Questa Rock Pile Weathering and Stability Project

THE EFFECT OF PARTICLE SIZE FRACTIONS ON CHEMISTRY, MINERALOGY, AND ACID POTENTIAL OF THE QUESTA ROCK PILES, TAOS COUNTY, NEW MEXICO

BY

JOHN MORKEH[1] and VIRGINIA T. MCLEMORE[2]

[1]Barrick Gold Corporation, Ruby Hill Mine, NV
[2]New Mexico Bureau of Geology and Mineral Resources, New Mexico Tech
Socorro, New Mexico 87801

Open-file Report 545

March, 2012

ABSTRACT

Understanding the effect of mineralogy, chemistry, and acid potential of different particle size fractions is important to understand mobility and availability of minerals to dissolution and oxidation during weathering. The purpose of this report is to describe the differences in mineralogy, chemistry, and acid potential between different particle size fractions of samples from the Questa rock piles, debris flows, and alteration scars. There were differences between the particle size fractions. The finer-size fraction, typically <25% of the sample, generally is higher in trace elements and certain minerals than the coarse-size fraction. Total clay minerals, gypsum, and jarosite are higher in the finer-size fractions. In some samples, calcite and pyrite decreases in the finer-size fractions. The finer-size fractions were more acid producing than the coarser-size fractions. The finer-size fractions had higher net acid producing potential (NAPP) and lower paste pH. Conversely, the coarser-size fractions had lower NAPP. For some samples, paste pH values decreases from the coarse-size fraction to the fine-size fraction, but not all samples show a large decrease. There was not a consistent trend in the chemistry and mineralogy between size fractions for all the samples observed. Al_2O_3 shows little change with different size fractions. For most of the samples, concentrations of feldspar, pyrite, Na_2O and K_2O decreased from coarse to fine fractions, while the concentration of FeO, CaO, and SO_4 and total sulfates (gypsum + jarosite) increased with decreasing size fraction for most samples. Silicate dissolution can be recognized from coarse- to fine-size particles, as indicated by the decrease in feldspar, Na_2O and K_2O from coarse- to fine-size fractions. Similar trends were found by Graf (2008) in the Hansen alteration scar. Collectively, these results are consistent with weathering being more pronounced in the fine-size fraction than the coarse-size fraction. The dissolution of pyrite, calcite, and to a lesser extent some combination of chlorite, illite, feldspars, smectite, and other silicate minerals are the predominant chemical reactions that results in the precipitation of gypsum, jarosite, soluble efflorescent salts, and Fe oxide/hydroxide minerals, mostly in the fine-size fractions, although some authigenic gypsum crystals can be quite large. No single process is responsible for the differences in composition between size fractions. The effects of primary igneous crystallization, pre-mining hydrothermal alteration, and post-mining emplacement into the rock pile and subsequent weathering affect the composition of each size fraction. This emphasizes the need to determine not only the composition of the different size fractions, but also perform detailed mineralogy and petrology investigations to understand the processes involved in controlling the compositional differences between size fractions. Although the results are generally consistent, there still is some variation between samples and it is recommended that composition of different particle sizes be examined at other sites.

TABLE OF CONTENTS

INTRODUCTION

PURPOSE AND SCOPE

Understanding the distribution of minerals and major and trace elements in different particle size fractions is important to understand the mobility and availability of minerals to dissolution and oxidation during weathering. In most geologic materials, the composition of the different size fractions is a result of the composition of the parent material and the geologic, geochemical, and pedological processes responsible for the formation of the geologic materials, as well as post-mining blasting, hauling, dumping, and emplacement into the waste rock pile. Composition of various size fractions provides an insight into what chemical changes can be expected as geological materials break down to smaller particles. Weathering of minerals involves mostly surface reactions and the rates of these reactions depend upon the available reactive surface area of the mineral. Mineral surface area is dependent upon the mineralogy, the extent to which the mineral is liberated from the rock matrix, particle size (especially mineral grain size), particle shape, and the surface morphology (i.e. roughness of the mineral surface; Lapakko et al., 1998; Lapakko, 2003). Furthermore, when mineral surfaces are covered with coatings, such as Fe oxyhydroxides, oxidation and dissolution of the mineral can be inhibited. Thus, particles of different particle sizes expose different proportions of the surfaces for chemical reaction, which plays an important role in weathering.

Chevron Mining Inc. sponsored an extensive multi-disciplinary study of the Questa waste rock piles in order to further understand the effects of weathering on the stability of the Questa waste rock piles (McLemore et al., 2009a). One aspect of this larger study is to examine the compositional differences between different size fractions of samples from the rock piles. The purpose of this report is to describe the differences in geochemistry, mineralogy, and acid-base accounting (ABA) between different particle size fractions of samples from the Questa rock piles, debris flows, and alteration scars. *Rock piles*, the preferred term by some in the metal mining industry today, refer to the man-made structures consisting of piles of non-ore overburden material that had to be removed in order to extract ore. This material, referred to in older literature as mine waste, mine soils, overburden, subore, or proto-ore, does not include the tailings material, which consists of non-ore material remaining after milling. Alteration scars are natural, colorful (red to yellow to orange to brown), unstable landforms that are characterized by steep slopes (greater than 25 degrees), moderate to high pyrite content (typically greater than 1%), little or no vegetation, and extensively fractured bedrock. The resulting topography is often referred to as badlands topography. More than 20 naturally forming “alteration scars,” are found along the margins of Red River between the towns of Questa and Red River (Meyer and Leonardson, 1990; McLemore et al., 2004; McLemore, 2009).

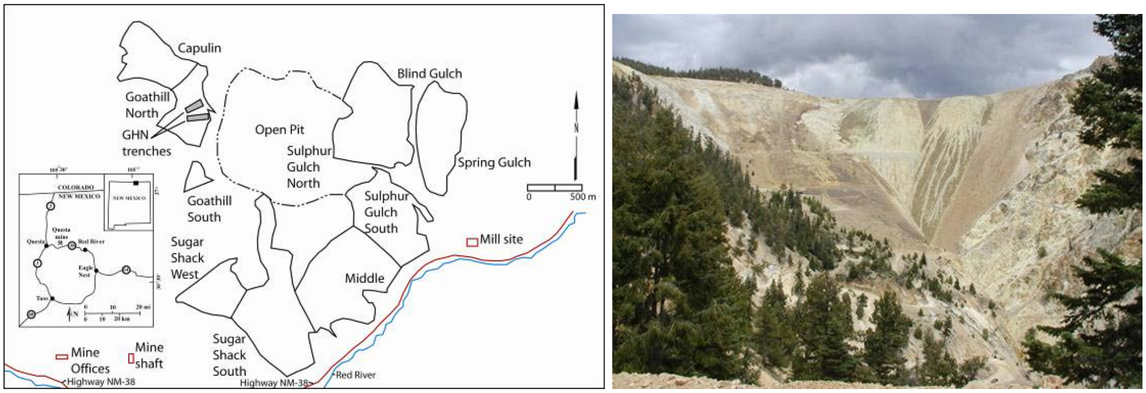
BACKGROUND

Numerous studies have examined the variations in composition between different particle size fractions. Strömberg and Banwart (1999) showed large differences in weathering rates between fine waste rock material and larger particles (diameters >0.25

mm) at the Aitik copper mine in northern Sweden and found that waste rock with diameters less than 0.25 mm (27% of the total mass) accounts for 80% of both the sulfide and silicate weathering. In addition, they found that calcite within grains larger than 5-10 mm reacts too slowly to neutralize the acid produced from the sulfide minerals. Taboada et al. (2006) showed that Zr and Ti behave differently in residual weathering soil profiles; Zr is enriched in the silt fraction, whereas Ti is enriched in the silt and clay fractions and depleted in the sand fraction. Dultz (2002) cautions that normally, feldspars are found in the coarser fractions of soils, but breakdown of feldspar grains by physical weathering could increase the surface area and therefore, increase the reactivity of the grains to weathering. Dultz (2002) also cautions that the parent material affects the weathering of feldspars. Acosta et al. (2011) examined the major and trace element concentrations of different particle size fractions in soils derived from eight different lithologies and found that lithology and mineralogy control the concentrations of major and trace elements in the different size fractions. Brandvold and McLemore (1998) and McLemore et al. (1995) found that the smallest size fractions (<63 μm) of stream sediments contained the largest concentrations of metals (Cu, Pb, Zn) in the Pecos and La Bajada Rivers in northern New Mexico. Munroe et al. (1999) in a study of waste rock piles from different types of deposits in the Hillsboro district in central New Mexico, found that the less than 0.25 mm size fraction typically contained the highest metal concentrations. Dinelli et al. (2007) found that the effects of grain-size distribution on mineralogy and geochemistry are greater in sediments that have not undergone diagenesis, compaction, or lithification. Some chemical indices are not affected by grain size distribution, including Ni/Al, Cr/Al, and Mg/Al and other indices are affected only by the coarse fraction, including SiO_2/Al_2O_3, Na/Al, Zr/Rb, Zr/V, Y/Rb, Y/V, and Ti/V (Dinelli et al., 2007). In a study of samples from waste rock piles from 9 mining districts in New Mexico, Herring et al. (1998), found that the finer-size fraction, typically 10 to 15% of the sample mass, generally, but not always, is markedly enriched in trace elements by a factor of 2 to 5 over the coarser fractions. Graf (2008) found an increase in FeO, CaO, and SO_4 between the coarse- and fine-size fractions in weathered samples from the Hansen alteration scar, east of the Questa mine. He attributed the increase in CaO and SO_4 to the precipitation of gypsum. Silicate dissolution can be recognized from coarse- to fine-size particles, as indicated by the decrease in Na_2O and K_2O, and the large change in total feldspar from coarse- to fine-size fractions. The clay mineralogy was consistent between the coarse- and fine-size fractions in these natural geologic materials.

SITE DESCRIPTION OF THE QUESTA MINE

The Questa molybdenum mine (Chevron Mining Inc., formerly Molycorp, Inc.), in north-central New Mexico, USA (Fig. 1) is on southward facing slopes (elevation 2290-3280 m). The climate at the Questa mine is semi-arid (51.8 cm/yr of precipitation) and alpine. During the period of Questa open-pit mining (1969-1982), approximately 317.5 million metric tons of overburden rock was removed and deposited onto mountain slopes and into tributary valleys forming nine rock piles surrounding the open pit (Fig. 1).



a) b)

FIGURE 1. a) Location of the Questa mine, Taos Range, north-central New Mexico showing rock piles and other mine features. b) GHN before regrading, looking east.

The geologic and mining history of the Questa mine area is complex and is described by others (Schilling, 1960, 1990; Lipman and Read, 1989; Meyer and Leonardson, 1990; Roberts et al., 1990; Meyer, 1991; Ross et al., 2002; Caine, 2003, 2006; Rowe, 2005; Samuels, 2008) and summarized by McLemore (2009). The Questa rock piles were constructed using standard mining practices at the time, primarily by haul-truck end-dumping in high, single lifts (URS Corporation, 2003; McLemore et al., 2009a). The sequence of construction was typically from the top down. End dumping generally results in the segregation of materials with finer-grained material at the top and coarser-grained material at the base. The Questa rock piles are up to 1600 ft high and hundreds of ft wide, and one of them, Goathill North (GHN), experienced some movement due to a pre-existing weak foundation (URS Corporation, 2003). The Questa molybdenum deposit is a Climax-type porphyry molybdenum (±tungsten) deposit, which is a large, low-grade (0.1–0.2% Mo) deposit that contains disseminated and stockwork veinlets of molybdenum sulfides and is associated with silica- and fluorine-rich porphyritic granitic intrusions (Fig. 1). The upper most portion of the open-pit deposit was weathered and had a sulfide cap (Luddington et al., 2005) and this material was mined first and forms portions of the base of the Questa rock piles. McLemore et al. (2009b) provides a lithologic atlas of the rock materials that were mined from the open pit and placed in the rock piles, including a summary of the paragenesis.

SAMPLING AND ANALTICAL PROCEDURES

Samples were collected in the field and analyzed in the laboratory, similar to other samples in the project (McLemore et al., 2009a, b). Three different types of samples were collected for this report: 1) rock-pile material that includes both the soil matrix and rock fragments of mixtures of different lithologies and alteration assemblages, 2) debris flow material, and 3) material from an alteration scar (Table 1). A composite sample of rock or other material was collected using picks, shovels and hand trowels at each site and stored in 5 gallon buckets for petrographic study, particle size distribution, and geochemical analyses. Sample equipment was brushed and wiped clean after each sample was collected. Each sample was assigned a unique number, logged on a field description form, and entered into the project database. Location information was obtained by GPS or surveying by the company. Table 1 shows the number of samples collected from each sample location and the number of size fractions used for this study. The exact locations of these samples are shown in Figure 2, and listed in Appendix 1.

TABLE 1. Samples used for the particle size fraction study. The geologic unit for samples from GHN is in parenthesis and described in more detail in McLemore et al. (2008). Locations of samples are in Figures 2 and 3.

Location	Samples	Number of Size Fraction	Size Fractions (inches)
Goathill North (GHN) rock pile	GHN-JRM-0001 (J) GHN-JRM-0002 (N) GHN-KMD-0088 (O)	5	0.75, 0.5, 0.187, 0.0787, <0.0787
Goat Hill Debris Flow	MIN-AAF-0001 MIN-AAF-0004 MIN-SAN-0002	5	1, 0.75, 0.5, 0.187, 0.0787
Questa Pit Alteration Scar	QPS-AAF-0001 QPS-AAF-0003 QPS-AAF-0005 QPS-AAF-0009 QPS-SAN-0002	5	1, 0.75, 0.5, 0.187, 0.0787
Spring Gulch (SPR) rock pile	SPR-SAN-0002	4	0.75, 0.5, 0.187, 0.0787

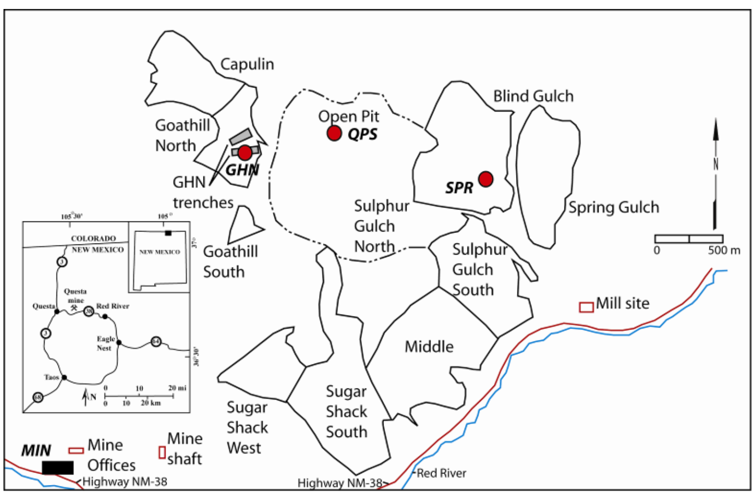


FIGURE 2. Questa rock piles and other mine features, including approximate locations of samples used for particle-size analysis.

A total of 12 samples were selected for the size fraction study and samples were selected for this study 1) to cover a range in weathering intensities, 2) to include waste rock pile and natural materials, and 3) on availability of enough of the sample to perform the analysis. However, not enough material was available for the SPR sample for the five different particle size fractions and only four fractions were obtained. The samples collected are composed of very heterogeneous mine soil material (Fig. 3) and these samples have a wide range of particle-size distribution ranging from large boulders to clay-size particles (Fig. 4; Appendix 1**)**. The size fractions selected for the study (1, 0.75, 0.5, 0.187, 0.0787 inch) cover a range of coarse-size fractions to fine-size fractions and they are the size fractions that had enough material for the entire test to be performed on them. The clay-size materials were not separated for the study because there was not enough material for most of the tests to be performed on just the clay-size material. The <0.0787inch size fraction includes the clay-sized material.

FIGURE 3. A typical sample site, sample being collected from the Questa Pit Scar at the Chevron Questa Mine, New Mexico by John Morkeh and Dr. Ali Fakhimi.

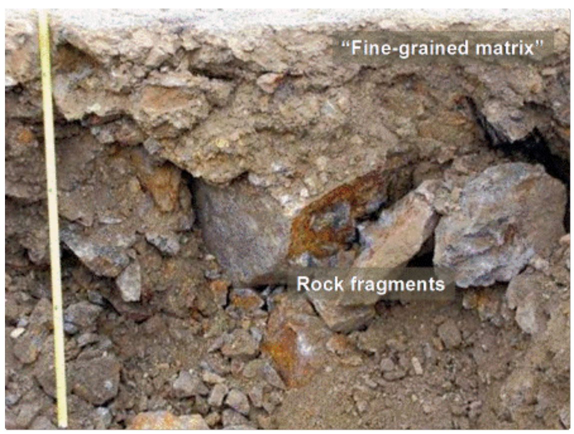


FIGURE 4. A typical sample site showing particle size distribution from large boulders to clay-size particles. Picture from Sugar Shack West (SSW) rock pile.

Each size fraction for chemical analyses was separated using stainless steel sieves, and then crushed in jaw crushers, pulverized by disc grinders to a particle size of <35 μm, homogenized, and sent to the laboratories for analyses. Precision was monitored by multiple analyses of sample duplicates and internal standards. In general, analyses obtained from the different laboratories and methods are in agreement with values of certified standards and precision is excellent between multiple analyses. The overall analytical error of the Questa samples is generally within ±5% (McLemore and Frey, 2010). Figure 5 shows a flow diagram of the sample preparation process.

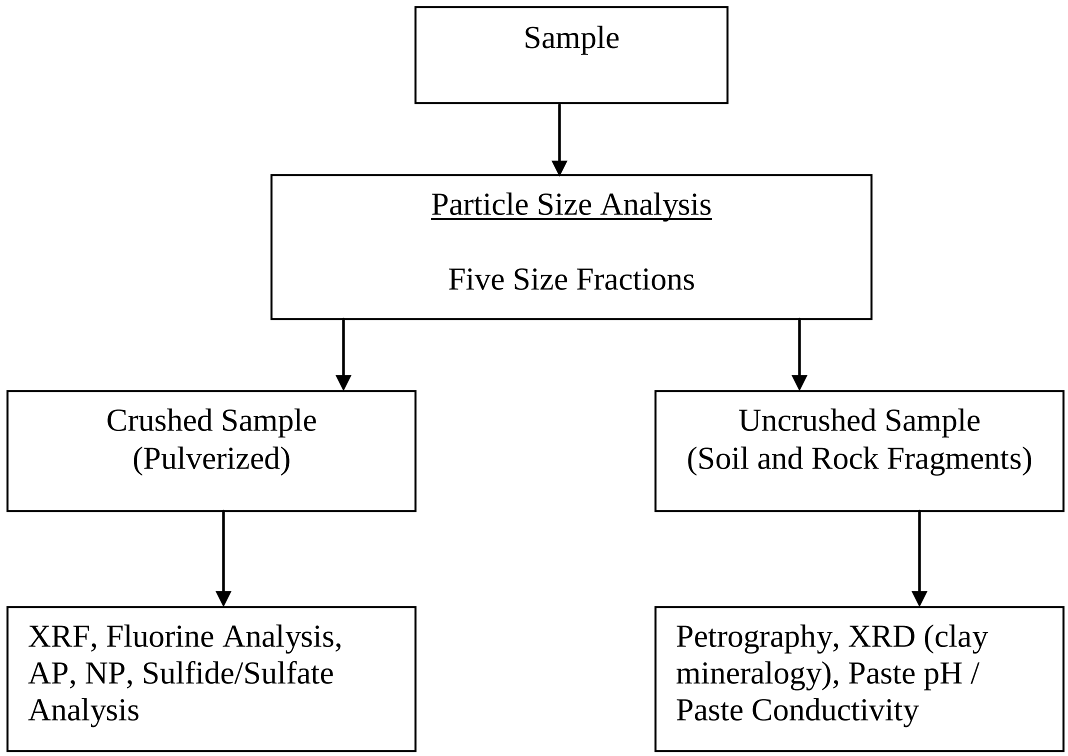


FIGURE 5. Flow chart of sample preparation process for size fraction study.

The laboratory methods employed were the same as those used in other studies of the project and included particle-size analysis, paste pH and paste conductivity measurements, Acid-Base-Accounting (ABA) tests, whole rock chemistry by X-ray fluorescence (XRF), clay mineralogy using X-ray diffraction (XRD), and bulk mineralogy determination (McLemore et al., 2009a). Petrographic analyses (mineralogy, lithology, type of hydrothermal alteration) were performed on both the soil matrix and rock fragments using a binocular microscope. The analyses were supplemented by thin section analysis, microprobe, and X-ray diffraction (XRD) analysis. The major clay mineral groups were identified using standard clay separation techniques and XRD analyses of the clay mineral separate on an oriented glass slide (Moore and Reynolds, 1989). This method does not liberate or measure the amount of clay minerals within the rock fragments. The concentrations of major and trace elements, except S, SO_4, C, LOI (loss on ignition), and F were obtained by X-ray fluorescence (XRF) spectroscopy. F concentrations were determined by selective ion electrode and LOI concentrations were determined by gravimetric methods. Total S and C were determined by Leco Furnace or XRF, and SO_4 was determined by sulfate-sulfur-carbonate leach. S as sulfide was determined by subtracting SO_4 from the total S. Quantitative mineralogy was determined using a modified ModAn (Paktunc, 2001) technique along with petrographic observations (including an estimated modal analysis), electron microprobe analysis, clay mineral analysis, and the whole-rock chemistry of the sample (McLemore et al., 2009c).

RESULTS

Descriptions of the samples are in Appendix 1. The particle size results are summarized in Table 2. Laboratory results are in Appendix 2 and summarized here. Figure 6 shows the differences in pH with different size fractions. Figure 7 shows the differences in mineralogy with different size fractions. Figure 8 shows the differences in major and trace elements with different size fractions. Figure 9 shows the difference in neutralizing potential with different size fractions.

TABLE 2. Summary of particle size results.

Debris Flow			
Sample ID	**% Gravel**	**% Sand**	**% Fines**
MIN-AAF-0001	80.15	16.28	3.57
MIN-AAF-0004	74.89	18.98	6.14
MIN-SAN-0002	26.45	70.74	2.81
Average	**60.50**	**35.33**	**4.17**
Questa Pit Alteration Scars			
Sample ID	**% Gravel**	**% Sand**	**% Fines**
QPS-AAF-0001	64.35	27.26	8.39
QPS-AAF-0003	60.76	31.18	8.06
QPS-AAF-0005	70.75	22.42	6.83
QPS-AAF-0009	67.61	23.64	8.75
QPS-SAN-0002	35.40	62.60	2.00
Average	**59.77**	**33.42**	**6.81**
Sugar Shack West Rock Pile			
Sample ID	**% Gravel**	**% Sand**	**% Fines**
SSW-SAN-0002	44.22	53.82	1.96
SSW-SAN-0006	31.57	67.12	1.30
Average	**37.90**	**60.47**	**1.63**
Goathill North Rock Pile			
Sample ID	**% Gravel**	**% Sand**	**% Fines**
GHN-JRM-0001	35.01	49.22	15.77
GHN-JRM-0002	32.46	50.57	16.97
GHN-KMD-0088	37.19	48.57	14.24
Average	34.89	49.43	15.66
Spring Gulch Rock Pile			
Sample ID	**% Gravel**	**% Sand**	**% Fines**
SPR-SAN-0002	52.54	42.04	5.42

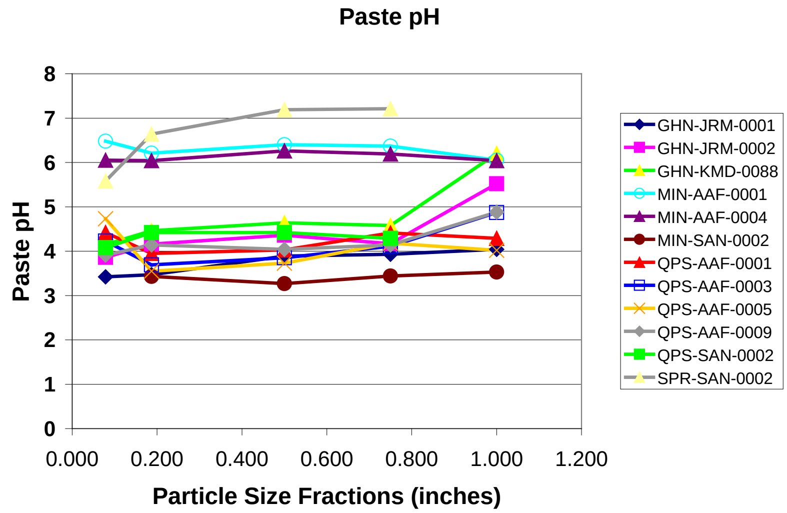


FIGURE 6. Variations of paste pH with different particle size fractions. Generally the fine-size fractions have lower paste pH values.

