**SAMPLE NUMBER:** 431479 12·8m

**SUMMARY:**

**This is a felsic polymict lava breccia or coarse-grained lithic tuff that has an intensely altered and recrystallized formerly ash (?) matrix now composed of polygonal quartz-barite-muscovite-sphalerite-opaque sulphides.**

**HAND SPECIMEN:**

This is a pale grey felsic polymict lava breccia with fragments of sparsely plagioclase-phyric dacite to several cm long, in a recrystallized matrix that contains abundant fine-grained pyrite and some white barite spots.

**THIN SECTION:**

Four of five distinct lava fragments are preserved in this section, and are obviously derived from at least three different original lithologies. Several fragments are of a distinctive flow-textured dacite with sparse albitized small plagioclase phenocrysts, that, unlike most of the dacitic rocks seen in this set, was originally more crystalline than glassy. The groundmass of these fragments is composed of orientated narrow laths of albite speckled with sericite and fine Fe-oxide dust. Others fragments were more typical of devitrified glassy felsic lava, with fine-grained quartz-albite-sericite mosaics recrystallized from the devitrified glass. These contain small angular and ragged patches of secondary quartz crystallizing from the matrix mosaic. The third fragment variety is also after glassy felsic lava that has recrystallized to fine-grained quartz and albite, but this type is cut by anastomosing sericite bands that produce a snake-skin pattern in the fragment.

The matrix between the various lava fragments in this sample is intensely altered and strongly recrystallized, suggesting that it was probably a porous vitric ash (although the extensive alteration and recrystallization has destroyed any original texture). It consists dominantly of relatively coarsely crystalline polygonal quartz with abundant opaque sulphides and intergrown pale yellow to colourless sphalerite. Less abundant components of the recrystallized strongly altered matrix are well-formed muscovite of phengite crystals commonly intergrown with sulphides, and polygonal anhedral crystals of barite.

**SAMPLE NUMBER:** 431480 32.4m

**SUMMARY:**

**This is an intensely hydrothermally altered formerly felsic lava or lava breccia that has been strongly silica-barite altered with abundant interstitial sphalerite and pyrite.**

**HAND SPECIMEN:**

This is an intensely altered former dacitic lava breccia(?) with vague evidence of a fragmental nature, overprinted by strong silicification of the groundmass and patches and streaks of pyrite, white barite and quartz.

**THIN SECTION:**

No trace of the original texture of this rock is preserved. It has suffered intense silica-barite-sericite-sulphide alteration. The sample is texturally very heterogeneous with most of the sample being composed of a well-formed polygonal intergrowth of quartz and barite that host large anhedral barite crystals with abundant fluid inclusions, strong internal strain features and subgrain recrystallization in high strain zones. High-strain zones with fibre quartz, elongate and stretched barite crystals and wispy trains of well-crystallized sericite wind through the more polygonal and coarse-grained matrix. Disseminated interstitial sulphides are quite abundant, perhaps making up 5-10 % of the sample overall. These consist of fine-grained pyrite always less than 0.5mm across, often with overgrowths of clear sphalerite; the latter also occurs as discrete grains interstitially.

This sample could originally have been a glassy dacitic lava or lava breccia. It has suffered intense silica-barite-sericite-sulphide hydrothermal alteration and has an almost annealed texture dominated by finer-grained quartz and coarser barite.

**SAMPLE NUMBER: 431481** 35.0m

**SUMMARY:**

**This is a totally hydrothermally altered and recrystallized formerly glassy felsic lava or lava breccia that suffered intense replacement by silica-barite-pyrite-galena-tetrahedrite-sphalerite. Further granulation and recrystallization in microshears cutting the sample rotated and digested some pyrite grains and may have been associated with remobilization of sphalerite and its replacing galena.**

**HAND SPECIMEN:**

This is an intensely altered and mineralized felsic lava breccia (?) with abundant disseminated pyrite, coarser clots of pyrite and barite, and minor galena and sphalerite in a strongly silica-altered matrix.

**THIN SECTION:**

This sample is composed of a few relic areas of recrystallized but not intensely altered formerly glassy felsic lava or lava breccia fragments in a strongly hydrothermally altered and recrystallized matrix. In these least altered areas, a few ghosts of former small feldspar phenocrysts are present, and are totally replaced by very fine-grained sericite. The groundmass of these areas is fine-grained mosaic-textured quartz riddled with small pyrite grains and anhedral small patches of colourless-pale yellow sphalerite that host bundles of well-formed muscovite or phengite crystals. Veins of barite and quartz with both pyrite and sphalerite along the vein margins transect the groundmass of some fragments (?). Most of the rest of this sample is composed of a polygonal fine- to medium grained intergrowth of barite and quartz in which much larger anhedral rather moth-eaten barite grains are set. These are cut by microshears in which barite has recrystallized to polygonal small interlocking grains. Sericite trains and streaks are quite common in the recrystallized quartz-barite-sulphide matrix. The sulphides in these recrystallized matrix areas are pyrite (fairly well-formed crystals and aggregates of a few crystals) and anhedral patches of clear sphalerite.

**OPAQUE MINERALOGY:**

The sulphides in this sample occur in diffuse bands. Pyrite is generally fine-grained (<0.5mm across) and many grains have clearly been rotated and partially reacted. Intergrown galena and sphalerite occur more abundantly in areas where pyrite

grains are less abundant. The galena occurs interstitially to the quartz-barite, and is clearly being replaced and overgrown by the sphalerite. Tetrahedrite is quite common, occurring mainly intergrown with galena, but not apparently being replaced by sphalerite. There is no chalcopyrite in this sample.

This sample was almost certainly a monomict lava breccia probably derived from a single glassy andesitic lava flow that was strongly recrystallized and brecciated by fluid fracturing during intense hydrothermal alteration.

**SAMPLE NUMBER: 431563** 64.1m

**SUMMARY:**

**This is a strongly recrystallized and altered formerly sparsely plagioclase-phyric glassy dacitic lava, with strong quartz-sericite-Fe oxide alteration of the original groundmass; it contains segregations with minor barite and sphalerite in addition to pyrite.**

**HAND SPECIMEN:**

This is a foliated grey dacitic lava breccia with cream coloured lava fragments to several cm long in a darker matrix.

**THIN SECTION:**

As is common in strongly altered originally glassy felsic lava breccias, the fragmental nature of this sample is not at all obvious in thin section. The rock was clearly a glassy sparsely plagioclase-phyric dacitic lava (breccia). Sericitized albite phenocrysts make up less than 2 modal% of the sample and were less than 1mm long. No former mafic phenocrysts were apparently present, but small leucoxenitized FeTi oxide microphenocrysts were not uncommon.

The groundmass of this sample was entirely glassy, but has recrystallized to a very fine-grained felted intergrowth of quartz and sericite (and possibly also albite) with abundant very fine-grained granular Fe oxide dust throughout. Streaky discontinuous veinlets of quartz and sericite parallel the weak foliation defined by sericite and trains of oxides in the altered groundmass. An area more than 1cm wide is composed of much coarser-grained polygonal secondary quartz and intergrown sericite and subordinate pyrite cubes; it also contains a few small patches of barite, and sphalerite overgrowing one large pyrite grain. Quartz veins branch off from this segregation, indicating that it is not a discrete fragment.

**SAMPLE NUMBER: 431564** 75.2m

**SUMMARY:**

**This is a thoroughly recrystallized felsic glassy lava that has suffered strong hydrothermal alteration and recrystallization to an assemblage dominated by polygonal quartz and barite, with abundant sphalerite and chalcopyrite replacing galena; pyrite is rare in this sample, possibly much of it has been replaced by the sphalerite.**

**HAND SPECIMEN:**

This is a grey-green strongly recrystallized and silicified glassy felsic lava with thin quartz veinlets, disseminated pyrite and a few patchy barite development.

