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PETROGRAPHY OF DRILL CORES
FROM THE RAFT RIVER GEOTHERMAL AREA,
SOUTHERN IDAHO

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ABSTRACT

One hundred seven thin sections from the Raft River basin have been examined and described. Most thin sections were taken from the Tertiary Salt Lake Formation consisting of tuffs, shales, siltstones, and sandstones.

The sediments are characterized by poorly sorted subangular quartz and feldspar grains with secondary calcite and pyrite. Most thin sections lack fossils and some contain organic material suggesting a non-acid reducing environment existed.

Sedimentary structures are present in thin section and outcrop. All are indicative of rapid deformation of water-saturated sediments.

Provenance studies show all the mountain ranges surrounding the Raft River valley are sources for the sediments. The relationship of volcanic quartz grains and rock fragments to plutonic and metamorphic quartz grains and rock fragments, shows a gradual increase in volcanic detritus and decrease in metamorphic and plutonic detritus from depth toward the surface.

PETROGRAPHY OF DRILL CORES FROM THE RAFT RIVER
GEOTHERMAL AREA, SOUTHERN IDAHO

INTRODUCTION

The purpose of this report is to summarize petrographic findings and describe the general nature of the Salt Lake Formation sediments at the Raft River geothermal site in Cassia County, Idaho. One hundred seven thin sections have been described and are included as Appendix I at the end of this report.

The Raft River basin lies in the northern part of the Basin and Range province near its boundary with the Snake River plain. It is 60 km long, 20 to 24 km wide, and has an average elevation of 1,400 m. The Raft River flows northward through the valley to the Snake River.

GEOLOGY

The Raft River valley lies in a north-trending basin that has been warped and downfaulted in late Cenozoic time. Volcaniclastic sediments and tuffs fill the basin to a depth of 1,300 to 1,600 meters and overlie a basement of metamorphic rocks.

Tertiary, Paleozoic, and Precambrian rocks flank the Raft River basin and are exposed in the mountains on the west, east, and south sides of the valley (Fig. 1). The Sublett Range and Black Pine Mountains on the east consist of Pennsylvanian and Permian sedimentary rocks. The Cotterel and Jim Sage Mountains on the west side of the valley are Tertiary rhyolites and tuffaceous sediments. West of these mountains lie the Albion Range composed of Precambrian gneiss dome complexes mantled

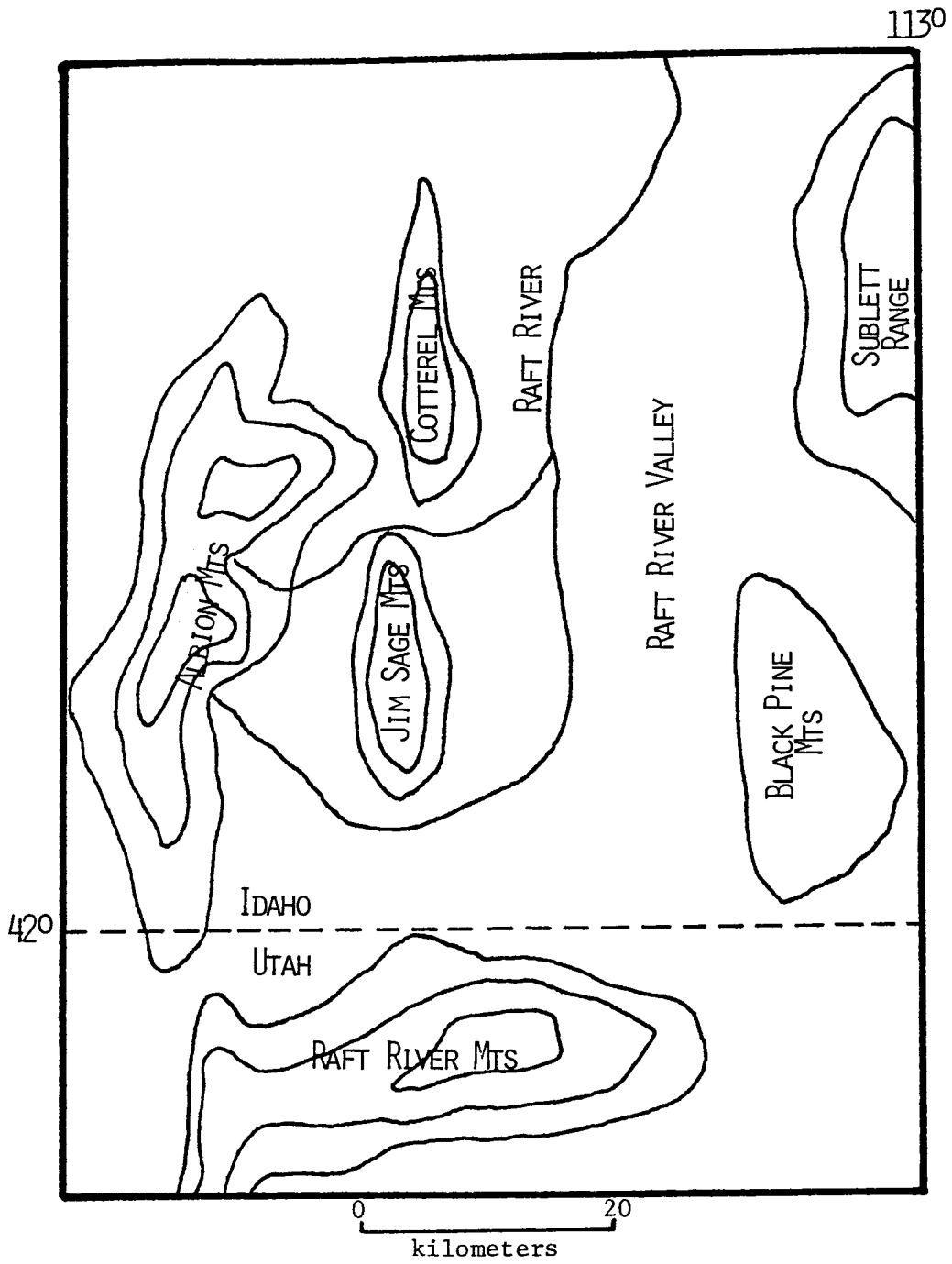


Figure 1. Map of the Raft River valley region.

by Paleozoic metasedimentary rocks. South of the basin lies the Raft River Mountains which are part of the metamorphic complex found in the Albion Range.

Stratigraphy of the Raft River Basin

Lithologic logs prepared by Covington (1977a, 1977b, 1977c, 1977d, 1978, 1979a, 1979b, 1979c, 1979d) describe the rocks found in seven deep wells drilled in the Raft River basin (Fig. 2). They consist of Tertiary sediments about 1,600 meters thick underlain by a metamorphic complex similar to that in the Albion and Raft River Ranges.

Salt Lake Formation. The Tertiary Salt Lake Formation in the Raft River basin consists mainly of light-green thin-bedded to massive, tuffaceous siltstone and sandstone with minor conglomerate. In the western part of the basin, the Salt Lake Formation is divided into upper and lower members separated by volcanic rocks of the Jim Sage Mountains (Williams and others, 1976).

The upper member is gray to light-green tuffaceous siltstone and sandstone with minor conglomerate composed of clasts of quartzite, dolomite, limestone, schist, and rhyolite.

The middle volcanic member at Jim Sage Mountains consists of rhyolite flows, tuffaceous siltstones and sandstone, and vitrophyre breccia. Lava flows consist of two main types. Some are black and glassy while others are reddish brown porphyritic to aphanitic calc-alkali rhyolite. Porphyritic rocks contain phenocrysts of oligoclase-andesine and pigeonite. The vitrophyre breccia lies between upper and lower lava flows and consists of black glass clasts up to 2 meters in diameter in a yellow and orange matrix of hydrated glass (Williams and others, 1976).

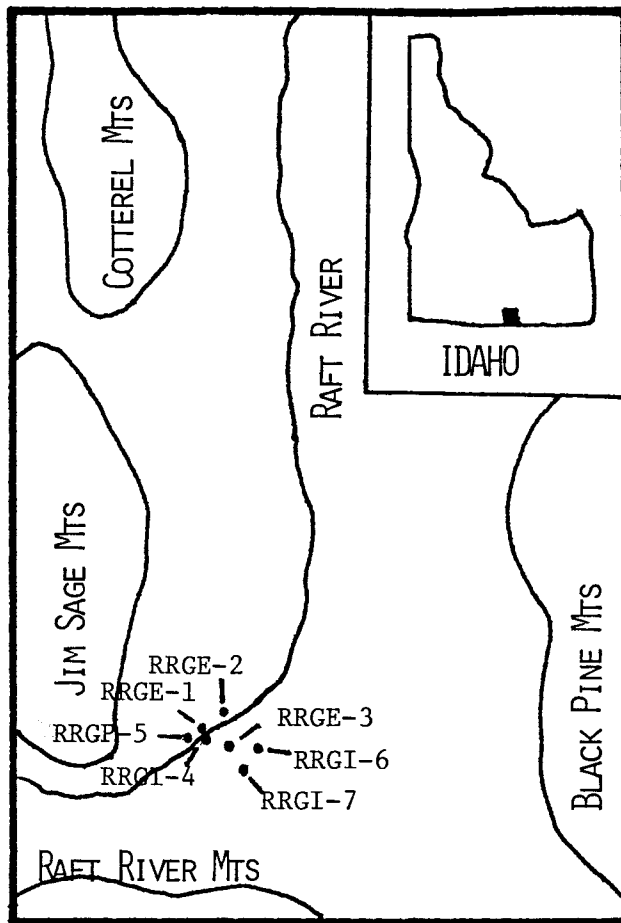


Figure 2. Location of deep drill holes in the Raft River valley.

PRECAMBRIAN | TERTIARY

□ Salt Lake Formation

□ Quartzite of Yost

▨ Schist of the Upper Narrows

▩ Elba Quartzite

□ Older Schist

□ Quartz Monzonite

• Thin section locations

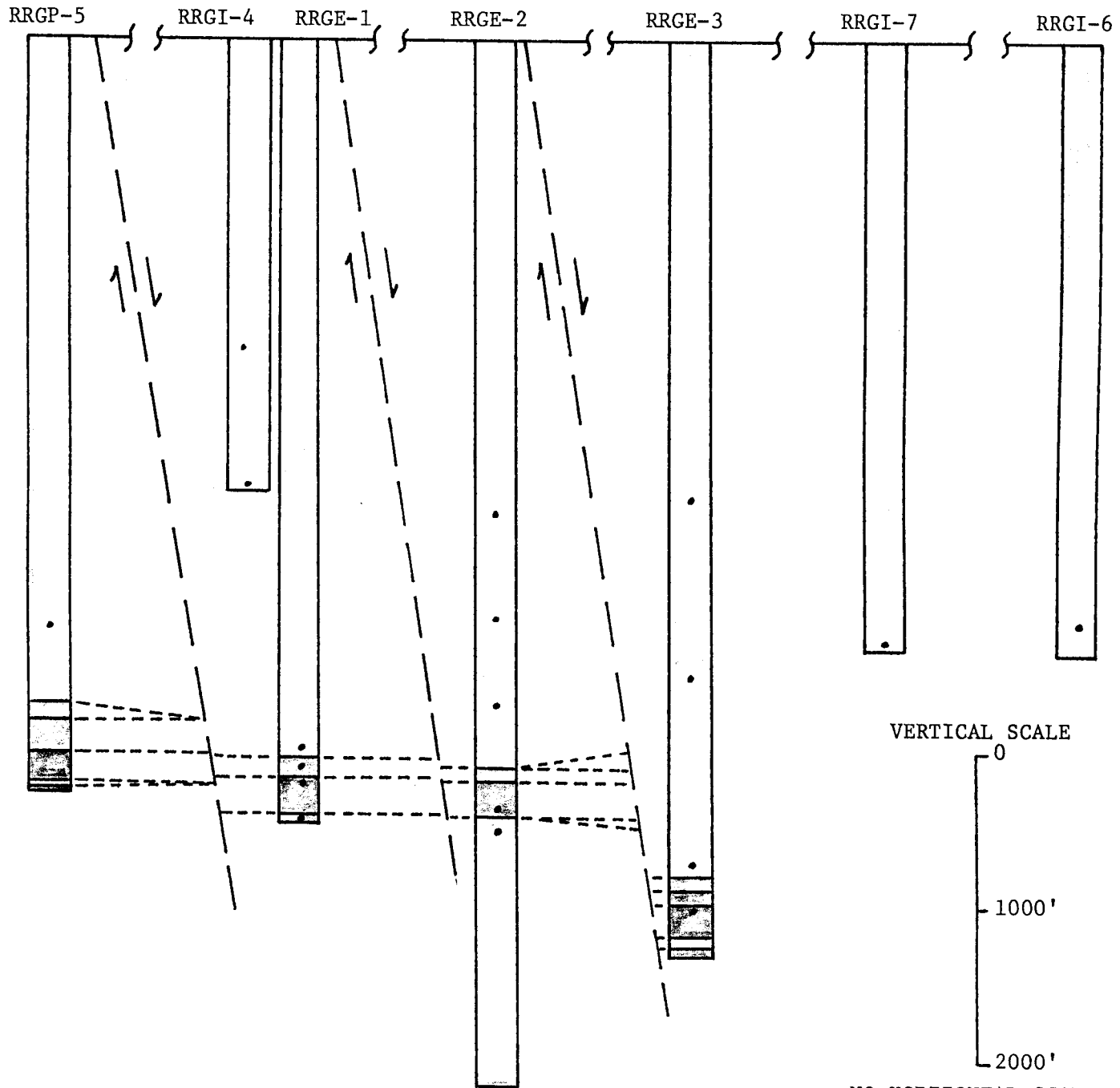


Figure 6. Cross-section of deep wells in the Raft River basin.

The lower member of the Salt Lake Formation consists of gray and white thin-bedded to massive tuffaceous sandstone with interbeds of claystone and siltstone, and some conglomerate with clasts of quartzite, dolomite, limestone, and schist.

Precambrian Rocks. Covington (1977a, 1977b, 1977c, 1977d, 1978, 1979a, 1979b, 1979c, 1979d) has equated the Precambrian rocks underlying the Salt Lake Formation in the Raft River basin to those exposed in the Raft River and Albion Ranges. The Precambrian rock units are described below from youngest to oldest.

The Quartzite of Yost is a white quartzite with moderate muscovite containing up to 10 percent K-feldspar (Compton, 1972). Thin sections show carbonate cement and veins of calcite associated with silica (Fig. 3).

The Schist of the Upper Narrows is a dark-brown to gray, fine- to medium-grained biotite schist and fine-grained gneiss containing quartz or quartz-feldspar lenses (Compton, 1972) (Fig. 4).

The Elba Quartzite is a white, tan, or pale-green quartzite with some interbeds of muscovite-quartz schist (Compton, 1972) (Fig. 5). Thin sections from the Raft River area show this unit also consists of quartzo-feldspathic gneiss with porphyroblasts surrounded by mortared quartz grains.

The Older Schist is brown mica-rich schist composed of muscovite-biotite-quartz schist, mica-plagioclase-microcline-quartz schist, and muscovite-quartz schist (Compton, 1972).

The Quartz Monzonite is a light to dark greenish-gray quartzo-feldspathic gneiss with K-feldspar porphyroblasts surrounded by mortared quartz and a trace of pyrite and magnetite.

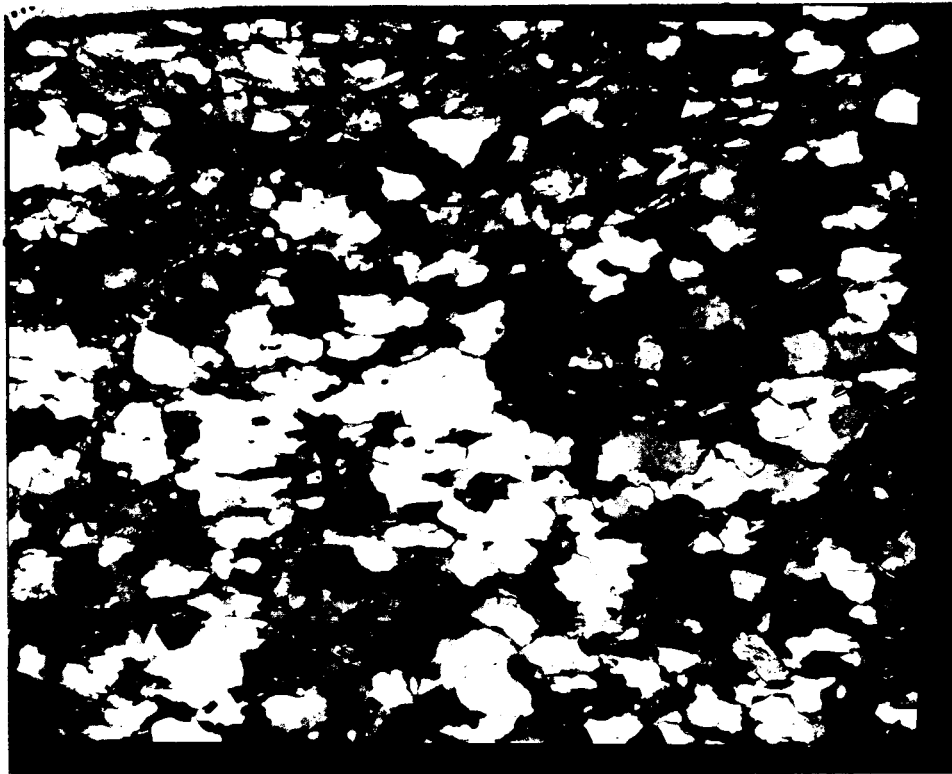


Figure 3. Example of quartzite schist from the Quartzite of Yost (RRGP-4B 4655). Crossed-nichols. Length of picture is 2.0mm.

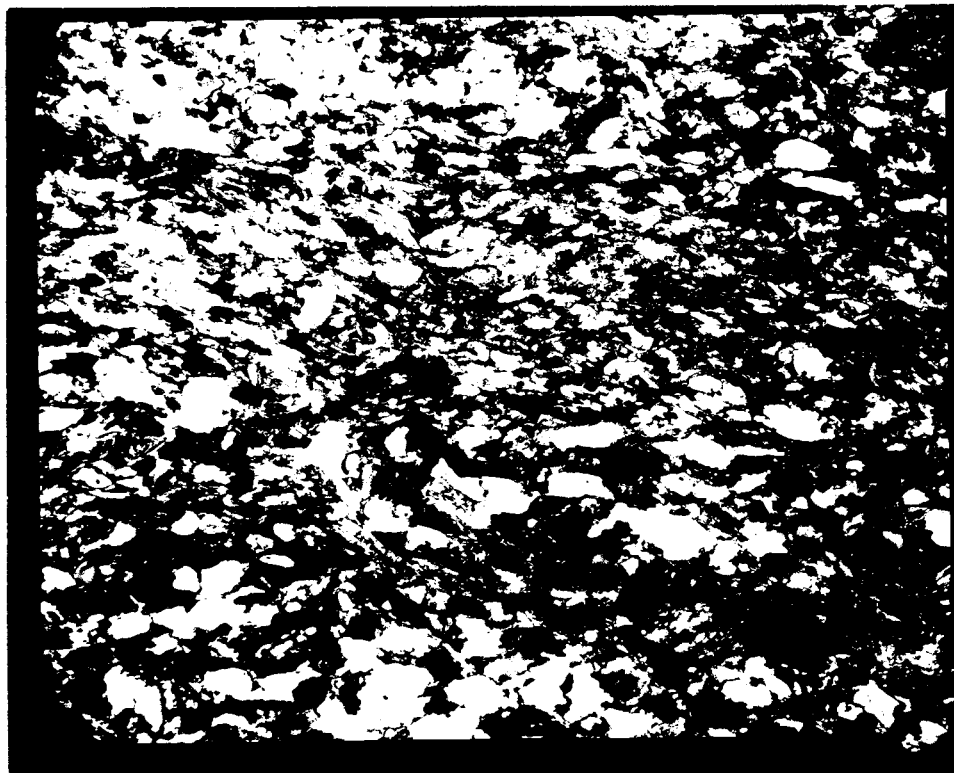


Figure 4. Example of quartzite schist from the Schist of the Upper Narrows (RRGE-1 4698). Crossed-nichols.