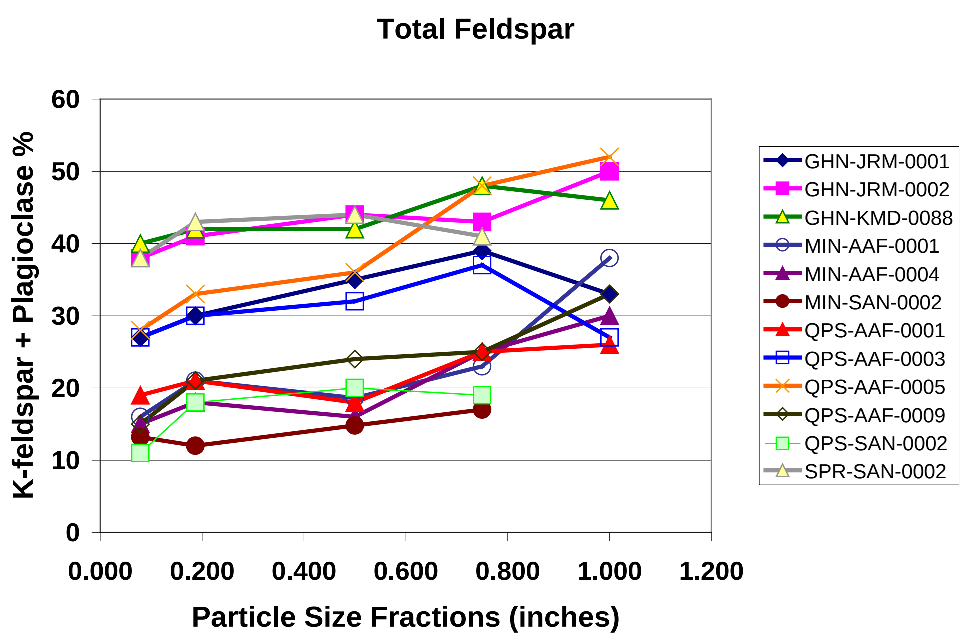


FIGURE 7. Variations in total feldspar, clay minerals, pyrite, calcite and sulfate minerals with different size fractions.

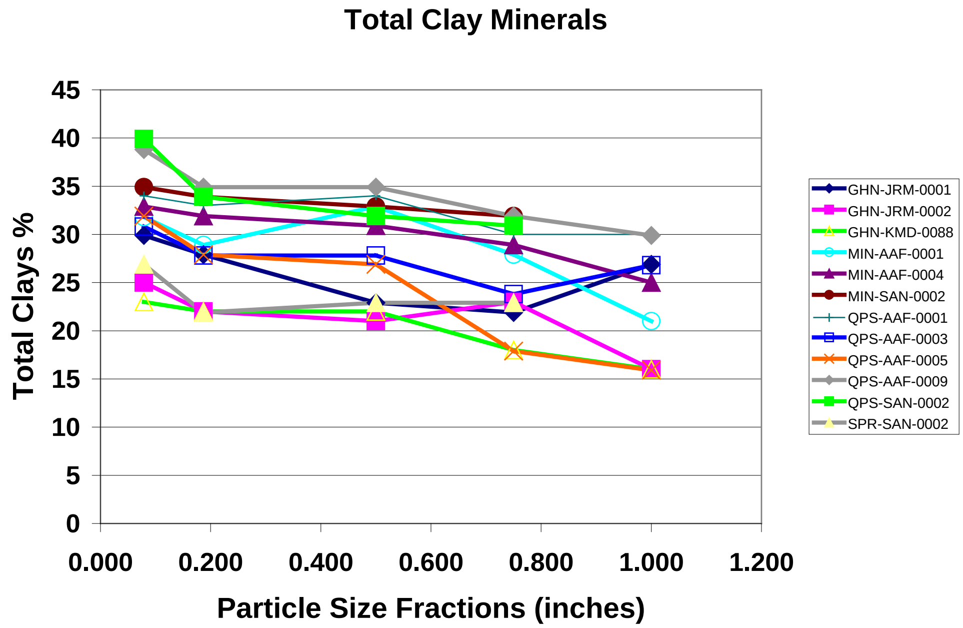
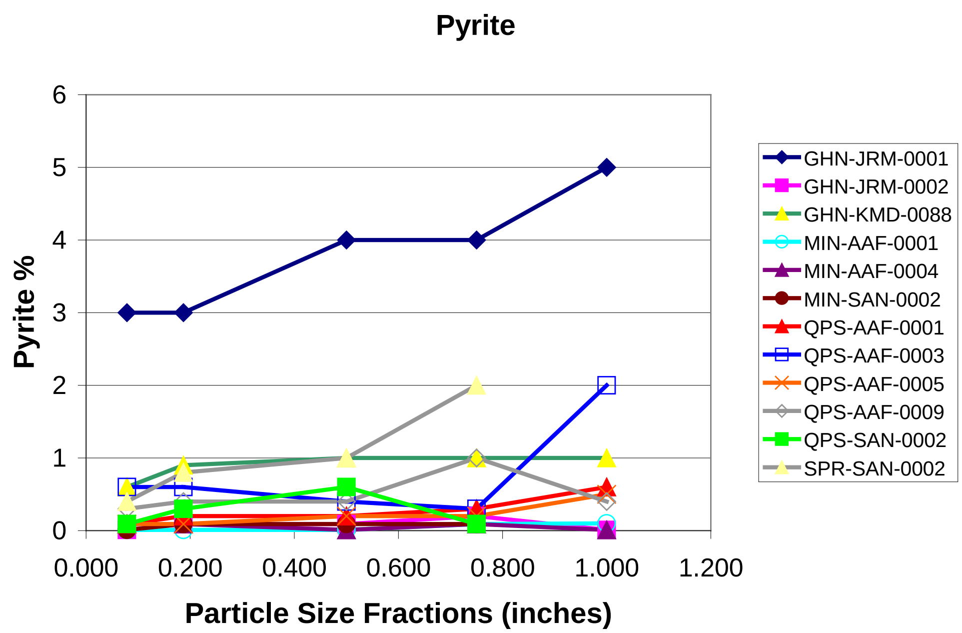


FIGURE 7 continued. Variations in total feldspar, clay minerals, pyrite, calcite and sulfate minerals with different size fractions.



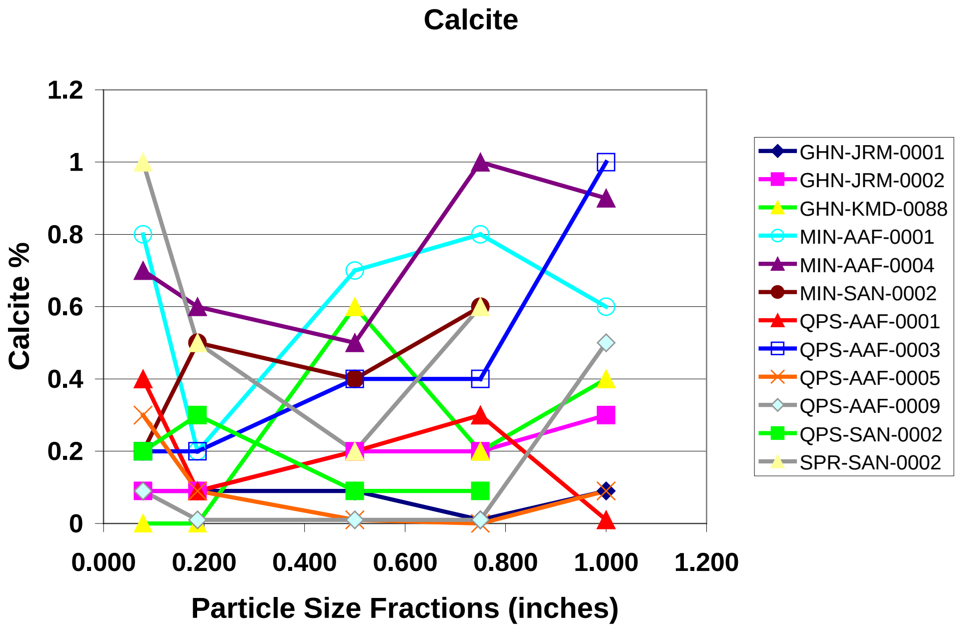
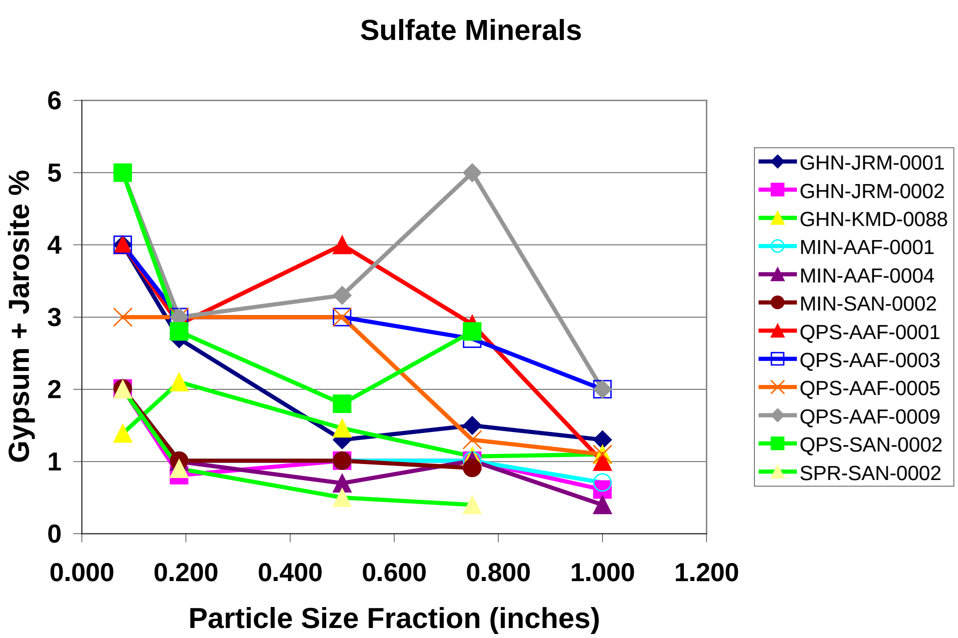


FIGURE 7 continued. Variations in total feldspar, clay minerals, pyrite, calcite and sulfate minerals with different size fractions.



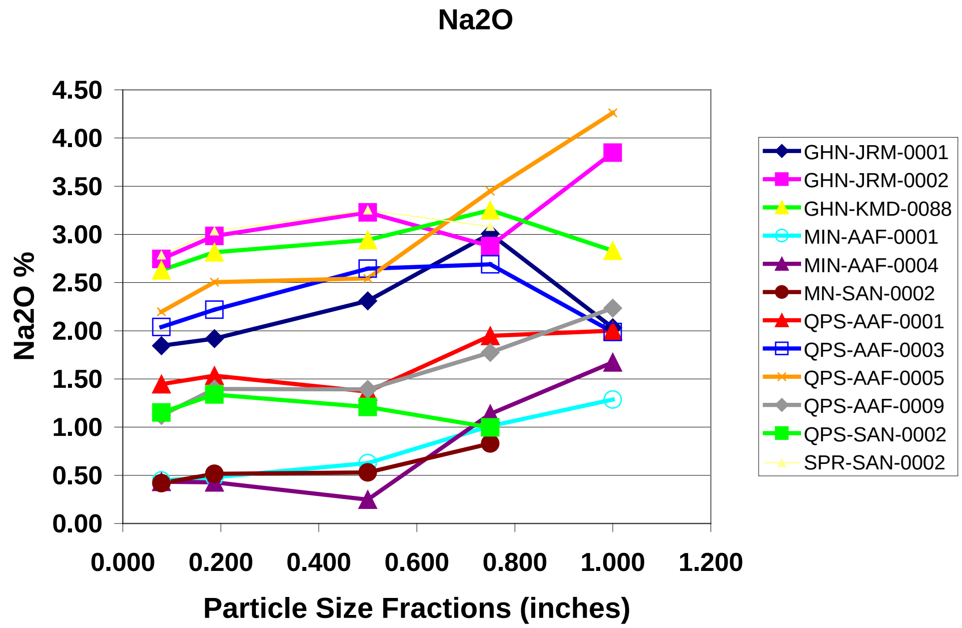
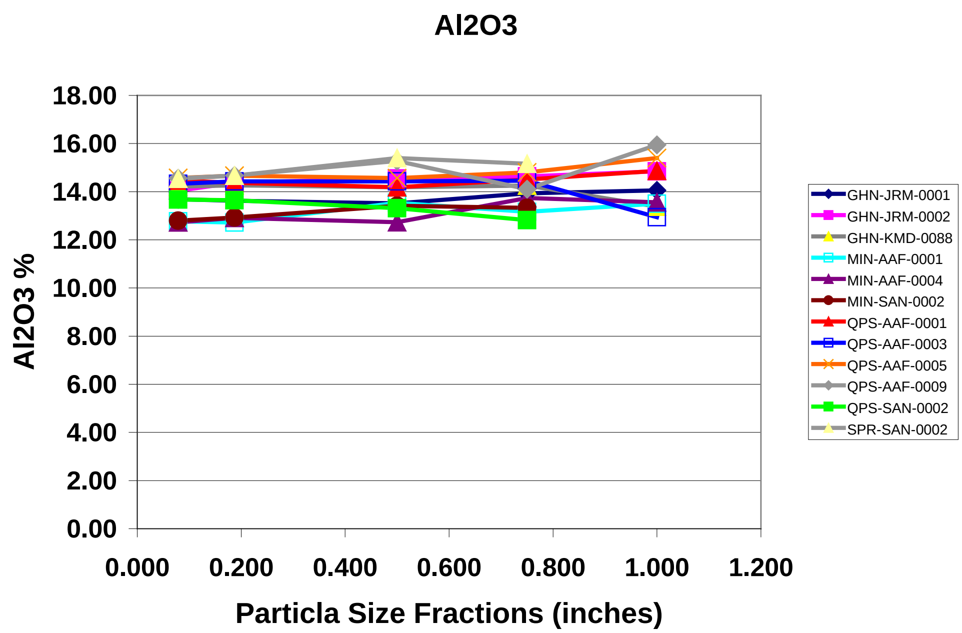


FIGURE 7 continued. Variations in total feldspar, clay minerals, pyrite, calcite and sulfate minerals with different size fractions.



Sulfide

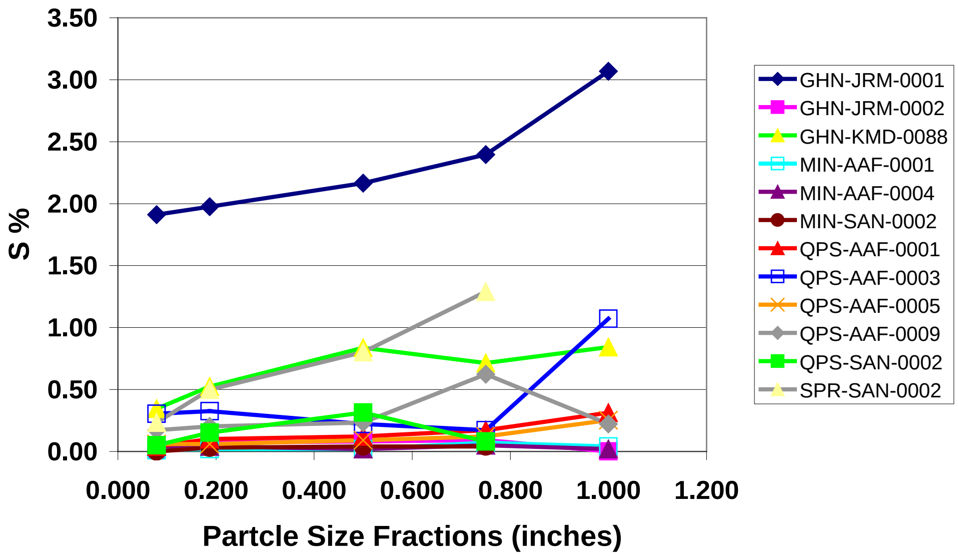


FIGURE 8. Variations in Na_2O, Al_2O_3, S and SO_4 minerals with different size fractions.

Sulfate

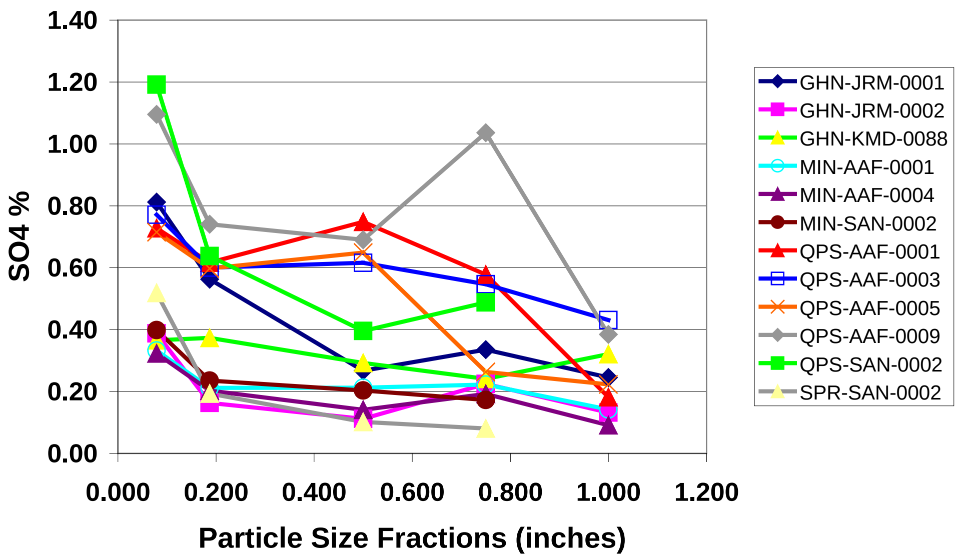


FIGURE 8 continued. Variations in Na_2O, Al_2O_3, S and SO_4 minerals with different size fractions.

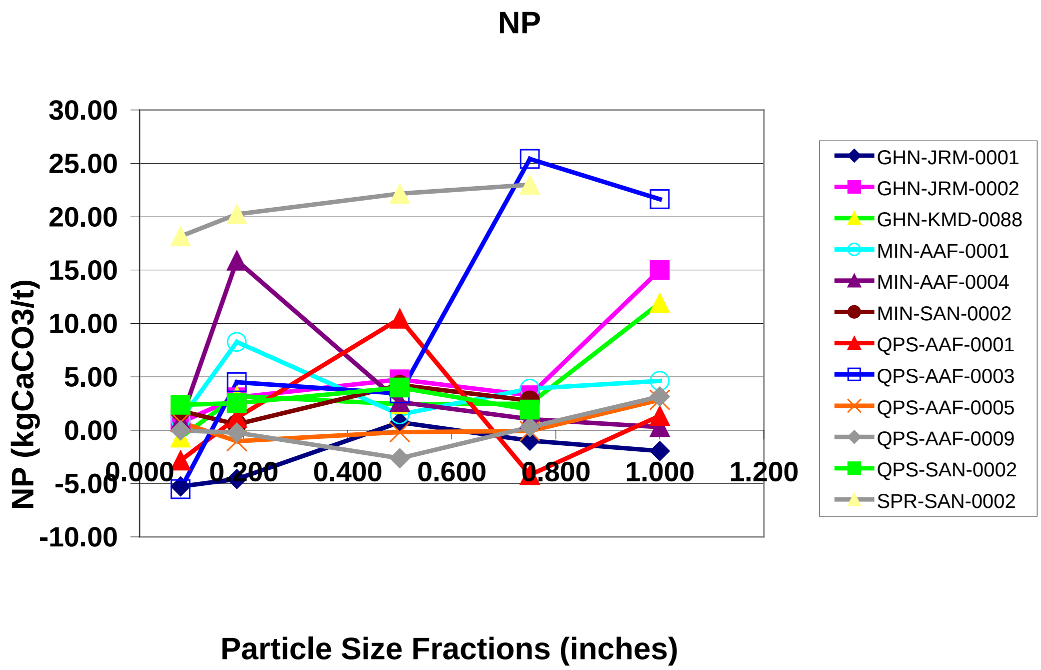


FIGURE 9. Plot of neutralizing potential distribution vs. size fraction.

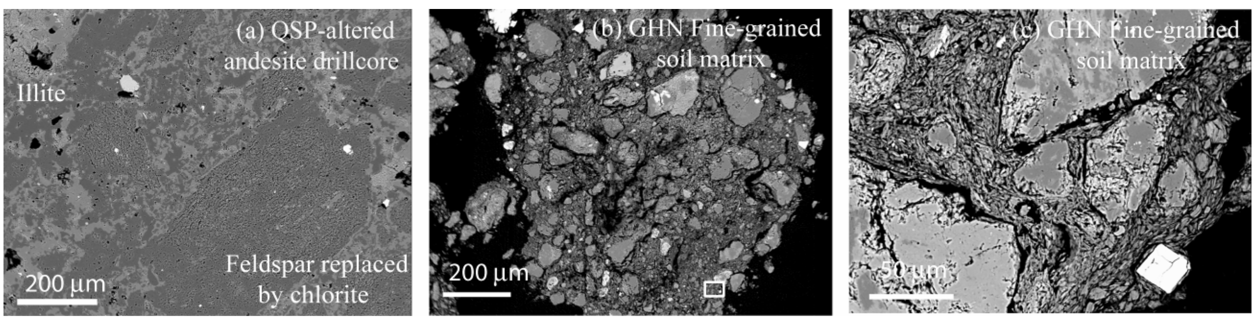
DISCUSSION

Detailed petrographic examinations of materials forming the rock piles as well as local host rocks provides insights into understanding the geologic, geochemical, pedological and man-influenced processes that can result in the variations in mineralogy and chemistry with different particle size fractions. The size of the original primary igneous minerals during crystallization, often in a fine-grained groundmass, results in minerals of different sizes that are subsequently liberated from the rock fragments (Fig. 10; McLemore et al., 2008). Some of these minerals, such as biotite and hornblende, are more susceptible to weathering and liberation from the host rock then other, more resistant minerals, such as quartz (Acosta et al., 2011).

Pre-mining hydrothermal alteration and weathering can result in the replacement of larger primary silicate minerals by smaller hydrothermal clay minerals (Fig. 11; Molling, 1968; Graf, 2008; McLemore et al., 2008). These replacement clay minerals can remain in the coarse-size fractions until liberated during mining and dumping into the rock piles or subsequent physical weathering (see below). Much of the material forming waste rock piles is actually small rock fragments that contain these minerals (McLemore et al., 2010). In many rock pile samples, the fine-grained soil matrix is weathered, while interiors of rock fragments (even within weathered rock pile material), exhibit little or no signs of weathering (McLemore et al., 2008, 2009a, 2009b, 2010).

A B

FIGURE 10. (A) Sample ROC-VTM-G010 is pink, plagioclase aplite porphyry to porphyritic aplite with large quartz, feldspar, and biotite phenocrysts. (B) Sample ROC-VTM-G005 showing typical porphyritic texture of the cream-colored Goathill Porphyry with a finer-grained matrix. From the Questa mine (McLemore et al., 2009b).



A B C

FIGURE 11. Evidence of primary igneous minerals being replaced by pre-mining, hydrothermal clay minerals (A) Backscatter (BSE) images of QSP-altered andesite drill core (pre-mining alteration), (B) fine-grained soil matrix samples from GHN rock pile, (C) the magnification of fine-grained soil matrix outlined by the white box in figure 1b. From the Questa mine (McLemore et al., 2009a, 2010).

The mineralized, ore material can be more friable and less cemented, compared to other more resistant, typically silicified material that can form the wall rock in many districts (Herring et al., 1998), which can result in different size fractions within the waste rock pile. Regional fracturing of the pre-mined rock during igneous intrusion and hydrothermal alteration results in materials of different sizes (Ludington et al., 2005). The breaking up of the rock material during blasting, hauling, and dumping during mining also contributes to differences in size fractions (McLemore et al., 2009a, b). Physical (freeze-thaw) and chemical weathering can further produce different size fractions within the rock piles (Fig. 12; Ludington et al., 2005; Graf, 2008).

