

GL02970-3

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ROGER STOKER-

HERE ARE DESCRIPTIONS FOR ALL THE THIN SECTIONS
WE HAVE. WE'RE READY FOR MORE WHENEVER
YOU CAN SEND THEM.

STEVE DEWINE

This ash flow is mostly crystalline with a minor amount of glass present. The rock is seriate porphyritic with a microlitic groundmass. There is a slight degree of devitrification in a few pumice lumps.

The phenocrysts present are quartz, plagioclase, pumice lumps, sanidine, zircon, monazite, muscovite, glass shards and opaques. A few of the quartz grains are embayed.

Hydrothermal alteration is indicated by the presence of zeolites occurring as veins, the altering of feldspar to sericite, and the altering of glass shards to carbonate, feldspar, and an unidentified green mineral.

Light compaction is indicated by the slightly flattened shards. The pumice lumps show no evidence of collapse.

The grains range from anhedral to euhedral in shape and consist of 7 percent zeolites, 5 percent quartz, 4 percent unidentified green mineral, 4 percent carbonate, 2 percent plagioclase, 1 percent pumice lumps, and traces of zircon, muscovite, monazite, sanidine, and glass shards. The remaining 72 percent is groundmass that is too small to be identified.

MINERALS

Quartz--occurs as phenocrysts, subhedral to anhedral, .18mm x .15mm to microlitic

Plagioclase--occurs as phenocrysts, anhedral to euhedral, .14mm x .07mm to .08mm x .04mm

Unidentified green mineral--usually occurs as replacement of glass shards but also in individual grains, subhedral to anhedral, .18mm x .12mm to .4mm x .2mm

Zeolites--occurs in veins throughout slide, subhedral, .13mm x .03mm to .03mm x .02mm

Carbonate--occurs as replacement of shards and in veins

Pumice lumps--occurs as phenocrysts with some alteration to clay, anhedral, .4mm x .4mm to .85mm x .75mm

Muscovite--occurs as phenocrysts, subhedral elongate, .14mm x .014mm to .02mm x .01mm

Monazite?--occurs as phenocrysts, subhedral, .07mm x .06mm to .18mm x .12mm

Sanidine--occurs as phenocrysts, euhedral to subhedral, .07mm x .16mm to .17mm x .12mm

Glass shards--occurs as phenocrysts, subhedral, .4mm x .3mm to .25mm x .25mm

Opaques--occurs as phenocrysts, anhedral, .35mm x .17mm to microscopic

Zircon--occurs as phenocryst, subhedral, .03mm x .02mm

An immature, strongly layered shale composed of a bed with clay-size particles as a matrix and well sorted medium to very fine silt-size particles floating in the matrix. This clay is overlain by beds of medium to very fine silt-size particles that are well sorted. These silt beds grade from coarse to fine from bottom to top and are 1 to 2 mm in thickness. Within the clay bed is a 1.5 to 2 mm thick, very well sorted clay bed that is faulted and has extension fractures filled with carbonate.

Soft sediment deformation is indicated in several areas. pieces of a clay bed have been broken and rotated and are floating within a silt bed showing ball and pillow structure. Muscovite grains parallel the bedding except near fractures where they are angular (about 45°) to the bedding. The silt beds show a pinching and swelling in thickness.

Detrital grains in this rock include quartz, plagioclase, orthoclase, sanidine, microcline, opaques, and muscovite. Secondary minerals formed during diagenesis are carbonate, zeolites, and some opaques. The carbonate and zeolites occur in veins in the clay bed and carbonate occurs as cement in the silt bed. Opaques occur throughout the slide with some suggesting a diagenetic origin by the pushing aside of surrounding grains as they grew.

The clay bed is composed of 67 percent matrix, 11 percent muscovite, 9 percent quartz, 3 percent opaques, 3 percent plagioclase, 3 percent sanidine, 2 percent carbonate, 2 percent zeolites, and a trace of orthoclase and microcline.

The silt bed is composed of 31 percent quartz, 21 percent matrix, 18 percent carbonate, 10 percent orthoclase, 6 percent opaques, 5 percent plagioclase, 5 percent sanidine, 4 percent muscovite, and a trace of microcline.

MINERALS

Quartz--detrital, angular to rounded, .12mm x .12mm to .02mm x .02mm.

Muscovite--detrital, subangular elongate parallel to bedding, 1 mm x .037mm to .02mm x .037mm.

Opaques--some grains detrital and some secondary formed during diagenesis, angular to rounded, .6mm x .23mm to .02mm x .02mm.

Plagioclase--detrital, subrounded, .18mm x .02mm to .072mm x .037mm.

Orthoclase--detrital, subrounded, .18mm x .02mm to .072mm x .037mm.

Carbonate--occurs as secondary mineral in silt beds as cement and as veins in clay.

Zeolites--occurs as secondary mineral in veins, subangular, .07mm x .02mm to microscopic.

Sanidine--detrital, subangular, .14mm x .07mm to .07mm x .07mm.

Microcline--detrital, subrounded, .2mm x .18mm.

A strongly layered shale composed of two distinct units. The lower unit is a bed with clay-size particles as matrix. Floating in this matrix are poorly sorted, very fine to medium sand-size particles. Above this unit are beds of fine- and medium-grained sandstone. This unit consists of several small beds most of which grade from coarse to fine in an upward direction and are well sorted.

The lower clay unit has a silt bed .75mm thick interbedded with it. Several faults exist in this unit and all fractures are filled with carbonate and zeolites. The detrital grains consist of quartz, muscovite, plagioclase, orthoclase, sanidine, and opaques. The carbonate and zeolites occur in veins as secondary minerals. Many of the opaques have pushed aside surrounding grains suggesting a diagenetic origin. The lower clay unit is composed of 65 percent matrix, 11 percent quartz, 7 percent carbonate, 6 percent orthoclase, 5 percent muscovite, 3 percent plagioclase, 3 percent opaques, and a trace of zeolites and sanidine.

The beds of the upper sandstone unit contain the same detrital grains as the lower clay unit. Secondary minerals are carbonate occurring as cement and some diagenetic opaques. This upper unit is composed of 29 percent quartz, 23 percent carbonate, 19 percent clay matrix, 8 percent muscovites, 7 percent plagioclase, 7 percent orthoclase, 4 percent sanidine, and 3 percent opaques.

Soft sediment deformation is indicated in several areas. Differential compaction exists at the clay-sandstone contact. Muscovite grains parallel the bedding except near areas of fractures where they are angular to the bedding. The sandstone beds show pinching and swelling with some portions of the coarser beds broken off and floating within the finer beds.

MINERALS

Carbonate--occurs as veins up to 1mm thick or as cement, individual grains are few, rounded, .07mm to .07mm to .04mm x .03mm.

Quartz--detrital, angular to rounded, .35mm x .17mm to .014mm x .014mm, elongate grains lie parallel to bedding, some grains are polycrystalline.

Muscovite--detrital, angular and elongate parallel to bedding, .4mm x .04mm to microscopic.

Plagioclase--detrital, subangular to subrounded, .14mm x .14mm to .07mm x .04mm.

Zeolites--occurs in veins, subangular, microscopic.

Orthoclase--detrital, subangular, .07mm x .07mm.

Sanidine--detrital, subangular, .14mm x .05mm.

Opaques--detrital and diagenetic, rounded to subrounded, 1.6mm x .8mm to microscopic.

RR 1-4

5987' ? - Not in PRC E-1

A quartzo-feldspathic gneiss with porphyroblastic feldspars surrounded by quartz grains with mortar texture and sutured boundaries.

The porphyroblasts consist of microcline, plagioclase, and orthoclase. All are poikilitic and are altering to sericite, epidote, and carbonate. The porphyroblasts are fractured with the fractures being parallel from grain to grain and filled with biotite, chlorite, and carbonate.

The sutured quartz grains surround the porphyroblasts and are strained. Some quartz grains are granular in texture. Pieces of the porphyroblasts are broken off and occur with the sutured quartz. Also occurring with the sutured quartz grains are biotite, chlorite, muscovite, epidote, monazite, apatite, and a small amount of carbonate cement.

The rock is composed of 59 percent quartz, 15 percent microcline, 14 percent plagioclase, 7 percent orthoclase, 3 percent chlorite, 1 percent carbonate, and a trace of epidote, monazite, zircon, apatite, biotite, muscovite and opaque minerals.

MINERALS

Quartz--sutured boundaries, strained, mortar and granular texture, anhedral, .07mm x .09mm to .7mm x .2mm.

Carbonate--occurs as cement and fills fractures in feldspars.

Microcline--porphyroblast, poikilitic, perthitic, anhedral, 2.8mm x 1.5mm to .2mm x .35mm.

Plagioclase--porphyroblast, poikilitic, .4mm x .3mm to 3.3mm x 3.3mm.

Orthoclase--porphyroblast, poikilitic, 1.7mm x .85mm to .7mm x .4mm.