**THIN SECTION:**

The only trace of the original texture or mineralogy left in this sample is a few ghost remnants of former plagioclase phenocrysts now replaced by polycrystalline quartz. The remainder of the rock is composed of a medium- to coarse-grained intergrowth of polygonal quartz and abundant anhedral barite that often occurs as rather large grains to several mm long in a finer-grained recrystallized matrix of polygonal quartz and barite. By far the most abundant other phase is colourless to very pale yellow sphalerite, that occurs as abundant interstitial amorphous patches, that in about half of the thin section form a connected intergrowth.

**OPAQUE MINERALOGY**

Disseminated pyrite grains are much less common than in many of the other samples in this set, and occur as rather ragged, moth-eaten grains (eaten by the rare migratory moth, the spotted Sudanese sulphide-sucker, that stinks when you squash it). The abundant sphalerite contains relic patches of galena being replaced by the sphalerite. Many contacts between sphalerite and galena are sites of chalcopyrite growth, but chalcopyrite never seems to occur within galena unless there is sphalerite also in contact. This sample contains more chalcopyrite than the previous two polished thin sections, probably totalling around 5 modal% of the sulphide assemblage.

**SAMPLE NUMBER: 431565** 113.8m

**SUMMARY:**

**This is a formerly sparsely plagioclase-phyric glassy dacite that has undergone a silica-sericite ± pyrite alteration.**

**HAND SPECIMEN:**

This is a pale grey-green recrystallized and possibly silicified glassy dacitic lava with thin quartz veinlets, disseminated pyrite and a few tiny fuchsite spots.

**THIN SECTION:**

This sample was clearly a sparsely plagioclase-phyric glassy dacitic lava that has been devitrified and extensively recrystallized. Former plagioclase phenocrysts are either totally altered to sericite or recrystallized as aggregates of small polygonal quartz grains. They were rarely larger than 1mm long and make up only about 2-3 modal% of this rock. There were no quartz phenocrysts in this rock, but the occasional small FeTi oxide phenocrysts are altered to sericite and limonitic material.

The groundmass of this sample was originally entirely glassy. The glass probably devitrified but then was strongly altered, recrystallizing to a fine-grained patchy mosaic quartz intergrowth streaked with fine meshes of sericite. Subparallel with the sericite streaking are many elongate patches of coarser-grained secondary quartz. These are cut by narrow veinlets of fibre quartz. Disseminated small pyrite grains make up about 1 modal% of the rock, and are scattered throughout the recrystallized groundmass. Fine-grained granules of either Fe oxide of pyrite are very common in the quartz-sericite groundmass.

This sample was a glassy dacite that has suffered some silica-sericite-pyrite alteration.

**SAMPLE NUMBER: 431566** 125.0m

**SUMMARY:**

**This is a polymict felsic lava breccia or coarse-grained lithic tuff that has suffered weak silica-sericite-pyrite alteration, more strongly in the formerly ashy matrix than the lava fragments.**

**HAND SPECIMEN:**

This is a pale grey strongly altered and recrystallized felsic polymict lava breccia with fragments to at least 1cm long; it contains a very small amount of disseminated pyrite.

**THIN SECTION:**

This sample retains clearly in thin section the fragmental nature of the rock. Various fragments are all formerly glassy felsic lava, some aphyric, and some sparsely feldspar+quartz-phyric. The groundmass of all samples has recrystallized to varying degrees with variable textures from devitrified glass. Some fragments have quite clear mosaic-textured intergrowths of quartz and minor albite, overprinted by abundant sericite alteration, whereas others are exceptionally fine-grained quartz-sericite intergrowths hosting abundant small ragged patches of recrystallized secondary quartz. Former plagioclase phenocrysts are small and totally sericitized, and quartz phenocrysts are rather well-formed (not rounded and reacted as in many of the felsic rocks described herein), but also less than 0.8mm long.

The matrix between the lava fragments is a devitrified and probably silicified formerly highly glassy ash that contains occasional quartz and feldspar (sericitized) crystal fragments. It is less sericitized than the lava fragments and contains quite common well-formed small pyrite euhedra that are absent in the lava fragments. In a few places, this matrix is strongly sheared and fibre quartz with well-crystallized sericite and abundant tiny pyrite cubes have crystallized from the matrix.

This was clearly a felsic polymict lava breccia or coarse-grained lithic tuff. It has suffered weak silica-sericite-pyrite alteration that most strongly affected the ashy matrix.

**SAMPLE NUMBER: 431567** 217.6m

**SUMMARY:**

**This is a barite-sulphide vein composed of polygonal barite with diffuse bands of pyrite with interstitial galena; sphalerite is replacing both pyrite and galena; chalcopyrite is a minor opaque phase, probably being released during sphalerite replacement of galena and pyrite.**

**HAND SPECIMEN:**

This is a grey rock composed of finely crystalline barite with diffuse bands of pyrite, and occasional patches of much coarser-grained barite.

**THIN SECTION:**

This sample consists almost entirely of medium-grained intergrown polygonal barite in which a few larger anhedral porphyroblasts of barite are preserved. Sulphides form several diffuse bands through the barite, and include a sphalerite band and several bands of abundant small pyrite grains with sparse intergrown barite. In reflected light, the pyrite grains are seen to be idiomorphic and up to several mm across. Some have narrow rims and veinlets in cracks of chalcopyrite, although this is modally insignificant. As pyrite in bands become less abundant or more diffuse, more galena and sphalerite occur interstitially to the pyrite. Chalcopyrite occurs in these minerals as small blobs and spots. As in the three other polished sections described herein, the sphalerite clearly post-dates and is overgrowing the galena, and to a much lesser extent, the pyrite.

**SAMPLE NUMBER: 431568** 224.5m

**SUMMARY:**

**This is a formerly glassy felsic lava breccia that suffered strong silica-sericite-pyrite alteration, and further silicification and recrystallization in a hydrothermal alteration event that produced silica-barite-pyrite-galena-tetrahedrite-sphalerite assemblages, in which sphalerite was clearly the last phase to precipitate.**

**HAND SPECIMEN:**

This is an extensively hydrothermally altered and recrystallized felsic lava breccia, with a few fragments to 1.5cm across still evident.It contains abundant disseminated pyrite and minor barite, in a matrix that is probably highly siliceous.

**THIN SECTION:**

A few lava fragments are still obvious, with variable textures following devitrification of glassy groundmass. Most have fine-grained quartzose mosaic textures in which sparse former plagioclase phenocrysts are replaced by polycrystalline quartz. The recrystallized quartzose groundmasses of the various lava fragments are also variably peppered by tiny opaques, some of which may be exceptionally fine-grained sphalerite. Meandering narrow quartz veinlets cut the fragments, and pass into inter-fragment matrix areas composed of medium- to coarse-grained polygonal quartz riddled with tiny sericite-muscovite needles and submicroscopic Fe oxide(?) dust and very fine-grained disseminated sphalerite. These areas contain abundant pyrite grains (to almost 1mm across) and anhedral patches of colourless to pale yellow sphalerite. Barite occurs as a subordinate phase intergrown with polycrystalline quartz in veinlets and strongly recrystallized inter-fragment matrix areas.

**OPAQUE MINERALOGY**

The sulphides in this sample form extensive stockworks through the inter-fragment matrix areas. Pyrite grains, mainly less than 0.5mm across, are well-formed and inclusion-free, and occur as disseminated grains and disrupted small trains and veinlets. Amorphous colourless to pale yellow anhedral sphalerite occurs as patches to several mm across, and is clearly replacing and overgrowing pyrite. It is probably the most abundant sulphide phase in this rock. Galena occurs as anhedral patches interstitial to pyrite, and as quite large (to several mm) pools unrelated to pyrite, and is also being overgrown by sphalerite. Tetrahedrite

occurs overgrowing galena in a few patches, and the borders between tetrahedrite and the galena are decorated with small blebs and trains of chalcopyrite. The tetrahedrite is being invaded and replaced by sphalerite that has abundant tiny inclusions of chalcopyrite.