Precipitation of weathered minerals, such as gypsum, along fractures and veins, which increase the mineral volume and break apart the rock (Fig. 12) as well as produces new minerals of different sizes. Some of these precipitated minerals can actually cement the rock fragments, thereby increasing the particle size. Other minerals, such as pyrite and galena can form rims of less soluble oxides and other minerals that can armor the original crystals and prevent further weathering (Fig. 13; Munroe et al., 1999, 2000; McLemore et al., 2008, 2009a, b).

A B

FIGURE 12. (A) Boulder of andesite that fell apart along veins filled with pyrite, partially altered to jarosite and Fe oxides, gypsum, and calcite. This is a result of physical weathering. (B) Surficial zones of white to yellow-brown soluble salts, gypsum, and jarosite within the Goathill North rock pile at Questa, an example of chemical weathering (McLemore et al., 2008).

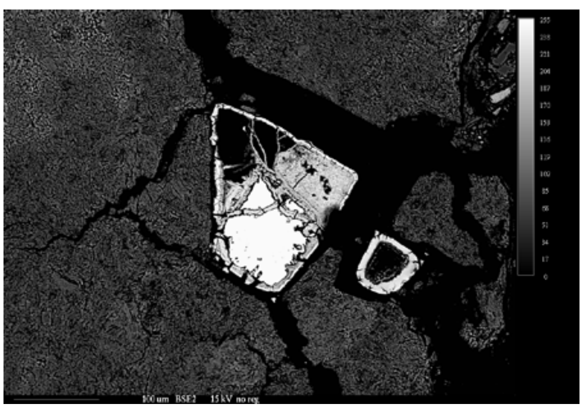


FIGURE 13. (A) Oxidation of pyrite from Questa rock pile (back-scattered electron microprobe image of sample GHN-KMD-0074-30-02, McLemore et al., 2008).

CONCLUSIONS

Although both man-made waste rock piles and natural materials (stream sediment, debris flows, alteration scars) and materials of different lithologies and deposit types were examined, in general there are consistent results. The finer-size fractions are typically the smallest amount by weight (generally, <25% in the <2 mm fraction). However, the greatest enrichments of trace elements typically, but not always, occur in the finer-size portion of the sample. Feldspar, quartz, and pyrite generally are higher in the coarser-size fraction. Total clay minerals, gypsum, and jarosite are higher in the finer-size fraction. Paste pH values decreases from the coarse-size fraction to the fine-size fraction, but not all samples show a large decrease. The coarser-size fractions are less acid generating than finer-size fractions. Na_2O and S increase in the coarser-size fraction, whereas SO_4 decreases in the coarse-size fraction. Al_2O_3 shows little change with different size fractions.

Collectively, these results are consistent with weathering being more pronounced in the finer-size fraction than the coarser-size fraction. The dissolution of pyrite, calcite, and to a lesser extent some combination of chlorite, illite, feldspars, smectite, and other silicate minerals are the predominant chemical reactions that results in the precipitation of gypsum, jarosite, soluble efflorescent salts, and Fe oxide/hydroxide minerals, mostly in the finer-size fractions, although some authigenic gypsum crystals can be quite large.

No single geologic, geochemical, pedological or man-influenced process is responsible for the differences in composition between particle-size fractions. The effects of primary igneous crystallization, pre-mining hydrothermal alteration and weathering, and post-mining blasting, hauling, dumping, and emplacement into the rock pile and subsequent weathering affect the composition of each size fraction. This emphasizes the need to determine not only the composition of the different size fractions, but also perform detailed mineralogy and petrology investigations to understand the processes involved in controlling the compositional differences between size fractions. Although the results are generally consistent, there still is some variation between samples and it is recommended that composition of different particle sizes be examined at environmental sites, especially mine sites.

The importance of understanding the effect of composition on particle size can be used to 1) help plan and assess reclamation procedures, 2) compare trace-element concentrations in mined versus undisturbed areas, 3) determine background concentrations, 4) determine the best size fractions for prediction tests, such as humidity cells tests, and 5) provide background data that can assist with the planning of future mining operations. Benefits to the public include the assessment of changes in environmental parameters of pre-, post-, and abandoned-mined lands, including changes where mining and reclamation activity has improved the quality of those environmental parameters.

ACKNOWLEDGEMENTS

This project was funded in part by Chevron Mining Inc. (formerly Molycorp, Inc.) as a subcontract between the University of Utah and the New Mexico Bureau of Geology and Mineral Resources (NMBGMR), a division of New Mexico Institute of Mining and Technology (NMIMT). We would like to thank the professional staff and students of the large multi-disciplinary field team for their assistance in mapping, sampling, and laboratory analyses. Discussions with Mark Logsdon proved invaluable in bettering our understanding of weathering and statistics. We also would like to thank Cathy Aimone-Martin and Ali Fakhimi of NMIMT, Bruce Walker, Dave Jacobs, Jim Vaughn, and Mike Ness of Chevron Mining, Inc. and John Purcell of Golder Associates for their training and assistance in this study. This report is part of an on-going study of the environmental effects of the mineral resources of New Mexico at NMBGMR, L. Greer Price, Interim Director and State Geologist.

REFERENCES

Acosta, J.A., Martinez-Martinez, S., Faz, A., and Aroncena, J., 2011, Accumulations of major and trace elements in particle size fractions of soils on eight different parent materials: Geoderma, v. 161., p. 30-42.

Brandvold, L.A. and McLemore, V.T., 1998, A study of the analytical variation of sampling and analysis of stream-sediments from areas contaminated by mining and milling: Journal of Geochemical Exploration, v. 64, p. 185-196.

Caine, J.S., 2003, Questa Baseline and Pre-Mining Ground-Water Quality Investigation. 6. Preliminary Brittle Structural Geologic Data, Questa Mining District, southern Sangre de Cristo Mountains, New Mexico. U.S. Geological Survey Open-File Report 03-280, http://pubs.usgs.gov/sir/2005/5149/, accessed 11/8/08.

Caine, J.S., 2006, Questa Baseline and Pre-Mining Ground-Water Quality Investigation. 18. Characterization of brittle structures in the Questa caldera and speculation on their potential impacts on the bedrock ground-water flow system, Red River watershed, New Mexico. U.S. Geological Survey Professional Paper 1729, 37 p., http://pubs.usgs.gov/of/2003/ofr-03-280/, accessed 11/8/08.

Dinelli, E., Tateo, F., and Summa, V., 2007, Geochemical and mineralogical proxies for grain size in mudstones and siltstones from the Pleistocene and Holocene of the Po alluvial plain, Italy; in Aiibas, J., Critelli, S., and Johnson, M.J., eds., Sedimentary province and petrogenesis: Perspectives from petrography and geochemistry: Geological Society of America; Special Paper 420, p. 25-36.

Dultz, S., 2002, Effects of parent material and weathering on feldspar content in different particle size fractions from forest soils in NW Germany: Geoderma, v. 106, p. 63-81.

Graf, G.J., 2008, Mineralogical and geochemical changes associated with sulfide and silicate weathering, natural alteration scars, Taos County, New Mexico: M. S. thesis, New Mexico Institute of Mining and Technology, Socorro, 193 p., http://geoinfo.nmt.edu/staff/mclemore/Molycorppapers.htm, accessed April 28, 2008.

Herring, J.R., Marsh, S.P., and McLemore, V.T., 1998, Major and trace element concentrations and correlations in mine dump samples from mining districts in Sierra, Socorro, and Otero counties, south-central New Mexico—Mockingbird Gap, Lava Gap, Salinas Peak, Goodfortune Creek, Bearden Canyon, and Sulfur Canyon mining districts of the northern San Andres Mountains, Sierra and Socorro County; Lake Valley mining district of Sierra County; and Tularosa and Orogrande mining districts of Otero County: U.S. Geological Survey Open-File Report 98-486, 21 p.

Lapakko, K., 2003, Solid phase characterization for metal mine waste drainage quality prediction: Preprint 03-093, 8 p.

Lapakko, K.A., Haub, J., and Antonson, D.A., 1998, Effect of dissolution time and particle size on kinetic test results: Society for Mining, Metallurgy, and Exploration, SME, Littleton, CO, preprint 98-114.

Lipman, P.W. and Reed, J.C., Jr., 1989, Geologic map of the Latir volcanic field and adjacent areas, northern New Mexico: U.S. Geological Survey, Miscellaneous Investigations Map I-1907, scale 1:48,000.

Ludington, S., Plumlee, G.S., Caine, J.S., Bove, D., Holloway, J.M., and Livo, K.E., 2005, Questa Baseline and Pre-Mining Ground-Water Quality Investigation. 10. Geologic influences on ground and surface waters in the lower Red River watershed, New Mexico. U.S. Geological Survey Scientific Investigations Report 2004-5245, http://pubs.usgs.gov/sir/2004/5245/, accessed 11/8/08.

Meyer, J.W., 1991, Volcanic, plutonic, tectonic and hydrothermal history of the southern Questa Caldera, New Mexico: University Microfilms, Ph.D. dissertation, 348 p.

Meyer, J.W., and Leonardson, R.W., 1990, Tectonic, hydrothermal and geomorphic controls on alteration scar formation near Questa, New Mexico; *in* Bauer, P.W., Lucas, S.G., Mawer, C.K., and McIntosh, W.C. (eds.), Tectonic development of the southern Sangre de Cristo Mountains, New Mexico: New Mexico Geological Society, Guidebook 41, p. 417-422.

McLemore, V.T., 2009, Geologic Setting and Mining History of the Questa mine, Taos County, New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file Report 515, 29 p., http://geoinfo.nmt.edu/publications/openfile/details.cfml?Volume=515

McLemore, V.T., Brandvold, L.A., Hossain, A.M., Pease, T.C., 1995, The effect of particle size distribution on the geochemistry of stream sediments from the upper Pecos River, San Miguel County, New Mexico: New Mexico Geological Society, Guidebook 46, p. 323–329.

McLemore, V.T., Dickens, A., Boakye, K., Campbell, A., Donahue, K., Dunbar, N., Gutierrez, L., Heizler, L., Lynn, R., Lueth, V., Osantowski, E., Phillips, E., Shannon, H., Smith, M., Tachie-Menson, S., van Dam, R., Viterbo, V.C., Walsh, P., and Wilson, G.W., 2008, Characterization of Goathill North Rock Pile: New Mexico Bureau of Geology and Mineral Resources, Open-file report 523, http://geoinfo.nmt.edu/publications/openfile/details.cfml?Volume=523

McLemore, V.T., Dunbar, N., Tachie-Menson, S., and Donahue, K., 2010, The Effect of Weathering on the Acid-Producing Potential of the Goathill North Rock Pile, Questa mine, NM: CRC Press, Taylor and Francis Group, London, Tailings and Mine Waste ’10, p. 213-227.

McLemore, V., Heizler, L., Donahue, K., and Dunbar, N., 2009a, Characterization of Weathering of Mine Rock Piles: Example from the Questa Mine, New Mexico, USA: Securing the Future and 8th ICARD, June 23-26 2009, Skelleftea, Sweden, conference proceedings, 10 p., http://www.proceedings-stfandicard-2009.com/pdfer/Virginia_McLemore_P_T2_Characterization-of-weathering-of-mine-rock-piles-example-from-the-Questa-mine-New-Mexico-USA.pdf

McLemore, V.T. and Frey, B.A., 2009, Appendix 8—Quality control and quality assurance report (Task B1); *in* McLemore, V.T., Dickens, A., Boakye, K., Campbell, A., Donahue, K., Dunbar, N., Gutierrez, L., Heizler, L., Lynn, R., Lueth, V., Osantowski, E., Phillips, E., Shannon, H., Smith, M., Tachie-Menson, S., van Dam, R., Viterbo, V.C., Walsh, P., and Wilson, G.W., Characterization of Goathill North Rock Pile: New Mexico Bureau of Geology and Mineral

Resources, Open-file report 523, http://geoinfo.nmt.edu/publications/openfile/details.cfml?Volume=523.
McLemore, V.T., Sweeney, D., and Donahue, K., 2009b, Lithologic atlas: New Mexico Bureau of Geology and Mineral Resources, Open-file Report 516, 73 p., http://geoinfo.nmt.edu/publications/openfile/details.cfml?Volume=516
McLemore, V., Sweeney, D., Dunbar, N., Heizler, L. and Phillips, E., 2009c, Determining quantitative mineralogy using a combination of petrographic techniques, whole rock chemistry, and MODAN: Society of Mining, Metallurgy and Exploration Annual Convention, Denver, Feb 2009, Preprint 09-20, 19 p.
Molling, P.A., 1989, Applications of the reaction progress variable to hydrothermal alteration associated with the deposition of the Questa molybdenite deposit, NM: PhD dissertation, Johns Hopkins University, 227 p.
Moore, O. M. and Reynolds, R. O., Jr., 1989, X-ray diffraction and the identification and analyses of clay minerals: Oxford University Press, New York. 378 p.
Munroe, E. A., McLemore, V. T., and Kyle, P., 1999, Waste rock pile characterization, heterogeneity and geochemical anomalies in the Hillsboro mining district, Sierra County, New Mexico: Journal of Geochemical Exploration, v. 67, p. 391-405
Munroe, E.A., McLemore, V.T., and Dunbar, N.W., 2000, Mine waste rock pile geochemistry and mineralogy in southwestern New Mexico, USA; in ICARD 2000—Proceedings from the 5th international conference on acid rock drainage: Society for Mining, Metallurgy, and Exploration, Inc., Littleton, Colo., p. 1327-1336.
Paktunc, A.D., 2001, MODAN—A Computer program for estimating mineral quantities based on bulk composition: Computers and Geosciences, v. 27, p. 883-886.
Roberts, T.T., Parkison, G.A., and McLemore, V.T., 1990, Geology of the Red River district, Taos County, New Mexico: New Mexico Geological Society, Guidebook 41, p. 375-380.
Ross, P.S., Jebrak, M., and Walker, B.M., 2002, Discharge of hydrothermal fluids from a magma chamber and concomitant formation of a stratified breccia zone at the Questa porphyry molybdenum deposit, New Mexico: Economic Geology, v. 97, p. 1679-1699.
Rowe, A., 2005, Fluid evolution of the magmatic hydrothermal breccia of the Goat Hill orebody, Questa Climax-type porphyry molybdenum system, New Mexico—a fluid inclusion study: M.S. thesis, New Mexico Institute of Mining and Technology, Socorro, 134 p.
Samuels, K.E., 2008, Weathering and landscape evolution recorded in supergene jarosite, Red River valley, northern New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, Socorro, 171 p.
Schilling, J.H., 1960, Mineral resources of Taos County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 71, 124 p.
Schilling, J.H., 1990, A history of the Questa molybdenum (moly) mines, Taos County, New Mexico: New Mexico Geological Society, Guidebook 41, p. 381-386.
Strömberg, B. and Banwart, S.A., 1999, Experimental study of acidity-consuming processes in mining waste rock: some influences of mineralogy and particle size: Applied Geochemistry, v. 14, p. 1-16.

Taboada, T., Cortizas, A.M., García, C., García-Rodeja, E., 2006, Particle-size fractionation of titanium and zirconium during weathering and pedogenesis of granitic rocks in NW Spain: Geroderma, v. 131, p. 218-236.

URS Corporation, 2003, Mine rock pile erosion and stability evaluations, Questa mine: unpublished Report to Molycorp, Inc., 4 volumes.

APPENDIX 1. DETAILED DESCRIPTION OF WHOLE ROCK SAMPLES

This appendix includes detailed sample descriptions of whole rock samples including all the data of their size fractions.

DESCRIPTION OF SAMPLE GHN-JRM-0001

LOCATION

This sample was collected at the Goathill north rock pile. The UTM coordinates of sample collection are 13N4062137, 453642.2E, and the sample was collected 9602 ft above sea level.

HAND SAMPLE DESCRIPTION

In hand sample the color of the sample is yellow to orange before washing (Fig. 1-1) and grey after washing. The rock fragments are angular to sub-angular and range in size from sand to coarse gravel. Visible euhedral to subhedral pyrite cubes up to 1.5 mm can been seen in andesite rock fragments. The sample has a fair amount of clay adhering to rock fragments and iron oxide staining. There is a minor amount of cementing and carbonate prior to rinsing.

FIGURE 1-1. Photograph of unrinsed sample split with a small amount of cementing matrix adhering to the grains.

PETROGRAPHIC DESCRIPTION

In thin section the sample is seen as a highly altered matrix-dominated sample. Quartz is present as rounded clasts within the matrix and as remnant phenocrysts within highly altered clasts. Large quartz phenocrysts are also present within clasts of Amalia Tuff. Most feldspars have completely altered to clay. Some remnant albite and K-spar are present within altered clasts. Secondary (?) K-spar is present as large euhedral-subhedral crystals within highly altered clasts or as overgrowths on quartz. Euhedral bladed aggregates of gypsum (up to 100 micron blades) occur along edges of adhered soil matrix and are intergrown within the illite and jarosite matrix (Fig. 1-2). The sample contains abundant illite clay within the mine soil matrix (dominantly illite +/-jarosite) as well as within alteration clasts. Large areas of the sample appear to be cemented by an illite and jarosite mixture; there are also localized areas of pure jarosite cement. No carbonate, mafic silicates, or epidote was observed in the sample. Pyrite (≤300 μm) is observed in the sample typically as isolated grains in the matrix and within some clasts; there are also areas of localized concentrations. Pyrite in the sample is often seen with irregular shapes, embayed grains, and with evidence of dissolution; many pyrites also contain numerous inclusions (Fig. 1-3).

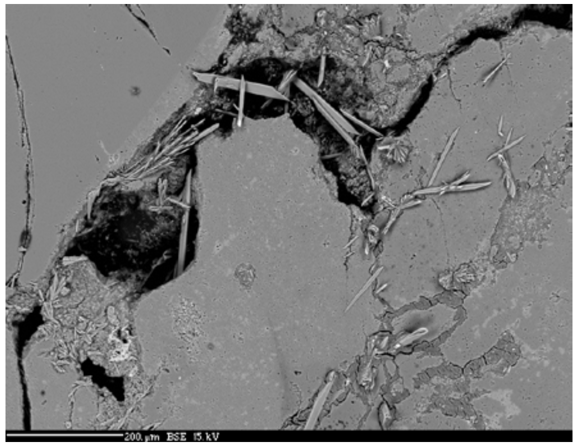


FIGURE 1-2. Microprobe image of bladed gypsum formed in a crack in between two rock fragments altering to clays.

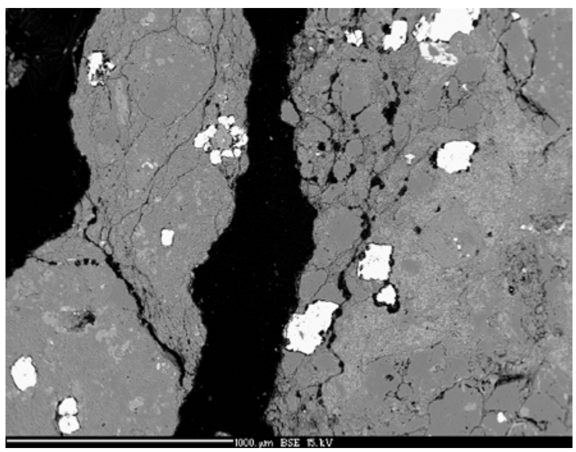


FIGURE 1-3. Microprobe image of pyrites (bright areas) displaying dissolution features as well as embayed grains and irregular shapes.

LABORATORY ANALYSES

TABLE 1-1. Various laboratory analyses for sample GHN-JRM-0001.

Atterberg Limits	
LL	37.4
PL	19.6
PI	17.7
Paste pH	2.14
Paste Conductivity	6.31
Specific Gravity	3
NAG pH	2.87
NAG value	28.03

TABLE 1-2. Chemical and mineralogical analysis for sample GHN-JRM-0001.

Chemistry	Weight Percent	Mineralogy	%
SiO2	61.64	Quartz	35
TiO2	0.53	K-spar/orthoclase	8
Al2O3	13.65	Plagioclase	16
Fe2O3T	5.24	Albite	-
FeOT	4.76	Anorthite	-
FeO	2.86	Biotite	0.01
Fe2O3	2.09	Clays/groundmass	-
MnO	0.08	Illite	25
MgO	1.28	Chlorite	4
CaO	0.98	Smectite	2
Na2O	1.87	Kaolinite	0.9
K2O	3.91	Mixed layered	-
P2O5	0.19	Epidote	0.01
S	2.01	Magnetite	-
SO4	1.12	Fe oxides	0.2
C	0.07	Goethite	-
LOI	8.81	Hematite	-
Total	101.38	Rutile	0.5
Trace elements	ppm	Apatite	0.4
Ba	832	Pyrite	3
Rb	134	Calcite	0.5
Sr	136	Gypsum	1
Pb	153	Detrit gypsum	-
Th	11	Auth gypsum	-
U	5	Zircon	0.03
Zr	163	Sphalerite	-
Nb	16	Molybdenite	-
Y	25	Fluorite	-
Sc	9	Jarosite	3
V	74	Copiapite	-
Ni	30	Other S minerals	-
Cu	172		
Zn	92		
Ga	21		
Cr	57		
F	1646		
REE	ppm		
La	49		
Ce	96		
Nd	40.3		

Chemistry	Weight Percent	Mineralogy	%
Sm	7.3		
Eu	1.15		
Gd	5.3		
Yb	1.18		
Lu	0.88		

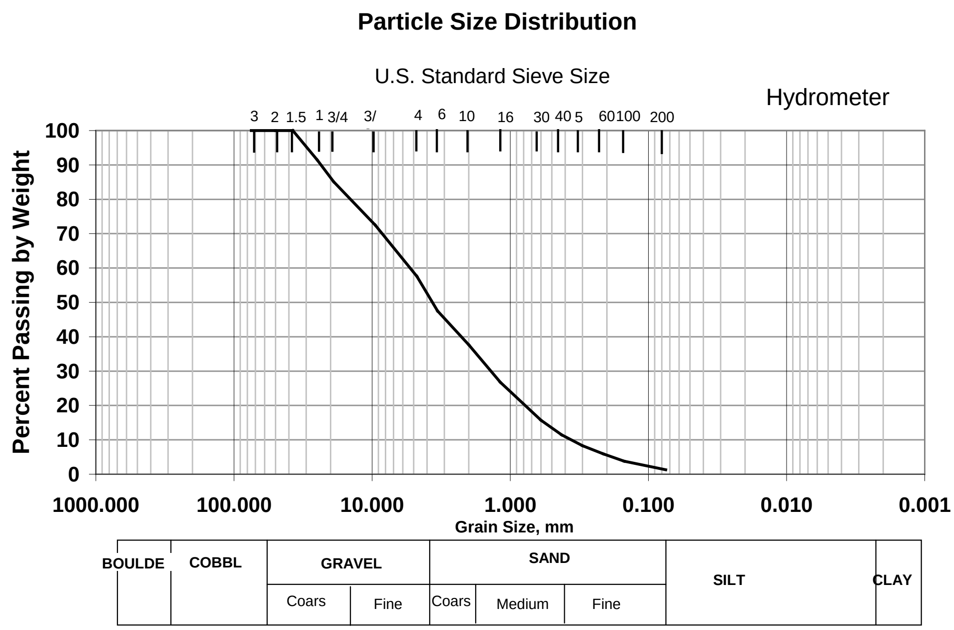


FIGURE 1-4. Particle size analysis plot of bulk sample GHN-JRM-0001

DESCRIPTION OF SAMPLE GHN-JRM-0002

LOCATION

This sample was collected at the Goathill North rock pile. The UTM coordinates of sample collection are 13N4062137, 453642.4E, and the sample was collected 9601 ft above sea level.

HAND SAMPLE DESCRIPTION

In hand sample the color is tan to yellow before washing and grey after washing (Fig. 1-5). Rock fragments are sand to gravel sized, sub-angular to sub-rounded, composed of andesite and rhyolite (Amalia Tuff), and are variously altered. The rock fragments are well cemented by clays and iron oxides. Epidote and bladed authigenic gypsum can be seen in and on rock fragments; fine grained epidote is also seen on rock surfaces and in vugs. There is limited cementation of the sample prior to rinsing and carbonate was detected with a fizz test. Pyrite is seen as rounded cubes, and all the cubes are coated with Fe oxides.