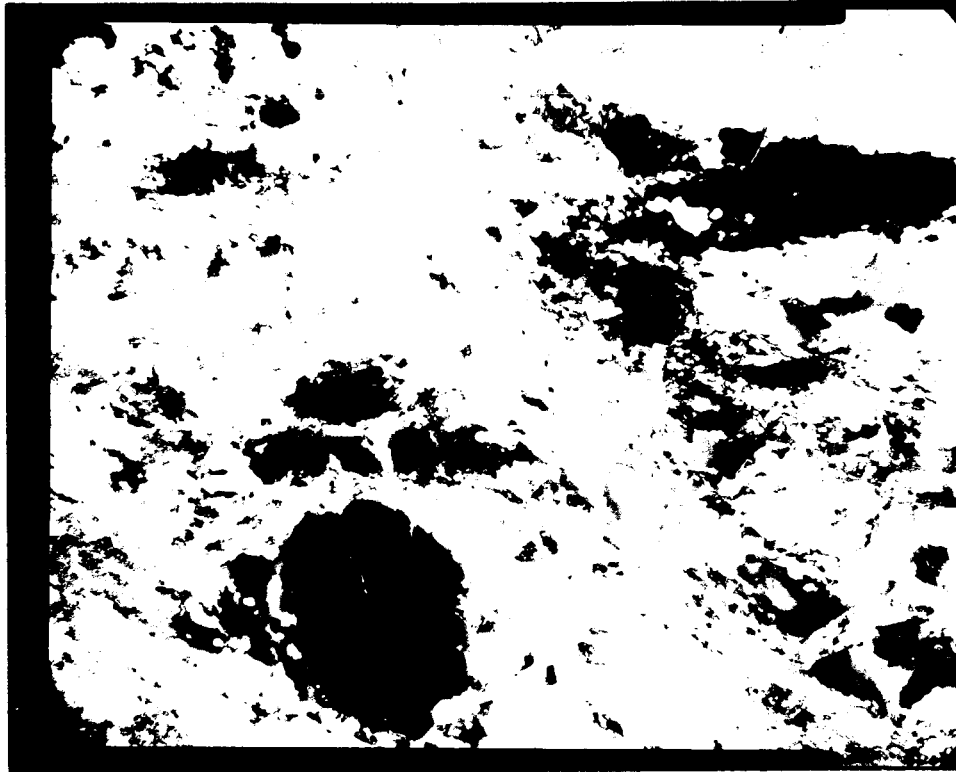


Figure 5. Example of quartzite altering to carbonate and muscovite from the Elba Quartzite (RRGE-3C 5550). Crossed-nichols. Lenth of picture is 2.0mm.

LITHOLOGIES

Several lithologies are noted for rocks found in drill holes from the Raft River basin. The lithologies discussed below are only those described in thin section. Figure 6 is a cross-section of drill holes RRGE-1, RRGE-2, RRGE-3, RRG1-4, RRG1-5, RRG1-6, and RRG1-7 based on lithologic logs by Covington (1977a, 1977b, 1977c, 1977d, 1978, 1979a, 1979b, 1979c, 1979d). Also shown are the locations of thin sections studied.

Most of the thin sections studied from the Raft River basin were taken from the Salt Lake Formation. The four major lithologies noted in the thin section are shales, siltstones, sandstones, and tuffs. Gravels and conglomerates are also important lithologies in the Salt Lake Formation and are described by Covington (1977a, 1977b, 1977c, 1977d, 1978, 1979a, 1979b, 1979c, 1979d).

Shales

The shales examined contain sparse silt- and fine sand-sized grains dispersed in a matrix of clay or ash. The clay may be an alteration product of the ashy matrix. Table 1 shows the modes and locations of shales examined in thin section. The grains are well sorted and subangular. Many shales are interbedded with siltstones. Figure 7 shows a typical laminated shale and siltstone from the Salt Lake Formation. Secondary (probably diagenetic) minerals are pyrite and calcite. The calcite occurs as veins filling fractures and as an alteration product of clay. Fossil fragments are rare.

Table 1 - Mineralogical Composition of Shales based on estimated Modal Analyses

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	<u>H</u>	<u>I</u>	<u>J</u>	<u>K</u>	<u>AVE</u>
Quartz	9	11	5	8	-	3	7	7	15	4	10	7
Feldspar	6	9	4	4	-	2	7	10	10	6	9	6
Muscovite	11	5	2	2	-	1	2	11	6	9	5	5
Pyrite	3	3	3	3	-	10	4	5	6	5	6	4
Calcite	2	7	24	41	-	23	11	5	18	14	tr	13
Clay	67	65	62	42	100	31	35	31	21	29	35	48
Ashy Matrix	-	-	-	-	-	30	34	30	20	29	35	16
Other	2	-	-	-	-	-	-	1	4	4	-	1

<u>Drill Hole</u>	<u>Depth in ft.</u>
A - RRGE-1	4509
B - RRGE-1	4515
C - RRGE-2	4373
D - RRGE-2	5160
E - RRGs-3	1251
F - RRGE-3C	5269
G - RRGP-4	4646
H - RRGi-6	3005
I - RRGi-6	3015
J - RRGi-6	3017
K - RRGi-6	3087

Siltstones

Table 2 shows the modes of grains and matrix found in siltstones from the Salt Lake Formation. Most of the samples are well sorted with subangular grains dispersed in a clay or ashy matrix. The clay may be an alteration product of the ashy matrix. Much of the ash and clay matrix has altered to calcite. Zeolites also occur in some samples and are associated with the calcite veins. Secondary pyrite is present in all siltstones and sometimes forms pyrite-rich beds (Fig. 8). Organic material occurs and where present lies parallel to the bedding. The siltstones usually show signs of compaction by the orientation of elongate grains. Fossils are rarely found in thin section except in drill hole RRG-5. Most fossils are distorted by compaction but appear to be ostracods and/or pelecypods.

Sandstones

The majority of sandstones investigated in thin section from the Salt Lake Formation are feldspathic graywackes and lithic wackes. Figure 9 is a typical graywacke of the Salt Lake Formation. The classification of Pettijohn, Potter, and Siever (1972) was used to name the sandstones. The wackes are those sandstones with greater than 15 percent matrix. Feldspathic graywackes also contain more than 15 percent feldspar and lithic wackes contain more than 15 percent rock fragments.

Table 3 shows the modes and locations of the coarser-grained graywackes from the Salt Lake Formation. The grains are subangular with a matrix of clay or ash partly altered to calcite (Fig. 10). No calcite veins are present in the graywackes. Secondary pyrite occurs, but in

Table 2 - Mineralogical Composition of Siltstones based on estimated Modal Analyses

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	<u>H</u>	<u>I</u>	<u>J</u>	<u>K</u>	<u>L</u>
Quartz	31	21	24	11	25	17	30	19	20	4	5	7
Feldspar	20	21	13	11	7	17	29	34	21	3	4	6
Muscovite	4	1	4	7	4	10	6	6	6	5	8	6
Pyrite	6	5	8	7	5	8	7	8	6	7	11	7
Calcite	18	9	14	4	27	24	8	11	10	46	16	17
Clay	21	43	-	25	31	10	8	-	-	35	56	57
Ashy Matrix	-	-	31	35	-	9	7	22	34	-	-	-
Other	-	-	6	-	1	5	5	-	3	-	-	-

	<u>Drill Hole</u>	<u>Depth in ft.</u>		<u>Drill Hole</u>	<u>Depth in ft.</u>
A -	RRGE-1	4509	G -	RRGI-6	3084
B -	RRGE-2	4227	H -	RRGI-6	3085
C -	RRGS-3	705	I -	RRGI-6	3086
D -	RRGE-3	2804	J -	RRGP-5	3727
E -	RRGI-4	2849	K -	RRGP-5	3729
F -	RRGI-6	3022	L -	RRGP-5	3730

Table 2 - continued.

	<u>M</u>	<u>N</u>	<u>O</u>	<u>P</u>	<u>Q</u>	<u>R</u>	<u>S</u>	<u>T</u>	<u>U</u>	<u>V</u>	<u>W</u>	<u>X</u>	<u>AVE</u>
Quartz	2	3	5	2	13	2	4	2	6	2	3	18	12
Feldspar	2	2	2	2	10	2	3	1	1	1	2	18	10
Muscovite	4	6	4	5	5	8	3	2	tr	1	2	5	5
Pyrite	8	7	9	7	4	8	5	1	1	5	4	5	5
Calcite	12	9	21	12	23	13	9	11	37	23	25	18	17
Clay	72	73	59	36	45	67	76	-	-	-	-	-	30
Ashy Matrix	-	-	-	36	-	-	-	83	55	68	63	25	20
Other	-	-	-	-	-	-	-	-	-	-	1	11	1

	<u>Drill</u>	<u>Depth</u>		<u>Drill</u>	<u>Depth</u>
	<u>Hole</u>	<u>in ft.</u>		<u>Hole</u>	<u>in ft.</u>
M -	RRGP-5	3731	S -	RRGP-5	3738
N -	RRGP-5	3732	T -	RRGP-5	3739
O -	RRGP-5	3733	U -	RRGP-5	3740
P -	RRGP-5	3734	V -	RRGP-5	3741
Q -	RRGP-5	3735	W -	RRGP-5	3742
R -	RRGP-5	3736	X -	RRGI-7	3832

Table 3 - Mineralogical Composition of Graywackes based on estimated Modal Analyses

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	<u>H</u>	<u>I</u>	<u>J</u>	<u>K</u>	<u>L</u>	<u>M</u>	<u>N</u>	<u>O</u>	<u>AVE</u>
Quartz	45	39	36	18	34	23	6	15	8	10	16	18	31	24	15	23
Feldspar	19	25	7	20	14	27	6	22	7	10	18	23	23	24	36	19
Rock Fragments	6	10	4	7	18	15	19	8	18	31	-	10	21	25	39	12
Matrix	17	16	28	36	8	29	44	35	25	47	58	39	15	25	39	31
Micas	5	4	8	6	8	3	-	7	6	2	5	7	2	5	3	5
Other	8	6	17	13	18	3	25	13	36	-	3	3	8	22	1	10

	<u>Drill Hole</u>	<u>Depth in ft.</u>		<u>Drill Hole</u>	<u>Depth in ft.</u>
A -	RRGE-2	3722	H -	RRGI-6	3011
B -	RRGE-2	3733	I -	RRGI-6	3025
C -	RRGI-4	2847	J -	RRGI-6	3082
D -	RRGI-4	4643.5	K -	RRGI-7	3833
E -	RRGI-4	4647	L -	RRGI-7	3834
F -	RRGI-4	4655u	M -	RRGI-7	3837
G -	RRGP-5	3743	N -	RRGI-7	3840
			O -	RRGI-7	3843

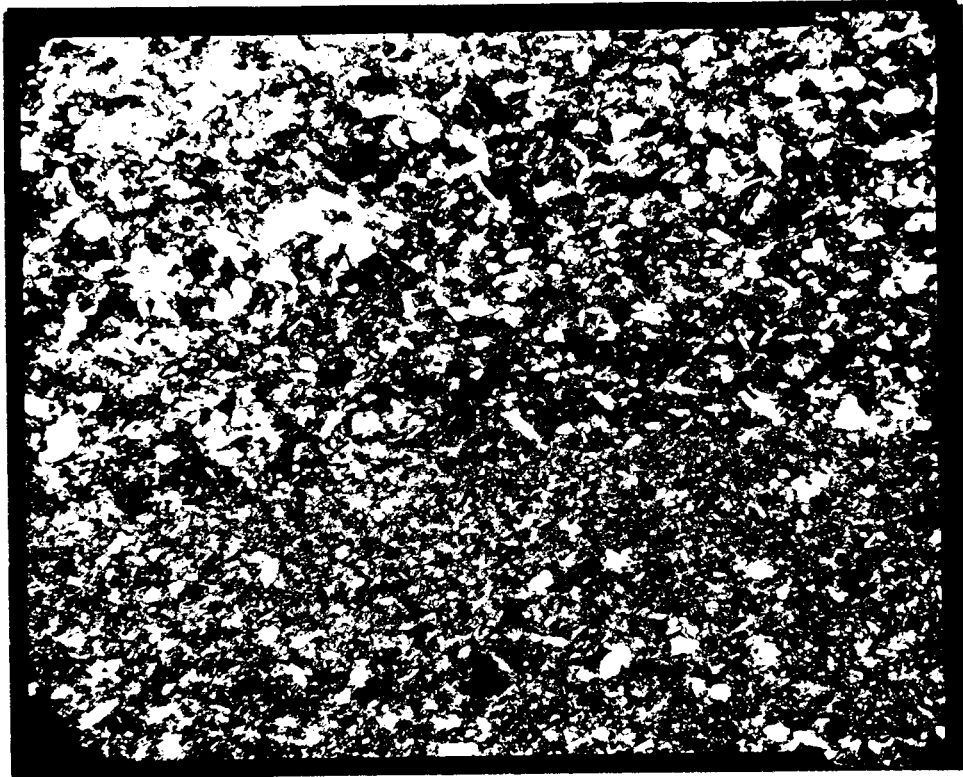


Figure 7. Typical laminated shale and siltstone from the Salt Lake Formation (RRGI-6 3015). Crossed-nichols. Length of picture is 2.0mm.



Figure 8. Secondary pyrite-rich bed in siltstone (RRGI-6 3005). Plane light. Length of picture is 2.0mm.

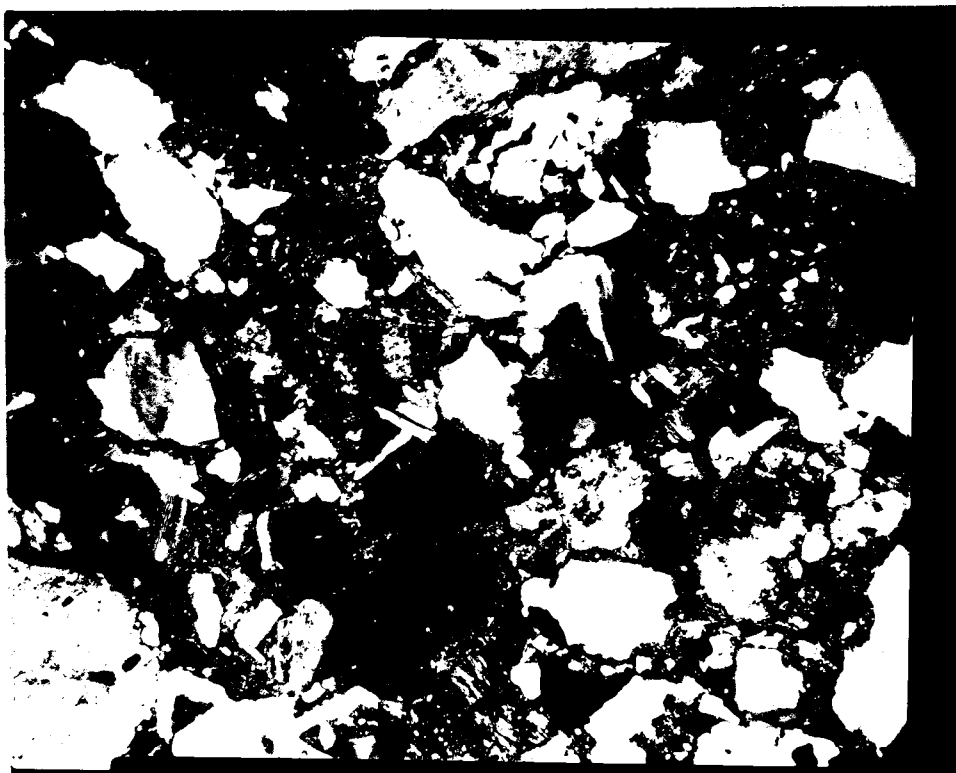


Figure 9. Typical graywacke from the Salt Lake Formation (RRGE-2 3722). Crossed-nichols. Length of picture is 2.0mm.

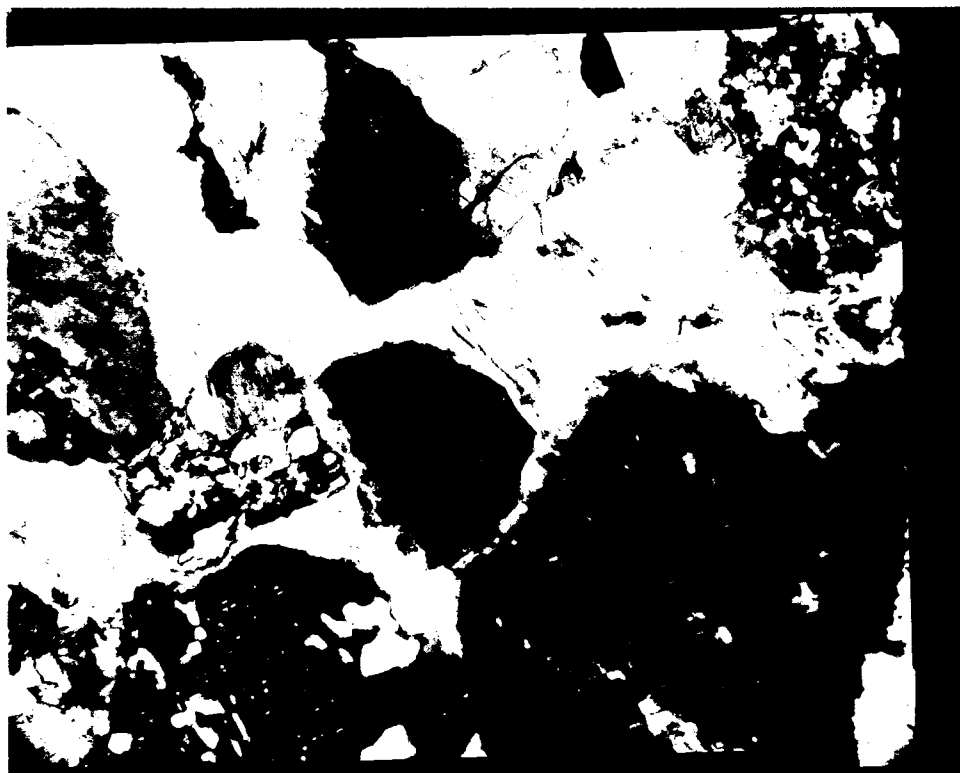


Figure 10. A graywacke with matrix altered to calcite (RRGI-7 3843). Crossed-nichols.

smaller amounts than in the finer-grained sediments. Rock fragments are found in most graywackes and usually consist of metamorphic, plutonic, and volcanic rocks. Some limestone fragments are found in wells RRG1-6 and RRG1-7 located farther east in the basin. No signs of compaction are present in the graywackes. Fossil fragments are absent from the coarser-grained sediments. Volcanic glass shards, commonly altered to calcite, are present in many of these sediments.

Very few arenites were examined, but the few that were are fine-grained and well sorted, with more calcite cement than the graywackes. The arenites are usually found as very thin beds interbedded with siltstones and contain less than 15 percent matrix.

Tuffs

The distinction between tuffaceous sandstones and sandy tuffs is difficult. For this investigation, the authors based the distinction on the appearance of the matrix and the grains present. Thin sections were identified as a tuff if the matrix is mostly ash with little alteration and few grains dispersed in the matrix. Figure 11 is a typical tuff found in thin section.

Most of the tuffs identified in thin section are from RRG3-3. This drill hole also contained a sample of a volcanic rock which is probably from a lava flow (Williams and others, 1976). Figure 12 shows this sample which consists of equant plagioclase phenocrysts in an aphanitic perlitic groundmass.