Zircon--anhedral, .05mm x .05mm.

Apatite--anhedral, .3mm x .18mm to .13mm x .1mm.

Epidote--anhedral, .7mm x .5mm to .02mm x .03mm.

Biotite--anhedral, .8mm x .35mm to .07mm x .02mm.

Chlorite--anhedral, .35mm x .14mm to .07mm x .01mm.

Muscovite--anhedral, .14mm x .35mm to .1mm x .05mm.

Opaques--anhedral, .3mm x .3mm to microscopic.

Monazite--anhedral, .06mm x .06mm to microscopic.

A shale composed of subangular to subrounded grains of very fine sand-size to medium silt-size grains located in three different beds. The top and bottom beds are well sorted with carbonate cement and a minor amount of clay-size particles as matrix. The middle bed contains clay-size particles as matrix, a minor amount of carbonate cement, and well sorted grains floating in the matrix.

Detrital grains present consist of quartz, muscovite, sanidine, rock fragments, orthoclase, plagioclase, opaques, and microcline. Carbonate is of secondary origin occurring as cement.

The top and bottom beds are well sorted very fine-grained sandstones and consist of 31 percent carbonate, 24 percent quartz, 11 percent plagioclase, 11 percent microcline, 7 percent sanidine, 6 percent clay matrix, 6 percent opaques, 2 percent orthoclase, 2 percent muscovite, and a trace of rock fragments.

The middle bed consists of 43 percent matrix, 21 percent quartz, 17 percent plagioclase, 9 percent carbonate, 5 percent opaques, 4 percent sanidine, 1 percent muscovite, and a trace of orthoclase and microcline.

Soft sediment deformation is indicated by differential compaction present at the contacts of the upper and lower beds with the middle bed.

MINERALS

Quartz--detrital, subangular to subrounded, .18mm x .1mm to .02mm x .02mm, elongate grains parallel bedding.

Muscovite--detrital, subangular elongate parallel to bedding, .08mm long to .015mm long.

Carbonate--occurs in veins and as cement, few individual grains, subrounded, .07mm x .04mm to .2mm x .07mm.

Sanidine--detrital, subangular, .12mm x .07mm.

Rock fragments--detrital, subrounded, .34mm x .16mm to .3mm x .05mm.

Orthoclase--detrital, subangular, .07mm x .04mm to .03mm x .02mm.

Plagioclase--detrital, subrounded to subangular, .07mm x .04mm.

OPAQUES--detrital, subrounded to elongate, subangular grains parallel bedding, .14mm x .03mm to .04mm x .04mm.

Microcline--detrital, subrounded, .36mm x .36mm to .06mm x .04mm.

A strongly laminated shale containing pelecypods and sponge spicules lying parallel to the bedding. Several carbonate veins occur filling fractures from microfaults. Well sorted medium silt to very fine sand-size grains float in a matrix of clay-size particles and carbonate cement.

Detrital grains consist of quartz, muscovite, sanidine, rock fragments, orthoclase, plagioclase, opaques, zircon, microcline, and monazite. Carbonate is the only secondary mineral and occurs as cement.

The grains are angular to rounded and consist of 5 percent quartz, 3 percent opaques, 2 percent muscovite, 2 percent plagioclase, 1 percent sanidine, 1 percent orthoclase, and a trace of rock fragments, zircon, monazite, and microcline. There is 62 percent clay matrix and 24 percent carbonate cement.

MINERALS

Quartz--detrital, elongate grains parallel bedding, some grains polycrystalline, angular to subrounded, .18mm x .1mm to .02mm x .02mm.

Muscovite--detrital, subangular elongate parallel to bedding, .08mm long to .015mm long.

Carbonate--occurs as veins with a few individual grains, subrounded, .07mm x .04mm to .2mm x .07mm.

Sanidine--detrital, subangular, .12mm x .07mm

Rock fragments--detrital, subrounded, .34mm x .16mm to .3mm x .05mm.

Orthoclase--detrital, subangular, .07mm x .04mm to .03mm x .02mm.

Plagioclase--detrital, subrounded to subangular, .07mm x .04mm.

Opaques--detrital, rounded to elongate, subangular grains parallel bedding, .14mm x .03mm to .04mm x .04mm.

Zircon--detrital, subangular, .18mm x .12mm.

Microcline--detrital, subrounded, .1mm x .04mm.

Monazite--detrital, subrounded, .07mm x .04mm to .14mm x .03mm.

RR 2-3 5160'

A strongly laminated shale with carbonate veins filling fractures from microfaults. Well sorted medium sand to medium silt-size grains float in a matrix of clay-size particles and carbonate cement.

Detrital grains consist of quartz, zircon, plagioclase, microcline, opaques, muscovite, sanidine, and orthoclase. Carbonate occurs as a secondary mineral in veins and as cement.

The shale is composed of 42 percent matrix, 41 percent carbonate, 8 percent quartz, 4 percent plagioclase, 3 percent opaques, 2 percent muscovite, and a trace of sanidine, orthoclase, zircon, and microcline.

Some minor folding suggests soft sediment deformation.

MINERALS

Quartz--detrital, angular to subrounded, .75mm x .08mm to .01mm x .01mm.

Carbonate--occurs as veins and cement with a few individual grains occurring inside elongate opaques, subangular to subrounded, .32mm x .18mm to .04mm x .04mm.

Zircon--detrital, subangular, .03mm x .02mm.

Plagioclase--detrital, subangular to rounded, .03mm x .02mm.

Microcline--detrital, subangular, .07mm x .06mm.

Opaques--detrital, some elongate particles may be organic material, subrounded to subangular elongate parallel to bedding, .14mm x .02mm to microscopic.

Muscovite--detrital, subangular elongate parallel to bedding, .3mm x .09mm to .03mm long.

Sanidine--detrital, subrounded, .05mm x .07mm to .03mm.

Orthoclase--detrital, subrounded, .04mm x .02mm to .08mm x .04mm.

A quartz-feldspathic gneiss with porphyroblastic feldspars surrounded by quartz grains with mortar texture and sutured boundaries.

The porphyroblasts are plagioclase, orthoclase, and microcline. All are poikilitic and are altering to sericite. The porphyroblasts are fractured with the fractures being parallel from grain to grain and filled with carbonate and chlorite.

The sutured quartz grains surround the porphyroblasts and are strained. Some quartz grains are granular in texture. Occurring with the quartz are biotite, chlorite, epidote, carbonate cement, and monazite rimmed with iron and epidote.

The rock is composed of 34 percent quartz, 23 percent microcline, 17 percent orthoclase, 17 percent plagioclase, 4 percent chlorite, 1 percent monazite, 1 percent carbonate, 1 percent biotite, and a trace of epidote and opaque minerals.

MINERALS

Quartz--sutured boundaries, mortar and granular texture, anhedral, 1.8mm x 1.3mm to .048mm x .048mm.

Plagioclase--porphyroblast, poikilitic, anhedral, 2.25mm x 3.0mm to .5mm x .75mm.

Orthoclase--porphyroblast, poikilitic, anhedral, 5mm x 6mm to 1.3mm x .5mm.

Microcline--porphyroblast, poikilitic, perthitic, anhedral, 10mm x 10mm to .14mm x .14mm.

Chlorite--anhedral, 1.5mm x .5mm to .07mm x .03mm.

Monazite--surrounded by rims of iron and epidote, anhedral, .7mm x .4mm to .07mm x .07mm.

Carbonate--fills fractures in feldspars and occurs as cement in quartz.

Biotite--anhedral, some altering to chlorite, .7mm x .8mm to .14mm x .14mm.

Epidote--anhedral, .8mm x .04mm to microscopic.

Opaques--anhedral to subhedral, .35mm x .1mm to microscopic.

RR 2-5 5310'

A well sorted fine-grained sandstone altering to carbonate. Much alteration is indicated by carbonate veins occurring throughout the slide, an abundance of carbonate cement, and alteration of feldspars to carbonate.

Detrital grains consist of quartz, plagioclase, orthoclase, and some opaques. Secondary minerals include carbonate occurring as cement and veins, clay veins, and euhedral opaques.

The sandstone consists of 61 percent carbonate, 21 percent quartz, 10 percent clay, 3 percent opaques, 3 percent plagioclase, and 2 percent orthoclase.

MINERALS

Quartz--detrital, subrounded, .27mm x .18mm to .048mm x .018mm.

Carbonate--occurs as veins and cement with a few individual grains present, subrounded, .18mm x .18mm to .04mm x .18mm.

Clay-- occurs as veins.

Plagioclase--detrital, subrounded, .2mm x .15mm to .07mm x .06mm.

Opaques--detrital and diagenetic, subrounded to angular, .75mm x .4mm to microscopic.

Orthoclase--detrital, subrounded, .2mm x .1mm to .07mm x .05mm.

