DESCRIPTION OF VARIOUS ROCKS FROM THE MT. PAINTER AREA

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The Director,
Department of Mines,
P.O. Box 151,
EASTWOOD, SA 5063

Attention: Mr R.B. Major

REPORT MP 1621/76

YOUR REFERENCE:	Application dated 21/11/75
MATERIAL:	18 rocks (for 22 sections)
LOCALITY:	Mt. Painter Area, N Flinders Range
IDENTIFICATION:	P360/75 - P381/75
DATE RECEIVED:	24/11/75
WORK REQUIRED:	Petrographic descriptions

Investigation and Report by: Sylvia Whitehead

Officer in Charge, Mineralogy/Petrology Section: Dr K.J. Henley

for F.R. Hartley
Director

mhb

DESCRIPTION OF VARIOUS ROCKS FROM THE MT. PAINTER AREA

1. INTRODUCTION

This report contains descriptions of eighteen rocks from the Mt. Painter area including one from a crush zone across which several thin sections were requested. Where possible some interpretation is given concerning the origin and history of these rocks.

SUMMARY OF SPECIMENS

P360/75
TS34899

Micaceous metaquartzite. There is a foliation defined by flakes and streaks of muscovite and some elongate quartz grains but no conclusive evidence to show whether or not this is parallel to original bedding. Some aggregates of muscovite may have replaced earlier metamorphic mineral grains indicating more than one phase of metamorphism.

P361/75
TS34900

Micaceous metaquartzite. It lacks the foliation shown by P360/75 and the mica is finer-grained. It has been extensively fractured and some joints now contain goethite which probably replaced, either carbonate or sulphide.

P362/75
TS34901

Breccia formed in micaceous quartzite and quartz-mica schist. Specular hematite, chlorite and very minor monazite? have crystallized along the numerous fractures some of which are now healed mainly by quartz. There may have been more than one episode of fracturing.

P363/75
TS34902

Contact between Freeling Heights Quartzite (micaceous metaquartzite and a finer-grained rock composed of quartz, muscovite/sericite and hematite. The actual contact is now represented by a stylolitic seam. The finer-grained rock is composed of material almost certainly derived from the quartzite and, although a cataclastic origin is favoured, the possibility of a sediment cannot be entirely excluded.

P364/75
TS34903

Silicified hematite-bearing siltstone. A thin coarser-grained layer contains a higher concentration of hematite flakes (many of which are subparallel to the bedding) and small angular cleavage fragments of monazite. These features are interpreted as indicating a clastic, sedimentary origin for the hematite and monazite. The concentration of hematite and monazite and lack of other heavy mineral grains indicates a local origin. (Plate 1a, b

P365/75
TS34904

Silicified hematite-bearing siltstone overlain by silicified hematite-bearing breccia which was almost certainly of sedimentary origin. Both phases contain clasts of specular hematite, angular fragments of quartz crystals and traces of angular monazite probably derived from local rocks or quartz-hematite veins. There is some evidence of graded bedding. All matrix clay and other silicates have been replaced by turbid, iron oxide-stained quartz. (Plate 1c, d).

P366/75 TS34905 — A thick layer of silicified, hematite-bearing sandstone containing some large fragments of granitic or gneissic rock is conformally overlain by thinly bedded, hematite-bearing sandstone, siltstone and shale showing some evidence of graded bedding. Much of the detrital material was probably derived from local rocks and therefore it is probably not a varved sediment. As in previous samples the matrix clay has been replaced by iron oxide-stained quartz.

P367/75 TS34906 — Silicified, hematite-bearing sandstone and siltstone showing some cross-bedding. It is similar to the previous samples in composition but also contains a few detrital grains of partly metamict zircon? and very few of sphene. (Plate 2a, b).

P368/75 TS34907 — Crushed and recrystallised pegmatite? or granite?. It is composed largely of microcline with lesser quartz, minor altered plagioclase and some introduced hematite locally associated with a trace of leucoxene/sphene and a metamict mineral.

P369/75 TS34908 — Oxidized magnetite- and apatite-bearing, feldspathic schist or gneiss. It is composed of K-feldspar, relatively minor quartz, partly altered biotite, oxidized magnetite and minor apatite and sphene. No conclusive evidence of origin.

P370/75 TS34909 — Martite and apatite-bearing, feldspathic gneiss similar to P369/75 has been fractured and invaded by hydrothermal solutions which have deposited chlorite, iron oxide and minor monazite in fractures. There is some late quartz.

P371/75 TS34910 — Crushed granitic rock. Fractures contain minor opaque oxide some leucoxene and traces of monazite.

P372/75 TS34911 — Amphibolite derived from dolerite. Original textures are preserved therefore there has been little or no tectonic stress.

P373/75 TS34912 — Chloritized granitic rock with remnants of large microcline crystals which have been extensively veined and replaced by chlorite. There are also some isolated, corroded remnants of microcline which are still in optical continuity. The remaining quartz also appears corroded. (Plate 2c, d).

P374/75 TS34913 — Partly chloritized granitic rock. Some K-feldspar has been partly replaced by a network of chlorite veins and patches. These enlarge and extend until locally the feldspar has been completely altered to chlorite. In general, feldspar appears to be attacked first, possibly where there is a perthitic intergrowth and the plagioclase has been partly or completely sericitized. Quartz is little altered in this sample although some appears slightly corroded where it was closely intergrown with feldspar.

P375/75 TS35066 — Hematitic and granitic breccia containing abundant specular hematite (hydrothermal) some of which contains inclusions of pyrite. An autoradiograph showed only a few spots of very weak radioactivity coinciding with monazite crystals which are up to 2 mm long. Quartz has crystallised across hematite.

P376/75 - P381/75
TS34914 - TS34919

Fractured and crushed, granitic rock. In general the fractures are stained by reddish-brown oxide and healed by quartz. P376/75 has a zone of quartz-feldspar-biotite gneiss in sharp contact with the crushed granitic rock. The contact is probably fractured and is defined locally by stylolitic? seams of dark material. The crushed granitic rock is composed mainly of microcline and quartz with a few crystals replaced by sphene, very few zircon grains and small, metamict mineral grains and locally, minor amounts of biotite and/or muscovite. The more extensively crushed zones are stained by red-brown oxide and leucoxene.

Locally there are traces of monazite and in P380/75 there is a dark zone containg specular hematite and more abundant monazite as crystals and aggregates 1-2 mm in size. This zone is very similar to sample P375/75 and there is a definite association of monazite with hematite.

An autoradiograph showed only a few spots of weak radioactivity corresponding to the monazite. (Plate 3).

DESCRIPTION OF VARIOUS ROCKS FROM THE MT. PAINTER AREA

Sample: P360/75; TS34899

Applicant's Mark and Location:
RBM178A/75. NFM R20/049 (1) SP. MacDonnell Shear Zone.
3/4 mile ESE of Mt McDonnell Mine

Rock Type:
Micaceous metaquartzite.

Hand Specimen:
A grey, medium-grained siliceous rock with numerous veins and some leached voids containing brown limonite. The rock has a distinct foliation and tends to split along some of these foliation planes revealing films of fine-grained muscovite.

