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SELECTED ROCKS FROM THE TENNANT CREEK AREA, N.T. WITH SPECIAL REFERENCE TO THE ORIGIN OF MAGNETITE AND TALCOSE ROCKS.

by

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INTRODUCTION

A number of selected specimens from the Tennant Creek mining field were submitted for examination by N.J. McMillan. The object was to investigate the possibility that the talc in the area was derived by the metamorphism of ultrabasic rocks.

Thirty-eight portions of drill core and ten polished sections were cut from suitable specimens for determination of the opaque constituents. In addition, minerals in ten other rocks collected in the field were identified. Forty X-ray diffraction photographs were taken during the investigation.

The rocks examined can be divided into four groups:

Talc-chlorite schists
Porphyry
Greywacke
Sericitic rocks

A representative rock from each group was described, and differences or changes seen in other specimens in the group noted.

TALC CHLORITE ROCKS

Black Angel 340'

A very fine-grained chlorite (penninite) schist containing veins of magnetite intergrown with hematite; the hematite has formed by oxidation along the grain boundaries and along fractures in the magnetite. Along the edges of the main iron oxide mass, small crystals of magnetite with an average cross section of 0.25 mm. are developed. The coarse-grained magnetite in the vein itself is strongly fractured, and the fractures are filled with coarse-grained talc and penninite. Isolated crystals of magnetite are distributed throughout the fine-grained chlorite; all are surrounded by haloes of coarse-grained penninite. A densely packed mass of euhedral talc crystals borders the main iron oxide vein; the crystals are most dense at the contact of chlorite and vein material, and gradually thin away from the vein. Fractures in the chlorite almost normal to the veins are filled almost entirely by a densely-felted mass of crystals (Plate 7). This texture most probably represents the diffusion outwards from the vein of the Mg-rich metasome.

Skipper Mine DDH No. 2 958'

A fine-grained talc schist containing large irregular patches of strongly fractured magnetite ranging up to 15.0 mm. across. The magnetite is slightly anisotropic and contains some hematite. The identity of the talc was verified by X-ray diffraction.

Skipper Mine DDH No. 2 975'

Consists largely of crushed magnetite which is partly altered to hematite; the fractures in the rock are filled with coarse-grained talc. (Plate 6).

Skipper Mine DDH No. 2 939'

A fine-grained talc schist containing large clots of green chlorite, veins of granular quartz, and large irregular masses of fractured magnetite.

Skipper Mine DDH No. 2 929'

A fine-grained talc schist containing uniformly distributed aggregates of granular magnetite. The identity of the talc was confirmed by X-ray.

Skipper Mine DDH No. 2 859'

A fine-grained talc schist containing isolated patches of strongly fractured magnetite.

Skipper Mine DDH No. 2 835'

A fine-grained talc schist with a large quantity of disseminated magnetite. The identity of the talc was confirmed by X-ray.

Skipper Mine DDH No. 2 990'

A fine-grained talc schist with disseminated magnetite. The identity of the talc was confirmed by X-ray.

Skipper Mine DDH No. 2 828'

A chlorite schist with quartz veins and felted clusters of hematite needles. The interstices of these clusters are filled with a chlorite-talc intergrowth and a small quantity of quartz. The chlorite was identified by X-ray diffraction.

Skipper Mine DDH No. 2 867'

A fine-grained talc schist containing uniformly disseminated magnetite grains. The talc was identified by X-ray diffraction.

Skipper Mine DDH No. 2 1,000'

A very fine-grained chlorite schist having a mottled appearance, probably the result of aggregation of carbonaceous constituents of the rock, typical of the early stages of low-grade metamorphism. The identity of the chlorite was confirmed by X-ray diffraction.

Skipper Mine DDH No. 2 904'

A talc schist with a large quantity of disseminated magnetite and a very minor quantity of chlorite. The talc was identified by X-ray.