RR 2-6 5353'

A quartzo-feldspathic gneiss with porphyroblastic feldspars surrounded by quartz grains with mortar texture and sutured boundaries.

The porphyroblasts are plagioclase and microcline. The plagioclase is poikilitic and altering to sericite. All the porphyroblasts are fractured with the fractures being parallel from grain to grain and filled with carbonate and chlorite.

The sutured quartz grains surround the porphyroblasts and are strained. Some quartz grains show a granular texture. Occurring with the quartz are biotite, chlorite, monazite, epidote, apatite, and some carbonate cement.

The rock is composed of 37 percent quartz, 26 percent orthoclase, 17 percent plagioclase, 9 percent microcline, 4 percent chlorite, 3 percent carbonate, 3 percent biotite, 1 percent opaques, and a trace of apatite and monazite.

MINERALS

Quartz--sutured boundaries, mortar and granular texture, anhedral, 1.2mm x .6mm to .07mm x .07mm.

Plagioclase--porphyroblast, poikilitic, anhedral, 2.5mm x 1.8mm to 1.3mm x .35mm.

Carbonate--fills fractures in feldspars and occurs as cement with quartz.

Apatite--subhedral to euhedral, .09mm x .07mm to .15mm x .15mm.

Biotite--anhedral, 1.6mm x .38mm to .05mm x .05mm.

Chlorite--anhedral, 1.2mm x .035mm to .07mm x .14mm.

Monazite--anhedral, .3mm x .12mm to .06mm x .06mm.

Epidote--anhedral, minute particles surrounding monazite.

Microcline--porphyroblast, perthitic, anhedral, 10mm x 10mm to .5mm x .3mm.

YO QM-1 Surface

A quartzo-feldspathic gneiss with porphyroblasts of microcline surrounded by quartz and feldspar grains with mortar texture and sutured boundaries. The porphyroblasts are poikilitic and altering to sercite.

Sutured quartz grains surround the microcline porphyroblasts and exhibit undulatory extinction. Some feldspar grains also surround the porphyroblasts and have mortar texture. These feldspars are also poikilitic. Linedated muscovite and biotite are located with mortared feldspar and quartz grains.

The rock shows foliation between poikilitic feldspars, mortared quartz, and long, slender veins of muscovite.

This gneiss is composed of 36 percent microcline, 27 percent plagioclase, 25 percent quartz, 8 percent orthoclase, 3 percent muscovite, 1 percent biotite, and a trace of monazite.

Minerals

Microcline - porphyroblast; poikilitic; inclusions of quartz; subhedral; 1.9mm x 1.3mm to .36mm x .2mm.

Plagioclase - mortar texture; poikilitic; anhedral; .5mm x .5mm to .08mm x .07mm.

Quartz - mortar and granular texture; strained; sutured boundaries; anhedral; 1mm x .7mm to .08mm x .14mm.

Orthoclase - mortar texture; poikilitic; anhedral; .5mm x .35mm to .2mm x .18mm.

Muscovite - linedated; occurs within mortar textured grains; anhedral; .25mm x .25mm to .05mm x .02mm.

Biotite - linedated; occurs within the mortar textured grains; anhedral; 1.5mm x .5mm to .09mm x .07mm.

Monazite - anhedral; .3mm x .12mm to .18mm x .07mm.

RRGS3-1 382.5'

A finely laminated tuffaceous sandstone with well sorted grains floating in matrixes of clay and ash. The fine laminations are caused by the alternating of beds with clay matrix and beds with an ash matrix. Some of the ash matrix appears to be altering to clay.

Detrital grains in this rock include quartz, biotite, monazite, muscovite, plagioclase, microcline, zircon, and augite. There are also pumice lumps and rock fragments present. No secondary minerals are noted.

This sandstone consists of 56 percent matrix, 17 percent quartz, 8 percent plagioclase, 7 percent pumice lumps, 5 percent biotite, 4 percent microcline, 2 percent muscovite, and 1 percent rock fragments. There is a trace of glass shards, monazite, zircon, and augite.

Minerals

Quartz - some polycrystalline grains; some grains are undulose; rounded to angular; .2mm x .2mm to .03mm x .05mm.

Plagioclase - some grains are poikilitic; subangular to subrounded; .35mm x .3mm to .07mm x .07mm.

Pumice lumps - some are altering to an unidentified green mineral; rounded to blocky; .35mm x .35mm to .3mm x .2mm.

Biotite - rounded; .3mm x .1mm to .18mm x .06mm.

Microcline - some grains perthitic; subangular to subrounded; .25mm x .12mm to .06mm x .05mm.

Muscovite - elongate and rounded; .3mm x .07mm to .15mm x .06mm.

Rock fragments - rounded; .35mm x .2mm to .12mm x .08mm.

Glass shards - minor devitrification present; elongate and Y-shaped; .1mm long.

Monazite - subangular; .18mm x .18mm to .07mm x .06mm.

Zircon - subrounded; .14mm x .12mm to .12mm x .05mm.

Augite - subangular; .12mm x .12mm.

RRGS3-2 498'

A crystal tuff with phenocrysts of plagioclase, microcline, quartz, and biotite. The groundmass is composed of ash-sized particles and muscovite microlites. Amygdules of tridymite are common as are a few small tridymite veins.

The microcline phenocrysts are myrmekitic and some of the plagioclase phenocrysts are poikilitic altering to sericite. Many of the quartz phenocrysts are polycrystalline.

This tuff is composed of 61 percent matrix, 23 percent quartz, 7 percent plagioclase, 5 percent microcline, 2 percent biotite, 2 percent tridymite, and a trace of chlorite, muscovite, rock fragments, and carbonate.

Minerals

Quartz - some polycrystalline grains; anhedral; .6mm x .35mm to 2.0mm x 1.8mm.

Plagioclase - some grains poikilitic; subhedral; .7mm x .6mm to .35mm x .3mm.

Microcline - myrmekitic; subhedral; .9mm x .8mm to .3mm x .2mm.

Biotite - subhedral; .75mm x .2mm to .15mm x .06mm.

Tridymite - secondary mineral filling vesicles and veins; euhedral; vesicles range from .75mm x .5mm to .18mm x .07mm.

Carbonate - secondary mineral replacing ash matrix.

Rock fragments - subangular; .35mm x .2mm.

Muscovite - microlitic in groundmass; subhedral; .35mm x .2mm to microlitic.

Chlorite - anhedral; .36mm x .2mm.

RRGS3-3 560.5'

A fine-grained tuff above and below a thin, poorly sorted tuffaceous sandstone bed. Glass shards are common throughout.

The tuff contains only a few phenocrysts of feldspar ranging up to .07mm x .07mm in size. A few amygdules of tridymite are present. The matrix consists of ash-sized particles and microlites of muscovite. Slight compaction is indicated by the orientation of microlites.

The sandstone matrix is composed of ash-sized particles. The larger, poorly sorted grains consist of quartz (some polycrystalline), plagioclase, and microcline.

The tuffaceous sandstone bed is composed of 46 percent matrix, 18 percent glass shards, 15 percent quartz, 12 percent plagioclase, 6 percent microcline, 3 percent biotite, and a trace of rock fragments and chlorite.

Minerals

Glass shards - elongate, Y-shaped, and blocky; some slightly compacted; .3mm x .1mm to microlitic.

Quartz - detrital; some polycrystalline grains; subrounded; .8mm x .7mm to .06mm x .06mm.

Plagioclase - detrital; some grains poikilitic altering to sericite or chlorite; subangular; 1.7mm x 1.0mm to .14mm x .1mm.

Microcline - detrital; subangular; 2.0mm x 1.3mm to .17mm x .07mm.

Biotite - detrital; subangular; .35mm x .14mm to .14mm x .05mm.

Rock fragments - volcanic; rounded; 1.6mm x .6mm to .3mm x .1mm.

Chlorite - possibly formed by altering feldspars; rounded; .18mm x .15mm to .1mm x .1mm.

RRGS3-4 705'

A well sorted tuffaceous siltstone with some carbonate cement. In the center of the slide is a rounded piece of tuffaceous siltstone almost completely altered to carbonate.

Detrital grains present include muscovite, biotite, quartz, microcline, plagioclase, opaques, and glass shards. Slight compaction is indicated by the orientation of biotite, muscovite, and glass shards.

The rock is composed of 31 percent glass shards, 24 percent quartz, 14 percent carbonate cement, 9 percent plagioclase, 8 percent opaques, 6 percent biotite, 4 percent microcline, and 4 percent muscovite.

Minerals

Glass shards - elongate, Y-shaped, and blocky; size ranges up to .15mm x .15mm.

Quartz - detrital, subangular to rounded; .18mm x .15mm.

Carbonate - secondary mineral occurring as cement.

Plagioclase - detrital; subangular; .18mm x .18mm.

Opaques - detrital; subangular; .2mm x .09mm.

Biotite - detrital; rounded; .15mm x .04mm.