FIGURE 1-5. Photograph of rinsed hand sample. Field of view is 6 cm.

PETROGRAPHIC DESCRIPTION

In thin section this is a clast-dominated sample consisting of rounded clasts of altered andesite rock with adhered soil matrix. Quartz, K-spar, and albite (some with visible laths) are present within andesite rock fragments. Epidote is present as phenocrysts within rock fragments. Individual irregular and subhedral grains of quartz (to 100 microns) with rounded or broken edges are dispersed within the soil matrix. The soil matrix contains individual Fe-oxide grains with dissolved edges and/or interiors that appear to be magnetite that has largely altered to goethite. Minor small grains of jarosite (to 50 microns) are also dispersed within soil matrix. Alteration clays dominantly consist of illite and smectite that appears to be intermixed with goethite or goethite/jarosite cement in some areas; minor chlorite clay is also present. Pyrite is seen as sub-rounded cubes in some rock fragments (Fig. 1-6). Fe oxide cement is present along the edges of grains and acts as a pervasive cement, especially within one dominantly clay clast (Fig. 1-7). No mafic silicates, carbonate, or pyrite was observed in the sample.

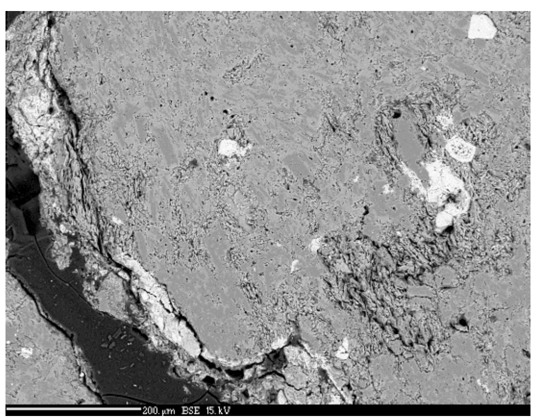


FIGURE 1-6. Microprobe image of an altering andesite rock fragment. A sub-rounded pyrite can be seen in the upper right corner.

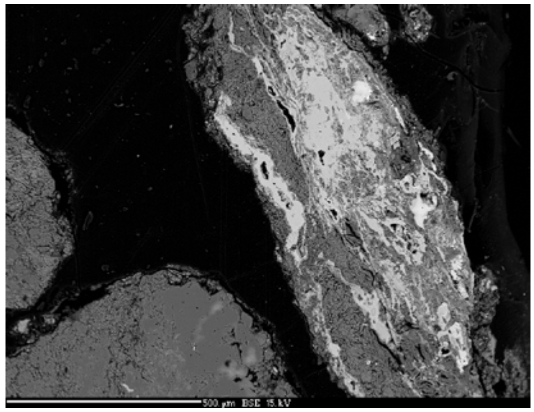


FIGURE 1-7. Microprobe image f a clay-rich altered clast that has an abundant amount of jarosite cement (brightest areas).

LABORATORY ANALYSES

TABLE 1-3. Various laboratory analyses for sample GHN-JRM-0002.

Atterberg Limits	
LL	36.14
PL	24.34
PI	11.8
Paste pH	2.15
Paste Conductivity	5.46
Specific Gravity	
NAG pH	3.8
NAG value	12.78

TABLE 1-4. Chemical and mineralogical analysis for sample GHN-JRM-0002.

Chemistry	Weight Percent	Mineralogy	%
SiO2	61.04	Quartz	26
TiO2	0.84	K-spar/orthoclase	18
Al2O3	14.36	Plagioclase	19
Fe2O3T	7.59	Albite	-
FeOT	6.90	Anorthite	-
FeO	4.39	Biotite	-
Fe2O3	2.76	Clays/groundmass	-
MnO	0.36	Illite	16
MgO	2.57	Chlorite	6
CaO	1.72	Smectite	4
Na2O	2.82	Kaolinite	-
K2O	3.33	Mixed layered	-
P2O5	0.40	Epidote	0.3

Chemistry	Weight Percent	Mineralogy	%
S	0.14	Magnetite	0.01
SO4	0.34	Fe oxides	7
C	0.06	Goethite	-
LOI	4.66	Hematite	-
Total	100.22	Rutile	0.5
Trace elements	ppm	Apatite	0.9
Ba	1222.8	Pyrite	0.3
Rb	92.5	Calcite	0.6
Sr	512.4	Gypsum	-
Pb	130.7	Detrit gypsum	0.2
Th	7.3	Auth gypsum	1
U	1.1	Zircon	0.03
Zr	173	Sphalerite	-
Nb	11.8	Molybdenite	-
Y	18.5	Fluorite	-
Sc	10.8	Jarosite	0.01
V	106	Copiapite	-
Ni	49.3	Other S minerals	-
Cu	87.6		
Zn	294.8		
Ga	21.3		
Cr	86.9		
F	1047		
REE	ppm		
La	45		
Ce	102		
Nd	46		
Sm	8.2		
Eu	1.54		
Gd	5.88		
Yb	1.22		
Lu	0.84		

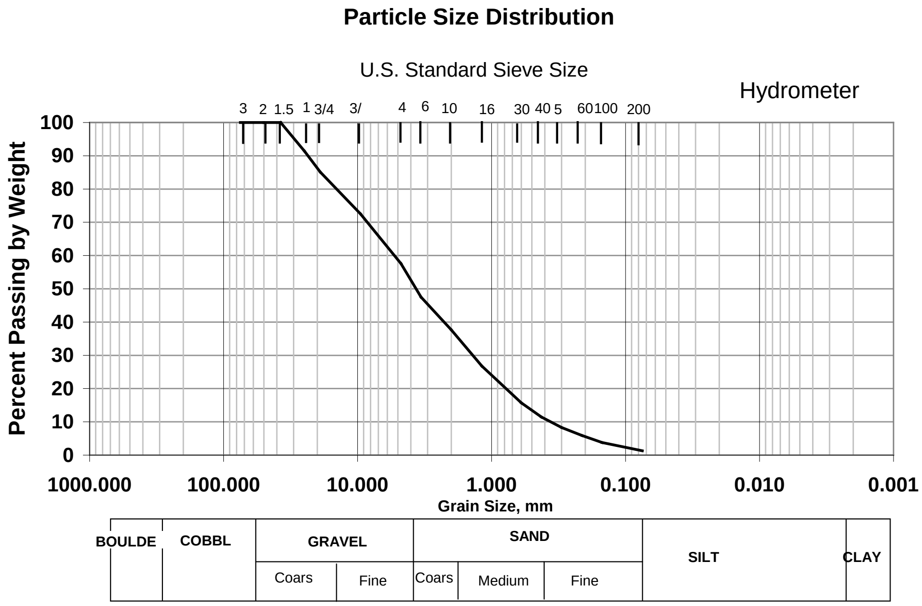


FIGURE 1-8. Particle size analysis plot of bulk sample GHN-JRM-0002

DESCRIPTION OF SAMPLE GHN-KMD-0088

LOCATION

This sample was collected at the Goathill North rock pile. The UTM coordinates of sample collection are 13N4062127, 453657.4E, and the sample was collected 9635 ft above sea level.

HAND SAMPLE DESCRIPTION

In hand sample there was limited cohesion prior to rinsing the sample. The sample is yellow to tan prior to rinsing (Fig. 1-9). There is a pink non-fizzing phase present in sample that is not a carbonate mineral.

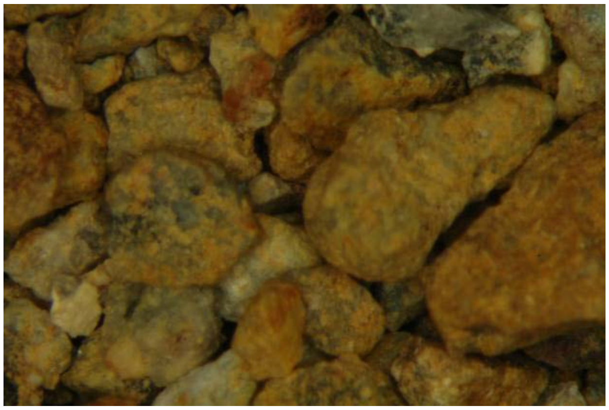


FIGURE 1-9. Photograph of unrinsed hand sample. Field of view is 5 cm.

PETROGRAPHIC DESCRIPTION

In thin section the sample is composed of quartz and feldspar rock fragments in a clay/small rock/mineral matrix material. Sample contains lots of rock fragments and a relatively minor amount of soil; rock fragments are variably altered and some rock fragments are composed of Amalia Tuff. K-feldspar, albite, and quartz are present in rock fragments and as loose fragments in the matrix; large albite phenocrysts and K-spar are observed in the groundmass as well. No mafic silicates, gypsum, or epidote is observed in the sample, save for one large clot of epidote that was intergrown with chlorite. The sample contains notably few mineral phases. Some areas of rock are replaced by clay minerals and carbonate is observed in these areas, along with some other parts of the rock. The sample is unfractured with very little observable cement. Clay is present in groundmass and in some rock fragments. Some sericitic material is present, along with areas of illitic and chloritic material, although some areas appear to represent mixtures that include kaolinite and smectite; some clay-rich veins are seen. There is some Mn associated with clay-rich areas and small amounts of rutile are observed. Carbonate, when present, is granular or blocky and is no greater than 50 um in size. Small pieces of slightly dissolved carbonate are associated with clay pockets. Pyrite is present in rock fragments and is seen as blocky, cubic, or disaggregated pieces of 50 um or less. No oxidation is observed, but pyrites near the edges of rock fragments have moats around individual grains (Fig. 1-10).

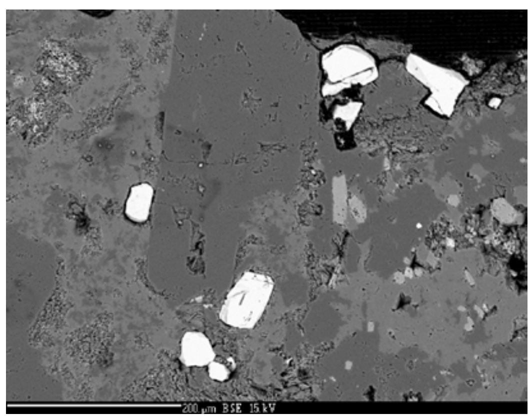


FIGURE 1-10. Microprobe image of rounded pyrite cubes, some having associated moats.

LABORATORY ANALYSES

TABLE 1-5. Various laboratory analyses for sample GHN-KMD-0088.

Atterberg Limits	
LL	40.56
PL	20.2
PI	20.35
Paste pH	2.63
Paste Conductivity	6.09

Specific Gravity	2.75
NAG pH	8.99
NAG value	0

TABLE 1-6. Chemical and mineralogical analysis for sample GHN-KMD-0088.

Chemistry	Weight Percent	Mineralogy	%
SiO2	64.35	Quartz	29
TiO2	0.49	K-spar/orthoclase	22
Al2O3	14.19	Plagioclase	19
Fe2O3T	4.19	Albite	-
FeOT	3.81	Anorthite	-
FeO	2.14	Biotite	-
Fe2O3	1.84	Clays/groundmass	-
MnO	0.16	Illite	15
MgO	1.51	Chlorite	4
CaO	1.13	Smectite	2
Na2O	2.92	Kaolinite	2
K2O	3.80	Mixed layered	-
P2O5	0.21	Epidote	0.01
S	0.55	Magnetite	-
SO4	0.41	Fe oxides	3
C	0.04	Goethite	-
LOI	5.14	Hematite	-
Total	99.09	Rutile	0.4
Trace elements	ppm	Apatite	0.5
Ba	1216.00	Pyrite	0.9
Rb	102.00	Calcite	0.2
Sr	374.00	Gypsum	1.5
Pb	60.00	Detrit gypsum	1
Th	7.00	Auth gypsum	0.1
U	4.00	Zircon	0.03
Zr	176.00	Sphalerite	-
Nb	13.00	Molybdenite	-
Y	25.60	Fluorite	-
Sc	6.00	Jarosite	0.4
V	60.00	Copiapite	-
Ni	31.00	Other S minerals	-
Cu	40.00		
Zn	221.00		
Ga	20.00		
Cr	47.00		
F	1015.00		
REE	ppm		

Chemistry	Weight Percent	Mineralogy	%
La	41.00		
Ce	102.00		
Nd	53.80		
Sm	10.20		
Eu	1.07		
Gd	8.09		
Yb	1.81		
Lu	1.32		

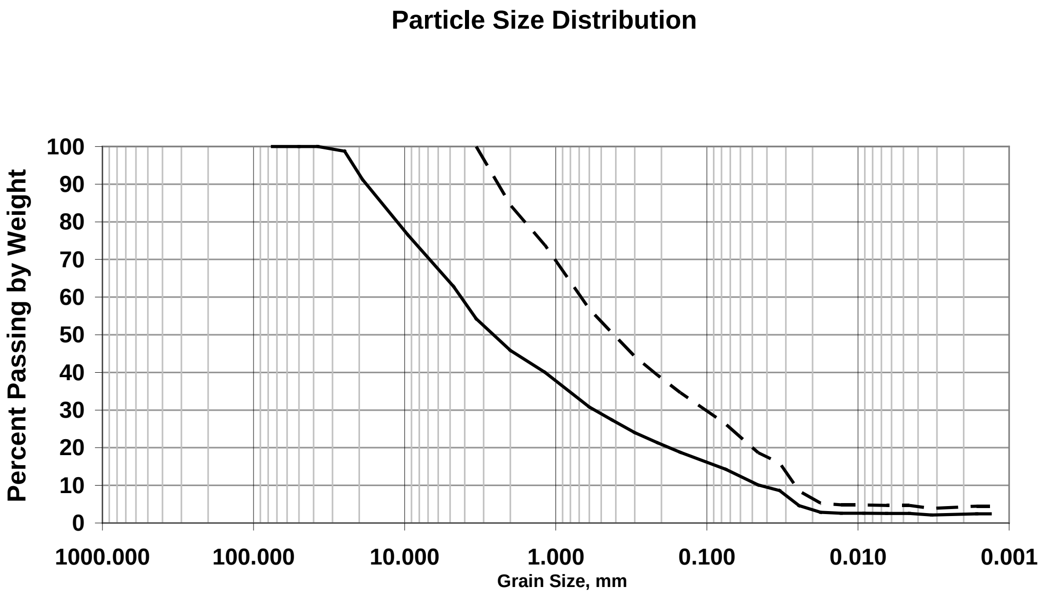


FIGURE 1-11. Particle size distribution graph for sample GHN-KMD-0088. The solid line represents the whole sample as collected from the field and the dashed line represents the scalped sample that was used to measure friction angle in the laboratory.

DESCRIPTION OF SAMPLE MIN-AAF-0001

LOCATION

Sample MIN-AAF-0001 was collected from the forest SW of gas pipeline to administration building (UTM 452374E, UTM 4059911N, zone 13). It is a Goathill debris flow material above road cut and a site of in situ test with 2 ft shear box.

HAND SPECIMEN DESCRIPTION

Sample MIN-AAF-0001 is a subangular to subrounded spherical silt to gravel material. It is tan in color and a bulk sample that consists of soil matrix and rock fragments that vary in size. It has poor sorting and poor cementation with no plasticity

PETROGRAPHIC DESCRIPTION

Sample MIN-AAF-0001 is highly QSP altered with 70% Amalia tuff (rhyolite), 20% andesite and 10% intrusive (porphyry) rock. It has 90% rock fragments and 4% Fe-oxide. It has no chlorite or epidote present.

LABORATORY ANALYSES

Below are laboratory results of sample MIN-AAF-0001. The results of the bulk sample and the size fractions are specified above each result.

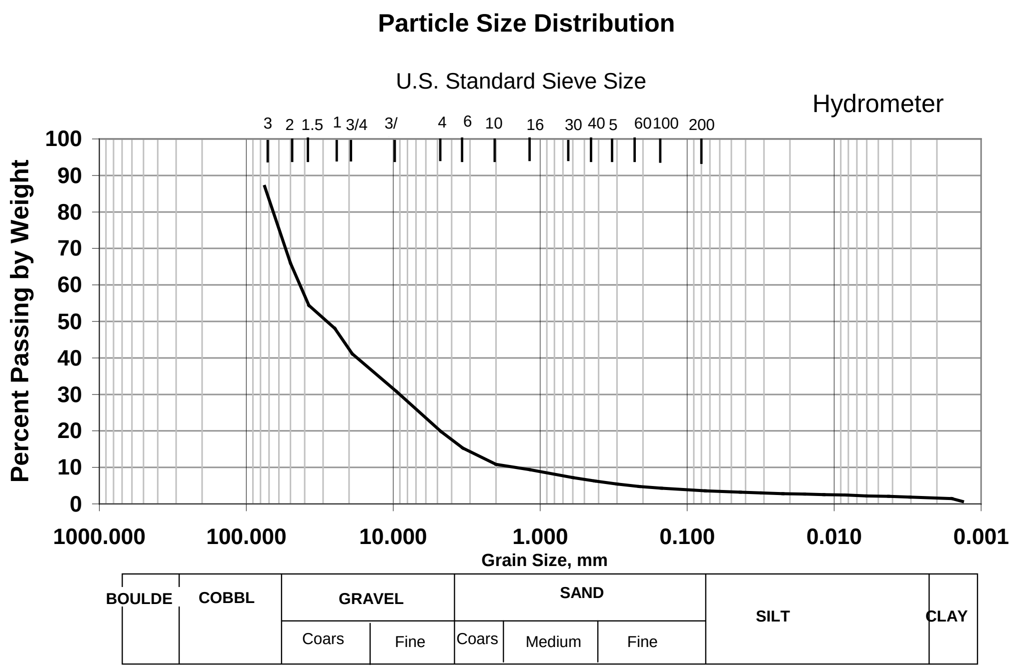


FIGURE 1-12. Particle size analysis plot of bulk sample MIN-AAF-0001.

TABLE 1-7. Laboratory results of bulk sample MIN-AAF-0001

Chemistry		Geochemistry		Mineralogy	
SiO2	73.3	pastepH	2.04	quartz	52
TiO2	0.39	pasteCond	0.22	K-feldspar	7
Al2O3	12.82	pasteTDS	0.11	Plagioclase	1
FeOT	2.740	WaterCont	4.11	epidote	0.01
MnO	0.02	NAGpH	6.22	calcite	0.6
MgO	0.66	NAGvalue	0	pyrite	0.01
CaO	0.10	AP	8.38	FeMnOxide	2
Na2O	0.39	NP	-3.8	Gypsum	0.01
K2O	4.29	netNP	-12.17	apatite	0.01
P2O5	0.11	NPAP	12.17	Total Clay	34.9
Ni	0			kaolinite	2
Cr	24	**Geotechnical**		chlorite	2

Chemistry		Geochemistry		Mineralogy	
Sc	4	Slake Index	98.35	illite	30
V	46	FrictAngle	45.2	smectite	0.9
Ba	591	ResidFA	35.2	jarosite	2
Rb	149	Cohesion	31.39	rutile	0.3
Sr	92	QMWI	6	zircon	0.04
Zr	229	DryDensity	2.46		
Y	36	SpecGrav	2.69		
Nb	25	LL	22.47		
Ga	22	PL	18.87		
Cu	18	PI	3.61		
Zn	20	MatriSuc	25.3		
Pb	93	% Gravel	80.15		
La	54	% Sand	16.28		
Ce	102	% Fines	3.57		
Th	13	D10	1.18		
Nd	40	D30	8.5		
U	3	D50	26		
F	1284	D60	37.5		
S	0				
SO4	0.38				
C	0.23				
LOI	4.27				

TABLE 1-8. Laboratory results of the size fractions of sample MIN-AAF-0001

Size Fraction(inch)	1.000	0.750	0.500	0.187	0.0787
Mineralogy					
quartz	38	45	45	47	48
K-feldspar	36	19	18	21	16
Plagioclase	2	4	0.6	0.01	0.01
epidote	0.01	0.01	0.01	0.01	0.01
calcite	0.6	0.8	0.7	0.2	0.8
pyrite	0.1	0.09	0.01	0.01	0.01
FeMnOxide	1	2	2	2	2
Gypsum	0.01	0.01	0.01	0.01	0.01
apatite	0.01	0.01	0.01	0.09	0.01
TotalClay	21	27.9	32.9	28.9	31.8
kaol	2	2	2	2	0.9
chlorite	2	1	2	2	2

Size Fraction(inch)	1.000	0.750	0.500	0.187	0.0787
illite	16	24	28	24	28
smectite	1	0.9	0.9	0.9	0.9
jarosite	0.7	1	1	1	2
rutile	0.4	0.3	0.4	0.3	0.3
zircon	0.04	0.04	0.04	0.04	0.04
Chemistry					
SiO2	71.7	73.7	73.4	74.8	73.8
TiO2	0.4	0.3	0.4	0.4	0.4
Al2O3	13.3	13.0	13.4	12.6	12.7
FeOT	2.1	2.2	2.1	1.9	2.4
MnO	0.0	0.0	0.0	0.0	0.0
MgO	0.8	0.5	0.7	0.7	0.6
CaO	0.2	0.1	0.2	0.1	0.1
Na2O	1.3	1.0	0.6	0.5	0.4
K2O	5.8	4.3	4.4	4.2	4.3
P2O5	0.1	0.1	0.1	0.1	0.1
Ni	7.4	5.1	7	3.9	4.6
Cr	34.3	28.1	26.9	27.9	25
Sc	6.6	4.4	5	5.1	3.5
V	59	39	48	47	40
Ba	1034	608.6	543.6	493.9	579
Rb	159.8	129.8	146.3	143.8	140.9
Sr	134.7	64.9	97.9	67.8	93.4
Zr	259.2	275.7	230.6	248	241.1
Y	41.9	48.1	35.4	41.5	37.7
Nb	23.7	28.5	28.3	27.3	26.9
Ga	20.9	23.8	23.7	22	20
Cu	14.9	26.7	12.4	16.3	15.8
Zn	26.8	19.2	17.4	21.7	20.1
Pb	54.1	176	50.7	82.6	90.6
La	46.3	55.5	46.9	53.7	52.5
Ce	87	104.7	96.4	110.9	102.2
Th	11.2	11.7	11.6	11.9	12.9
Nd	36.1	47.1	36.2	43.1	40.2
U	3.9	4	3.5	4	4.7
F	747	924	1098	1098	1057
S	0.04	0.07	0.02	0.02	0.01
SO4	0.14	0.22	0.21	0.21	0.33

Size Fraction(inch)	1.000	0.750	0.500	0.187	0.0787
C	0.1	0.17	0.1	0.11	0.16
LOI	2.55	3.12	3.25	3.42	3.95
Geochemistry					
pH	6.05	6.37	6.4	6.21	6.48
P.conductivity	0.19	0.25	0.2	0.29	0.22
AP	1.25	2.19	0.63	0.63	0.31
NP	4.61	3.89	1.46	8.26	0.98
NetNP	3.36	1.7	0.83	7.63	0.67

DESCRIPTION OF SAMPLE MIN-AAF-0004

LOCATION
Sample MIN-AAF-0004 was collected from the Goathill debris flow area in forest SW of gas pipeline to administration building (UTM 452374E, UTM 4059912N, zone 13), above Goathill debris flow road cut, 1 m north of site of in situ test with.

HAND SPECIMEN DESCRIPTION
Sample MIN-AAF-0004 is tan in color, gravelly sand with boulders and fines as its grain size and poorly sorted. It is massive, no plastic and weak cementation with clay and gypsum as cementing minerals.

PETROGRAPHIC DESCRIPTION
Sample MIN-AAF-0004 is subangular and spherical. It is QSP altered with 98% intrusive, 2% Amalia. It has trace amount of pyrite, gypsum, carbonates, 4% of Fe-oxides, 6% quartz and 90% rock fragments.

LABORATORY ANALYSES
Below are laboratory results of sample MIN-AAF-0004. The results of the bulk sample and the size fractions are specified above/below each result.

