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EXPLORATION
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MINERALOGY AND GEOCHEMISTRY

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Samples:

14 rock samples, as listed below, were sectioned, stained and examined under the microscope:

TL 13A; TL 13B; RB 30; RB 30Y (slide numbered 30A in error); RB 66A;
RB 66C; RB 70; RB 72A; 4247; RB 87; RB 94; Canyon; RB 101; RB 56

Summary

The rocks of this suite exhibit a number of consistent features. Two main groupings can be distinguished.

The first, and larger, consists of various forms of siliceous breccia in which a fragmented fine-grained brown rock is cemented by crystalline quartz.

The siliceous cement typically shows rapid small-scale variations in grain size, from relatively coarse comb structures crustified on fragments or filling vugs, to very fine-grained aggregates showing the typical allotriomorphic interlocking microcrystalline texture of chert.

The "brown rock" composing the fragments is made up of varying proportions of very fine-grained sericite, biotite, clays, chlorite, and sometimes carbonate, always with more or less limonite which causes the characteristic colouration. It commonly shows a micro-fragmental or micro-porphyritic texture.

The brown fragments are permeated and replaced to a varying degree by fine-grained silica. This process has reached the point that many "fragments" are now no more than ghostly outlines of hazy clay or limonite staining in the cherty matrix. The siliceous cement commonly contains small shreds and inclusions of the fragment material dispersed throughout, suggesting that many fragments have now been assimilated by essentially total replacement.

RB 66C represents the maximum concentration of "brown rock" in the study suite. RB 101 also has a fairly high proportion of fragments, whilst in 4247, 13A, 13B, 66A and 72A, the matrix quartz is dominant. In the latter two samples the quartz is essentially all cherty. RB 70 is, in effect, an end member of this group, in that it is a crustified quartz aggregate, but one in which there are no (surviving) fragments.

Several of the samples of this group contain trace amounts of K-feldspar. Its origin is obscure but in view of the intensely altered nature of these rocks it seems unlikely to be an original host rock component, so may well represent a minor component of introduced adularia.

The nature of the "brown rock" can only be guessed at. It appears to be totally altered. It does not resemble Nicola volcanic material (at least, not of the type exemplified in RB 87). If the mineralogy and textures seen in the surviving fragments are at all original, this material most closely resembles a fine-grained tuff or totally altered vitric volcanic.

The other main group within the suite is made up of the carbonate-rich rocks, RB 30, Canyon and RB 66C. These are related to the first group in that the ubiquitous "brown rock" is present, but are distinguished by a high content of carbonate, often fractured and existing as fragments. They show complex brecciation and re-brecciation. The Canyon sample contains chalcedony and traces of K-spar.

RB 30Y is possibly a related type, but lacks the brown rock and is not brecciated.

The remaining three rocks of the suite are individual types. RB 87 is the porphyritic Nicola volcanic; RB 94 is a fluorite rock; and RB 56 is vein quartz with carbonate.

It is interesting that the fluorite rock contains intergranular microcrystalline quartz with intergrown sericite - suggesting that the latter mineral is not confined to the altered fragments. Fluorite occurs as an accessory in one of the siliceous rocks of the first group (RB 72A).

With regard to fluid inclusions, the quartz of the siliceous breccias seems generally unfavourable. Inclusions occur but they are very small and are not obviously two-phase.

Probably usable inclusions were found in quartz of RB 30Y and definitely usable ones in the vein quartz of RB 56. The fluorite (RB 94) also has potential for yielding observable inclusions.

FROM AREA OF OLD SHAFT
BOILING INDICATED



J.F. Harris Ph.D.

November 7th, 1983

Sample TL 13A

The hand-specimen consists of numerous rounded to sub-angular brown fragments set in a crustified greyish-white siliceous cement. Fragments range in size from > 5cm down to < 1mm and make up c. 50% of the rock.

The thin section is from an area of small fragments.