Microcline - detrital; subangular; .15mm x .07mm.

Muscovite - detrital; subangular; .09mm x .03mm.

RRGS 3-5 792'

A silty tuff with well sorted grains in an ashy matrix. A trace of carbonate cement is present as the alteration product of the matrix. Laminations are present but difficult to see due to the well sorted grains.

The silt-sized grains present are detrital and consist of 29% plagioclase, 19% quartz, 5 % opaques, 2% muscovite, 2% biotite, 2% microcline, and a trace of apatite and diopside. The remaining 41% is glass shards and matrix.

Minerals

Plagioclase - detrital; angular to subangular; .18mm x .06mm to .04mm x .03mm.

Quartz - detrital; rounded to subangular; .17mm x .12mm to .05mm x .03mm.

Opaques - detrital; subangular to subrounded; .17mm x .17mm to .07mm x .03mm.

Muscovite - detrital; subangular to rounded; .18mm x .18mm to .08mm x .07mm.

Biotite - detrital; subrounded; .18mm x .06mm to .04mm x .04mm.

Microcline - detrital; subangular to rounded; .18mm x .18mm to .08mm x .07mm.

Diopside - detrital; subangular to subrounded; .03mm x .05mm to .09mm x .07mm.

Apatite - detrital; subangular; .07mm x .07mm to .04mm x .03mm.

Carbonate - secondary mineral replacing ash matrix.

A poorly sorted tuffaceous sandstone with a matrix of ash particles and a trace of glass shards. Many of the feldspars are altered. Also present are some polycrystalline quartz and rock fragments.

The sandstone consists of 39 percent quartz, 39 percent plagioclase, 7 percent rock fragments, 5 percent opaques, 4 percent matrix, 3 percent biotite, 2 percent microcline, 1 percent muscovite, and a trace of hornblende, diopside, and chlorite.

Minerals

Quartz - detrital; rounded to angular; some polycrystalline grains;
.12mm x .08mm to 1.2mm x .75mm.

Plagioclase - detrital; subangular to subrounded; many grains poikilitic;
.09mm x .18mm to .75mm x .85mm.

Microcline - detrital; subangular to subrounded; .12mm x .08mm to .75mm x .85mm; some grains myrmekitic.

Rock fragments - subangular; .1mm x .25mm to .65mm x .75mm.

Opaques - detrital; subangular to subrounded; .3mm x .75mm to microlitic.

Biotite - detrital; subangular to rounded; .04mm x .07mm to .65mm x .85mm.

Muscovite - detrital; subangular; .08mm x .14mm to .02mm x .65mm.

Hornblende - detrital; subangular; .2mm x .2mm to .2mm x .35mm.

Diopside - detrital; subangular; .06mm x .12mm to .2mm x .35mm.

Chlorite - angular; detrital; .1mm x .2mm.

A poorly sorted silty tuff with grains and glass shards floating in a matrix of ash-sized particles. Some shards have altered to an unidentified green mineral. There are isolated patches of carbonate-rich matrix that is the product of alteration of the ash matrix.

Light compaction is indicated by the parallel orientation of elongate grains and glass shards. Bedding is present between beds of low grain-matrix ratio alternating with beds of high grain-matrix ratios.

The tuff is composed of 82 percent glass shards and matrix, 7 percent quartz, 6 percent plagioclase, 2 percent biotite, 2 percent opaques, 1 percent muscovite, and a trace of an unidentified green mineral.

Minerals

Quartz - detrital; angular to subrounded; .09mm x .09mm to .04mm x .03mm.

Plagioclase - detrital; subangular; .07mm x .07mm to .05mm x .02mm.

Biotite - detrital; subangular to subrounded; .18mm x .07mm to .03mm x .02mm.

Opaques - detrital; subangular to subrounded; .2mm x .2mm to microlitic.

Muscovite - detrital; subangular; .14mm x .03mm to .03mm x .02mm.

Unidentified green mineral - appears to be secondary replacing the matrix and glass shards; subangular; .14mm x .12mm to .05mm x .05mm.

RRGS 3-8 902'

A tuff with well sorted silt- and sand-sized grains floating in a matrix of ash-sized particles. A few vesicles and rock fragments are present. Light compaction is indicated by the orientation of shards and elongate grains.

Some of the glass shards are devitrified and some have been replaced by a clay mineral.

The tuff consists of 62 percent matrix, 27 percent glass shards, 3 percent quartz, 3 percent opaques, 2 percent plagioclase, 2 percent muscovite, 1 percent biotite, and a trace of microcline, rock fragments, and zircon.

Minerals

Glass shards - minor devitrification; blocky, elongate, and Y-shaped; .75mm x .3mm to microlitic; some shards have altered to an opaque.

Quartz - detrital; subangular to subrounded; .35mm x .35mm to .04mm x .03mm.

Opaques - detrital and secondary; angular; .3mm x .07mm x .03mm x .02mm.

Muscovite - detrital; subangular; .16mm x .12mm to microlitic in groundmass.

Plagioclase - detrital; angular to subangular; .18mm x .15mm to .08mm x .04mm.

Biotite - detrital; subangular; .15mm x .12mm to .07mm x .04mm.

Microcline - detrital; subrounded; .18mm x .18mm.

Zircon - detrital; subrounded; .07mm x .06mm to .04mm x .04mm.

Rock fragments - rounded; .4mm x .2mm to .18mm x .18mm.

RRGS 3-9. 918'

A tuff with poorly sorted grains floating in a matrix of ash-sized particles. Microlitic opaques are abundant in the groundmass.

Reaction rims have formed around vesicles and some of the quartz grains. A few glass shards are present and are devitrified.

The tuff consists of 93 percent matrix, 3 percent quartz, 3 percent vesicles, 1 percent plagioclase, and a trace of biotite, muscovite, and pumice lumps.

Minerals

Quartz - detrital; subangular to subrounded; .75mm x .3mm to .04mm x .02mm.

Plagioclase - detrital; angular to subangular; .2mm x .2mm to .12mm x .05mm.

Biotite - detrital; subangular; .04mm x .02mm to .18mm x .09mm.

Pumice lumps - subrounded; .2mm x .2mm.

Muscovite - detrital; subangular; .2mm x .2mm to .07mm x .06mm.

GEOPHYSICAL INSTITUTE

C. T. ELVEY BUILDING
UNIVERSITY OF ALASKA
FAIRBANKS, ALASKA 99701

December 17, 1975

Mr. Roger Stoker
Engineering Lab
Aerojet Nuclear Company
550 Second Street
Idaho Falls, ID 83401

Dear Roger:

A thousand pardons for the long delay in sending the petrographic reports. Unfortunately I have been away so much this semester that I have hardly had a chance to say hello to my wife! Anyway, here are the reports, and I will return the samples via air parcel post in the next few days.

Again, my regrets for the long silence. Such delays are not my usual style. I assure you it was not because of lack of interest.... but overcommitment.

Sincerely,



R. B. Forbes
Professor of Geology

RBF/fr

Enc.

PETROGRAPHY

Sample No. RRGE-1 (5005' core; Raft River Geothermal Area)

Rock Name: Gneissic Quartz Monzonite

Major and Minor Constituents

K feldspar

quartz

plagioclase (oligoclase-andesine)

biotite (altered to chlorite)

Accessories

muscovite (from K feldspar)

epidote (from plagioclase)

carbonate (hydrothermal?)

PETROGENESIS

The gneissic fabric of this rock is dominantly derived from cataclasis. It may have developed during emplacement...and in that case, it would be more properly called a "protoclastic" fabric.

The chloritization of the biotite, saussuritization of the plagioclase and introduction of carbonate indicates late stage hydrothermal activity.

It would be interesting to compare the recrystallization age of the schist terrane to that of the quartz monzonite to determine whether the hydrothermal alteration is later than these earlier events.

PETROGRAPHIC ANALYSIS

Sample No. RRGE-1 (4650' core; Raft River Geothermal Well)

Rock Name: Phyllitic Schist

Major and Minor Constituents

quartz
muscovite (var. sericite)
albite
biotite (incipient)

Accessory Minerals

tourmaline (zoned)
carbonaceous material

PETROGENESIS

This rock was derived from the synkinematic recrystallization of a parent argillaceous sediment. The assemblage quartz-albite-muscovite (+ incipient biotite) is stable under conditions of the "greenschist facies." The presence of incipient biotite would imply that recrystallization temperatures had just attained those of the biotite isograd (if the biotite was in equilibrium with the synkinematic assemblage. The question here is whether the biotite is later than the synkinematic assemblage(?), and due to superimposed hornfelsing from the thermal pulse accompanying the emplacement of the underlying quartz monzonite pluton. If the later case applies, late biotite should increase in volume and grain size in core samples taken from increasing depth.

Accessory tourmaline grains display some overgrowth textures, but these grains may record a history dating back to clastic source rocks.

The phyllitic schist is a typical product of regional metamorphism.

