

APPENDIX 6

PETROLOGICAL REPORT

to

TRENCHING AND DRILLING REPORT

on the

METS 1 AND 2 MINERAL CLAIMS

on behalf of

Manson Creek Resources Ltd.

GEOLOGICAL BRANCH  
ASSESSMENT REPORT

16,692

**PART 5 OF 7**

FILMED



# Vancouver Petrographics Ltd.

JAMES VINNELL, Manager  
JOHN G. PAYNE, Ph.D. Geologist  
A.L. LITTLEJOHN, M.Sc. Geologist  
JEFF HARRIS, Ph.D. Geologist

P.O. BOX 39  
8887 NASH STREET  
FORT LANGLEY, B.C.  
VOX 1J0

PHONE (604) 888-1323

Invoice #6610

August 10th, 1987

Report for: Bruce T. Evans,  
Golden Rule Resources Ltd.,  
c/o J. Warren,  
Central Mountain Air Ltd.,  
Smithers, B.C.

### Samples:

36 samples of drill core and surface rocks from the Mets property, Toadogone area, B.C.

Samples are numbered as follows:

87-21-1	87-23-1	DAR 87-05
2	2	07
3	3	10
4	4	11
5	5	13
6	87-24-1	15
7	87-27-1	17
87-22-1	2	19
2	87-28-1	
3	2	
4	3	
5	4	
6		
7		
8		
9		

All samples were prepared as polished thin sections to permit petrographic examination of host rock, alteration and ore minerals.

Sample 87-21-1 was described previously (my report of July 24th).

### Summary:

Petrographic studies confirm that these rocks are volcanic flows and pyroclastics showing widely varying degrees and styles of alteration.

The principal rock types appear to be andesite, latites, trachytes and tuffs made up of fragmented material of these rock types. These are undersaturated rocks carrying only minor amounts of primary quartz.

Recognition of original rock type becomes more difficult with increasing degree of alteration, and is impossible in the most strongly altered samples.

Alteration intensity ranges from essentially nil to almost total. The principal alteration minerals are sericite, kaolinite, quartz and carbonate. Minor amounts of epidote, chlorite and alunite are also observed.

The alteration minerals occur in many combinations, and a simple classification of alteration types is not easily devised. Interpretation of alteration assemblages in terms of depth in the epithermal system should be made with care as the various primary lithologies may well have reacted differently to a given set of physico-chemical conditions.

Principal groupings of samples by rock type are as follows:

Trachytes: 23-1, 23-2, 23-3, 23-4, 23-5, 28-4, 87-13 (tuff?)

Latites: 21-5, 22-3, 22-6, 87-07, 87-10

Andesites: 21-7, 22-5, 27-2, 28-1(tuff?), 87-19

Tuffs: 21-2, 21-3, 21-6, 22-4, 24-1, 87-05, 87-11, 87-15, 87-17

Altered rocks of indeterminate type: 21-1, 21-4, 22-1, 22-2, 22-7, 22-8, 22-9, 27-1, 28-2, 28-3

Groupings by alteration assemblages are as follows:

Sericite-quartz: 21-2, 27-2

Sericite-carbonate: 21-7, 22-4, 22-5, 23-2, 23-3

Sericite-quartz-carbonate: 21-3

Sericite-quartz-kaolinite: 21-4, 28-1

Sericite-carbonate-quartz-kaolinite: 24-1, 28-3

Quartz-kaolinite: 21-1, 22-1, 22-2, 22-7, 22-8, 22-9, 27-1, 28-2. Many of this group have traces of alunite. They represent the most intense form of alteration, with total textural destruction.

Quartz-carbonate-limonite: 87-13

Quartz-carbonate: 23-1

Carbonate: 22-3, 28-4

Carbonate-kaolinite: 21-5, 21-6, 22-6

Epidote: 87-05, 87-17

Essentially fresh: 23-4, 23-5, 87-07, 87-10, 87-11, 87-15, 87-19

The identification of the clay mineral throughout these rocks is based on X-ray diffraction scans done on two samples (22-9 and 28-2). The clay component in the other samples appears optically identical.

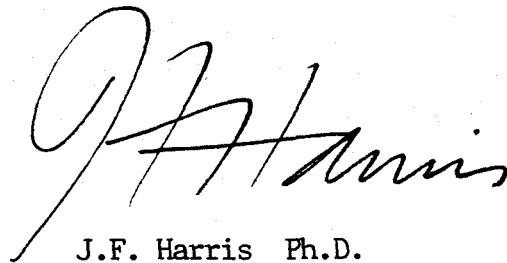
Ore mineralogy in these samples is very consistent. Approximately two thirds of the samples contain disseminated pyrite, in amounts ranging from trace to about 3%. Generally pyrite is the only sulfide, but traces of chalcopyrite, chalcocite

sphalerite, galena and, possibly, tetrahedrite were observed in a few cases. The pyrite is typically disseminated in random fashion, without apparent structural control, and without consistent association with any particular alteration mineral. The generally fresh samples of the DAR series, and the trachytes from M-87-23, lack pyrite.

The alteration likewise tends to be mainly of a pervasive character, and veining is seldom seen.

Indications of deformation were seen in only one sample (22-4).

Individual petrographic descriptions are attached. These provide the necessary information for more detailed collation and comparison of the petrographic data.

A handwritten signature in cursive script, reading "J.F. Harris". The signature is written in dark ink and is positioned above the typed name.

J.F. Harris Ph.D.

COPY TO: Golden Rule Resources Ltd, Calgary.



# Vancouver Petrographics Ltd.

JAMES VINNELL, Manager  
JOHN G. PAYNE, Ph.D. Geologist  
A.L. LITTLEJOHN, M.Sc. Geologist  
JEFF HARRIS, Ph.D. Geologist

P.O. BOX 39  
8887 NASH STREET  
FORT LANGLEY, B.C.  
VOX 1JO

PHONE (604) 888-1323

Invoice #

July 24th, 1987

Report for: Bruce Evans,  
Golden Rule Resources Ltd.,  
c/o J. Warren  
Central Mountain Air Ltd.,  
SMITHERS, B.C.

## Samples:

1 rock sample, 87-21-1, included in a larger suite submitted for sectioning and petrographic examination.

Rush treatment was requested for this particular sample, which is the subject of the present report.

## Description:

Sample 87-21-1

SILICIFIED FRAGMENTAL VOLCANIC

### Estimated mode

Quartz	87
Alunite	5
Zeolites	trace
Leucoxene	2
Pyrite	6
Limonite	trace

The fragmental character of this rock is clearly visible on the etched cut-off block. It appears to be made up of somewhat rounded fragments, up to 15mm or more in size, of a porphyritic volcanic. It is either a lapilli tuff or some form of breccia.

The original composition of the rock is totally obscured by intense alteration.

The groundmass of the porphyritic fragments is totally silicified and consists of an even-grained, chert-like, anhedral aggregate of turbid quartz, of grain size 5 - 20 microns. Randomly distributed, fine-grained pyrite and tiny flecks of leucoxene are disseminated constituents.

The original phenocrysts are recognizable as prismatic pseudomorphs, 0.5 - 2.0mm in size. These are mainly composed of mixtures of granular quartz and a

tabular, moderately birefringent mineral believed to be alunite. These are probably altered feldspars. A smaller proportion of pseudomorphs are composed essentially of leucoxene - sometimes structureless, sometimes lamellar-textured, with intergrown quartz and sericite. These are presumably altered mafic phenocrysts.

