

P- 154

Petrographic Analysis of Sidewall Cores

for

Canada Northwest Energy Ltd.
Calgary, Alberta

by

PINA - 154.

James K. Russell

B. Edwards

K. Arden

Igneous Petrology Laboratory
The University of British Columbia

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IPL@UBC

<http://www.geology.ubc.ca>

Sample:1-1174.6

Petrographic description: Porphyritic, intersertal/hyalocystalline groundmass. Phenocrysts 5%, groundmass 95%.

Mineralogy

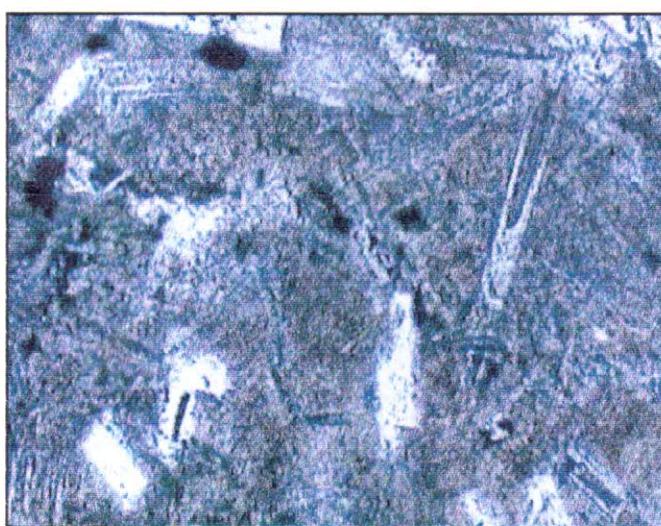
| Mineral | Phase | Estimated Mode | Other |
|-------------|------------|----------------|--|
| plagioclase | phenocryst | variable 5% | euhedral laths to blocks with straight edges, 1.4-0.5 mm long up to 0.5 mm wide, some albite twinning, some oscillatory zoning |
| quartz | phenocryst | <1% | anhedral rounded shapes, irregular margins, 1.0 to 0.25 mm |
| plagioclase | groundmass | 47% | lath-shaped, random orientation, max. 0.1 mm long |
| quartz | groundmass | 2% | primary, anhedral, rounded, max. 0.1 mm |
| oxide | groundmass | <1% | anhedral-subhedral, max. 0.2-0.05 mm |
| glass | groundmass | 50% | altered to chlorite, quartz, oxides |

Crystallization Sequence

| Mineral | Magmatic | |
|-------------|----------|------|
| | Early | Late |
| plagioclase | - | |
| quartz | - | |
| plagioclase | - | |
| quartz | - | |
| oxide | - | |
| glass | - | |

Interpretation:

This is a porphyritic volcanic rock. Several of the groundmass feldspars (white in photomicrograph) have thin, branching terminations ("swallow-tail texture") that indicate rapid growth. These are consistent with cooling in an aqueous environment.



Rock name: plagioclase-quartz-porphyritic dacite flow/dome

Field of view is 1.65 mm wide.

Sample: 2 - 1173.60

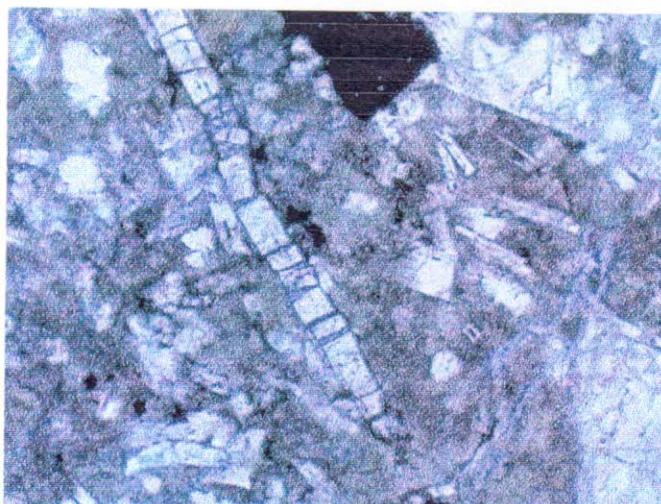
Petrographic description: This sample is probably from the same flow unit as Sample #1 but looks fresher, less altered. Massive, porphyritic, with a intersertal/hyalocrustalline groundmass.

Mineralogy:

| Mineral | Phase | Estimated Mode | Other |
|---------------------|------------|----------------|--|
| plagioclase An15 | phenocryst | variable 5% | euhedral laths to blocks, straight crystal margins, max. 2.1 mm long & 1.1 mm wide, albite twinning, most are separate crystals, but some in clusters, altered |
| [chlorite+oxide] | phenocryst | <1% | pseudomorphs after cpx(?), rectangular-square shapes, straight crystal margins, 0.84 to 0.33 mm |
| apatite | phenocryst | <1% | euhedral laths associated with plagioclase |
| plagioclase | groundmass | 50% | euhedral laths to blocks, max. 0.1 mm long, random orientation |
| quartz | groundmass | 2% | anhedral, irregular shapes, max. 0.17 mm |
| glass | groundmass | 48% | altered to chlorite, oxides, quartz |

Crystallization Sequence

| Mineral | Magmatic | |
|-------------|----------|------|
| | Early | Late |
| plagioclase | --- | |
| cpx(?) | --- | |
| plagioclase | --- | --- |
| quartz | --- | --- |
| glass | --- | |



Interpretation: This is probably the same unit as Sample #1. There are some slight variations in phenocryst composition, but this may be due to within-flow variation.

Rock name: plagioclase-porphyritic dacite flow/dome

Field of view is 3.1 mm wide.

Sample: 3 - 1168.70

Petrographic description: Clastic/fragmental texture, lapilli to ash-sized clasts. Clast types comprise (1) vitrophyric, perlitic microlitic porphyritic dacite flow/dome, with 7% phenocrysts and 93% groundmass (Figure 1) (2) broken crystals of plagioclase with or without attached glass (3) broken crystals of primary oxide with or without attached glass (4) glass fragments with perlitic texture, identical to the glass groundmass in clast type 1. Clasts are separated by a very fine grained glassy (devitrified) matrix (Figure 2). Unit is matrix-supported. No accidental clasts visible. Clast type 1 is dominant, but there is a complete compositional and textural gradation between all clast types.