Mineral Assemblage:

	%
Quartz	>75
Muscovite	15-20
Supergene goethite	3-5
Sphene	trace
Zircon	minute trace

The rock is now composed predominantly of recrystallized quartz much of which has a grain size between 0.2 and 0.6 mm but it varies outside of these limits. There are some elongate quartz crystals which tend to be subparallel to a foliation.

Muscovite is distributed unevenly through the rock occurring as elongate aggregates and thin layers or streaks subparallel to the foliation but many of these aggregates are wavy or undulose and change direction. There are also a few aggregates of finer grained muscovite in which the individual flakes have apparently random orientation and it is suggested that these probably represent completely altered grains of an earlier metamorphic mineral. Most of these muscovite aggregates which vary in size up to 0.8 mm have irregular shapes but one smaller aggregate has a hexagonal cross section. Brown iron oxide is now associated with much of this muscovite.

Most of the quartz in this section contains clouds of minute voids some of which tend to occur in planes at a high angle to the direction of foliation. Very few of these appear to have fluid bubbles.

Conclusion:
The high proportion of quartz is indicative of derivation from a sandstone and although the foliation may be parallel to the original bedding no conclusive evidence to confirm this could be found. The presence of some aggregates of muscovite which has probably replaced earlier metamorphic mineral grains suggests at least two phases of metamorphism. The dominant foliation is probably a result of shearing and the presence of clouds and planes of minute voids within the quartz probably indicates some hydrothermal activity at the time the quartz recrystallized.

Sample: P361/75; TS34900

Applicant's Mark and Location:
RBM178B/75. NFM R20/049 (1) SP. MacDonell Shear Zone.

Hand Specimen:
A pinkish-grey siliceous rock which appears to have been extensively fractured probably by crushing. Some joints contain limonite.

Mineral Assemblage:

	%
Quartz	>80
Muscovite/sericite	10-15
Sphene or rutile	trace
Clay	1-2
Goethite	1-2
Zircon	minute trace

This is essentially very similar to sample P360/75 but it does not show a foliation and lacks the subparallel streaks or planes containing muscovite. Most of the muscovite in this rock is fine-grained and occurs as irregularly shaped aggregates averaging 0.5 mm in size and as flakes scattered along grain boundaries.

The grain size of most of the recrystallized quartz in this rock varies from 0.2 to 1 mm but there are scattered and generally isolated patches up to 2 mm in size which contain much finer grained quartz with an average grain size of 0.05 to 0.1 m intergrown with finer grained muscovite. These probably represent remnants which have escaped the later phase of more extensive recrystallization. Most of the coarser grained recrystallized quartz and also some of the finer grained quartz contain clouds and planes of minute voids or vacuoles similar to those noted in sample P360/75. A few of these show regular crystallographic shapes (negative crystals?) but very few show evidence of fluid bubbles.

The rock is cut by numerous small fractures many of which now contain reddish-brown goethite and a few contain some clay. Relict textures are not well preserved by the goethite but some traces of former crystal shapes suggest that it possibly replaced either carbonate or sulphide.

Conclusion:
This is a metaquartzite probably derived originally from an argillaceous sandstone. There has been extensive recrystallization of quartz probably under hydrothermal conditions and the rock has been crushed and fractured.

Sample: P362/75; TS34901

Application's Mark and Location:
RBM179/75. NFM R20/049 (3) SP. MacDonnell Breccia body.

Hand Specimen: MICACEOUS METAQUARTZITE 1¼ miles E.S.E. m'm^c Donnell Mine
A breccia composed of angular fragments of pale pinkish grey siliceous rock. Darker minerals occur along fractures and in interstices between the fragments.

Mineral Assemblage:

	%
Quartz	60-70
Muscovite	20-25
Hematite	5-10
Chlorite	3-5
Monazite	trace
Zircon	minute trace
Goethite	trace

The mineralogy of the rock is similar to that of samples P360 and 361/75 in that it is predominantly recrystallized quartz and muscovite but in general the quartz is slightly finer grained (mainly 0.1 to 0.5 mm) and there is more evidence of a foliation defined by preferred orientation of much of the muscovite. Zones containing a low percentage of muscovite would be classified as micaceous quartzite but other zones containing a higher percentage of muscovite could be described as quartz-mica schist. Some quartz grains or aggregates are also elongated in this direction of foliation.

Some of the recrystallized quartz contains clouds and planes of minute voids and this is similar to sample P360/75 in that streaks and planes containing concentrations of these voids are almost at right angles to the direction of foliation.

The rock has been extensively fractured and solutions penetrating along these fractures have deposited specular hematite and probably trace amounts of monazite. In some of the larger fractures the hematite is asociated with radiating and spherulitic aggregates of a chlorite now stained yellow to orange by iron oxide and although it is clear that the chlorite crystallized after the hematite it is possible that they were deposited during the same phase of hydrothermal activity.

Some of the hematite crystals and aggregates have been fractured and deformed by later movement and some of the monazite has also been fractured. Many of these fractures have since been healed by recrystallized quartz.

In some zones the crystals of hematite also show a preferred orientation parallel to the foliation suggesting a continuation of or repetition of compressive stress after the hematite was introduced.

Conclusion:

This breccia was formed from micaceous quartzite and quartz-mica schist of similar composition to the micaceous quartzites of samples P360/75 and 361/75. Specular hematite and possibly also traces of monazite were deposited from hydrothermal solutions invading the breccia and there is also evidence to suggest another episode of tectonic stress after crystallization of the hematite and monazite. Chlorite crystallized in fractures at some stage following crystallization of hematite but whether or not this was during the same period of hydrothermal activity is not clear. Many of the fractures were then healed by recrystallized quartz.

Sample: P363/75; TS34902

Applicant's Mark and Location:
RBM180/75. NFM R20/049 (7) SP. MacDonell Breccia body.

Rock Type:
Contact between Freeling Heights quartzite and a fine-grained rock which is probably cataclastic.

Hand Specimen:
Predominantly a grey rock stained by iron oxides with an almost planar surface separating the coarser grained quartzite from the finer grained rock.

Mineral Assemblage:

	%
Quartzite	
Quartz	>75
Muscovite/sericite	15-20
Opaque oxide	2-3
Monazite?	minute trace
Finer grained rock	
Quartz	>65
Muscovite-sericite	15-20
Hematite	10-12
Chlorite	2-3

The coarser grained quartzite is composed of recrystallized quartz and fine-grained muscovite similar to those in the previous samples and it also contains some disseminated iron oxides which tend to occur in interstices. There is a weak foliation defined by preferred orientation of some of the fine-grained mica and also elongate aggregates and/or crystals of quartz. This foliation is at a moderat angle to the contact with the finer grained rock.

Contact with the finer grained rock is sharply defined and now shows all the features of a stylolitic seam along which there is some concentration of iron oxide.

