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PETROGRAPHIC EXAMINATION

OF 119 SERIES THIN SECTIONS

by

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This report describes the results of a petrographic examination of six samples 119505, 119549, 119618, 119722, 119751, and 119760 that were submitted by Ms. Rosie Moore. The rocks were studied in thin sections that, with the exception of sample 119760, had been stained for potassium feldspar. Individual descriptions of the samples are given at the end of this report. With the exception of samples 119549 and 119618, the rocks in this suite are equigranular to porphyritic granites that display generally similar alteration and primary mineral assemblages. Sample 119549 appears to be a devitrified rhyodacite that may represent a dike or sill. Sample 119618 is considered to be a hydrothermal breccia composed of altered fragments of granite.

All of the rocks are contain moderate temperature hydrothermal alteration assemblages that consist of variable proportions of sericite, chlorite, sphene, leucoxene, pyrite, traces of epidote, and in sample 119760, calcite.

The vein assemblages are also mineralogically simple. With the exception of sample 119760, the veins consist dominantly of quartz that is accompanied locally by adularia, sericite, chlorite, and pyrite. In sample 119760, the veins consist of calcite.

The hydrothermal breccia in sample 119618 displays a relatively complex history. This sample shows evidence of hydrothermal alteration and brecciation that was followed by the emplacement of veins consisting of quartz and in places, adularia and pyrite. The presence of adularia in these veins suggests that the fluid was boiling at the time of mineral deposition.

The textures and fluid inclusions in sample 119618 provide some insight into the temperatures during vein deposition. In the quartz veins, plumose overgrowths on coarse-grained quartz and relict botryoidal textures suggest that some of the silica was deposited originally as chalcedony, not quartz. The formation of chalcedony indicates that temperatures were no higher than 180°C at

this time (Fournier, 1985).

The temperatures during deposition of the quartz can be determined from the fluid inclusions it contains. Although no microthermometric measurements were made, the morphologies of the inclusions and their liquid to vapor ratios suggest minimum formation temperatures were on the order of 200° to 225°C. The absence of minerals typical of higher temperatures, such as epidote, in the veins is consistent with this estimate.

The presence of calcite in sample 119760 marks an important change in the mineralogy of the alteration assemblages. The occurrence of this mineral is strongly dependant on the CO_2 content of the hydrothermal fluids. Although gas contents can vary due to processes such as boiling, abrupt changes over short distances are unusual. Thus, the alteration assemblages may represent different hydrothermal events.

Sample: 119505
Rock Type: Porphyritic Granite

Description:

Primary Mineralogy Assemblages

The cuttings in this sample are coarse-grained porphyritic granite consisting of zoned plagioclase (40%; An 50), quartz (25%), potassium feldspar (15%), biotite (10%), pleochroic brown to pale green hornblende (10%), and accessory apatite and magnetite. Plagioclase, hornblende and biotite occur as phenocrysts up to 4 mm across and, in places with quartz and potassium feldspar as interstitial grains. The quartz and potassium feldspar commonly display well developed graphic intergrowths.

Alteration Assemblages

Most chips are characterized by moderate to strong alteration. Plagioclase displays weak to moderate alteration to sericite and traces of epidote. Hornblende has been strongly altered to biotite, chlorite and magnetite. Biotite is variably altered to

chlorite, sphene, leucoxene, and pyrite, which is also found replacing magnetite. The potassium feldspar displays incipient alteration to sericite, giving it a dusty appearance.

Veining

No veins were observed in this sample.

Sample: 119549
Rock Type: Porphyritic Rhyodacite

Description:

Primary Mineralogy Assemblages

The rock in this sample is characterized by phenocrysts of plagioclase, biotite, and rare resorbed quartz in a matrix of devitrified and altered glass. Plagioclase is the most abundant and largest of the phenocrysts, forming approximately 30% of the rock. It ranges up to 5 mm in its greatest dimension. Biotite and quartz phenocrysts together make up less than 5% of the sample.

The matrix of the rhyodacite consists of patchy intergrowths of quartz, potassium feldspar, fine-grained chlorite and sphene. Apatite and zircon occur in trace amounts as accessory phases. The irregular boundaries between the quartz and potassium feldspar suggest that these minerals represent devitrification products of an originally glassy matrix.

Alteration Assemblages

The rhyodacite exhibits moderate alteration to sericite, chlorite, quartz, sphene, leucoxene, pyrite, and epidote. Sericite and traces of epidote replace plagioclase and occur along with sphene, chlorite, and quartz as alteration products of biotite. Leucoxene occurs as an alteration product of ilmenite. Pyrite, which forms up to approximately 5% of the rock, is associated with chlorite and leucoxene in the devitrified matrix of the rhyodacite. Its association with leucoxene suggests that pyrite, in part, has replaced iron-titanium oxides.

No primary ferromagnesium minerals that could have altered to

chlorite and sphene can be identified in the matrix of the rocks. Thus, the these phases may represent minerals that replace clay minerals and oxides that formed during early alteration of the glassy matrix.

Veining

A single vein consisting of quartz and sericite was observed in this sample. The vein is approximately 0.2 mm across.