Skipper Mine DDH No. 2 888'

A very fine-grained talc schist with some irregular chlorite areas, containing subhedral crystals of magnetite ranging up to 2.0 mm. in length, as well as very small, uniformly distributed, euhedral crystals of magnetite 0.05 mm. in cross section. The talc was identified by X-ray.

Golden Forty Mine DDH No.9 410'

A talc schist with veins of calcite and small masses of chlorite.

Golden Forty Mine DDH No. 9 378'

A talc schist with quartz-calcite veins. Small irregular areas of chalcopyrite are associated with the quartz-calcite veins; this mineral is partly altered to covellite along its grain boundaries. Irregular patches of magnetite in the section are strongly fractured and mostly altered to hematite. The copper sulphides are all associated with calcite, indicating that they are probably introduced with this mineral. The calcite, and its associated sulphides, moulds and re-cements magnetite, and veins of it cut through the complete mineral assemblage.

Golden Forty Mine DDH No. 10 240'

A talc schist with clusters of hematite crystals and isolated patches of quartz.

Golden Forty Mine DDH No. 10 488'

A chlorite schist with large irregular talc areas. A densely packed band of hematite crystals is formed along the edges of the talc areas very close to the chlorite mass (Plate 1). The chloritic part of the rock has a mottled appearance, due to aggregation of dark material, probably of organic origin.

Peko Mine DDH No. 922 361'

A very fine-grained talc schist containing strongly fractured irregular magnetite areas, moulded by galena. Galena also fills larger fractures in the magnetite. Rare arsenopyrite crystals are present - the largest of these measures 0.12 mm. across. One area of galena contains numerous rhombs of calcite and some irregular patches of sphalerite, the whole moulding coarse crystals of talc.

PORPHYRY

White Devil Mine DDH No. 1 371' (Plate 2)

This is a granite porphyry - the least altered specimen of porphyry in the collection. It consists of phenocrysts of euhedral quartz ranging up to 5.00 mm., and of microcline feldspar ranging up to 4.00 mm., in a matrix of very fine-grained quartz, sericite, and patchy chlorite. The quartz crystals have strong undulose extinction, and are strongly fractured.

All the phenocrysts have a fairly wide corona of secondary quartz which is optically continuous with the original crystal. These coronas are crowded with inclusions of fine-grained sericite, and were formed by sericitization and silicification of the groundmass. Generally the phenocrysts are well preserved, but some are partly corroded, especially around feldspar where the quartz and some chlorite has formed as relatively coarse crystals along fractures. Patches of coarsely crystalline chlorite probably represent altered ferro-magnesian mineral.

White Devil Mine DDH No. 1 523' (Plate 3)

A similar rock to that at 371' but has a greater degree of silicification in the groundmass - the feldspar has developed thin borders of sericite but otherwise has not radically altered as compared with that at 371'. Patches of coarsely crystalline chlorite, sericite and iron oxide probably represent the end products of decomposition of the ferro-magnesian constituents.

White Devil Mine DDH No. 1 264' (Plate 4)

Similar to 523'. Progressive alteration is manifest in complete alteration of the feldspar to sericite, which pseudomorphs the original mineral.

White Devil Mine DDH No. 1 492' (Plate 5)

Very few phenocrysts remain in this section, feldspar has decomposed, and the groundmass now consists of coarsely crystalline quartz with an interstitial filling of mainly fine-grained sericite. No trace of any sericite pseudomorphs after feldspar remains (they have been dispersed in the course of more severe silicification) and the section is cut by veins of coarse-grained penninite and quartz. The penninite has grown outwards into interstices between the quartz grains, and corroded the grains to form fairly coarsely-crystalline aggregates.

White Devil Mine DDH No. 1 411'

A rock consisting of grains of quartz ranging up to 4.00 mm. in diameter, most of which have been corroded by granular silica, which has separated out from the groundmass and collected around the larger solid fragments. The residual fragments are strongly fractured; but the fractures do not extend out into the granular silica. The groundmass is entirely coarse-grained penninite which has corroded the original quartz fragments. It is possible that this rock is a sericitised greywacke, although it is more probably a further stage in the alteration of the porphyry from this mine. The alteration was accompanied by the migration of silica in the groundmass to the quartz crystals. This is a further development of the quartz coronas in the specimen from 371', with complete sericitization of the groundmass. The incipient stages of these processes were evident in the section taken at 492'.