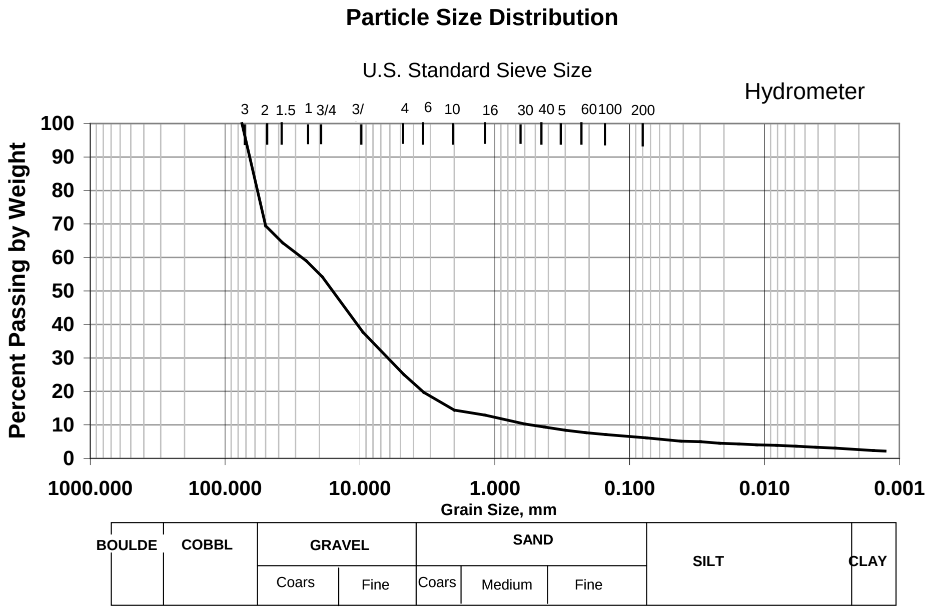


FIGURE 1-13. Particle size analysis plot of bulk sample MIN-AAF-0004

TABLE 1-9. Laboratory results of bulk sample MIN-AAF-0004

Chemistry		**Geochemistry**		**Mineralogy**	
SiO2	71.9	pastepH	4.23	quartz	43
TiO2	0.38	pasteCond	0.19	K-feldspar	22
Al2O3	13.14	pasteTDS	0.09	plagioclase	0.01
FeOT	2.900	WaterCont	5.37	epidote	0
MnO	0.02	NAGpH	5.68	calcite	0.4
MgO	0.62	NAGvalue	0	pyrite	0.01
CaO	0.09	AP	7.13	FeMnOxide	3
Na2O	0.45	NP	-5.09	Gypsum	0.01
K2O	4.39	netNP	-12.22	apatite	0.01
P2O5	0.12	NPAP	12.22	TotalClay	28.9
Ni	0			kaol	2
Cr	25			chlorite	1
Sc	3	**Geotechnical**		illite	25
V	47	SlakeIndex	96.1	smectite	0.9
Ba	658	FrictAngle	40.6	Jarosite	2
Rb	150	ResidFA	37.9	rutile	0.2
Sr	102	DryDensity	1.89	zircon	0.04
Zr	240	SpecGrav	2.72		
Y	37	LL	22.8		

Chemistry		Geochemistry		Mineralogy	
Nb	26	PL	18.32		
Ga	23	PI	4.49		
Cu	23	MatriSuc	26.3		
Zn	21	% Gravel	74.89		
Pb		% Sand	18.98		
La		% Fines	6.14		
Ce	124	D10	0.51		
Th	16	D30	6.2		
Nd		D50	17.53		
U	2	D60	27		
F	1258				
S	0.01				
SO4	0.43				
C	0.26				
LOI	4.71				

TABLE 1-10. Laboratory results of the size fractions of sample MIN-AAF-0004

Size Fraction(inch)	**1**	**0.75**	**0.5**	**0.187**	**0.0787**
Mineralogy					
quartz	40	41	50	47	47
K-feldspar	22	21	15	18	15
plagioclase	8	4	1	0.01	0.01
epidote	0	0	0	0	0
calcite	0.9	1	0.5	0.6	0.7
pyrite	0.01	0.09	0.01	0.09	0.09
FeMnOxide	3	2	0.9	1	2
Gypsum	0.4	0.01	0	0	0.01
apatite	0.3	0.01	0.01	0.01	0.01
TotalClay	25	28.9	30.9	31.9	32.9
kaol	2	2	2	2	2
chlorite	2	2	1	2	2
illite	20	24	27	27	28
smectite	1	0.9	0.9	0.9	0.9
jarosite	0	1	0.7	1	2
rutile	0.3	0.5	0.3	0.4	0.3
zircon	0.04	0.04	0.04	0.04	0.04
Chemistry					
SiO2	72.2	71.1	76.1	74.2	73.5

Size Fraction(inch)	**1**	**0.75**	**0.5**	**0.187**	**0.0787**
TiO2	0.4	0.6	0.3	0.4	0.4
Al2O3	13.4	13.6	12.6	12.7	12.6
FeOT	2.5	2.7	1.4	2.0	2.4
MnO	0.0	0.0	0.0	0.0	0.0
MgO	0.8	0.8	0.5	0.7	0.6
CaO	0.8	0.3	0.1	0.1	0.1
Na2O	1.7	1.1	0.2	0.4	0.4
K2O	4.0	4.4	4.5	4.3	4.2
P2O5	0.1	0.1	0.1	0.1	0.1
Ni	5.4	8.3	3.4	4.2	5.2
Cr	16.9	37.3	16.7	25.4	24.4
Sc	6	6.6	3.1	5.1	4.8
V	53	65	32	43	43
Ba	719.9	952.7	509.9	567.5	626.1
Rb	121.9	141.8	147.8	141.4	139.3
Sr	222.9	190	47.8	80.3	104.6
Zr	238.4	207.7	266.6	244.3	236.7
Y	32.6	26.6	46.6	35.9	37.5
Nb	23.4	20.8	29.1	25.2	25.9
Ga	21.2	19.1	21.5	21	21.3
Cu	12.7	17.7	11.6	21.1	19.1
Zn	27.2	32.3	17.6	20.6	21.4
Pb	39.3	55.8	70	73.9	92
La	38	44.8	43.1	53	48.9
Ce	75.7	82.2	89.1	97.2	95.2
Th	11.2	10.4	12.3	10.8	12
Nd	28	31.1	34.5	37.2	36.7
U	3.3	3.9	5.1	4.2	3
F	913	1044	1071	1089	958
S	0.02	0.05	0.02	0.04	0.04
SO4	0.09	0.19	0.14	0.2	0.32
C	0.1	0.16	0.1	0.11	0.13
LOI	2.92	3.65	3.15	3.45	4.11
Geochemistry					
paste pH	6.04	6.19	6.26	6.04	6.09
paste conductivity	0.17	0.3	0.19	0.19	0.35
AP	0.63	1.56	0.63	1.25	1.25
NP	0.29	1.03	2.64	15.89	0.84

DESCRIPTION OF SAMPLE MIN-SAN-0002

LOCATION

Sample MIN-SAN-0002 was collected from Goathill debris flow at the site of in situ test MIN-AAF-0001. It is at UTM 452369E, 4059919N and on zone 13.

HAND SPECIMEN DESCRIPTION

Sample MIN-SAN-0002 is a light brown, well graded and poorly sorted material. It is massive, angular and non plastic with dry water content.

PETROGRAPHIC DESCRIPTION

Sample MIN-SAN-0002 is fine sand to gravel with subrounded subdiscoidal shape of clast. It has 95% intrusive and 5% Amalia rock fragments. It is QSP altered with slight argillic alteration. It has 10% Fe-oxides, trace amount of gypsum and muscovite and 83% rock fragments.

FIGURE 1-14. Sample MIN-SAN-0002 with subrounded shape of clast with some F-oxide stains (field of view is4mm).

LABORATORY ANALYSES

Below are laboratory results of sample MIN-SAN-0002. The results of the bulk sample and the size fractions are specified above each result.

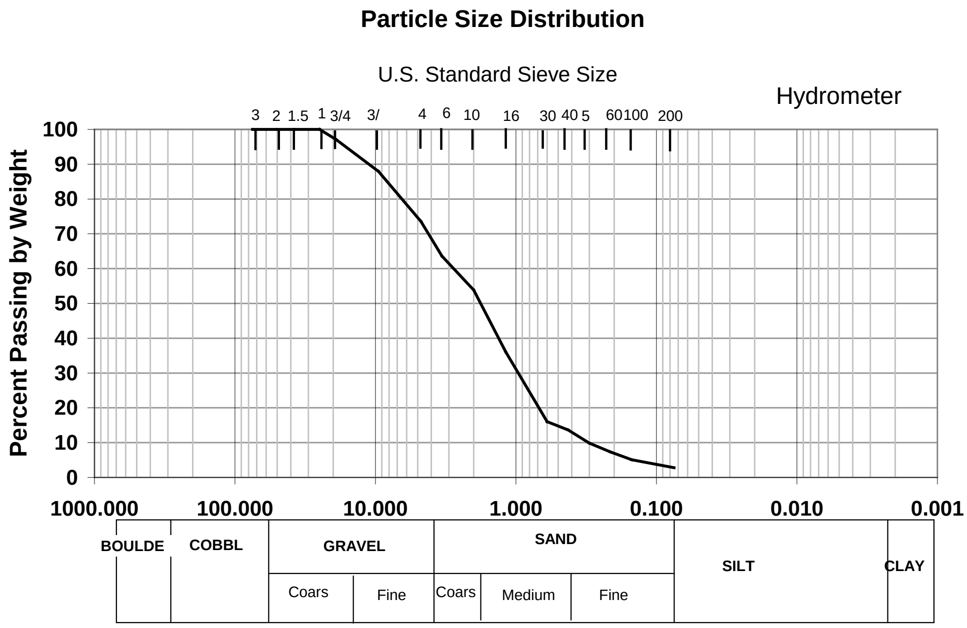


FIGURE 1-15. Particle size analysis plot of bulk sample MIN-SAN-0002

TABLE 1-11. Laboratory results of bulk sample MIN-SAN-0002

Chemistry		Geochemistry		Mineralogy	
SiO2	71.07	pastepH	3.53	quartz	50
TiO2	0.45	pasteCond	0.16	K-feldspar	4
Al2O3	12.74	pasteTDS	0.08	plagioclase	6
FeOT	2.69	WaterCont	5.77	epidote	0
MnO	0.02	NAGpH		calcite	0.5
MgO	0.64	NAGvalue		pyrite	0.01
CaO	0.1	AP	1.25	FeMnOxide	1
Na2O	0.69	NP	-5.09	Gypsum	0.01
K2O	4.23	netNP	-6.34	apatite	0.01
P2O5	0.12			TotalClay	34.9
Ni	2.6	**Geotechnical**		kaol	3
Cr	31.1	SlakeIndex	98.61	chlorite	2
Sc	4.5	FrictAngle	39.7	illite	29
V	56.8	ResidFA	40.1	smectite	0.9
Ba	703	Cohesion		Jarosite	3
Rb	137.6	QMWI		rutile	0.4
Sr	116	PointLoad	5	zircon	0.04
Zr	228.7	DryDensity	2.15		
Y	35	SpecGrav	2.71		

Chemistry		Geochemistry		Mineralogy	
Nb	24.5	LL	26.9		
Ga	21.6	PL	18.1		
Cu	24.9	PI	8.7		
Zn	19.2	% Gravel	26.45		
Pb		% Sand	70.74		
La		% Fines	2.81		
Ce	88.2	D10	0.3		
Th	13.1	D30	1		
Nd		D50	1.86		
U	3.9	D60	3		
F	1092				
S	0				
SO4	0.54				
C	0.3				
LOI	4.68				

TABLE 1-12. Laboratory results of the size fractions of sample MIN-SAN-0002

Size Fraction(inch)	0.75	0.5	0.187	0.0787
Mineralogy				
quartz	48	49	51	47
K-feldspar	11	14	10	13
plagioclase	6	0.8	2	0.2
epidote	0	0	0	0
calcite	0.6	0.4	0.5	0.2
pyrite	0.09	0.09	0.09	0.01
FeMnOxide	2	1	1	2
Gypsum	0.01	0.01	0.01	0.01
apatite	0.01	0.01	0.01	0.09
TotalClay	31.9	32.9	33.9	34.9
kaol	3	3	3	3
chlorite	2	2	2	2
illite	26	27	28	29
smectite	0.9	0.9	0.9	0.9
jarosite	0.9	1	1	2
rutile	0.4	0.4	0.3	0.3
zircon	0.04	0.04	0.04	0.04

Size Fraction(inch)	**0.75**	**0.5**	**0.187**	**0.0787**
Chemistry				
SiO2	72.6	73.3	73.3	71.7
TiO2	0.5	0.4	0.4	0.4
Al2O3	13.1	13.2	12.6	12.5
FeOT	2.1	1.8	1.9	2.6
MnO	0.0	0.0	0.0	0.0
MgO	0.7	0.6	0.6	0.6
CaO	0.1	0.1	0.1	0.1
Na2O	0.8	0.5	0.5	0.4
K2O	4.5	4.6	4.2	4.1
P2O5	0.1	0.1	0.1	0.1
Ni	0	0	0	0
Cr	34.3	27.7	25.4	26.6
Sc	5.8	4.6	4.9	4.9
V	52	50	42	44
Ba	889.8	728.2	576.5	649.3
Rb	143.1	153.4	133.2	133.6
Sr	105	69.8	113.5	112.8
Zr	240.6	227.3	239.9	223.6
Y	34	34.5	39.9	38.7
Nb	23.8	23.1	26.1	24.7
Ga	21	20.6	21.6	20.8
Cu	44.8	14.1	14.2	19.4
Zn	22	16.1	18.9	18.8
Pb	117.2	61.6	58.9	92.1
La	40.9	45	49.5	50.8
Ce	79.9	90.3	98.2	98.2
Th	13.1	12.5	11.9	13
Nd	34.5	36.4	37.7	37.5
U	3.3	4.4	3.4	3.9
F				
S	0.04	0.04	0.03	0
SO4	0.17	0.2	0.23	0.39
C	0.1	0.07	0.09	0.15
LOI	3.59	3.33	3.74	4.71
Geochemistry				
paste pH	3.53	3.44	3.27	3.53
paste conductivity	0.16	0.24	0.24	0.23

Size Fraction(inch)	0.75	0.5	0.187	0.0787
AP	1.25	1.25	0.94	0
NP	2.77	4.23	0.55	1.79

DESCRIPTION OF SAMPLE QPS-AAF-0001

LOCATION

Sample QPS-AAF-0001 was collected from the upper most roads in Questa pit scar at the edge of colluvium coming off outcrop within alteration scar (UTM 454144E, UTM 4062571N, zone 13). It was also an in situ site.

HAND SPECIMEN DESCRIPTION

Sample QPS-AAF-0001 is a clayey gravel and brown in color. The sample is subangular and well cemented with clay materials. It has high plasticity and damp water content.

PETROGRAPHIC DESCRIPTION

Sample QPS-AAF-0001 is QSP altered and it is made of 75% andesite and 25% intrusive rock. It has 8% Fe-oxides, trace amount of gypsum, trace amount of carbonate minerals and 90% rock fragments. No chlorite or epidote alteration observed for this sample.

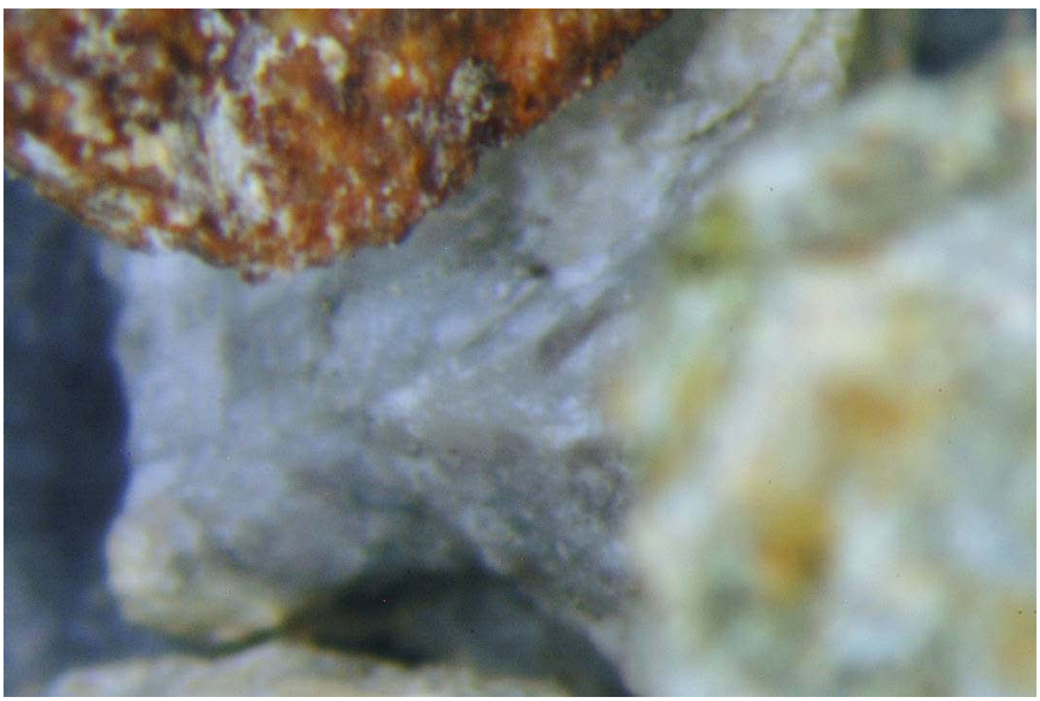


FIGURE 1-16. Sample QPS-AAF-0001 with Fe-oxide stains on rock fragments (field of view is 6mm)

LABORATORY ANALYSES

Below are laboratory results of sample QPS-AAF-0001. The results of the bulk sample and the size fractions are specified above each result.

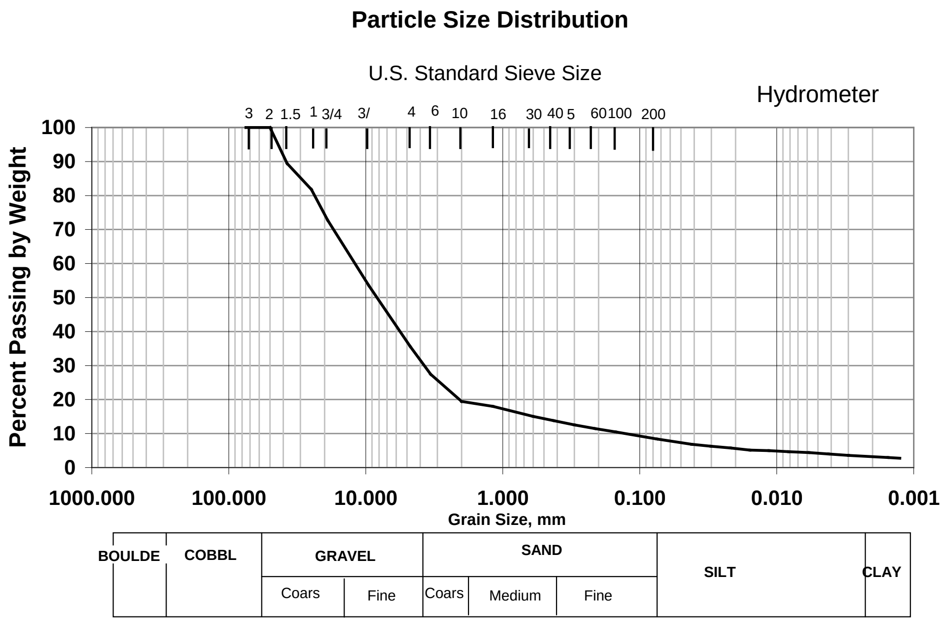


FIGURE 1-17. Particle size analysis plot of bulk sample QPS-AAF-0001

TABLE 1-13. Laboratory results of bulk sample QPS-AAF-0001

Chemistry		Geochemistry		Mineralogy	
SiO2	66.2	pastepH	3.09	quartz	38
TiO2	0.60	pasteCond	3.16	K-feldspar	12
Al2O3	14.16	pasteTDS	1.58	Plagioclase	13
FeOT	3.530	WaterCont	9.14	epidote	0.01
MnO	0.05	AP	3.09	calcite	0.7
MgO	1.23	NP	3.44	pyrite	0.2
CaO	0.89	netNP	-1.31	FeMnOxide	2
Na2O	1.85			Gypsum	0.9
K2O	3.61	**Geotechnical parmeters**		apatite	0.4
P2O5	0.20	SlakeIndex	97.1	TotalClay	30
Ni	11	FrictAngle	46.5	kaol	0
Cr	66	ResidFA	39.8	chlorite	3
Sc	9	DryDensity	1.68	illite	27
V	83	SpecGrav	2.82	smectite	0
Ba	1017	LL	34.52	jarosite	2
Rb	99	PL	20.75	rutile	0.5
Sr	326	PI	13.79	zircon	0.03
Zr	176	% Gravel	64.35		

Chemistry		Geochemistry		Mineralogy	
Y	23	% Sand	27.26		
Nb	15	% Fines	8.39		
Ga	21	D10	0.15		
Cu	39	D30	3.6		
Zn	64	D50	8.9		
Pb		D60	11.5		
Ce	47				
Th	11				
Nd					
U	3.8				
S	0.11				
SO4	0.55				
C	0.09				
LOI	5.27				

TABLE 1-14. Laboratory results of the size fractions of sample QPS-AAF-0001

Size Fraction(inch)	1.000	0.750	0.500	0.187	0.0787
Mineralogy					
quartz	39	38	40	10	8
K-feldspar	11	10	8	11	11
Plagioclase	15	15	10	0.01	0.01
epidote	0.01	0.01	0.01	0.09	0.4
calcite	0.01	0.3	0.2	0.2	0.09
pyrite	0.6	0.3	0.2	2	3
FeMnOxide	3	3	2	0.9	1
Gypsum	0.4	0.9	1	0.4	0.4
apatite	0.6	0.4	0.4	33	34
TotalClay	30	30	34	0	0
kaol	0	0	0	3	3
chlorite	3	3	3	30	31
illite	27	27	31	0	0
smectite	0	0	0	2	3
jarosite	0.6	2	3	0.6	0.6
rutile	0.6	0.5	0.5	0.03	0.03
zircon	0.03	0.03	0.03	67.1	66.0
Chemistry					
SiO2	69.4	66.9	66.5	0.6	0.6

Size Fraction(inch)	1.000	0.750	0.500	0.187	0.0787
TiO2	0.6	0.6	0.6	14.2	14.3
Al2O3	14.7	14.3	14.0	3.5	3.8
FeOT	2.9	3.7	3.7	0.0	0.0
MnO	0.0	0.0	0.0	1.2	1.3
MgO	1.0	1.1	1.2	0.7	0.9
CaO	0.4	0.8	0.9	1.5	1.4
Na2O	2.0	1.9	1.4	3.6	3.7
K2O	3.2	3.5	3.6	0.2	0.2
P2O5	0.4	0.2	0.2	16.7	17.6
Ni	15.2	19.1	15.8	70	71.3
Cr	63.1	63.5	62	9.9	9.7
Sc	10.2	8.6	9.9	86	88
V	86	76	84	954.2	927.3
Ba	1057.9	876.6	882.9	102.5	104.1
Rb	84.1	94.4	101.5	311.5	309.3
Sr	423.5	349.2	274.5	175.3	177
Zr	177.8	184	178.8	20.6	21.2
Y	22.1	30.8	24.1	15.1	13.9
Nb	14.3	18	16.1	20.5	19
Ga	19.7	21.2	20.1	34.9	37.1
Cu	44.4	24.8	31.2	45.9	49.9
Zn	39.2	54	44.2	44.3	58.7
Pb	24.8	39.6	43.5	34.3	37.7
La	34.4	40.1	35.9	66.9	69.2
Ce	69.1	73.4	74.7	7.3	8.5
Th	9.4	9.8	8.8	30.5	29.1
Nd	28.5	32.4	29.2	4.4	2.4
U	3	2	4.9	982	1220
F	801	907	1829	0.1	0.04
S	0.31	0.17	0.12	0.61	0.72
SO4	0.18	0.57	0.74	0.05	0.06
C	0.04	0.05	0.04	5.43	5.81
LOI	3.77	4.8	5.84		
Geochemistry					
pH	4.29	4.14	4.03	3.13	1.25
P.conductivity					
AP	9.69	5.31	3.75	1.16	-2.85

Size Fraction(inch)	1.000	0.750	0.500	0.187	0.0787
NP	1.35	-4.19	10.45	-1.97	-4.1
NetNP	-8.34	-9.5	6.7	-3.13	-1.25

DESCRIPTION OF SAMPLE QPS-AAF-0003

LOCATION

Sample QPS-AAF-0003 was collected from the Questa scar from the edge of colluvium coming off outcrop within alteration scar (UTM 454144E, 4062571N, zone 13). It is an in situ test site QPS-AAF-0003 run 2.