Table 4 gives the modes and locations of tuffs identified in thin section. Many of the tuffs are composed of very fine-grained ashy material with few or no grains present. Some contain abundant glass

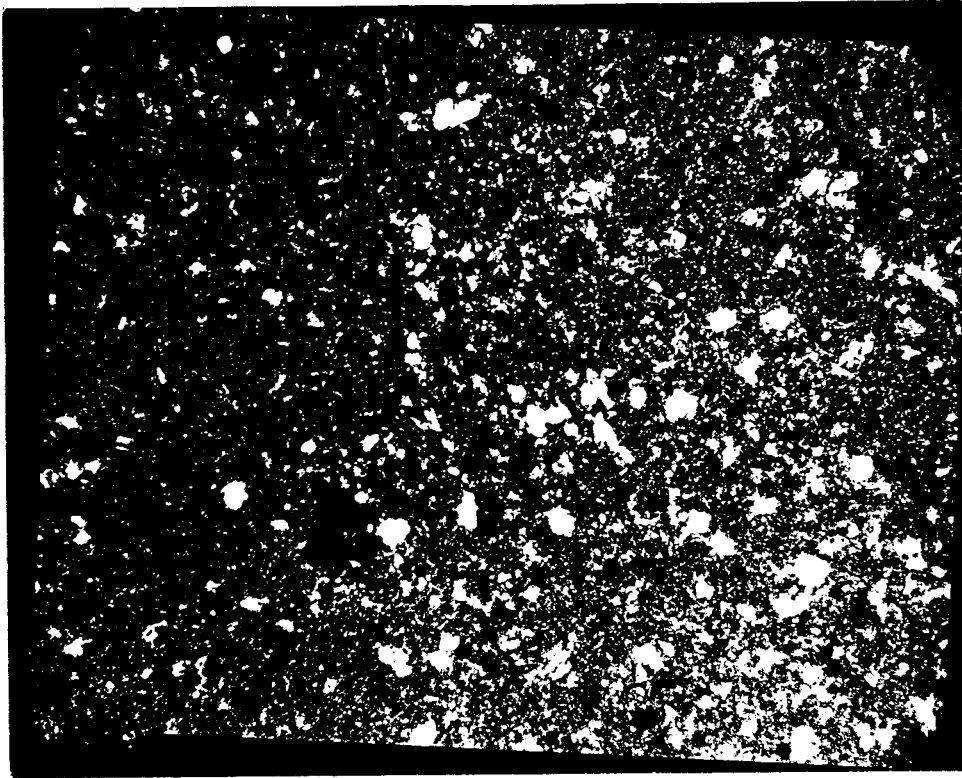


Figure 11. Typical tuff from the Salt Lake Formation (RRGE-2 3074). Crossed-nichols. Length of picture is 2.0mm.



Figure 12. A volcanic rock showing equant plagioclase phenocrysts in an aphanitic devitrified groundmass (RRGS-3 1330).

Table 4 - Mineralogical Composition of Tuffs based on estimated Modal Analyses

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	<u>H</u>	<u>I</u>	<u>J</u>	<u>K</u>	<u>L</u>	<u>M</u>	<u>N</u>	<u>O</u>	<u>P</u>	<u>Q</u>	<u>R</u>	<u>S</u>	<u>AVE</u>
Quartz	5	8	23	-	19	7	3	3	9	12	3	1	1	2	17	1	7	6	14	7
Feldspar	2	tr	12	tr	31	6	2	1	33	tr	2	3	22	4	5	tr	1	6	20	8
Muscovite	tr	1	tr	-	2	1	2	tr	1	3	1	-	-	-	1	-	1	-	8	1
Pyrite	tr	2	tr	-	tr	2	3	-	tr	10	9	8	4	5	4	2	6	18	6	4
Calcite	4	-	tr	-	-	-	-	-	37	-	-	-	-	35	9	1	-	7	10	5
Clay	-	-	-	-	-	-	-	-	-	-	-	-	-	54	-	-	-	-	-	3
Ashy Matrix	72	89	61	100	41	82	62	93	-	75	84	88	63	-	59	94	85	44	34	65
Other	17	-	4	-	7	2	28	3	20	-	1	-	10	-	5	2	-	19	8	7

<u>Drill Hole</u>	<u>Depth in ft.</u>	<u>Drill Hole</u>	<u>Depth in ft.</u>
A - RRGE-1	4505	K - RRGs-3	1147
B - RRGE-2	3074	L - RRGs-3	1219
C - RRGs-3	498	M - RRGs-3	1330
D - RRGs-3	560.5	N - RRGs-3C	4979
E - RRGs-3	792	O - RRGE-3C	4992
F - RRGs-3	846	P - RRGE-3C	5267
G - RRGs-3	902	Q - RRGE-3C	5268
H - RRGs-3	918	R - RRGP-5	3743
I - RRGs-3	956	S - RRGi-7	3830X
J - RRGs-3	1079		

shards and some contain none. Small amounts of calcite alteration are present in some tuffs, as are zeolite veins. Compaction is indicated by the orientation of elongate grains parallel to the bedding. No textures or structures are present to indicate if these tuffs are of ash-fall or ash-flow origin, and it is presumed that most are water lain.

MINERALOGY

Table 5 is a list of minerals found in thin section from the Salt Lake Formation. The source of these minerals includes all the mountain ranges surrounding the Raft River valley. The petrology section of this report discusses the sources of the Salt Lake Formation in this area.

Quartz and Feldspar

The most abundant minerals found in thin section are quartz and feldspar. Grains of these minerals are characterized by their subangular shape. The quartz grains have undulatory to non-undulatory extinction. Some grains are polycrystalline. A wide variety of feldspars are present including plagioclase, microcline, orthoclase, and sanidine. Many of the feldspar grains show alteration to calcite or sericite.

Muscovite and Biotite

The micas are the next most abundant minerals found in Salt Lake Formation thin sections with muscovite usually being dominant. They are found in all rock types as detrital grains and are usually sub-rounded and elongate. When found in the shales and siltstones, they usually parallel the bedding and indicate compaction of the sediments.

Table 5 - List of constituents found in rocks of the Salt Lake Formation

<u>MAJOR CONSTITUENTS</u>		<u>MINOR CONSTITUENTS</u>
QUARTZ	ASHY MATRIX	ZEOLITES
PLAGIOCLASE	CLAY MATRIX	GLASS SHARDS
ORTHOCLASE	CARBONATE CEMENT	PUMICE LUMPS
MICROCLINE	ROCK FRAGMENTS	FOSSILS
SANIDINE	ZIRCON	APATITE
MUSCOVITE	MONAZITE	AUGITE
BIOTITE	EPIDOTE	TRIDYMIT
PYRITE	CHLORITE	DIOPSIDE
		HORNBLLENDE
		GARNET

Muscovite and biotite are also present in the metamorphic basement rocks. Usually these minerals have a parallel orientation or schistosity but sometimes form as alteration products, especially in the quartzites.

Opaques

Opaque grains in the Salt Lake Formation are predominantly secondary pyrite. Individual grains vary from euhedral to rounded. The very fine-grained rounded pyrite grains form masses in some laminated fine-grained sediments (Fig. 8). Secondary pyrite is found in all lithologies of the Salt Lake Formation. Sometimes the secondary pyrite is associated with calcite. Detrital pyrite also occurs in the sediments but is minor in abundance.

Organic material occurs in the Salt Lake Formation, most commonly in siltstone. This material is very small and elongate, always parallel to the bedding. The presence of organic material and secondary pyrite-rich beds suggests a reducing environment existed at some point during the depositional history of the Salt Lake Formation.

Pyrite is also found in the metamorphic basement rocks but to a lesser extent than other opaques. More abundant in these rocks (but in small amounts) are hematite, magnetite, and leucoxene.

Other Minerals

Other minerals noted in Salt Lake Formation sediments include monazite, zircon, pyroxene, zeolites, chlorite, epidote, hornblende, garnet, and cristobalite (or tridymite).

Most of these minerals occur only in trace amounts and are found in varying lithologies. The monazite, zircon, epidote, pyroxene, hornblende, and garnet are found in siltstones and sandstones. All these grains are subrounded except zircon which is usually subangular to euhedral.

Zeolite grains are found only in veins and are usually associated with calcite but sometimes occur alone. They are euhedral and bladed with parallel extinction. They are also length fast with a negative sign and are probably stilbite.

Chlorite seldom occurs as individual grains and is usually associated with biotite. Alteration of biotite to chlorite indicates these grains are derived from metamorphic rocks as the temperatures and pressures necessary for this transformation are not reached during diagenesis.

Cristobalite or tridymite are found only in tuffs from drill hole RRG-3. When present, it appears to be an alteration product of the ashy matrix and sometimes occurs in very small veins.

Fossils

Fossils are rare in the Salt Lake Formation sediments except for in siltstones from drill hole RRGP-5. When present, they are difficult to identify because of distortion due to compaction. Williams and others (1976) have identified ostracods in Salt Lake Formation outcrops in the Jim Sage Mountains. The fossils found in thin section appear to be ostracods and/or pelecypods.

Glass Shards

Glass shards occur in varying amounts in all lithologies of the Salt Lake Formation except shales. When present, they are either glassy, divitrified, or completely altered to calcite (Fig. 13).

SEDIMENTARY STRUCTURES

Primary Structures

Bedding in the shales and siltstones varies from massive to very thin. The very thin laminated beds are 2 to 3 mm in thickness and are seldom graded (Fig. 7). The coarser-grained graywackes are massive-bedded and show normal and reverse grading.

Deformational Structures

Most deformational structures are present in outcrop, however, a few show up in thin section and in drill core. The most common sedimentary structures observed in thin section, drill core, and outcrop are microfaults. Also noted in drill core are breccias. These two types of structures indicate slumping of steeply dipping sediments. Ball and pillow structures are noted in thin section and outcrops. They consist of fine-grained sediments forming pseudonodules that sink into an underlying semi-fluid bed. These structures require a sudden downward movement which may be catastrophic. Convolute laminations are present in drill core and outcrop and suggest a readjustment of material in a quick condition although an exact interpretation is unknown. Sandstone dikes are present in outcrop BP-1 (see Appendix 2) and occur when water-saturated sands are injected into an overlying unit that has been fractured



Figure 13. Glass shards altered to calcite in a siltstone (RRGI-6 3025). Crossed-nichols. Length of picture is 2.0mm.

by some shock. The sandstone dikes observed in outcrop are not straight-walled indicating they were injected prior to consolidation (Pettijohn, Potter, and Siever, 1973).

DISCUSSION

Sediments of the Salt Lake Formation are characterized by sub-angular quartz and feldspar grains and secondary minerals formed probably during diagenesis. No thin sections were examined that had rounded quartz and feldspar grains and very few lack secondary or diagenetic minerals.

Petrology

All lithologies in the Salt Lake Formation contain varying amounts of clay, ash, and carbonate cement. Figure 14 shows the modal relationship of these three constituents to the shales, siltstones, and tuffs of the Salt Lake Formation. Sandstones usually contain no clay so they are not included in this diagram. Shales usually contain clay and calcite with a few samples containing minor amounts of ash. The siltstones contain varying amounts of all three constituents with the majority containing more ash and clay and less calcite. The tuffs contain trace amounts of clay if present at all. They are comprised mostly of ash and carbonate.

The shales, siltstones, and sandstones of the Salt Lake Formation also show a relationship between quartz and feldspar grains and carbonate with depth. Figure 15 illustrates this modal relationship. A decrease in percentage of quartz and feldspar grains and an increase in carbonate is noted with depth in the Raft River basin.

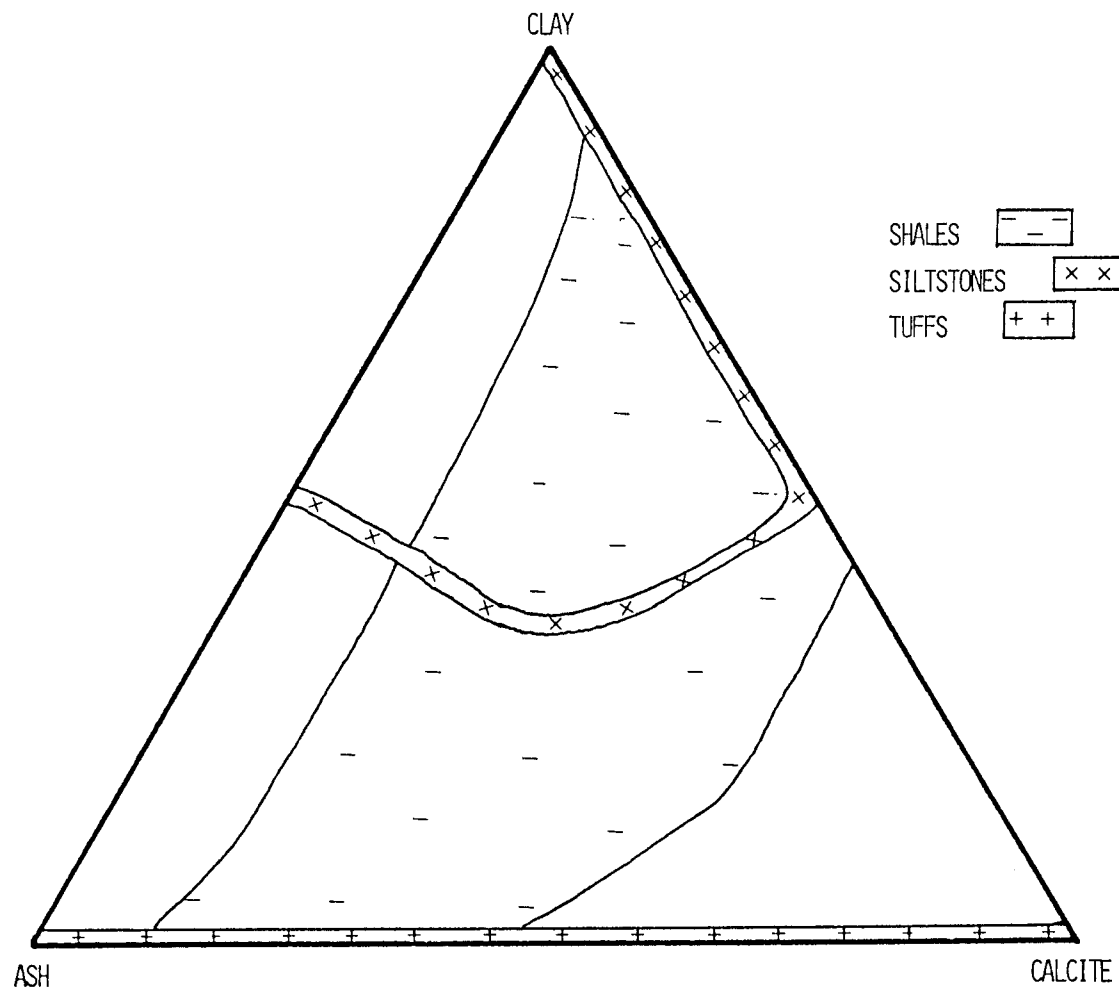


Figure 14. Mutual proportions of clay, ash, and calcite to shales, siltstones, and tuffs of the Salt Lake Formation.

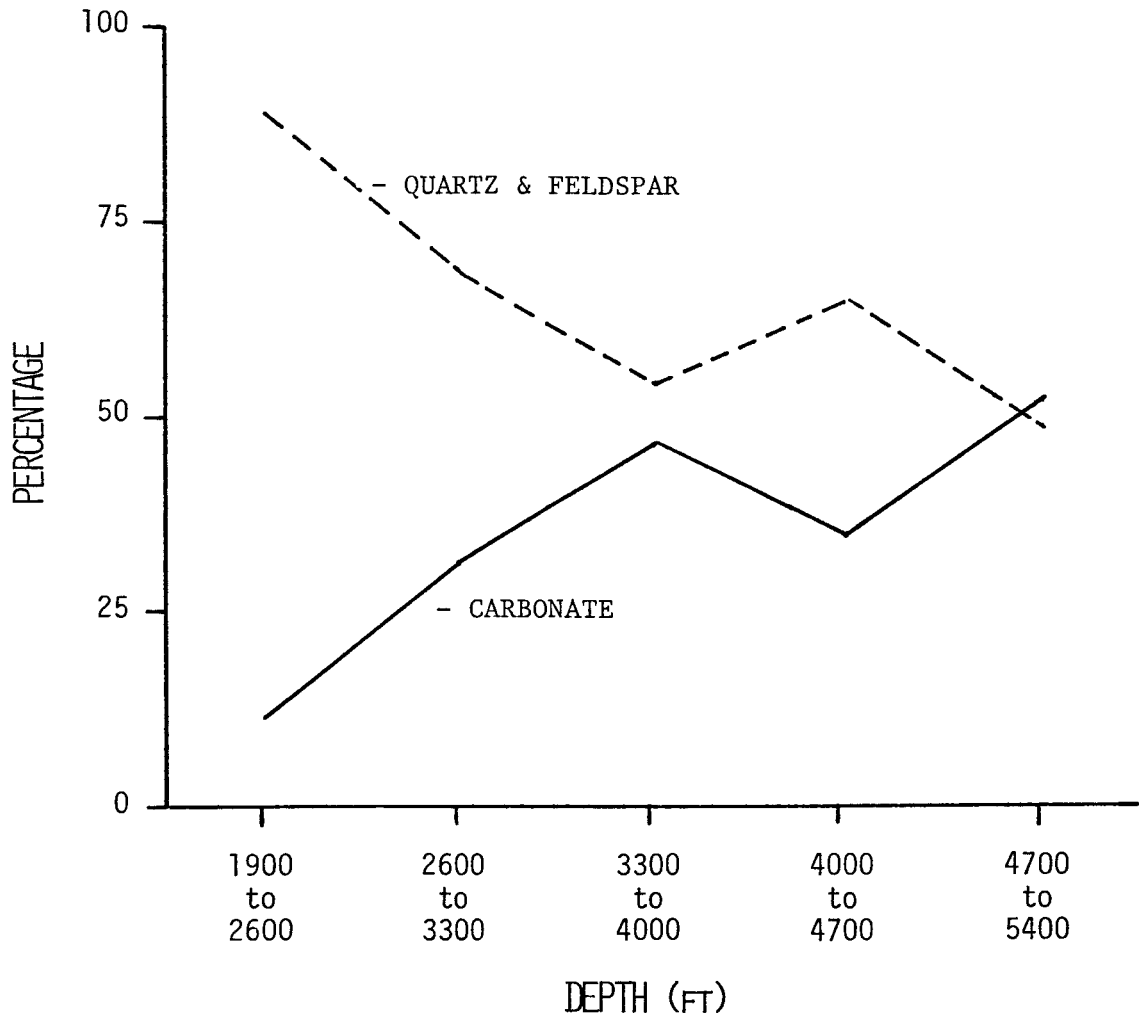


Figure 15. Modal relationship of quartz and feldspar and carbonate in shales, siltstones, and sandstones with depth.

The major constituents of all rock-types in the Salt Lake Formation are quartz and feldspar, matrix, and carbonate cement. Figures 16 and 17 illustrate where each rock-type falls when plotted with respect to these three components. The shales contain mostly matrix with some quartz and feldspar but usually show minor amounts of carbonate. Siltstones show this same trend but generally contain larger amounts of quartz and feldspar. The major components of the sandstones are quartz and feldspar with carbonate and usually lesser amounts of matrix. The tuffs are mostly matrix with little quartz and feldspar and little carbonate.

Examination of quartz grains gives some insight into the provenance of sediments in the Salt Lake Formation. A study by Reimer (1971) illustrates the use of volcanic quartz grains in graywackes as an indicator of provenance. Volcanic quartz grains have non-undulatory extinction and are inclusion-free except for possibly some inclusions of glass. Metamorphic or plutonic quartz grains have undulatory extinction and may contain inclusions. A study of this type is limited to graywackes because of their limited degree of transportation. Larger undulose quartz grains can break down into smaller non-undulose grains during transport. Reimer used only quartz grains above 0.1mm for his study because they would be less likely to lose their undulatory extinction if they were broken down from larger grains.