Estimated mode

Quartz	90
Biotite	4
Sericite	1
Clays	2
Limonite	1
K-feldspar	2

The above mode is distorted by the fact that the fragments were very prone to plucking during sectioning. Many now exist in the slide only as shreds and partial rims.

The overall aspect is of a mass of radial outgrowths (crustifications) of quartz centred on fragments, or partially replaced remnants thereof. The successive layers of quartz show rapid variations in grain size, from fine-grained cherty material (grains 0.02 - 0.05mm) up to parallel, elongate prismatic grains of 5mm or more (comb structures). The cusped areas at the points of contact of the radial growths are filled with fine to medium-grained quartz mosaic or, less commonly, are empty (vugs).

The coarser quartz locally shows fine-grained "dusty" patches. These are seen under high power to be zones of sub-parallel, elongate or tube-like fluid inclusions. These seem to lack a vapour phase and are, in any event, too small for proper observation.

The fragments are variable in character. The commonest component appears to be a fine-grained, felted, golden-brown biotite. This grades imperceptibly into even finer-grained hazy brown material which appears to be limonite-stained clay. Occasionally the biotite has intergrown sericite.

A few 1 - 2mm fragments are clearly composed of K-feldspar, extensively altered to biotite/sericite.

Many of the fragments are more or less replaced by fine-grained quartz and consist of nothing more than shreds and intergranular films of biotite and limonitic clays in the quartz mosaic. Small interstitial particles of limonitic material occur dispersed throughout the siliceous aggregate and are probably the remnants of otherwise totally replaced fragments.

Sample TL 13B

In hand specimen this rock consists of agate-like, grey-white concentrically banded ovoid silica outgrowths, centred on a few grey-brown, often elongate fragments up to a cm or so in size.

The thin section includes parts of four such fragments.

Estimated mode

Quartz	88
Biotite	4
Sericite	1
Clays	2
Limonite	2
K-feldspar	1
Carbonate	2

This rock is basically similar to 13A in thin section. The coarse, parallel-growth comb quartz occurs only in immediate contact with the fragments and overall the quartz is fine-grained (locally minutely so). Nevertheless there is considerable size variation, giving rise to the agate-like banding. The cusped areas which represent the cavities at the contact points of the growing ovoid masses are filled with medium-grained quartz (0.2 - 0.5mm) with dusty patches of densely clustered sub-parallel fluid inclusions as described in 13A (and, like them, unsuitable for heating studies).

The fragments are again rather variable. Some are extensively replaced by quartz and consist only of shreds and clusters of remnants composed of biotite and limonitic clay. Some of the silicified remnants have a micro-fragmental or micro-porphyrific (tuff-like) aspect which may be an original texture, or may be an effect of the partial replacement.

A difference from 13A is the presence of carbonate, as small patches and minute granules within some of the partially absorbed fragments.

K-spar is again present (as revealed by detailed scrutiny of the stained chip). It occurs as specks within some of the fragments and also as threadlike veinlets (or banded remnants) associated with biotite.

Sample RB 30

In hand specimen this is a brown rock with veinlets of white carbonate, and breccia zones with small fragments of the brown rock cemented by crustified white quartz. The slide also shows a fine-scale microbreccia which is not readily noticeable in hand specimen.

Estimated mode

Quartz	50
Carbonate	22
Biotite	9
Chlorite	12
Clay	5
Limonite	2

This is a complex microbreccia consisting about 60% fragments and 40% siliceous cement.

The fragments, from < 1mm to several cm in size are generally much more coherent than in TL 13A and 13B, though there are some which are extensively replaced by silica. They consist of admixtures of fine-grained biotite, chlorite, carbonate, cryptocrystalline feldspar and limonitic clay in various proportions, showing banded, blotchy, pelletal, cellular and microfragmental textures.

Carbonate is a major constituent, occurring as pervasive patches and veins in the fragments, and as vuggy pockets, dispersed granules and fragments (disrupted veins?) in the siliceous cement.