GEOPHYSICAL INSTITUTE

C. T. ELVEY BUILDING
UNIVERSITY OF ALASKA
FAIRBANKS, ALASKA 99701

June 28, 1976

Mr. R. C. Stoker
Aerojet Nuclear Co.
550 Second Street
Idaho Falls, ID 83401

Dear Roger:

Based on our telephone conversation a few days ago, I would be most pleased to conduct petrologic and geochemical analyses of selected core material out of the Raft River drill holes.

Attached is a budget which covers the required activities.

Sincerely,

R. B. Forbes
R. B. Forbes
Professor of Geology

RBF/fp

Enc.

cc: K. Mather, Director
N. Stilkey, Business Manager

PETROLOGIC AND GEOCHEMICAL ANALYSES
OF SELECTED CORE MATERIAL OUT OF THE
RAFT RIVER DRILL HOLES

Salaries

Principal Investigator, R. B. Forbes		
Prof. of Geology (see other direct costs)		
Research/Admin. Asst., 1 mo. @ \$1,571	<u>1,571</u>	
Subtotal	<u>1,571</u>	
Reserve for annual leave 12%	189	
Holiday and sick leave 9.5%	<u>149</u>	
Total Salaries		1,909

Staff Benefits

Hospitalization, Social Security, Retirement - 12% of total salaries		229
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Overhead

51.7% of total salaries		987
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Materials and Supplies

Film, glassware, reagents, etc.		400
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Travel

1 round trip, Fairbanks-Idaho Falls incl. subsistence @ \$30/day		750
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Services

Thin section preparation, 40 @ \$4.50/ea.	180	
Bulk chemical analyses, 6 @ \$120/ea.	720	
Potassium/argon analyses, 3 @ \$600/ea.	<u>1,800</u>	2,700

Other Direct Costs

Consultant, R. Forbes, Prof. of Geology, 1 mo. @ \$4,209/mo.	4,209	
Shipping, mailing, xerox, etc.	<u>400</u>	<u>4,609</u>

Total Budget		<u><u>11,584</u></u>
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A lithic tuff with large angular grains and rock fragments floating in a matrix that has completely altered to carbonate. A piece of crystal tuff, 11mm x 10.5mm is included within the lithic tuff. Many of the rock fragments and grains are altering to carbonate. Hydrothermal alteration is indicated by the complete alteration of matrix to carbonate cement.

Detrital grains include rock fragments, plagioclase, chlorite, microcline, biotite, quartz, sanidine, muscovite, zircon, and augite. The only secondary mineral present is the carbonate cement.

The rock consists of 37% carbonate cement, 29% plagioclase, 19% rock fragments, 9% quartz, 2% sanidine, 2% microcline, 1% biotite, 1% muscovite, and a trace of zircon, augite, and opaques.

MINERALS

Plagioclase - subangular to subrounded; 2.0mm x 1.5mm to .3 mm x .2mm; detrital.

Rock fragments - angular to subangular; 11mm x 10.5mm to .35mm x .35mm; appear to be volcanic.

Quartz - subangular to subrounded; .5mm x .5mm to .18mm x .09mm; some polycrystalline; detrital.

Sandine - angular; .3mm x .3mm; appears detrital.

Microcline - subangular to subrounded; .35mm x .2mm to 1.0mm x .75mm; some poikilitic altering to sericite; some are myrmekitic and perlitic; detrital.

Biotite - subangular; .8mm x .5mm to .35mm x .1mm; some altering to chlorite; detrital.

Muscovite - angular; .35mm x .07mm; detrital.

Zircon - subangular; .12mm x .04mm; detrital.

Augite - subangular; .18mm x .09mm; detrital.

Chlorite - rounded; .35mm x .2mm; detrital.

A lithic tuff with large angular grains and rock fragments floating in a matrix that has completely altered to carbonate. A piece of crystal tuff, 11mm x 10.5mm is included within the lithic tuff. Many of the rock fragments and grains are altering to carbonate. Hydrothermal alteration is indicated by the complete alteration of matrix to carbonate cement.

Detrital grains include rock fragments, plagioclase, chlorite, microcline, biotite, quartz, sanidine, muscovite, zircon, and augite. The only secondary mineral present is the carbonate cement.

The rock consists of 37% carbonate cement, 29% plagioclase, 19% rock fragments, 9% quartz, 2% sanidine, 2% microcline, 1% biotite, 1% muscovite, and a trace of zircon, augite, and opaques.

MINERALS

Plagioclase - subangular to subrounded; 2.0mm x 1.5mm to .3 mm x .2mm; detrital.

Rock fragments - angular to subangular; 11mm x 10.5mm to .35mm x .35mm; appear to be volcanic.

Quartz - subangular to subrounded; .5mm x .5mm to .18mm x .09mm; some polycrystalline; detrital.

Sandine - angular; .3mm x .3mm; appears detrital.

Microcline - subangular to subrounded; .35mm x .2mm to 1.0mm x .75mm; some poikilitic altering to sericite; some are myrmekitic and perlitic; detrital.

Biotite - subangular; .8mm x .5mm to .35mm x .1mm; some altering to chlorite; detrital.

Muscovite - angular; .35mm x .07mm; detrital.

Zircon - subangular; .12mm x .04mm; detrital.

Augite - subangular; .18mm x .09mm; detrital.

Chlorite - rounded; .35mm x .2mm; detrital.

RRGS 3-11 1079'

A lithic tuff with an ashy matrix composed of minute particles. Well sorted silt-sized detrital grains float in the matrix.

A slight degree of alteration is indicated by the matrix altering to a clay mineral in some areas and the devitrification of glass shards. Light compaction is indicated by the orientation of elongate grains.

Detrital grains include quartz, zircon, muscovite, plagioclase, and opaques. The only secondary mineralization noted was the occasional occurrence of the ashy matrix altering to a clay mineral.

The rock consists of 75% groundmass, 12% quartz, 10% opaques, 3% muscovite, and a trace of plagioclase and zircon.

MINERALS

Quartz - subangular to rounded; .12mm x .07mm to .03mm x .03mm; detrital.

Opaques - subrounded to subangular; .15mm x .15mm to microlitic in groundmass; detrital.

Muscovite - subrounded; .2mm x .12mm to .1mm long; detrital.

Plagioclase - subangular; .12mm x .12mm to .04mm x .02mm; detrital.

Zircon - subrounded; .08mm x .03mm to .04mm x .04mm; detrital.

RRGS 3-12 1147'

A lithic tuff with well sorted silt-sized grains floating in an ashy matrix. Some veins are completely filled with cristobalite or tridymite and other veins are only partially filled.

The groundmass and glass shards present are devitrified. Minor portions of the groundmass are altering to a clay mineral.

Detrital grains present are zircon, sanidine, plagioclase, muscovite, and quartz. The opaques present could be secondary as most show good crystal faces.

The rock consists of 84% matrix, 9% opaques, 3% quartz, 1% sanidine, 1% plagioclase, 1% zircon, and 1% muscovite.

MINERALS

Opagues - euhedral; .18mm x .15mm to microlitic in groundmass; possibly secondary.

Quartz - angular; .04mm x .03mm to .07mm x .03mm; detrital.

Zircon - subangular; .12mm x .07mm; detrital.

Sanidine - subangular; .08mm x .06mm to .07mm x .03mm; possibly detrital.

Plagioclase - angular; .07mm x .06mm to .07mm x .03mm; detrital.

Muscovite - subangular; .12mm x .02mm x .07mm x .01mm; detrital.

RRGS 3-13 1219'

A lithic tuff with a few well sorted silt-sized grains floating in an ashy matrix. The groundmass is devitrified, and in places is altering to a clay mineral. Light compaction is indicated by the orientation of elongate minerals.

Detrital grains include quartz, sanidine, plagioclase, and zircon. The opaques may be secondary as many show good crystal faces.

The rock consists of 88% matrix, 8% opaques, 2% sanidine, 1% quartz, 1% plagioclase, and a trace of zircon.

MINERALS

Opagues - subangular; .12mm x .07mm to microlitic in groundmass; possibly secondary.

Sanidine - subangular; .18mm x .12mm to .12mm x .04mm; detrital.

Plagioclase - subrounded; .15mm x .07mm to .07mm x .04mm; appears to be altering around edges; detrital.

Quartz - rounded; .12mm x .06mm to .04mm x .03mm; detrital.

Zircon - subangular; .12mm x .07mm; detrital.

RRGS 3-14 1251'

A very fine-grained shale with slightly larger well sorted particles floating in a matrix of clay-sized particles. Bedding is distinguished only by color, some beds being red and some gray. Some gray staining is present in some of the red beds and is also present on either side of fractures running through the red beds. This may indicate that the gray beds are not beds at all but are alteration products reacting with the red beds.

The fine-grained texture of this rock does not allow a petrographic analysis to be done on any of the grains.