HAND SPECIMEN DESCRIPTION

Sample QPS-AAF-0003 is a brown clayey gravel material with poor sorting and subangular grain shape. It is well cemented with clay materials, has high plasticity with damp water content.

PETROGRAPHIC DESCRIPTION

Sample QPS-AAF-0003 is a pale brown QSP altered material with slight argillic alteration. It is 50% andesite and 50% intrusive rock material. It is cemented with gypsum and clay materials. It has 3% gypsum (detrital), 4% Fe-oxides, 1% carbonate and 91% rock fragments.

FIGURE 1-18. Sample QPS-AAF-0003 with gypsum as cementing mineral. Iron coating on rock fragments (field of view is 6mm).

LABORATORY ANALYSES

Below are laboratory results of sample QPS-AAF-0003. The results of the bulk sample and the size fractions are specified above each result.

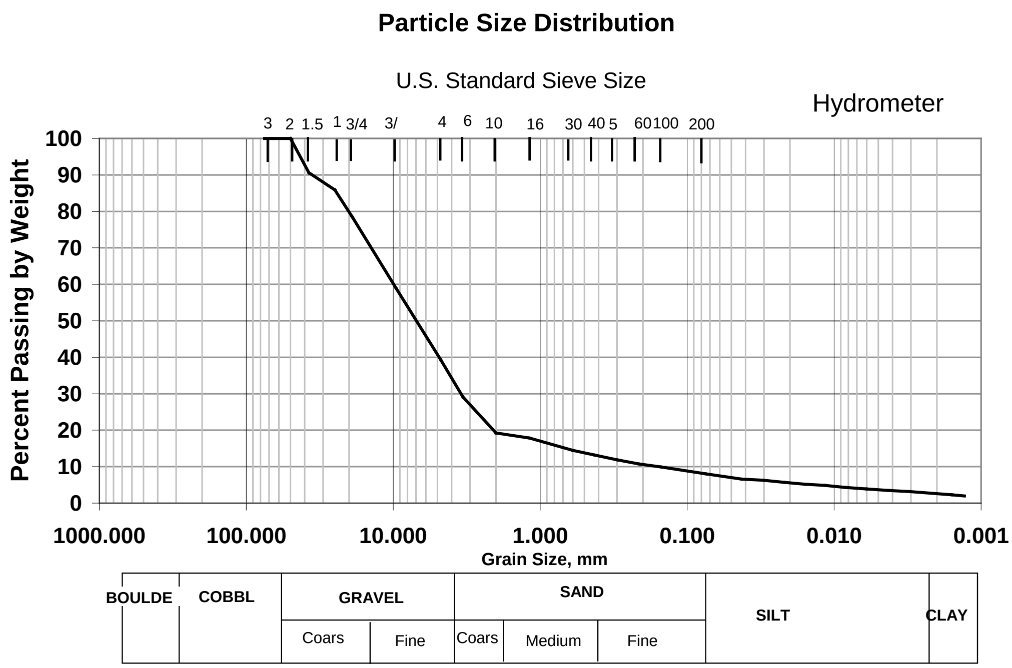


FIGURE 1-19. Particle size analysis plot of bulk sample QPS-AAF-0003

TABLE 1-15. Laboratory results of bulk sample QPS-AAF-0003

Chemistry		**Geochemistry**		**Mineralogy**	
SiO2	63.06	pastepH	3.19	quartz	34
TiO2	0.592	pasteCond	1.18	K-spar	10
Al2O3	14.53	pasteTDS	0.6	plagioclase	14
FeOT	4.36	WaterCont	9.14	epidote	0.01
MnO	0.054	NAGpH	4.21	calcite	0.09
MgO	1.57	NAGvalue	5.71	pyrite	0.09
CaO	1.25	AP	21.88	FeMnOxide	3
Na2O	1.88	NP	0.36	Gypsum	2
K2O	3.71	netNP	-21.51	apatite	0.4
P2O5	0.241	NPAP	21.51	TotalClay	33.8
Ni	20			kaol	0.9
Cr	63	**Geotechnical**		chlorite	4
Sc	9	SlakeIndex	90.1	illite	28
V	88	FrictAngle	36.5	smectite	0.9

Chemistry		Geochemistry		Mineralogy	
Ba	1416	ResidFA	37	Jarosite	2.5
Rb	117	DryDensity	1.88	rutile	0.5
Sr	362	SpecGrav	2.82	zircon	0.03
Zr	168	LL	34.8		
Y	20	PL	23.6		
Nb	12.5	PI	11.2		
Ga	21	MatriSuc	0		
Cu	44	% Gravel	60.76		
Zn	82	% Sand	31.18		
Pb		% Fines	8.06		
La		D10	0.16		
Ce	55	D30	3.3		
Th	11	D50	8.1		
Nd		D60	10		
U	3				
F	1291				
S	0.06				
SO4	0.91				
C	0.03				
LOI	6.74				

TABLE 1-16. Laboratory results of the size fractions of sample QPS-AAF-0003

Size Fraction(inch)	**1**	**0.75**	**0.5**	**0.187**	**0.0787**
Mineralogy					
quartz	38	31	33	34	34
K-spar	14	19	13	15	12
plagioclase	13	18	19	15	15
epidote	0.01	0.01	0.01	0.01	0.01
calcite	1	0.4	0.4	0.2	0.2
pyrite	2	0.3	0.4	0.6	0.6
FeMnOxide	2	4	3	3	3
Gypsum	2	2	1	2	2
apatite	0.5	0.4	0.4	0.4	0.4
TotalClay	26.8	23.8	27.8	27.8	30.8
kaol	0.9	0.9	0.9	0.9	0.9
chlorite	6	4	5	4	4
illite	19	18	21	22	25
smectite	0.9	0.9	0.9	0.9	0.9

Size Fraction(inch)	**1**	**0.75**	**0.5**	**0.187**	**0.0787**
jarosite		0.7	2	1	2
rutile	0.6	0.4	0.5	0.5	0.5
zircon	0.03	0.03	0.03	0.03	0.03
Chemistry					
SiO2	66.6	64.8	64.8	64.8	63.8
TiO2	0.6	0.6	0.6	0.6	0.6
Al2O3	12.9	14.3	14.3	14.2	14.1
FeOT	3.8	4.1	4.0	4.0	4.1
MnO	0.1	0.1	0.1	0.0	0.0
MgO	2.1	1.5	1.7	1.5	1.6
CaO	1.8	1.3	1.1	1.1	1.2
Na2O	2.0	2.7	2.6	2.2	2.0
K2O	3.0	3.6	3.4	3.6	3.6
P2O5	0.3	0.2	0.3	0.2	0.2
Ni	41.6	30.2	30.5	29.6	29.7
Cr	69.3	57.4	69.9	65.7	67
Sc	10.6	8.5	9.3	8.8	9
V	84	76	82	80	82
Ba	929.8	1099.8	1226.9	1070.3	1094.1
Rb	92.1	110.1	102.3	106.1	107.3
Sr	310.7	733.8	383.9	379.2	376.9
Zr	151	167.2	164.3	165.3	162.5
Y	24.3	21.1	20.6	20.4	20.4
Nb	10.1	12.1	12.2	12	12.8
Ga	16.4	19.2	20	19.5	19
Cu	63.8	50	41.1	50.5	45.9
Zn	107.8	91.4	86.5	85.2	84.7
Pb	52.2	33.3	44.1	40.4	46.1
La	29.3	33.9	35.4	33.3	33.3
Ce	65.8	64.9	64.6	64.9	61.1
Th	6.1	8.7	8.1	8.2	7.3
Nd	33.1	31.5	30.7	29.8	27.5
U	1.6	4	1.9	2.7	2.6
F	3373	2354	1090	2145	1453
S	1.07	0.17	0.22	0.32	0.3
SO4	0.43	0.54	0.61	0.59	0.76
C	0.16	0.06	0.06	0.04	0.04

Size Fraction(inch)	1	0.75	0.5	0.187	0.0787
LOI	5.06	4.81	5.32	4.95	6.05
Geochemistry					
paste pH	4.87	4.11	3.85	3.69	4.23
paste conductivity	2	2.02	1.76	1.6	1.84
AP	33.44	5.31	6.88	10	9.38
NP	21.64	25.42	3.44	4.49	-5.53
NetNP	-11.8	20.11	-3.44	-5.51	-14.91

DESCRIPTION OF SAMPLE QPS-AAF-0005

LOCATION
Sample QPS-AAF-0005 was collected from the Questa scar on the upper most road in scar on the edge of colluvium coming off outcrop within alteration scar (UTM 454144E, 4062571N, zone 13). It is an in situ site test for sample QPS-AA-0001 run 3.

HAND SPECIMEN DESCRIPTION
Sample QPS-AAF-0005 is brown rocky clayey gravel with subangular grain shape. It is stratified with well cemented clays. It is poorly sorted, has high plasticity and a damp water content.

PETROGRAPHIC DESCRIPTION
Sample QPS-AAF-0005 is a pale brown QSP and argillic altered gravel material. It is 80% andesite and 20% intrusive rock materials with clay materials as cements showing some cohesion. It has 2% gypsum (detrital), 2% Fe-oxide, trace amount of carbonate and 93% rock fragments.

FIGURE 1-20. Sample QPS-AAF-0005 showing Amalia Tuff grains with Fe-oxide coatings (field of view is 6mm).

LABORATORY ANALYSES

Below are laboratory results of sample QPS-AAF-0005. The results of the bulk sample and the size fractions are specified above each result.

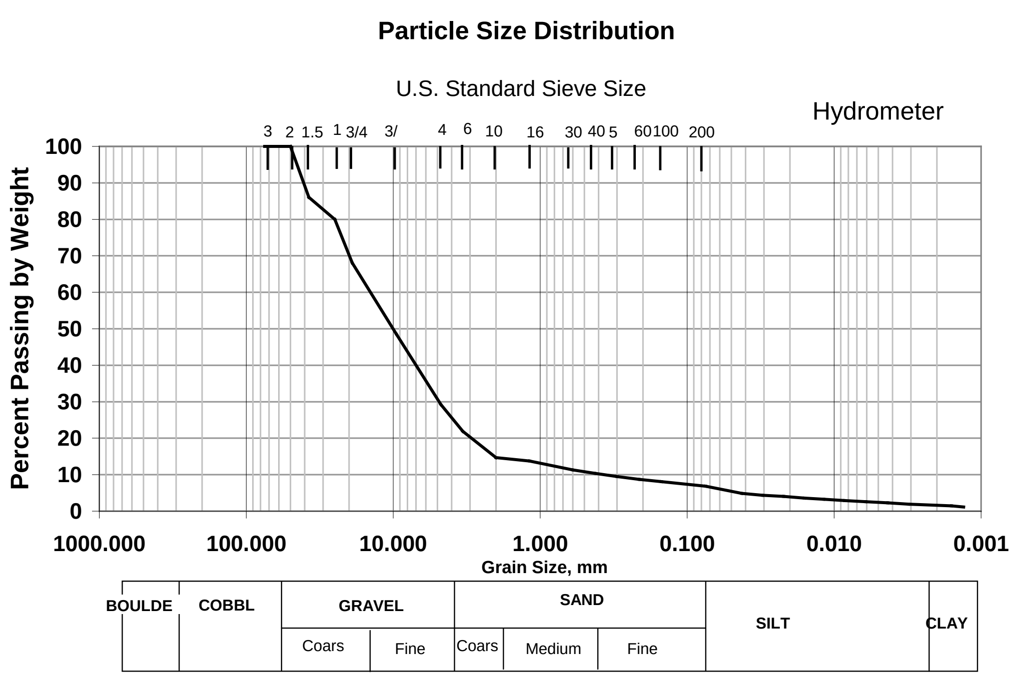


FIGURE 1-21. Particle size analysis plot of bulk sample QPS-AAF-0005

TABLE 1-17. Laboratory results of bulk sample QPS-AAF-0005

Chemistry		**Geochemistry**		**Mineralogy**	
SiO2	61.9	pastepH	2.98	quartz	34
TiO2	0.60	pasteCond	1.53	K-feldspar	6
Al2O3	14.31	pasteTDS	0.77	plagioclase	14
FeOT	4.400	WaterCont	9.14	epidote	0.01
MnO	0.05	NAGpH	4.72	calcite	0.09
MgO	1.54	NAGvalue	3.89	pyrite	0
CaO	1.44	AP	24.75	FeMnOxide	3
Na2O	1.82	NP	-3.3	Gypsum	2
K2O	3.65	netNP	-28.05	apatite	0.4
P2O5	0.23	NPAP	28.05	TotalClay	36.9
Ni	17			kaol	3
Cr	61	**Geotechnical**		chlorite	4
Sc	10	SlakeIndex	97	illite	29
V	86	FrictAngle	45.01	smectite	0.9
Ba	1086	ResidFA	38.7	Jarosite	3
Rb	116	Cohesion	23.9	rutile	0.5
Sr	371	QMWI	7	zircon	0.03
Zr	169	PointLoad			
Y	18	DryDensity	1.66		
Nb	12	SpecGrav	2.82		
Ga	20	LL	34.28		
Cu	43	PL	17.91		
Zn	73	PI	16.38		
Pb		MatriSuc	0		
La		% Gravel	70.75		
Ce	58	% Sand	22.42		
Th	10	% Fines	6.83		
Nd		D10	0.38		
U	2	D30	5		
F	1164	D50	9.8		
S	0.02	D60	15		
SO4	1.17				
C	0.03				
LOI	8.03				

TABLE 1-18. Laboratory results of the size fractions of sample QPS-AAF-0005

Size Fraction(inch)	1	0.75	0.5	0.187	0.0787
Mineralogy					
quartz	25	29	30	32	33
K-feldspar	22	25	19	16	12
plagioclase	30	23	17	17	16
epidote	0.01	0.01	0.01	0.01	0.01
calcite	0.09		0.01	0.09	0.3
pyrite	0.5	0.2	0.2	0.09	0.09
FeMnOxide	4	3	3	3	3
Gypsum	0.7	0.6	2	1	1
apatite	0.3	0.3	0.4	0.4	0.4
TotalClay	15.9	17.9	26.9	27.9	31.9
kaol	3	3	3	3	3
chlorite	2	3	4	4	4
illite	10	11	19	20	24
smectite	0.9	0.9	0.9	0.9	0.9
jarosite	0.4	0.7	1	2	2
rutile	0.4	0.5	0.5	0.5	0.5
zircon	0.03	0.03	0.03	0.03	0.03
Chemistry					
SiO2	65.4	66.6	64.0	64.7	64.1
TiO2	0.6	0.6	0.6	0.6	0.6
Al2O3	15.2	14.6	14.4	14.5	14.5
FeOT	4.0	3.5	4.0	3.9	4.0
MnO	0.1	0.1	0.0	0.1	0.1
MgO	1.1	1.3	1.5	1.6	1.7
CaO	0.6	0.5	1.1	0.8	1.0
Na2O	4.3	3.4	2.5	2.5	2.2
K2O	3.6	4.1	4.0	3.8	3.7
P2O5	0.2	0.2	0.2	0.2	0.2
Ni	22.9	23.6	23.4	23.9	23.7
Cr	52.3	59.4	63.9	61.5	63.8
Sc	7.5	8.9	9.2	9	9.5
V	72	83	83	82	88
Ba	1156.2	1395.5	1188.2	1171.3	1185.9
Rb	99.1	118.4	119.6	115.1	112.4
Sr	570.8	461	385.4	384.2	369.7
Zr	175.3	172.8	170.6	172.4	169.9

Size Fraction(inch)	1	0.75	0.5	0.187	0.0787
Y	17.7	14	17.1	18	19.2
Nb	11.8	10.9	14.1	12.3	13.6
Ga	16.2	18	19.4	19.8	18.8
Cu	27.9	26.3	35.8	38.7	41.4
Zn	69.2	62.5	76.1	76.5	80.8
Pb	27.5	30.4	47.8	53.9	53.5
La	24.6	23.7	29.3	29.8	35.1
Ce	47.7	42.9	57.5	57.3	59.5
Th	11.1	8.5	9.3	8.2	8.3
Nd	24.3	21	24.6	22.8	24.6
U	2.1	1.6	2.3	0.6	0.9
F	599	745	1801	937	997
S	0.25	0.12	0.09	0.06	0.06
SO4	0.22	0.26	0.64	0.59	0.71
C	0.03	0.02	0.02	0.03	0.05
LOI	3.2	3.47	5.47	5.37	6.52
Geochemistry					
paste pH	4.02	4.18	3.73	3.55	4.73
paste conductivity	1.31	1.7	2.28	1.61	2.22
AP	7.81	3.75	2.81	1.88	1.88
NP	2.85	-0.08	-0.18	-1.03	0.73
NetNP	-4.96	-3.83	-2.99	-2.91	-1.15

DESCRIPTION OF SAMPLE QPS-AAF-0009

LOCATION

Sample QPS-AAF-0009 was collected from Questa scar from approximately 50 yards west of QPS-AAF-0001, 2 m east of QPS-AAF-0008, same level as QPS-AAF-0008(UTM 454138E, UTM 4062528N, zone 13). It is an in situ test site for sample QPS-AAF-0009 run 1 2 ft shear box.

HAND SPECIMEN DESCRIPTION

Sample QPS-AAF-0009 is yellowish brown clayey gravel with cobbles. It is angular and poorly sorted. It is stratified with medium plasticity. It is well cemented with clays enhancing some cohesion and has moist water content.

PETROGRAPHIC DESCRIPTION

Sample QPS-AAF-0009 is pale yellow material with subangular to sub roundness grain shape. It is an AmaliaTuff rock fragments and altered by QSP and some argillic alteration. It has 2% gypsum (authigenic), 2% Fe-oxides and 94% rock fragments.


FIGURE 1-22. Sample QPS-AAF-0009 with Amalia Tuff rock fragments with few iron coatings (field of view is 6mm).

LABORATORY ANALYSES

Below are laboratory results of sample QPS-AAF-0009. The results of the bulk sample and the size fractions are specified above each result.

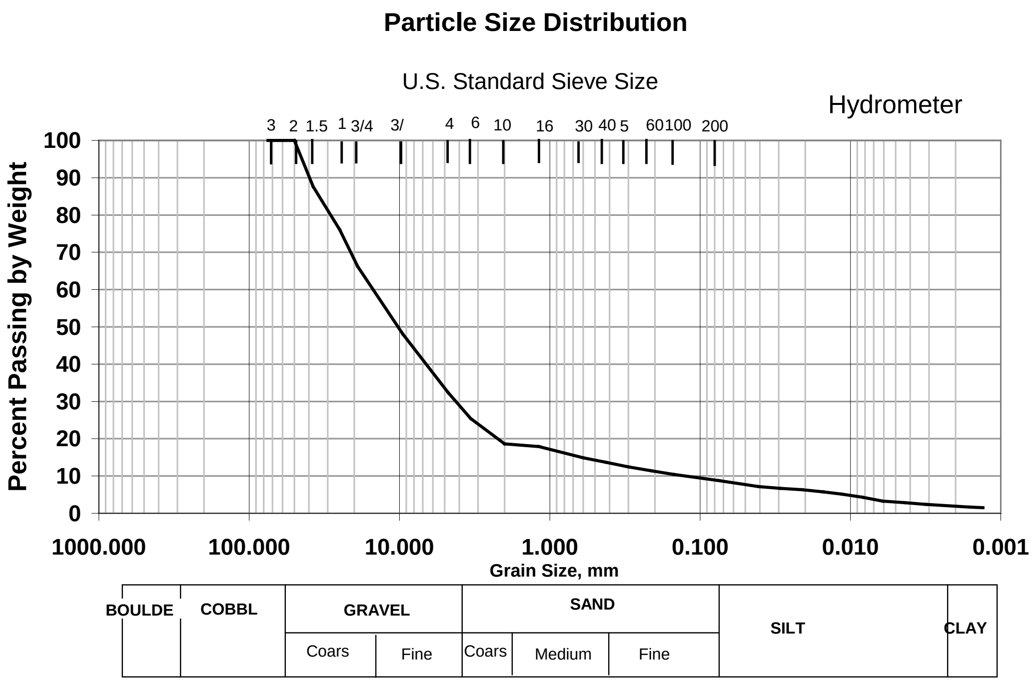


FIGURE 1-23. Particle size analysis plot of bulk sample QPS-AAF-0009

TABLE 1-19. Laboratory results of bulk sample QPS-AAF-0009

Chemistry		**Geochemistry**		**Mineralogy**	
SiO2	63.95	pastepH	2.96	quartz	37
TiO2	0.692	pasteCond	2.03	K-feldspar	4
Al2O3	14.47	pasteTDS	1.02	plagioclase	9
FeOT	3.94	WaterCont	10.41	epidote	0.01
MnO	0.028	NAGpH	3.4	calcite	0.09
MgO	1.02	NAGvalue	8.83	pyrite	0.3
CaO	1.61	AP	25.13	FeMnOxide	2
Na2O	1.21	NP	-0.84	Gypsum	3
K2O	3.65	netNP	-25.96	apatite	0.4
P2O5	0.263	NPAP	25.96	TotalClay	39.9
Ni	11			kaol	2
Cr	68	**Geotechnical**		chlorite	3
Sc	10	SlakeIndex	94.9	illite	34
V	97	FrictAngle	41.7	smectite	0.9
Ba	933	ResidFA	35.8	Jarosite	3
Rb	103	Cohesion		rutile	0.6
Sr	380	QMWI		zircon	0.03

Chemistry		Geochemistry		Mineralogy	
Zr	170	PointLoad			
Y	18	DryDensity	1.92		
Nb	11.5	SpecGrav	2.84		
Ga	19	LL	35.47		
Cu	29	PL	22.22		
Zn	29	PI	13.25		
Pb	40	MatriSuc	5		
La	37	% Gravel	67.61		
Ce	67	% Sand	23.64		
Th	9	% Fines	8.75		
Nd	29	D10	0.16		
U	3	D30	4		
F	940	D50	9.9		
S	0.18	D60	16		
SO4	1.18				
C	0.03				
LOI	6.93				

TABLE 1-20. Laboratory results of the size fractions of sample QPS-AAF-0009

Size Fraction(inch)	**1**	**0.75**	**0.5**	**0.187**	**0.0787**
Mineralogy					
quartz	27	33	32	36	37
K-feldspar	19	13	16	12	7
plagioclase	14	12	8	9	8
epidote	3	0.01	0.01	0.01	0.01
calcite	0.5	0.01	0.01	0.01	0.09
pyrite	0.4	1	0.4	0.4	0.3
FeMnOxide	3	4	4	3	3
Gypsum	2	5	3	2	3
apatite	0.7	0.4	0.4	0.4	0.4
TotalClay	29.9	31.9	34.9	34.9	38.8
kaol	0.9	2	2	2	0.9
chlorite	5	4	3	3	3
illite	22	25	29	29	34
smectite	2	0.9	0.9	0.9	0.9
jarosite			0.3	1	2
rutile	0.6	0.4	0.5	0.5	0.5
zircon	0.03	0.03	0.03	0.03	0.03

Size Fraction(inch)	1	0.75	0.5	0.187	0.0787
Chemistry					
SiO2	63.0	62.9	64.1	65.2	63.7
TiO2	0.7	0.7	0.7	0.7	0.7
Al2O3	15.7	14.0	15.0	14.5	14.4
FeOT	4.3	4.5	4.0	3.8	4.1
MnO	0.1	0.1	0.0	0.0	0.0
MgO	2.0	1.4	1.4	1.3	1.1
CaO	2.3	2.8	1.7	1.4	1.7
Na2O	2.2	1.8	1.4	1.4	1.1
K2O	3.7	3.2	3.9	3.7	3.7
P2O5	0.3	0.3	0.3	0.2	0.2
Ni	33.3	24.4	20	17	14.8
Cr	81.3	69.5	72.5	65.5	69.1
Sc	12.3	10.4	11.4	10.5	11.2
V	101	93	107	96	102
Ba	1263.7	1028.2	1014.9	1023.6	1014.2
Rb	86.5	83.4	101.2	96	100.2
Sr	529.8	337.7	319.2	345.4	345.8
Zr	168.4	151.1	165	164.5	164.2
Y	17.3	13.9	16.1	16.5	16.5
Nb	10.6	9.5	10.5	10.2	10.7
Ga	19.6	16.7	19.8	19.5	18.7
Cu	40.5	19.3	24.8	30.5	30.4
Zn	55.2	45.2	36.9	34.6	30.7
Pb	26.3	70.5	24.3	25.6	36.4
La	39.4	32.1	37.7	36.1	34.4
Ce	76.8	63.7	69	67.3	67.3
Th	8.4	5.7	6.1	5.4	5.5
Nd	32.1	28.6	29.1	27.8	27.3
U	1.1	3.5	2.7	3.3	3.7
F	872	765	918	961	885
S	0.22	0.62	0.23	0.2	0.17
SO4	0.38	1.03	0.68	0.73	1.08
C	0.06	0.02	0.02	0.02	0.03
LOI	3.7	6.1	5.05	5.44	6.57
Geochemistry					
paste pH	4.88	4.14	4.04	4.14	3.91

Size Fraction(inch)	1	0.75	0.5	0.187	0.0787
paste conductivity	2.08	1.98	2.24	1.81	1.93
AP	6.88	19.38	7.19	6.25	5.31
NP	3.15	0.28	-2.64	-0.24	-0.03
NetNP	-3.73	-19.1	-9.83	-6.49	-5.34

DESCRIPTION OF SAMPLE QPS-SAN-0002

LOCATION

Sample QPS-SAN-0002 was collected from Questa pit scar in between 2 in-situ test pits. It is located on road west of tree (UTM 454146E, UTM 4062551N).