GREYWACKES

Skipper Mine DDH No. 2 654'

A greywacke consisting of clastic quartz fragments ranging up to 0.5 mm. in a fine-grained matrix of intergrown sericite and chlorite. The section is cut by several veins containing coarse-grained quartz and chlorite. Small patches of coarse-grained sericite in the matrix probably represent the original feldspar which has been completely altered; the fragmental quartz shows some corrosion by the matrix, but to a very small extent. The rock could be more correctly called a sericitized greywacke.

Skipper Mine DDH No. 2 670'

A clastic rock as for specimen at 654', but with a better development of sericite pseudomorphs of what was originally feldspar. The rock is also a sericitized greywacke.

Skipper Mine DDH No. 2 765'

A similar rock to that at 670' but with the quartz fragments in general slightly larger; some veins of quartz are present. The rock is a sericitized greywacke.

Golden Forty Mine DDH No. 9 434'

A rock similar to that at 670', but containing elongated chloritised fragments of a shaley rock. Coarse-grained penninite is common in the groundmass, which is mostly composed of a very fine-grained chlorite.

The shale fragments range up to 10.0 mm. in length and their long axes have a uniform orientation, which is parallel to a slight schistosity developed in the coarse-grained chlorite within the groundmass.

SERICITIC ROCKS

Peko Mine DDH No. 922 334'

A fine-grained sericite rock - almost a phyllite - and containing a large quantity of crushed magnetite and other opaque minerals with which are associated fine-grained calcite and a coarser-grained sericite. The opaque minerals are magnetite, pyrite, maroasite, galena, chalcopyrite and sphalerite. The pyrite forms euhedral crystals which are probably contemporaneous with the magnetite. Marcasite moulds and corrodes pyrite, galena forms irregular areas associated with chalcopyrite and marcasite, sphalerite forms sporadic, very irregular masses. Marcasite, galena, chalcopyrite are associated with calcite, and were probably introduced with it after the rock was folded.

Skipper Mine DDH No. 2 714'

A very fine-grained sericite rock representing the stage between a shale and a phyllite, and containing veins of fairly coarse-grained quartz ranging up to 1.5 mm. in grainsize. The edges of the veins are lined with coarse-grained penninite, some of which has diffused out along small fractures in the body of the rock.

Skipper Mine DDH No. 2 786'

A rock identical with that at 714' except that the vein fillings are almost pure penninite, and magnetite is now emplaced along the edges of the veins.

Golden Forty Mine DDH No. 9 480'

A fine-grained sericite rock as at section 714'. This rock contains no quartz or chlorite veins but has occasional cubes of pyrite developed. These measure up to 0.25 mm. in size.

MISCELLANEOUS ROCKS

The following sections, with one exception (Golden Forty Mine DDH No. 9 432') are all calcite or magnetite, and probably do not represent any original rock type. They are probably sections from large veins of these minerals.

Golden Forty Mine DDH No. 9 415'

Consists of solid calcite containing small cubes of pyrite ranging up to 0.75 mm. across. An occasional irregular area of crystalline quartz is present. The grainsize of the calcite ranges from 0.025 to 0.5 mm.

Golden Forty Mine DDH No. 9 418'

Composed of coarse-grained calcite having a massive texture. Small euhedral and subhedral crystals of hematite are distributed throughout the sections in a random arrangement; the largest crystal measures 0.25 mm. Isolated skeletal quartz areas, ranging up to 0.5 mm., are present in the calcite; colourless chlorite forms similar but smaller irregular areas.

Golden Forty Mine DDH No. 10 235'

The specimen consists entirely of fine-grained calcite containing pockets of coarsely crystalline talc.