**SAMPLE NUMBER: 431569** 233.5m

**SUMMARY:**

**This is a strongly altered sparsely plagioclase- and apatite-phyric silicic andesite lava that suffered an earlier sericite alteration and was later overprinted by intense chlorite-quartz ± pyrite (the latter mainly in veinlets) alteration that produced a false brecciated texture in this rock.**

**HAND SPECIMEN:**

This is a grey mottled chloritized felsic lava with an unusual devitrification texture.

**THIN SECTION:**

This is a very difficult sample to diagnose with certainty. It certainly was a felsic sample, either a lava or a lava breccia, but it has suffered strong and variable alteration that has overprinted and largely obliterated the primary texture. Former feldspar phenocrysts make up about 5 modal% of the rock but are totally replaced by polycrystalline quartz. Small apatite needles are common in the secondary quartz replacing feldspar, and were almost certainly inclusions in the original feldspar. One or two small phenocrysts were possibly augite, but are also now replaced by polycrystalline quartz. The only other phenocryst phases were small FeTi oxide microphenocrysts that are totally altered to leucoxenic material, and not uncommon prismatic elongate apatite microphenocrysts.

The remainder of this rock is a rather heterogeneous textured matrix with what is probably a false pyroclastic or false breccia texture. A few least altered remnants have clear mosaic textures after devitrified glass. Domains from 0.5-4mm across (that give the rock its mottled appearance) have fairly sharp boundaries against other domains with variable alteration mineralogies. The dominant alteration assemblage is chlorite-sericite-pyrite-quartz, with the relative abundances of these minerals varying from domain to domain in the groundmass, with the paler-coloured domains being more silica- and sericite-rich. Sericite occurs as a fine web-like mesh lacking any obvious alignment or foliation. Chlorite is all-pervasive and relatively fine-grained except in veins. Diffuse veinlets composed of diaggregated polycrystalline quartz grains intimately sutured grain boundaries occur with in a matrix of pale green chlorite; idiomorphic pyrite grains rarely larger than 0.5mm across make up about 10-15 modal% of these veinlets

Much finer grained pyrite occurs in similar association as winding trains that wander in the interstitial areas bounding 'fragments' or domains.

I think that this was probably a dacitic to silicic andesite lava with a glassy groundmass. The relative abundance of apatite is generally unlike the dacites in the Que-Hellyer area that I am familiar with, and makes me lean towards silicic andesite. Intense alteration, probably in several stages, has almost destroyed the original identity of the rock. The first alteration event probably involved sericitization of devitrified glass and some feldspar phenocrysts. Subsequent silica-chlorite-pyrite alteration overprinted the sericite alteration.

**SAMPLE NUMBER: 431570** 265.6m

**SUMMARY:**

**This is a strongly silica-sericite ± pyrite-altered polymict felsic lava breccia composed originally of largely glassy lava fragments.**

**HAND SPECIMEN:**

This is a grey strongly sericitized polymict lava breccia composed of abundant fine-grained felsic lava fragments to about 1cm maximum length

**THIN SECTION:**

As is frequently the case with strongly altered formerly glassy felsic lava breccias, the fragmental texture is much less evident in thin section than in the hand specimen. A few undoubted totally recrystallized devitrified dacitic to rhyolitic lava fragments are obvious, but most of the others tend to merge imperceptibly into the matrix of the very altered rock. In the few clear lava fragments, sparse small feldspar phenocrysts have been totally replaced by polycrystalline quartz. The sample has been quite strongly silica-altered (silicified) with saccharoidal fine-grained silica replacing many former fragments and coarser-grained polycrystalline quartz being abundant through the matrix, usually intergrown with a pale sericite and very fine-grained Fe oxide dust, and minor crystalline pyrite. The pyrite occurs disseminated through matrix quartz as idiomorphic grains to about 0.4mm across. Several clots of multi-crystalline pyrite have pronounced quartz fringes in which coarse-grained sericite is growing. At first, these clots appear to be detrital, but I think

it is more likely that they are disaggregated veinlets, since some of the marginal pyrite grains in these aggregates are too 'loose and sticking out' to have survived transport.

This is clearly a polymict felsic lava breccia composed dominantly of formerly glassy lava fragments of sparsely plagioclase-phyric dacite to rhyolite, that has suffered strong silica-sericite-pyrite alteration. Your hand specimen description is spot on.

**SAMPLE NUMBER: 431571** 309.0m

**SUMMARY:**

**This is a totally recrystallized felsic lava or lava breccia that has suffered intense sericite-quartz alteration followed by veining by quartz-barite-calcite-pyrite-sphalerite. Sphalerite seems to have been the last-crystallized phase, and may have replaced pyrite in the cores of some veins.**

**HAND SPECIMEN:**

This is a pale grey strongly silica-sericite altered felsic lava(?) with veinlets of creamy quartz-barite-sphalerite-pyrite veins and quartz-pyrite veins with marginal barite envelopes, in which pyrite concentrations up to 4mm thick are present.

**THIN SECTION:**

The original identity of this sample has been obliterated by intense silica-sericite alteration. It was probably a very glassy felsic lava or lava breccia that has been totally replaced by a fine-grained rather heterogeneous mixture of quartz threaded throughout by intense sericite meshes, and disseminated pyrite. As for sample 431469, small prismatic apatite crystals are quite abundant.

The widest vein in this sample is zoned from outer marginal polygonal and well-formed quartz and subordinate intergrown anhedral barite to a core of non-pleochroic almost colourless, not very Fe-rich sphalerite rarely thicker than 1mm, that has rims of pyrite and calcite. It is possible that the sphalerite is replacing pyrite. Another cross-cutting vein has sheared quartz and sericite with idiomorphic pyrite grains to almost 1mm across, but only a very minor amount of colourless

sphalerite, and no barite. A couple of anastomosing quartz veinlets lacking sulphides have core of anhedral barite.

This rock was probably a glassy felsic lava that devitrified then suffered strong sericite - quartz alteration followed by fracturing and hydrothermal alteration that produced zoned quartz-barite-calcite-sphalerite-pyrite veins. The sphalerite-rich veins appear to post-date the more pyritic veinlets, but they may all be related to a single mineralizing event.

**SAMPLE NUMBER: 431572** 352.7m

**SUMMARY:**

**This is a totally quartz-sericite-Kspar(?) altered formerly glassy aphyric felsic lava cut by abundant quartz veinlets containing sparse barite and pyrite.**

**HAND SPECIMEN:**

This is a strongly quartz-sericite altered felsic glassy lava cut by a few diffuse veinlets of vuggy quartz-calcite-barite(?) -pyrite.

**THIN SECTION:**

This sample was probably a glassy felsic aphyric lava. A few small feldspar microphenocrysts have been replaced by polygonal quartz, and the entire sample has been silica-sericite altered, producing a fairly fine-grained and even-textured matrix peppered by fine-grained Fe oxides. About 30 modal% of the matrix is dirty brown, dusty material intergrown with quartz, that may be incipiently altered Kspar. Sericite forms mainly fine-grained patchy interstitial spots rather than a pervasive mesh.

The sample is cut by abundant narrow quartz veinlets with diffuse margins grading into the silicified matrix; the only other phases in the quartz veinlets are rare pyrite and interstitial anhedral barite.

**SAMPLE NUMBER: 431573** 372.7m

**SUMMARY:**

**This is a coarse volcaniclastic sandstone composed of detritus from altered felsic volcanics, and Animal Ck-type greywacke, cut by common quartz-chlorite veinlets.**

**HAND SPECIMEN:**

This is a polymict, probably silicified lava breccia including rather elongate (sheared?) clasts of both fine-grained felsic lava and darker chloritized lava to at least 2cm long.