This rock is essentially a shatter breccia, fractured and refractured during various stages of silicification. Fragments range from matching pieces to completely replaced ghosts.

The quartz cement is largely fine-grained, cherty, with only scattered local development of crustified or comb textures. Grain size variations often define angular patches which are apparently totally replaced fragments. The fine siliceous cement is locally cut by coarser vein quartz.

Fluid inclusions are rare and minute.

Sample RB 30Y

In hand specimen this is a fine-grained, brown, carbonate-rich rock with white streaks. A streaky banded texture is apparent on cut surfaces.

Estimated mode

Clear carbonate	35
Brown carbonate	30
Quartz	30
Dark brown sub-opaques	5

This rock differs texturally from the clearly brecciated nature of previous slides. On the scale of the thin section it appears to be a complex of sub-parallel bands or veins.

Carbonate, which is the dominant constituent, shows two clearly differentiated types which may or may not be mineralogically distinct. (This could be readily checked by XRD). One variety is strongly brown in appearance due to a high content of minute limonitic (?) inclusions and concentrations of limonite in cleavages and grain boundaries. Locally the brown limonitic material forms discrete clumps and irregular patches. The other carbonate is a clear, inclusion-free variety.

Doubt as to whether these really constitute different species stems from contact situations where there is apparently optical continuity of crystal form across the brown/white interface. This is analogous to brown/white dolomite relationships at Pine Point where what look like distinct vein or fragmental structures are nothing more than the sharply defined limits of brown inclusions in an otherwise continuous granular carbonate mosaic. The feature is probably an inherited one, perhaps relating to a phase of almost total replacement of ferruginous rock, subsequently modified by carbonate recrystallisation.

The brown carbonate occurs as sub-parallel discontinuous bands, with intergrown granular silica and patches of clear carbonate. These bands alternate with bands composed more dominantly of quartz (0.01 - 0.05mm) but containing very fine-grained dispersed carbonate throughout.

Clear carbonate forms cross-cutting discordant veinlets and also a zone, at one end of the slide, of close-spaced coarse equidimensional grains, 0.5 - 2.0mm, separated by networks of fine-grained quartz.

The quartz in this sample contains rather abundant fluid inclusions ranging up to 15 microns or more in size. These mostly appear to be empty but at least one was observed to have a mobile gas bubble which would have been amenable to heating studies.

Sample RB 66A

In hand specimen this is a structureless fine-grained brown rock with paler (weathered or leached?) zones.

Estimated mode

Quartz	92
Biotite	2
Sericite	2
Clay/limonite	4

In thin section this rock is revealed as an even-grained aggregate of cherty silica of grain size 0.01 - 0.05mm.

This contains fairly numerous, but very small (0.1 - 0.5mm) sub-angular to rounded fragments of felted biotite, sericite or brown-stained clay. These are sometimes dark brown, distinct; other times they are merely faint, hazy ghosts in the chert.

The chert itself contains minute shreds of limonitic clay dispersed throughout, producing the overall brown colour. This suggests that the rock is probably a totally silicified secondary product. There are also scattered rounded patches, similar in size to the fragments, of slightly coarser inclusion-free silica.

Sample RB 66C

In hand specimen this is a blocky fractured, fine-grained brown rock with translucent grey veins.

Estimated mode

Quartz	65
Chlorite	20
Limonite	7
Biotite	5
Sericite	3

In thin section the grey veining is seen to be silica - largely a fine-grained cherty aggregate (0.02 - 0.05mm) but with patchy development of coarser pockets and fringes.

The brown matrix is composed of a fine-grained mesh of chlorite, biotite and limonite intimately pervaded by cherty silica. In part it appears to be simply the chert of the cementing veins over-lain by a haze of fine-grained limonite staining and dispersed biotite/sericite; elsewhere it contains a high content of felted chlorite and/or golden-brown biotite, more or less intensely stained with limonite. It often exhibits the micro-fragmental/micro-porphyritic appearance (defined by different intensities of colour and mineralogical proportions) which seems typical of the "brown rock" whenever it occurs in this suite.