Golden Forty Mine DDH No. 9 385'

Consists entirely of crushed magnetite re-cemented by coarse-grained talc. The magnetite has altered along its grain boundaries to hematite, probably due to oxidation concurrent with the formation of talc.

Golden Forty Mine DDH No. 9 367'

Like section 385', this specimen consists of crushed magnetite but it is re-cemented by coarsely granular quartz with a mosaic texture. The magnetite has altered along grain boundaries and fractures to hematite. Prior to the introduction of silica, some mineral had veined the magnetite and the rock itself; no evidence of the nature of the original mineral remains, but the form of the veins is still preserved within the quartz. The veins show up only as clearer quartz in a 'matrix' of slightly cloudier quartz. However, the grain boundaries of the individual grains in the 'matrix' are continuous across these veins, and between crossed nicols, a uniform mosaic texture is observed. The quartz thus appears to have replaced some pre-existing rock, and is not merely a vein filling.

Some patches of chalcopyrite are present in the gangue. These range up to 0.25 mm. across, and are not related to the magnetite.

Golden Forty Mine DDH No. 9 432'

Consists of medium to coarse-grained penninite, containing randomly arranged, abundant, euhedral and subhedral crystals of epidote. These crystals range in size up to 0.6 mm., and except for a single patch consisting almost entirely of epidote, they are uniformly distributed throughout the rock.

No other minerals are present in the section. The rock could have been derived either by metamorphism of an ultrabasic rock such as pyroxenite, or an impure calcareous sediment: it may be largely of metasomatic origin. There is no way of deciding between these alternatives from the available evidence.

Ten samples collected from dumps at various mines were checked by X-ray diffraction for their major mineral content; they are:

Pit south-west of Mary Lane Mine - Tremolite

Mary Lane Mine No. 2 East - Chlorite

Pinnacles Dump East End - Talc

Big Ben Dump - Chlorite and Talc

Shamrock Dump - Quartz and Sericite

Pinnacles Dump - Chlorite

Maple Lead Dump - Talc

Shamrock Dump - Chlorite and Talc

Peter Pan Dump - Talc and Chlorite

Shamrock Dump - Talc

GEOLOGICAL HISTORY AND DISCUSSION

The earliest event of any significance in the history of the rocks described above is the intrusion into the Warramunga sediments of the soda-granites and their derivatives.

Lindgren has noted the associatiön of magnetite deposits with such granitic rocks, and Ivanac's maps show a clear relationship between them at Tennant Creek. The magnetite was emplaced before, or during, the folding and faulting of the sediments - this is clearly demonstrated by its highly shattered state. After the crushing of the magnetite, the rocks have been altered, first by chloritization, and later, by the formation of talc. Concurrent with these changes, much of the magnetite was altered to hematite. The abundance of almost pure chlorite in the chlorite schists indicates that there has been introduction of some of the components of chlorite into the country rocks; if this were not so, and the chlorite were derived directly from low-grade metamorphism of argillaceous sediments, some other minerals would have been present, e.g. quartz, sericite, and possibly tourmaline.

The origin of the Mg-rich solutions necessary for these changes can be accounted for using Reynold's hypothesis - the magnesium and iron components of granitized sediments, which cannot be assimilated by the granite, are expelled as a 'front' to the intrusion. It should be pointed out, at this stage, that the 'granitization' in the Tennant Creek area is only a local effect of intrusive granite on the surrounding sediments.

The first metasomatic change associated with the granitization appears to have been the almost complete chloritization of the argillaceous sediments. The fine grainsize of the sediments was retained. Fractures in rocks allowed the formation of the coarser chlorite veins. Plate 8 shows typical products of this early chloritization as chloritized slate fragments in a greywacke-type rock.

After the chloritization, talc was formed; the solutions had access along the 'veins' of fractured magnetite and other fractures in the rocks; this is evident from the large quantity of coarse-grained talc associated with the magnetite masses. Plate 7 shows a crushed magnetite vein containing talc and coarse-grained penninite infillings. The talc crystals have grown in the chlorite mass. They are most abundant along the edges of the magnetite vein, and become less abundant outwards from the vein borders.