A similar study has been done on the coarser-grained graywackes found in the Raft River basin. Approximately 150 quartz grains greater than 0.1mm were examined and their extinction and inclusions noted. Also noted were the ratios of volcanic rock fragments to plutonic

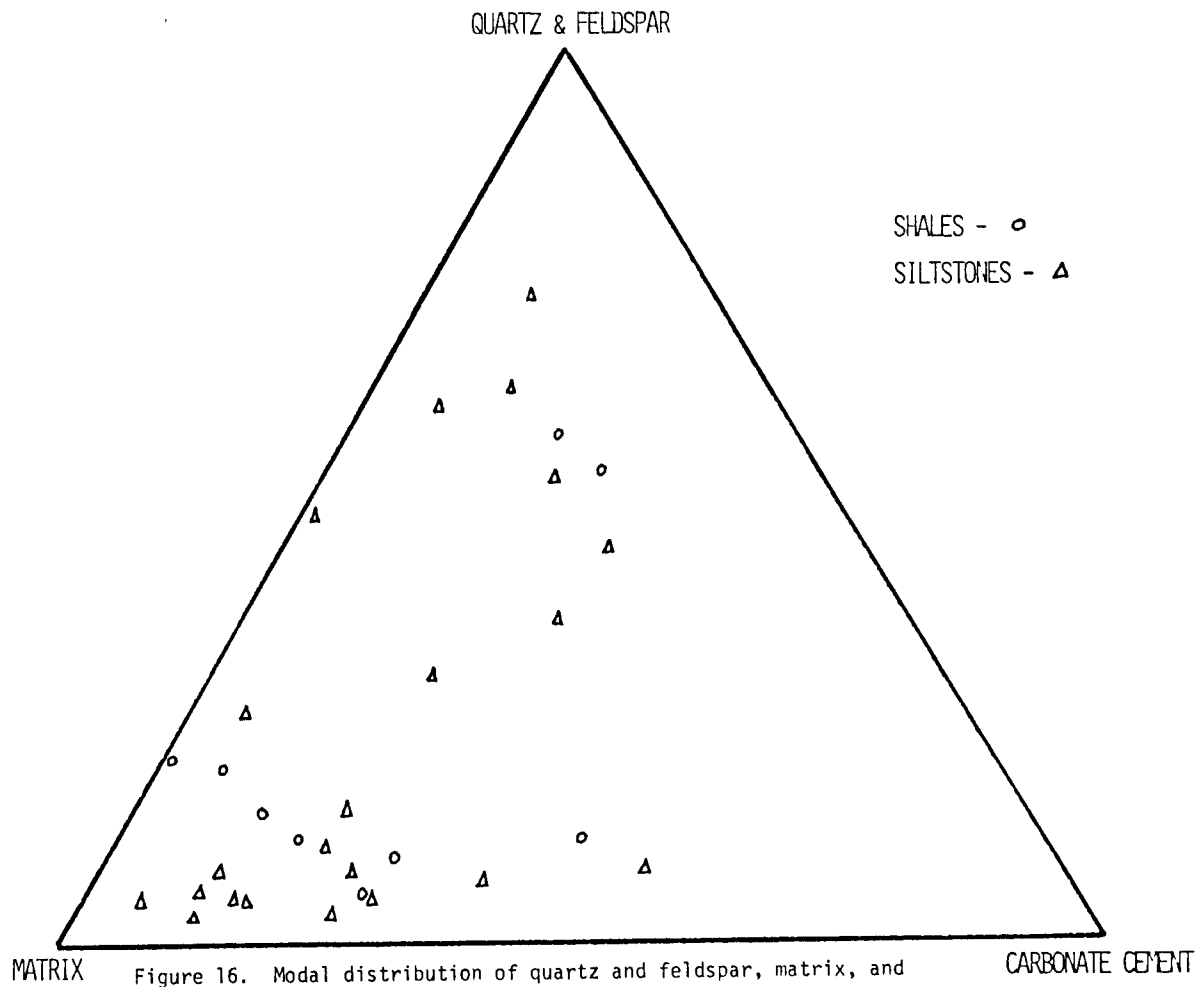


Figure 16. Modal distribution of quartz and feldspar, matrix, and carbonate cement in shales and siltstones of the Salt Lake Formation.

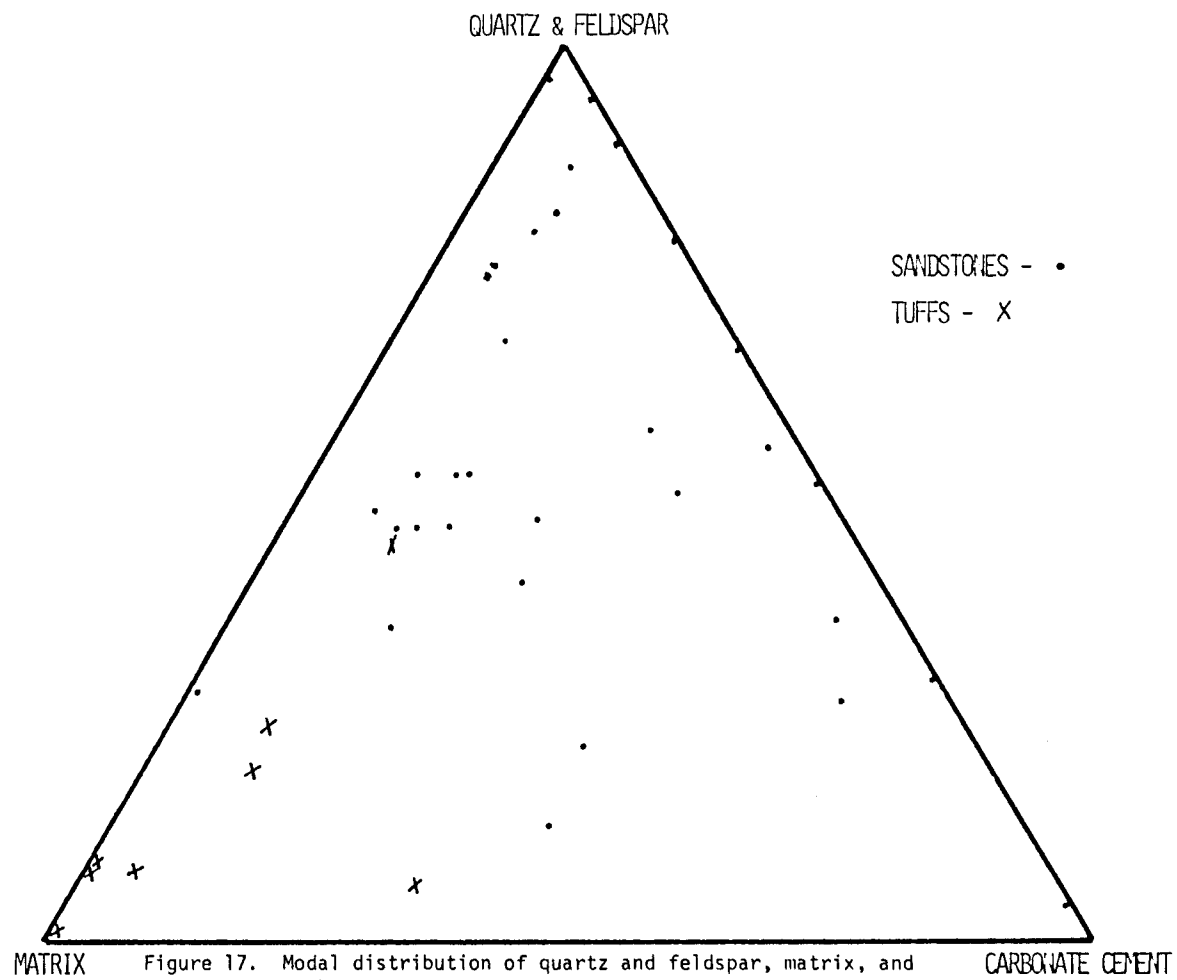


Figure 17. Modal distribution of quartz and feldspar, matrix, and carbonate cement in sandstones and tuffs of the Salt Lake Formation.

and metamorphic rock fragments. Figure 18 illustrates the relationship of volcanic quartz and volcanic rock fragments to plutonic and metamorphic quartz and rock fragments with depth. A gradual increase of volcanic detritus is noted toward the surface.

Feldspar types and shapes of grains also supply information about source rocks. Equant plagioclase and sanidine indicate a volcanic source while orthoclase and microcline are indicative of plutonic and metamorphic source rocks.

Rock fragments are the most easily observed indicators of provenance. Table 6 lists the mountain ranges surrounding the Raft River valley and the types of quartz, feldspar, and rock fragments found in Salt Lake Formation sediments derived from these ranges.

Hydrothermal Alteration

Hydrothermal alteration probably occurs throughout the majority of rocks in the Raft River basin, however, only a few thin sections show definite signs of being hydrothermally altered. Thin sections RRG-3 956, RRG-2 5310, RRG-3C 4979, and RRG-4B 4669.5 show complete or almost complete alteration to calcite. One sample of basement rock, RRG-3C 5268, is almost completely altered to calcite and muscovite.

Clay minerals in the Salt Lake Formation have been identified at Boise State University by X-ray analysis and probably are products of hydrothermal alteration (Jim Saunders, personal communication).

The secondary minerals noted in thin section are believed to have formed from diagenetic processes rather than hydrothermal alteration.

Table 6 - Types of detritus supplied to the Raft River valley from surrounding mountain ranges

<u>MOUNTAIN RANGES</u>	<u>DETRITUS</u>
Sublett and Black Pine Mountains	Limestone and clastic rock fragments
Raft River and Albion Range	Metamorphic and Igneous rock fragments, undulatory quartz, microcline, orthoclase
Jim Sage and Cotterel Mountains	Volcanic rock fragments, non-undulatory quartz, equant plagioclase, sanidine

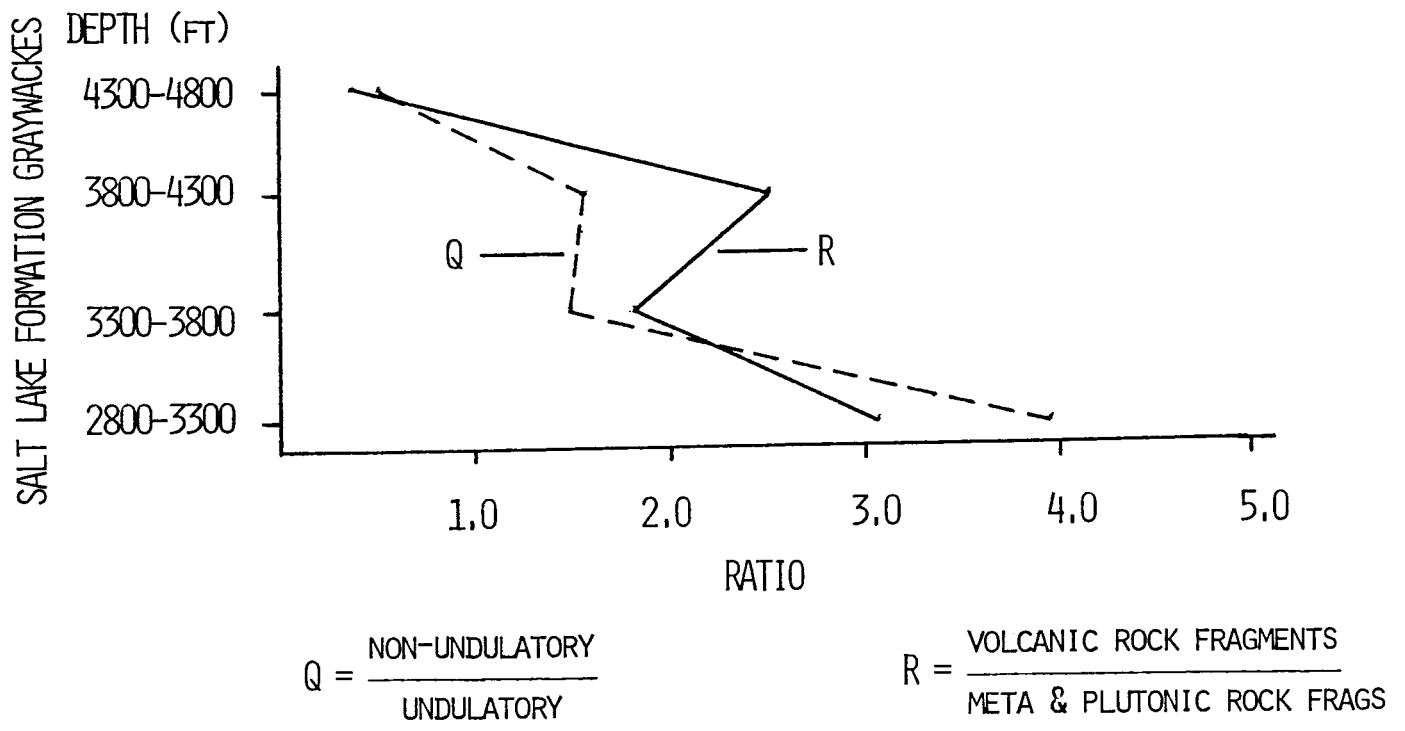


Figure 18. Relationship of volcanic quartz and rock fragments to plutonic and metamorphic quartz and rock fragments with depth.

Diagenetic Minerals

The most prominent secondary minerals found in the Salt Lake Formation are pyrite and calcite.

Calcite is the most abundant secondary mineral occurring as irregular grains altering from the matrix and as veins filling fractures. Some samples show two stages of calcite formation (Fig. 19) and some show calcite rimming individual grains (Fig. 20). Many times, calcite is associated with zeolites filling fractures (Fig. 21).

Secondary pyrite has been discussed in some detail previously. It occurs in nearly all samples of the Salt Lake Formation as euhedral crystals distributed evenly or in masses that parallel bedding. The presence of pyrite in these sediments indicates a non-acid reducing environment.

CONCLUSIONS

Studies of sedimentary structures, mineralogic composition, grain shape, and sorting suggest conditions that may have existed during deposition of the Salt Lake Formation.

The angularity and poor sorting of grains in most sediments suggests rapid deposition of immature sediments. The orientation of micas indicates the sediments were compacted prior to consolidation. Provenance studies show all the ranges surrounding the Raft River valley are probable sources for the sediments.

The formation of secondary pyrite, preservation of organic material, and laminated bedding indicate a reducing environment existed during deposition. Fossils are rare in thin section, except for RRGp-5, which

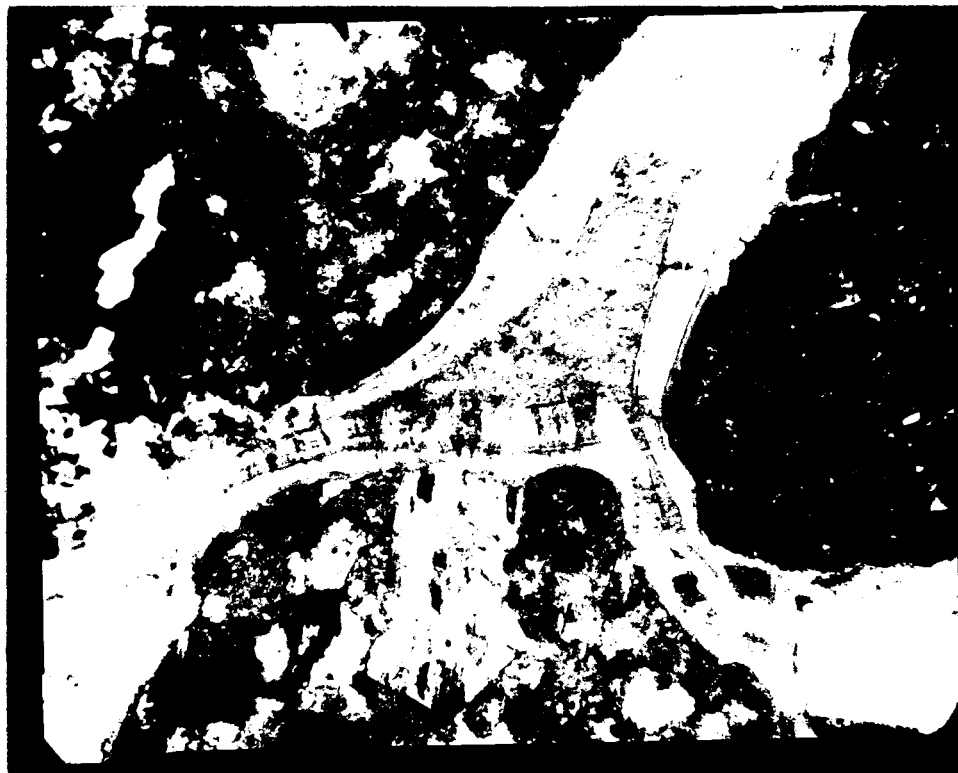


Figure 19. Two stages of calcite formation (RRGI-6 3082).
Crossed-nichols. Length of picture is 2.0mm.

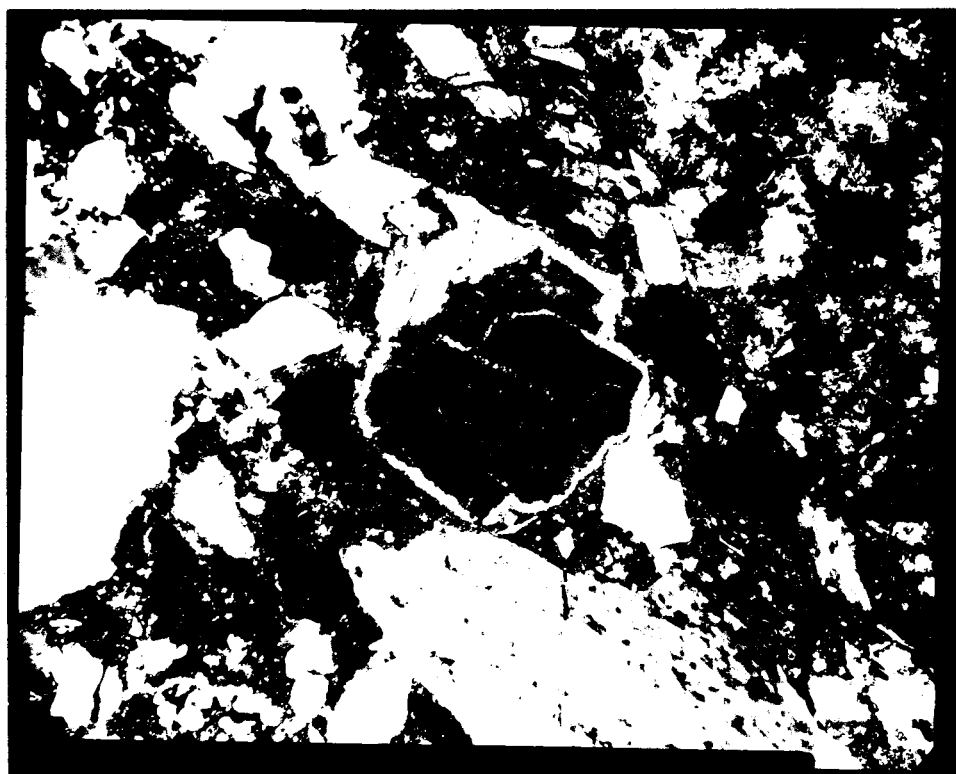


Figure 20. Calcite rimming a feldspar grain (RRGI-6 3080).
Crossed-nichols. Length of picture is 2.0mm.

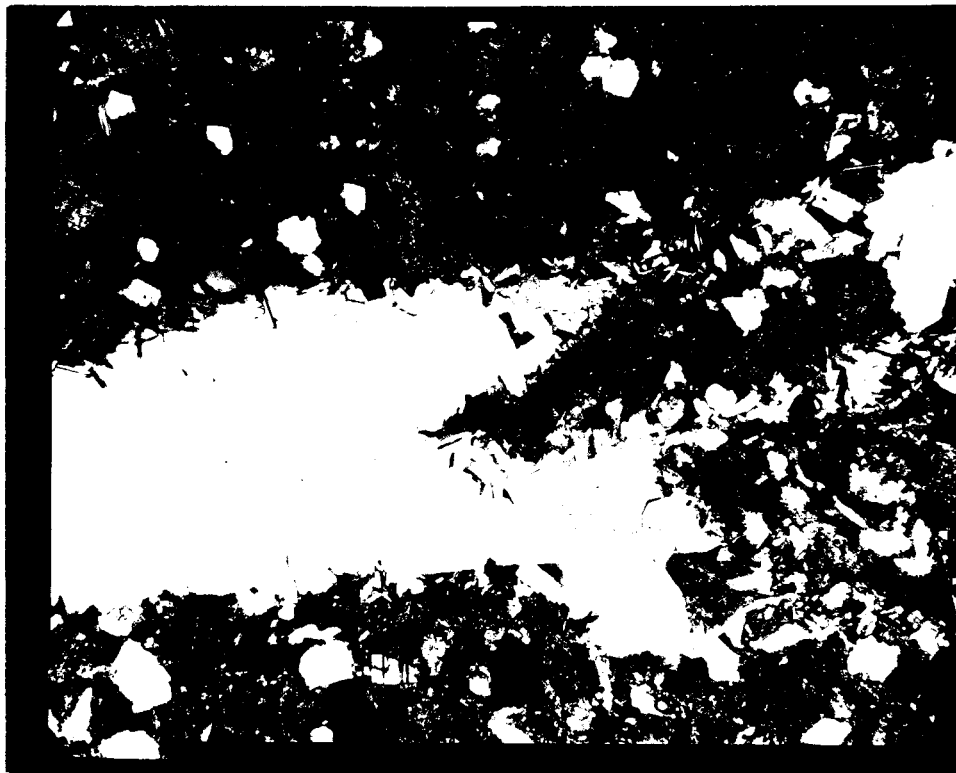


Figure 21. Calcite and zeolites occurring together filling a fracture (RRGE-3C 4992). Crossed-nichols. Length of picture is 2.0mm.

also may suggest a reducing environment at least in the deeper parts of the basin.