HAND SPECIMEN DESCRIPTION

Sample QPS-SAN-0002 is brown, well graded material and poorly sorted. It is angular to subangular. It has some plasticity and cemented with gypsum.

PETROGRAPHIC DESCRIPTION

Sample QPS-SAN-0002 is fine sand to gravel with subrounded subdiscoidal grain shape. It is 95% andesite and 5% intrusive and QSP and propyllitically altered. It has 83% rock fragments, trace amounts of carbonate, jarosite and chlorite, 4% gypsum (authigenic) and 13% Fe-oxide.

FIGURE 1-24. Sample QPS-SAN-0002 with andesite and intrusive rock fragments with iron coatings (field of view is 6mm).

LABORATORY ANALYSES

Below are laboratory results of sample QPS-SAN-0002. The results of the bulk sample and the size fractions are specified above each result.

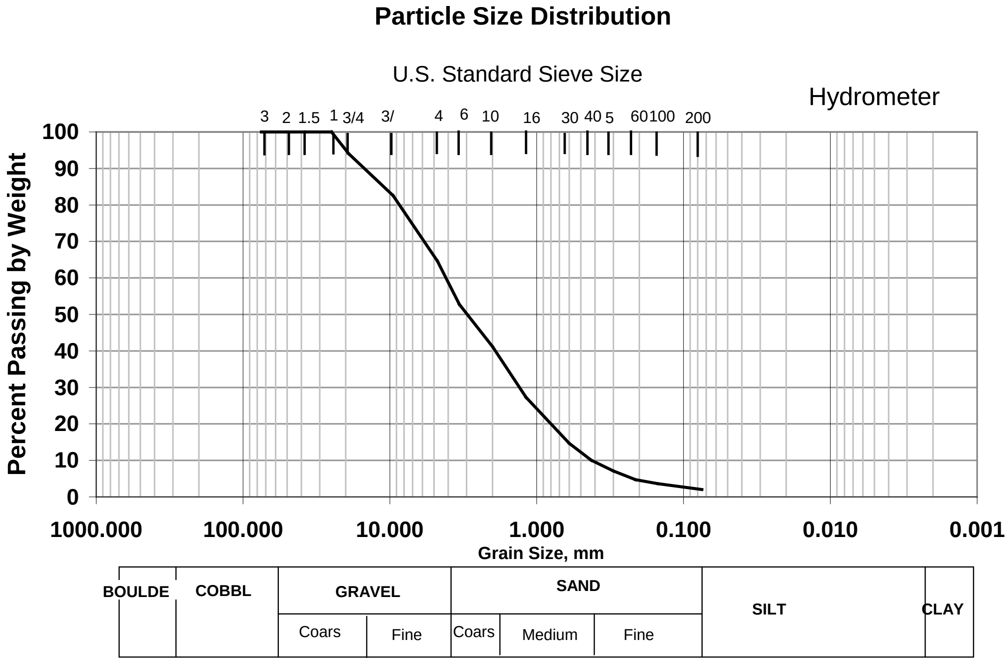


FIGURE 1-25. Particle size analysis plot of bulk sample QPS-SAN-0002

TABLE 1-21. Laboratory results of bulk sample QPS-SAN-0002

Chemistry		Geochemistry		Mineralogy	
SiO2	67.69	pastepH	2.84	quartz	42
TiO2	0.5	pasteCond	3.04	K-feldspar	3
Al2O3	13.66	pasteTDS	1.52	plagioclase	10
FeOT	3.06	WaterCont	10.56	epidote	0.01
MnO	0.02	NAGpH		calcite	0.3
MgO	0.93	NAGvalue		pyrite	0
CaO	0.68	AP	3.13	FeMnOxide	0.6
Na2O	1.24	NP	-0.52	Gypsum	0.8
K2O	3.71	netNP	-3.65	apatite	0.3
P2O5	0.17			TotalClay	38.9
Ni	7.8	**Geotechnical**		kaol	0.9
Cr	48.3	SlakeIndex	92.39	chlorite	3
Sc	7.8	FrictAngle	38.4	illite	32
V	68.9	ResidFA	36.9	smectite	3
Ba	724	Cohesion		Jarosite	4
Rb	109	QMWI		rutile	0.4

Chemistry		Geochemistry		Mineralogy	
Sr	285	PointLoad	2	zircon	0.04
Zr	200	DryDensity	2.02		
Y	28.5	SpecGrav	2.75		
Nb	19.4	LL	25.3		
Ga	22.8	PL	19.2		
Cu	33.7	PI	6.1		
Zn	33.7	MatriSuc	11		
Pb		% Gravel	35.4		
La		% Sand	62.6		
Ce	32.6	% Fines	2		
Th	11.1	D10	0.4		
Nd		D30	1.4		
U	5.1	D50	3.2		
F	1070	D60	4		
S	0				
SO4	0.97				
C	0.04				
LOI	5.13				

TABLE 1-22. Laboratory results of the size fractions of sample QPS-SAN-0002

Size Fraction(inch)	**0.75**	**0.5**	**0.187**	**0.0787**
Mineralogy				
quartz	44	44	42	41
K-feldspar	14	13	9	1
plagioclase	5	7	9	10
epidote	0.01	0.01	0.01	0.01
calcite	0.09	0.09	0.3	0.2
pyrite	0.09	0.6	0.3	0.09
FeMnOxide	2	1	1	2
Gypsum	0.8	0.8	0.8	1
apatite	0.3	0.3	0.3	0.4
TotalClay	30.9	31.9	33.9	39.9
kaol	0.9	0.9	0.9	0.9
chlorite	2	2	2	3
illite	25	26	28	33
smectite	3	3	3	3
jarosite	2	1	2	4
rutile	0.3	0.4	0.5	0.4

Size Fraction(inch)	0.75	0.5	0.187	0.0787
zircon	0.04	0.04	0.04	0.04
Chemistry				
SiO2	70.7	71.4	68.7	64.0
TiO2	0.4	0.4	0.5	0.5
Al2O3	12.6	13.1	13.5	13.4
FeOT	3.0	2.2	2.9	4.4
MnO	0.0	0.0	0.0	0.0
MgO	0.8	0.8	1.0	1.1
CaO	0.6	0.6	0.7	1.0
Na2O	1.0	1.2	1.3	1.2
K2O	3.8	3.5	3.6	3.6
P2O5	0.1	0.1	0.2	0.2
Ni	4.0	6.9	5.7	7.4
Cr	36.5	43.6	50.4	57.6
Sc	5.4	5.2	7.7	7.7
V	44	53	64	71
Ba	947.3	729.8	789.6	799.3
Rb	111.1	99.9	103.7	107.6
Sr	210.4	226.1	298.7	335
Zr	229.5	208.1	193.2	185.4
Y	44	38.4	31.2	29.4
Nb	27.7	23	19.3	18
Ga	21.5	20.8	20.6	21.9
Cu	31.5	26.6	30.2	37.5
Zn	30.7	31.1	36.5	42.2
Pb	47.3	24.2	33.1	50
La	65.6	55.8	52.3	41.9
Ce	107.6	104.8	92.7	76
Th	12.5	10.9	11	10.4
Nd	37.4	41.3	29	29.8
U	5.1	4.3	5	3.7
F				
S	0.08	0.31	0.15	0.05
SO4	0.48	0.39	0.63	1.17
C	0.02	0.02	0.05	0.04
LOI	4.69	4.34	5.48	7.42
Geochemistry				

Size Fraction(inch)	0.75	0.5	0.187	0.0787
paste pH	4.29	4.42	4.42	4.08
paste conductivity	1.64	2.15	1.82	2.04
AP	2.5	9.69	4.69	1.56
NP	1.92	3.98	2.52	2.37
NetNP	-0.58	-5.71	-2.17	0.81

DESCRIPTION OF SAMPLE SPR-SAN-0002

LOCATION

Sample SPR-SAN-0002 was collected from the top of the spring gulch rock pile (UTM 455255E, UTM 4062285N, zone 13). The material of this sample was screened to 1 inch size and from the same location as SPR-SAN-0001.

HAND SPECIMEN DESCRIPTION

Sample SPR-SAN-0002 is brown, well graded with poor sorting. It has some plasticity with no cementation.

PETROGRAPHIC DESCRIPTION

Sample SPR-SAN-0002 is an andesite with QSP and propyllitic alteration. It is angular to subangular with subdiscoidal sphericity. It has trace amount of pyrite, 1% gypsum, 15% Fe-oxide and 84% of rock fragments.

FIGURE 1-26. Sample SPR-SAN-0002 with QSP and propyllitic alteration on andesite rock fragments (field of view is 6mm).

LABORATORY ANALYSES

Below are laboratory results of sample SPR-SAN-0002. The results of the bulk sample and the size fractions are specified above each result.

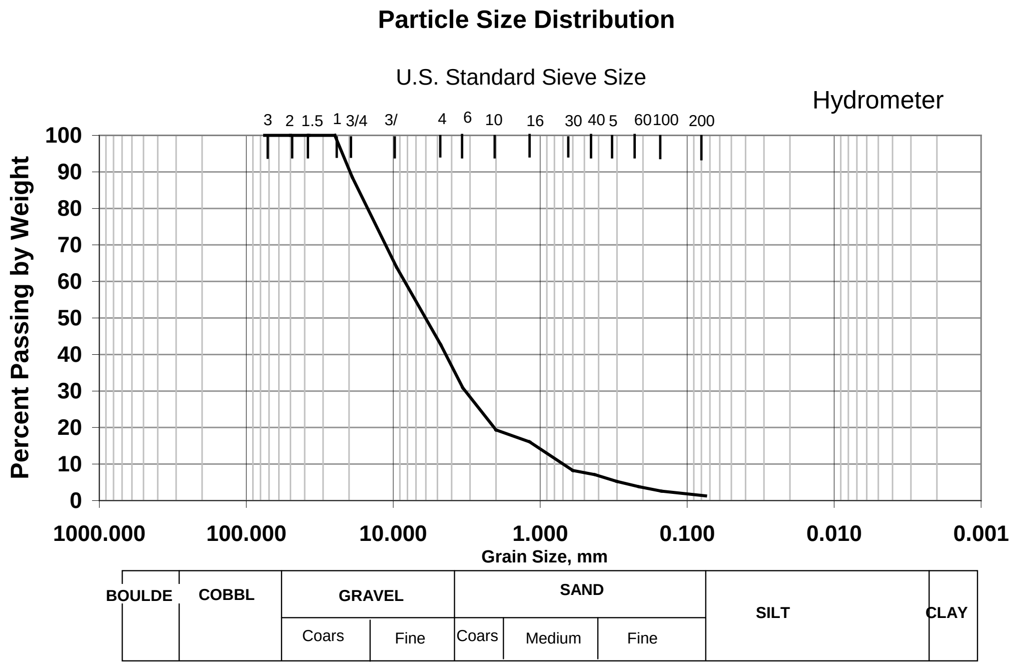


FIGURE 1-27. Particle size analysis plot of sample SPR-SAN-0002

TABLE 1-23. Laboratory results of bulk sample SPR-SAN-0002

Chemistry		**Geochemistry**		**Mineralogy**	
SiO2	59.75	pastepH	4.26	quartz	25
TiO2	0.73	pasteCond	3.4	K-feldspar	21
Al2O3	14.39	pasteTDS	1.71	Plagioclase	18
FeOT	5.36	WaterCont	5.49	epidote	2
MnO	0.11	AP	18.75	calcite	0.4
MgO	2.96	NP	18.96	pyrite	0.3
CaO	2.31	netNP	0.21	FeMnOxide	4
Na2O	2.79			Gypsum	2
K2O	3.5	**Geotechnical**		apatite	0.9
P2O5	0.38	SlakeIndex	97.96	TotalClay	25.9
Ni	62.8	FrictAngle	38.1	kaol	0.9
Cr	105.6	ResidFA	34.2	chlorite	8
Sc	13.8	PointLoad	2.3	illite	14
V	122	DryDensity	2.19	smectite	3
Ba	1075.1	LL	27.6	jarosite	0

Chemistry		Geochemistry		Mineralogy	
Rb	112.6	PL	21	rutile	0.5
Sr	725.2	PI	6.6	zircon	0.03
Zr	166.5	MatriSuc	13		
Y	20.5	% Gravel	52.54		
Nb	10.9	% Sand	42.04		
Ga	18.7	% Fines	5.42		
Cu	138.7	D10	0.7		
Zn	47.9	D30	3.2		
Pb	20.7	D50	7.4		
La	46.6	D60	8.1		
Ce	89.3				
Th	8				
Nd	37.5				
U	3				
S	0.18				
SO4	0.46				
C	0.05				
LOI	4.22				

TABLE 1-24. Laboratory results of the size fractions of sample SPR-SAN-0002

Size Fraction(inch)	**0.750**	**0.500**	**0.187**	**0.0787**
Mineralogy				
quartz	24	23	25	25
K-feldspar	21	23	24	20
Plagioclase	20	21	19	18
epidote	7	5	5	0.8
calcite	0.6	0.2	0.5	1
pyrite	2	1	0.8	0.4
FeMnOxide	0.6	2	2	4
Gypsum	0.4	0.5	0.9	2
apatite	0.7	0.8	0.8	0.8
TotalClay	22.9	22.9	21.9	26.9
kaol	0.9	0.9	0.9	0.9
chlorite	8	8	8	8
illite	11	11	10	15
smectite	3	3	3	3
jarosite	0	0	0	0
rutile	0.7	0.6	0.7	0.5

Size Fraction(inch)	0.750	0.500	0.187	0.0787
zircon	0.03	0.03	0.03	0.03
Chemistry				
SiO2	60.6	60.9	61.6	59.3
TiO2	0.8	0.8	0.7	0.7
Al2O3	15.1	15.2	14.4	14.3
FeOT	5.2	5.3	4.8	5.3
MnO	0.1	0.1	0.1	0.1
MgO	3.2	3.0	2.9	3.1
CaO	2.4	2.0	2.2	2.5
Na2O	3.1	3.3	3.0	2.8
K2O	3.3	3.5	3.6	3.4
P2O5	0.3	0.4	0.3	0.3
Ni	57.91	64.08	54.93	61.62
Cr	121.4	106	98.9	106.1
Sc	13.3	13.4	12	12.7
V	123	115	107	110
Ba	1205.5	1149.6	1182.2	1084.3
Rb	118.8	112.9	113.4	112.6
Sr	897.7	675.5	665.4	745.9
Zr	175.7	180.8	172.2	165.9
Y	19.9	19.5	19.5	19.4
Nb	10.5	12	11.5	10.4
Ga	18.5	19.2	17.8	18.2
Cu	132.1	146.9	123	150
Zn	42.4	49.2	61.6	63.6
Pb	7.5	19.8	24.1	30.4
La	43.4	41.7	43.7	50.2
Ce	82.6	84.3	86.6	92.3
Th	8.5	9.4	8.8	8.6
Nd	36	36	38	38.9
U	3.6	2.1	2.7	4.1
S	1.28	0.79	0.49	0.23
SO4	0.08	0.1	0.19	0.51
C	0.07	0.03	0.06	0.15
LOI	3.93	3.31	3.9	5.7
Geochemistry				
pH	7.21	7.19	6.64	5.58

Size Fraction(inch)	0.750	0.500	0.187	0.0787
P.conductivity	2.35	2.76	2.87	2.91
AP	40	24.69	15.31	7.19
NP	23	22.16	20.24	18.17
NetNP	-17	-2.53	4.93	10.98

DESCRIPTION OF SAMPLE SPR-SAN-0002

LOCATION
Sample SPR-SAN-0002 was collected from the top of the Spring Gulch rock pile at UTM coordinates 13N4062285, 455255E.

FIGURE 1-28. Photograph of sampling location for SPR-SAN-0002. Tennis ball, at right, is for scale.

HAND SPECIMEN DESCRIPTION
In hand sample the sample is brown in color, and after washing the hand sample is dark brown in color. The sample's lithology is 100% andesite and clay. The particle size for the rock fragments ranges from cobble to clay, the fragments are angular to sub-angular and there appears to be minor oxide staining on the outside of some fragments. The clays associated with this sample do not cement the rock fragments together, although smaller rock fragments are cemented to larger fragments in some instances. At the sampling location the sample well graded with poor sorting.

FIGURE 1-29. Photograph of washed rock fragments from hand sample. Field of view is 3 inches across.

PETROGRAPHIC DESCRIPTION

In thin section the sample is brown to grey in color, has silt- to gravel- sized particles that are sub-angular and sub-discoidal in shape. The lithology is 100% andesite with 35% QSP and 7% propyllitic alteration. The rock is composed of ~80% rock fragments, ~15% iron oxides, ~4% clays, ~1% gypsum, with trace amounts of pyrite and epidote. Epidote is seen in trace amounts on rock surfaces, chlorite is described as soapy green grains, and 98% of the gypsum crystals are clear and authigenic. The primary cement in this sample is Fe-oxides with minor amounts of clay and jarosite. Pyrite crystals have numerous small inclusions of apatite and quartz, and many pyrite crystals display eroded and scalloped grain edges, oxidized rims, and goethite replacement.

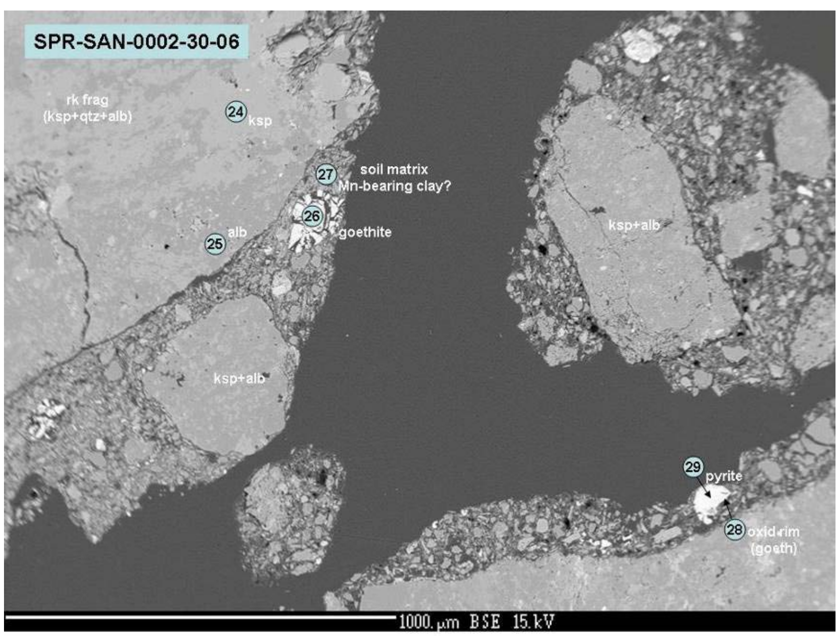


FIGURE 1-30. Overview image of rock fragments with soil matrix adhering to the larger rock fragments.

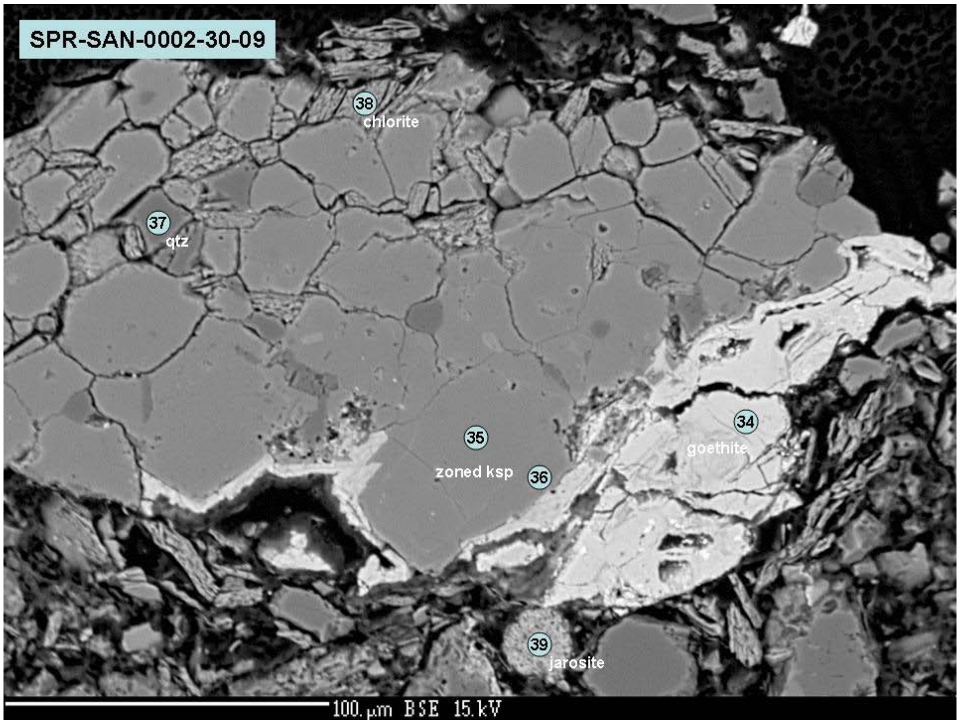


FIGURE 1-31. A close-up image of a rock fragment with an Fe-oxide (goethite) coating. A small rounded jarosite grain can be seen in the matrix. The jarosite and Fe-oxides are the brighter hues.

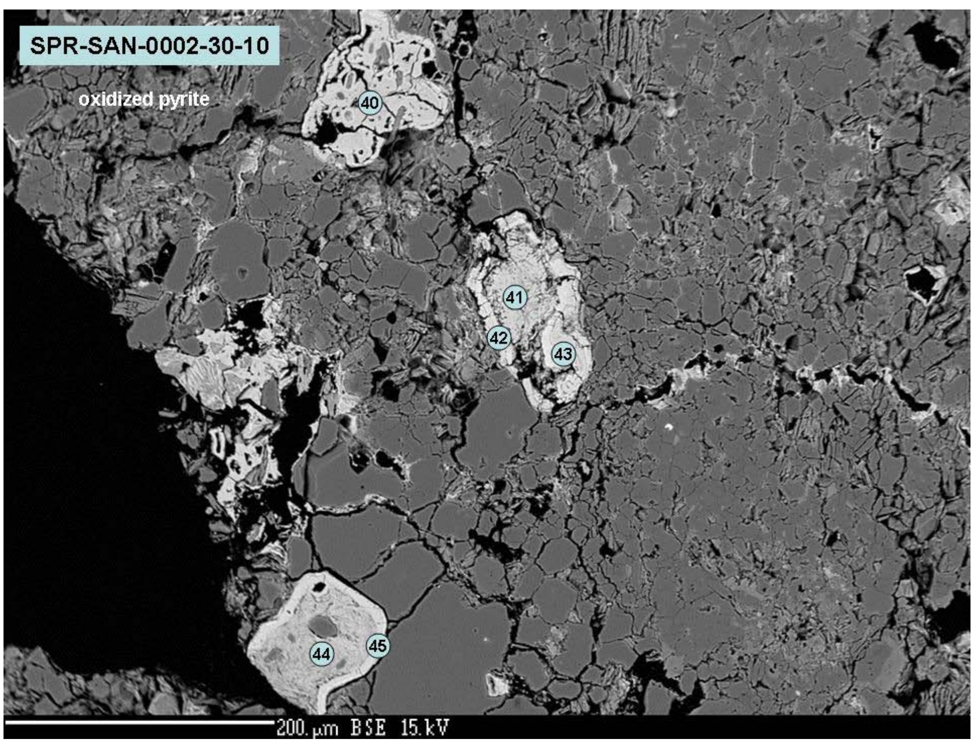


FIGURE 1-32. A close-up image displaying relict pyrite crystals (completely oxidized) that are being replaced by jarosite and Fe-oxides.