Almost pure talc has formed along fractures, and the fact that the talc is densest along the vein edges and fractures in the chlorite suggests that solutions moving outwards from the vein have been responsible for its formation; alternatively, the chlorite has been altered to talc by the removal of Fe and Al. Examination of drill core section from the Golden Forty Mine DDH No. 10 488' in hand specimen clearly shows the talc growing into the chlorite; hematite bands formed along the talc-chlorite border may be due to the removal of iron. Aluminium could have been entirely removed and redeposited in adjacent sediments.

The latest stage in the sequence of events was the introduction of carbonate containing the components of marcasite, galena, chalcopyrite, and sphalerite. The calcite containing these minerals filled fractures in the magnetite and moulded masses of interlocking laths of talc. Some veins and patches of quartz in the rocks are of obscure origin: either, they were introduced with the carbonate, or they are recrystallized masses of original quartz. More probably, they are a combination of both. The veins represent introduced silica, and the irregular patches, e.g. 'coronas' around phenocrysts in the porphyries, represent the recrystallized material.

During the late-stage changes, the original magnetite was altered extensively to hematite, and some hematite was formed from chlorite. This agrees with Edward's opinion that magnetite was probably the original iron ore, and shows that a combination of three sources for the hematite are possible:

1. Martitization of magnetite by late-stage hydrothermal solutions.

2. Derivation of hematite from alteration of chlorite, (probably a very minor source).

3. Oxidation of magnetite by surface agencies.

CONCLUSION

The investigation has produced evidence which supports Ivanac's contention that the Tennant Creek orebodies are of magmatic origin. It has been suggested also that the talc and chlorite were formed as a result of the intrusion of granites and their derivatives and not from the metamorphism of ultrabasic rocks. McMillan, (personal communication), states that no ultrabasic rocks have been found in the area. No trace of antigorite was found during the examination of the specimens, the presence of which would have provided evidence that these minerals were derived from an ultrabasic rock.

It is suggested that the serpentine schists and greenstone schists described by Owen are actually veins of green talc, which in hand specimen is difficult to distinguish from serpentine. These talc veins contain magnetite as small veins and small octahedra as described by Owen.

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Plate 1. Drill cores from the Golden Forty Mine, DDH No. 10 488', which show the formation of talc (white) in a fine-grained chlorite schist (dark grey). The talc has developed along a fissure in the chlorite of the larger core section. Coarsely crystalline hematite (black) has formed along the boundary of the talc and chlorite (X1).