The high fossil content of RRG-5 may indicate an area closer to the shoreline. A shallower more oxygenated area such as this would be more advantageous to animal life. Outcrop CT-1 may also be a basin margin as indicated by mudcracks.

The presence of graywackes in the Salt Lake Formation are suggestive of certain sedimentary processes. Graywackes are deposited as instantaneous events and are usually considered to be turbidite deposits. Crook (1970) has established classes of graywackes based on quartz content. The Salt Lake Formation graywackes average 23 percent quartz and fall in the intermediate class being of volcanic and sedimentary provenance.

The sedimentary structures observed in thin section and outcrop indicate rapid deformation of water-saturated sediments. The basin margins probably were steep causing slumping to occur and possibly the formation of turbidites.

The rapid deformation of these sediments may have occurred as shocks or at least very sudden events. The high volcanic content of the sediments (especially glass shards) suggests the shocks were caused by volcanic explosions.

RECOMMENDATIONS

1. A more detailed geologic study of the region surrounding the Raft River valley is needed to show the relationship of the Jim Sage Mountains to the Salt Lake Formation, the relationship of the Jim Sage Mountains to the Cotterel Range, and the relationship of all the mountain ranges surrounding the Raft River valley to the sediments of the Salt Lake Formation.
2. A close investigation of drill chips and cores would develop a stratigraphy within the Salt Lake Formation between drill holes.
3. A study of rock chemistry and experimental work on rock-water interactions would provide information on the water chemistry of the geothermal area.
4. Systematic petrographic/mineralogic studies on chips from the drill holes would provide information for provenance studies.
5. A study of hydrothermal alteration in rock chips would provide information on water temperatures and pressures at different depths.

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APPENDIX 1

THIN SECTION DESCRIPTIONS

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. Lineated 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 - lineated; occurs within mortar textured grains; anhedral; .25mm x .25mm to .05mm x .02mm.

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

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

RR 1-1 4505

A tuff with grains floating in an ashy matrix. Glass shards and portions of the matrix have altered to calcite. Compaction is indicated by the orientation of elongate grains. Zeolites are present in veins. All other grains present are detrital.

The rock consists of 72% matrix, 7% zeolites, 5% quartz, 4% unidentified green mineral, 4% calcite, 2% feldspar, 1% pumice lumps, and traces of zircon, muscovite, monazite, sanidine, and glass shards.

Minerals

Quartz - detrital; subangular to subrounded; .18mm x .15mm
to .02mm x .02mm.

Feldspar - detrital; subangular to subrounded; .14mm x .07mm
to .08mm x .04mm.

Unidentified green mineral - occurs as replacement of glass shards;
subangular to subrounded; .18mm x .12mm to .4mm x .2mm.

Zeolites - secondary; subhedral; .13mm x .03mm to .03mm x .02mm.

Muscovite - detrital; subangular and elongate; .14mm x .02mm
to .02mm x .02mm.

Monazite - detrital; subrounded; .07mm x .06mm to .18mm x .12mm.

Opagues - detrital; subrounded to subangular; .35mm x .17mm
to .02mm x .02mm.

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

RR 1-2 4509

A shale with grains floating in a clay matrix overlain by a siltstone bed. The siltstone shows reversed grading and is 1 to 2mm thick with some calcite present as an alteration product of the matrix. Zeolites occur in veins.

Soft sediment deformation is present as microfaults, ball and pillow structure, and pinching and swelling of the siltstone bed. Compaction is indicated by the orientation of elongate grains.

Calcite, zeolites, and some opaques are secondary with all other grains being detrital. The clay bed consists of 67% matrix, 11% muscovite, 9% quartz, 6% feldspar, 3% opaques, 2% calcite, 2% zeolites, and a trace of orthoclase and microcline. The siltstone consists of 31% quartz, 21% matrix, 20% feldspar, 18% calcite, 6% opaques, 4% muscovite, and a trace of microcline.

Minerals

Quartz - detrital, subangular to subrounded; .12mm x .12mm to .02mm x .02mm.

Muscovite - detrital; subangular and elongate; 1mm x .04mm to .02mm x .04mm.

Opaques - detrital and secondary; subangular to subrounded; .6mm x .2mm to .02mm x .02mm.

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

Zeolites - secondary; subangular; .07mm x .02mm to .02mm x .02mm.

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

RR 1-3 4515

A laminated shale composed of two distinct units. The lower bed is a shale with poorly sorted grains floating in a clay matrix. The upper bed is a well sorted, fine-grained sandstone with graded bedding. Microfaults are common throughout and the fractures are filled with calcite and zeolites. Some of the opaques are also secondary with all other grains being detrital. Compaction is indicated by the orientation of elongate grains.

The upper sandstone is composed of 29% quartz, 23% calcite, 19% matrix, 18% feldspar, 8% muscovite, and 3% opaques.

Minerals

Quartz - detrital; subangular to subrounded; .35mm x .17mm to .02mm x .02mm.

Muscovite - detrital; angular and elongate; .4mm x .04mm to .02mm long.

Feldspar - detrital; subangular to subrounded; .14mm x .14mm to .07mm x .04mm.

Opaques - detrital and secondary; rounded to subrounded; 1.6mm x .8mm to .02mm x .02mm.

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.

RR 1-4 5987

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.

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

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

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 sub-
rounded; .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.

RR 2-1 4227

A siltstone composed of three different beds. The top and bottom beds are well sorted with grains floating in a clay matrix that is altering to calcite, The middle bed contains well sorted grains floating in a clay matrix that is slightly altered to calcite. Convolute laminations are present at the contacts of the upper and lower beds with the middle bed. Calcite is the only secondary mineral with all other grains being detrital.

The top and bottom beds consist of 31% calcite, 31% feldspar; 24% quartz, 6% matrix, 6% opaques, 2% muscovite, and a trace of rock fragments. The middle bed consists of 43% matrix, 21% quartz, 21% feldspar, 9% calcite, 1% muscovite, and a trace of orthoclase and microcline.

Minerals

Quartz - detrital; subangular to subrounded; .18mm x .1mm to .02mm x .02mm.

Muscovite - detrital; subangular and elongate; .08mm long to .02mm long.

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

Feldspar - detrital; subangular to subrounded; .07mm x .04mm to .03mm x .02mm.

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

Opaques - detrital; subrounded to elongate; some may be organic; .14mm x .03mm to .04mm x .04mm.

RR 2-2 4373

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.

RR 2-4 5235

A quartzo-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.

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--porphyroblase, perthitic, anhedral, 10mm x 10mm to .5mm x .3mm.

RRGS 3-1 382.5

A finely laminated graywacke with well sorted grains floating in a clay and ash matrix. The ashy matrix appears to be altering to clay. All grains present appear to be detrital.

The rock is composed of 56% matrix, 17% quartz, 12% feldspar, 7% pumice lumps, 5% biotite, 2% muscovite, 1% rock fragments, and a trace of glass shards, monazite, zircon, and augite.

Minerals

Quartz - detrital; rounded to angular; .2mm x .2mm to .03mm x .05mm.

Feldspar - detrital; subangular to subrounded; .35mm x .3mm to .07mm x .07mm.

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

Microcline - detrital; subangular to subrounded; .25mm x .12mm to .06mm x .05mm.

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

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

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

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

Augite - detrital; 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.

A silty tuff with well sorted grains in an aëhy 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.

RRGS 3-6 823

A very poorly sorted tuffaceous feldspathic arenite with a small amount of ashy matrix. Very little alteration is present except for some of the feldspar grains that are slightly altered to calcite.

This rock consists of 41% feldspar, 39% quartz, 7% rock fragments, 5% opaques, 4% matrix, 3% biotite, 1% muscovite, and a trace of hornblende, diopside, and chlorite.

Minerals

Quartz - detrital; subrounded to angular; 1.2mm x .75mm to .12mm x .08mm.

Feldspar - detrital; subangular to subrounded; .85mm x .75mm to .18mm x .09mm.

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

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

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

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

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

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

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

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

RRGS 3-7 846

A poorly sorted silty tuff with grains floating in an ashy matrix. Glass shards have altered to an unidentified green mineral. Portions of the matrix have altered to calcite. Compaction is indicated by the orientation of elongate grains. Calcite and the unidentified green mineral are the only secondary minerals with all other grains being detrital.

The rock consists of 82% glass shards and matrix, 7% quartz, 6% feldspar, 2% biotite, 2% opaques, 1% muscovite, and a trace of an unidentified green mineral.

Minerals

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

Feldspar - 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
.02mm x .02mm.

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

Unidentified green mineral - secondary; subangular; .14mm x .12mm
to .05mm x .05mm.

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.

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.

RRGS 3-10 956'

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 .08mm 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

Opaques - 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 fine-grained bedded feldspathic graywacke. Some beds contain a clay matrix and some contain an ashy matrix that has partly altered to calcite. Some of the beds are graded. Compaction is indicated by the orientation of elongate grains. Calcite and opaques are secondary with all other grains being detrital.

The rock consists of 25% calcite, 22% quartz, 21% matrix, 16% feldspar, 5% muscovite, 5% chlorite, 3% biotite, 3% opaques, and a trace of rock fragments, sanidine, and zircon.

Minerals

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

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

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

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

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

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

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

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

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

RRGS 3-16 1330

A volcanic rock fragment with phenocrysts floating in a devitrified groundmass. Portions of the groundmass are altering to calcite. Perlitic texture is also present in the groundmass. Phenocrysts of plagioclase, sanidine, quartz, and opaques are present as are detrital rock fragments, zircon, and microcline.

The rock consists of 63% groundmass, 22% feldspar, 4% opaques, 1% quartz, and a trace of zircon, microcline, and rock fragments.

Minerals

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

Opagues - subhedral; .4mm x .35mm to .02mm x .02mm; some are inclusions in phenocrysts.

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

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

Rock fragments - subrounded to rounded; volcanic; .75mm x .75mm.

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

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

RRGS 3-17 1423

A well sorted feldspathic graywacke with grains in a clay matrix partially altered to calcite. Compaction is indicated by the orientation of elongate grains. This rock is in contact with a quartzite described in the previous description. Calcite is the only secondary mineral with all others being detrital.

This rock consists of 38% quartz, 16% feldspar, 12% calcite, 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.

Feldspar - detrital; angular to subrounded; .5mm x .4mm to .12mm x .14mm.

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.

RRGS 3-17X 1423

A well sorted feldspathic graywacke composed of angular grains in a clay or ash matrix. Bedding is present with some beds having an ash-rich matrix. Some of the matrix has altered to calcite.

This graywacke appears to be in contact with a quartzite unit. This unit contains schistose muscovite grains and sutured quartz. Calcite is the only secondary mineral with all other grains being detrital.

This rock consists of 54% quartz, 20% feldspar, 16% calcite, 4% muscovite, 4% biotite, 1% rock fragments, 1% opaques, and a trace of augite, chlorite, diopside, and monazite.

Minerals

Quartz - detrital; subangular to subrounded; .9mm x .75mm to .2mm x .15mm.

Feldspar - detrital; subangular to subrounded; .75mm x .35mm to .18mm x .12mm.

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

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

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

Rock fragments - subrounded to rounded; volcanic and metamorphic; .3mm x .3mm to .5mm x .5mm.

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.

RRGE-3 2804

A siltstone with well sorted grains floating in an ashy matrix. A few very thin beds have clay matrix. Compaction is indicated by the orientation of the elongate grains parallel to the bedding. Some very large opaques (possibly secondary) are concentrated in certain beds.

All grains appear to be detrital except for some small patches of carbonate cement and possibly a very large opaque.

The rock consists of 11% quartz, 11% plagioclase, 7% opaques, 7% muscovite, 4% carbonate cement, 35% ashy matrix, 25% clay matrix, and a trace of biotite.

MINERALS

Muscovite - subangular; detrital; .35mm x .07mm to .06mm long.

Opaques - detrital and secondary; subangular to subrounded; a few elongate opaques that parallel the bedding may be organic; .35mm x .3mm to .01mm x .01mm.

Plagioclase - detrital; angular to subrounded; .15mm x .09mm to .03mm x .01mm.

Quartz - detrital; angular to subangular; .2mm x .17mm to .03mm x .01mm.

Biotite - detrital; subangular to subrounded; .14mm x .04mm to .08mm long.

RRGE-3 2805

A moderate to well sorted siltstone with grains floating in a matrix of clay and ash. Compaction is indicated by the orientation of elongate grains. Secondary pyrite is concentrated in three horizons that parallel the bedding. Calcite occurs in veins and as an alteration product of the matrix. All other grains present are detrital. Some organic material is present.

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

MINERALS

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

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

Pyrite - secondary; subrounded to elongate; 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.

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

RRGE-3 3970

A feldspathic graywacke composed of well sorted grains floating in a clay matrix in contact with a shale consisting of well sorted silt-sized grains also floating in a clay matrix. Many of the opaques appear to be organic. The shale unit is finely laminated. Compaction is indicated by the orientation of elongate minerals.

Minor portions of the matrix are altering to carbonate. All other grains present are detrital.

The rock consists of 13% quartz, 12% plagioclase, 4% muscovite, 3% opaques, 2% rock fragments, 1% biotite, 64% matrix, 1% carbonate, and a trace of microcline and augite.

MINERALS

Quartz - detrital; subangular to subrounded; .25mm x .2mm to .02mm x .02mm.

Plagioclase - detrital; subangular to subrounded; .18mm x .18mm to .02mm by .02mm.

Microcline - detrital; subangular to subrounded; .5mm x .4mm to .12mm x .07mm.

Carbonate - detrital; subrounded; .14mm x .08mm to .07mm x .07mm.

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

Biotite - detrital; subangular and elongate; .35mm x .1mm to .14mm x .05mm.

Rock fragments - subangular to subrounded; volcanic; .2mm x .18mm to .09mm x .07mm.

Opaques - detrital and secondary; subrounded; .7mm x .7mm to .02mm x .02mm.

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

RRGE-3 3976

A well sorted laminated very fine-grained graywacke with an ashy matrix altering to carbonate. Compaction is indicated by the orientation of elongate grains. Soft sediment deformation is indicated by microfaults. Calcite and pyrite are secondary with all other grains being detrital.

The rock consists of 32% quartz, 12% carbonate, 11% feldspar, 6% muscovite, 5% biotite, 5% pyrite, 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.

Feldspar - detrital; subangular; .2mm x .12mm to .05mm x .03mm.

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

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

Pyrite - secondary; subangular to elongate; .35mm x .2mm to .05mm x .03mm.

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 4976

An angular-grained well sorted feldspathic quartz arenite with a small amount of ashy and clay matrix. The rock is laminated with some very fine-grained clay-rich beds. Portions of the matrix are altering to carbonate. Some of the opaques follow grain boundaries and may be secondary.

Detrital grains are plagioclase, quartz, rock fragments, monazite, microcline, muscovite, biotite, opaques, and garnet. Carbonate cement is the only secondary mineral.

This rock consists of 39% quartz, 26% plagioclase, 7% rock fragments, 5% matrix, 5% biotite, 5% opaques, 6% carbonate, 4% microcline, 3% muscovite, and a trace of monazite and garnet.

MINERALS

Plagioclase - detrital; subangular to subrounded; .6mm x .2mm to .12mm x .07mm; some grains were poikilitic.

Quartz - detrital; angular to subrounded; .5mm x .2mm to .07mm x .07mm.

Rock fragments - subrounded; volcanic; .2mm x .2mm to .18mm x .09mm.

Monazite - detrital; subangular; .09mm x .09mm to .07mm x .05mm.

Microcline - detrital; subangular to subrounded; .35mm x .14mm to .2mm x .1mm.

Muscovite - detrital; subangular and elongate; .35mm x .1mm to .04mm x .02mm.

Biotite - detrital; subangular to elongate; .14mm x .04mm to .5mm x .1mm; some altering to chlorite.

Opaques - detrital and secondary ; 1.0mm x .2mm to .3mm x .1mm.

Garnet - detrital; subangular; .35mm x .2mm.

A tuff in which many of the grains and glass shards have altered to carbonate and all of the matrix has altered to carbonate and clay. Carbonate and zeolite veins are present and sometimes occur together.

The rock appears to have been a very fine-grained tuff interbedded with thin clay-rich beds. Carbonate alteration has masked most of the original texture. Extensive fracturing has brecciated the rock. The sediments were still soft during fracturing as the coarser grains and glass shards from an overlying bed appear to have flowed into the larger fractures. Carbonate appears to have precipitated in two stages. One stage fills fractures as veins and another stage replaces the matrix.

All grains are detrital with carbonate and zeolites being secondary. Some of the opaques follow grain boundaries and may also be secondary.

The rock consists of 2% quartz, 4% plagioclase, 5% opaques, 35% carbonate cement, and 54% matrix.

MINERALS

Quartz - detrital; angular to subangular; .25mm x .18 mm to .03mm to .03mm.

Plagioclase - detrital; angular to subangular; .2mm x .1mm to .08mm x .07mm; some have euhedral shapes.

Muscovite - detrital; subangular and elongate; .09mm x .04mm to .07mm x .03mm.

Opaques - detrital; subrounded; .18mm x .12mm to .07mm x .04mm.

RRGE - 3C 4987

A well sorted graywacke with an ashy matrix altering to carbonate. Glass shards are present and have altered to calcite. Broken fossil fragments are also present but are unidentifiable. Calcite and zeolites occur together in veins filling fractures. Many of the grains are rimmed with calcite. Calcite, zeolites, and pyrite are secondary with all other grains being detrital.

The rock consists of 22% quartz, 15% feldspar, 5% pyrite, 1% rock fragments, 1% muscovite, 32% matrix, 24% carbonate cement, and a trace of microcline.

MINERALS

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

Feldspar - detrital; subangular and elongate; .2mm x .15mm to .07mm x .05mm.

Muscovite - detrital; subangular and elongate; .12mm x .04mm to .04mm long.

Pyrite - secondary; subrounded; .14mm x .12mm to .07mm x .04mm.

Rock fragments - volcanic; subrounded; .3mm x .3mm to .14mm x .1mm.

Microcline - detrital; subangular; .2mm x .18mm.

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 5268

A quartzite with some carbonate cement and crystalloblastic muscovite. Porphyroblasts of quartz and plagioclase are present with sutured boundaries and undulatory extinction. Veins are present and have carbonate lining the walls with silica crystallizing on the inside. Another type of silica is present flowing around the grains.

This rock consists of 78% quartz, 8% plagioclase, 4% sphene, 3% silica, 3% muscovite, 2% carbonate, 1% muscovite, 1% opaques, and a trace of epidote, microcline, and monazite.

MINERALS

Epidote - subhedral; .18mm x .1mm.

Microcline - anhedral; .2mm x .14mm.

Monazite - subhedral; .35mm x .2mm to .03mm x .03mm.

Quartz - anhedral; 2.0mm x .7mm to .12mm x .07mm.

Plagioclase - anhedral; 1.7mm x .5mm to .15mm x .1mm.

Opaque - anhedral; .14mm x .04mm to .03mm x .03mm.