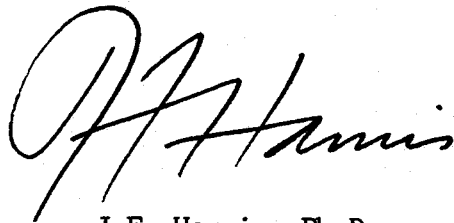
A minor proportion of alunite is present as sparsely dispersed tiny flecks throughout the silicified groundmass. It also occurs as fine-grained aggregate clusters intergrown with the pockets and networks of slightly coarser quartz (0.05 - 0.1mm) which apparently constitutes the matrix or cementing phase between the altered fragments.

The abundant fine-grained pyrite in this rock shows a somewhat inconsistent relationship to the fragmental structure. It clearly concentrates as rims to some of the fragments, but not to all of them: it also occurs disseminated within them. Locally it appears to follow micro fractures. The pyritization is, in fact, pervasive (as individual euhedral grains 0.02 - 0.1mm) and concentrates in strings and small clusters in zones of weakness which sometimes, but not always, follow fragment outlines. The pyrite does not appear to be specifically associated with the granular quartz-alunite cementing phase.

Other constituents are scattered, small pockets of prismatic, very low birefringent crystals which look like a zeolite (possibly stilbite). These may be original amygdules or, more likely, are another manifestation of the intense hydrothermal alteration.

At one end of the slide there is minor development of limonite, as pervasive, intergranular wisps, and as trains and networks of small granules - probably representing the oxidation of pyrite.

Unfortunately no 'red mineral' appears to be present in the portion of the sample sectioned. The remaining sample material is not in my possession at present, but when I receive it I will take a look at it and attempt to answer your specific question.



J.F. Harris Ph.D.

## Estimated mode

Sericite	}	88
Altered glass		
Quartz		6
Kaolinite		2
Altered biotite		2
Rutile	}	trace
Leucoxene		
Pyrite		2

This is a heterogenous, strongly altered rock which, from examination of the stained cut-off chip, is fairly evidently of fragmental character. It is probably a rather coarse-grained tuff of glassy, partly pumiceous fragments in a matrix of vitric ash.

The glassy material is largely converted to sericite - sometimes streaky, felted to compact, sometimes cryptocrystalline.

The latter form (altered matrix) contains more or less diffuse patches of somewhat coarser sericite, including some streaky, pumiceous masses with intergrown leucoxene, which represent altered fragments.

A few recognizable flakes of altered biotite (converted to sericite and leucoxene) are seen, but there are no recognizable pseudomorphs of feldspar phenocrysts. Primary quartz phenocrysts are likewise absent.

Quartz occurs as a minor pervasive silicification in the form of scattered, small, rather diffuse, locally coalescent pockets and clumps. It may be concentrated in specific clasts, though this is not clearly apparent. The slide includes one discrete clast composed almost entirely of granular quartz.

A few of the quartz pockets have cores or interstitial fillings of kaolinite.

Pyrite occurs disseminated as rather fine-grained, polygonal, sometimes concentrically zoned granules, 2 - 50 microns in size. A few coarser coalescent clusters and irregular replacements (of leucoxene?) are seen. The pyrite occurs irregularly through the heterogenous, altered melange, except that it tends to be absent from the large pumiceous clasts.

## Estimated mode

Sericite	60
Felsite	17
Quartz	15
Carbonate	5
Rutile	} trace
Leucoxene	
Pyrite	3
Sphalerite	trace

This is another strongly altered, heterogenous rock of generally similar type to 21-2. Although its fragmental character is barely apparent in the stained cut-off chip, the streaky aspect under the microscope is strongly suggestive of an altered tuff of pumiceous fragments.

Again the rock lacks any recognizable feldspar phenocrysts or pseudomorphs thereof, suggesting that it originated as something other than the typically strongly porphyritic flow rocks recognizable elsewhere in the suite.

An alternative is that evidence of original porphyritic character may have been totally destroyed in the more intensely altered rocks such as this one. This possibility also applies to the several examples of the quartz-koalinite alteration sub-type represented in the suite.

The rock consists of streaky sub-parallel masses of concentrated sericite, separated by pockets and networks of microgranular quartz. There are also areas of very fine-grained felsitic material which show more or less intense sericitization, and are diffusely pervaded by fine-grained silica.

An additional component not seen in 21-2 is carbonate. This occurs as irregular wisps and patches of very fine-grained material, often quite a strong brown in colour. Sometimes the carbonate concentrates in the streaky shard-like sericite masses. A little carbonate occurs in better crystallized form as interstitial pockets in the patches of granular quartz.

Pyrite is relatively abundant and evenly disseminated as tiny, individual grains, from a few microns up to 0.25mm in size. These are often irregular, poikilitic, sometimes skeletal. Occasionally they appear intimately intergrown with leucoxene. The distribution of the pyrite appears totally random.

One small grain of sphalerite was seen in a vein-like segregation of quartz and carbonate.



Sample 87-21-4

BANDED PORCELLANITE(?)

Estimated mode

Cryptocrystalline felsite	}	86
Altered glass		
Sericite		6
Quartz		1
Kaolinite		6
Alunite(?)		1
Pyrite		trace

This is an extremely fine-grained rock of uncertain composition and origin. It consists largely of a homogenous, turbid, cryptocrystalline material, possibly of feldspathic composition. This may be weakly sericitized throughout, but is so fine grained as to make this uncertain; alternatively it may contain considerable clay and/or leucoxene.

It exhibits a crude banding defined by roughly parallel laminar variations of several kinds: e.g. zones containing small, equant patches of slightly coarser, more sericitic, or somewhat silicified material, which are presumably pseudomorphs of phenocrysts or clasts; diffuse zones of stronger sericitization; subtle, diffusion-type bands of differing degrees of turbidity; and irregular, laminar concentrations of disseminated, very fine-grained pyrite.

Sub-parallel, anastomosing, locally discordant, thin seams and pockets of kaolinite reflect the same crude banding which, presumably, originated as flow banding in a glass or layering in a fine, porcellanous ash tuff.

The rock contains a few localized, irregular/elongate zones of equant, porphyroblastic grains of what is thought to be alunite. Cubic pits of unknown origin are also common in the vicinity of these zones.

Quartz is rare, being confined to a few small, cherty, microgranular pockets.

## Estimated mode

Plagioclase	18
K-feldspar	30
Quartz	trace
Sericite	5
Kaolinite	12
Carbonate	32
Altered biotite	3
Pyrite	trace

This is a rock of uncertain affinities whose original mineralogy and texture has been modified by strong alteration. There is a suggestion of fragmental texture from the stained cut-off chip, but this is not recognizable in the thin section.

Phenocrysts (0.2 - 2.0mm) appear to have been principally plagioclase. These show moderate sericitic alteration, overlain, except in the smallest ones, by strong carbonate replacement. A few phenocrysts (similarly altered) appear to have been K-spar.

Mafics include altered biotite (pseudomorphed by lamellar intergrowths of carbonate and sericite), and possibly some hornblende (totally pseudomorphed by carbonate).

