chalcopyrite-bornite-wittichenite, with little or no carbonate. The absence of significant amounts of carbonates is compatible with the absence of the higher status talcose alteration.

The presence of chalcocite in the interval RL 700 - RL 500, is simply an expression of the supergene sulphide enrichment process upon the chalcopyrite and bornite.
In the intermediate levels (vide DDH 8, 12A). The quartz-magnetite-hematite-sulphide assemblages persist, but with decreased amounts of magnetite; the carbonates increase greatly in quantity (accompanied by talcose and amphibolitic alterations to the mineralised rock); while the wittichenite component decreases to zero. This decrease in depth of the bismuth mineralisation, is a feature of some orebodies at Tennant Creek, particularly those with a significant gold content.

In the deeper levels (vide. DDH 12A). The mineralising assemblage is typified by a great abundance of carbonate, and by greatly decreased proportions of quartz, magnetite and sulphides. However, chalcopryite also exists without its normal associates, in disseminated habit, in completely unaltered footwall rock.

PETROGRAPHIC - MINERAGRAPHIC FEATURES OF THE CORE SAMPLES.

DDH. 5.

The mineralised hanging wall zone.

403ft. Mineralised chlorite schist: bornite-chalcocite.

The schist is strongly fissile and generally of very fine grained texture, except for small porphyroblasts of penninite. The principal mass of the schist consists of clinochlore which is in minute parallel-oriented flakes. The penninite porphyroblasts are randomly oriented in respect to the principal cleavage direction, and each contains numerous minute inclusions of leucoxene.

There are sparse minute talc flakes, and trace amounts of zircon and quartz, but otherwise the chlorites constitute the bulk of the schist.
Mineralisation of an epigenetic type was incident along the principal cleavage direction, mainly in widely spaced veinlets of 1-2mm. thickness. These veinlets consist of bornite (with encrusting supergene chalcocite), magnesite and very minor quartz, but they contain no magnetite. Disseminated mineralisation by bornite (now fully converted to supergene chalcocite), was also incident beyond the vein structures where elongate grains of 0.1-1.0mm. length, formed at close intervals along rock cleavage planes. This feature of disseminated mineralisation without accompanying gangue minerals or magnetite, is important in assessing the genetic significance of the disseminated chalcopyrite in DDH. 12 - 904ft.

The bornite-supergene chalcocite association establishes the depth of the zone of supergene sulphide enrichment.

407'6". Weakly mineralised chlorite schist: bornite-chalcocite.

The schist is less distinctly fissile than that at 403ft., and it has an evenly fine grained texture with no silicate porphyroblasts. It is distinctly magnetic because of the presence of both disseminated magnetite subhedra (0.03-0.3mm grain size), and sparse magnetite-sulphide porphyroblasts of about 3.0mm. maximum size.

The schist consists only of the one variety of chlorite, viz., penninite. The penninite acquired a coarser grain size locally in proximity to the magnetite-sulphide porphyroblasts; and along certain cleavage-oriented zones where thin magnesite veins were formed.

Most of the magnetite-sulphide porphyroblasts are contained in zones which are the loci of both the magnesite veinlets, and the more coarsely crystallised penninite. These zones may be the channels of incipient magnetite-magnesite-sulphide mineralisation. The sulphides appear from binocular microscope observation to be bornite-chalcocite intergrowths with magnetite, but this was not verified by polished section examination.
Mineralised Zone.

420ft. Quartz-magnetite-chalcopyrite-wittichenite lode.

This lode assemblage consists mainly of quartz and magnetite with subordinate amounts of specularite and sulphides; and it encloses many irregularly elongate entrained fragments of the penninite schist host (wall) rock.

The most distinctive feature of the lode assemblage is its strongly stressed and well-developed lineation structures which are most manifest in the medium grained vein quartz intergrowths. The magnetite crystals were extensively brecciated, and the fragments were drawn apart. Vein quartz, recrystallised penninite, specularite and the sulphides, formed together in the interfragmentary spaces. The phenomena of stress, brecciation and mineralisation appear to have constituted a progressive and related sequence of events; and the paragenetic sequence was magnetite-quartz-sulphides.