Mineralogy: Clast type 1

| Mineral | Phase | Estimated Mode | Other |
|-------------------|------------|----------------|--|
| plagioclase An10 | phenocryst | 5% | euhedral laths to blocks with straight margins, some glomeroporphyrs, max. 1.4 mm long to 1.0 mm wide, some oscillatory zoning |
| oxide (magnetite) | phenocryst | 2% | subhedral blocky shapes, max. 0.3 mm long |
| plagioclase | groundmass | 2% | euhedral lath shapes, random orientation, max. 0.2 mm long |
| glass | groundmass | 98% | devitrified perlite |

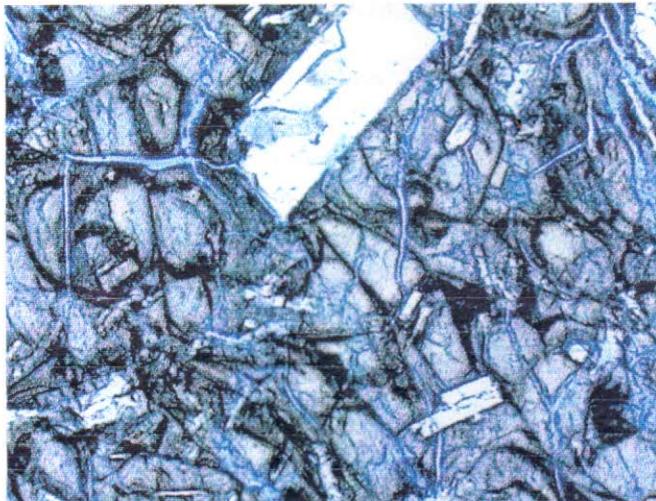
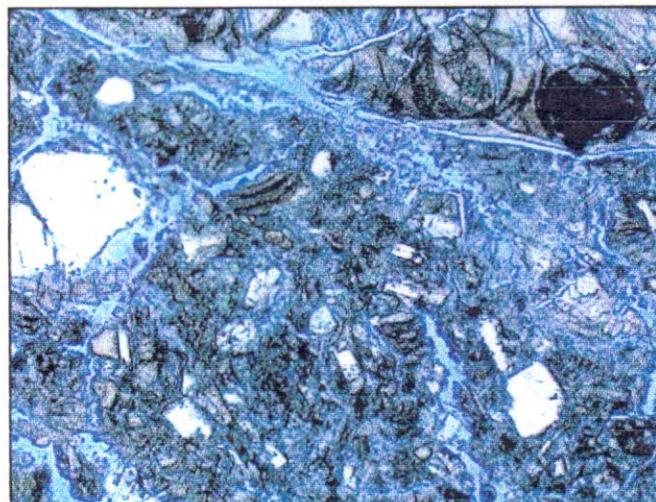


Figure 1: Field of view is 3.1 mm wide.



Interpretation: The compositional and textural similarities observed between all clast types suggest they are genetically related and the unit is monolithic. This sample is a volcanic breccia that was derived by fragmentation of a plagioclase & magnetite-phyric vitrophyric dacite flow/dome. The angularity of the clasts indicates that it may be a flow breccia (fragmented in situ without significant transportation) but may be a tectonic breccia.

Rock name: plagioclase, magnetite-phyric dacite/rhyolite flow/dome breccia.

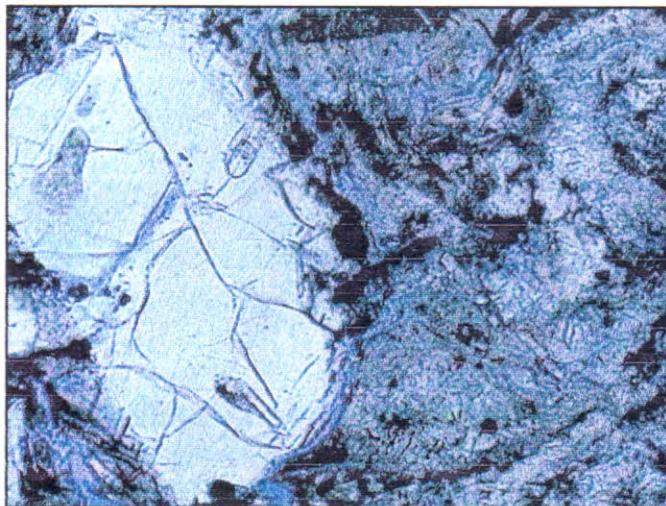
Figure 2: Field of view is 3.1 mm

Sample: 4 - 1155.10

Petrographic description: Clastic fragmental texture, lapilli to ash-sized clasts. Sample is similar to Sample #3 but is more highly altered. Clast types comprise (1) plagioclase+oxide+cpx(?) porphyritic microlitic vitrophyric dacite with perlitic groundmass, ~10% phenocrysts, 90% groundmass, (2) separate crystals of plagioclase with or without attached glass (3) separate oxide crystals with or without attached glass (4) broken pieces of glass identical to the groundmass of clast type 1. Clasts are separated by a very fine grained glassy (devitrified) matrix. Unit is matrix-supported. No accidental clasts visible. Clast type 1 is dominant, but there is a complete compositional and textural gradation between all clast types.

Mineralogy: Clast Type 1

| Mineral | Phase | Estimated Mode | Other |
|------------------|------------|-------------------------|--|
| plagioclase An16 | phenocryst | extremely variable 1-7% | euhedral laths to blocks, max. 2.1 mm long to 0.6 mm wide, albite twinning, straight crystal edges |
| oxide | phenocryst | <1% | euhedral to subhedral blocky shapes, max. 0.3 mm |
| [chl+ox] | phenocryst | <1% | pseudomorph after cpx(?), blocky subhedral shapes, max. 0.5 mm wide |
| plagioclase | groundmass | 2% | euhedral lath shapes, random orientation, 0.07 mm long |
| glass | groundmass | 98% | devitrified, altered to chlorite+oxide+quartz, some remnant perlitic texture |



Field of view is 1.65 mm wide.

Interpretation: This is probably the same unit as Sample #3. The clastic texture, the textural and compositional similarities of the clast types suggest a breccia with a single volcanic provenance. It may represent a flow breccia or a tectonic breccia.

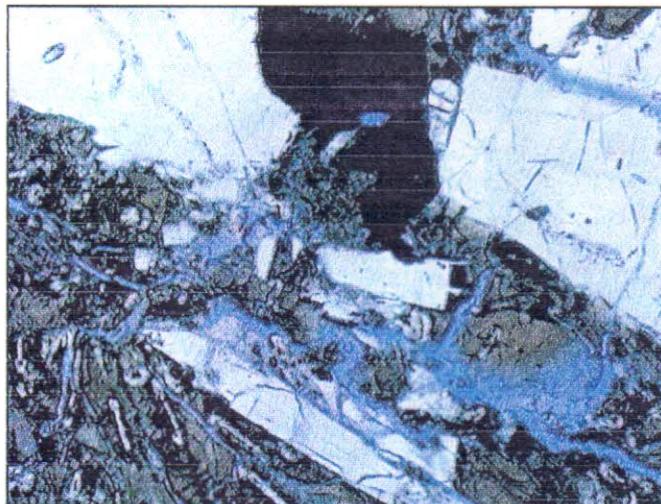
Rock name: plagioclase-, pyroxene-, oxide-phyric dacite/andesite flow/dome breccia

Sample: 5 - 1146.60

Petrographic description: Clastic/fragmental texture, lapilli to ash-sized clasts. This sample is similar to sample #3. Clast types include (1) vitrophyric, glomeroporphyritic (plagioclase, cpx(?), magnetite) dacite/andesite flow, groundmass is glassy perthite, ~17% phenocrysts, ~83% groundmass, one clast is >3cm wide (2) broken plagioclase crystals with or without attached glass (3) pieces of glass identical to the groundmass in clast type 1. The unit is clast to matrix supported. The matrix is very fine grained, recrystallized. No accidental clasts visible. Clast Type 1 is dominant, but here is a complete textural and compositional gradation between clast types.