**THIN SECTION:**

Thin section examination shows that this sample is a weakly sheared coarse-grained epiclastic sediment. The largest clast in the section is an aphyric silica-sericite-altered formerly glassy felsic lava very similar to many of the altered fragments in 431570. Several other highly altered clasts have elongate sericite blotches that strongly resemble altered, flattened pumice fragments in a recrystallized and silicified felsic vitric tuff matrix.

A single large distinctive clast is petrographically clearly identical to the Animal Ck Greywacke, being a poorly-sorted quartz-rich arenite with abundant detrital muscovite and three or four large chromite grains derived from the ophiolite (I've checked this on similar samples), in a chloritic matrix.

The sample is cut by several quartz-chlorite veins, and contains disseminated idiomorphic pyrite to about 0.3mm across.

This is clearly a volcanogenic coarse, sandstone derived from a mixed felsic volcanic - Animal Ck greywacke source. I think it is important to note that the Animal Ck Greywacke was being eroded and redeposited at this stage, reflecting the local instability of the basin in which all this was going on.

**SAMPLE NUMBER: 431574** 382.1m

**SUMMARY:**

**This is a either a lithic-vitric tuff derived from a submarine ash-cloud type eruption, or else from a mass flow that resulted from basin margin tectonism that loosened and transported basinward a cloud of silty volcanic ash (now devitrified and altered).**

**HAND SPECIMEN:**

This is a dark grey, possibly silica-altered lava breccia, probably polymict, with lava fragments to at least 2cm across.

**THIN SECTION:**

This sample is probably a lithic vitric tuff. Most of the sample is composed of an unusual heterogeneous lithotype that was originally sparsely plagioclase-phyric and largely glassy, and has a texture strongly suggesting a vitric tuff, although the degree of recrystallization is too severe to have preserved glass shard shapes. This section of the sample is composed of irregular fine-grained spots of angular secondary quartz and streaky sericite in an exceptionally fine-grained irresolvable matrix probably after devitrified glass.

A few small clasts of altered felsic lava composed of polycrystalline quartz-sericite, and a larger clast of glassy felsic lava-derived mosaic-textured quartz-albite with sericite-calcite alteration, are also present. A few narrow calcite veinlets transect this sample.

This rock is rather difficult to diagnose, but I would say that is is either a hot cloud-type ash flow erupted into this submarine basin, or else it is a mass flow unit involving abundant silty felsic volcanic ash that was shaken loose and flowed basinward from basin-margin instability.

**SAMPLE NUMBER: 431575** 394.5m

**SUMMARY:**

**This is a volcaniclastic sediment derived from a mixed basaltic lapilli - felsic lava source; it has suffered intense carbonate alteration with minor pyrite crystallization or recrystallization during the carbonate alteration.**

**HAND SPECIMEN:**

This is a pale grey polymict strongly calcite-sericite-altered volcaniclastic sediment or lava breccia with fragments to several cm long. Most fragments appear to be fine-grained felsic lava. Bright green chlorite or fuchsite is a notable and not uncommon alteration phase.

**THIN SECTION:**

This sample is intensely calcite-altered, with most of the original texture completely obliterated by the alteration. However several small areas have original textures preserved. In these, it seems that the sample was a volcaniclastic sediment or vitric tuff, lacking detrital quartz (primary or secondary), but composed mainly of strongly altered basaltic lapilli and slightly flattened fragments of highly vesicular altered basaltic lava. Several perfectly euhedral red chromite microphenocrysts are present, supporting the textural indication that this material was originally basaltic. A few small clasts composed almost solely of very fine-grained saccharoidal quartz could be silicified felsic lava fragments. Disseminated small pyrite grains are common in the sample, and are associated with the calcite alteration, which is pervasive, and appears to post-date an alteration event in which much of the matrix of this sample was altered to very fine-grained silica. A single half centimeter-sized concentration of very fine-grained pyrite grains is seen to be a core cluster of intergrown pyrite euhedra with strong quartz-chlorite pressure fringes passing out into fine-grained quartz-chlorite-calcite riddled with tiny pyrite grains.

This sample is a polymict volcaniclastic sediment containing a mixed basaltic and felsic component, that has been intensely carbonate ± minor pyrite altered .

**SAMPLE NUMBER: 431482** 432.1 m

**SUMMARY:**

**This is a rhyolitic lava breccia that has suffered quite strong sericite-silica alteration, with the introduction of minor disseminated pyrite.**

**HAND SPECIMEN:**

This is a pale grey sericite-altered monomict felsic lava breccia with darker chloritic matrix between fragments and disseminated pyrite.

**THIN SECTION:**

This sample is actually quite well-preserved texturally, despite rather pervasive very fine-grained sericite. alteration. It was clearly a glassy, sparsely plagioclase + quartz-phyric rhyolitic lava breccia. Former plagioclase phenocrysts are small (<1mm long) and make up only a few modal% of the sample, and are totally replaced by sericite. Quartz phenocrysts are much less common still than plagioclase phenocrysts and are mainly less than 0.5mm long and quite strongly resorbed and rounded. FeTi oxide microphenocrysts are replaced by dirty brown leucoxenic material.

The groundmass of this sample was undoubtedly glassy and devitrified before it recrystallized to a uniform-textured fine-grained quartz-sericite intergrowth in which the sericite mainly forms a fine oriented mesh through the rock. Disseminated clusters of small (<0.5mm across) pyrite euhedra make up about 1-2 modal% of the sample and often have quartz-coarse-grained sericite pressure fringes. A few narrow quartz-sericite-calcite veinlets subparallel to the weak foliation defined by the sericite mesh contain relatively abundant small pyrite euhedra.

**SAMPLE NUMBER: 431483** 451.5m

**SUMMARY:**

**This is a strongly silica-sericite-altered aphyric felsic lava with disseminated pyrite.**

**HAND SPECIMEN:**

This is a dark grey-green weakly foliated felsic(?) lava or lava breccia with disseminated pyrite and streaks of black chlorite.

**THIN SECTION:**

This rock is very strongly sericite-quartz altered, to the extent that the original texture is almost obliterated. It was almost certainly an almost aphyric, slightly vesicular glassy lava. A few sericitized sites with slightly stretched euhedral crystal shapes were probably former sericitized plagioclase phenocrysts. No mafic phenocrysts were present, although small former FeTi oxide now altered to leucoxenic material and sericite are not uncommon.

The originally glassy slightly vesicular groundmass of this sample has altered to a weakly foliated sericite-quartz matrix in which small rounded to ovoid vesicles are filled by polycrystalline quartz, and abundant small anhedral polycrystalline quartz blebs are distributed in irregular fashion. The matrix material is unusual in that it is intensely riddled with tiny Fe oxide (?) grains related to alteration of the original glass. Patches of former quartz-albite mosaic textured groundmass derived from devitrified glass are still evident, but are intensely pervaded by sericite; the latter forms an orientated mesh throughout the sample. Several angular fractures subparallel to the foliation are filled by pale green chlorite and overprinting calcite, with which occasional euhedral pyrite grains to around 1mm across are associated. Disseminated pyrite grains with quartz-sericite pressure fringes are fairly uncommon throughout the sample.

The question of whether this sample was andesitic or dacitic cannot be answered from thin section alone. It is far too recrystallized and altered. I would have guessed that it was a dacitic lava, but aphyric slightly vesicular, originally glassy andesites are not uncommon beneath the Hellyer basalts in this area (Mines Dept hole and Placer holes). These are far fresher than the MC26 material, thus more easily recognizable as dacites or andesites.