Limonite forms streaky fracture fillings, dispersed granules and scattered euhedral pseudomorphs.

Sample RB 70

In hand specimen this is a banded agate.

Estimated mode

Silica	98
Dusty inclusions	2
Limonite/opaque	trace

This is essentially monomineralic silica as a random crystalline aggregate showing highly variable grain size from finest material in the .02 - .05mm range to coarser bands, patches and vug fillings in the 0.2 - 0.5mm range. The slide contains one much coarser radial comb-like patch, with crystals up to 2mm, around a plucked core.

Certain bands and patches, commonly the finest-grained silica, contain a high content of tiny dusty inclusions (contributing to the colour banding seen in hand specimen). These are seen under high power to be rounded granules (0.005 - 0.01mm) of high relief, often yellow-brown material. Carbonate?

The rock contains sparse disseminated grains (c. 0.1mm) of opaques or limonite.

Fluid inclusions are rare and very small.

Sample RB 72A

IN hand specimen this is a structureless fine-grained pale brown rock with small whitish flecks.

Estimated mode

Quartz	85
Sericite/clay	10
Limonite	2
Fluorite	3

The rock consists of an evenly fine-grained cherty aggregate of silica, of grain size 0.02 - 0.05mm.

It contains scattered angular to sub-angular small patches, 0.2 - 1.0mm, of more or less limonite-stained fine-grained sericite or illitic clay. This same material occurs in sparsely dispersed form throughout the chert, as wisps and micron-sized granules.

Fluorite occurs as scattered small cubic or rounded grains 0.2 - 0.5mm in size. These are not associated with the sericitic patches.

The slide contains many empty pits which presumably contained sericite/clay or fluorite.

Sample 4247

In hand specimen this rock consists of large and small fragments of brown porcellanous material set in a white cement.

Estimated mode

Quartz	80
Chlorite	3
Biotite	3
Sericite	3
Clay	5
Limonite/opagues	5
K-feldspar	1

The slide contains four or five "fragments" each a couple of cm. long. These fragments, though clearly defined by comb-type fringes in the cementing quartz, are themselves largely replaced by granular silica and differ from the cement only in their content of dispersed brownish clay. However, within the outlines of the larger fragments are numerous smaller angular to rounded patches, 0.2 - 2mm in size, which are more or less unreplaced by silica and consist of varying proportions of scaly biotite, chlorite, sericite, clay and limonite. K-feldspar forms small patches in some of the fragments.

The silica cement shows typical rapidly varying grain size from c. 0.01mm up to c. 0.5mm. Fluid inclusions are small and not abundant.

This rock is similar in general features to TL 13A and others.

Sample RB 87

This is the typical Nicola augite porphyry.

Estimated mode

Phenocrysts	Augite	25
	Amphibole?	15
	Carbonate	5
	Epidote	3
	Opaques	2
Groundmass	Plagioclase	20
	Amphibole	10
	Epidote	15
	Carbonate	5

The rock consists of abundant euhedral phenocrysts of augite, 0.5 - 5.0mm, set in a granular groundmass of grain size 0.5 - 2.0mm.

The phenocrysts are variably altered to a green, strongly pleochroic structureless to fibrous material tentatively identified as uralitic amphibole. Its birefringence is too high for chlorite, being more like that of biotite. However it lacks the typical cleavage and form of biotite. It also lacks the characteristic cleavage of amphibole. Less abundant alteration products of the augite are granular epidote and carbonate.

Some phenocrysts (presumably originally something other than augite) are more or less completely pseudomorphed by epidote and/or carbonate, sometimes with boxworks of opaques oxides.

The groundmass consists of remnant plagioclase plus abundant granules of epidote and slender needles of amphibole. Carbonate occurs as diffuse patches and local veins.

This is a strongly altered basalt-andesite.