Mineralogy: Clast Type 1

| Mineral | Phase | Estimated Mode | Other |
|------------------|------------|----------------|---|
| plagioclase An38 | phenocryst | variable 15% | euhedral laths to blocks, average 0.25 to 0.5 mm, commonly in glomeroporphyrites, albite twinning, some strong oscillatory zoning |
| [chl] | phenocryst | 1% | pseudomorphs after amphibole(?), euhedral lath shapes, max. 2.1 mm long |
| magnetite | phenocryst | 1% | euhedral -subhedral blocky shapes, max. 0.3 mm |
| plagioclase | groundmass | 10% | euhedral laths, some parts show alignment, max. 0.12 mm long |
| glass | groundmass | 90% | perlitic texture, devitrified |



Field of view is 3.1 mm wide.

Interpretation: This is a similar unit to Samples #3 and #4. The clastic texture, the textural and compositional similarities of the clast types suggest a breccia with a single volcanic provenance. The composition of the plagioclase suggests an andesite/dacite volcanic provenance. The alignment of the plagioclase laths in the groundmass suggests that there was flow within the andesite/dacite. It may be a flow breccia or tectonically-derived breccia.

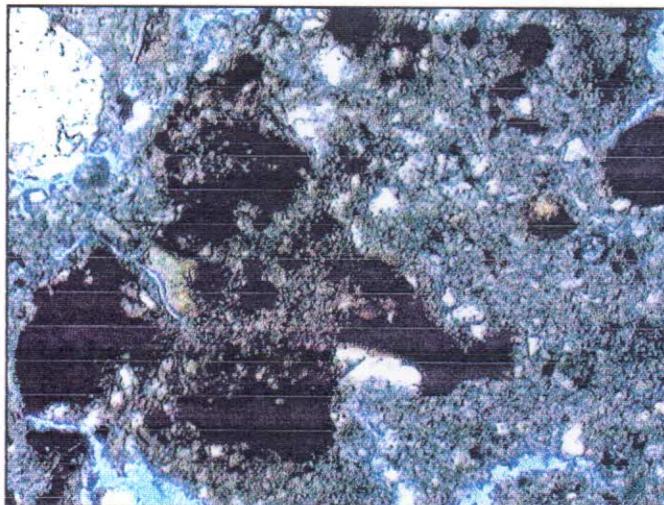
Rock name: plagioclase-, pyroxene-, oxide-phryic andesite/dacite flow breccia

Sample: 6 (1144.0m)

Petrographic description: This sample is not similar to any sample seen before. It has a clastic texture, with clast types: (1) rounded porphyritic intersertal dacite (2) dark brown rounded to blocky aphyric intersertal dacite with plagioclase laths in (3) separate crystals (plagioclase). A fine grained matrix is also visible. The unit is matrix-supported.

Mineralogy:

| Mineral | Phase | Estimated Mode | Other |
|---------------------|------------|----------------|---|
| Clast 1 | | | |
| Plagioclase An52-33 | phenocryst | 1-5% | euhedral, lath to blocky shapes with straight crystal margins, albite twinning, oscillatory zoning, max. 0.9 mm long, 0.4 mm wide |
| plagioclase | groundmass | ~50% | euhedral, lath shapes, max. 0.2m long, no preferred orientation |
| glass | groundmass | ~50% | devitrified, altered to chl, ox |
| Clast 2 | | | |
| plagioclase | groundmass | 40% | euhedral, lath-shaped, max. 0.25 mm |
| glass | groundmass | 60% | devitrified, altered to chl, ox and qz |
| Clast 3 | | | |
| plagioclase An30 | | | anhedral to subhedral blocks with broken to straight crystal edges, albite twinning, max. 0.9 mm long |
| Matrix | | | Very fine grained, altered to oxide, chl, qz, pg |



Interpretation: This rock is not a primary volcanic deposit. The dissimilar nature of the clast types as well as the variable An contents of the plagioclase support a volcaniclastic origin for the unit. The clasts were derived from several different volcanic units, most of these were probably andesite-dacite flows. Some of these are plagioclase phryic, others aren't, although this may be an artifact of the clasts derivation process.

Rock name: volcaniclastic lapilli-tuff

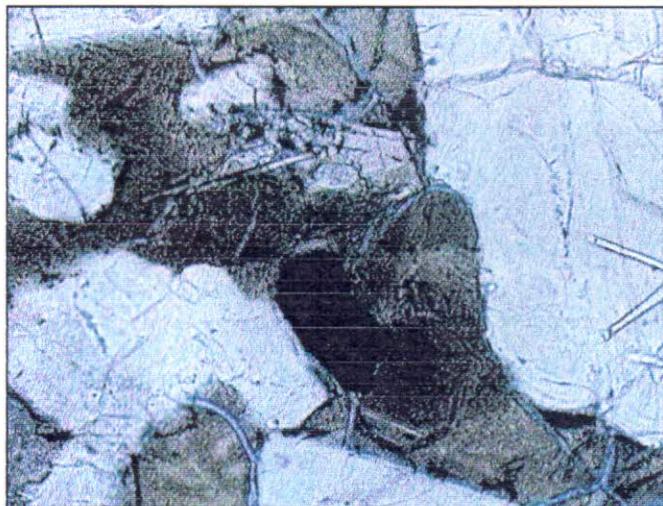
Field of view is 3.1 mm.

Sample: 7-1136.6

Petrographic description: This sample is similar to Sample 3,4 but there are some differences. Clastic texture with the following clast types (1) subrounded to subangular porphyritic vitrophyric dacite flow/dome (2) aphyric vitrophyric dacite flow/dome, identical to Type 1 except there are no large phenocrysts (3) angular separate crystals of plagioclase and oxide with identical characteristics to the phenocrysts in Type 1 and (4) glass with perlitic texture identical to the glass in Types 1,2. There are compositional gradations between all types. The unit is matrix supported; the matrix is more abundant in this sample than in samples 3, 4 or 5.

Mineralogy:

| Mineral | Phase | Estimated Mode | Other |
|------------------|------------|----------------|--|
| Clast 1 | | | |
| Plagioclase An12 | phenocryst | 1-5% | euhedral, lath to blocky shapes, max. 0.9 mm long, 0.5 mm wide, straight crystal edges, albite twinning, oscillatory zoning, some are extensively altered to chl |
| oxide | phenocryst | 1% | euhedral to subhedral, blocky shapes, straight edges, max. .25 mm |
| plagioclase | groundmass | ~3% | euhedral lath shapes, max. 0.2 mm long |
| glass | groundmass | 97% | perlitic texture |
| Matrix | | * | very fine grained, altered |



Field of view is 1.65 mm wide.

Interpretation: The similarity of this sample to samples 3 and 4 suggest that it has the same origin. It is not part of the same unit (s) as these; this sample is higher in the section and is separated from the lower two by a volcaniclastic unit. In addition, the ratio of clasts to matrix is lower in this sample than the other two. The similarity of the clast types to one another, the complete textural and compositional range between the clasts and the lack of accidental lithics suggests there is only one provenance for this breccia unit. It may represent either a flow breccia or a tectonically-derived breccia.

Rock name: plagioclase-magnetite-porphyritic dacite breccia

Sample:8-1131.6

Petrographic description: This is a massive porphyritic intersertal sample.