Chalcopyrite is the major sulphide, and associated with it are small amounts of wittichenite. These co-exist with specularite in the fractures amongst the magnetite aggregates, but they also exist singly in the entrained chloritic rock, and amongst the vein quartz.

446'6". Faintly mineralised host rock inclusion in lode.

This portion of enclosed host rock consists almost entirely of very coarsely recrystallised penninite, all of which is in parallel orientation, and accordingly, the rock is fissile. It contains very fine grained disseminated leucoxene, and in some areas, several % of evenly disseminated silt-grade quartz, but only trace amounts of magnetite.

Single, and multiple branching systems of thin magnesite-minor quartz veinlets traversed the schist along cleavages; and they introduced sparse minutely granular aggregates of magnetite and bornite. This feature was not confirmed by polished section examination, but it is apparent by binocular microscope observation.
The rock inclusion thus illustrates incipient marginal mineralisation following upon the complete recrystallisation of the country rock schist to a mono-chloritic rock.

The footwall zone.

458ft. **Intercalated chloritic siltstone and siliceous chloritic schist.**

(veined with quartz: weakly mineralised by magnetite)

The rock is clearly a partly recrystallised siliceous-chloritic sediment in which the initial facies variations are still apparent. Only the chlorite component was recrystallised; whereas the silt-grade quartz retains its original features.

The more strongly siliceous lamellae contain amongst commonly oriented well-crystallised penninite, some 40-50% quartz of 0.01mm. grain size, and some 2-3% leucoxene of similar size. These are taken to have been lamellae of chloritic siltstone.

The less siliceous lamellae are similar except that they contain only 10-15% of the silt-grade quartz. These were lamellae of a highly chloritic shale facies.

Sinuous, highly stressed quartz veins of several mm. thickness, penetrated the rock mainly along the cleavages (which in this rock are parallel with bedding interfaces), but at regular intervals they were cross-cutting, thus providing the sinuous trends. Very much thinner carbonate veinlets were incorporated within the quartz veins; and since these conformed only to the rock cleavage, they were transgressive in respect to the quartz veins when these transected the rock cleavages.

However, the well-defined lineation structure within the quartz veins, maintains a constant rock-cleavage-orientation, despite the changes in direction of the vein quartz; and it is to this orientation that the carbonate veins conform. These veinlets are clearly of slightly later origin than the quartz.

Magnetite grains of 1-3mm. size exist at the margins of, and in
proximity to the quartz veins. They are enclosed by coarsely crystal-
ised penninite, but they do not appear to embody sulphides (binocular
examination only).

DDH. 8.

The hanging wall zone.

520ft. Chlorite schist.

The schist is highly fissile and extremely fine grained, but
it does contain several % small porphyroblasts of penninite. The
main fabric is like that of the core of DDH. 5 at 403ft. in that
it consists mainly of parallel-oriented minute flakes of clinoclere
amongst which are some 2% minutely granular leucoxene.

Most of the chlorite conforms to the principal cleavage orientation,
but a small proportion conforms to a weak second cleavage (possibly
an older one) which lies at 30° to the principal cleavage.

There are thin barren quartz veinlets in the schist. The thickest
and most continuous of these followed the weaker second cleavage. Most
of the thinner ones are irregularly trending, and thus randomly oriented.

The Mineralised zone.

(with supergene chalcocite)

The lode assemblage consists principally of highly stressed
medium grained quartz and magnetite. There is no regularly oriented
lineation feature in the quartz, but as in DDH. 5, brecciation is
again apparent in the magnetite.

This assemblage contains entrained fragments of the chloritic
wall rock which was recrystallised to penninite aggregates, but which
also to some extent, was converted to talc. The talc now appears
mainly amongst the fractured magnetite, with or without scattered penninite aggregates.

The magnetite is a strongly titaniferous variety which encloses an abundance of primary hematite inclusions. The peculiar texture of the magnetite aggregates is that of radiating sheaf-like aggregates, and this may be the pseudomorphous form of silicate aggregates (chlorite or talc) which it replaced.