The groundmass has a distinctive texture, being composed of abundant, equant granules (10 - 30 microns) of K-spar and minor plagioclase, interstitially cemented by kaolinite. It is probably an altered, partially devitrified potassic glass. It may contain a small component of quartz.

The clear carbonate of the altered feldspar phenocrysts and totally pseudomorphed mafics is commonly enveloped and linked by a very fine-grained, brownish, sub-opaque form of carbonate which forms irregular, sub-parallel schlieren and diffuse small wisps throughout.

Quartz (other than a possible minor groundmass component) is apparently confined to a single small patch of veining and impregnation.

Sulfides are likewise very rare, consisting of rather ragged grains of pyrite, 0.01 - 0.1mm in size, mainly concentrated in and around the single patch of silicification. One or two minute, discrete specks of chalcopyrite were also noted.

The rock displays a weak sub-parallelism of altered biotite flakes and carbonate wisps, which may reflect an incipient flow texture.

This is a heterogenous, strongly altered rock which is clearly of fragmental character. It appears to be composed predominantly of lithic clasts of various kinds, up to about 10mm in size.

These are mainly very fine, felsitic or glassy types, sometimes with euhedral plagioclase phenocrysts to 4mm. The latter are strongly replaced by carbonate; a few phenocrysts of altered biotite are also seen.

Some fragments contain pockets and networks of kaolinite, and others are more or less strongly replaced by fine-grained quartz. Wisps and networks of tiny hematitic or limonitic granules are common in the strongly silicified clasts.

Some areas have the streaky, sericitized appearance of altered pumice.

The whole melange is cut by sub-parallel, anastomosing veinlet zones and irregular networks of fine-grained, brownish carbonate.

The rock contains only traces of very fine-grained, disseminated pyrite.

## Estimated mode

Plagioclase	46
K-feldspar	}
Potassic lithic fragments	
Sericite	11
Carbonate	35
Quartz	trace
Apatite	trace
Sphene	}
Leucoxene	
Pyrite	1

Low power examination of the stained cut-off chip (especially when wet) clearly reveals the fragmental character of this rock. Fragments include blocky porphyritic andesite and ragged, elongate, glassy potassic fragments up to 10mm or more in size. These may be clasts in a lapilli tuff, or xenoliths in a contaminated andesite flow.

This feature is much less obvious in the thin section, where the texture is largely obscured by the strong carbonate alteration.

The rock consists dominantly of plagioclase phenocrysts, 0.2 - 2.0mm, in a groundmass of microgranular plagioclase of grain size 0.02- 0.05mm. The phenocrysts show moderate to strong sericitization. The groundmass shows mild pervasive sericitization.

Mafics are rare. A few phenocrystic grains of obvious altered biotite are seen (lamellar intergrowths of sericite, carbonate and leucoxene), plus scattered, small pseudomorphs of intergrown carbonate and lattice-textured leucoxene after some other type of mafic.

The rock shows strong carbonate alteration. This takes the form of diffuse, patchy, fine-grained impregnations and irregular wispy veinlets throughout. In addition, the plagioclase phenocrysts show strong, sometimes total replacement by carbonate (apparently superimposed on the sericitization).

Opaques consist dominantly of pyrite, as randomly disseminated, individual euhedra, 0.04 - 0.4mm in size. Very rare tiny specks of chalcopyrite are present.

The xenolithic fragments show a variable but generally comparable level of alteration to the enclosing rock.

Estimated mode

Altered glass(?)	62
Quartz	15
Kaolinite	20
Pyrite	3
Galena	trace

This is a very fine-grained rock of uncertain character. It is composed essentially of a homogenous, cryptocrystalline material, of grain size 5 - 10 microns, which may be of felsitic or glassy character, or is possibly an intimate intergrowth of quartz and kaolinite in various proportions.

This rock shows an overall breccia-like texture on the scale 0.1 - 1.0mm. This is delineated by patches, pockets and networks of slightly different grain size. Some of these areas are composed of kaolinite, while others appear to include minutely fine-grained quartz.

At one end of the slide the rock is unquestionably of siliceous composition. Here anhedral aggregate quartz, of grain size 20 - 50 microns, forms a matrix to more or less diffuse patches of kaolinite.

The rock contains rather abundant, randomly disseminated pyrite as individual euhedra 0.03 - 0.3mm in size. This shows no relation to the breccia fabric or the compositional variations in the matrix. Traces of galena are seen as small, discrete grains, inclusions in pyrite, and apparent marginal replacements of pyrite.

Estimated mode

Quartz	75
Kaolinite	25
Pyrite	trace
Galena(?)	trace
Chalcopyrite	trace

This is an intensely altered rock consisting entirely of an intergrowth of quartz and kaolinite. No evidence remains as to original textures or rock type. There is some suggestion of breccia or fragmental structure.

Quartz is the dominant constituent, as granular aggregates of grain size 20 - 50 microns. This material makes up irregular, essentially monomineralic masses, showing pockety variations in grain size, and minor vuggy or veinlike inclusions of kaolinite.

The totally silicified areas pass gradationally to material composed of individual, tiny, prismatic grains of quartz, more or less densely disseminated through a matrix of evenly fine-grained kaolinite. All gradations from 100% quartz to 100% clay are present in diffuse, patchy relationship.

A little sparsely disseminated pyrite occurs as rather irregularly distributed clusters of anhedral grains, 10 - 100 microns in size, locally coalescing to coarser patches. The pyrite occasionally has intergrown traces of a grey mineral (galena - or possibly tetrahedrite or chalcocite) and rare chalcopyrite.

## Estimated mode

Plagioclase	12
K-feldspar	73
Carbonate	12
Chlorite	trace
Rutile	trace
Pyrite	3

This is a relatively fresh rock of simple composition.

It is a porphyritic volcanic consisting of phenocrysts of K-feldspar and plagioclase in a fine-grained potassic groundmass.

The phenocrysts are 0.2 - 4.0mm in size, and subhedral prismatic in form; They make up about 40% of the rock. They are fresh but for a patchy brownish turbidity (mild argillization) and irregular splashes of carbonate.

The groundmass is a felsitic aggregate of K-feldspar of grain size 3 - 30 microns. It contains a sprinkling of slightly coarser, randomly oriented, lath-like grains to 0.1mm, which appear to be plagioclase (at least in part). The aphanitic K-spar aggregate is generally rather clear but for a light dusting of micron-sized rutile.

The rock shows moderate pervasive carbonate alteration in the form of rather evenly distributed, irregular-shaped, small patches throughout the groundmass, locally also affecting the feldspar phenocrysts.

Some of the carbonate patches may represent altered mafics (especially a few which show lamellar texture with intergrown chlorite and fine-grained rutile), but the majority show no trace of pseudomorphic form. There is no indication of structural control in the distribution of the carbonate.

Opagues are evenly disseminated, rather fine-grained pyrite as individual euhedra, mainly in the size range 0.02 - 0.2mm. Despite the relative abundance of pyrite in this rock, no associated sulfide phases could be seen.

This sample is a bedded tuff showing possible shear structures.

The principal lithotype in the section is a tuff composed of close-packed, sub-angular clasts, 0.05 - 0.25mm in size.

The clasts are of three kinds: well-defined, sub-equant, trachytic lithic fragments; fragmented K-spar crystals; and a rather diffuse, sometimes elongate, wispy, turbid, sericitized material (possibly an altered felsite or glass). These are set in a minimal matrix of fine-grained, foliaceous sericite which wraps around the small, rather equigranular clasts to define a strong crenulate foliation.