Sample: 119618
Rock Type: Hydrothermal Breccia

Description:

Primary Mineral Assemblages

The chips in this sample consist of fragments of granite in a fine-grained matrix of crushed rock and quartz. The granite fragments are similar in their primary mineralogy to the granite found in sample 119505. The essential minerals include quartz, plagioclase, potassium feldspar, hornblende, and biotite. In places, the potassium feldspar and quartz display well developed graphic intergrowths. Apatite is a conspicuous accessory phase.

Alteration Assemblages

This granite in this sample has had a complex hydrothermal history. Hydrothermal alteration has resulted in the replacement of the feldspars by sericite, the mafic minerals to chlorite and sphene, and the deposition of locally abundant pyrite. This hydrothermal alteration may have been associated with the hydrothermal brecciation of the granite. The matrix of the breccia is fine-grained and consists mainly of quartz, sericite, pyrite, and comminuted granite. Potassium feldspar is present in the matrix but may have been derived mainly from the granite.

The breccia is cross cut by quartz veins. Several generations of quartz veins are present as indicated by cross cutting relationships. These veins consist of fine- to coarse-grained

quartz accompanied locally by adularia and pyrite. In places, the veins consisting of fine-grained quartz are characterized by relict botryoidal textures. In other veins, euhedral crystals of quartz display plumose overgrowths that radiate outward from the cores. These textures suggest that the fine-grained and plumose quartz overgrowths may have originally been deposited as chalcedony.

The age relationships between the veins in which the silica was originally deposited as chalcedony and those where it was quartz are ambiguous. In places, quartz veins with no evidence of a chalcedonic origin crosscut veins with relict botryoidal textures. In other veins, chalcedony appears to have formed as overgrowths on earlier deposited quartz crystals.

Some insight into the temperatures during deposition of the veins can be obtained from fluid inclusions in the coarse-grained quartz and from information on the thermal stability of chalcedony. According to Fournier (1985), the upper temperature limit for the formation of chalcedony is about 180°C. Thus, the coarse-grained quartz must have formed at higher temperatures. Fluid inclusions are common in some of the coarse-grained crystals. These inclusions define growth zones, indicating that they are primary in origin, that is they formed at the time of mineral growth. Liquid to vapor ratios and the morphologies of the inclusions suggest that they have homogenization temperatures (minimum trapping temperatures) in the range of 200° to 225°C.

Sample: 119722
Rock Type: Equigranular to Porphyritic Granite

Description:

Primary/Alteration Mineral Assemblages

The chips in this sample consist of highly altered equigranular to porphyritic granite. This alteration has resulted in the nearly complete destruction of all of the major primary phases except quartz. The relative abundance of quartz and feldspar, and the presence of rare graphic intergrowths of quartz

and potassium feldspar suggest that this rock is similar to the granite samples encountered at shallower depths.

The secondary minerals are similar to those encountered at shallower depths.

Veining

Traces of veins occur in this sample. These veins consist of: 1) coarse, euhedral quartz crystals accompanied, in places by adularia; 2) stringers of pyrite and sericite; and 3) hydrothermally brecciated granite. The coarse quartz veins (type 1) are similar to those occurring in sample 119618. The breccias (vein type 3) consist of angular fragments in a matrix of fine-grained quartz, chlorite, and sericite. Crosscutting relationships indicate that the quartz veins are younger than the breccias.

Sample: 119751
Rock Type: Porphyritic Granite

Description:

Primary Mineral Assemblage

The cuttings in this sample consist of coarse-grained porphyritic granite. Most of the chips consist of phenocrysts of plagioclase and highly altered biotite and hornblende(?) in a matrix of potassium feldspar, quartz, and plagioclase. Apatite is a common accessory phase. Graphic intergrowths of quartz and potassium feldspar, which are common in some of the shallower samples, are present but rare in this sample. The feldspar phenocrysts range up to 4 mm in length, whereas the biotite phenocrysts are 1 to 2 mm in maximum dimension.

Less commonly, the chips contain feldspar phenocrysts that consist of a core of seriticized potassium feldspar rimmed by plagioclase. The matrix of these chips consists of plagioclase, quartz, and rare potassium feldspar. This variety of granite makes up less than 1% of the sample.

Alteration Assemblages

The granite has been strongly altered and partially silicified. The secondary minerals are similar to those found in other the shallower samples. This alteration was accompanied by the deposition of up to several percent pyrite, which occurs disseminated crystals, as an alteration product of the mafic minerals and in veins.

Veining

Two types of veins are present in the sample. These veins consist of: 1) fine- to coarse-grained quartz; and 2) quartz, sericite, adularia, pyrite, and chlorite. In one chip, crosscutting relationships indicate that the quartz veins are younger than the pyrite-bearing veins. Veins of coarse-grained quartz are present as a few isolated chips.

Sample: 119760
Rock Type: Porphyritic Granite

Description:

Primary Mineral Assemblages

This sample consists of porphyritic granite that is similar in composition to the granite encountered in sample 119751. It lacks, however the rare graphic intergrowths of quartz and potassium feldspar that occur in the shallower sample. It is characterized by phenocrysts of plagioclase and hornblende that are up to 3 mm in length, and biotite that has a maximum dimension of 2 mm. Some of the amphibole crystals have pale green rims that are in optical continuity with the darker cores.

Alteration Assemblages

Most of the chips in this sample are characterized by weak hydrothermal alteration and the presence of secondary calcite as an alteration phase. In contrast, calcite was not observed in the other samples. It occurs with sericite and trace amounts of