Sample RB 94

In hand specimen this is apparently a portion of a fluorite vein consisting of a core of coarse-grained transparent fluorite surrounded by whiter material, all enclosed by an envelope of finer-grained colourless fluorite.

Estimated mode

Fluorite	85
Cherty quartz	10
Sericite/clay	5
Limonite	trace

This sample consists of an aggregate of coarse, well-cleaved fluorite grains 1 - 5mm in size.

Fine-grained cherty quartz with patches and wisps of fine-grained sericite and clay occur interstitially to the fluorite.

The fluorite contains rather abundant fluid inclusions. The larger ones are empty, but active vapour phases were seen in several smaller ones (5 - 10 microns)

Sample "Canyon"

Estimated mode

Carbonate	65
Chalcedony	5
Quartz	5
Felsite	12
Sericite	5
Chlorite	2
K-feldspar	1
Limonite)	
Opagues)	5

This rock is a complex carbonate-rich breccia of a type dissimilar to any others of the suite.

Carbonate occurs in several forms. Most prominent are angular fragments from 5mm down to 0.1mm. Some of the larger fragments are themselves composed of carbonate breccia, others are clearly fragmented vein material. Some contain minor intergrown quartz, others are strongly rimmed and impregnated along cleavages with limonite. Another common fragment type is a very fine-grained sub-opaque micritic carbonate, often studded with small grains of clear crystalline material.

These fragments are set in a matrix consisting of a very fine-grained felsitic material which appears to be in part feldspar but may be largely fine-grained chert or chalcedony. It contains varying proportions of minutely granular (micron-sized) carbonate and/or flecks of sericite. Locally it contains pockets of chlorite and in other areas is heavily loaded with tiny opaque granules. In a few places a minor component of K-feldspar is present.

This carbonate/felsite material cements, permeates and replaces the various types of carbonate fragments.

The whole complex is cut by several stages of slender carbonate veinlets and veins up to 6mm thick of sparry carbonate and chalcedony.

Sample RB 101

In hand specimen this is a fine-grained grey rock containing small light-coloured chips and streaks.

Estimated mode

Quartz	50
Biotite	7
Chlorite	5
Clay	15
Sericite	8
Carbonate	8
Opagues	5
K-feldspar	2

This is a quartz breccia similar in some respects to TL 13 and others, but with a greater proportion of unreplaced fragments.

These range in size from 1cm or more down to 0.2mm and in shape from angular to rounded. A few are elongate, streaky.

They consist of various combinations of fine-grained golden-brown biotite, chlorite, sericite, brown limonitic or dusty inclusion-filled clays, carbonate and opaques. Some are themselves micro-fragmental in texture. A few contain K-feldspar (see stained chip).

These fragments are set in a matrix of quartz of widely varying grain size. Some of them are wholly or partly encrusted with relatively coarse comb quartz. Pockets and veins of this coarse quartz (grain size up to 2mm) also occur throughout the mainly fine-grained siliceous aggregate (0.02 - 0.2mm). Fluid inclusions are small and sparsely distributed.

The presence of ghost-like fragment shapes of included material in the chert indicates that considerable replacement has occurred.

The opaques are disseminated grains, 0.2 - 0.5mm, of pyrite (sometimes rimmed by limonite) with minor chalcopyrite.

Sample RB 56

Estimated mode

Quartz	90
Carbonate	8
Chlorite	2

This rock consists largely of coarse-grained vein-type quartz as an anhedral aggregate of strongly strain-polarized grains up to several cm in size. Locally this material is strongly shattered and is cemented by fine-grained cherty quartz with minor carbonate. Carbonate also forms coarse pockets and veinlets in the coarse-grained quartz. Chlorite forms clusters of small rosettes associated with some of the cherty cement.

The only opaques present in the slide are traces of hematite, limonite and pyrite.

The vein quartz of this sample contains abundant fluid inclusions up to 25 microns in size. Many of these have clearly defined, perpetually mobile gas bubbles.