The finer grained rock contains numerous, slightly larger grains and patches of coarser grained quartz 0.1 to 0.3 mm in size and aggregates of hematite 0.05 to 0.1 mm in size in a much finer grained matrix with an average grain size of less than 0.03 mm in which quartz, fine-grained muscovite and hematite are closely intergrown. The larger quartz grains contain numerous minute voids or vacuoles and they are very similar to the quartz in the adjacent quartzite. The iron oxide however differs in texture from that in the quartzite and occurs mainly as aggregates of small tabular or specular crystals and as isolated small tabular crystals. Muscovite is very fine-grained and has apparently random orientation.

There is some variation in grain size in that the band or layer 6 to 8 mm thick adjacent to the quartzite is very fine-grained but further from the contact coarser grained quartz is more abundant. There are some polycrystalline aggregates of coarser grained quartz containing intergrown muscovite which have undoubtedly been derived from the Freeling Heights Quartzite. Around the boundaries of the clasts of coarser grained quartz it is intergrown with the finer grained quartz of the matrix although some appear to be surrounded by a

thin film of fine-grained muscovite.

In one zone there appears to be a gradual transition from a patch of strained and partly granulated coarser grained quartz to the finer grained matrix.

The actual contact has been microfaulted along a rather irregular fracture and some spherulitic and radiating aggregates of chlorite now heavily stained by iron oxide have been deposited along this and other fractures and some also occurs along the contact.

Conclusion:

The actual contact between the Freeling Heights Quartzite and the finer grained rock now appears to be a stylolitic seam.

More than one interpretation is possible concerning the finer grained rock but undoubtedly it is composed of material derived from the Freeling Heights Quartzite. The more probable interpretation is that it is a cataclastic rock in which quartz, muscovite and iron oxide have been extensively granulated and recrystallized but through which there are scattered remnants of the coarser grained quartzite. However although there is a faint suggestion of a lineation or layering it lacks the foliation commonly found in mylonitic rocks.

A sedimentary origin cannot be entirely excluded although on the general appearance of the thin section it is not favoured. Some of the scattered and isolated larger quartz grains certainly appear rounded but this could possibly occur during extensive crushing and granulation.

Sample: P364/75; TS3490 93

Applicant's Mark and Location:

RBM181C/75. NFM R16/062 (7) SP. Mount Painter Summit.

Rock Type:

Silicified hematite-bearing siltstone.

Hand Specimen:

Most of the sample is composed of a very fine-grained, red rock with a thin layer of slightly coarser grained material. The sample also includes a portion of a much coarser grained quartz-hematite vein?

Mineral Assemblage:

	%
Detrital quartz	20-30
Specular hematite flakes	10-15
Lithic grains	trace
Detrital monazite	1-2 (more locally)
Altered grains	5-10?
Leucoxene	trace
Turbid silicified matrix and iron oxide staining	50-60

Silicified finer grained siltstone predominates in this section and it contains detrital quartz grains up to 0.05 mm in size and also numerous other detrital grains which have apparently been replaced by microcrystalline quartz. There are

also flakes or small tabular crystals of deep red hematite generally less than 0.05 mm in size but varying up to 0.1 mm and a few very small, angular cleavage fragments of monazite. These are scattered through a very turbid matrix which is now heavily stained by red iron oxide and in which the former clay and/or other silicate minerals have been completely or almost completely replaced by extremely fine-grained quartz.

The section contains a coarser grained layer 5 to 6 mm thick which contains detrital quartz grains up to 0.1 mm in size and more abundant flakes of hematite and angular fragments of monazite. One boundary of this layer against the finer grained sediment is sharply defined and many of the flakes or tabular crystals of hematite are subparallel to this boundary which almost certainly represents a bedding plane. This is interpreted as a sedimentary layer of coarser grained detritus containing a concentration of heavy mineral grains in this case probably locally derived, specular hematite and monazite. There may also be a few small grains of zircon but these are difficult to distinguish from monazite. This particular layer contains up to 30% of hematite and 3 to 5% monazite. As in the other parts of the rock the fine-grained interstitial matrix probably originally clay has been silicified and is now composed mainly of very fine-grained quartz stained by varying concentrations of red to brown iron oxides. Microcrystalline quartz has also replaced a few detrital grains of undetermined identity.

The coarser grained quartz-hematite vein was not included in the section.

Conclusion:

This is a silicified hematite-bearing siltstone and the distribution and general appearance of the hematite flakes is interpreted as indicating a clastic sedimentary origin. One coarser grained layer contains a higher concentration of this hematite and also of small angular cleavage fragments of monazite but few if any other heavy mineral grains which suggest that specular hematite and monazite were present in local rocks which, when eroded supplied much of the detrital material now forming this sediment. (Plate 1a, b).

Sample: P365/75; TS34904

Applicant's Mark and Location:

RBM183/75 NFM R16/062 (9) SP. 75 metres north-east of Mt. Painter Summit.

Rock Type:

Silicified hematite-bearing sedimentary ?breccia overlying silicified hematite-bearing siltstone.

Hand Specimen:

The sample contains a fine-grained, finely laminated pink rock in sharp contact with a much coarser grained, porous siliceous rock containing flakes of specular hematite and some fragments which have been replaced by white clay. Other grains have been completely leached. The contact between finer and coarser grained phases approximately follows the fine laminations but there is poorly defined evidence of some cross bedding.

Mineral Assemblage:

	%
Secondary quartz stained by iron oxide	>75
Hematite flakes	10-15 (varies)
Monazite	trace
Leached voids and clay	5-10

The finely laminated portion of the sample contains scattered flakes of dark red hematite, a few relict textures of detrital quartz fragments up to 0.05 mm in size and very few small angular fragments of monazite and possibly zircon in a turbid matrix which has been silicified by microcrystalline quartz. Relict textures and the general appearance indicate that this was probably a layered siltstone. Some layers show evidence of graded bedding in that there are concentrations of larger hematite flakes and relict angular quartz fragments up to 0.1 mm in size near the bottom of the layer and a gradual decrease in size of these components towards the top of the layer which is up to 5 mm thick.

The coarser grained breccia has also been silicified and now contains flakes and tabular crystals of hematite many between 0.5 and 1 mm long and some angular fragments of prismatic quartz crystals up to 2 mm long. These are scattered through a slightly turbid matrix which has been replaced by secondary quartz, coarser grained than that in the silicified siltstone layers. Angular fragments of prismatic quartz crystals are surrounded by thin, optically continuous overgrowths intergrown with the surrounding secondary quartz and these overgrowths contain clouds of minute opaque particles and/or minute voids. This breccia layer also contains a few small angular fragments of monazite and some voids from which an undetermined mineral has been leached.

The coarser grained, silicified breccia differs from the underlying siltstone in that there is less evidence of preferred orientation of hematite flakes parallel to the bedding but 6 to 8 mm above its contact with the underlying, finer grained sediment there is another thin layer of hematite-bearing siltstone which could represent the top of a coarser grained layer with graded bedding. Smaller hematite fragments are concentrated along the top of this finer grained layer.

Conclusion:

This was originally a finely bedded hematite-bearing siltstone overlain by a coarser grained hematite-bearing breccia which was almost certainly also of sedimentary origin. Both siltstone and overlying breccia also contain some angular fragments of quartz crystals and very few angular fragments of monazite. The detrital fragments of hematite, angular quartz and monazite were very probably derived from local rocks. All matrix clay and/or other silicates have been replaced by secondary quartz. A few grains or fragments in the breccia layer have been replaced by clay or completely leached.