Mineralogy:

| Mineral | Phase | Estimated Mode | Other |
|---------------------|------------|----------------|--|
| Plagioclase An32 | phenocryst | 10% | euhedral, lath shapes with straight to partially embayed margins in places, max 2.2mm long, 1.0mm wide, albite twinning, some oscillatory zoning |
| oxide | phenocryst | 2% | subhedral, square shapes, slightly irregular crystal margins, max 0.25 mm |
| plagioclase | groundmass | 40% | euhedral lath-shaped, no preferred orientation, max 0.1mm long |
| glass | groundmass | 60% | altered to chl and ox; in places there are surrounded to slightly square areas of chl recrystallization |

Crystallization Sequence

| Mineral | Magmatic ¹ | |
|-------------|-----------------------|-------|
| | Early | Late |
| plagioclase | ----- | |
| oxide | --- | |
| plagioclase | | • |
| glass | | ----- |

Field of view is 1.65 mm wide



Interpretation: The massive nature of this sample, the presence of phenocrysts and glass supports its interpretation as a volcanic flow. The plagioclase composition suggests that it is an andesite rather than a dacite. No evidence of flow is preserved. There were probably several stages of crystal nucleation, as shown by the presence of plagioclase phenocrysts and microlites in the groundmass. It is not clear what the areas of chlorite recrystallization in the groundmass represent. In some respects, they have shapes reminiscent of vesicles, but the presence of a

brown isotropic material in the middle of others (with square shapes) may suggest that the chlorite merely represents recrystallization of glass.

Rock name: Massive porphyritic andesite flow/dome

Sample: 9-1111.6

Petrographic description: Massive porphyritic, glomeroporphyritic (see figure), intersertal/hyalocystalline volcanic rock

Mineralogy:

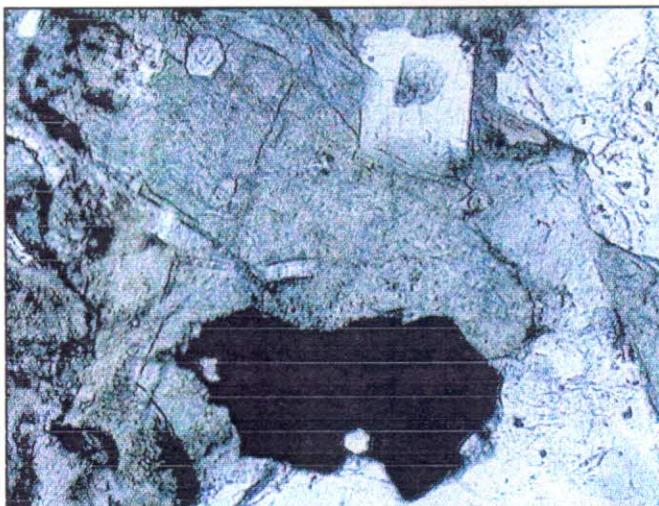
| Mineral | Phase | Estimated Mode | Other |
|---------------------|------------|----------------|---|
| plagioclase An20 | phenocryst | 20% | In glomerocrysts (with oxides) to 2 mm by 2.5 mm, euhedral laths to blocks, separate crystals max 2.8 mm long, albite twinning, some oscillatory zoning |
| [chl] | phenocryst | 1% | pseudomorph after px?, lath-shaped, rectangular shapes, max 0.7 mm long |
| oxide | phenocryst | 3% | subhedral to anhedral shapes, equant to triangular, max 0.5 mm long |
| plagioclase | groundmass | 30% | euherdral, skeletal lath-shaped, max 0.1mm |
| oxide | groundmass | 10% | skeletal, max 0.06 mm, lath-shaped |
| microvesicles | groundmass | ~5% (variable) | rounded irregular to spherical shapes, max 0.06mm |
| glass | groundmass | 55% | altered to chl, oxide |

Crystallization Sequence

Crystallization Sequence

| Mineral | Magmatic | |
|-------------|----------|-------|
| | Early | Late |
| plagioclase | ----- | |
| [chl] | ----- | |
| oxide | ----- | |
| plagioclase | ----- | |
| oxide | ----- | |
| glass | | ----- |

Interpretation: The massive nature of this rock, the presence of phenocrysts, glass and vesicles support its origin as a volcanic rock. No evidence for flow is preserved. The composition of the plagioclase indicates a dactite composition.



Rock name: plagioclase-porphyritic dacite dome/flow

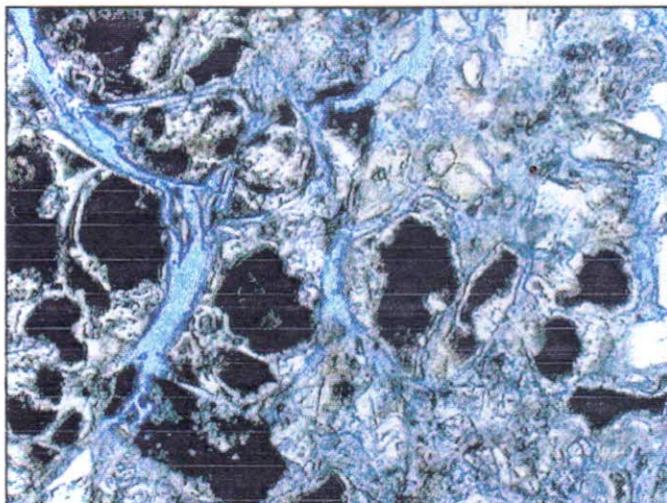
Field of view is 1.65 mm wide.

Sample:10-1104.6

Petrographic description: Clastic texture, ash to lapilli-sized clasts. Clasts comprise (1) porphyritic (plagioclase-augite-mt) vitrophyric with perlitic texture andesite (2) aphyric perlite (3) single broken crystals of plagioclase and augite. There is complete textural and compositional ranges between clast types. The rock is matrix supported.

Mineralogy: Clast Type 1

| Mineral | Phase | Estimated Mode | Other |
|------------------|------------|----------------|--|
| plagioclase An36 | phenocryst | variable 1-5% | euhedral lath-shapes, max 2.1 mm long, albite twinning, straight to slightly irregular edges |
| augite | phenocryst | ~2% | anhedral irregular shapes, max 0.5 mm |
| oxide (mt) | phenocryst | 1% | equant, blocky shapes, max 0.2 mm |
| plagioclase | groundmass | variable 5-30% | euhedral laths, max 0.1 mm |
| glass | groundmass | 95-70% | perlitic texture, devitrified |



Interpretation: The clastic texture of this unit suggests that it is a breccia. The nature (compositions and textures within) of the clasts suggests that the clasts have a volcanic provenance. The similar composition of the clast types suggests that the clasts are all genetically related and have a volcanic flow provenance.

Rock name: andesite volcanic breccia

Field of view is 3.1 mm wide.

Sample: 11-1097.70 m

Petrographic description: massive, porphyritic, glomeroporphyritic, medium grain size, intergranular.

Mineralogy

| Mineral | Phase | Estimated Mode | Other |
|------------------|------------|----------------|--|
| plagioclase An36 | phenocryst | 10-15% | 0.05 - 0.1 mm, strong oscillatory zoning |
| augite | phenocryst | <5% | anhedral, max 0.2 mm |
| oxide (mt) | phenocryst | <5% | equant, blocky shapes, max 0.02 - 0.025 mm |
| plagioclase | groundmass | variable 5-30% | euhedral laths, max 0.1 mm |
| glass | groundmass | 95-70% | perlitic texture, devitrified |

Crystallization Sequence

| Mineral | Magmatic | |
|-------------|----------|-------|
| | Early | Late |
| plagioclase | ----- | |
| augite | ----- | |
| oxide | ----- | * |
| plagioclase | ----- | . |
| glass | | ----- |



Interpretation: Skeletal nature of plagioclase and opaque grains result from rapid cooling, which is consistent with subaqueous eruption.