The sericitic clasts have a strong green body colour. The trachytic and K-spar crystals clasts are fresh and unaltered.

Scattered, coarser clasts, to 4.0mm in size, are composed of porphyritic trachyandesite (K-spar and plagioclase phenocrysts in a felsitic groundmass). These often contain wisps and patchy impregnations of brown, fine-grained carbonate. Similar carbonate is also seen as rare, small, dispersed flecks in the tuff at large.

This lithotype passes via a sharply gradational (bedded?) contact, to a distinctive variant consisting of extremely fine-grained, compact sericite, lensily interlaminated with brown carbonate. This rock lacks the abundant, small, equigranular clasts of the main lithotype, and shows strong shear-type microstructures with local contortion and disruption of the carbonate lenses. It contains rare discrete lithic and crystal fragments (trachyte and K-spar) about, 0.5mm in size, which appear unaltered and undeformed.

The sericite-carbonate lithotype appears to represent a fine-grained, largely ashy variant of the adjacent bed.

The rock contains 1 - 2% of disseminated pyrite, as individual euhedral grains, 10 - 150 microns in size, sometimes clumped. These occur randomly scattered through the rock, but are only rarely seen within the coarser clasts. The pyrite in the fine ashy bed is generally somewhat coarser than in the granular tuff.



## Estimated mode

Plagioclase	54
K-feldspar	3
Trachytic xenoliths	3
Quartz	2
Sericite	8
Carbonate	30
Leucoxene	trace
Pyrite	trace
Chalcopyrite	trace

This is a fine-grained porphyritic rock showing strong carbonate alteration.

Most of the original phenocrysts are obliterated by total carbonate replacement, but remnants suggest that they were dominantly plagioclase and 0.1 - 2.0mm in size. Some of the relatively less altered phenocrysts are of K-spar, and there are also a few scattered, rounded or corroded quartz phenocrysts.

The groundmass is cryptocrystalline to minutely felsitic, of estimated grain size 5 - 10 microns. It appears, from the lack of positive stain on the cut-off block, to be composed essentially of plagioclase. Some of the small, discrete, phenocryst-like patches of positive K-stain are actually xenoliths of microgranular trachyte, 0.1 - 0.5mm in size.

The groundmass shows light pervasive sericitization, with occasional, tiny, totally sericitized sub-phenocrysts.

The predominant alteration phase is a fine-grained, often brownish, sub-opaque carbonate. This occurs evenly dispersed throughout as individual, locally semi-coalescent, ragged patches. In part these may represent altered feldspar (and possibly mafic) phenocrysts, and some contain cores of remnant feldspar. Sometimes the carbonate rims or encrusts feldspars. Much of it appears to be as random pervasive impregnations. A small proportion of the carbonate is in the form of rather irregular hairline veinlets, apparently following microfractures.

The browner, more opaque carbonate may contain a component of intimately intergrown leucoxene, clays and/or limonite. No recognizable mafic silicates are present, any that once existed having apparently been totally replaced by carbonate.

Opaques are sparse. They consist of scattered pyrite grains, 0.01 - 0.2mm in size, often somewhat rounded and possibly microgranular aggregates rather than simple euhedra. One patch of chalcopyrite, intimately intergrown with carbonate and leucoxene, was seen.

## Estimated mode

K-feldspar	48
Plagioclase	8
Kaolinite )	7
Altered glass )	
Quartz	2
Sericite	20
Carbonate	9
Altered biotite	2
Apatite	trace
Leucoxene )	2
Sub-opaque dust )	
Pyrite	2

This rock is similar in many respects to Sample 87-21-5, but its fragmental (or partly fragmental) character is somewhat more clearly recognizable.

Subhedral phenocrysts of K-feldspar, 0.1 - 2.0mm in size, are moderately sericitized (i.e. about 50% altered to fine-grained sericite).

These are set in a felsitic groundmass, of grain size 10 - 30 microns, composed of K-spar with an indeterminate proportion of intergrown plagioclase. An interstitial, diffuse, very low birefringent component is sometimes discernible: this may be kaolinite or a form of glass. The groundmass shows incipient, pervasive sericitization, and is turbid with included sub-opaque dust.

Sparsely scattered, sub-oriented flakes of biotite are totally altered to carbonate, sericite and leucoxene. Quartz occurs as occasional, small, microgranular pockets and rare, short, hairline veinlets.

A prominent feature is the occurrence throughout the rock of brown, very fine-grained, sub-opaque carbonate. This occurs as discrete, irregular, sub-parallel, locally anastomosing schlieren. These tend to develop into more diffuse concentrations where they intersect strongly sericitized feldspar phenocrysts.

The rock contains rather evenly disseminated pyrite as relatively coarse, individual euhedra, 0.05 - 0.5mm in size (rarely to 1.0mm). The pyrite sometimes has inclusions of the very fine-grained rutile which occurs throughout the groundmass. Its distribution shows no particular relationship to the carbonate alteration.

Some distinct lithic fragments are recognizable under the microscope, and the stained cut-off chip displays a diffuse fragmental structure on the scale 1 - 8mm. A weakly developed, streaky, laminar texture is also discernable, and the rock may be an altered flow breccia.

Estimated mode

Quartz	50
Kaolinite	46
Leucoxene	) 4
Limonite	
Alumite	trace
Pyrite	trace

This is a similar type of rock to Sample 22-1.

It consists predominantly of a rather homogenous, very fine-grained, felsitic matrix of uncertain composition. This material is of slightly coarser grain size than in 22-1 (5 - 20 microns), and can be fairly confidently identified as an intimate intergrowth of minutely granular quartz and kaolinite.

Small, often angular forms, 0.2 - 1.0mm in size, (pseudomorphs of original phenocrysts or clasts) are common throughout the matrix. These are just distinguishable under the microscope as patches of slightly coarser quartz, or varying proportions of quartz to kaolinite. More prominent features are patches of diffuse, brown stained leucoxene (ex-mafics?). The latter material also forms a few sub-parallel schieren, and is disseminated as dust-sized flecks.

Rare, partially assimilated remnants of primary quartz phenocrysts are seen.

Kaolinite, as felted aggregates, concentrates in streaky patches and networks, outlining areas of apparent breccia structure. Some kaolinite pockets are rimmed by tiny euhedra of quartz.

Pyrite is present only as rare traces.

This rock appears to be a totally altered tuff or fine-grained porphyry.

Sample 87-22-8

QUARTZ-KAOLINITE ROCK (ALTERED TUFF?)

Estimated mode

Quartz	67
Kaolinite	30
Leucoxene	) 2
Limonite	
Alunite	trace
Pyrite	1

This rock is identical to 22-7 in all essential respects.

It differs slightly in having a higher quartz/clay ratio, lacking the angular, relict fragmental or porphyritic forms of 22-7, and in having slightly more disseminated pyrite.

Kaolinite concentrates partly as sub-parallel schlieren in this rock, and there is a weakly perceptible, streaky/fragmental fabric (best seen by reflected light), which may be indicative of an original, more glassy (pumiceous?) character. The etched cut-off chip clearly indicates that the silicified matrix is brecciated, and that the kaolinite (white) concentrates as a cementing phase.