Sample: P366/75; TS34905

Applicant's Mark and Location:

RBM184B/75. NFM R16/062 (10) SP. 150 metres north-east of Mt. Painter Summit.

Rock Type:

Silicified hematite-bearing siltstone and sandstone.

Hand Specimen:

A finely laminated, red sedimentary rock in which layers of siltstone generally 1 to 3 mm thick alternate with layers of grey hematite-bearing sandstone of similar thickness. Below these finely laminated siltstones and sandstones there is a much thicker layer of hematite-bearing sandstone which also contains some large fragments up to a few centimetres in size of granitic or gneissic rock and these contain clay which has probably replaced feldspar.

The thin laminations have been slightly displaced along a few small microfaults.

Mineral Assemblage:

	%
Quartz (primary and secondary)	>75
Hematite flakes	10-15
Monazite	trace-1
Iron oxide staining	5-10

The sandstone layers contain angular quartz grains 0.1 to 0.3 mm in size, some other grains which have been replaced by microcrystalline quartz, numerous elongate flakes or tabular crystals of hematite, some grains which have been replaced by clay and very few angular fragments of monazite. Many of the hematite flakes and elongate cleavage fragments of monazite show a preferred orientation parallel to the bedding. These grains and fragments are now cemented by secondary microcrystalline and fine-grained quartz which has replaced earlier interstitial clay? and contains patches of iron oxide staining.

The finer grained layers contain some smaller angular quartz grains generally less than 0.05 mm in size and a lower concentration of hematite flakes in a very turbid matrix now composed of secondary microcrystalline quartz heavily stained by very fine-grained iron oxide.

Some of the layers show graded bedding in that the larger quartz fragments and hematite flakes are at the base and smaller ones occur at the top and in some layers there is a gradation from the coarser grained sandstone into the finer grained siltstone layer. In general there is a sharply defined boundary at the top of the siltstone or shale but some of the larger quartz fragments from the overlying coarser grained layer have penetrated or sunk into the presumably softer shale layer before the sediment was lithified. Scattered through this finely laminated sediment there are a few larger angular fragments of polycrystalline quartz one of which also contains some monazite and hematite. These larger fragments are unevenly distributed some occurring in finer grained siltstone/shale layers and some in a zone showing evidence of disturbance either microfolding or faulting.

Conclusion:

A layer of hematite-bearing sandstone containing some large fragments of granitic or gneissic rock is conformably overlain by thinly bedded hematite-bearing siltstone shale and fine-grained sandstone. Some of these thin layers show evidence of graded bedding but whether or not this could be the result of varve deposition cannot be determined from the structure.

The detrital fragments of quartz, specular hematite, feldspar?(now replaced by clay) traces of angular monazite and some large fragments of granitic and/or

gneissic rock have probably been derived from rocks in this locality and therefore it maybe less probable that this is a varved sediment.

The finer grained matrix of clay and other silicates has been completely replaced by microcrystalline to fine-grained quartz stained with varying proportions of very fine-grained iron oxide.

Sample: P367/75; TS34906

Applicant's Mark and Location:
RBM185/75. NFM R17/088 (12) SP. North-~~east~~ of Mt. Painter Summit.

Rock Type:
Silicified laminated hematite-bearing sandstone and siltstone.

Hand Specimen:
A silicified sandstone or quartzite with thin laminations defined by variations in grey and pink colours. The cut surface shows some evidence of lensing and cross bedding. The structures also suggest that some of the coarser grained sediment may have been mobile before this rock was consolidated.

Mineral Assemblage:

	%
Quartz (detrital and secondary)	>80
Hematite	10-15
Monazite	trace-1
Metamict zircon	trace
Sphene	trace
Leached grains and clay	3-5
Secondary hematite	1-2

This is similar to the previously described specimens in that the sandstone layers contain elongate flakes and fragments of tabular crystals of hematite, some relics of angular quartz fragments, a few angular fragments of monazite and some grains which have either been replaced by clay or completely leached. Many hematite flakes and elongate cleavage fragments of monazite are almost parallel to the bedding and these minerals also vary in size in the different layers. The coarser grained layers contain larger flakes and fragments of hematite and monazite with some hematite flakes up to 0.6 mm long and some monazite fragments up to 0.3 mm long. The finer grained layers contain much less hematite. (Plate 2a, b).

In general the layers are sharply defined and there is no definite evidence of graded bedding.

All finer grained matrix silicate and/or clay has been replaced by turbid, microcrystalline to coarser grained quartz which locally forms overgrowths on some of the angular detrital quartz fragments. In the coarser grained layers some interstices between intergrown secondary quartz crystals have been filled by fine-grained hematite and similar hematite is present in some of the leached voids.

Very few rounded, turbid, partly metamict zircon grains were found in this section and also very few grains of sphene. Some layers also contain very few altered almost opaque grains or fragments surrounded by halos of orange to brown staining

in the secondary quartz and probably these grains contained trace amounts of a radioactive mineral.

Conclusion:

This is a silicified, hematite-bearing sandstone and siltstone which is similar to other samples in that many layers contain detrital flakes of specular hematite and a few angular cleavage fragments of monazite. The detrital material was probably derived largely from local rocks and all of the clay matrix has been replaced by quartz.

Sample: P368/75; TS30907

Applicant's Mark and Location:

RBM190/75. NFM R17/088 (23) S. Torbenite Gap area.

Rock Type:

Crushed and recrystallized pegmatite or granite.

Hand Specimen:

A moderately coarse-grained, pink rock containing some irregular patches of white quartz. In some zones specular hematite occurs in irregular patches.

Mineral Assemblage:

	%
Quartz	15-20
Microcline	>75
Sericite/muscovite	1-2
Hematite	3-5 (varies)
Monazite	trace
Leucoxene	trace
Metamict mineral	trace

The rock is composed largely of complexly intergrown microcline crystals which show evidence of strain, granulation and recrystallization. Locally this microcline is intergrown with irregular patches up to 4 mm in size of partly granulated and recrystallized quartz. In one area there are a few crystals possibly once plagioclase which have been replaced by fine-grained mica and iron oxide and these are intergrown with coarser grained quartz some of which appears to be secondary.

The section contains an irregular patch of moderately coarse-grained specular hematite which has crystallized in interstices and encloses some crystals of microcline. Some of this hematite has veined and partly replaced microcline.

In an extensively fractured zone there is an irregular patch of leucoxene and probably metamict material surrounded by a halo of orange to brown staining. There are also some groups and small aggregates of fine-grained sphene associated with some of the hematite and traces of very small metamict mineral grains.

Conclusion:
This is a crushed and partly granulated and recrystallized pegmatite or granitic rock with some late hematite in interstices and along some fractures.

Sample: P369/75; TS34908 6737 RS 98

Applicant's Mark and Location:
RBM191A/75. NFM R18/006 (11)S. North of Mount Ward.

Rock Type:
Feldspathic schist or gneiss.