Rock name: andesite lava flow/dome

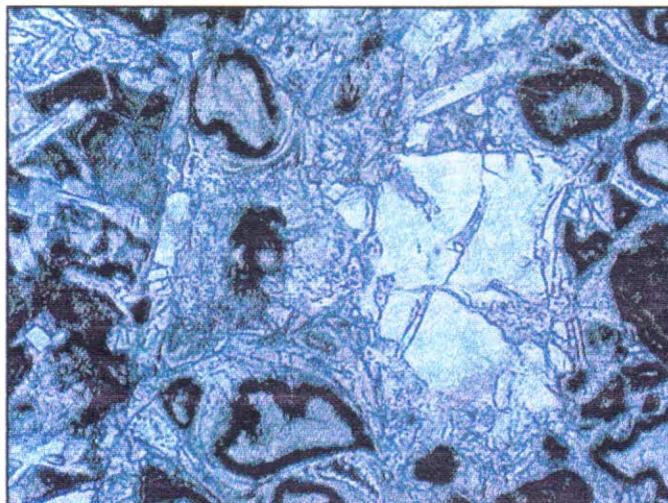
Field of view is 1.65 mm wide.

Sample: 12-1084.6

Petrographic description: This sample is similar to sample #10. Clastic texture with clast types (1) porphyritic (plagioclase, augite, mt) perlitic vitrophyric andesite (2) separate crystals (plagioclase, augite, mt) and (3) glass. Again there is a complete textural and compositional gradation between all clast types. Sample is matrix supported; the matrix is very fine grained and may have been glassy originally. Clasts are subrounded to subangular with a complete size range from 0.5 mm to >8mm.

Mineralogy: Clast Type 1

| Mineral | Phase | Estimated Mode | Other |
|------------------|------------|----------------|---|
| plagioclase An37 | phenocryst | 13% | euhedral to irregular shapes, albite twinning, some are strongly zoned, other unzoned, max 1.4 mm long but highly variable size (smallest 0.25 mm long) |
| augite | phenocryst | 1% | euhedral laths to equant blocks, some irregular, max 1.0mm long, most 4 mm, commonly as glomerocrysts with plagioclase and mt |
| magnetite | phenocryst | 2% | blocky to equant shapes, max 0.25mm wide, commonly as glomerocrysts with augite |
| plagioclase | groundmass | 25% | euhedral laths, max 0.1 mm long, no preferred orientation |
| oxide (mt) | groundmass | 1% | irregular to blocky shapes, max 0.02 mm wide |
| glass | groundmass | 75% | perlitic texture, devitrified, but some may still be fresh |



Field of view is 3.1 mm wide

Interpretation: The clastic nature of this rock suggests that it is a breccia. The similarity of the clast types to one another in terms of mineralogy and textures suggests that the clasts are genetically related to one another and have a single provenance. The porphyritic nature of the clasts and the presence of glass suggests that they are derived from a volcanic flow. The composition of the plagioclase and the presence of augite indicates an andesitic composition for the flow from which the clasts were derived.

Rock name: Andesite breccia

Sample: 16 - 1031.7

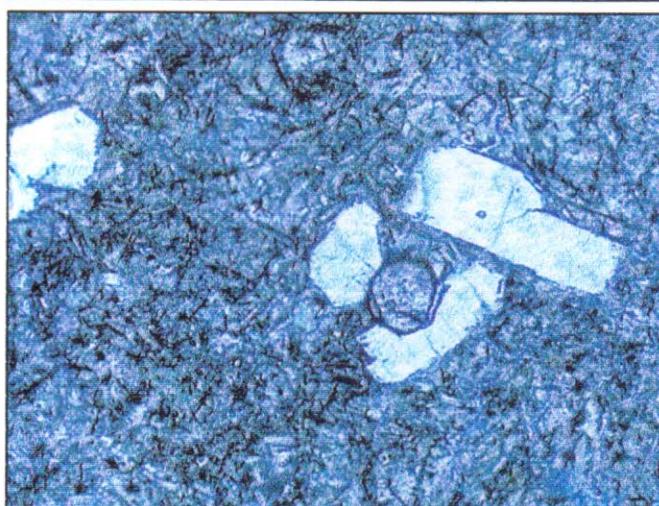
Petrographic description: Sample is massive, porphyritic, with rare clots of phenocrysts (plagioclase, cpx and oxide). Groundmass is felty, with a random distribution of plagioclase and oxide microlites; in places there is incipient variolitic texture. Phenocrysts 10%, groundmass 90%.

Mineralogy:

| Mineral | Phase | Estimated Mode | Other |
|---------------------------|------------|----------------|--|
| plagioclase An50 | phenocryst | 5% | euhedral to subhedral lath to blocky to diamond shapes, crystal margins are straight to slightly embayed, max 2.0mm to 0.25 mm long, most have albite twinning, some have carlsbad-albite twins, some have strong oscillatory zoning, silicate melt+oxide+apatite inclusions |
| [carbonate] after cpx? | phenocryst | 3% | no remnant cpx, euhedral rectangular to equant shapes, max 0.5mm |
| oxide | phenocryst | 2% | euhedral equant to subhedral rounded shapes, max 0.5mm long |
| plagioclase | groundmass | 15% | lath-blade shapes, max 0.1 mm long, random orientation |
| oxide | groundmass | 30% | thin laths/blades, max 0.1mm long, random orientation |
| px | groundmass | 15% | altered to chl |
| glass? | groundmass | 40% | altered to chl |

Crystallization Sequence

| Mineral | Magmatic | |
|-------------|----------|------|
| | Early | Late |
| plagioclase | ----- | |
| cpx | ----- | |
| oxide | ----- | |
| plagioclase | ----- | |
| px | ----- | |
| oxide | ----- | |
| glass | ----- | |



Interpretation: This is a massive volcanic rock. Plagioclase (An50) and cpx formed rare clusters with oxide, but separate crystals also exist. The groundmass consists of very fine grained plagioclase, px and oxides and it has a more crystalline appearance than in any other sample - it may have been crystalline rather than glassy. In a few areas on the slide, there appears to be some incipient variolitic texture. The composition of the plagioclase (determined from carlsbad-albite twins) indicates an andesitic composition, as does the presence of cpx phenocrysts. No evidence of flow is preserved.

Rock name: plagioclase-cpx porphyritic andesite dome/flow

Field of view is 3.1 mm wide.

Sample: 17 - 1010.6

Petrographic description: This sample is massive, porphyritic. The groundmass is microvesicular and there is a slightly trachytic texture. 18% phenocrysts, 82% groundmass. Clusters of plagioclase, oxide and augite phenocrysts are observed.