Alunite occurs in this rock (as in 22-7) as rare, small, porphyroblast-like individuals.

## Estimated mode

Quartz	48
Kaolinite	50
Leucoxene	) 2
Limonite	
Zircon	trace
Pyrite	trace

This rock is of essentially identical type to 22-7 and 22-8, being composed of a minutely fine-grained intergrowth of quartz and kaolinite.

In this sample the kaolinite forms irregular, pockety concentrations throughout, without perceptible banded or pseudomorphic structures. A crude, irregular streakiness and clumping of more quartzose areas is apparent in the etched cut-off chip. Evidence as to original rock type is essentially lacking, though relict perlitic or crystallite forms are occasionally discernable within areas of cherty silicification, suggesting a possible glassy character.

Leucoxene in this rock occurs as a few ghost-like pseudomorphs, but mainly as diffuse networks with reddish (hematitic?) staining, and as dust-sized disseminations.

Rare, tiny remnant granules of zircon were seen.

Pyrite is present only in faint traces, as scattered clusters of minute subhedra.

## Estimated mode

K-feldspar	80
Quartz	10
Chlorite	trace
Carbonate	8
Apatite	trace
Leucoxene )	
Sphene )	1
Rutile )	
Fe-Ti oxides	1

This is a porphyritic trachyte, generally similar to a number of other samples in the suite (especially from M-87-23).

Phenocrysts make up about 45% of the rock. These are predominantly K-feldspar (orthoclase), subhedral in form and 0.3 - 3.0mm in size. These are notably free of sericitization or argillization, but are more or less strongly altered to carbonate via fine-grained microfracture networks.

Scattered small mafic phenocrysts, 0.1 - 0.5mm in size, are totally altered and recognizable only as ghost outlines of fine-grained rutile. Sometimes they include a proportion of chlorite, carbonate and sphene/leucoxene. They have forms suggestive of derivation from biotite and hornblende.

Rare, small, corroded phenocrysts of primary quartz are also present, as well as a few relatively coarse grains of ilmenitic oxides.

The groundmass is uniformly very fine-grained, felsitic-textured K-feldspar of grain size 5 - 20 microns. It contains rather abundant accessory quartz as small grains and microgranular pockets. Locally these concentrate as areas of diffuse silicification or angular (fracture-controlled?), vein-like segregations, sometimes with intergrown carbonate.

Carbonate is also prominent throughout, as fine flecks and networks in the groundmass, expanding to irregular partial replacements of some feldspar phenocrysts.

It is difficult to estimate what proportion of the quartz in this rock is primary. The scattered phenocrysts and some of the randomly scattered groundmass flecks and pockets seem primary, but the latter form grades to diffuse replacements and distinct veinlets (both with associated carbonate). Possibly the quartz developed predominantly as a late stage, deuteric component.

The rock can be considered either as a silicified, carbonated trachyte or a rhyolite.

Estimated mode

K-feldspar	82
Sericite	10
Chlorite	4
Quartz	2
Carbonate	trace
Apatite	trace
Rutile	) 2
Fe-Ti oxides	

This is a rock of generally similar, K-rich type to 23-1, but differs significantly in various respects.

Phenocrysts are slightly less abundant (estimated 35%). They are dominantly K-feldspar which shows moderately strong sericitization, as a rather even dusting or flecking. The K-spar phenocrysts are 0.2 - 4.0mm in size, often somewhat rounded in form, and clumped.

Mafic phenocrysts are totally altered to chlorite (an uncommon mineral in this suite), sometimes with minor rutile and, rarely, carbonate and/or granular quartz. They are sometimes recognizable as pseudomorphs of biotite and hornblende.

Rare corroded phenocrysts of primary quartz are seen.

The groundmass contains abundant, small, lath-like K-spar grains, to 0.1mm in size, and exhibits a sub-trachytic texture. The interstitial material to these microlites is cryptocrystalline to glassy. Fine-grained, micron-sized rutile and Fe-Ti oxides occur evenly disseminated throughout. The groundmass lacks the flecks and pockets of quartz noted in 23-1, but shows mild pervasive sericitization.

Apatite is a notable, though trace-level, accessory, as tiny, often brownish striated euhedra.

The rock contains quartz, as rare thread-like veinlets and localized areas of diffuse silicification. Occasional microfractures are filled with sericite.

Estimated mode

K-feldspar	68
Sericite	15
Biotite	2
Chlorite	12
Carbonate	1
Apatite	trace
Quartz	trace
Rutile	) 2
Fe-Ti oxides	

This is another porphyritic trachyte. It is very similar to 23-2, but the K-spar phenocrysts are smaller and more strongly sericitized, as is the groundmass.

Mafics are rather abundant and of two distinct types. The commonest is a totally altered form, consisting of chlorite pseudomorphs, 0.1 - 1.0mm in size, sometimes with oxide inclusions. The other consists of distinct grains of red-brown biotite, typically rimmed by and packed with inclusions of rutile and Fe oxides.

Chlorite also occurs in this rock as an interstitial phase in the groundmass, and occasionally as a minor alteration product of K-spar.

No quartz phenocrysts are present, nor is quartz seen as a primary groundmass constituent. It occurs in traces as rare, tiny, hair-line veinlets and associated pockets. Carbonate, likewise, is rare, but does occur pervasively as minute, disseminated flecks in the groundmass, and as occasional brownish wisps associated with altered phenocrysts.



## Estimated mode

K-feldspar	83
Sericite	4
Quartz	2
Biotite	2
Chlorite	6
Carbonate	1
Rutile	) 2
Fe-Ti oxides	

This is another variant of the porphyritic trachyte exemplified by the preceding few samples. It is the least altered of the group.

It is basically similar to 23-3, but the K-spar phenocrysts are mostly only weakly sericitized.

Mafics are similar to those in 23-3, including some recognizable biotite, though often partially bleached and chloritized, and typically rimmed by or lamellarly intergrown with, fine-grained rutile and oxides. The predominant type of mafic is totally altered to chlorite, occurring as relatively coarse, irregular patches and tiny prismatic forms rimmed by dusty oxides. Scattered grains of ilmenitic oxides, to 0.5mm, show a random distribution.

The groundmass is rather homogenous felsitic K-spar with disseminated, fine-grained oxides.

Quartz occurs as scattered, small pockets and discontinuous, hairline veinlets. Carbonate occurs as rare, fine-grained, brown wisps and flecks, associated with K-spar and altered mafic phenocrysts.

The rock is cut by occasional sericitized microfractures.

Estimated mode

K-feldspar	80
Sericite	2
Altered Biotite	2
Chlorite	6
Quartz	5
Carbonate	3
Rutile	) 2
Fe-Ti oxides	
Chalcopyrite	trace

This rock is compositionally similar to the preceding trachyte samples, but differs in exhibiting an obscure fragmental structure. This is only barely perceptible on the stained cut-off chip, but is recognizable in thin section as irregular, patchy variations in groundmass texture and abundance of finely intergrown quartz.

The rock is basically similar to 23-4. K-spar phenocrysts are mildly sericitized; they also show a light hematitic dusting. Rare, corroded, primary quartz phenocrysts are seen.

Mafics are minor. They include altered (but still recognizable) biotite, and small pseudomorphs of felted chlorite, occasionally with accessory quartz.