Hand Specimen:
This is a massive, dull pink rock of uniform composition and texture. It does however contain some dark green mica which shows evidence of parallel orientation particularly on a fractured surface.

Staining with cobaltinitrite shows an abundance of potash feldspar.

Mineral Assemblage:

	%
Potash feldspar	>60
Quartz	10-15
Biotite	10-15
Oxidized magnetite	3-5
Apatite	1-2
Sphene	1-2
Sericite-clay	2-3
Interstitial chlorite	1-2

The rock is composed of turbid potash feldspar with an average grain size between 0.5 and 1 mm intergrown with finer grained quartz (grain size 0.05 to 0.2 mm) and with flakes of partly altered biotite which show a preferred orientation defining a weak foliation. There are scattered subhedral crystals of probably oxidized magnetite 0.2 to 0.5 mm in size and some elongated aggregates of recrystallized leucoxene or sphene most of which are subparallel to the foliation. Small grains of apatite 0.05 to 0.2 mm in size are scattered generally in groups throughout the rock.

The potash feldspar is very turbid and shows patchy replacement by sericite. Crystals are anhedral to subhedral and show a tendency to be elongated parallel to the foliation. Some enclose small quartz grains and magnetite or martite crystals.

The biotite flakes are 0.2 to 0.5 mm long and show a preferred orientation. Most of them are slightly bleached and/or partly altered to chlorite and some very fine-grained titaniferous material. In the area sectioned and also in the hand specimen there is no evidence of compositional layering and the iron oxide, biotite, quartz and apatite are uniformly distributed.

Conclusion:
This is a metamorphic rock which has recrystallized under conditions of tectonic stress. Original textures have not been preserved but its massive appearance and uniform composition are more suggestive of derivation from an igneous rock than from a sediment.

Sample: P370/75; TS34909

Applicant's Mark and Location:
RBM191B/75. NFM R18/006 (11)S. North of Mount Ward.

Rock Type:
Fractured feldspathic gneiss showing evidence of hydrothermal alteration and introduction of monazite.

Hand Specimen:
Portion of the sample is a massive dull pink rock very similar to sample P369/75. This has been extensively fractured and interstices in the breccia now contain dull green chlorite and minor migratory quartz.

Mineral Assemblage:

	%
Potash feldspar	>60
Quartz	10-15 (varies)
Magnetite-martite	3-5
Partly chloritized biotite	5-10
Apatite	1-2
Sphene	1-2
Monazite	1-2 (local)
Stained chlorite	3-5 (more locally)
Migratory iron and titanium oxides	2-3

Much of this rock is a feldspathic gneiss very similar to sample P369/75 and therefore the description will not be repeated.

This feldspathic gneiss has been extensively fractured and in the fractured zones interstices now contain varying proportions of fine-grained, green chlorite, opaque oxide and leucoxene, minor sericite and locally some aggregates of medium-grained monazite. It is possible that at least some of the phosphate now present as monazite may have been derived from the apatite formerly present in the gneissic rock. There may be or may have been other radioactive minerals in this crushed and fractured zone but these cannot be identified by examination of the thin sectior After crystallization of monazite, secondary iron oxide and sphene there appears to have been some additional movement and the breccia zone is now cut by later small veins of quartz.

Conclusion:
This is a massive feldspathic gneiss similar to sample P369/75 which has been extensively fractured or crushed and invaded by hydrothermal solutions which have deposited chlorite, iron and titanium oxides, monazite and late quartz.

Sample: P371/75; TS34910

Applicant's Mark and Location:
RBM193A/75. NFM R18/006 (19)S. Top of Mount Ward.

Rock Type:
Crushed granitic rock.

Hand Specimen:
A medium-grained, pink rock composed predominantly of feldspar and lesser quartz stained by iron oxides. In hand specimen it has a crushed and fragmental appearance.

Mineral Assemblage:

	%
Quartz	25-30
Potash feldspar	40-50
Plagioclase	3-5?
Sericitized feldspar	15-20
Zircon	trace
Monazite	trace
Apatite	trace
Muscovite	trace
Opaque oxide	2-3

This is an altered and stained, granitic rock composed largely of turbid orange to pink-stained potash feldspar intergrown with quartz of very variable grain size. There are some zones of completely sericitized feldspar and a few small areas containing recognizable plagioclase. Some of the potash feldspar shows twinning typical of microcline. Some small almost globular quartz grains are enclosed by potash feldspar and this texture is similar to that found in some granitic rocks.

The rock has been extensively crushed and granulated and some zones are now composed of much finer grained recrystallized quartz and feldspar. One fine-grained extensively crushed zone also contains some scattered crystals and/or fragments of monazite and zircon. This is in sharp contact with another zone of crushed material containing minor amounts of muscovite and more abundant opaque oxide possibly hematite.

Aggregates of fine-grained opaque iron and titanium? oxides are scattered sporadically through the rock and are locally associated with crystals of zircon and apatite. Some aggregates and groups of opaque oxide are distributed along subparallel bands which may indicate a former gneissic texture and some elongate quartz aggregates are also parallel to this direction but, as much of the original texture has been disturbed or obliterated by crushing and fracturing it is not certain whether this was a granite or a granitic gneiss.

Conclusion:
This is a breccia derived from a granite or a granitic gneiss and some extensively crushed zones contain more abundant opaque oxide and traces of monazite.

Sample: P372/75; TS34911

Applicant's Mark and Location:
RBM193B/75. NFMR18/006 (19)S. Top of Mount Ward.

Rock Type:
Amphibolite derived from dolerite.

Hand Specimen:
A massive, medium-grained rock composed of light and dark coloured minerals. There is no evidence of a foliation.

Mineral Assemblage:

	%
Plagioclase	50–60
Hornblende	40–50
Opaque oxide	2–3
Apatite	trace
Sphene	trace
Oxidized pyrite	minute trace

The rock contains prismatic plagioclase crystals 0.5 to 2 mm long intergrown with apparently random orientation and interstices between these crystals now contain irregularly shaped aggregates of green hornblende. There are scattered crystals of opaque oxide varying in size up to 0.8 mm and some of these are associated with sphene. A few small crystals of apatite are distributed sporadically through the rock.

Conclusion:

This was an intrusive dolerite in which the original pyroxene has been completely replaced by amphibole but the original textures have been moderately well preserved and there is no evidence of tectonic stress.

Sample: P373/75; TS34912 6737 RS 102

AN28A2/76
Spectrographic Analysis
D.K. Rowley

Applicant's Mark and Location:

RBM194A/75. NFMR18/007 (23) SP. Armchair Creek.

Rock Type:

Chloritized granite which contains some large microcline crystals.

Hand Specimen:

A dull bluish-green, fine-grained rock containing some irregular patches of pink feldspar. The cut surface shows a mottling (probably relict textures) defined by variations in colour.

Mineral Assemblage:

	%
Chlorite	>75
Quartz	10–15
Microcline	5–10
Carbonate	trace
Sphene or anatase	trace–1
Muscovite	2–3
Zircon	trace
Biotite remnant	minute trace
Opaque oxide	trace

This rock is now composed largely of yellowish-green to bluish-green, fine-grained chlorite much of which occurs as very small radiating aggregates with small scale colloform textures defined by small amounts of brown staining.