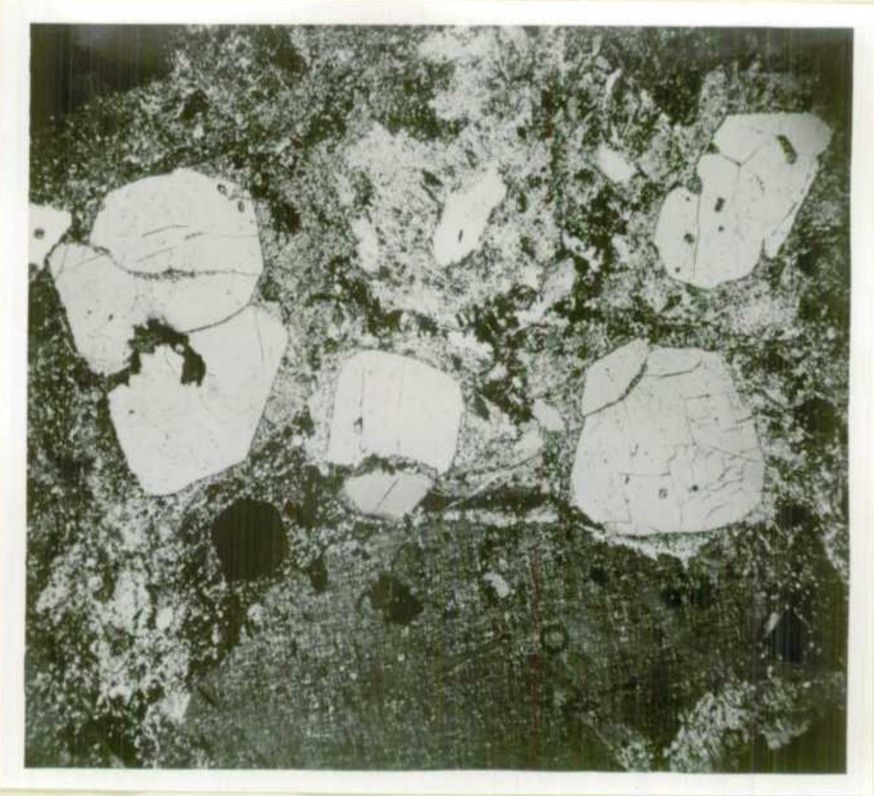

Plate 2. The least altered porphyry composed of fractured quartz crystals (white), microcline feldspar (bottom, dark grey), and a sericitized groundmass. Crossed nicols, White Devil Mine DDH No. 1 371'. (X20).

Plate 3. A further stage in the alteration of the porphyry from the White Devil Mine. The photo shows the partial sericitization of a microcline crystal. The white areas in the coarse-grained sericite are feldspar. Polarised light. x 10. White Devil Mine DDH No. 1, 523'.

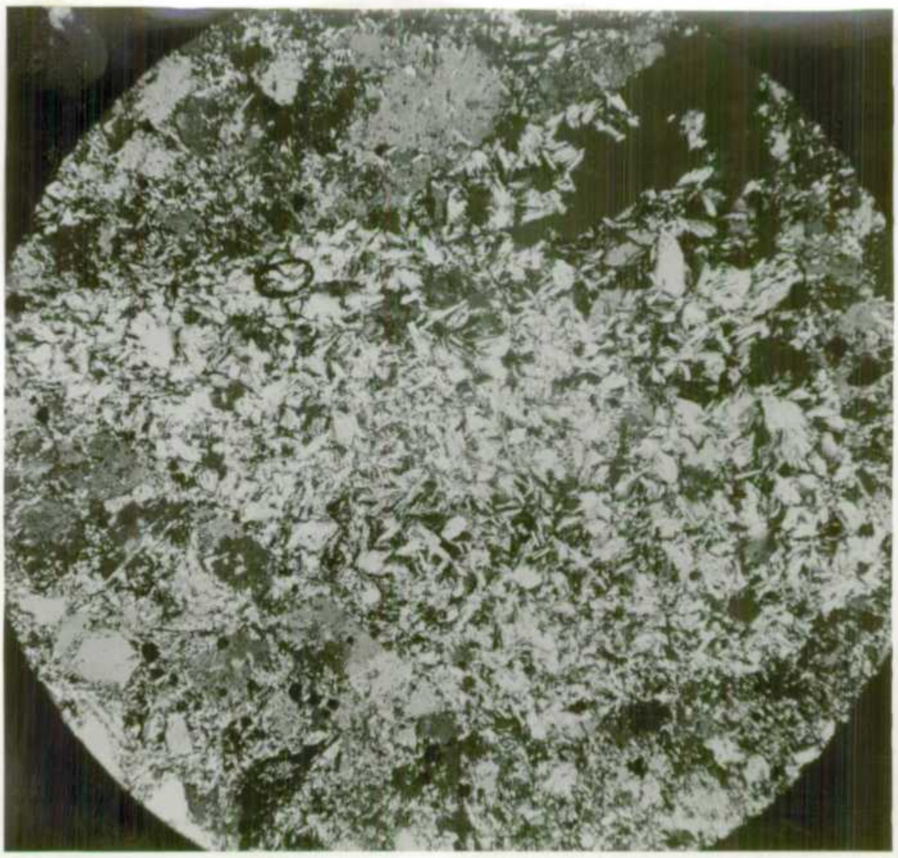

Plate 4. Further alteration of the White Devil porphyry. The photo shows a feldspar crystal completely altered to sericite. Crossed nicols, x 40. White Devil Mine DDH No.1, 264'.