RRGS 3-15 1265'

A finely bedded sandstone with a few very thin clay-rich beds. Other beds have an ashy matrix with carbonate cement. Some of the beds are graded. Light compaction is indicated by the orientation of elongate minerals.

Detrital grains include carbonate, muscovite, biotite, sanidine, zircon, plagioclase, microcline, quartz, and chlorite. Secondary minerals include carbonate cement and opaques.

This rock consists of 25% carbonate, 22% quartz, 21% matrix, 14% plagioclase, 5% muscovite, 5% chlorite, 3% biotite, 3% opaques, 2% microcline, and a trace of rock fragments, sanidine, and zircon.

MINERALS

Carbonate - subrounded; .09mm x .07mm; detrital grains and secondary cement.

Quartz - subangular; .15mm x .07mm to .08mm x .08mm; some undulose; detrital.

Plagioclase - subangular to subrounded; .2mm x .15mm to .07mm x .07mm; detrital.

Muscovite - subangular; .05mm x .04mm to .75mm x .02mm; detrital.

Chlorite - subrounded; .06mm x .08mm to .14mm x .12mm; detrital.

Biotite - subangular; .3mm x .1mm to .09mm x .04mm; detrital.

Opaques - subangular; .6mm x .35mm to .03mm x .03mm; may be secondary.

Microcline - subangular; .18mm x .12mm to .2mm x .12mm; some myrmekitic; detrital.

Sanidine - subangular; .2mm x .18mm to .15mm x .1mm; detrital.

Zircon - subangular; .07mm x .04mm to .03mm x .03mm; detrital

A crystal-lithic tuff with poorly sorted grains floating in a devitrified groundmass. Portions of the groundmass are altering to carbonate as are some of the phenocrysts. The groundmass contains a few crystallites. Textures present are porphyritic to glomeroporphyritic and perlitic.

Phenocrysts present include plagioclase, sanidine, quartz, and opaques. Detrital grains are rock fragments, zircon, and microcline.

The rock consists of 63% groundmass, 21% plagioclase, 4% opaques, 1% sanidine, 1% quartz, and a trace of zircon, microcline, and rock fragments.

Minerals

Plagioclase - euhedral to subhedral; 1.3mm x 1.3mm to .14mm x .1mm; slightly poikilitic.

Opaques - subangular to subrounded; .4mm x .35mm to microlitic in groundmass; some are inclusions in phenocrysts.

Sanidine - subhedral; .14mm x .12mm to .07mm x .07mm.

Quartz - subrounded; 1.5mm x .7mm to .08mm x .07mm.

Rock fragments - subrounded to rounded; .75mm x .75mm; appear to be from another crystal tuff.

Zircon - subangular; .07mm x .07mm to .02mm x .03mm; detrital.

Microcline - subrounded; .19mm x .15mm; detrital.

A well sorted sandstone composed of angular grains with some carbonate cement. Bedding is present with some beds having a clay-rich matrix and some poor in clay matrix.

This sandstone is in contact with a quartzite unit. The quartzite has a lot of muscovite grains oriented parallel to each other. The quartz grains have sutured boundaries and undulatory extinction.

Detrital grains in the sandstone are quartz, microcline, plagioclase, muscovite, biotite, opaques, rock fragments, augite, monazite, chlorite, and diopside. Most of the carbonate occurs as secondary cement, however, a few detrital grains are present.

This sandstone consists of 54% quartz, 16% carbonate, 12% plagioclase, 8% microcline, 4% muscovite, 4% biotite, 1% rock fragments, 1% opaques, and a trace of augite, chlorite, diopside, and monazite.

MINERALS

Quartz - detrital; angular to subangular; .9mm x .75mm to .2mm x .15mm; some grains are polycrystalline with undulatory extinction.

Carbonate - detrital and secondary; subrounded; .25mm x .18mm to .15mm x .12mm.

Plagioclase - detrital; subangular to subrounded; .75mm x .35mm to .18mm x .12mm; many are zoned; some are poikilitic.

Microcline - detrital; subangular to subrounded; .4mm x .2mm to .35mm x .2mm.

Muscovite - detrital; subangular; .2mm x .12mm to .18mm x .07mm.

Biotite - detrital; subangular; .4mm x .2mm to .1mm x .07mm.

Rock fragments - subrounded to rounded; .3mm x .3mm to .5mm x .5mm; some are volcanic and some are quartzite.

Opaques - detrital; subangular; .2mm x .15mm to .04mm x .03mm.

Augite - detrital; subangular; .12mm x .12mm.

Monazite - detrital; subangular; .18mm x .07mm.

Chlorite - detrital; subangular to subrounded; .18mm x .09mm to .12mm x .07mm.

Diopside - detrital; subangular to subrounded; .18mm x .18mm to .07mm x .05mm.

A well sorted sandstone composed of angular grains in a clay matrix and a small amount of carbonate cement is isolated areas. Slight compaction is indicated by the orientation of elongate minerals. This sandstone is in contact with quartzite which was described in the previous thin section.

Detrital grains in this sandstone are quartz, plagioclase, biotite, monazite, diopside, muscovite, rock fragments, chlorite, microcline, opaques, and carbonate. Some carbonate also is present as cement.

This sandstone consists of 38% quartz, 16% plagioclase, 12% carbonate, 8% muscovite, 2% rock fragments, 1% monazite, 1% chlorite, and a trace of diopside.

MINERALS

Quartz - detrital; angular to subrounded; .4mm x .3mm to .09mm x .07mm.

Plagioclase - detrital; angular to subrounded; .5mm x .4mm to .12mm x .14mm; some myrmekitic and some poikilitic.

Carbonate - detrital and secondary; subangular to subrounded; .4mm x .4mm to .05mm x .04mm.

Muscovite - detrital; subangular; .15mm x .15mm to .09mm x .06mm.

Rock fragments - subrounded to rounded; .35mm x .2mm to .2mm x .1mm.

Monazite - detrital; subangular; .18mm x .12mm to .09mm x .07mm.

Chlorite - detrital; subangular; .18mm x .06mm to .15mm x .09mm.

Diopside - detrital; subangular; .1mm x .07mm to .07mm x .05mm.

A very poorly sorted sandstone with many rock fragments. Many of the rock fragments are siltstones with carbonate cement and quartzite fragments. Volcanic rock fragments are also present. Minor amounts of ashy matrix and carbonate cement are present. In places, the matrix is altering to carbonate.

Detrital grains present include plagioclase, rock fragments, microcline, carbonate, quartz, muscovite, monazite, biotite, chlorite, epidote, garnet, and opaques. Carbonate also occurs as secondary cement.

This sandstone consists of 30% rock fragments, 30% quartz, 22% plagioclase, 7% carbonate, 6% microcline, 2% muscovite, 2% opaques, 1% biotite, and a trace of monazite, chlorite, epidote, and garnet.

MINERALS

Rock fragments - subrounded; mostly quartzites and volcanics with perlitic structures; some contain secondary carbonate; 3.75mm x 2.25mm to .3mm x .3mm.

Quartz - detrital; subangular to subrounded; 1.5mm x 1.0mm to .18mm x .12mm.

Plagioclase - detrital; 2.1mm x 1.0mm to .36mm x .18mm; some are poikilitic.

Carbonate - subrounded; detrital and secondary; .8mm x .5mm to .4mm x .4mm.

Microcline - detrital; subangular to subrounded; 5.0mm x 2.5mm to .3mm x .2mm; some myrmekitic.

Muscovite - detrital; subangular; 1.5mm x .4mm to .2mm x .1mm.

Opaques - detrital; subangular; .75mm x .5mm to .06mm x .04mm.

Biotite - detrital; subangular; 1.0mm x .5mm to .7mm x .1mm; some are altering to chlorite.

Monazite - detrital; subrounded; .3mm x .2mm to .09mm x .07mm.

Chlorite - detrital; subangular; .35mm x .2mm to .18mm x .12mm.

Epidote - detrital; subangular; .15mm x .12mm to .3mm x .2mm; some grains are within plagioclase grains.

Garnet - detrital; subangular; .2mm x .15mm to .3mm x .35mm.

A well sorted laminated siltstone and shale. All the grains are well sorted with some floating in beds of clay-rich matrix, and others in beds rich in carbonate cement.

Microfaults are present in several areas. Soft-sediment deformation is indicated by the muscovite grains which follow the bedding contacts.

Carbonate cement is present in the beds that contain coarser grains. Some of these beds are graded. Some glass shards are present and have been totally replaced by carbonate.

Compaction is indicated in the clay-rich beds by the orientation of elongate minerals. The grains in these beds are finer than those in the carbonate-rich beds.

Detrital grains present include quartz, muscovite, carbonate, plagioclase, rock fragments, chlorite, opaques, biotite, and microcline. Carbonate cement is the only secondary mineral present.