Intergrown chalcopyrite and bornite, with or without wittichenite, exist both along the edges, and within the magnetite aggregates. Individual aggregates are generally less than 2.0mm. in size, and most of them are encrusted with supergene chalcocite.

537'6". Highly talcose magnetite-quartz-minor sulphide lode.

This position is probably best considered as a weakly mineralised section of the lode since it contains over narrow zones, secondary limonite which developed from sulphides. In any case, the presence of quartz and magnetite indicates mineralisation in the strict sense.

Extremely fine grained talc is the main silicate; and it is surely the product of alteration of chlorite. Where shear was most strongly incident, the talc was coarsely crystallised into parallel-oriented individuals, and the quartz and magnetite were dispersed along the shear planes. These magnetites contain small inclusions of limonite which indicate the sites of oxidised sulphide inclusions. Beyond the sheared zones, the microcrystalline, non-oriented talc embodies randomly-sited copious magnetite euhedra, subordinate quartz, occasional aggregates of penninite, and of magnesite.

600ft. Magnetite-talc-specularite-chalcopyrite lode.

This core should be regarded as a magnetite-rich section of the mineralised zone, even though the sulphide content is low. The strongly lineated structure of the lode is a function of both the habit and distribution of the magnetite in parallel-oriented elongate aggregates of subhedra and euhedra. The fine grained talc, which occupies the
elongate spaces between these aggregates, displays a common cleavage feature. This oriented at 45° to the magnetite lineation.

The magnetite is a titaniferous species, and its texture is again unusual, and possibly acquired from replaced parallel and radiating growths of columnar or flakey silicates.

Irregularly trending and discontinuous veinlets of chalcopyrite of 1mm. maximum thickness, are present in those parts of the magnetite aggregates which contain copious intergrown specularite. Chalcocite was not formed upon the chalcopyrite, hence this ore is in the hypogene zone.

The footwall zone.

608ft. Chloritic siltstone: weakly mineralised: altered.

The siltstone is stratified by virtue of the grain size gradations which are manifest mainly by the clastic quartz component. Angular quartz grains, which are within the silt-grade size range, constitute more than 50% of each of the lamellae. Extremely fine chlorite and minor leucoxene occupy the interstitial spaces amongst the clastic quartz, and in addition, there are several % disseminated fine grained magnetite. The latter, and the more sparsely distributed coarser grained magnetite-hematite-sulphide aggregates (1-5mm. in diameter), are epigenetic components of this chloritic siltstone.

The magnetite-hematite-sulphide aggregates are enclosed by quartz and by moderately well-crystallised penninite; and they retain as inclusions, unreplaced components of the siltstone. There are also thin transgressive subhedral granular epigenetic quartz veinlets at short intervals.

The siltstone does not in itself display readily apparent evidence of alteration, other than that associated with the weak mineralisation, i.e. the interstitial chlorite has neither been recrystallised, nor apparently replaced, except where the quartz and magnetite formed. However, when compared with the core immediately below, viz. at 613ft,
it is apparent that chloritisation was the principal manifestation of wall rock alteration.

The magnetite-hematite-sulphide aggregates have at their centres, relatively coarse granular intergrowths of bornite and chalcopyrite. The sulphide core is surrounded initially by hematite with small bornite inclusions, while the peripheral zone consists of intergrowths of magnetite, hematite, chlorite and quartz. Minute chalcopyrite inclusions are contained by all of this peripheral magnetite.

613ft. Weakly chloritised sericitic-pyritic siltstone: probably tuffaceous. This siltstone displays only weak cleavage, but no stratification structure. It consists of some 40% irregularly granular silt-grade quartz, amongst which there are major interstitial sericite, minor chlorite, 5% disseminated leucoxene, oxidised granular clastic pyrite, and minor zircon. Some of the sericite appears to be sericitised felspar.

This siltstone would appear from the range and proportions of its components to be composed in part of the finest clastic products of acid volcanism, and accordingly, it is considered as a tuffaceous sediment.

The incipient stage of chloritisation is manifest in numbers of thin chlorite veinlets, and in the formation of small chlorite crystals in some interstitial areas amongst the quartz. It is therefore postulated, that increasing chloritisation towards the mineralised area, could result in a completely chloritised siltstone such as that at 608ft.