The groundmass is homogenous, very fine-grained, fresh felsitic to sub-trachytic K-spar, dusted with disseminated rutile and Fe-Ti oxides - including discrete subhedral grains of the latter to 0.5mm in size.

This lithotype appears somewhat fragmented (possibly autobrecciated), and locally cemented by a similar but noticeably more siliceous phase in which fine-grained quartz occurs intimately intergrown in the groundmass. Quartz also forms occasional coarser pockets, veniform bodies, and prismatic pseudomorphs with accessory carbonate.

This rock appears to be an autobrecciated trachyte cemented by a slightly more siliceous late-stage differentiate.

Estimated mode

Sericite	40
Quartz	12
Kaolinite	29
Carbonate	16
Fe-Ti oxides	3
Pyrite	trace

This is another variety of totally altered rock. It resembles 27-2, 21-2 and 21-3 in that the dominant constituent is very fine-grained sericite. It is similar to the latter two in its heterogenous texture, probably inherited from a rather coarse lithic tuff. It is gradational to the silica-clay alteration facies by virtue of its high content of kaolinite.

Various more or less distinct components can be recognized, in diffuse patchy/streaky intergrowth. The most common is what appears to be an altered, meshwork-textured groundmass phase, now consisting of totally sericitized, diffuse, lathlike forms, 0.05 - 0.15mm in size, in an interstitial matrix of kaolinite. This contains totally altered phenocrysts to 2.0mm in size, consisting of compact cryptocrystalline sericite and/or kaolinite, occasionally with a little granular quartz.

Rare, corroded, primary quartz phenocrysts are recognizable.

Carbonate is a prominent constituent, occurring in distinctive form as sub-parallel wisps, streaks and anastomosing networks of minutely fine-grained brown material. The form of the carbonate is sometimes suggestive of replacement of original pumiceous clasts. Carbonate often forms a superimposed alteration, as patches and impregnations, in the sericite-clay-quartz phenocryst pseudomorphs.

One end of the slide shows a crudely-banded fabric with laminar alternations of microgranular quartz, and of altered felsite clasts cemented by brown carbonate.

Opagues in this rock are principally Fe-Ti oxides, as lattice-textured grains up to 0.5mm in size.

Traces of pyrite occur as very fine-grained wisps and tiny disseminated grains.

Estimated mode

Quartz	87
Kaolinite	12
Sericite	trace
Alunite	trace
Zircon	trace
Pyrite	1

This is another variant of the quartz-kaolinite alteration lithotype abundantly represented in the suite.

It differs texturally from the compositionally similar rocks in the 87-22 series, and has a high ratio of quartz to kaolinite. Much of the quartz is of significantly coarser size than in those samples, with extensive areas made up of anhedral granular aggregates in the size range 20 - 100 microns. Other areas are of the minutely fine-grained type, with diffuse pockets and veinlike segregations of coarser crystallization.

Kaolinite forms discrete pockets and prismatic pseudomorphs throughout the compact quartz, and locally forms a cementing phase to clumps of larger quartz grains.

A unique feature is the occurrence of abundant, individual, subhedral-euhedral quartz grains, 0.1 - 1.0mm in size, throughout the silicified matrix. These sometimes show corroded forms and marginal assimilation, and clearly represent remnant primary quartz phenocrysts in what presumably originated as a rhyolite or quartz porphyry. Occasional discrete patches and faint diffuse wisps of sericite are also seen, as are rare, tiny zircons.

This rock lacks the ferruginous leucoxene component of the 87-22 series counterparts.

Some brecciation of the totally silicified matrix appears to have occurred. A texturally distinctive cementing phase is composed of close-packed, subhedral quartz grains with interstitial kaolinite and disseminated, fine-grained pyrite. Traces of alunite occur in this association.

Minor pyrite, including some relatively coarse, irregular grains to 0.4mm, with silicate inclusions, occurs disseminated at large within the silicified mass.

## Estimated mode

Sericite	78
Quartz	15
Altered biotite	3
Carbonate	trace
Rutile	4
Fe-Ti oxides	

This is an intensely altered rock of a type not represented elsewhere in the suite. Original textures are well preserved, but the rock is largely converted to fine-grained, felted sericite and quartz.

It clearly originated as a porphyritic flow with euhedral feldspar phenocrysts, 0.5 - 3.0mm in size, set in a glassy to sub-trachytic groundmass, with abundant fine-grained oxides (partly as rims to tiny, altered sub-phenocrysts). Discrete phenocrysts of altered biotite (laminar sericite with fine-grained rutile, rimmed by Fe-Ti oxides) and occasional corroded primary quartz phenocrysts are also present.

The original feldspar phenocrysts are totally altered to sericite, sometimes with rims or diffuse replacement patches of granular quartz.

Quartz, of apparent secondary origin, also occurs throughout the groundmass as small, more or less discrete pockets, grading to irregular veinlets and networks of diffuse silicification.

The stained cut-off chip shows a total absence of K-spar. This may be indicative of an original andesitic or dacitic composition, possibly similar to DAR 87-19. Alternatively the lack of stain could be a function of the total alteration.

## Estimated mode

Sericite	35
Felsite	45
Quartz	5
Kaolinite	9
Carbonate	2
Fe-Ti oxides	2
Pyrite	2

This rock appears, from the stained cut-off chip, to be of porphyritic character. Microscopic examination of the thin section reveals, however, that many of the apparent phenocrysts are actually lithic clasts up to 5mm or more in size. The rock is probably an altered andesitic tuff, or possibly (since the fragment type appears consistent throughout) an autobrecciated flow.

The material of the fragments is a strongly sericitized felsite with abundant disseminated Fe-Ti oxides, sometimes of fine-grained, ragged or acicular form, sometimes forming skeletal pseudomorphs, and sometimes as individual euhedra to 0.5mm. Scattered, small grains and pockets of quartz probably represent an incipient silicification.

Many of the fragments contain totally altered pseudomorphs of what were presumably plagioclase phenocrysts up to 2mm in size. These are typically converted to fine-grained sericite and/or clays. Rarely they are partially silicified or carbonated.

Occasional laminar sericite/oxide pseudomorphs and carbonate patches with lattice-work oxides probably represent altered mafic phenocrysts. Rare, primary quartz phenocrysts are also seen.

A matrix phase of very fine-grained, less sericitized felsite, with a lower content of disseminated oxides, is locally recognizable.

Pyrite occurs as sporadic, rather coarse, individual euhedra, up to 1.0mm in size. These are of random distribution, and show no particular relation to the fragmental fabric; in fact, they are sometimes seen within sericitized feldspar pseudomorphs. They often have inclusions of oxides and silicates, suggesting porphyroblastic growth.

Chalcopyrite is a notable accessory, as small patches independent of the pyrite, often partially altered to bornite and chalcocite.

Estimated mode

Quartz	80
Kaolinite	19
Leucoxene )	1
Limonite )	
Pyrite	trace

This is another example of the siliceous sub-facies of the totally altered quartz-kaolinite rocks.

It consists dominantly of a rather even-grained, anhedral aggregate of quartz, of grain size 0.02 - 0.1mm. This shows slight local coarsening, especially peripheral to pockets of kaolinite, and has diffuse, patchy areas of intimate intergrowth with kaolinite.

The kaolinite occurs as discrete, irregular, sometimes branching or elongate pockets of compact felted material & in more dispersed form as meshwork clusters of tiny, lath-like pseudomorphs(?), and interstitial flecks intimately intergrown with microgranular quartz.