Sphene - anhedral; .2mm x .05mm to .03mm x .03mm.

RRGE-3C 5269

A shale with a few silt-sized grains floating in a matrix of clay and ash. Much of the matrix is altering to carbonate cement. Many elongate opaques are present and may be organic. Several microfaults are present throughout the slide.

Detrital grains present are quartz, plagioclase, muscovite, and opaques. Carbonate occurs as secondary cement.

The rock consists of 3% quartz, 2% plagioclase, 1% muscovite, 10% opaques, 20% ashy matrix, 31% clay matrix, and 23% carbonate cement.

MINERALS

Quartz - detrital; angular to subangular; .14mm x .06mm to .03mm x .03mm.

Plagioclase - detrital; subangular to subrounded; .07mm x .07mm to .05mm to .04mm.

Opaques - detrital; subangular and elongate; .08mm x .05mm to .03mm long.

Muscovite - detrital; subangular; .4mm x .12mm to .14mm long.

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.

RRGE-3C 5551.5

A quartzite with porphyroblasts of quartz and feldspar. Sutured boundaries and undulose extinction exists throughout and a slight schistosity of muscovite grains is present.

This rock consists of 57% quartz, 38% plagioclase, 3% muscovite, 1% sphene, 1% opaques, and a trace of microcline and monazite.

MINERALS

Plagioclase - anhedral; 3.0mm x 1.5mm to .35mm x .2mm.

Monazite - subhedral to anhedral; .1mm x .1mm to .9mm x .05mm.

Microcline - subhedral; .14mm x .07mm to .3mm x .15mm.

Quartz - subhedral; 3.5mm x 1.0mm to .14mm x .07mm.

Muscovite - subhedral; .1mm x .03mm to .02mm long.

Sphene - subhedral; .07mm x .07mm to .02mm x .01mm.

Opaques - euhedral to subhedral; .07mm x .07mm to .01mm x .01mm.

RRGI 4-1 1900

A very poorly sorted feldspathic lithic arenite with minor amounts of ashy matrix and carbonate cement. Rock fragments consist of siltstones and quartzites altered to calcite and a few volcanics. Calcite is secondary with all other grains being detrital.

The rock consists of 30% rock fragments, 30% quartz, 28% feldspar, 7% carbonate, 2% muscovite, 2% pyrite, 1% biotite, and a trace of monazite, chlorite, epidote, and garnet.

MINERALS

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

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

Feldspar - detrital; subangular; 2.1mm x 1.0mm to .36mm x .18mm.

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

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

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

Biotite - detrital; subangular; 1.0mm x .5mm to .7mm x .1mm.

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

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

Epidote - detrital; subangular; .15mm x .12mm to .3mm x .2mm.

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

RRGI-4 2843

A moderate to well sorted feldspathic lithic arenite. A small amount of ash 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.

A laminated rock with interbeds of shale, siltstone, and sandstone. The shale and siltstone beds are well sorted with the sandstone bed being very poorly sorted. All units have a clay matrix. Extensive microfaults exist throughout the slide. The rock appears to have been water saturated during deformation as the sediments have seeped down the fractures. Compaction during deposition is indicated by the orientation of elongate minerals parallel to the bedding. The matrix is altering to carbonate in places. All other grains present are detrital.

The sandstone unit consists of 25% quartz, 24% plagioclase, 7% muscovite, 3% biotite, 5% opaque, 2% microcline, 28% matrix, 6% carbonate, and a trace of rock fragments.

MINERALS

Muscovite - detrital; subangular and elongate; 1.2mm x .3mm to .07mm x .03mm.

Biotite - detrital; subangular to subrounded and elongate; .35mm x .35mm to .12mm x .04mm.

Quartz - detrital; subangular to subrounded; 1.0mm x .75mm to .04mm x .04mm. Some polycrystalline.

Plagioclase - detrital; subangular to subrounded; 1.0mm x .7mm to .04mm x .03mm.

Rock fragments - subangular; .75mm x .75mm; quartzite.

Microcline - detrital; subangular to subrounded; .5mm x .4mm to .14mm x .14mm.

Opaques - detrital; subangular to subrounded; .5mm x .15mm to .05mm x .05mm.

RRGP4B-2 4643.5

A well sorted gray wacke in contact with a sandstone unit whose matrix has completely altered to carbonate. The graywacke unit contains angular grains floating in a matrix of ash and clay. Portions of the matrix are altering to carbonate. A few glass shards are present and have also altered to carbonate. Some of the matrix has altered to a clay mineral which appears to be saponite. Some opaques are detrital but most appear secondary growing around grain boundaries. All other grains present are detrital.

The rock consists of 18% quartz, 17% plagioclase, 6% muscovite, 3% microcline, 7% rock fragments, 5% opaques, 2% biotite, 36% matrix, 6% carbonate, and a trace of zircon, saponite, and monazite.

MINERALS

Plagioclase - detrital; subangular to subrounded; .5mm x .4mm to .04mm x .02mm; some poikilitic.

Quartz - detrital; subangular to subrounded; .6mm x .3mm to .04mm x .03mm; some polycrystalline.

Microcline - detrital; subangular to subrounded; .3mm x .3mm to .25mm x .18mm.

Muscovite - detrital; subangular and elongate; .4mm x .2mm to .04mm long.

Monazite - detrital; subangular; .08mm x .06mm to .03mm x .02mm.

Rock fragments - subrounded; volcanic; .35mm x .35mm to .25mm x .2mm.

Biotite - detrital; subangular and elongate; .5mm x .04mm to .04mm long.

Zircon - detrital; prismatic and elongate; .15mm x .09mm.

Opaques - detrital and secondary; .3mm x .2mm to .02mm x .02mm.

Saponite ? - secondary; identification not certain; optical properties are parallel extinction, length slow, olive to brownish pleochroism.

RRGP4B-3 4646

A shale with poorly sorted silt-and sand sized grains floating in a matrix of ash and clay. Some of the matrix is altering to carbonate. Microfaults and areas of brecciation occur throughout with fractures being filled with carbonate. All other grains present are detrital.

The rock consists of 7% quartz, 7% plagioclase, 2% muscovite, 4% opaques, 69% matrix, 11% carbonate, and a trace of biotite.

MINERALS

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

Plagioclase - detrital; subangular to subrounded; .18mm x .09mm to .04mm x .03mm.

Muscovite - detrital; subangular and elongate; .18mm x .06mm to .07mm x .04mm.

Biotite - detrital; subangular and elongate; .4mm x .2mm to .04mm long.

Opaques - detrital; subangular to subrounded; .4mm x .2mm to .05mm x .05mm.

A lithic wacke with very large rock fragments and very poorly sorted grains in a matrix of clay and ash. Rock fragments present are all quartzite schist. Some of the matrix is altering to carbonate. Secondary opaques are also present. All other grains are detrital.

The rock consists of 34% quartz, 14% plagioclase, 8% muscovite, 18% rock fragments, 13% opaques, 8% matrix, 5% carbonate, and a trace of monazite.

MINERALS

Quartz - detrital; subangular to subrounded; 1.0mm x .6mm to .07mm x .07mm.

Plagioclase - detrital; subangular to subrounded; 1.0mm x .7mm to .07mm x .07mm.

Muscovite - detrital; subangular and elongate; .5mm x .4mm to .04mm long.

Monazite - detrital; subangular to subrounded; .15mm x .04mm to .12mm x .12mm.

Rock fragments - subrounded; quartzite schist; 15.0mm x 5.0mm to 1.25mm x .5mm.

Opaques - detrital and secondary; detrital grains are subrounded; .25mm x .25mm to .04mm x .04mm; secondary opaques occur around grain boundaries.

RRGP4B-5 4655 u

A lithic wacke with very poorly sorted grains in a matrix of ash and clay. No alteration to carbonate is present. This unit is in contact with an igneous rock. Rock fragments present are quartzites and fragments of the igneous unit. Opaques and chlorite are secondary growing along grain boundary contacts. All other grains are detrital.

The rock consists of 23% quartz, 21% plagioclase, 15% rock fragments, 6% microcline, 3% muscovite, 3% opaques, 29% matrix, and a trace of chlorite.

MINERALS

Plagioclase - detrital; subangular to subrounded; .9mm x .75mm to .02mm x .02mm; most are poikilitic.

Quartz - detrital; subangular to subrounded; 1.0mm x .75mm to .02mm x .02mm.

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

Muscovite - detrital; subangular and elongate; .3mm x .2mm to .18mm x .05mm.

Rock fragments - subrounded; igneous and quartzites; 4.0mm x 3.0mm to 6.5mm x 5.5mm.

Chlorite - secondary; .5mm x .4mm to .2mm x .07mm; growing along grain contacts with opaques.

Opaques - secondary; occur as streaks along grain boundaries with chlorite.

RRGP4B-6 4655

A quartzite schist with lepidoblastic biotite, chlorite, and muscovite. The parent rock was probably a quartz arenite with minor muscovite and opaques which was metamorphosed in the greenschist facies. Biotite, chlorite, sphene, epidote, and apatite grew during metamorphism. The schistose character suggests mechanical deformation. A few fractures are present and are filled with carbonate.

The rock consists of 80% quartz, 7% biotite, 1% muscovite, 4% chlorite, 6% apatite, 2% opaques, and a trace of epidote and sphene.

MINERALS

Quartz - anhedral; average size .18mm x .2mm; undulose.

Biotite - schistose; occurs in streaks rather than in individual grains; some altering to chlorite.

Muscovite - schistose; subhedral to anhedral; .35mm x .2mm to .12mm x .06mm.

Chlorite - schistose; occurs in streaks rather than in individual grains; some are alteration products of biotite.

Sphene - anhedral; .2mm x .2mm; associated with the biotite and chlorite.

Opaques - anhedral; .5mm x .2mm to .18mm x .12mm.

Epidote - anhedral; .04mm x .04mm to .04mm x .02mm; associated with the biotite and chlorite.

Apatite - anhedral; .09mm x .08mm to .04mm x .03mm.

RRGP4B-7 4657.5

A quartzite schist that has been extensively fractured. A quartz vein runs through the slide, but appears to be pre-kinematic as it has been fractured and metamorphosed with the schist. A trace of secondary carbonate is present. Chlorite and some opaques are also secondary and occur around grain boundaries. Chlorite occurs as an alteration product of biotite.

The rock consists of 46% quartz, 30% plagioclase, 11% muscovite, 1% biotite, 1% opaques, and 11% chlorite.

MINERALS

Quartz - subangular to subrounded; .18mm x .18mm to .05mm x .04mm.

Plagioclase - subangular to subrounded; .18mm x .15mm to .05mm x .03mm.

Muscovite - subangular to elongate; .5mm x .4mm to .06mm long.

Biotite - subangular and elongate; .35mm x .2mm to .05mm long; most grains are altering to chlorite.

Opaques - angular to subrounded; .35mm x .2mm to .02mm x .02mm; secondary opaques are associated with chlorite occurring around grain boundaries.

RRGP4B-8 4659

A lithic arenite that has been extensively fractured throughout. All rock fragments present are quartzites schists. Secondary muscovite and opaques are present in the fractured areas. A small amount of secondary carbonate is also present. All other grains are detrital.

The rock consists of 12% quartz, 11% plagioclase, 17% muscovite, 1% biotite, 3% opaques, 55% rock fragments, a trace of matrix, and 1% carbonate.

MINERALS

Quartz - detrital; subrounded; .18mm x .18mm to .05mm x .04mm.

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

Muscovite - detrital and secondary; detrital grains are subangular to elongate; .09mm x .09mm to .05mm long; secondary muscovite occurs in streaks.

Biotite - detrital; subrounded and elongate; .2mm x .1mm to .15mm long.

Opaques - detrital and secondary; detrital grains are subrounded; .2mm x .18mm to .02mm x .02mm; secondary opaques occur around grain boundaries in the fractured areas.

Rock fragments - subrounded; quartzite schists; 9.0mm x 6.0mm to 1.0mm x .75mm.

RRGP4B-9 4668

A quartz monzonite with one very large fracture running through the slide. The fracture zone contains fragments of all sizes of quartz monzonite. This is the only igneous rock noted thus far in thin section. No stained slab was available for modal analysis, so the feldspar grains are divided into microcline and feldspars.

The rock consists of 29% feldspar, 29% quartz, 8% microcline, 6% muscovite, 1% opaques, and a trace of chlorite.

MINERALS

Quartz - subhedral to anhedral; 4.5mm x 2.25mm to .14mm x .1mm; undulose.

Feldspar - (untwinned plagioclase and orthoclase); equant to subhedral; 3.75mm x 2.75mm to .14mm x .07mm; poikilitic.

Microcline - subhedral; 3.0mm x 2.25mm to .14mm x .14mm.

Chlorite - subhedral; 1.0mm x .3mm to .2mm x .1mm.

Muscovite - subhedral; 1.5mm x .3mm to .3mm x .1mm.

Opaques - anhedral; .2mm x .1mm to .03mm x .03mm; some opaques surround chlorite grains and some occur around grain boundaries in the fracture zone.

RRGP4B-10 4669.5

This rock has been completely altered to carbonate. The only grains present are a few subrounded opaques. Streaks of silica are also present but occur only in trace amounts. Mechanical deformation has occurred after the rock altered to carbonate. In places the rock appears to be sheared with the development of boudins.

The rock consists of 100% carbonate with a trace of opaques and silica.

RRGP 5-1 3727'

A siltstone with moderately well sorted grains floating in a clay matrix. The matrix is altering to carbonate. Compaction is indicated by the orientation of elongate grains. Secondary minerals include pyrite and carbonate occurring in veins and as an alteration product of the clay matrix. All other grains present are detrital.

The rock consists of 46 percent carbonate, 35 percent matrix, 7 percent pyrite, 5 percent muscovite, 4 percent quartz, 3 percent feldspar, and a trace of microcline and rock fragments.

Minerals

Quartz - detrital; subrounded to subangular; .2mm x .12mm to .02mm x .02mm.

Feldspar - detrital; equant to subrounded; .14mm x .03mm to .02mm x .02mm.

Microcline - detrital; subangular to subrounded; .14mm x .08mm to .04mm x .04mm.

Muscovite - detrital; subangular and elongate; .18mm x .07mm to .02mm long.

Pyrite - secondary; subangular to subrounded; .12mm x .12mm to .02mm x .02mm.

Rock Fragments - subrounded; igneous; .75mm x .5mm.

RRGP 5-1 3728'

A fine-grained well sorted sandstone almost completely altered to carbonate. Many fossil fragments are present and indicate compaction due to their orientation. Secondary minerals present include pyrite and carbonate occurring in veins and replacing the matrix. All other grains present are detrital.

The rock consists of 91 percent carbonate, 4 percent pyrite, 2 percent quartz, 2 percent feldspar and 1 percent muscovite.

Minerals

Quartz - detrital; subangular to subrounded; .2mm x .2mm to .1mm x .1mm.

Feldspar - detrital; subangular to subrounded; .6mm x .3mm to .1mm x .1mm.

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

Pyrite - secondary; .2mm x .18mm to .02mm x .02mm.

RRGP 5-1 3729'

A siltstone with well sorted grains floating in a clay matrix. Much of the matrix is altering to carbonate. Carbonate also occurs as veins filling fractures. Secondary pyrite is also present with all other grains being detrital. Compaction is indicated by the orientation of elongate grains. A few fossil fragments are present but cannot be identified. Some small patches of ashy matrix are present and suggest the clay may be an alteration product of the ash which was in turn altered to carbonate.

The rock consists of 56 percent clay matrix, 16 percent carbonate, 8 percent muscovite, 8 percent pyrite, 5 percent quartz, 4 percent feldspar, 3 percent organic material, and a trace of microcline.

Minerals

Feldspar - detrital; subangular to subrounded; .35mm x .2mm to .04mm x .04mm.

Quartz - detrital; subangular to subrounded; .35mm x .2mm to .04mm x .03mm.

Muscovite - detrital; subangular and elongate; .18mm x .02mm to .04mm long.

Pyrite - secondary; subangular to subrounded; .5mm x .35mm to .02mm x .02mm.

Microcline - detrital; subangular to subrounded; .2mm x .18mm to .04mm x .02mm.

RRGP 5-1 3730'

A moderately well sorted siltstone with grains floating in a clay matrix. Also present are a few very thin (.5mm thick) beds of coarser-grained siltstone with a lot of secondary carbonate. Secondary carbonate and pyrite are also present in the finer-grained clay-rich beds but to a lesser extent. All other grains present are detrital. Compaction is indicated by the orientation of elongate grains. A few fossil fragments are present but can not be identified.

The rock consists of 57 percent matrix, 17 percent carbonate, 7 percent quartz, 6 percent feldspar, 6 percent muscovite, 4 percent pyrite, 3 percent organic material, and a trace of microcline.

Minerals

Quartz - detrital; subangular to subrounded; .2mm x .07mm to .02mm x .02mm.

Feldspar - detrital; subangular to subrounded; .18mm x .15mm to .03mm x .02mm.

Muscovite - detrital; subangular and elongate; .3mm x .02mm to .03mm long.

Pyrite - secondary; subangular to subrounded; .35mm x .1mm to .02mm x .02mm.

Microcline - detrital; subangular; .3mm x .2mm to .18mm x .15mm.

RRGP 5-1 3731'

A well sorted siltstone interbedded with a well sorted fine-grained sandstone. The siltstone contains well sorted grains floating in a clay matrix. The sandstone beds are 1.5mm thick with graded bedding and much carbonate alteration. The siltstone beds have lesser amounts of carbonate. Secondary pyrite is present in both beds. Compaction is indicated by the orientation of elongate grains. A few fossil fragments are present but cannot be identified. All other grains present are detrital.

The rock consists of 72 percent matrix, 12 percent carbonate, 5 percent pyrite, 4 percent muscovite, 3 percent organic material, 2 percent quartz, and 2 percent feldspar.

Minerals

Quartz - detrital; subangular to subrounded; .35mm x .2mm to .03mm to .02mm.

Feldspar - detrital; subangular to subrounded; .18mm x .12mm to .02mm x .02mm.

Muscovite - detrital; subangular and elongate; .3mm x .18mm to .04mm long.

Pyrite - secondary; subangular to subrounded; .18mm x .12mm to .02mm x .02mm.

RRGP 5-1 3732'

A siltstone with well sorted grains floating in a clay matrix. Carbonate exists as veins filling fractures and as an alteration product of the clay. Pyrite is also secondary with all other grains present being detrital. Compaction is indicated by the orientation of elongate grains. A few fossil fragments are present but cannot be identified.

The rock consists of 73 percent matrix, 9 percent carbonate, 6 percent muscovite, 4 percent pyrite, 3 percent organic material, 3 percent quartz, 2 percent feldspar, and a trace of biotite.

Minerals

Quartz - detrital; subangular to subrounded; .2mm x .1mm to .03mm x .02mm.

Feldspar - detrital; subangular to subrounded; .35mm x .1mm to .02mm x .02mm.

Pyrite - secondary; subangular to rounded; .75mm x .5mm to .04mm x .02mm.

Muscovite - detrital; subangular and elongate; .18mm x .02mm to .02mm long.

Biotite - detrital; subangular and elongate; .2mm x .02mm.

RRGP 5-1 3733'

A siltstone with well sorted grains floating in a clay matrix. A medium-grained well sorted sandstone bed is also present and has almost completely altered to carbonate. Secondary carbonate is also present in veins and as an alteration product of the clay matrix. Pyrite is also secondary with all other grains present being detrital. Compaction is indicated by the orientation of elongate grains.

The rock consists of 59 percent clay matrix, 21 percent carbonate, 8 percent pyrite, 5 percent quartz, 4 percent muscovite, 2 percent feldspar, and 1 percent organic material.

Minerals

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

Pyrite - secondary; subangular to subrounded; .3mm x .2mm to .02mm x .02mm.

Quartz - detrital; subangular to subrounded; .18mm x .07mm to .04mm x .02mm.

Feldspar - detrital; subangular to subrounded; .14mm x .07mm to .02mm x .02mm.