DDH. 12A.

Hanging wall zone.

708ft. Chlorite schist.

The schist is very fine evenly grained and strongly fissile. It consists mainly of clinoclore, amongst which there are several %
leucoxenised ilmenite granules, and some 5% penninite crystals. The latter are evenly dispersed flakes of slightly larger grain size than the main clinochlore component.

Veins of penninite with minor associated vein quartz, proceeded transgressively across the cleavage planes of the rock. These are roughly parallel with thin strings of opaque mineral granules, and with thin quartz veinlets which appear elsewhere in the schist. These several features constitute evidence of very incipient alteration.

Mineralised zone.

736ft. Talcose magnesite-magnetite-quartz-chalcopyrite-bornite lode.

The lode has a complex structure. This involves sets of parallel shears which enclose between them, zones of foliated magnetite-carbonate-quartz-talc. These foliae are oriented diagonally at 45° to the enclosing shears.

The shears contain lenses of talc and of fine grained magnesite, with or without fine grained magnetite and sulphides. The diagonally-disposed foliated zones contain the bulk of the magnetite and the sulphides, with coarser grained magnesite, subhedral granular vein quartz and relatively minor talc. Within the foliae, the talc displays an orientation which is the same as that of the shears; hence the shears are structures of post-mineralisation origin.

The essential components of the lode assemblage are the magnesite, magnetite, quartz, bornite and chalcopyrite. The talc is surely the altered-metasomatised form of chloritic rock.

765ft. Weakly mineralised-strongly carbonatised talcose shear.

This core represents one of the post-ore shear zones within the mineralised area; and the attenuated magnetite-sulphide intergrowths have been dispersed along the planes of shear.

The shear is occupied by successive and overlapping lenses of talc, of fine grained magnesite, or of both minerals together. Most
of the small content of magnetite and sulphides is dispersed along the highly fissile talc-rich foliae.

The talc is considered to be the completely metasomatised chlorite schist. The lode assemblage is represented by the magnesite, minor magnetite and sulphides which were sheared away from their initial sites within the altered chloritic schist.

The coarsest of the chalcopyrite retains its intergrowth relationship with magnetite, and this magnetite also retains numerous minute chalcopyrite inclusions. The finest chalcopyrites are elongate individuals dispersed along the planes of shear with single magnetite crystals, most of which retain minute chalcopyrite inclusions.

**Shift. Magnetite-magnesite-quartz mineralisation in altered country rock.**

Sulphides were not detected in this core, but it is nevertheless included in the mineralised zone because of the magnetite-magnesite-quartz assemblage. This encloses highly altered country rock which is mainly in the form of aggregates of relatively well-crystallised grunerite, although some chlorite and talc still remain.

The core is a highly complex intergrowth of the epigenetic minerals which constitute the mineralising medium, and the grunerite and relic chlorite. There are however, weakly developed foliation and lineation structures.

The grunerite, which is the optically negative and high Fe member of the cummingtonite-grunerite series of hydrous Fe-Mg silicates, indicates that the stress-temperature characteristics of the lode at this point were high, and equivalent to those obtaining in advanced amphibolite facies metamorphism. Only trace amounts of talc (green schist facies equivalent) still remain.

**Shift. Magnetite-magnesite mineralisation in altered country rock.**

The epigenetic mineralising medium consists mainly of magnetite with subordinate well-crystallised magnesite. These replaced at their
sites, the completely talcose altered form of a fissile chloritic schist.

The alteration of the schist proceeded in part beyond the talcose stage since indeterminate amphiboles can be seen in process of incipient formation in many parts of the talc intergrowths.

858ft. Magnetite-magnesite-minor sulphide mineralisation in altered country rock.

Because of the magnetite-magnesite intergrowths which are dispersed along the cleavage planes of this rock, this core is considered as part of the mineralised zone. Further justification is provided by the presence of small but significant amounts of pyrite and chalcopyrite in and about the magnetite.

This fissile highly talcose schist retains thin foliae and lensoids of penninite which are interpreted as non-metasomatised relics of chlorite schist.

Carbonatised footwall zone.

863ft. Highly carbonatised variably chloritised-talcose schist.