Rare remnant primary quartz phenocrysts, ferruginous leucoxene pseudomorphs after original mafics, and tiny zircon grains are seen. Micron-sized sub-opaque dust occurs dispersed throughout. Pyrite is a minor constituent.

No recognizable remnant texture indicative of original rocktype, or structural features localizing the alteration can be seen. Apparently the rock is a product of pervasive replacement with total textural destruction.

## Estimated mode

Felsite	17
Sericite	18
Quartz	30
Kaolinite	9
Carbonate	26
Leucoxene	trace
Apatite	trace
Pyrite	trace
Sphalerite	trace
Galena	trace

This is yet another strongly altered rock. It exhibits a combination of all the alteration types represented in the suite (sericitization, silicification, kaolinitization, carbonatization).

Its texture is heterogenous, and the original rock type is indeterminate.

The matrix is felsitic, more or less strongly sericitized, silicified via small pockets and threads of microgranular quartz, and sometimes showing diffuse impregnations and small pockets of kaolinite.

Irregular wispy to prismatic patches of stronger sericitization, and/or of granular quartz, may represent original phenocrysts or clasts. A few skeletal patches of leucoxene may represent altered mafics.

The rock is intimately pervaded by abundant, fine-grained, brownish carbonate as wisps, compact patches and network intergrowths.

It is also cut by a distinct veinlet, 3 - 4mm thick, of vari-granular quartz. Smaller quartz veinlets and irregular replacement patches branch off the main veinlet.

The relationship of the quartz and carbonate is inconsistent. Sometimes carbonate appears to form envelopes to quartz veinlets, but elsewhere the quartz veinlets definitely cross-cut the carbonate. Clearly the alteration is multi-stage.

Pyrite occurs only as traces, but shows a strong association with carbonate. Sphalerite and rare galena are notable associates.



## Estimated mode

K-feldspar	55
Quartz	7
Carbonate	36
Chlorite	trace
Rutile	trace
Pyrite	2
Galena	trace
Tetrahedrite	trace

This is another variant of the porphyritic trachytes. It is distinctive in exhibiting strong carbonate alteration with no accompanying sericitization, and in containing disseminated sulfides rather than the oxides characteristic of the trachytic samples from M-87-23.

It appears that K-spar phenocrysts were rather sparse and generally small (mainly up to 1.0mm). They are almost totally obliterated by the strong carbonate alteration.

The latter is manifested as abundant, diffuse, fine-grained patches and coalescent networks. These carbonate patches often seem to be centred on original K-spar phenocrysts (remnants of which may still be recognizable), but also appear to occur as diffuse impregnations of the groundmass around and between the replaced phenocrysts. Pseudomorphic shapes are rare.

A few carbonate masses show a vestigial lamellar texture, with minor intergrown chlorite and leucoxene, and are probably replacements of biotite. The rock generally has a 'clean' appearance, with only minor amounts of dispersed rutile and opaques, suggesting that it was of rather leucocratic type.

The groundmass is a homogenous, feathery-textured aggregate of very fine-grained K-spar. It shows no trace of sericitization.

Quartz occurs in minor amount as scattered, small, microgranular pockets and diffuse flecks, sometimes, but not always, associated with the carbonate patches. The majority of quartz in the rock is contained in a discrete, highly irregular veinlet exhibiting a fine-grained anhedral aggregate texture.

The opaques in this sample are pyrite as disseminated, individual euhedra, 0.02 - 0.5mm in size, often clumped and showing a strong spatial association with the carbonate patches. Tiny inclusions of galena and probable tetrahedrite occur in some of the pyrite grains.

Estimated mode

Crystal clasts	
Plagioclase	10
K-feldspar	10
Lithic fragments	
Trachytic	20
Andesitic	25
Chloritic	10
Matrix	
Felsite	15
Epidote	5
Chlorite	5
Fe-Ti oxides	trace

This is a mixed lithic crystal tuff of varied fragment types in a felsitic matrix. It is totally free of the sericite, carbonate or siliceous alteration seen in the drill core samples, but contains chlorite and epidote.

Crystal clasts are angular fragments of fresh feldspars 0.05 - 0.5mm in size.

Lithic fragments range up to 5mm or more in size, and consist of porphyritic andesites and trachytes with fresh, microlitic, feldspathic or chloritic groundmasses.

The cryptocrystalline felsitic matrix phase contains fine-grained chlorite and disseminated micron-sized epidote. Epidote also concentrates as scattered, small, crystalline pockets which may represent altered mafic crystal clasts.

The rock contains no sulfides.

## Estimated mode

Plagioclase	40
K-feldspar	49
Quartz	5
Altered mafics	5
Epidote	trace
Leucoxene	trace
Limonite )	
Pyrite )	1

This is a largely unaltered porphyritic latite.

Approximately 40% of the rock consists of euhedral plagioclase phenocrysts, 0.2 - 3.0mm in size, and fresh but for a slight argillic cloudiness.

These are set in a felsitic to meshwork-textured groundmass of K-feldspar of grain size 0.02 - 0.1mm. This contains evenly distributed, small flecks and pockets of microgranular quartz which appear to be a primary constituent. The rock also contains rare, corroded, monocrystalline quartz phenocrysts.

The groundmass is of fresh appearance, and its only other constituents are a light dusting of micron-sized epidote and rutile/leucoxene.

Mafic phenocrysts are totally altered to diffusely intergrown mixtures of sericite, leucoxene, epidote, limonite, clays and quartz. For the most part they are plucked from the thin section, and even in the cut-off chip are represented largely by empty casts. They reach a size of several mm and show prismatic and 8-sided forms suggestive of having originated as pyroxenes and/or amphiboles.

Minor pyrite occurs as disseminated individuals and clusters of anhedral grains, sometimes seemingly constituting a component of small, altered (mafic) pseudomorphs. Some of the pyrite is partially limonitized, and the rock is cut by a few limonite-filled fractures.

Estimated mode

Plagioclase	32
K-feldspar	42
Quartz	14
Chlorite	4
Sericite	4
Carbonate	3
Rutile )	1
Sphene )	
Pyrite	trace

This is a similar type of rock to DAR 87-07, but rather more siliceous. It is also somewhat more altered.

Plagioclase phenocrysts, 0.3 - 3.0mm in size, make up about 35% of the rock. They show a slight pervasive cloudiness and reddening, and sometimes contain localized splashes of carbonate.

They are set in a very fine-grained felsitic matrix of K-feldspar containing rather abundant small anhedral grains and pockets of quartz, 0.1 - 0.5mm in size. The groundmass also contains a little diffuse interstitial sericite and chlorite with minute granules of sphene.

Mafic phenocrysts are totally altered to sericite, chlorite and rutile/leucoxene, occasionally with a little carbonate and/or quartz. They show rather clearly defined pseudomorphic forms of biotite (lamellar masses) and hornblende (diamond shapes).

Traces of disseminated pyrite are in the form of scattered, relatively coarse, subhedral individuals, 0.1 - 0.4mm in size. They are locally limonitized.

The quartz in this rock is probably primary, though no true phenocrysts are seen. It has a 'late' appearance, and occasionally shows apparent marginal replacement of plagioclase phenocrysts. It may be a late magmatic or deuteritic component.