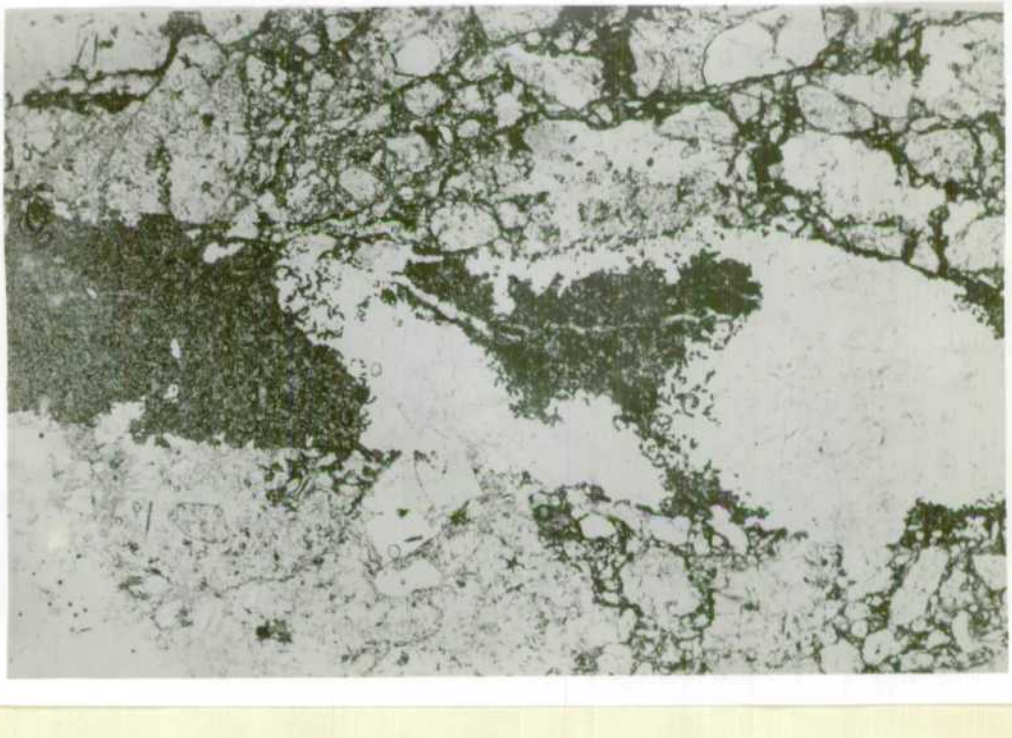

Plate 5. A quartz-chlorite vein in a highly altered porphyry; the chlorite (dark grey) can be seen growing into the interstices between the quartz areas (white and light grey). Plane polarized light. x 10. White Devil Mine DDH No. 1, 492'.