Mineralogy:

| Mineral | Phase | Estimated Mode | Other |
|------------------|------------------|----------------|--|
| plagioclase An32 | phenocryst | 15% | euhedral laths to blocks, max 3mm long, 1mm wide, albite twinning, contain melt inclusions and oxides, some oscillatory zoning |
| augite | phenocryst | 2% | subhedral to anhedral irregular to equant rounded shapes, max 0.7mm, some alteration |
| oxide | phenocryst | 1% | subhedral equant to triangular shapes, straight margins, max 0.5 mm |
| apatite | micro-phenocryst | <1% | euhedral shapes with straight edges, in clots with pg and px, max 0.1mm |
| plagioclase | groundmass | 20% | lath shapes, max 0.1 mm long, some alignment of laths |
| px | groundmass | 15% | lath shapes, max 0.1 mm long, alignment of laths |
| ox | groundmass | 10% | equant to lath shapes, max 0.07 mm long |

Crystallization Sequence

| Mineral | Magmatic | |
|-------------|----------|-------|
| | Early | Late |
| plagioclase | ----- | ----- |
| augite | ----- | ----- |
| oxide | ----- | ----- |
| apatite | ----- | ----- |
| plagioclase | ----- | ----- |
| px | ----- | ----- |
| oxide | ----- | ----- |
| glass | ----- | ----- |

Interpretation: This rock is a massive volcanic flow. The alignment of the microlites in the groundmass (plagioclase and px) suggests that there has been flow of the lava after eruption.

Rock name: plagioclase-augite porphyritic dacite flow



Field of view is 3.1 mm

Sample: 19 - 986.6

Petrographic description: Massive, porphyritic, amygdaloidal volcanic rock. 20% phenocrysts, 78% groundmass, 2% amygdules. Groundmass is very fine grained, appears glassy?

Mineralogy

| Mineral | Phase | Estimated Mode | Other |
|---|------------|----------------|--|
| plagioclase An 50-55 in large crystals | phenocryst | 18% | euhedral, lath to blocky shapes, straight to slightly embayed edges, some crystals appear broken, albite and carlsbad-albite twinning, oscillatory zoning in some, some grains cored by px and other inclusions (ox), occurs in clots with px and ox as well as separate grains, size 4.0-0.5 mm |
| augite | phenocryst | 1% | anhedral to subhedral crystals with irregular to blocky shapes, max. 1.3 mm long, altered, in clots with plagioclase |
| opx | phenocryst | rare | irregular anhedral shapes, max. 0.25 mm, in clots with augite and pl |
| oxide | phenocryst | 1% | subhedral equant to anhedral irregular shapes, max. 0.3 mm, in clots with px and pg and as separate grains |
| groundmass | groundmass | 80% | very fine grained, contains ~5-10% plagioclase laths max. 0.1 mm long, devitrified and altered to chlorite |
| amygdules | groundmass | 2% | oval to spherical shapes, max. 0.5 mm long, filled with chlorite |

Crystallization Sequence

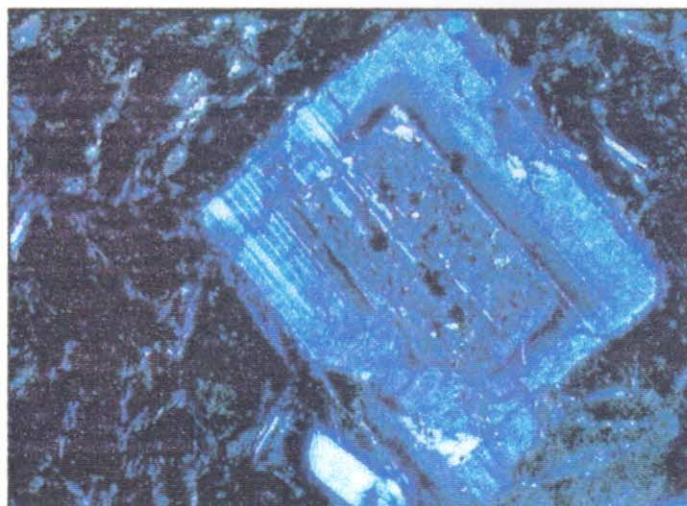
| Mineral | Magmatic | |
|-------------|----------|------|
| | Early | Late |
| opx | --- | |
| cpx | --- | |
| plagioclase | | --- |
| oxide | --- | |

Interpretation: This is a massive volcanic rock. Crystallization began before eruption, with the formation of opx and augite phenocrysts. Oxide and plagioclase crystallization occurred; plagioclase grains incorporated some px and oxides. The phenocrysts often occur in clots, although separate grains are visible.

No flow features are preserved. Amygdules indicate the presence of a degassed volatile phases; these have been filled by chlorite. The groundmass is very fine grained and represents devitrified glass??

Rock name: plagioclase-pyroxene porphyritic andesite lava/dome

Field of view is 3.1 mm wide

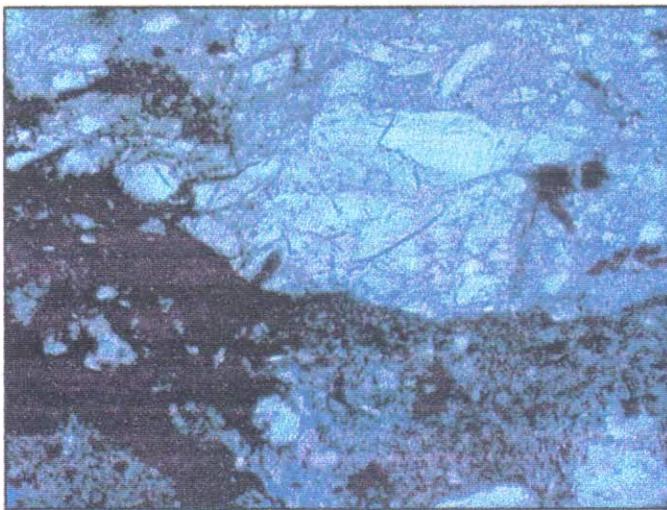


Sample: 20-979.7

Petrographic description: Clastic texture. Dominant clast type (1) is an amygdaloidal plagioclase porphyry with a crystallized groundmass. Other clast types include (2) quartz lithics (3) broken plagioclase crystals. The matrix consists of fine grained clastic material with green-brown igneous mineral (amphibole/biotite/px). Sample is matrix supported. Clasts range from subrounded to angular.

Mineralogy

| Mineral | Phase | Estimated Mode | Other |
|-------------|--------------------------|----------------|--|
| Clast 1 | | | |
| plagioclase | phenocryst | 5% | euhedral lath shapes, straight crystal edges, 2.0-0.2 mm, albite twinning, apatite inclusions, |
| groundmass | groundmass | 93% | well crystallized, consists of plagioclase laths with a random orientation + oxides + [chlorite] after Fe-Mg mineral |
| amygdules | groundmass | 2% | oval to spherical shapes, filled with quartz, average 0.2 mm |
| Clast 2 | | | |
| quartz | -- | 100% | clasts are oval, subrounded with regular/curved edges, 2.1-0.75 mm long, contain only quartz |
| Clast 3 | | | |
| plagioclase | broken crystal fragments | -- | subhedral to anhedral shapes with broken/jagged irregular edges, 0.1-1.4 mm long, albite twinning |
| Matrix | | | fine grained, contains feldspar and other igneous minerals (amph/bio/px) and small rock fragments |



Field of view is 3.1 mm.

Interpretation: This is a clastic rock; it contains three different clast types that have no apparent genetic association, inferred by the different compositions and textures. The dominant clast type is an amygdaloidal plagioclase andesite/hawaiite (depending on original composition of [chl]) suggesting a volcanic provenance. The broken plagioclase crystals may have either a volcanic, which may or may not be related to clast type 1, or plutonic provenance. The quartz clasts most likely represent a sedimentary deposit. The matrix comprises small pieces of all the above rock fragments.