Scattered through this massive fine-grained chlorite there are corroded remnants of both quartz and microcline varying in size from less than 0.1 mm up to 1 mm and scattered small flakes of muscovite. Groups of microcline remnants which are

now quite separate are still in optical continuity and show that the rock formerly contained some large crystals of microcline at least 5 mm in size. The section contains one less altered microcline crystal which is extensively veined by chlorite. Remants of quartz scattered throughout the rock all show embayed and corroded outlines and clearly show spherulitic and colloform masses of chlorite invading and replacing the quartz. Much of the quartz once had a grain size of between 0.5 and 2 mm. (Plate 2b, c).

Some patches of chlorite contain porous aggregates or loosely packed groups of very small crystals of anatase or sphene which have almost certainly been derived from leucoxene which replaced either ilmenite or titaniferous magnetite. In some of these aggregates outlines of the former opaque oxide crystals are imperfectly preserved and suggest that octahedral crystals were once present. Crystals of zircon are associated with some of these aggregates of sphene or anatase. In one area there is a larger aggregate of opaque oxide crystals (now hematite) and this encloses a few crystals of zircon. It has been extensively veined by chlorite associated with calcite.

Conclusion:

This was a medium to coarse-grained granite which contained some large crystals of microcline. It has been very extensively replaced by chlorite and there are now only minor corroded remants of microcline and quartz with traces of zircon and iron and titanium oxides.

Sample: P374/75; TS34913 6737 RS 103

Applicant's Mark and Location:

RBM194B/75. NFM R18/007 (23) SP. Armchair Creek.

Rock Type:

Granite partly replaced by chlorite.

Hand Specimen:

A medium-grained, predominantly pink rock but with irregular mottled textures containing dull green, fine-grained chlorite.

Mineral Assemblage:

	%
Quartz	30-35
Microcline	30-35
Sericite and muscovite	5-10
Chlorite	20-25
Opaque oxide and leucoxene	1-2
Zircon	trace
Monazite?	minute trace

This is a moderately coarse-grained granite which is also porphyritic in that it contains some large microcline crystals over 1 cm in size. The larger quartz grains have recrystallized and there is some evidence to show that quartz has migrated into fractures in a crushed or fractured zone. If plagioclase was formerly present it has been completely altered and replaced by sericite and chlorite. Fine-grained muscovite occurs mainly in a crushed zone where it has replaced some feldspar and probably other minerals.

Many of the feldspar crystals have been veined and partly replaced by fine-grained chlorite generally associated with some sericite. In some of these crystals the pattern of replacement suggests that the feldspar was perthitic and that included plagioclase was first replaced by sericite and these sericitic zones were then more susceptible to replacement by chlorite. In more extensively altered crystals the chlorite appears to have extended outwards from the numerous small veins which possibly were once sericitized plagioclase in the perthitic microcline.

Some quartz also shows evidence of corrosion and veining by chlorite but in this section it is clear that the feldspar and in particular the sericitized plagioclase component was much more susceptible to replacement by chlorite than the quartz. There is one area in which a quartz aggregate contains scattered small radiating spherulites of chlorite which may indicate the early stages of chloritization of the quartz.

The rock also contains some groups of opaque oxide crystals generally associated with a few zircon crystals. Some opaque oxide has been replaced by recrystallized leucoxene. (∴ oxide was ilmenite)

Conclusion:

In this partly chloritized, porphyritic granite the feldspar and in particular the sericitized plagioclase component of perthite has been more susceptible to alteration and was the first component to be replaced by chlorite. This extended into the remainder of the potash feldspar, some crystals of which have now been extensively replaced by chlorite. In general the quartz shows only minor evidence of replacement by chlorite.

Sample: P375/75; TS35066

Applicant's Mark and Location:

RBM197B/75. NFM R17/090 (59) SP. South of Minerva Heights. 1km South of Mt Painter Camp

Rock Type:

Hematite, secondary quartz and minor monazite in granitic breccia.

Hand Specimen:

This is a breccia containing some fragments of rock up to several centimetres in size which are composed predominantly of quartz and feldspar in a dark red matrix which contains crystals of specular hematite.

An autoradiograph obtained from a slab of the rock showed only a few spots of relatively weak radioactivity and most of these were subsequently found to coincide with the presence of crystals or aggregates of monazite. One elongate streak of very weak radioactivity corresponds to a small fracture.

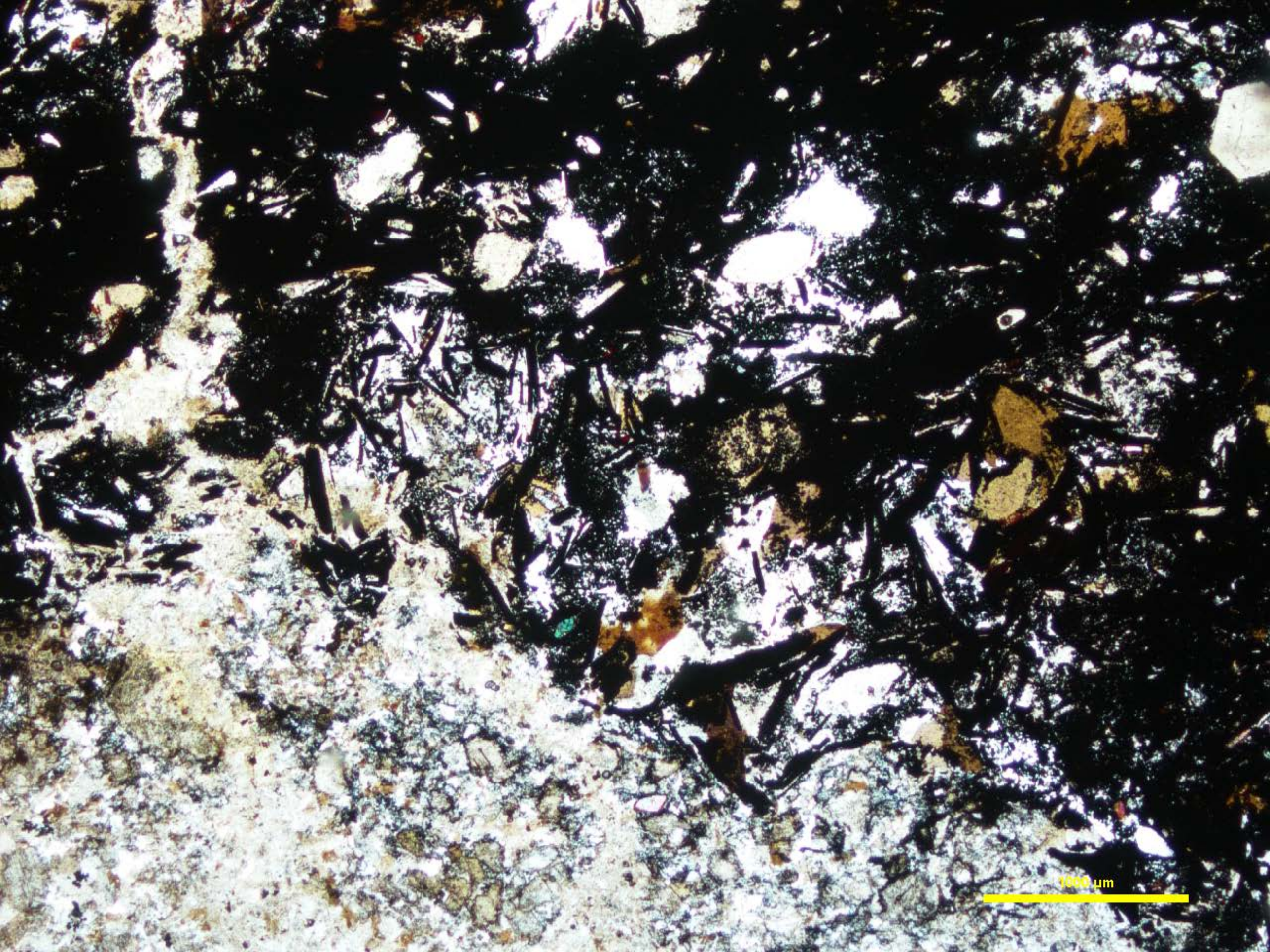
X-ray Diffraction:

This showed only quartz and hematite.

Thin Section:

An estimate of the proportions of the constituents in this sample would have little meaning.

The section contains portions of some fragments of granitic or gneissic rock composed predominantly of turbid potash feldspar and quartz with a few small aggregates of fine-grained sphene and a few scattered crystals of monazite. The quartz and feldspar in this rock has been extensively granulated and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recrystallized and locally there are irregular patches and veins of migratory or secondary quartz. Original textures are not sufficiently well preserved to show whether this was a granite or a gneiss.

The matrix contains crystals and aggregates of specular hematite with some interstitial, fine-grained to ochreous hematite, a few hexagonal quartz crystals and some crystals and crystalline aggregates of monazite. These are all cemented by, and also at least partly enclosed by late migratory quartz. The specular hematite crystals are mainly between 0.2 and 0.5 mm long and in many places they show some evidence of preferred orientation but others have apparently random orientation. Some of these hematite crystals and aggregates have been deformed, bent or fractured and in general they are surrounded by secondary quartz heavily stained and impregnated with very fine-grained hematite. In one area in the polished section some of the very fine-grained to ochreous hematite shows relict textures suggesting that it replaced a silicate ?mineral with cleavage which may possibly have been feldspar or carbonate.

Small monazite crystals or fragments averaging 0.1 mm in size are scattered throughout the mass of specular hematite crystals and one rounded grain of partly metamict zircon was also found. The section also contains one larger aggregate of coarser grained monazite in which crystals are up to 2 mm long. This aggregate shows evidence of fracturing and is now surrounded by extremely fine-grained to ochreous hematite. Some of the prismatic quartz crystals associated with the specular hematite also show evidence of fracturing and/or recrystallization and most of these are now isolated and surrounded by the very fine-grained hematite. Secondary or late quartz has filled all interstices and cemented the hematite and monazite crystals in this matrix.

Conclusion:

This is a fractured and crushed granitic or gneissic rock composed largely of quartz and potash feldspar and it has been invaded by solutions from which specular hematite, monazite and quartz have crystallized. There is evidence of repeated movement after crystallization of the specular hematite and monazite and these are now cemented by a matrix of very fine-grained to ochreous hematite and late quartz. Weak radioactivity is due to the presence of scattered crystals and aggregates of monazite.

Samples: P376/75 - P381/75; TS's 34914 - 34919 Radium Creek Metamorphics

Applicant's Mark and Location:

RBM197A/75. NFM R17/090 (59) SP. South of Minerva Heights.

Rock Type:

Breccia or cataclastic rock derived from gneissic, granitic and pegmatitic rocks. One small zone contains introduced specular hematite and monazite.

Hand Specimen:

Most of the sections were cut from a continuous section of rock which contains a few relatively large clasts 2 to 3 cm in size composed mainly of pink feldspar and quartz in a fine-grained matrix which is also composed largely of pink feldspar and quartz with minor iron oxides. This matrix shows a weak foliation possibly a result of shearing.

At one end of the sample there is a zone 1 to 2 cm thick in which the matrix is a dark red colour due to the presence of some specular and fine-grained hematite.

In general appearance this hematitic section is very similar to sample P375/75.

Thin Sections:

Most of these are very similar and therefore separate descriptions will not be given.

All of these sections show a granulated and partly recrystallized rock composed largely of turbid, pink-stained microcline and quartz with minor amounts of biotite, muscovite, iron oxide and sphene and trace amounts of zircon and apatite. Grain size is very variable with some remnant crystals up to 2 mm but much of the rock is very fine-grained. The general texture is cataclastic with the larger remnants of quartz and microcline showing considerable undulose or strain extinction between crossed nicols and in general all late fractures have been healed by quartz. (Plate 3a, b).

There are a few larger lithic clasts composed mainly of coarse-grained quartz, microcline and muscovite±biotite and some of these show a gneissic texture. Others may have been derived from pegmatite. Thin sections of P376/75 and P379/75 (TS34914 and 34917) both show contacts between portions of coarse-grained clasts and the cataclastic or granulated matrix. These contacts appear to be fractured but in part of P376/75 there is a gradation where the material has not been as extensively crushed and granulated. These contacts have been modified by the introduction of secondary or migratory quartz which has filled numerous fractures and in P376/75 part of one contact is now defined by small seams of dark material very similar to stylolitic seams.

In very few places there are small radiating groups of fibrous or acicular crystals now represented by brown iron oxide and these are enclosed in quartz. Their origin remains obscure.

Some late fractures contain relict textures suggesting that there were once some crystals of carbonate which have now been replaced by fine-grained quartz.

Thin section 34918 (P380/75) includes portion of the hematite-bearing zone. This is a breccia containing clasts composed of quartz and sericitized feldspar in a matrix in which specular hematite crystals, some fragments of microcline, some crystals and aggregates of monazite and very few crystals or fragments of tourmaline are surrounded and cemented by secondary or late quartz containing varying concentrations of extremely fine-grained hematite. This zone is therefore very similar to sample P375/75. It contains one large aggregate of radiating monazite crystals which average 0.8 mm long and a few smaller aggregates of monazite. These aggregates of monazite caused dark spots on the autoradiograph but there was no evidence of additional radioactivity. (Plate 3

Conclusion:

This rock comes from an extensively crushed zone composed largely of material derived from quartz-feldspar-biotite gneiss and possibly pegmatitic material. The general texture is cataclastic and all late fractures have been healed by secondary or migratory quartz.

Portion of this zone contains some specular and finer grained hematite associate with minor monazite probably deposited from hydrothermal solutions. This hemati bearing zone is very similar to sample P375/75 and has also been recemented by secondary or late quartz.