RRGP 5-1 3734'

A siltstone with moderately well sorted grains floating in a matrix of ash and clay. A thin bed (2mm) of fine-grained sandstone is also present and is almost completely altered to carbonate. Secondary carbonate also exists as veins and as an alteration product of the matrix. Secondary pyrite is also present with all other grains being detrital. Compaction is indicated by the orientation of elongate grains.

The rock consists of 72 percent matrix, 12 percent carbonate, 7 percent pyrite, 5 percent muscovite, 2 percent quartz and 2 percent feldspar.

Minerals

Quartz - detrital; subangular to subrounded; .14mm x .06mm to .03mm x .02mm.

Feldspar - detrital; subangular to subrounded; .1mm x .08mm to .02mm x .02mm.

Pyrite - secondary; subangular to rounded; .4mm x .35mm to .02mm x .02mm.

Muscovite - detrital; subangular and elongate; .2mm x .02mm to .02mm long.

RRGP 5-1 3735'

A siltstone with well sorted grains floating in a clay matrix in contact with a well sorted fine-grained sandstone. The matrix in the sandstone bed has completely altered to carbonate. The matrix in the siltstone has also altered to carbonate but to a lesser extent. Pyrite is also a secondary mineral with all other grains present being detrital. Compaction is indicated by the orientation of elongate grains.

The rock consists of 45 percent matrix, 23 percent carbonate, 13 percent quartz, 10 percent feldspar, 5 percent muscovite, and 4 percent pyrite.

Minerals

Quartz - detrital; subangular to subrounded; .15mm x .15mm to .03mm x .02mm.

Feldspar - detrital; subangular to subrounded; .14mm x .07mm to .02mm x .02mm.

Muscovite - detrital; subangular and elongate; .2mm x .02mm to .04mm long.

Pyrite - secondary; subangular to subrounded; .35mm x .02mm to .03mm x .03mm.

RRGP 5-1 3736'

A siltstone with moderately well sorted grains floating in a clay matrix. Secondary carbonate occurs in veins and as an alteration product of the matrix. Secondary pyrite is also present with all other grains being detrital. Compaction is indicated by the orientation of elongate grains.

The rock consists of 67 percent clay matrix, 13 percent carbonate, 8 percent muscovite, 5 percent pyrite, 3 percent organic material, 2 percent quartz and 2 percent feldspar.

Minerals

Quartz - detrital; subangular to subrounded; .3mm x .2mm to .02mm x .02mm.

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

Muscovite - detrital; subangular and elongate; .36mm x .04mm to .02mm long.

Pyrite - secondary; subangular to subrounded; 1.5mm x .3mm to .02mm x .02mm.

RRGP 5-1 3737.5'

A well sorted siltstone with an ashy matrix altering to carbonate and clay. These two alteration products have formed a sharp bedding contact with some beds being clay-rich and some carbonate-rich. Secondary pyrite is also present with all other grains being detrital. Compaction is indicated by the orientation of elongate grains.

The rock consists of 29 percent carbonate, 21 percent quartz, 18 percent clay matrix, 14 percent feldspar, 9 percent muscovite, 4 percent pyrite, 3 percent ashy matrix, and 2 percent organic material.

Minerals

Quartz - detrital; subangular to subrounded; .18mm x .12mm to .02mm x .02mm.

Feldspar - detrital; subangular to subrounded; .2mm x .09mm to .03mm x .03mm.

Muscovite - detrital; subangular and elongate; .2mm x .1mm to .02mm long.

Pyrite - secondary; subangular to rounded; .07mm x .07mm to .02mm x .02mm.

RRGP 5-1 3738'

A siltstone with well sorted grains floating in a clay matrix. Some of the matrix is altering to carbonate. Pyrite is also secondary with all other grains being detrital. Compaction is indicated by the orientation of elongate grains.

The rock consists of 76 percent clay matrix, 9 percent carbonate, 4 percent pyrite, 4 percent quartz, 3 percent feldspar, 3 percent muscovite, and 1 percent organic material.

Minerals

Quartz - detrital; subangular to subrounded; .08mm x .06mm to .02mm x .02mm.

Feldspar - detrital; subangular to subrounded; .07mm x .05mm to .02mm x .02mm.

Muscovite - detrital; subangular and elongate; .1mm x .02mm to .02mm long.

Pyrite - secondary; subangular to rounded; .09mm x .08mm to .03mm x .02mm.

RRGP 5-1 3739'

A siltstone with well sorted grains floating in an ashy matrix in contact with a fine-grained sandstone almost completely altered to carbonate. The ashy matrix is also altering to carbonate. Carbonate also occurs in veins. Secondary pyrite is also present with all other grains being detrital. A few glass shards are present and have altered to carbonate. Compaction is indicated by the orientation of elongate grains.

The rock consists of 83 percent matrix, 11 percent carbonate, 2 percent quartz, 2 percent muscovite, 1 percent feldspar, 1 percent pyrite, and a trace of organic material.

Minerals

Quartz - detrital; subangular to subrounded; .14mm x .1mm to .03mm x .03mm.

Feldspar - detrital; subangular to subrounded; .2mm x .09mm to .02mm x .02mm.

Muscovite - detrital; subangular and elongate; .14mm long to .02mm long.

Pyrite - secondary; subangular to rounded; .12mm x .07mm to .02mm x .02mm.

RRGP 5-1 3740'

A siltstone with well sorted grains floating in an ashy matrix. Carbonate occurs in veins and as an alteration product of the matrix. Pyrite is also secondary with all other grains being detrital.

The rock consists of 55 percent matrix, 37 percent carbonate, 6 percent quartz, 1 percent feldspar, 1 percent pyrite, and a trace of epidote and muscovite.

Minerals

Quartz - detrital; subangular to subrounded; .18mm x .15mm to .04mm x .02mm.

Feldspar - detrital; subangular to subrounded; .2mm x .15mm to .02mm x .02mm.

Muscovite - detrital; subangular and elongate, .07mm x .02mm to .02mm long.

Epidote - detrital; angular; .08mm x .07mm.

Pyrite - secondary; subangular to rounded; .15mm x .08mm to .02mm x .02mm.

RRGP 5-1 3741'

A siltstone with well sorted grains floating in an ashy matrix in contact with a slightly coarser-grained siltstone. The coarser-grained bed contains a few fossils (ostracods) and some glass shards that have altered to carbonate. The ashy matrix is altering to carbonate in both beds but to a greater degree in the coarser bed. Carbonate also occurs as veins filling fractures in two different stages. One state occurs on the walls of the fractures and another occurs filling the center. Pyrite is also secondary with all other grains present being detrital. Compaction is indicated by the orientation of elongate grains.

The rock consists of 68 percent matrix, 23 percent carbonate, 4 percent pyrite, 2 percent quartz, 1 percent feldspar, 1 percent muscovite, 1 percent organic material, and a trace of biotite.

Minerals

Quartz - detrital; subangular to subrounded; .14mm x .07mm to .02mm x .02mm.

Feldspar - detrital; angular to subrounded; .15mm x .14mm to .04mm x .03mm.

Muscovite - detrital; subangular and elongate; .18mm x .03mm to .02mm long.

Biotite - detrital; subangular and elongate; .2mm x .04mm.

Pyrite - secondary; subangular to rounded; .25mm x .18mm to .02mm x .02mm.

RRGP 5-1 3742'

A siltstone with well sorted grains floating in an ashy matrix. Carbonate occurs as veins filling fractures and as an alteration product of the matrix. Secondary pyrite is also present with all other grains being detrital. Glass shards are present and have altered to carbonate. Compaction is indicated by the orientation of elongate grains. Soft sediment deformation occurs in the form of microfaults.

The rock consists of 63 percent matrix, 25 percent carbonate, 4 percent pyrite, 3 percent quartz, 2 percent feldspar, 2 percent muscovite, and 1 percent biotite.

Minerals

Quartz - detrital; subangular to subrounded; .18mm x .06mm to .03mm x .03mm.

Feldspar - detrital; subangular to subrounded; .12mm x .07mm to .02mm x .02mm.

Muscovite - detrital; subangular and elongate; .75mm x .02mm to .02mm long.

Biotite - detrital; subangular and elongate; .3mm x .02mm to .14mm long.

Pyrite - secondary; subangular to rounded; .5mm x .2mm to .02mm x .02mm.

RRGP 5-1 3743'

A lithic tuff with moderately well sorted grains floating in a matrix of ash and volcanic glass. Many of the rock fragments and glass shards are altering to carbonate. Secondary pyrite is also present with all other grains being detrital.

The rock consists of 44 percent matrix, 19 percent rock fragments, 18 percent pyrite, 7 percent carbonate, 6 percent quartz, and 6 percent feldspar.

Minerals

Quartz - detrital; subangular to subrounded; .5mm x .3mm to .12mm x .04mm.

Feldspar - detrital; subangular to subrounded; .5mm x .3mm to .15mm x .08mm.

Rock Fragments - subrounded; volcanic; 2.25mm x 2.25mm to .7mm x .35mm.

Pyrite - secondary; subangular to rounded; .75mm x .2mm to .07mm x .05mm.

RR6-1 3005

A finely laminated siltstone and shale with well sorted grains floating in a matrix of ash and clay. Some of the matrix is altering to carbonate. Compaction is indicated by the orientation of elongate grains. A few glass shards are present in the silty beds. An opaque horizon is present parallel to the bedding and appears to be secondary. All other grains present are detrital.

The rock consists of 10% plagioclase, 7% quartz, 11% muscovite, 1% biotite, 5% opaques, 61% matrix, 5% carbonate, and a trace of microcline.

MINERALS

Microcline - detrital; subangular to subrounded; .14mm x .06mm to .05mm x .05mm.

Plagioclase - detrital; subangular to subrounded; .14mm x .12mm to .05mm x .03mm.

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

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

Biotite - detrital; subangular and elongate; .21mm x .03mm to .04 mm long.

Opaques - detrital and secondary; subangular to subrounded; some elongate opaques may be organic; .3mm x .2mm to .07mm x .03mm.

A well sorted feldspathic gray wacke with grains floating in a matrix of clay and ash. Parts of the matrix are altering to carbonate. Compaction is indicated by the orientation of elongate grains. Carbonate and some opaques are secondary. All other grains present are detrital.

The rock consists of 24% plagioclase, 16% quartz, 6% muscovite, 4% biotite, 3% opaques, 36% matrix, 11% carbonate, and a trace of zircon, epidote, and microcline.

MINERALS

Biotite - detrital; subangular and elongate; .35mm x .1mm to .07mm x .03mm.

Muscovite - detrital; subangular and elongate; .36mm x .12mm to .04mm long.

Microcline - detrital; subangular to subrounded; .2mm x .18mm.

Quartz - detrital; subangular to subrounded; .2mm x .2mm to .05mm x .04mm.

Plagioclase - detrital; subangular to subrounded; .2mm x .14mm to .06mm x .03mm.

Epidote - detrital; subangular; .06mm x .03mm.

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

Opaques - detrital and secondary; .5mm x .3mm to .09mm x .08mm; elongate opaques appear to be organic.

RR6-3 3011

A fine-grained well sorted lithic wacke with angular grains floating in an ashy matrix. Much of the matrix is altering to carbonate. All rock fragments are volcanic. Carbonate cement is the only secondary mineral present.

The rock consists of 22% plagioclase, 15% quartz, 5% biotite, 8% rock fragments, 2% muscovite, 4% opaques, 35% matrix, 9% carbonate, and a trace of zircon and microcline.

MINERALS

Quartz - detrital; subangular to subrounded; .3mm x .18 mm to .04mm x .03mm.

Plagioclase - detrital; subangular to subrounded; .3mm x .3mm to .03mm x .02mm; some are poikilitic.

Microcline - detrital; subangular to subrounded; .2mm x .2mm to .06mm x .06mm.

Biotite - detrital; subangular to elongate; .3mm x .2mm to .15 mm x .12mm.

Rock fragments - subrounded; volcanic; .3mm x .2mm to .18mm x .12mm.

Zircon - detrital; subrounded; .1mm x .07mm to .07mm x .07mm.

Muscovite - detrital; subangular to elongate; .4mm x .04mm to .02mm long.

Opaques - detrital; subrounded; .35mm x .2mm to .08mm x .07mm.

A moderately well sorted lithic arinite with angular grains and a small amount of ashy matrix. Much of the matrix is altering to carbonate. Glass shards are present and completely altered to carbonate. Slight compaction is indicated by the orientation of elongate minerals. Carbonate is the only secondary mineral with all other grains being detrital.

The rock consists of 16% plagioclase, 23% quartz, 10% rock fragments, 6% biotite, 4% opaques, 4% muscovite, 3% microcline, 2% matrix, 32% carbonate, and a trace of monazite and augite.

MINERALS

Opagues - detrital; subangular to subrounded; .5mm x .3mm to .07mm x .04mm.

Muscovite - detrital; subangular and elongate; .75mm x .2mm to .1mm x .04mm.

Microcline - detrital; subangular to subrounded; .35mm x .1mm to .12mm
x .07mm.

Monazite - detrital; subrounded; .12mm x .07mm to .18mm x .12mm.

Augite - detrital; subangular; .12mm x .07mm to .05mm x .05mm.

Biotite - detrital; subangular and elongate; 1.2mm x .2mm to .1mm long.

Quartz - detrital; subangular to subrounded; .35mm x .18mm to .05mm
x .04mm.

Plagioclase - detrital; subangular to subrounded; .25mm x .2mm to .07mm x
.04mm.

Rock fragments - subangular to subrounded; .5mm x .4mm to .2mm x .2mm;
all appear to be volcanic.

RR6-5 3015

A laminated siltstone and shale with well sorted grains floating in a matrix of ash and clay. Compaction is indicated by the orientation of elongate grains. Some of the matrix is altering to carbonate. All other grains present are detrital.

The rock consists of 15% quartz, 10% plagioclase, 6% opaques, 6% muscovite, 4% biotite, 41% matrix, 18% carbonate, and a trace of zircon and microcline.

MINERALS

Quartz - detrital; subangular to subrounded; .2mm x .12mm to .05mm x .03mm.

Plagioclase - detrital; subangular to subrounded; .12mm x .1mm to .05mm x .04mm.

Opaques - detrital; subangular to subrounded; .25mm x .2mm to .03mm x .03mm;
elongate opaques appear organic.

Microcline - detrital; subangular to subrounded; .15mm x .12mm.

Muscovite - detrital; subangular and elongate; .14mm x .07mm to .02mm long.

Biotite - detrital; subangular and elongate; .1mm x .05mm to .04mm long.

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

RR6-6 3017

A fine-grained shale with silt-sized grains floating in a matrix of clay and ash. Some of the matrix is altering to carbonate. Compaction is indicated by the orientation of elongate grains. A few glass shards are also present. Carbonate and a few of the opaques are secondary with all other grains present being detrital.

The rock consists of 4% quartz, 6% plagioclase, 9% muscovite, 4% biotite, 5% opaques, 58% matrix, 14% carbonate, and a trace of augite.

MINERALS

Augite - detrital; subrounded; .14mm x .08mm.

Muscovite - detrital; subangular and elongate; .12mm x .07mm to .04mm x .02mm.

Quartz - detrital; subangular to subrounded; .08mm x .07mm to .02mm x .02mm.

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

Biotite - detrital; subangular and elongate; .12mm x .05mm to .04mm long.

Opaques - detrital and secondary; subangular to subrounded; elongate opaques appear to be organic; .2mm x .18mm to .07mm x .05mm.

RR6-7 3022

A laminated siltstone with well sorted grains floating in a matrix of clay and ash. The matrix in some beds is altering to carbonate. Some of the beds have very few grains and are almost entirely matrix. A few glass shards are present and have completely altered to carbonate. Compaction is indicated by the orientation of elongate minerals parallel to the bedding. In one very fine-grained bed, an opaque horizon is present parallel to the bedding and may be secondary. All other grains present are detrital.

The rock consists of 17% quartz, 17% plagioclase, 10% muscovite, 8% opaque, 5% biotite, 19% matrix, and 24% carbonate.

MINERALS

Quartz - detrital; subangular to subrounded; .2mm x .09mm to .02mm x .02mm.

Plagioclase - detrital; subangular to subrounded; .18mm x .12mm to .02mm x .02mm.

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

Biotite - detrital; subangular and elongate; .18mm x .12mm to .02mm long.

Opagues - detrital and secondary; subrounded to elongate; .18mm x .12mm to .02mm x .02mm.

RR6-8 3025

A lithic wacke with very poorly sorted grains in a matrix of clay and ash. Much of the matrix is altering to carbonate. Glass shards are present and have also altered to carbonate. Rock fragments are volcanic rocks and quartzites with at least one welded tuff. Most volcanic rock fragments are altering to carbonate. Opaques occurring around grain boundaries and carbonate are the secondary minerals, with all other grains being detrital.

The rock consists of 8% quartz, 6% plagioclase, 1% microcline, 6% muscovite, 18% rock fragments, 8% opaques, 25% matrix, 28% carbonate, and a trace of zircon and biotite.

MINERALS

Quartz - detrital; subangular to subrounded; some grains are polycrystalline; 1.5mm x .75mm to .02mm x .02mm.

Plagioclase - detrital; subangular to subrounded; 1.0mm x .75mm to .03mm x .02mm.

Microcline - detrital; subangular to subrounded; 1.5mm x 1.0mm to .3mm x .2mm.

Biotite - detrital; subangular to subrounded and elongate; .75mm x .3mm to .14mm x .06mm.

Muscovite - detrital; subangular and elongate; .35mm x .2mm to .02mm long.

Rock fragments - subrounded; volcanic rocks and quartzites; 10.0mm x 9.5mm to .5mm x .4mm.

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

Opaques - detrital and secondary; subrounded; .3mm x .3mm to .1mm x .06mm; secondary opaques occur around grain boundaries.

RR6-9 3080

A poorly sorted lithic arenite with angular grains and a small amount of ashy matrix. Some of the matrix is altering to carbonate cement and a few of the grains are rimmed with carbonate. Rock fragments consist of volcanic rocks, tuffs, quartzites, and sandstone. Some have almost completely altered to carbonate. All grains present are detrital. Carbonate occurs in two stages. One stage is rimming the grains and the other stage is cement.

The rock consists of 16% quartz, 15% plagioclase, 2% microcline, 3% biotite, 2% muscovite, 24% rock fragments, 5% opaques, 9% matrix, 24% carbonate, and a trace of monazite.

MINERALS

- Biotite - detrital; subangular to subrounded and elongate; 1.2mm x .75 mm to .3mm x .1mm; some are altering to carbonate and an opaque mineral.
- Quartz - detrital; subangular to subrounded; 2.0mm x 1.0mm to .1mm x .09mm.
- Plagioclase - detrital; subangular to subrounded; 3.0mm x 2.0mm to .1mm x .09mm.
- Microcline - detrital; subangular to subrounded; .35mm x .2mm to 2.25mm x .75mm.
- Muscovite - detrital; subangular and elongate; .75mm x .1mm to .08mm x .04mm.
- Rock fragments - subrounded; 4.5mm x 3.0mm to 1.0mm x 1.0mm.
- Monazite - detrital; subrounded; .18mm x .12mm.
- Opaques - detrital; subangular to subrounded; .75mm x .75mm to .2mm x .18mm.

RR6-10 3080.5

A very poorly sorted lithic arenite with minor ashy matrix altering to carbonate. The grains and rock fragments are rimmed with carbonate. Glass shards present have completely altered to carbonate. Rock fragments consists of volcanic rocks, tuffs, quartzites, and carbonates. Carbonate is the only secondary mineral present with all other grains being detrital.

The rock consists of 21% plagioclase, 13% quartz, 7% opaques, 2% microcline, 1% muscovite, 1% biotite, 37% rock fragments, 18% carbonate, and a trace of monazite.

MINERALS

Microcline - detrital; subangular to subrounded; 1.2mm x 1.2mm to .18mm x .15mm.

Plagioclase - detrital; subangular to subrounded; 2.25mm x .75mm to .18mm x .18mm.

Muscovite - detrital; subangular and elongate; .75mm x .1mm to .06mm long.

Monazite - detrital; subangular; .35mm x .2mm.

Biotite - detrital; subangular and elongate; .75mm x .3mm to .5mm x .2mm.

Rock fragments - subrounded; 5.5mm x 4.5mm to .6mm x .5mm; many have altered to carbonate before deposition.