At this position, the core consists of variably altered, but strongly carbonatised country rock; and since only trace amounts of ore minerals were introduced, it is interpreted as the footwall zone rather than as the mineralised zone. However, it would be equally valid to classify this core as faintly mineralised rock on the grounds that, although virtually barren, it contains the epigenetic gangue medium.

The core displays a complexly sheared, and in part boudinaged structure; as well as gradations from clinohlore schist, through penninite schist, to talcose schist.

Large amounts of medium grained magnesite entered the sheared-boudinaged rock along cleavage planes and planes of slippage. The carbonates extensively replaced the schist leaving highly embayed
remnants which consist mainly of clinochlore, of penninite or of talc.

It would be anticipated that the core at successively greater depths would exhibit lesser degrees of carbonisation, and that it would merge into clinochlore schist, without penninite and talc.

DDH. 12.

The hanging wall zone.


The silicification of this area of country rock was induced by the quartz-carbonate veins which abound in it. These are composite veins with carbonate centres, and quartzose outer zones. The quartz is relatively coarsely crystallised within the veins, but towards the contacts with the host rock, the quartz grain size progressively decreases, finally becoming the same as that of the host rock, i.e. the vein quartz merges imperceptibly into the enclosing silicified sediment.

The nature of the original sediment was almost completely obscured by silicification; but, by virtue of swarms of microlitic opaque mineral inclusions which were not replaced by the epigenetic silica, the presumed outlines of the components which contained these, were preserved.

These "ghost" forms also outline the bedded structure. The rock would thus appear to have consisted of successive layers of finer and coarser grains and fragments which embodied the swarms of opaque mineral inclusions. Accordingly, it is highly probable that such grains and fragments were of volcanic origin, and that the rock was bedded crystal-lithic tuff, cf. core at 904ft.

The carbonate of these veins is calcite. Both the simple calcite veins, and the composite quartz-calcite veins, entered along the bedding interfaces within the host rock. Systems of thin encircling and branching veinlets were also established where the calcite entered the spaces amongst the "opaque mineral studded" silicified fragments.
Small grains of sulphides were contained by some of these veins, but all were oxidised to pseudomorphs in limonite and microcrystalline malachite. This is the green material which is visible in the core, and the presence of pyrite and chalcopyrite is thus established.

811ft. Intercalated chloritic siltstone and schist: weakly mineralised.

This sediment was altered only to the extent that all of the chlorite was converted to penninite which was well-crystallised in parallel orientation, thus providing a strong rock cleavage.

The sediment consists of alternating lamellae which consist respectively: mainly of penninite with minor clastic quartz, i.e. chloritic schist; and of penninite with copious clastic quartz, i.e. chloritic siltstone.

The incipient stage of mineralisation in this sediment is manifest in sporadically-sited clusters (1-4mm. diameter) of magnetite-quartz-magnesite intergrowths which contain no sulphides.

The mineralised zone.

824ft. Magnesite-magnetite mineralisation in talc schist.

The core contains more than 50% magnesite, some 10% magnetite, and trace amounts of oxidised sulphides (limonite), all of which are dispersed amongst parallel-oriented coarsely crystallised talc and ?phlogopite. There is no relic chlorite, since this was entirely converted to talc. It is furthermore apparent from the textural relationships between the talc and magnesite, that the magnesite is in process of replacing the talc. Amongst the talc there are light brown pleochroic flakes which appear to be phlogopite K(Mg3Al(OH)Si4O10, but in view of the optical similarity with talc, the distinction could be positively established only by XRD methods. However, since the chloritic rock was aluminous, the presence of phlogopite would not be unexpected.
The footwall zone.

865ft. Weakly mineralised-altered chlorite schist.

The chlorite schist consists mainly of clinochlore which is present as minute well-oriented flakes. Amongst this, there are several % minute leucoxene granules, small porphyroblasts of penninite, and small amounts of both disseminated and vein-form sulphides.

The penninite is an indicator of incipient second stage alteration of the wall rock; while the disseminated sulphides, and the thin transgressive quartz-sulphide veinlets, indicate incipient marginal mineralisation.