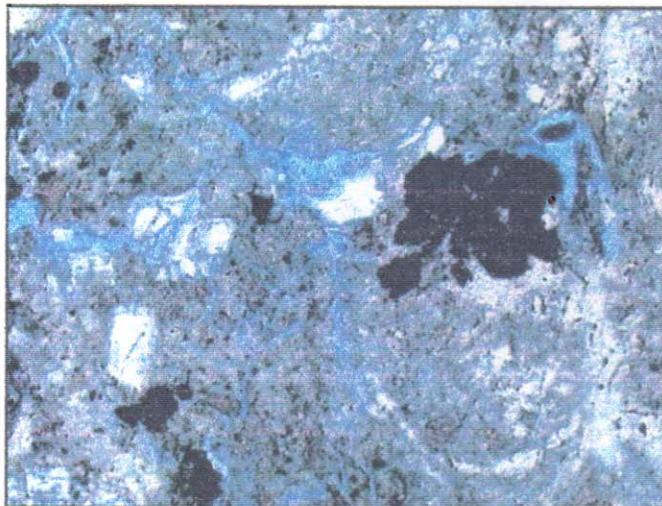
Rock name: volcaniclastic breccia

Sample: 21 - 968.6

Petrographic description: This sample is grossly altered thus the analysis is of low precision. Definitely a clastic texture. Several clast types can be discerned (1) large clast of plagioclase porphyritic volcanic flow (2) glass clasts with perlitic texture? (3) rock fragments with fine grained oxides with or without large oxide phenocrysts. The rest of the "clasts" may be remnants of a perlitic-textured matrix??? The matrix appears to be very fine grained and the rock is matrix supported. Clasts are dominantly angular to subangular

Mineralogy

| Mineral | Phase | Estimated Mode | Other |
|-------------|------------|----------------|---|
| Clast 1 | | | |
| plagioclase | phenocryst | 15% | euhedral lath shapes, generally straight margins, average 1 mm (0.5-2.5 mm) long, albite twinning, some contain oscillatory zoning, partially to highly altered |
| groundmass | | 85% | very fine grained and altered, there may be some remnants of perlitic/spherulitic texture?? |



Field of view is 3.1 mm wide.

Interpretation:

This sample is not a volcanic rock. It is a clastic rock with several different clast types that are genetically unrelated to one another, suggesting multiple sources. The plagioclase-phyric rock has a volcanic flow/dome provenance. The other clast types are too altered to adequately describe and so their provenance cannot be determined with any degree of certainty.

Rock name: volcaniclastic breccia.

Sample: 22-947.7

Petrographic description: Clastic texture. Sample is matrix supported. Many different types of clasts present, including broken crystals of plagioclase and oxide, glass with perlitic texture, plagioclase porphyry with glassy, perlitic groundmass, glassy amygdaloidal clasts with or without plagioclase phenocrysts, fine grained volcanic clasts with granular oxides & plagioclase, fine grained volcanic clasts with plagioclase microlites with trachytic texture. Clasts range from subrounded to angular, most are subangular. The matrix is very fine grained & chlorite rich. There is a complete size range of clasts from 2 mm to 0.04 mm.

Interpretation: Although there is wide diversity in clast type (composition and textures), they all appear to have a volcanic provenance. However, this is not a primary volcanic breccia. There are no sedimentary clasts visible, nor are there any biogenetic fragments that might suggest deposition within a marine basin. The matrix is clastic.



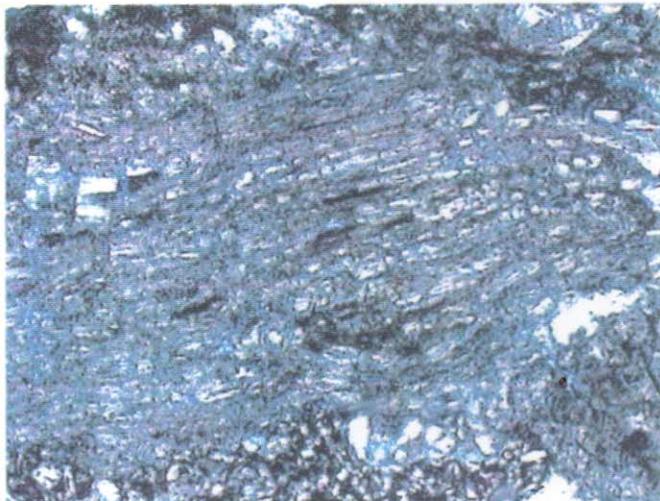
Field of view is 3.1 mm wide.

Rock name: volcaniclastic tuff/sandstone

Sample: 23 - 921.6

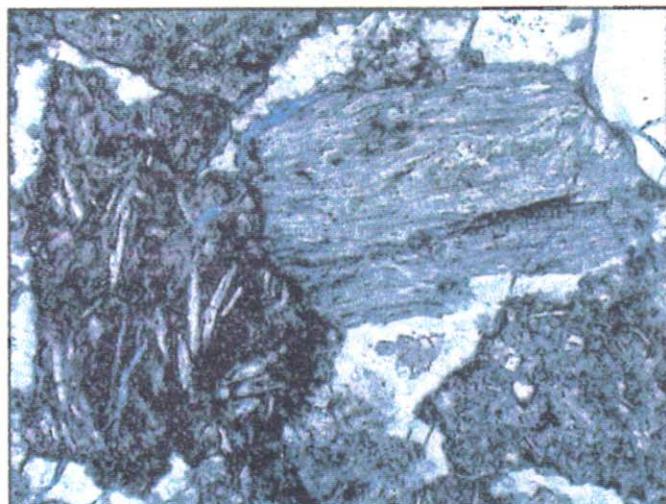
Petrographic description: Clastic texture fragmental. Contains pumice fragments (see figure), lithic clasts, broken crystals (plagioclase crystals are albite twinned and oscillatory-zoned, some contain inclusions of oxides, other minerals and melt). Some of the lithic fragments are volcanic (plagioclase-phyric with glassy groundmass) while others are sedimentary/volcaniclastic (contain rounded clasts of volcanic material). The clasts range from subangular to angular; the matrix is hard to discern but the unit appears to be clast- (dominantly) to matrix- (locally) supported. The unit also contains fragments of flow banded? or welded/compacted aphyric volcanic rocks.

Interpretation: This unit is volcaniclastic. It could be a primary volcanic deposit (ie pyroclastic flow, welded ignimbrite) or near primary (reworked volcanic deposit), suggested by the low abundance of matrix material and the angular shapes.



Field of view is 3.1 mm wide.

Rock name: Volcaniclastic tuff/lithic-crystal tuff.