This rock consists of 27% carbonate, 25% quartz, 31% clay matrix, 5% opaques, 7% plagioclase, 4% muscovite, 1% biotite, and a trace of rock fragments, microcline, and chlorite.

MINERALS

Carbonate - detrital and secondary; .4mm x .5mm to .04mm x .03mm.

Quartz - detrital; subangular; .35mm x .3mm to .03mm x .02mm; a few polycrystalline grains.

Opaques - detrital; subangular to subrounded; .18mm x .07mm to .04mm to .03mm.

Plagioclase - detrital; subangular; .3mm x .3mm to .04mm x .03mm; some grains are myrmekitic and some are poikilitic.

Muscovite - detrital; subangular; .35mm x .04mm to .07mm x .03mm.

Biotite - detrital; subangular; .07mm x .05mm to .12mm x .04mm.

Rock fragments - subrounded; volcanic origin; .12mm x .13mm to .6mm x .3mm.

Microcline - detrital; subangular; .12mm x .06mm to .35mm x .2mm.

Chlorite - detrital; subrounded; .18mm x .05mm.

RRGE-1 4698

A quartzite with well developed schistosity of muscovite and biotite. Sutured contacts are present at the boundaries of quartz and feldspar grains.

Muscovite, biotite, and carbonate are the secondary minerals present. They occur as parallel veins throughout the rock. Opaque minerals are also secondary. Detrital grains present are quartz, plagioclase, and zircon.

This rock consists of 47% quartz, 27% biotite, 20% muscovite, 3% carbonate, 2% opaques, and 1% plagioclase.

MINERALS

Quartz - detrital; subrounded to elongate; sutured boundaries; undulatory extinction; .2mm x .09mm to .04mm to .03mm.

Biotite - secondary; occurs filling fractures; seldom occurs as individual grains; lepidoblastic.

Muscovite - secondary; lepidoblastic.

Zircon - detrital; subangular; .07mm x .03mm to .06mm x .05mm.

Plagioclase - detrital; subangular to subrounded; .04mm x .03mm to .07mm x .07mm.

Carbonate - secondary; occurs as cement and as veins perpendicular to schistosity.

Opaques - secondary; subhedral; .18mm x .15mm to .07mm x .02mm.

RRGE-2 3074

A porphyritic fine-grained crystal tuff with well sorted grains floating in a devitrified groundmass of granular-shaped quartz and feldspar grains. This tuff is probably an ash flow because several vesicles are present with cristobalite or tridymite growing around the edges. No glass shards were observed but a few small pumice lumps are present.

This tuff consists of 89% groundmass, 8% quartz, 2% opaques, 1% muscovite, and a trace of plagioclase and pumice lumps.

MINERALS

Quartz - euhedral to subhedral; glomerophytic; some are embayed; .08mm x .07mm to .04mm x .03mm.

Opaques - subhedral; .14mm x .07mm to .03mm x .02mm.

Muscovite - euhedral; .07mm x .03mm to .05mm x .02mm.

Plagioclase - anhedral to subhedral; poikilitic; .15mm x .15mm to .02mm x .02mm.

Pumice lumps - subangular to subrounded; .18mm x .18mm to .07mm x .05mm.

RRGD-2 3722

A very poorly sorted arkosic lithic wacke. The matrix and some of the grains are altering to sericite. Carbonate cement is also present.

Detrital grains are quartz, plagioclase, microcline, carbonate, biotite, muscovite, opaques, and rock fragments.

This rock is composed of 45% quartz, 14% plagioclase, 6% rock fragments, 5% microcline, 5% carbonate, 3% biotite, 3% opaques, 2% muscovite, and 17% matrix.

MINERALS

Quartz - detrital; subangular; some polycrystalline; .7mm x .7mm to .18mm x .18mm; undulose.

Plagioclase - detrital; subangular; 1.0mm x .7mm to .18mm x .07mm; some poikilitic and some myrmekitic.

Rock fragments - subrounded; most are volcanic and some have altered to carbonate; .8mm x .5mm to .6mm x .3mm.

Opaques - detrital; subrounded; .4mm x .4mm to .15mm x .08mm.

Microcline - detrital; subangular; .2mm x .18mm to .8mm x .7mm.

Carbonate - detrital and secondary; subrounded; .35mm x .2mm to .15mm x .12mm.

Biotite - detrital; subangular; .6mm x .5mm to .2mm x .06mm.

Muscovite - detrital; subangular; .18mm x .12mm to .12mm x .04mm.

RRGE-2 3724

A moderately sorted very fine-grained arkosic lithic wacke. The matrix is ashy and is altering to carbonate. A few very thin clay-rich beds are present. Soft sediment deformation is indicated by microfaults.

Detrital grains include quartz, plagioclase, microcline, sanidine, carbonate, muscovite, opaques, zircon, and rock fragments. Secondary minerals are carbonate, opaques, and zeolites.

The rock consists of 27% quartz, 25% plagioclase, 10% carbonate, 6% opaques, 5% sanidine, 4% rock fragments, 3% muscovite, 1% microcline, 19% matrix, and a trace of zircon and zeolites.

MINERALS

Quartz - detrital; subangular; .3mm x .18mm to .08mm x .06mm.

Plagioclase - detrital; subangular; some poikilitic and myrmekitic; .2mm x .15mm to .03mm x .03mm.

Carbonate - detrital and secondary; subangular to subrounded; .15mm x .07mm to .02mm x .01mm.

Opaques - detrital and secondary; detrital grains are subangular to subrounded; .07mm x .07mm to .02mm x .02mm.

Sanidine - detrital; subrounded; .2mm x .18mm to .07mm x .04mm.

Rock fragments - subrounded; .2mm x .2mm to .1mm x .07mm.

Muscovite - detrital; subangular; .15mm x .05mm to .02mm x .01mm.

Microcline - detrital; subrounded; .35mm x .2mm to .12mm x .08mm.

Zircon - detrital; subangular; .06mm x .04mm.

Zeolites - secondary; subangular; .03mm x .01mm.

RRGE-2 3733

A very poorly sorted arkosic lithic wacke. Rock fragments present are crystal tuffs, volcanic rocks with spherulitic structure, sandstones altering to carbonate, and quartzites.

Detrital grains are quartz, plagioclase, microcline, monazite, muscovite, biotite, carbonate, opaques, and rock fragments. Secondary minerals are chlorite and carbonate. The matrix appears to be altering to sericite in a few places.

The rock consists of 39% quartz, 21% plagioclase, 10% rock fragments, 5% carbonate, 4% microcline, 3% biotite, 1% muscovite, 1% opaques, 16% matrix; and a trace of chlorite, sericite, and monazite.

MINERALS

Quartz - detrital; subangular; 2.25mm x .75mm to .12mm x .08mm; some undulose and polycrystalline.

Plagioclase - detrital; subangular; 1.3mm x .8mm to .18mm x .15mm; some poikilitic and myrmekitic.

Rock fragments - subrounded to subangular; 19.0mm x 7.0mm to .5mm x .5mm.

Carbonate - detrital and secondary; subrounded to subangular; .5mm x .3mm to .12mm x .12mm.

Microcline - detrital; subangular; 1.5mm x 1.0mm to .35mm x .2mm.

Biotite - detrital; subangular; 1.0mm x .2mm to .1mm x .1mm; some altering to chlorite.

Muscovite - detrital; subangular; .3mm x .3mm to .2mm x .05mm.

Opaques - detrital; subangular; .2mm x .2mm to .07mm x .05mm.

Chlorite - secondary; subrounded; .3mm x .1mm.

Monazite - detrital; subangular; .3mm x .18mm.

RRGE-3 2805

A moderate to well sorted very fine-grained silty sandstone. Matrix consists of ash and clay. Compaction is indicated by the orientation of elongate minerals. The opaque grains are concentrated in three horizons that parallel the bedding.

Detrital grains are quartz, plagioclase, opaques, muscovite, biotite, and microcline. Secondary minerals are carbonate, occurring in veins and as cement, and some opaques. Some unknown organic material is also present.

The rock consists of 23% quartz, 13% carbonate, 9% muscovite, 7% opaques, 5% plagioclase, 3% biotite, 40% matrix, and a trace of microcline.

MINERALS

Quartz - detrital; subangular; .18mm x .18mm to .03mm x .02mm.

Plagioclase - detrital; subangular; .15mm x .05mm to .04mm x .02mm.

Opaques - detrital and secondary; subrounded to elongate; some appear to be organic; 1.0mm x .5mm to .04mm x .03mm.

Muscovite - detrital; subangular; .18mm x .04mm to .03mm long.

Biotite - detrital; subangular; .12mm x .06mm to .04mm x .02mm.

Carbonate - secondary; occurs in veins and as cement.

Microcline - detrital; subangular; .06mm x .04mm.

RRGE-3 3976

A well sorted laminated very fine-grained silty sandstone. The ashy matrix is altering to carbonate. This alteration is greater in some beds than in others. Compaction is indicated by the orientation of elongate minerals. Soft sediment deformation is indicated by microfaults.