**SAMPLE NUMBER: 431484** 475.0m

**SUMMARY:**

**This is a sericite-silica ± pyrite-altered formerly glassy aphyric andesitic lava.**

**HAND SPECIMEN:**

This is a medium grey massive silicified felsic(?) lava with chloritic fractures.

**THIN SECTION:**

This sample is a weakly vesicular even-textured sparsely plagioclase-phyric felsic lava that was originally largely glassy. The glassy matrix has altered to a quartz-sericite intergrowth in which scattered small pyrite grains and finer-grained Fe oxide dust are set. The rare small feldspar phenocrysts are replaced by sericite. Chlorite occurs as three associations: firstly in microshears with calcite, secondly in vesicles with secondary quartz and pyrite, and thirdly with disseminated pyrite as small marginal coatings and pressure fringes.

There is nothing petrographically in this sample to judge with any certainty whether the rock was originally dacitic to andesitic. It looks more like the glassy aphyric andesites I have seen (and analyzed) from the Placer holes W of the highway. I think it can also correlate with the diverse andesite-dacite ± basalt sequence in the lower half (360m - 495m depth) of the Mines Dept Mt Charter hole MCH-1.

**SAMPLE NUMBER: 431485** 494.7m

**SUMMARY:**

**This is a formerly glassy aphyric dacitic lava in which the groundmass has suffered sericite-silica alteration.**

**HAND SPECIMEN:**

This is a massive, uniform buff-coloured felsic lava with a few tiny green fuchsite-like spots.

**THIN SECTION:**

This is a texturally well-preserved felsic lava in which sparse euhedral sericitized plagioclase phenocrysts and quite rounded and resorbed quartz phenocrysts less than 0.4mm across in a recrystallized formerly glassy matrix. Phenocrysts probably make up less than one modal% of this rock, which could be described as aphyric.

The groundmass of this sample was originally glassy. It devitrified and then crystallized to an even-textured, fine-grained quartz-sericite intergrowth with rare small pyrite grains. As well as forming a weakly foliated dispersed web through the groundmass, sericite also forms elongate, sheared clots that form along microshears.

This sample is petrographically rhyolitic to dacitic, and is relatively well-preserved, although the groundmass probably underwent the same silica-sericite alteration that has affected all the samples described in the previous pages.

**SAMPLE NUMBER: 431486** 512.5m

**SUMMARY:**

**This is a thoroughly recrystallized former basaltic lapilli tuff that suffered strong chlorite-quartz-pyrite alteration, followed by strong calcite overprinting.**

**HAND SPECIMEN:**

This is a uniform-textured mafic lava with fairly extensive alteration, probably calcite-chlorite dominated.

**THIN SECTION:**

This sample bears minor relict textural evidence that it was originally an exceptionally vesicular basaltic lava, or else a basaltic lapilli tuff. Rounded to ovoid bodies often aggregated too close to have been vesicles, are defined by chlorite and secondary quartz. The few outlines of former phenocrysts are suggestive of olivine precursors, and a few deep red chromite inclusions are present, supporting this interpretation. Most of the rock consists of extremely variable textured intergrowths of very fine-grained saccharoidal secondary quartz and chlorite, and this has been overstamped by strong to intense calcite alteration. Calcite probably constitutes 50 modal% of the sample. In a few areas, secondary quartz and chlorite are coarser-grained and may represent disrupted veinlets. Idiomorphic pyrite grains to about 0.5mm maximum diameter are not uncommon disseminated throughout the sample, and often have quartz pressure fringes.

This sample was almost certainly composed essentially of glassy basaltic lapilli. It has been very strongly silica-chlorite ± pyrite altered, leading almost complete recrystallization and obliteration of the original texture. Subsequent calcite alteration, with no associated pyrite mineralization, has strongly overprinted the rock.

**SAMPLE NUMBER: 431487** 529.1m

**SUMMARY:**

**This is a basaltic lava breccia composed of formerly glassy to less rapidly cooled lava fragments of olivine-phyric, vesicular lava that has suffered strong chlorite-quartz alteration with associated weak disseminated pyrite mineralization. Later calcite and sericite alteration has overprinted the original alteration assemblage.**

**HAND SPECIMEN:**

This is a strongly altered mafic tuff or lava that has suffered strong chlorite-calcite alteration. It has almost a fragmental appearance, but this may be due to the alteration.

**THIN SECTION:**

This sample is texturally better-preserved than the previous sample. It was clearly a strongly vesicular basaltic lava or lava breccia with common large totally chloritized former olivine phenocrysts. The olivine phenocrysts probably constituted around 10-15 modal% of the rock, and are replaced by pale green chlorite and also by secondary quartz intergrown with the chlorite in some former crystal sites. Some were at least 2-3mm long and quite well-formed, and small chromite inclusions are present in many crystals.

The groundmass of this sample shows enough primary textural variation to suggest that the rock was originally a basaltic lava breccia. Some domains of the thin section are clearly originally glassy, with glass replaced by quartz and chlorite in a mottled texture typical of recrystallization of devitrified glass. In other areas, the groundmass was more slowly cooled, with small albite microlites randomly orientated in chlorite after interstitial glass. The abundant vesicles in this rock are filled by rather coarse-grained polygonal secondary quartz with less abundant chlorite and calcite, and common idiomorphic crystals of pyrite, usually two or three per vesicle. The sample is cut by a weak web of sericite, and calcite occurs in clots overprinting large areas of the section.

**SAMPLE NUMBER: 4317488** 532.3m

**SUMMARY:**

**This is a formerly glassy sparsely plagioclase-phyric dacitic lava that has suffered strong silica-sericite alteration.**

**HAND SPECIMEN:**

This is a pale grey even-textured felsic aphyric lava with a few thin calcite veinlets and spots of darker chlorite concentration.

**THIN SECTION:**

Despite intense alteration and recrystallization, this sample preserved its original texture well enough that the rock can be confidently identified as having been a sparsely plagioclase-phyric glassy dacite lava. The former plagioclase phenocrysts are entirely sericitized, and some are slightly stretched out and deformed; they originally made up less than about 2 modal% of this rock and were smaller than 1mm long.

The originally glassy groundmass of this sample probably devitrified then recrystallized as quartz and albite. However, relatively strong alteration has led to extensive recrystallization of the groundmass to fine-grained and rather uniform-textured quartz riddled by sericite and small Fe oxide grains. The sericite shows a weak orientation across the section. Disseminated pyrite grains to about 0.3mm across are sparse. A few thin calcite veinlets transect the sample, but calcite overprinting is insignificant.

**SAMPLE NUMBER: 431489** 536.0m

**SUMMARY:**

**This is a formerly glassy olivine-phyric basaltic lava or lava breccia, less vesicular than 431487 but otherwise very similar. It underwent a strong silica-chlorite ± minor pyrite alteration of glass, then was overprinted by intense calcite alteration.**

**HAND SPECIMEN:**

This is a medium to dark grey strongly altered and recrystallized mafic lava or lava breccia with abundant calcite alteration.

**THIN SECTION:**

This sample is remarkably similar to sample 431487 in most respects, except that it was much less vesicular. It is composed of about 5-10 modal% of totally chloritized former olivine phenocrysts, some up to 2mm long, with occasional chromite inclusions, in a recrystallized formerly glassy groundmass. Vesicles are much smaller and less abundant than in similar sample 431487. The once glassy groundmass has been twice altered, first to fine-grained quartz and chlorite, and later it was totally overprinted by calcite, so that very little of the first stage of alteration is preserved. Disseminated pyrite grains to about 0.5mm across are not uncommon, and almost certainly are associated with the earlier stage of alteration. This sample could have been either a basaltic lava or a lava breccia; whichever was the case, it was certainly highly glassy.