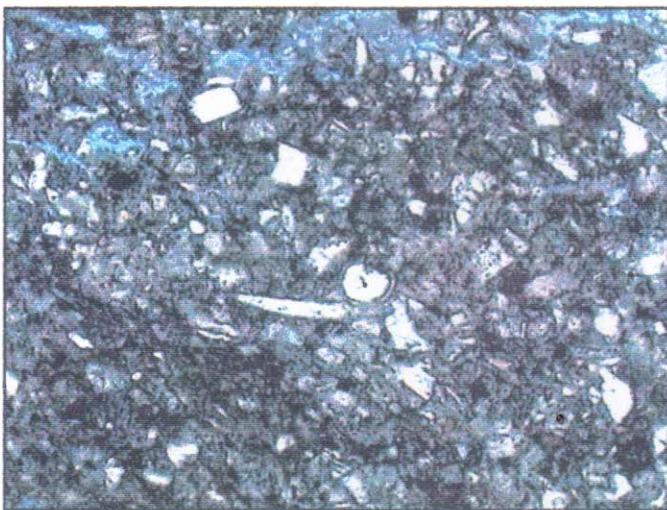


Field of view is 3.1 mm wide.

Sample: 24 - 913.6

Petrographic description: Fragmental texture, most particles are ash-sized. Unit is matrix-supported, clast types include 0.1 mm broken fresh crystals, microfossils (shell fragments, radiolaria??), lithic (volcanic) clasts (0.25 mm long, very fine grained granular). Most clasts are subangular to subrounded. The matrix is very fine grained ash-sized. There are some unusual circular clear, subrounded to rounded oval items; these are clear (filled with very low birefringent mineral??) or partially filled with green chlorite. Not sure what these represent. Could they also be fossils (radiolaria with sulphides??)? There may also be some shards but they are very hard to discern or identify. No structures are identified (no bedding).

Interpretation: The presence of microfossils suggests that this unit formed in a marine setting. It could be a vitric/crystal ash tuff in pelagic marine sediments. The fine grain size indicates that the sample represents a distal/reworked facies.



Field of view is 3.1 mm wide.

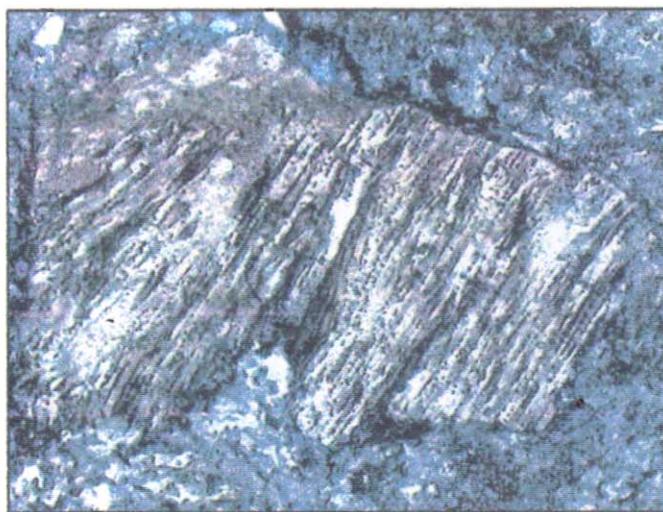
Rock name: Ash tuff

Sample: 25 - 889.6

Petrographic description: Fragmental texture. This sample is somewhat similar to sample 23. Clasts are subrounded to angular, the unit is matrix-supported. Clasts/fragments include: broken crystals (plagioclase: fresh, complex zoning patterns, lath to broken shapes; oxides), lithic clasts (plagioclase-phyric with glassy aphanitic to plagioclase-microlitic groundmass), pumice, flow banded/welded particles similar to those in sample 23. The matrix is very fine grained, chloritic. There is a crude fabric observed.

Interpretation: This is a very similar rock to sample 23, although the two samples are not from the same unit. No marine fossils or sediments are present.

Although there is a great diversity in clast type (textures and composition), they all appear to have a volcanic provenance. This may represent an unsorted, unstructured pyroclastic flow deposit; however, no shards were observed.



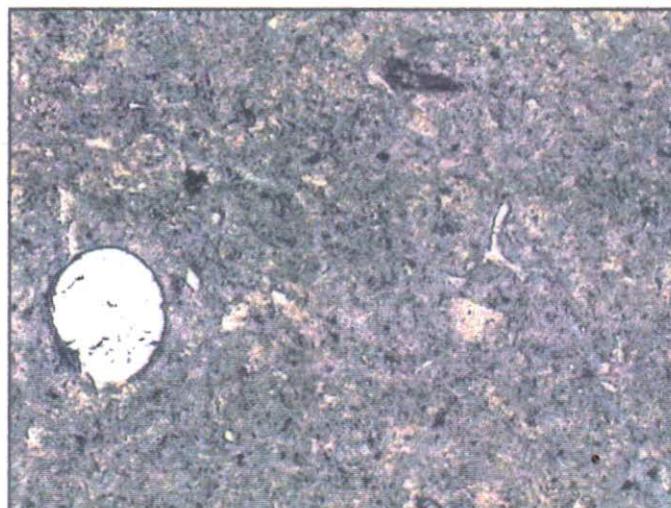
Field of view 3.1 mm wide.

Rock name: Lithic-crystal tuff

Sample: 26 - 844.6

Petrographic description: Clastic/fragmental texture. Clasts are ash-sized. Clasts include <5% broken magmatic plagioclase and amphibole(?) with cusp-like grain boundaries, 10% glass shards and splinters (altered), >60% mud matrix (brown coloured, very fine grained) Microfossils (20%) are also present (radiolaria?). Darker coloured areas are associated with fractures within the sample.

Interpretation: The presence of broken shards/splinters and crystals suggest that this is a primary volcanic deposit. The presence of pelagic mud and the microfossils indicate the deposit was laid underwater. The alteration associated with the fractures resemble worm burrows but this is unlikely.



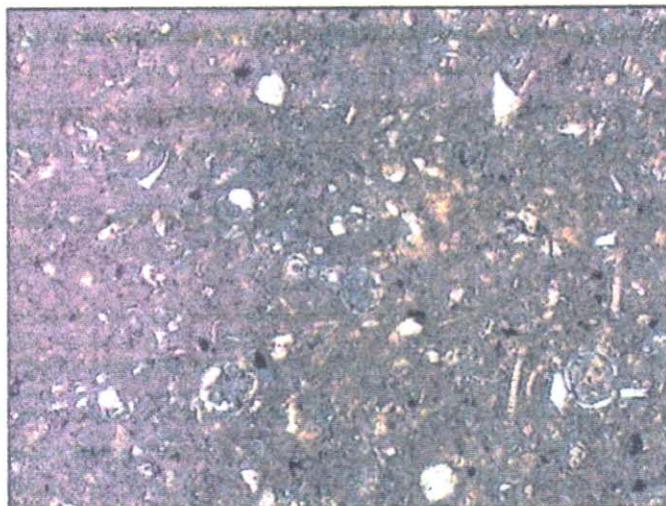
Field of view is 3.1 mm wide.

Rock name: Ash-tuff

Sample: 27 - 834.7

Petrographic description: Clastic texture. Clasts are all ash-sized and consist of: microfossils (radiolaria tests?), the clear oval features similar to those seen in sample 24 (microfossils?), plagioclase laths (broken, 0.02-0.1 mm), oxide-rich lithics (appear black). The matrix is very fine grained and is brown-coloured (marine mud). There are some glass shards and bubble splinters visible (some are altered).

Interpretation: The presence of shards and broken plagioclase laths indicate that this is a primary volcanic deposit, probably distal facies as suggested by the fine grain size. The presence of microfossils suggests that this ash was water-laid.



Field of view is 3.1 mm wide.

Rock name: vitric ash tuff