Only chalcopyrite of less than 0.3mm. grain size is contained in the quartz veinlets, and only chalcopyrite is present in the disseminated habit.

904ft. Disseminated sulphides in tuffaceous sediments.

This rock is an intercalated sequence of fissile sericitic-chloritic slate, and of sericitic-chloritic tuffaceous sandstone. Apart from small aggregates of recrystallised-intergrown muscovite and penninite at many centres in the slate facies, there are no other manifestations of wall rock alteration.

A well-defined cleavage structure is present in both facies, and it is oriented at 60° to the bedding plane interfaces. This structure is important since it provided the planes in which the elongate disseminated sulphides lie. These sulphides are much more abundant in the sandstone facies.

Both facies however, contain these elongate irregularly shaped chalcopyrites of 0.2 X 0.02mm. - 1.0 X 0.3mm. size. The smallest of these (within the sandstone facies) are located in the intergranular spaces amongst the sand-grade size quartz, and other clastic components. The larger chalcopyrites enwrapped numbers of these clastics and enclosed some as inclusions. Only the finest of the chalcopyrites are present, but in smaller numbers, in cleavage planes in the slate facies.
The sandstone facies contains in addition to clastic quartz, considerable numbers of fragments of acid volcanic rocks. These include microcrystalline quartzo-felspathic intergrowths, and devitrified opaque mineral-studded glassy components of rhyolitic lavas.

The origin of the sulphides might be interpreted in two ways. Firstly, these particles could have had a syngenetic origin as clastic volcanic products which were originally in bedding planes, and which were most abundant in the coarser facies. Their movement into the secondary cleavage structures, and their elongation, could have been affected by low grade regional metamorphic influence, aided by interstitial rock fluids. A second interpretation is, that they originated through pervasive epigenetic mineralisation along the cleavage planes, and through the preferential accumulation in the more permeable sandstone facies by replacement of the intergranular sericite and chlorite.

There are in this core, no features which would lend support to either interpretation; and the solution to this important point requires further examination of adjacent core samples.

CONCLUSION.

The textural features, and intergrowth relationships amongst those minerals which are considered to be the introduced-epigenetic components of the mineralised zone, lead to the following conclusions.

The paragenetic sequence of mineralisation involved initially, the replacement of country rock by quartz, magnetite and sulphides. This was accompanied by partial magnesian metasomatism, as expressed by halos of chloritisation. There followed immediately, the brecciation of this vein assemblage, and the advent of strong carbonatisation. There was further sulphide mineralisation, but no additional magnetite was introduced. This second stage in mineralisation was
accompanied by completion of magnesian metasomatism, hence the conversion of chlorite to talc; and by the partial carbonisation of the talc to magnesite.

The carbonisation and complete magnesian metasomatism were essentially deeper-seated phenomena, the manifestations of which are scarcely seen high in the ore zone profile.

It therefore follows that the co-existence of a magnetic anomaly and completely chloritised country rocks, provides an initial guide to hidden subsurface mineralisation where there is a complete absence of an oxidised outcrop or gossan.

However, if the plane of erosion intersected a mineralised zone near the top of its depth profile, a quartz-magnetite-sulphide gossan should be present, and it should be encircled by chloritised rocks.

Gossans derived from mineralised zones which have been intersected further down the depth profile of mineralisation by the plane of erosion, should exhibit the boxwork features of a quartz-magnetite-carbonate-silicate-sulphide assemblage; and they should be enclosed by chloritised, silicified and possibly also by carbonatised country rocks. Gossans derived in this manner may not overlie more than a weak magnetic anomaly because the investigation indicates a decrease in the incidence of magnetite in the deeper levels of the mineralised zone. Added to this, is the probability that the extension of the zone of oxidation for 100 - 200 ft. below surface would affect martitisation of the magnetite, and so remove all the magnetic response.

These criteria are readily applicable in areas where outcrop is present, and in particular, attention should be paid to the critical textural examination of outcropping ironstone bodies. The application to areas covered by transported soils and sands is more difficult, but it is still possible by auger chip sampling of the rock surface beneath the overburden. The smallest magnetic anomaly might be of significance in cases such as this.

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