**SAMPLE NUMBER: 431500** 541.6 m

**SUMMARY:**

**This is a sparsely plagioclase+quartz-phyric formerly glassy rhyolitic lava breccia, probably monomict, with variably silica-sericite -altered fragments and disseminated pyrite.**

**HAND SPECIMEN:**

This is probably a formerly glassy dacitic lava breccia with abundant clots and irregular veinlets of pyrite, a few calcite veinlets, and some dark clots of chlorite-rich material.

**THIN SECTION:**

This sample in thin section is clearly a felsic lava breccia, probably monomict, with the original texture still fairly well-preserved despite strong recrystallization after devitrification of the glassy groundmass. The sample contained around 3-5 modal% of albitized plagioclase phenocrysts, mainly single crystals less than 1mm long, that have been totally sericitized. Quartz phenocrysts are slightly less abundant, and show fairly strong reaction and rounding, and are also rarely larger than 1mm diameter. Small former FeTi oxide phenocrysts are leucoxenitized.

The groundmass of this sample is composed of recrystallized devitirified glass. However the texture of the groundmass varies from fragment to fragment depending on the degree of alteration. Some fragments have a weakly altered very fine-grained mosaic-textured quartz-feldspar intergrowth with minor sericite, whereas others are

clearly much more intensely sericitized, with coarser grained saccharoidal quartz between the dense sericitic mesh. Sericite also occurs as dense streaks some 2-5mm wide that may define margins of some lava fragments. Pyrite occurs as quite common disseminated grains and grain aggregates with grainsize up to about 0.6mm across. A few veinlets of fibre calcite cut the sample.

**SAMPLE NUMBER: 431548** 556.2m

**SUMMARY:**

**This is a strongly recrystallized silica-sericite-altered formerly glassy sparsely feldspar+quartz-phyric rhyolitic lava.**

**HAND SPECIMEN:**

This is a massive, uniform-textured almost aphyric pale grey dacitic lava.

**THIN SECTION:**

This sample is clearly a strongly recrystallized formerly glassy dacite lava with a few plagioclase and quartz phenocrysts. The former feldspar phenocrysts are less than 1mm long and totally sericitized. The few small quartz phenocrysts are strongly rounded and blend marginally into quartz in the altered groundmass. FeTi oxide microphenocrysts are altered to leucoxenitic material, with opaque granular margins and sericite-quartz cores.

The groundmass of this sample is quite strongly recrystallized from what was almost certainly devitrified glass. It is composed of granular quartz averaging around 0.1-0.2mm across with interstitial sericite pervading this matrix as an orientated meshwork. Chlorite is rare in this sample, calcite also, and pyrite is present only as a few small grains.

This is a strongly recrystallized silica-sericite-altered rhyolitic lava.

**SAMPLE NUMBER: 431549** 577.7m

**SUMMARY:**

**This is a formerly glassy sparsely plagioclase+augite-phyric andesitic lava with strong silica-sericite alteration of the groundmass**

**HAND SPECIMEN:**

This is a massive dark apparently aphyric grey felsic to intermediate lava with a few chloritic veinlets and fracture fillings.

**THIN SECTION:**

This sample is a sparsely plagioclase+augite-phyric andesitic lava that originally had a glassy groundmass. The former plagioclase phenocrysts are totally sericitized small euhedra less than 1mm long, that make up less than 2 modal% of the sample. Only two or three former augite phenocrysts were noted, all less than 1mm long and all completely chloritized. Former FeTi oxide microphenocrysts are relatively common and all replaced by translucent brown leucoxenic material and limonite(?).

The groundmass of this sample was originally glassy, but has devitrified than recrystallized to a medium-grained mosaic texture composed of quartz and sericite, quite strongly pervaded by wispy pale green chlorite and riddled with tiny equigranular Fe oxide grains. Dispersed commonly throughout the groundmass are small anhedral patches of angular secondary quartz, often polycrystalline, that are growing from the matrix. The rock is transected by a few diffuse and meandering chlorite veins, and disseminated small pyrite grains make up about 0.2 - 0.5 modal% of the sample.

With regard to your comment about dacitic versus andesitic affinities of this sample and 431548, I offer the following thoughts. Although nobody could have ever picked it from hand specimen alone, particularly if, as you say, the interval from 548 to 549 is gradational in hand specimen (chlorite content etc), these two samples are undoubtedly petrographically different. 548 is unambiguously a rhyolitic lava, while the present sample (549) is notably more mafic, as indicated by the few augite phenocrysts, the abundant chlorite, and the abundant Fe oxides in the recrystallized groundmass. As I noted earlier in this report, I have seen quite a few aphyric to sparsely plagioclase and augite-phyric formerly largely glassy andesitic lavas in the sections between the Hellyer basalts and the Animal Ck Greywacke. I draw your attention to the

Mines Dept hole MCH-1 (that I'm sure you know more about than me) in the interval 407-494m, where evolved andesites to dacites with Ti/Zr from 11-14 overlie more andesitic lavas with Ti/Zr from 16-18. Is correlation with this level of MCH-1 reasonable?

**SAMPLE NUMBER: 431597** 584.5m

**SUMMARY:**

**This is a vesicular aphyric formerly glassy andesite lava almost identical to the previous sample.**

**HAND SPECIMEN:**

This is a pale grey weakly vesicular dacitic lava with a stockwork of fractures highlighted by dark chlorite and quartz.

**THIN SECTION:**

This sample is seen in thin section to be a vesicular aphyric andesite lava very similar texturally to the previous lava except that this rock contains even fewer sericitized plagioclase phenocrysts, and no augite phenocrysts.

The groundmass of this sample contains around 10 modal% of rounded to ovoid vesicles filled by polycrystalline quartz and minor pale green chlorite. It was probably glassy to vitrophyric, with small totally sericitized plagioclase laths set in modally dominant glass. The glass has recrystallized to a medium-grained intergrowth of quartz and minor sericitized albite, with common sericite pervading the matrix as a weak mesh, and relatively abundant interstitial chlorite and tiny granular Fe oxide grains. Quartz-chlorite veinlets cut the sample, and some of the thicker of these have marginal zones in which small idiomorphic pyrite grains have crystallized.

This is definitely an andesitic lava essentially identical to the previously described sample, with the same implications. I would say that the Ti/Zr value would have to be around 16-17.

**SAMPLE NUMBER: 431550** 588.5m

**SUMMARY:**

**This is an intensely sericite-silica-altered sparsely plagioclase-phyric formerly glassy dacitic lava breccia with quartz-chlorite veinlets post-dating the sericite-quartz alteration.**

**HAND SPECIMEN:**

This is a mid-grey strongly sericite-altered felsic lava or lava breccia.

**THIN SECTION:**

This is an intensely altered and recrystallized felsic lava breccia with few traces remaining of the original texture. Only rather abrupt textural variations in the style and extent of alteration and recrystallization of the groundmass allow identification of this sample as a lava breccia. The few areas of the sample where sericite-quartz alteration has not obliterated the texture indicate that this was a very sparsely plagioclase-phyric dacite lava breccia.

The groundmass of this rock has recrystallized entirely from glass to a heterogeneous but fine-grained mixture of saccharoidal quartz and dirty brown sericite. Some fragments have less sericite and coarser-grained quartz, and more Fe oxide granules through the quartz. The sample is cut by intersecting and meandering quartz-chlorite veinlets without associated pyrite.

**SAMPLE NUMBER: 431551** 594.0m

**SUMMARY:**

**This is a formerly glassy sparsely plagioclase-phyric acid andesite lava with strongly recrystallized silica-sericite groundmass; it is almost identical to 431597.**

**HAND SPECIMEN:**

This is a grey aphyric recrystallized and altered dacitic to andesitic lava cut by chlorite-quartz veinlets.