This sample consists of occasional coarse lithic lapilli (up to 30mm or so in size) scattered through a homogenous tuff.

Both the large fragments and the tuffaceous host appear to be of similar, strongly potassic composition.

The former (of which one appears in the slide) is similar to 87-23-4. It is made up of euhedral phenocrysts of K-feldspar and lesser plagioclase, to 2.0mm in size, set in a sub-trachytic matrix of K-spar. A few mafics appear to be partially chloritized and ferruginized biotite. The groundmass contains scattered, small, irregular grains and pockets of quartz, and there are a few quartz phenocrysts.

The feldspar phenocrysts commonly consist of K-spar and plagioclase in intimate patchy or zonal intergrowth. They show mild sericitization, and sometimes have strongly turbid rims.

The groundmass of the large fragment is flecked and pervasively dusted with a brownish, cloudy (ferruginous leucoxene?) material.

The tuffaceous host phase is composed of close-packed, rather even-sized, angular clasts, 0.1 - 0.5mm, of feldspar and occasional quartz crystals and latitic material i.e. the finely fragmented equivalent of the coarse block. It shows weak, pervasive sericitization, and is overlain by a strong, diffuse, brown cloudiness.

The rock contains no sulfides. Fine-grained oxides are, in part, limonitic.

Estimated mode

K-feldspar	64
Quartz	15
Kaolinite	10
Limonite	10
Fe-Ti oxides	1

This is a rock of uncertain origin and composition.

It is composed dominantly of K-feldspar. This occurs in several forms: as phenocrysts to 3 or 4mm in size, now strongly altered; as very fine-grained cryptocrystalline to felsitic material; and as clusters of small, unaltered crystals, 0.05 - 0.1mm in size, developed randomly within the felsitic form.

Other components are kaolinite and quartz. The proportions of these are difficult to estimate as they are very similar in appearance to the finest felsitic and microgranular forms of K-spar respectively.

The coarse K-spar phenocrysts are typically strongly altered to kaolinite and dark brown amorphous limonite. Occasional crystals of microgranular quartz are sometimes associated with these alteration products. The alteration often concentrates in the cores of the crystals, leaving a thin rim of clear, fresh K-spar preserving the euhedral crystal shape.

The K-spar in the groundmass appears essentially unaffected by this alteration.

Much of the fine cryptocrystalline to felsitic K-spar appears to be in the form of fragments, up to several mm in size, and this rock may well be tuffaceous in origin.

The reasonably well-defined altered phenocrysts and felsitic lithic fragments are set in an interstitial phase characterized by abundant microgranular K-spar, together with pockets and individual grains of quartz, and an indeterminate proportion of pockety and interstitial kaolinite.

This form of alteration is different from that seen in any of the other samples. The lack of any sericite or carbonate is notable, and the association of limonite and kaolinite is unique. The rock shows no veining or segregations. No recognizable mafic minerals are present.

Fine-grained Fe-Ti oxides occur as sparse, dusty disseminations throughout (especially in some of the potassic lithic clasts). Pyrite is absent.

## Estimated mode

Crystal clasts		
K-feldspar	28	
Plagioclase	10	
Quartz	trace	
Altered mafics	2	
Lithic clasts		
Trachytic	15	
Andesitic	15	
Matrix		
Felsite	20	
Chlorite	3	
Carbonate	3	
Quartz	2	
Sphene	2	}
Rutile		
Fe-Ti oxides	trace	}
Pyrite		

This rock is a medium-grained tuff consisting of mixed lithic and crystal fragments of trachytic and andesitic type.

It shows a perceptible banding (presumably an original depositional layering) defined by slight variations in clast size and type, and clast to matrix ratio.

Clasts include K-feldspar and somewhat less abundant plagioclase crystals. These are unsericitized but show a strong, even, argillic clouding and/or hematitic reddening. Rare quartz crystal chips are also seen.

Lithic clasts are present in approximately equal proportions to crystals, and are of similar size, ranging mainly from 0.2 - 2.0mm. They tend to be rather equidimensional in form and sub-angular in shape. They consist of various fine-grained trachytic and andesitic types, the latter often quite chloritic.

The matrix is a fine structureless felsitic material, locally with wisps and pockets of chlorite and diffuse microgranular quartz. Carbonate occurs as sporadic irregular patches, sometimes apparently pseudomorphing mafic crystals, other times apparently acting as a local cement to lithic clasts.

The rock contains only faint traces of disseminated pyrite, often marginally limonitized.

This is another medium grained tuff, of similar character to DAR 87-05 and 15.

It is somewhat distinctive in that the crystal clasts (which are dominant over lithic fragments) are mainly plagioclase, and the matrix more potassic. This is the reverse relationship to DAR 87-15. It is also slightly finer grained overall than the previous sample, crystal clasts chiefly being in the size range 0.1 - 1.0mm. They show argillic clouding and incipient sericitization.

Quartz is apparently absent and there are no recognizable mafic crystal fragments.

Lithic clasts, similar in size to the crystals, include trachytic-textured and chloritic varieties.

Epidote is a notable, though minor, constituent occurring as sparsely disseminated, tiny granules in the felsitic matrix phase, and as flecks and pockets (altered mafics?) in some of the lithic clasts.

Carbonate occurs in similar mode to DAR 87-15, as occasional irregular patches of groundmass replacement.

The rock contains a few discrete grains of Fe-Ti oxides, 0.1 - 0.6mm in size, but no pyrite.



## Estimated mode

Plagioclase	78
Sericite	2
Carbonate	10
Quartz	4
Epidote )	1
Sphene )	
Rutile )	5
Fe-Ti oxides )	

This sample incorporates two similar but distinct rock types in somewhat irregular contact (adjacent flows? xenolith of one in the other?). They are relatively weakly altered porphyritic rocks of andesitic composition.

The darker coloured, less abundantly porphyritic lithotype consists of scattered euhedral plagioclase phenocrysts, 0.5 - 2.5mm in size, set in a relatively coarse meshwork-textured groundmass of plagioclase, of grain size 0.1 - 0.3mm.

The plagioclase phenocrysts are essentially unaltered but for a slight patchy cloudiness. However, the accessory mafic phenocrysts which accompany them are totally altered to carbonate, sometimes with a little fine-grained epidote and sphene, and rarely with intergrown granular quartz. They are characteristically rimmed by very fine-grained rutile and oxides. They typically show distinct pseudomorphic prismatic outlines suggestive of derivation from pyroxenes and, possibly, also hornblende.

The groundmass is very sparsely dusted with sericite, but is otherwise fresh. It contains a high proportion of disseminated, fine-grained rutile and Fe-Ti oxides.

The other rock type has more abundant plagioclase phenocrysts (also essentially fresh) and has a finer, felsitic groundmass with less disseminated opaques. It also shows a more quartz-rich composition. The quartz occurs as scattered, irregular flecks and pockets throughout the groundmass, and is a common constituent of the opaque-rimmed, altered mafic pseudomorphs. The latter include some lamellar-textured forms clearly derived from biotite.

The rock is cut by sparse, hairline veinlets of carbonate, and contains scattered, much coarser, irregular and veniform masses of sparry carbonate which appear to cross-cut the contact between the two rock types. Plagioclase phenocrysts incorporated within these localized carbonate segregations show more or less strong replacement by the carbonate.

This rock contains no sulfides.