Detrital grains are quartz, plagioclase, microcline, opaques, biotite, muscovite, rock fragments, epidote, zircon, and some carbonate. Secondary minerals are carbonate and some opaques.

The rock consists of 32% quartz, 12% carbonate, 8% plagioclase, 6% muscovite, 5% biotite, 5% opaques, 3% microcline, 2% rock fragments, 27% matrix, and a trace of epidote and zircon.

MINERALS

Quartz - detrital; subangular to subrounded; .2mm x .08mm to .04mm x .04mm; some undulose.

Plagioclase - detrital; subangular; .2mm x .12mm to .05mm x .03mm; some myrmekitic.

Microcline - detrital; subangular; .35mm x .2mm to .1mm x .1mm.

Rock fragments - subangular to subrounded; .5mm x .2mm to .15mm x .15mm.

Opaques - detrital and secondary; subangular to elongate; .35mm x .2mm to .05mm x .03mm.

Carbonate - detrital and secondary; subangular to subrounded; .2mm x .1mm to .08mm x .06mm.

Muscovite - detrital; subangular; .18mm x .09mm to .09mm long.

Biotite - detrital; subangular; .4mm x .1mm to .12mm long.

Epidote - detrital; subrounded; .08mm x .06mm.

Zircon - detrital; subangular; .14mm x .07mm to .04mm x .03mm.

RRGE-3C 4992

A sandy tuff with well sorted grains floating in an ashy matrix. The matrix is devitrified with spherulites present and is altering to carbonate. Fossil fragments are present and may be ostracods. Zeolites and carbonate occur together in veins.

Detrital grains are quartz, sanidine, plagioclase, zircon, muscovite, microcline, opaques, and rock fragments. Secondary minerals are carbonate, zeolites, chlorite, and some opaques.

The rock consists of 17% quartz, 9% carbonate, 5% plagioclase, 4% opaques, 3% rock fragments, 1% zircon, 1% zeolites, 1% muscovite, 59% matrix, and a trace of sanidine, microcline, and chlorite.

MINERALS

Quartz - detrital; subangular to rounded; .35mm x .18mm to .04mm x .03mm; some undulose.

Sanidine - detrital; subangular; .4mm x .3mm to .04mm x .04mm.

Plagioclase - detrital; subangular; .3mm x .18mm to .12mm x .12mm.

Zircon - detrital; angular; .18mm x .07mm x .2mm x .08mm.

Zeolites - secondary; occur in veins; euhedral to subhedral; .12mm x .03mm to .02mm long.

Chlorite - secondary; occurs as minute particles around the edges of vesicles.

Muscovite - detrital; subangular; .14mm x .04mm to .12mm x .04mm.

Rock fragments - subrounded; .35mm x .35mm to .2mm x .2mm.

Microcline - detrital; subangular; .2mm x .15mm to .15mm x .1mm.

Opaques - detrital and secondary; subangular to subrounded; .1mm x .09mm to .07mm x .02mm.

Carbonate - secondary; occurs in veins and as a replacement product of the groundmass.

RRGE-3C 5267

A lithic-crystal tuff with a few fine-grained particles floating in an ashy matrix. The matrix is devitrified and is altering to carbonate. A few vesicles are present with zeolites forming around their edges.

Detrital grains are quartz, plagioclase, opaques, and zircon. Secondary grains are zeolites and carbonate.

The rock is composed of 2% zeolites, 2% opaques, 1% quartz, 1% carbonate, 94% matrix, and a trace of plagioclase and zircon.

MINERALS

Zeolites - secondary; euhedral to subhedral; .07mm x .04mm to .06mm long.

Opaques - detrital; subangular; .2mm x .2mm to .12mm x .03mm.

Quartz - detrital; subangular to subrounded; .35mm x .12mm to .07mm x .04mm.

Carbonate - secondary; occurs as veins and as cement.

Zircon - detrital angular; .08mm x .03mm.

Plagioclase - detrital; subangular; .2mm x .18mm to .04mm x .03mm.

RRGE-3C 5268

A sandy tuff with well sorted grains floating in an ashy matrix that is almost completely altered to clay and carbonate. Fossil fragments are present and may be ostracods. Compaction is indicated by the orientation of elongate grains. Soft sediment deformation is indicated by microfaults.

Detrital grains are quartz, plagioclase, muscovite, opaques, microcline, and zircon. Secondary minerals are clay, carbonate, and some opaques.

The rock consists of 7% quartz, 6% opaques, 1% muscovite, 1% plagioclase, 85% matrix, and a trace of zircon and microcline.

MINERALS

Quartz - detrital; subangular; .2mm x .15mm to .04mm x .03mm.

Opaques - detrital and secondary; subangular; .2mm x .18mm to .02mm x .02mm.

Plagioclase - detrital; subangular; .15mm x .15mm to .04mm x .03mm.

Muscovite - detrital; subangular; .14mm x .02mm to .04mm long.

Microcline - detrital; subangular; .18mm x .15mm.

Zircon - detrital; angular; .04mm x .03mm.

Carbonate - secondary; occurs as cement.

RRGE-3C 5550

A quartzite schist with well developed schistosity of muscovite grains. Sutured boundaries exist between the quartz grains.

Detrital grains are quartz, muscovite, opaques, and zircon. The rock is altering to carbonate throughout.

The rock is composed of 51% quartz, 41% carbonate, 6% muscovite, 2% opaques, and a trace of zircon.

MINERALS

Quartz - detrital; undulose; sutured boundaries; 1.0mm x .06mm to .15mm x .07mm.

Carbonate - secondary; occurs as alteration product throughout rock.

Muscovite - detrital; subangular; .18mm x .07mm to .14mm x .03mm.

Opaques - detrital; subangular; .12mm x .07mm to .04mm x .03mm.

Zircon - detrital; subrounded; .12mm x .12mm to .04mm x .03mm.

RRGI-4 2843

A moderate to well sorted feldspathic lithic arenite. A small amount of ashy matrix is present and is altering to carbonate.

Detrital grains include quartz, plagioclase, microcline, rock fragments, zircon, biotite, muscovite, and opaques. Carbonate is the only secondary mineral and occurs as cement.

The rock is composed of 71% quartz, 5% plagioclase, 5% microcline, 5% rock fragments, 4% biotite, 3% muscovite, 2% opaques, and 5% carbonate. A trace of zircon was noted.

MINERALS

Quartz - detrital; subangular to subrounded; 1.0mm x .7mm to .12mm x .12mm; some undulose.

Zircon - detrital; subangular; .08mm x .05mm.

Muscovite - detrital; subangular; .9mm x .1mm to .08mm x .06mm.

Biotite - detrital; subangular; .5mm x .2mm to .12mm x .08mm.

Plagioclase - detrital; subangular to subrounded; some myrmekitic and poikilitic; .35mm x .2mm to .2mm x .15mm.

Microcline - detrital; subangular to subrounded; .5mm x .3mm to .14mm x .12mm.

Rock fragments - subrounded; .5mm x .5mm to .2mm x .2mm.

Opaques - detrital; subrounded to subangular; .2mm x .15mm to .07mm x .06mm.

Carbonate - secondary; occurs as cement.

RRGI-4 2847

A poorly sorted tuffaceous feldspathic lithic wacke. The ashy matrix is altering to carbonate. Glass shards are present and have altered to carbonate. Compaction is indicated by the orientation of elongate grains.

Detrital grains are quartz, plagioclase, microcline, rock fragments, biotite, muscovite, opaques, zircon, chlorite, and some carbonate. The only secondary mineral is carbonate which occurs as cement and as an alteration product of glass shards.

The rock consists of 36% quartz, 28% matrix, 12% carbonate, 5% opaques, 4% rock fragments, 4% muscovite, 4% biotite, 4% plagioclase, 3% microcline, and a trace of chlorite and zircon.

MINERALS

Quartz - detrital; subangular to subrounded; .7mm x .6mm to .06mm x .03mm; some undulose and polycrystalline.

Chlorite - detrital; subrounded; .5mm x .2mm to .4mm x .2mm.

Microcline - detrital; subangular to subrounded; .6mm x .6mm to .15mm x .09mm.

Biotite - detrital; subangular; .5mm x .2mm to .2mm x .09mm.

Muscovite - detrital; subangular; .9mm x .02mm to .18mm x .04mm.

Plagioclase - detrital; subangular to subrounded; some myrmekitic; .7mm x .5mm to .2mm x .18mm.

Zircon - detrital; subangular; .15mm x .15mm.

Rock fragments - subangular to subrounded; some volcanic and some quartzites; 1.0mm x .75mm to .2mm x .2mm.

Opaques - detrital; subangular to subrounded; .35mm x .2mm to .03mm x .03mm.

Carbonate - detrital and secondary; .3mm x .2mm to .14mm x .07mm; detrital grains are subrounded.