**THIN SECTION:**

Although the glassy groundmass of this sample has recrystallized thoroughly to a silica-sericite intergrowth, the texture is relatively well-preserved. The sample is composed of about 3-5 modal% of small plagioclase phenocrysts that are completely sericitized, and one or two small chloritized augite phenocrysts, and small leucoxenized FeTi oxide grains in a uniform recrystallized groundmass. The groundmass is composed of granular secondary quartz and abundant interstitial sericite, with minor chlorite, and relatively abundant equidimensional Fe oxide grains. A few narrow chlorite-quartz grains cut the sample.

This sample is very similar to 431597 in every way, and has the same implications. It is an evolved andesitic lava with silica-sericite alteration of the originally glassy groundmass.

**SAMPLE NUMBER: 431552** 602.5m

**SUMMARY:**

**This is a sparsely quartz+feldspar-phyric glassy rhyolitic lava that has had the groundmass recrystallized as silica-sericite-pyrite.**

**HAND SPECIMEN:**

This is an almost aphyric pale grey formerly glassy felsic lava with strong silica-sericite alteration and a few quartz veinlets.

**THIN SECTION:**

This sample is clearly a sparsely quartz+feldspar-phyric rhyolitic lava that originally had a glassy groundmass. It consists of several modal% of small (<1mm across) subhedral to rounded and resorbed quartz

phenocrysts and subordinate small totally sericitized plagioclase phenocrysts, set in a recrystallized groundmass composed of equigranular almost saccharoidal quartz with interstitial webs of sericite. Well-formed pyrite grains to 1.5mm across occur scattered throughout the sample, but make up much less than 1 modal% of this rock. Most pyrite grains are <0.2mm across, and many are associated with quartz veinlets and have pronounced quartz pressure fringes.

This sample is clearly a sparsely quartz+feldspar-phyric formerly highly glassy rhyolitic lava in which the groundmass recrystallized via strong silica-sericite alteration, as in most of the felsic samples described in this set of rocks.

**SAMPLE NUMBER: 431553** 618.4m

**SUMMARY:**

**This is a strongly silica-altered sparsely plagioclase and quartz-phyric formerly glassy rhyolitic lava.**

**HAND SPECIMEN:**

This is a creamy pink coloured probably silicified aphyric felsic lava.

**THIN SECTION:**

This sample is a formerly glassy felsic lava with around 3-5 modal% of small (<<1mm long) completely sericitized feldspar phenocrysts, and one or two small almost totally resorbed quartz phenocrysts set in a strongly silicified very fine-grained groundmass composed of almost chalcedonic silica with much less interstitial sericite than is present in many of the other recrystallized groundmasses in the felsic lavas described in this report. A few microshears are emphasized by coarser-grained recrystallized quartz and concentrations of extremely fine-grained Fe oxides in a manner resembling stylolites, indicating these shears are sites of pressure solution. A very small amount of well-formed pyrite grains to about 0.5mm across are disseminated throughout the sample. This sample has suffered stronger silicification than many of the other samples of felsic lavas in this hole.

**SAMPLE NUMBER: 431554** 647.7m

**SUMMARY:**

**This is a sparsely plagioclase+augite-phyric formerly glassy andesite lava with notably more apatite in the groundmass than in the foregoing andesites; it is much less altered than most of the samples described herein.**

**HAND SPECIMEN:**

This is a mid-grey altered intermediate lava with a few narrow pyritic veinlets and spots of dark chlorite.

**THIN SECTION:**

In thin section, it is clear that this is an andesitic lava. It consists of approximately equal modal abundances (around 1-2 modal%) of very small plagioclase phenocrysts (<1mm long) that are totally replaced by aggregates of polycrystalline quartz, and small well-formed augite prisms that are completely chloritized.

The formerly glassy groundmass of this sample is texturally well-preserved and consists of a mosaic-textured intergrowth of quartz and minor albite riddled by fine-grained sericite and tiny Fe oxide granules, with quite common interstitial chlorite and a notable amount of small apatite microphenocrysts and needles throughout the groundmass. Whereas most other features of this sample are similar to the andesites from higher in this hole, such as 431549 and 431597, the absence of apatite in both the latter and its relative abundance in this sample clearly indicate differing magmatic groups, albeit andesitic, for these rocks. A small amount of disseminated pyrite occurs throughout this rock.

**SAMPLE NUMBER: 431555** 658.7 m

**SUMMARY:**

**This is a formerly glassy aphyric andesitic lava that was silica-sericite altered during recrystallization of the glassy groundmass, then hydrofractured during a second episode of intense silica-alteration. Disseminated pyrite seems associated with the silica-sericite alteration.**

**HAND SPECIMEN:**

This is a stongly altered polymict(?) lava breccia with intense fluid fracturing autobrecciation and silica-carbonate in interfragment areas. Some fragments are dark and chlorite-rich whereas others are probably silica-sericite altered.

**THIN SECTION:**

In thin section, this sample is seen to be a lava breccia or coarse lithic tuff that at first appears quite polymict; however careful examination of the section shows that much of the brecciation is probably hydrothermal, and the rock may originally have been a felsic or intermediate lava. Most fragments are composed of fairly coarse mosaic-textured intergrowth of anhedral quartz and feldspar, the latter intensely riddled by tiny sericite flakes. A few ghost outlines of sericitized and recrystallized former small feldspar phenocrysts are evident, but most of the primary texture of this sample has been thoroughly destroyed. Opaque grains include quite common altered FeTi oxide microphenocrysts, larger and sharper-edged disseminated pyrite (<< 1 modal%) and abundant tiny Fe oxide granules throughout the recrystallized groundmass. Chlorite occurs commonly throughout the rock intergrown with quartz and sericite.

The rock has been quite strongly silicified, with the silica alteration being responsible for the false brecciation of the rock so evident in the hand specimen. In thin section, this interstitial silica alteration between 'fragments' appears as extremely fine-grained microcrystalline material that is almost chalcedonic. It contains small patches that are recrystallizing as coarser-grained quartz, and is overprinted by small common calcite rhombs. It appears that this silica alteration post-dates the sericite-silica alteration that produced recrystallization of the once devitrified glassy groundmass.

I would say that this sample was originally a glassy, almost aphyric andesitic lava (abundant chlorite and tiny Fe oxide grains suggest a more

mafic precursor than dacite) that suffered strong sericite-silica alteration during recrystallization of the glassy groundmass, then a later strong fluid fracturing alteration event that brecciated the sample along fluid passageways and caused intense silica alteration.

**SAMPLE NUMBER: 431556** 673.3m

**SUMMARY:**

**This is a formerly glassy sparsely plagioclase and quartz-phyric rhyolitic lava in which the groundmass recrystallized during strong silica-sericite ± pyrite alteration. It is essentially identical to 431552 and 553.**

**HAND SPECIMEN:**

This is a massive pale grey silicified felsic lava with irregular dark spotting of more chlorite-rich matrix.

**THIN SECTION:**

This sample is a silica-sericite altered formerly glassy sparsely plagioclase-phyric dacite lava almost perfectly identical to 431552 and 553. It consists of a few modal % of small totally sericitized plagioclase phenocrysts smaller than 1mm long, and a few almost completely resorbed and rounded quartz phenocrysts in a silica-sericite-altered once-glassy matrix. The latter has recrystallized as an even-textured intergrowth of equidimensional granular quartz with grains less than 0.05mm across, and interstitial pale sericite that does not (at least in the orientation of this section) form an orientated mesh as often seen in such rocks. The sample is cut by a few strained quartz-chlorite veinlets that contain common idiomorphic pyrite grains to about 0.7mm across. Disseminated grains of pyrite are quite common throughout the recrystallized matrix.

**SAMPLE NUMBER: 431557** 685.7m

**SUMMARY:**

**This is a formerly glassy sparsely plagioclase+augite-phyric dacite or acid andesite lava that has undergone extensive silica-chlorite (+minor sericite) alteration.**

**HAND SPECIMEN:**

This is a dark green-grey andesitic lava or lava breccia with paler coloured silica-altered (?) areas between apparent fragments.