Quartz - detrital; angular to subangular; 1.5mm x .75mm to .25mm x .18mm.

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

RR6-11 3082

A lithic wacke with the matrix completely altered to carbonate. Rock fragments are mostly quartzites and volcanic rocks. Some have altered to carbonate. Two stages of carbonate formation are present. One stage rims the rock fragments and the other replaces the matrix. Some opaques are also secondary and occur around grain boundary contacts. All other grains are detrital.

The rock consists of 10% quartz, 7% plagioclase, 3% microcline, 31% rock fragments, 4% opaques, 2% muscovite, 49% carbonate, and a trace of biotite and monazite.

MINERALS

Quartz - detrital; subangular to subrounded; 1.5mm x .75mm to .35mm x .2mm.

Plagioclase - detrital; subangular to subrounded; .9mm x .4mm to .3mm x .2mm; some are poikilitic.

Microcline - detrital; subangular to subrounded; .6mm x .5mm to .35mm x .35mm.

Monazite - detrital; subangular; .08mm x .07mm.

Rock fragments - subrounded; volcanic rocks and quartzites; 7.0mm x 6.0mm to .5mm x .3mm.

Muscovite - detrital; subangular and elongate; .08mm x .02mm to .2mm x .1mm.

Biotite - detrital; subangular and elongate; .5mm x .4mm to .2mm x .02mm.

Opaques - detrital and secondary; subrounded; .2mm x .2mm to .02mm x .02mm; secondary opaques forming around grain boundaries.

RR6-12 3084

A well-sorted siltstone with grains floating in a matrix of clay and ash. The matrix is partly altered to carbonate. Compaction is indicated by the orientation of elongate minerals. Carbonate cement is the only secondary mineral with all grains being detrital.

The rock consists of 30% quartz, 25% plagioclase, 6% muscovite, 4% microcline, 5% biotite, 7% opaques, 15% matrix, and 8% carbonate.

MINERALS

Quartz - detrital; subangular to subrounded; .12mm x .14mm to .04mm x .04mm.

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

Muscovite - detrital; subangular and elongate; .14mm x .06mm to .02mm long.

Microcline - detrital; subangular to subrounded; .14mm x .09mm to .07mm x .07mm.

Biotite - detrital; subrounded and elongate; .2mm x .06mm to .02mm long.

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

RR6-13 3085

A massive siltstone with well sorted grains floating in an ashy matrix. Part of the matrix has altered to carbonate. No bedding and no signs of compaction are present.

Carbonate and some opaques are the only secondary minerals with all other grains being detrital.

The rock consists of 29% plagioclase, 19% quartz, 5% microcline, 6% muscovite, 8% opaques, 22% matrix, 11% carbonate, and a trace of biotite and zircon.

MINERALS

Quartz - detrital; subangular to subrounded; .12mm x .07mm to .05mm x .05mm.

Plagioclase - detrital; subangular to subrounded; .36mm x .36mm to .04mm x .03mm.

Microcline - detrital; subrounded to subangular; .4mm x .3mm to .14mm x .12mm.

Muscovite - detrital; subangular and elongate; .14mm long to .2mm x .05mm.

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

Biotite - detrital; subangular and elongate; .14mm long.

Opaques - detrital and secondary; .3mm x .2mm to .07mm x .05mm.

A laminated siltstone with well sorted grains floating in an ashy matrix. Some of the matrix is altering to carbonate. Slight compaction is indicated by the orientation of elongate minerals. All grains are detrital with carbonate cement and a few opaques being secondary.

The rock consists of 21% plagioclase, 20% quartz, 6% muscovite, 6% opaques, 3% biotite, 34% matrix, and 10% carbonate.

MINERALS

Muscovite - detrital; subangular and elongate; .15mm x .05mm to .04mm long.

Biotite - detrital; subangular and elongate; .18mm x .05mm to .05mm long; some grains are altering to chlorite.

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

Quartz - detrital; subangular to subrounded; .15mm x .12mm to .04mm x .03mm.

Opaques - detrital and secondary; subrounded; .25mm x .2mm to .05mm x .04mm.

RR6-15 3087

A laminated shale with well sorted very fine-sized grains floating in a matrix of clay and ash. Part of the matrix is altering to carbonate. Slight compaction is indicated by the orientation of elongate minerals. All grains present are detrital.

The rock is composed of 10% quartz, 9% plagioclase, 6% opaques, 5% muscovite, and 70% matrix.

MINERALS

Quartz - detrital; subrounded to subangular; .07mm x .07mm to .02mm x .02mm.

Plagioclase - detrital; subrounded to subangular; .08mm x .05mm to .02mm x .02mm.

Muscovite - detrital; subangular and elongate; .12mm long to .02mm long.

Opaques - detrital; subangular to subrounded; .07mm x .07mm to .02mm x .02mm.

RR6-16 3088

A very poorly sorted lithic arenite with a small amount of ashy matrix altering to carbonate. Grains present are very angular. Rock fragments consists of volcanic rocks and quartzites. All grains present are detrital.

The rock consists of 20% quartz, 20% plagioclase, 4% microcline, 2% muscovite, 1% biotite, 40% rock fragments, 5% matrix, 5% carbonate, 3% opaques, and a trace of monazite.

MINERALS

Quartz - detrital; subangular to subrounded; .75mm x .5mm to .2mm x .2mm.

Opaques - detrital; subrounded; .35mm x .2mm to .07mm x .04mm.

Microcline - detrital; subangular to subrounded; 1.5mm x .75mm to .6mm x .3mm.

Rock fragments - subrounded; 4.0mm x 1.5mm to .8mm x .5mm.

Plagioclase - detrital; subangular to subrounded; 1.0mm x .8mm to .15mm x .15mm; some poikilitic.

Monazite - detrital; subangular; .08mm x .08mm.

Biotite - green and brown; detrital; subangular to subrounded; .5mm x .4mm to .18mm x .12mm.

Muscovite - detrital; subangular to subrounded; 1.5mm x .3mm to 1.8mm x .09mm.

RRGI 7-1 3829'

A lithic tuff with moderately well sorted grains in a matrix of ash and volcanic glass. Most of the matrix and glass shards have altered to carbonate. Secondary pyrite is also present with all other grains being detrital.

The rock consists of 32 percent matrix, 30 percent carbonate, 11 percent pyrite, 10 percent rock fragments, 5 percent biotite, 5 percent quartz, 4 percent feldspar, 3 percent muscovite, and a trace of microcline.

Minerals

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

Feldspar - detrital; subangular to subrounded; .4mm x .18mm to .04mm x .04mm.

Muscovite - detrital; subangular and elongate; .6mm x .1mm to .02mm long.

Microcline - detrital; subangular to subrounded; .2mm x .18mm to .05mm x .04mm.

Biotite - detrital; subangular and elongate; .75mm x .09mm to .14 mm long.

Rock Fragments - subrounded; volcanic; 1.0mm x .75mm to .4mm x .3mm.

Pyrite - secondary; subangular to rounded; .35mm x .35mm to .1mm x .1mm.

RRGI 7-1 3830'

A well sorted graywacke in contact with a siltstone bed composed of well sorted grains floating in a clay matrix. The matrix in both beds is altering to carbonate. Pyrite is also secondary with all other grains present being detrital. Compaction is indicated by the orientation of elongate grains.

The rock consists of 30 percent matrix, 20 percent quartz, 16 percent feldspar, 13 percent carbonate, 9 percent muscovite, 5 percent biotite, 4 percent pyrite, 1 percent rock fragments, 1 percent organic material, and a trace of zircon.

Minerals

Quartz - detrital; subangular to subrounded; .25mm x .18mm to .02mm x .02mm.

Feldspar - detrital; subangular to subrounded; .3mm x .15mm to .04mm x .03mm.

Muscovite - detrital; subangular and elongate; 1.0mm x .15mm to .02mm long.

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

Rock Fragments - subrounded; volcanic; .4mm x .18mm to .1mm x .1mm.

Biotite - detrital; subangular and elongate; .5mm x .2mm to .1mm long.

Pyrite - secondary subangular to rounded; .5mm x .2mm to .02mm x .02mm.

RRGI 7-1 3830' X

A well sorted lithic tuff with grains in an ashy and glassy matrix in contact with a siltstone bed 1mm thick composed of well sorted grains floating in a clay matrix. The matrix in both beds is altering to carbonate. All rock fragments present have altered to carbonate. Secondary pyrite is also present with all other grains being detrital. Compaction is indicated by the orientation of elongate grains.

The rock consists of 34 percent matrix, 20 percent feldspar, 14 percent quartz, 10 percent carbonate, 8 percent muscovite, 4 percent biotite, 4 percent rock fragments, 4 percent pyrite, 2 percent organic material, and a trace of microcline.

Minerals

Quartz - detrital; subangular to subrounded; .3mm x .2mm to .07mm x .06mm.

Feldspar - detrital; subangular to subrounded; .35mm x .2mm to .02mm x .02mm.

Muscovite - detrital; subangular and elongate; .35mm x .1mm to .04mm long.

Biotite - detrital; subangular and elongate to subrounded; .25mm x .2mm to .08mm long.

Microcline - detrital; subrounded; .15mm x .08mm.

Rock Fragments - subrounded; volcanic; .35mm x .35mm to .1mm x .08mm.

Pyrite - secondary; subangular to rounded; .5mm x .4mm to .02mm x .02mm.

RRGI 7-1 3832'

A siltstone with well sorted grains in an ashy matrix. Glass shards and the matrix are altering to carbonate. Secondary pyrite is also present with all other grains being detrital. Compaction is indicated by the orientation of elongate grains.

The rock consists of 25 percent matrix, 18 percent quartz, 18 percent feldspar, 18 percent carbonate, 5 percent biotite, 5 percent muscovite, 3 percent rock fragments, 3 percent pyrite, 2 percent organic material, and a trace of microcline.

Minerals

Quartz - detrital; subangular to subrounded; .18mm x .12mm to .05mm x .03mm.

Feldspar - detrital; subangular to subrounded; .2mm x .18mm to .04mm x .04mm.

Muscovite - detrital; subangular and elongate; .5mm x .1mm to .03mm long.

Biotite - detrital; subangular and elongate; .5mm x .1mm to .04mm long; many are altering to chlorite.

Rock Fragments - subrounded; volcanic; 1.0mm x .4mm to .35mm x .2mm.

Microcline - detrital; subangular; .18mm x .1mm.

Pyrite - secondary; subangular to rounded; .2mm x .2mm to .02mm x .02mm.

RRGI 7-1 3833'

A poorly sorted graywacke with an ashy matrix altering to carbonate. Glass shards present have also altered to carbonate. Secondary pyrite is present with all other grains being detrital.

The rock consists of 53 percent carbonate, 17 percent feldspar, 16 percent quartz, 5 percent matrix, 3 percent muscovite, 3 percent pyrite, 2 percent biotite, and 1 percent microcline.

Minerals

Quartz - detrital; subangular to subrounded; .35mm x .15mm to .02mm x .02mm.

Feldspar - detrital; subangular to subrounded; .3mm x .2mm to .02mm x .02mm.

Muscovite - detrital; subangular and elongate; .25mm x .09mm to .02mm long.

Microcline - detrital; subangular to subrounded; .5mm x .35mm to .1mm x .05mm.

Biotite - detrital; subangular and elongate to subrounded; .3mm x .15mm long; some are altering to chlorite.

Pyrite - secondary; subangular to subrounded; many are forming along grain contacts; .3mm x .3mm to .02mm x .02mm.

RRGI 7-1 3834'

A poorly sorted feldspathic graywacke with the matrix altered to carbonate. Rock fragments include igneous, metamorphic, and volcanic rocks. Secondary pyrite is present with all other grains being detrital.

The rock consists of 39 percent carbonate, 18 percent quartz, 17 percent feldspar, 10 percent rock fragments, 6 percent microcline, 5 percent muscovite, 3 percent pyrite, and 2 percent biotite.

Minerals

Quartz - detrital; subangular to subrounded; 1.0mm x 1.0mm to .02mm x .02mm.

Feldspar - detrital; subangular to subrounded; 1.5mm x .75mm to .04mm x .03mm.

Muscovite - detrital; subangular and elongate; .75mm x .2mm to .02mm long.

Microcline - detrital; subangular to subrounded; 1.0mm x .75mm to .2mm x .2mm.

Rock Fragments - subangular to subrounded; 3.75mm x 3.3mm to .75mm x .5mm.

Pyrite - secondary; subrounded; .05mm x .05mm to .02mm x .02mm.

RRGI 7-1 3837'

A poorly sorted feldspathic graywacke with the matrix altered to carbonate. Rock fragments include igneous, metamorphic, volcanic, and sandstone rocks. Secondary pyrite is also present with all other grains being detrital.

The rock consists of 31 percent quartz, 21 percent rock fragments, 19 percent feldspar, 15 percent carbonate, 5 percent pyrite, 4 percent microcline, 3 percent biotite, and 2 percent muscovite.

Minerals

Quartz - detrital; subangular to subrounded; 1.5mm x 1.5mm to .02mm x .02mm.

Feldspar - detrital; subangular to subrounded; 2.25mm x 1.0mm to .04mm x .03mm.

Muscovite - detrital; subangular and elongate; .6mm x .3mm to .15mm long.

Microcline - detrital; subangular to subrounded; 2.5mm x 2.0mm to .4mm x .3mm.

Rock Fragments - subrounded; 3.75mm x 3.75mm to .75mm x .75mm.

Biotite - detrital; subangular and elongate to subrounded; .7mm x .7mm to .2mm long.

Pyrite - secondary; subangular to subrounded; .5mm x .5mm to .02mm x .02mm.

RRGI 7-1 3840'

A moderately well sorted fine-grained graywacke with an ashy matrix altering to carbonate and clay. Secondary pyrite is also present with all other grains being detrital.

The rock consists of 25 percent ashy matrix, 24 percent quartz, 24 percent feldspar, 9 percent carbonate, 7 percent pyrite, 6 percent clay, 3 percent biotite, 2 percent muscovite, and a trace of rock fragments, microcline and monazite.

Minerals

Quartz - detrital; subangular to subrounded; .5mm x .4mm to .05mm x .05mm.

Feldspar - detrital; subangular to subrounded; 2.25mm x 1.0mm to .04mm x .04mm.

Muscovite - detrital; subangular and elongate; .2mm x .09mm to .02mm long.

Rock Fragments - subrounded; carbonate; .2mm x .14mm.

Microcline - detrital; subangular to subrounded; .8mm x .6mm to .7mm x .5mm.

Monazite - detrital; subangular; .08mm x .07mm.

Biotite - detrital; subangular and elongate to subrounded; .35mm x .2mm to .1mm long.

Pyrite - secondary; subangular to subrounded; .25mm x .2mm to .02mm x .02mm.

RRGI 7-1 3843'

A poorly sorted feldspathic graywacke with an ashy matrix altering to carbonate. Secondary pyrite is also present with all other grains being detrital. Rock fragments include igneous, metamorphic, and volcanic rocks.

The rock consists of 27 percent carbonate, 25 percent feldspar, 15 percent quartz, 12 percent matrix, 11 percent microcline, 6 percent rock fragments, 3 percent biotite, 1 percent pyrite, and a trace of muscovite.

Minerals

Quartz - detrital; subangular to subrounded; 1.5mm x 1.0mm to .06mm x .04mm.

Feldspar - detrital; subangular to subrounded; 2.25mm x 1.5mm to .08mm x .08mm.

Muscovite - detrital; subangular and elongate to subrounded; .7mm x .5mm to .05mm long.

Biotite - detrital; subangular and elongate to subrounded; 1.5mm x .5mm to .08mm long.

Microcline - detrital; subangular to subrounded; 2.0mm x 1.5mm to .08mm x .06mm.

Rock Fragments - subangular to subrounded; 2.25mm x 2.0mm to .75mm x .3mm.

Pyrite - secondary; subangular to subrounded; .6mm x .6mm to .02mm x .02mm.

APPENDIX 2

Salt Lake Formation Outcrops

<u>Location</u>	<u>Thickness</u>	<u>Description</u>
JS-1 NE 1/4, Sec 29, R26E, T15S	4 ft	Light gray massive-bedded silty tuff composed mainly of glass shards and ashy matrix. Also contains pumice lumps, quartz, feldspar, and biotite. N-S, 6E.
	3 ft	Light brown massive-bedded conglomerate. Very poorly sorted with subrounded cobbles up to 6". Fragments are mostly quartzite with some volcanics. Matrix is very fine-grained sandstone composed of quartz and feldspar with minor biotite and pyrite. N20W,33NE.
	3 ft	Light gray moderately well sorted fine-grained tuffaceous sandstone composed of quartz, feldspar, muscovite, biotite, pyrite, and glass shards. N32W,11NE.
	11 ft	Light brown massive bedded conglomerate. Very poorly sorted with subrounded cobbles up to 6". Fragments are mostly quartzite with some volcanics. Matrix is very fine-grained sandstone composed of quartz and feldspar with minor biotite and pyrite. N10E,10W.
	10 ft	Light gray massive bedded very fine-grained silty tuff composed mainly of glass shards and ash. A few grains of quartz, feldspar, and pyrite are also present. N20W,15NE.

<u>Location</u>	<u>Thickness</u>	<u>Description</u>
2 38	35 ft	Light gray heavily weathered massive to very thin-bedded silty tuff with a few quartz, feldspar, pyrite, and glass shards in ash. Convolute laminations are present. N10W,33NE.
	24 ft	Light gray massive-bedded tuffaceous sandstone interbedded with light gray very thin-bedded silty tuff. The sandstone is medium-grained and well sorted consisting of glass shards, quartz, and feldspar, with minor pyrite and muscovite. The silty tuff consists of ash with some quartz, feldspar, and glass shards. Convolute laminations are present. N30W,30NE.
Total thickness: 90 ft		
7 JS-2 NE1/4,Sec 32,R26E,T14S	1 ft	Light green to gray massive-bedded vesicular lithic tuff. Composed of fine-grained volcanic rock fragments and pumice lumps with minor quartz and feldspar in a silicified matrix.
CT-1 SE1/4,Sec 17,R26E,T13S	5 ft	Light gray massive-bedded poorly sorted tuffaceous sandstone composed of glass shards, pumice lumps, quartz, feldspar, and pyrite. N20E,12SE.
	26 ft	Light gray massive-bedded silty tuff with quartz, feldspar, glass shards, and pumice lumps in a matrix that has altered to clay. Below this unit is a very thin-bedded light gray tuffaceous siltstone with pumice lumps, quartz, and feldspar floating in an ashy matrix. Some beds are graded. Also present are convolute laminations and mudcracks. Upper unit is N55E,12SE. Lower unit is N35W,15SW.
Total thickness: 31 ft		

<u>Location</u>	<u>Thickness</u>	<u>Description</u>
SB-1 NE1/4,Sec 12,R28E,T10S	42 ft	Dark gray massive-bedded sandy tuff composed of subangular quartz, feldspar, and pumice lumps floating in a matrix of glass shards. Also present are some vitrophyre rock fragments up to 10mm.
SB-2 SE1/4,Sec 27,R28E,T11S	13 ft	Light gray thin-bedded tuffaceous siltstones and sandstones. Siltstones are composed of quartz, feldspar, and glass shards floating in an ashy matrix. The sandstones consist of quartz, feldspar, glass shards, and pumice lumps. Some of the sandstones coarsen upward. Also present are convolute laminations, ball and pillow structure, and microfaults. This unit grades into a massive unit with the same description as SB-1. The base of the upper massive unit contains fragments 2-4" in diameter of the underlying finer-grained sediments. N5W,18E.
SB-3 NW1/4,Sec 9,R28E,T12S	15 ft	Light gray massive to very thin-bedded silty tuff composed of quartz, feldspar, glass shards, and a few vitrophyre fragments in an ashy matrix. N30E,2NW.
BP-1 NW1/4,Sec 28,R28E,T14S	20 ft	Light gray thin-bedded to massive silty tuff composed of very few quartz and feldspar grains floating in an ashy matrix. Base of this unit is a conglomerate with pebbles of quartzite and siltstone in a sandstone matrix. This conglomerate coarsens downward. Sandstone dikes and microfaults are present. N35W,6NE.