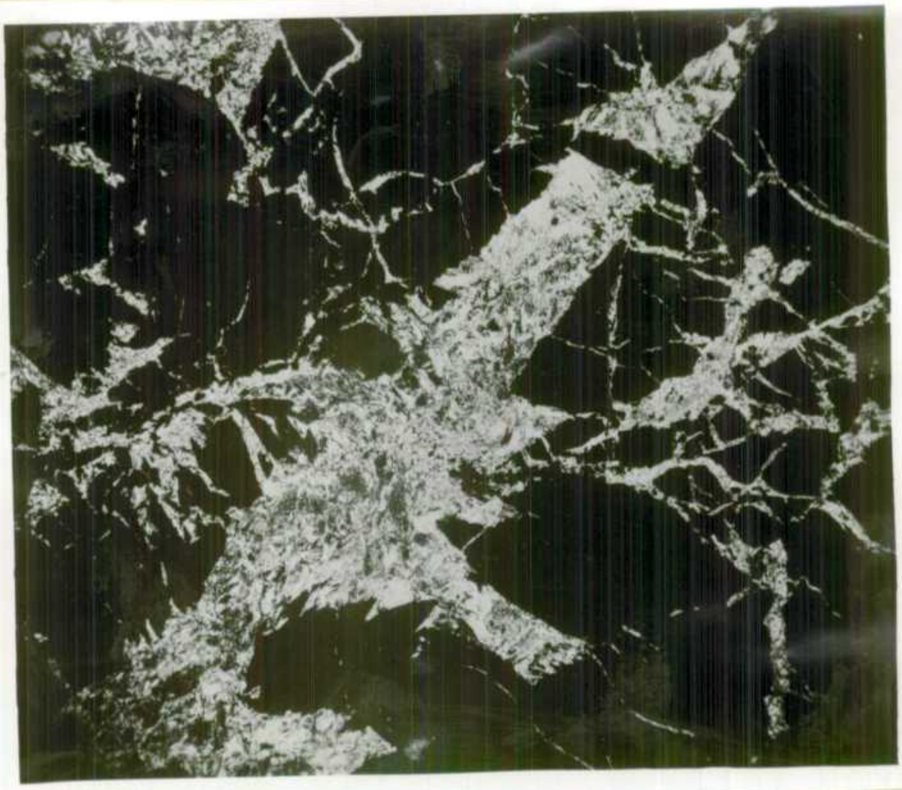

Plate 6. Crushed magnetite recemented by coarse-grained talc. Crossed nicols, x 25.
Skipper Mine DDH No. 2, 975'.

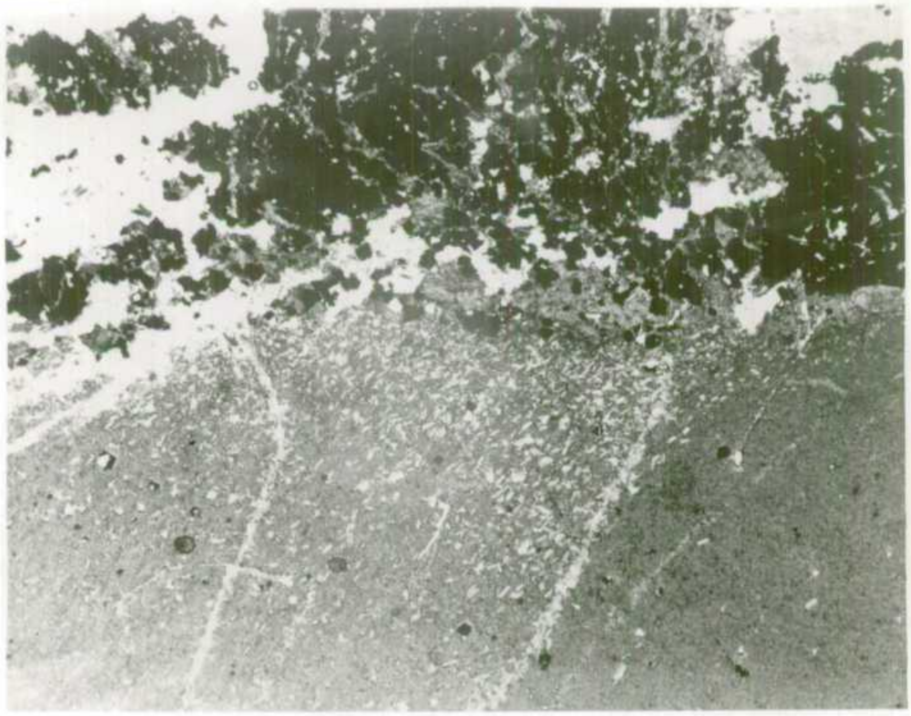

Plate 7. Talc (white) growing outwards from a vein of crushed magnetite. The greater abundance of talc along fissures in the chlorite can be clearly seen. Plane polarised light. x 10.
Black Angel Mine, DDH No. 340'. x 10.

Plate 8. Fragments of chloritized slate in altered greywacke. Plane polarized light. x 10. Specimen No. 27.