**THIN SECTION:**

This is an exceptionally strongly altered, slightly vesicular formerly glassy andesitic lava with totally altered sparse plagioclase phenocrysts and even less augite phenocrysts. The plagioclase phenocrysts are completely sericitized, and the few recognizable former augite phenocrysts are chloritized. The remainder of this rock is so heterogeneous as to almost defy description. It is composed of weakly foliated, curving, highly irregular domains of darker colour that have a very fine-grained chloritic base overprinted by secondary quartz and angular patchy areas of sericite. Paler coloured domains are more sericite and quartz-rich, and include areas with finely granular saccharoidal silica intergrown in an almost banded fashion with streaky pale green chlorite. Larger patches of deformed coarse secondary quartz appear to be slightly flattened vesicles.

The abundance of chlorite and the few augite phenocrysts suggest that this was a dacite to acid andesite. It has suffered intense silica-chlorite alteration, but has minimal associated pyrite.

**SAMPLE NUMBER: 431558** 703.5 m

**SUMMARY:**

**This is a strongly recrystallized and weakly foliated originally glassy dacitic to andesitic lava with strong silica-sericite alteration.**

**HAND SPECIMEN:**

This is a grey-green intensely sericitized felsic or intermediate lava or lava breccia with a weak foliation and cut by chloritic veinlets.

**THIN SECTION:**

This sample is a formerly glassy dacitic to andesitic lava composed of about 3-5 modal% of small altered plagioclase phenocrysts in a groundmass that is strongly and variably recrystallized, and weakly foliated. The former plagioclase phenocrysts are mainly less than 1mm long and are entirely replaced by polycrystalline aggregates of very fine-grained quartz and sericite. A few phenocrysts replaced entirely by fine-grained quartz may have been originally augite.

In the least-altered ares of groundmass, the texture is seen to be a fairly coarse snowflake texture after devitrified glass. However, this has been strongly modified by variably intense alteration and foliation development. The most common style of alteration is granular fine-grained ailica and intergrown sericite and subordinate chlorite.

Foliation planes and microshears, and crosscutting fractures are marked by strong chlorite development and recrystallization of groundmass secondary quartz. Patchy calcite alteration overprints the altered groundmass and the assemblages developed along the veinlets and foliation planes.

I think it is not possible to judge petrographically whether this sample is andesitic (as the Ti/Zr data suggest) or dacitic. I would say it is closer to dacite in thin section, as chlorite is a minor phase and augite phenocrysts were scarce.

**SAMPLE NUMBER: 431559** 709.8m

**SUMMARY:**

**This is a formerly glassy, sparsely plagioclase+quartz -phyric dacitic lava with a groundmass that is probably less silicified than many of the other samples in this set.**

**HAND SPECIMEN:**

This is a mid-green to grey mottled felsic to intermediate lava with a few diffuse patches of more chloritic matrix.

**THIN SECTION:**

This sample is texturally quite well-preserved, and one of the least-altered rocks in this set. It is a sparsely plagioclase+quartz-phyric dacitic lava with a very fine-grained groundmass after devitrified glass. The plagioclase phenocrysts are less than 1mm long and totally sericitized. A few phenocrysts that have shapes more typical of plagioclase than augite are replaced by pale green chlorite. Quartz phenocrysts are less than 1mm across and are strongly rounded and resorbed, with no crystal faces preserved. Former FeTi oxide phenocrysts were also not uncommon and are replaced by very fine-grained aggregates of leucoxenitic material.

The groundmass of this sample was originally devitrified glass that has recrystallized to a very uniform-textured intergrowth of fine-grained quartz and sericite. The extent of silicification of the recrystallized groundmass is less than most of the other samples described herein. A few fractures and microshear zones are defined by more intense sericite development and subordinate intergrown chlorite. This sample was originally very similar to most of the other dacites described above.

**SAMPLE NUMBER: 431560** 720.7 m

**SUMMARY:**

**This is a strongly recrystallized formerly glassy, sparsely plagioclase+augite-phyric andesitic lava with intense silica-chlorite ± pyrite alteration of the glassy groundmass. The original rock was very similar to 431557.**

**HAND SPECIMEN:**

This is a very strongly chlorite-silica altered andesitic lava or lava breccia.

**THIN SECTION:**

This sample was originally a sparsely plagioclase+augite-phyric andesitic lava with a slightly vesicular glassy groundmass. Former plagioclase phenocrysts are small and occur as single crystals less than 1mm long; some are albitized and others are sericitized; they originally made up less than 5 modal% of this rock. Former small augite phenocrysts were much less abundant than feldspar phenocrysts and are all altered to chlorite. Former FeTi oxide microphenocrysts have broken down to very fine-grained aggregates of leucoxenitic material.

The formerly glassy, weakly vesicular groundmass of this lava has altered to a variably coarse-grained, heterogeneous intergrowth dominated by chlorite and secondary quartz. Sericite is developed in abundance locally, but does not form a meshwork through the rock as in many of the other samples described herein. Vesicles make up only 1-2 modal% of the rock and are filled by coarse-grained secondary quartz. Similar strained coarse-grained quartz forms disrupted veins through the sample. Small grains of disseminated pyrite are present through the rock, but not common.

**SAMPLE NUMBER: 431561** 733.9 m

**SUMMARY:**

**This is a formerly glassy sparsely plagioclase-phyric dacitic lava in which the glassy groundmass has altered to silica-sericite ± pyrite.**

**HAND SPECIMEN:**

This is a massive cream coloured dacitic lava with some zones of more intense silicification of the originally glassy groundmass. It contains quite common disseminated pyrite.

**THIN SECTION:**

Despite thorough recrystallization of this originally highly glassy lava, its original identity is still obvious. It was a very sparsely plagioclase-phyric dacitic lava with less than 1 modal% of small (<0.7mm long) totally sericitized plagioclase microphenocrysts in a groundmass that has recrystallized to an even-textured fine-grained granular intergrowth of secondary quartz and sericite, pervaded by wispy meshworks of sericite. Clusters of disseminated pyrite grains mainly less than 0.5mm across are quite common, while a narrow veinlet composed entirely of fibrous quartz and idiomorphic pyrite also cuts the sample. A vein almost 1cm wide composed of coarse-grained quartz with calcite in the vein core is also present. This dacitic lava is very similar in most respects to the other felsic lavas decribed earlier on, except that this sample lacks quartz phenocrysts; the alteration is identical to 431552, 556 and 548.

**SAMPLE NUMBER: 431562** 763.9m

**SUMMARY:**

**This is a formerly augite+hornblende(?)+plagioclase-phyric andesitic lava breccia with intense quartz-chlorite-dominated alteration of the formerly glassy groundmass.**

**HAND SPECIMEN:**

This is a dark green strongly altered basaltic or andesitic lava breccia.

**THIN SECTION:**

This sample is clearly a andesitic lava breccia that has extensively recrystallized and altered. The least altered lava fragments were composed of quite abundant large well-formed former augite(?) or hornblende phenocrysts in a formerly glassy chloritic matrix in which perlitic cracks are preserved. The former mafic phenocrysts are euhedral, up to 2mm long and entirely replaced by polycrystalline granular quartz. Many crystal shapes are more like hornblende than augite. Some phenocrysts may also have been plagioclase, but are similarly altered. Most other fragments and their boundaries are rather indistinct and were probably like that just described, but with notably fewer phenocrysts and much stronger alteration. This alteration is broadly defined by two major types, chlorite-sericite-quartz and chalcedonic quartz. The latter is dominated by extremely fine-grained secondary quartz that is clearly interstitial between angular lava fragments in which primary glass has altered to chlorite-quartz-sericite mixtures.