PLATE 1

a-b Sample P364/75 TS34903 b = higher magnification

Specular hematite (black) of clastic sedimentary origin in a coarser grained layer overlying finer grained, hematite-bearing siltstone. The sediment has been silicified.

c-d Sample P365/75 TS34904 b = crossed nicols

Coarse-grained hematite and a few fragments of quartz crystals are present in the coarser grained layers and finer grained hematite is present in the finer grained layer.

The sediment is silicified and quartz fragments are surrounded by optically continuous overgrowths.

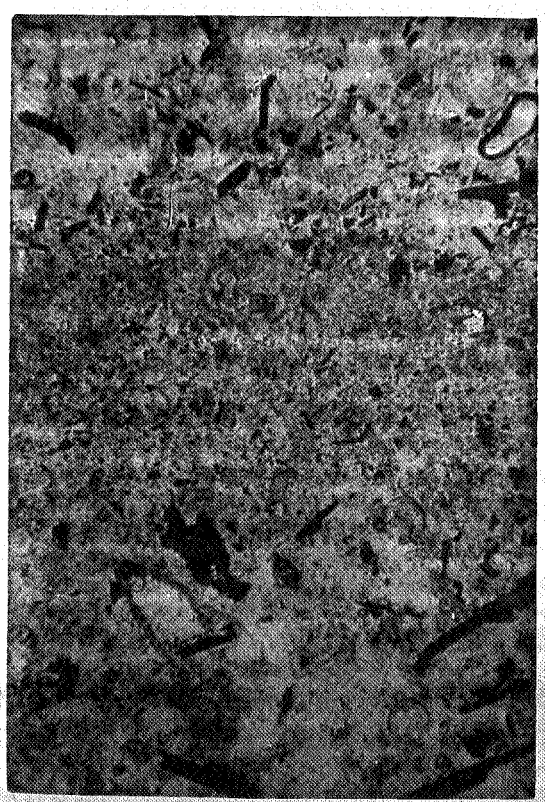
a.

1 mm

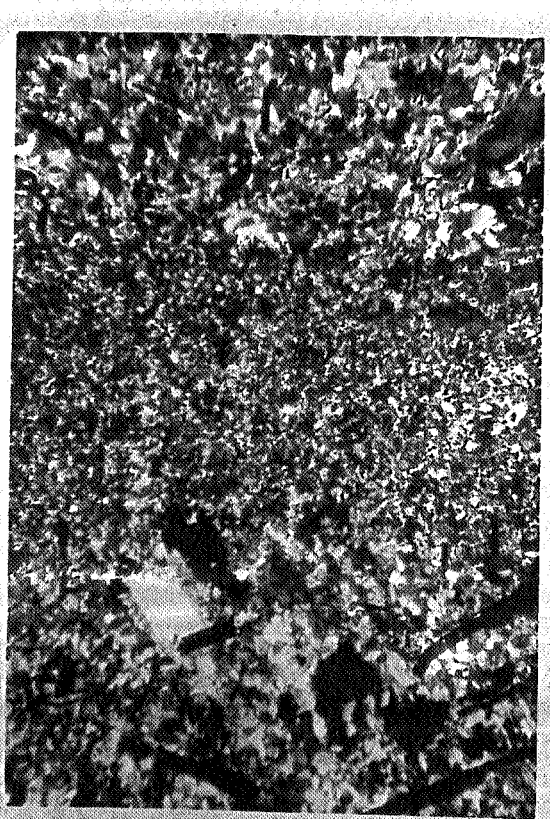
b.

0·1 mm

PLATE 1



c.



d.

1 mm

PLATE 2

a-b Sample P367/75 TS34906

b = higher magnification and crossed nicols.

Silicified, hematite-bearing siltstone and sandstone.

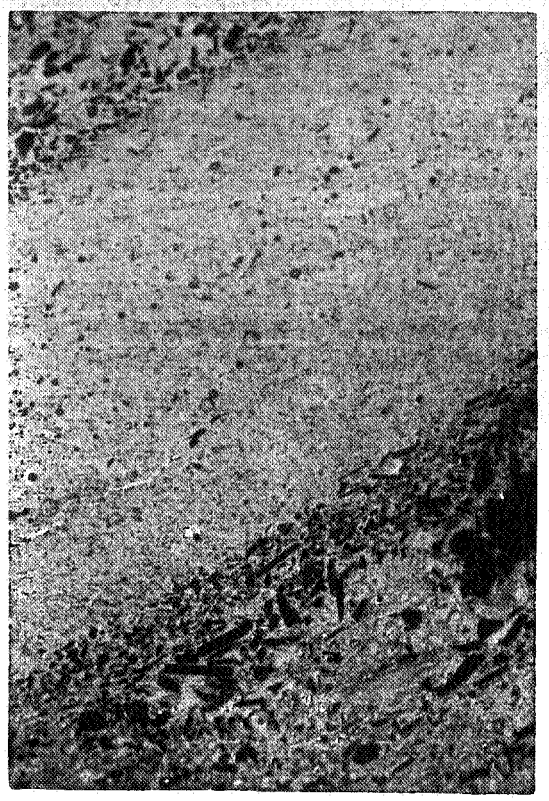
The coarser grained layers contain moderately abundant fragments of hematite crystals and also a few grains of monazite (M).

c-d Sample P373/75 TS34912

c = low magnification, crossed nicols
d = higher magnification of a different field of view, nicols not crossed

Chloritized granitic rock showing remnants of microcline extensively veined by chlorite (lower centre c, bottom left d) and some corroded remnants of quartz.

The microcline was perthitic and replacement by chlorite has occurred preferentially along "veins" of sericitized plagioclase. With continued alteration the chlorite has then encroached on the remaining microcline leaving only scattered remnants as in d. Much of the feldspar in other parts of the section has been completely replaced by chlorite leaving only relict textures.



a.

1mm

b.

1 mm

PLATE 2

c.

1mm

d.

1 mm

PLATE 3

Breccia zone invaded by hematite, monazite and quartz

a. Sample P376/75 TS34914. Crossed nicols

Contact between acid gneiss (top) and the cataclastic matrix which has been extensively veined by quartz.

b. Sample P379/75 TS34917. Crossed nicols

Portion of a clast of granitic rock (top) in the cataclastic matrix which has been "healed" or cemented by quartz.

c. Sample P380/75 TS34918

Cataclastic breccia with a clast composed of quartz and sericitized feldspar.

Hematite (dark) is present in the matrix.

d. Sample P380/75 TS34918

Specular hematite (black) and some monazite (M) in the hematitic portion of the breccia. This is veined by quartz (Q) which, in turn is cut by a later fracture containing secondary minerals (S).

a.

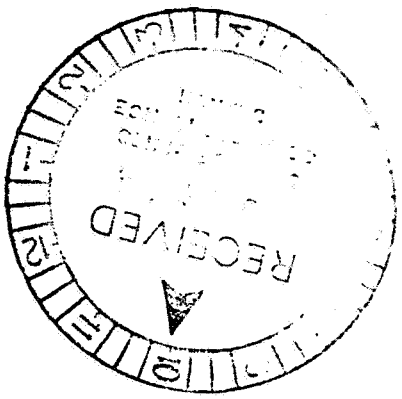
b.

PLATE 3

1mm

c.

d.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