LABORATORY ANALYSES

TABLE 25. Various laboratory analyses for sample SPR-SAN-0002.

pastepH	4.22
pasteCond	3.98
pasteRedox	-
pasteTDS	1.71
NAGpH	-
NAGvalue	-
AP	5.63
NP	18.96
netNP	-13.33
NPAP	13.33
QMWI	7
SWI	2

TABLE 26. Chemical and mineralogical analysis for sample SPR-SAN-0002.

Chemistry	Wt. % SPR-SAN-0002	Mineralogy	% SPR-SAN-0002
SiO2	59.74	Quartz	25
TiO2	0.73	K-spar/orthoclase	21
Al2O3	14.39	Plagioclase	18
Fe2O3T	5.9	Albite	-
FeOT	5.36	Anorthite	-
FeO	3.27	Biotite	-
Fe2O3	2.3	Clay	-
MnO	0.11	Illite	14
MgO	2.96	Chlorite	8
CaO	2.31	Smectite	3
Na2O	2.79	kaolinite	0.9
K2O	3.5	mixed layered	-
P2O5	0.38	Epidote	2
S	0.18	Magnetite	-
SO4	0.46	Fe oxides	4
C	0.05	Goethite	-
LOI	4.22	Hematite	-
Total	97.72	Rutile	0.5
Trace elements		Apatite	0.9
Ba	1075	Pyrite	0.3
Rb	112.6	Calcite	0.4
Sr	725.2	Gypsum	2
Pb	20.7	detrit gypsum	-
Th	8	auth gypsum	-
U	3	Zircon	0.03

Chemistry	Wt. % SPR-SAN-0002	Mineralogy	% SPR-SAN-0002
Zr	166.5	Sphalerite	-
Nb	10.9	Molybdenite	-
Y	20.5	Fluorite	0.5
Sc	13.8	Jarosite	-
V	122	Copiapite	-
Ni	62.8	Chalcopyrite	-
Cu	138.7		
Zn	47.9		
Ga	18.7		
Cr	105.6		
F	2498		
REE			
La	46.6		
Ce	89.3		
Nd	37.5		
Sm	-		
Eu	-		
Gd	-		
Yb	-		
Lu	-		

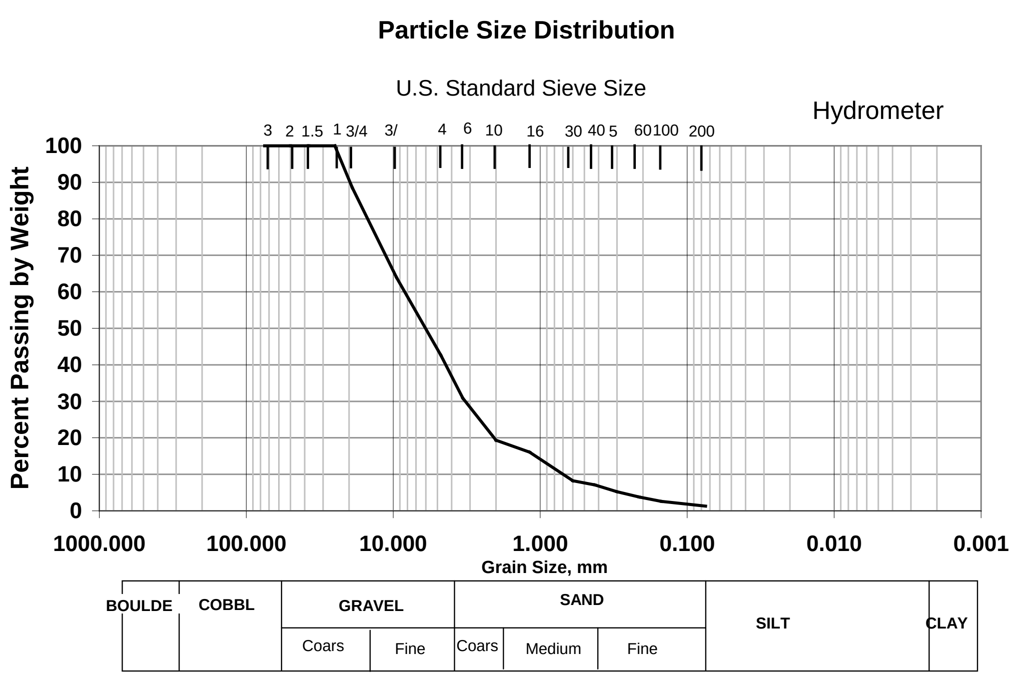


FIGURE 1-33. Particle size analysis plot of sample SPR-SAN-0002

APPENDIX 2

This appendix contains table of results and plots of chemistry and mineralogy of whole rock samples and their size fractions

TABLE 2-1. Summary of paste pH and paste conductivity results of different particle size fractions.

Sample	Size Fraction (inches)	Paste pH	Paste Conductivity(mS/cm)
GHN-JRM-0001	1.000	4.04	1.86
	0.750	3.93	2.25
	0.500	3.89	2.19
	0.187	3.47	1.89
	0.079	3.42	3.21
	<0.0787	2.43	4.8
GHN-JRM-0002	1.000	5.52	1.37
	0.750	4.17	1.88
	0.500	4.36	0.7
	0.187	4.16	1.23
	0.079	3.86	2.28
	<0.0787	2.57	3.3
GHN-KMD-0088	1.000	6.2	2.55
	0.750	4.58	2.47
	0.500	4.64	2.7
	0.187	4.46	2.68
	0.079	4.15	1.72
	<0.0787	2.83	4.32
MIN-AAF-0001	1.000	6.05	0.19
	0.750	6.37	0.25
	0.500	6.4	0.2
	0.187	6.21	0.29
	0.079	6.48	0.22
MIN-AAF-0004	1.000	6.04	0.17
	0.750	6.19	0.3
	0.500	6.26	0.19
	0.187	6.04	0.19
	0.079	6.05	0.19
MIN-SAN-0002	1.000	3.53	0.16
	0.750	3.44	0.24

Sample	Size Fraction (inches)	Paste pH	Paste Conductivity(mS/cm)
	0.500	3.27	0.24
	0.187	3.43	0.23
	0.079		
QPS-AAF-0001	1.000	4.29	0.92
	0.750	4.41	1.81
	0.500	4.03	1.68
	0.187	3.95	1.68
	0.079	4.42	1.85
QPS-AAF-0003	1.000	4.87	2
	0.750	4.11	2.02
	0.500	3.85	1.76
	0.187	3.69	1.6
	0.079	4.23	1.84
QPS-AAF-0005	1.000	4.02	1.31
	0.750	4.18	1.7
	0.500	3.73	2.28
	0.187	3.55	1.61
	0.079	4.73	2.22
QPS-AAF-0009	1.000	4.88	2.08
	0.750	4.14	1.98
	0.500	4.04	2.24
	0.187	4.14	1.81
	0.079	3.91	1.93
QPS-SAN-0002	1.000		
	0.750	4.29	
	0.500	4.42	
	0.187	4.42	
	0.079	4.08	
SPR-SAN-0002	1.000		
	0.750	7.21	
	0.500	7.19	
	0.187	6.64	
	0.079	5.58	

TABLE 2-2. Summary of ABA results of different particle size fractions.

Sample	AP (Kg CaCO3/ton)				
	1.0-0.75 inch	0.75-0.5 inch	0.5-0.187 inch	0.187-0.0787 inch	0.0787inch
GHN-JRM-0001	97.81	75.94	68.44	62.50	60.31
GHN-JRM-0002	0	2.81	2.50	2.19	0.63
GHN-KMD-0088	26.25	22.19	25.94	16.25	10.63
MIN-AAF-0001	1.25	2.19	0.63	0.63	0.31
MIN-AAF-0004	0.63	1.56	0.63	1.25	1.25
MIN-SAN-0002	na	1.25	1.25	0.94	0
QPS-AAF-0001	9.69	5.31	3.75	3.13	1.25

QPS-AAF-0003	33.44	5.31	6.88	10	9.38
QPS-AAF-0005	7.81	3.75	2.81	1.88	1.88
QPS-AAF-0009	6.88	19.38	7.19	6.25	5.31
QPS-SAN-0002	na	2.50	9.69	4.69	1.56
SPR-SAN-0002	na	40	24.69	15.31	7.19
	NP (Kg CaCO3/ton)				
	1.0-0.75 inch	0.75-0.5 inch	0.5-0.187 inch	0.187-0.0787 inch	0.0787inch
GHN-JRM-0001	-1.95	-0.99	0.74	-4.58	-5.27
GHN-JRM-0002	15.01	3.27	4.75	3.07	0.72
GHN-KMD-0088	11.91	2.47	2.45	3.19	-0.69
MIN-AAF-0001	4.61	3.89	1.46	8.26	0.98
MIN-AAF-0004	0.29	1.03	2.64	15.89	0.84
MIN-SAN-0002	na	2.77	4.23	0.55	1.79
QPS-AAF-0001	1.35	-4.19	10.45	1.16	-2.85
QPS-AAF-0003	21.64	25.42	3.44	4.49	-5.53
QPS-AAF-0005	2.85	-0.08	-0.18	-1.03	0.73
QPS-AAF-0009	3.15	0.28	-2.64	-0.24	-0.03
QPS-SAN-0002	na	1.92	3.98	2.52	2.37
SPR-SAN-0002	na	23	22.16	20.24	18.17

na – size fraction not collected

TABLE 2-3. Chemical composition of samples and different particle size fractions. Major element oxides, S, SO4, and LOI are in weight percent. Trace elements are in parts per million. Total iron is calculated as FeOT.

Sample	Size Fraction (inch)	SiO_2	TiO_2	Al_2O_3	FeOT	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
GHN-JRM-0001	whole rock	61.6	0.53	13.65	4.760	0.08	1.28	0.98	1.87	3.91	0.19
GHN-JRM-0001-56	1.000	66.2	0.54	14.33	4.425	0.07	0.99	0.41	2.03	4.18	0.20
GHN-JRM-0001-57	0.750	65.9	0.50	14.12	4.514	0.07	1.19	0.43	3.01	3.58	0.21
GHN-JRM-0001-58	0.500	67.1	0.48	13.67	4.258	0.08	1.19	0.47	2.31	3.98	0.18
GHN-JRM-0001-61	0.187	65.5	0.50	13.79	4.201	0.07	1.15	0.55	1.92	4.24	0.14
GHN-JRM-0001-62	0.079	63.6	0.53	13.82	4.331	0.08	1.21	0.82	1.84	4.06	0.16
GHN-JRM-0002	whole rock	61.0	0.84	14.36	6.896	0.36	2.57	1.72	2.82	3.33	0.40
GHN-JRM-0002-56	1.000	62.8	0.78	14.61	4.963	0.22	2.46	1.89	3.85	3.40	0.35
GHN-JRM-0002-57	0.750	61.9	0.83	14.33	5.137	0.21	2.53	1.53	2.88	3.88	0.33
GHN-JRM-0002-58	0.500	62.0	0.85	14.29	5.743	0.26	2.52	1.37	3.23	3.43	0.35
GHN-JRM-0002-61	0.187	61.8	0.84	14.09	5.869	0.29	2.46	1.32	2.98	3.54	0.33
GHN-JRM-0002-62	0.079	60.1	0.83	13.76	6.698	0.35	2.38	1.39	2.74	3.43	0.35
GHN-KMD-0088	whole rock	64.4	0.49	14.19	3.810	0.16	1.51	1.13	2.92	3.80	0.21
GHN-KMD-0088-56	1.000	68.6	0.35	13.34	2.763	0.11	1.08	1.03	2.83	4.33	0.14
GHN-KMD-0088-57	0.750	66.4	0.46	14.19	3.599	0.16	1.47	0.98	3.25	4.10	0.19
GHN-KMD-0088-58	0.500	65.9	0.47	14.08	3.551	0.30	1.38	0.86	2.94	3.91	0.20

Sample	Size Fraction (inch)	SiO_2	TiO_2	Al_2O_3	FeOT	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
GHN-KMD-0088-61	0.187	65.6	0.49	14.14	3.709	0.17	1.58	1.05	2.82	3.89	0.21
GHN-KMD-0088-62	0.079	65.5	0.48	13.99	3.593	0.18	1.58	0.95	2.63	3.90	0.21
MIN-AAF-0001	whole rock	73.3	0.39	12.82	2.740	0.02	0.66	0.10	0.39	4.29	0.11
MIN-AAF-0001-56	1.000	71.7	0.44	13.30	2.054	0.03	0.85	0.16	1.29	5.76	0.15
MIN-AAF-0001-57	0.750	73.7	0.32	13.02	2.233	0.01	0.54	0.09	1.01	4.29	0.08
MIN-AAF-0001-58	0.500	73.4	0.42	13.40	2.133	0.02	0.71	0.21	0.63	4.39	0.09
MIN-AAF-0001-61	0.187	74.8	0.41	12.60	1.856	0.03	0.67	0.08	0.48	4.25	0.09
MIN-AAF-0001-62	0.079	73.8	0.38	12.67	2.353	0.02	0.61	0.10	0.45	4.28	0.10
MIN-AAF-0004	whole rock	71.9	0.38	13.14	2.900	0.02	0.62	0.09	0.45	4.39	0.12
MIN-AAF-0004-56	1.000	72.2	0.44	13.43	2.507	0.03	0.76	0.76	1.67	4.04	0.13
MIN-AAF-0004-57	0.750	71.1	0.56	13.57	2.696	0.03	0.79	0.34	1.14	4.39	0.15
MIN-AAF-0004-58	0.500	76.1	0.31	12.64	1.397	0.02	0.53	0.05	0.25	4.53	0.06
MIN-AAF-0004-61	0.187	74.2	0.41	12.74	2.017	0.02	0.68	0.08	0.43	4.27	0.08
MIN-AAF-0004-62	0.079	73.5	0.39	12.60	2.421	0.02	0.63	0.09	0.43	4.22	0.10
MIN-SAN-0002	whole rock	71.1	0.45	12.74	2.690	0.02	0.64	0.10	0.69	4.23	0.12
MIN-SAN-0002-57	0.750	72.6	0.46	13.12	2.092	0.03	0.70	0.13	0.83	4.50	0.11
MIN-SAN-0002-58	0.500	73.3	0.41	13.19	1.845	0.03	0.63	0.06	0.53	4.64	0.07
MIN-SAN-0002-61	0.187	73.3	0.38	12.65	1.903	0.02	0.62	0.09	0.51	4.18	0.08
MIN-SAN-0002-62	0.079	71.7	0.37	12.52	2.591	0.02	0.63	0.09	0.42	4.10	0.11
QPS-AAF-0001	whole rock	66.2	0.60	14.16	3.530	0.05	1.23	0.89	1.85	3.61	0.20
QPS-AAF-0001-56	1.000	69.4	0.63	14.72	2.924	0.03	1.00	0.44	2.00	3.18	0.36
QPS-AAF-0001-57	0.750	66.9	0.56	14.31	3.667	0.03	1.11	0.75	1.95	3.48	0.22
QPS-AAF-0001-58	0.500	66.5	0.56	14.02	3.716	0.03	1.18	0.89	1.37	3.62	0.21
QPS-AAF-0001-61	0.187	67.1	0.63	14.22	3.474	0.03	1.23	0.71	1.54	3.61	0.21
QPS-AAF-0001-62	0.079	66.0	0.63	14.31	3.786	0.04	1.27	0.87	1.45	3.68	0.21
QPS-AAF-0003	whole rock	63.1	0.59	14.53	4.360	0.05	1.57	1.25	1.88	3.71	0.24
QPS-AAF-0003-56	1.000	66.6	0.60	12.92	3.761	0.12	2.10	1.82	1.99	2.97	0.25
QPS-AAF-0003-57	0.750	64.8	0.56	14.28	4.137	0.06	1.49	1.32	2.69	3.62	0.24
QPS-AAF-0003-58	0.500	64.8	0.62	14.29	4.045	0.06	1.70	1.07	2.64	3.38	0.25
QPS-AAF-0003-61	0.187	64.8	0.59	14.18	4.011	0.05	1.53	1.12	2.22	3.61	0.22
QPS-AAF-0003-62	0.079	63.8	0.60	14.11	4.112	0.05	1.60	1.21	2.04	3.58	0.23
QPS-AAF-0005	whole rock	61.9	0.60	14.31	4.400	0.05	1.54	1.44	1.82	3.65	0.23
QPS-AAF-0005-56	1.000	65.4	0.57	15.18	4.021	0.05	1.05	0.58	4.26	3.56	0.22
QPS-AAF-0005-57	0.750	66.6	0.60	14.63	3.507	0.05	1.31	0.49	3.45	4.07	0.19
QPS-AAF-0005-58	0.500	64.0	0.61	14.37	3.963	0.05	1.53	1.15	2.54	3.96	0.22
QPS-AAF-0005-61	0.187	64.7	0.59	14.48	3.924	0.06	1.55	0.81	2.50	3.85	0.21
QPS-AAF-0005-62	0.079	64.1	0.60	14.48	3.998	0.06	1.71	0.96	2.20	3.71	0.22
QPS-AAF-0009		64	0.692	14.47	3.94	0.03	1.02	1.61	1.21	3.65	0.263
QPS-AAF-0009-56	1.000	63.0	0.71	15.75	4.306	0.07	2.01	2.32	2.23	3.72	0.31
QPS-AAF-0009-57	0.750	62.9	0.66	14.02	4.536	0.05	1.44	2.79	1.78	3.18	0.25
QPS-AAF-0009-58	0.500	64.1	0.72	15.05	3.989	0.05	1.37	1.71	1.39	3.91	0.26
QPS-AAF-0009-61	0.187	65.2	0.69	14.46	3.792	0.04	1.27	1.43	1.40	3.66	0.22
QPS-AAF-0009-62	0.079	63.7	0.69	14.35	4.074	0.03	1.13	1.68	1.12	3.69	0.23
QPS-SAN-0002	whole rock	67.7	0.50	13.66	3.060	0.02	0.93	0.68	1.24	3.71	0.17

Sample	Size Fraction (inch)	SiO_2	TiO_2	Al_2O_3	FeOT	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
QPS-SAN-0002-57	0.750	70.7	0.37	12.61	3.002	0.02	0.85	0.63	1.00	3.78	0.15
QPS-SAN-0002-58	0.500	71.4	0.44	13.12	2.216	0.02	0.82	0.63	1.21	3.53	0.15
QPS-SAN-0002-61	0.187	68.7	0.49	13.48	2.926	0.03	0.96	0.73	1.34	3.63	0.17
QPS-SAN-0002-62	0.079	64.0	0.51	13.42	4.371	0.03	1.08	1.04	1.15	3.61	0.23
SPR-SAN-0002		59.8	0.73	14.39	5.36	0.11	2.96	2.31	2.79	3.5	0.38
SPR-SAN-0002-57	0.750	60.6	0.78	15.06	5.165	0.10	3.16	2.40	3.08	3.30	0.32
SPR-SAN-0002-58	0.500	60.9	0.75	15.18	5.309	0.09	3.00	1.98	3.25	3.53	0.36
SPR-SAN-0002-61	0.187	61.6	0.73	14.43	4.826	0.09	2.89	2.19	3.04	3.62	0.34
SPR-SAN-0002-62	0.079	59.3	0.72	14.30	5.261	0.13	3.07	2.48	2.78	3.40	0.34

Sample	S	SO_4	C	LOI	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y
GHN-JRM-0001	2.01	1.12	0.07	8.81	30	57	9	74	832	134	136	163	25
GHN-JRM-0001-56	3.13	0.25	0.02	5.2	23	55	10	89	773	147	85	139	23
GHN-JRM-0001-57	2.43	0.34	0.02	5.09	13	46	8	73	795	120	146	147	24
GHN-JRM-0001-58	2.19	0.27	0.01	4.87	24	47	7	58	801	126	155	165	27
GHN-JRM-0001-61	2	0.57	0.02	6.55	20	50	8	65	860	138	138	171	27
GHN-JRM-0001-62	1.93	0.82	0.03	7.71	16	53	8	73	836	133	139	164	27
GHN-JRM-0002	0.14	0.34	0.06	4.66	49	87	11	106	1223	93	512	173	19
GHN-JRM-0002-56	0	0.13	0.03	2.96	48	81	8	98	1333	72	609	180	15
GHN-JRM-0002-57	0.09	0.22	0.02	4.04	40	81	9	100	1554	100	502	170	13
GHN-JRM-0002-58	0.08	0.11	0.02	3.9	40	85	9	96	1357	83	511	180	14
GHN-JRM-0002-61	0.07	0.16	0.01	4.25	40	83	9	100	1322	89	490	182	14
GHN-JRM-0002-62	0.02	0.38	0.02	5.53	41	83	10	99	1287	89	461	170	16
GHN-KMD-0088	0.41	0.04	5.14	5.14	31	47	6	60	1216	102	374	176	26
GHN-KMD-0088-56	0.84	0.32	0.06	3.87	13	30	5	41	776	124	293	229	43
GHN-KMD-0088-57	0.71	0.24	0.02	3.8	17	40	7	56	1049	101	365	202	32
GHN-KMD-0088-58	0.83	0.29	0.07	4.46	18	43	6	52	987	112	335	180	62
GHN-KMD-0088-61	0.52	0.37	0.02	4.58	19	47	7	61	1070	109	341	187	27
GHN-KMD-0088-62	0.34	0.36	0.02	4.69	20	44	7	61	1076	109	324	182	30
MIN-AAF-0001	0	0.38	0.23	4.27	0	24	4	46	591	149	92	229	36
MIN-AAF-0001-56	0.04	0.14	0.1	2.55	7	34	7	59	1034	160	135	259	42
MIN-AAF-0001-57	0.07	0.22	0.17	3.12	5	28	4	39	609	130	65	276	48
MIN-AAF-0001-58	0.02	0.21	0.1	3.25	7	27	5	48	544	146	98	231	35
MIN-AAF-0001-61	0.02	0.21	0.11	3.42	4	28	5	47	494	144	68	248	42
MIN-AAF-0001-62	0.01	0.33	0.16	3.95	5	25	4	40	579	141	93	241	38
MIN-AAF-0004	0.01	0.43	0.26	4.71	0	25	3	47	658	150	102	240	37
MIN-AAF-0004-56	0.02	0.09	0.1	2.92	5	17	6	53	720	122	223	238	33
MIN-AAF-0004-57	0.05	0.19	0.16	3.65	8	37	7	65	953	142	190	208	27
MIN-AAF-0004-58	0.02	0.14	0.1	3.15	3	17	3	32	510	148	48	267	47
MIN-AAF-0004-61	0.04	0.2	0.11	3.45	4	25	5	43	568	141	80	244	36
MIN-AAF-0004-62	0.04	0.32	0.13	4.11	5	24	5	43	626	139	105	237	38
MIN-SAN-0002	0	0.54	0.3	4.68	3	31	5	57	703	138	116	229	35
MIN-SAN-0002-57	0.04	0.17	0.1	3.59	0	34	6	52	890	143	105	241	34
MIN-SAN-0002-58	0.04	0.2	0.07	3.33	0	28	5	50	728	153	70	227	35
MIN-SAN-0002-61	0.03	0.23	0.09	3.74	0	25	5	42	577	133	114	240	40
MIN-SAN-0002-62	0	0.39	0.15	4.71	0	27	5	44	649	134	113	224	39
QPS-AAF-0001	0.11	0.55	0.09	5.27	11	66	9	83	1017	99	326	176	23
QPS-AAF-0001-56	0.31	0.18	0.04	3.77	15	63	10	86	1058	84	424	178	22
QPS-AAF-0001-57	0.17	0.57	0.05	4.8	19	64	9	76	877	94	349	184	31
QPS-AAF-0001-58	0.12	0.74	0.04	5.84	16	62	10	84	883	102	275	179	24

Sample	S	SO_4	C	LOI	Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y
QPS-AAF-0001-61	0.1	0.61	0.05	5.43	17	70	10	86	954	103	312	175	21
QPS-AAF-0001-62	0.04	0.72	0.06	5.81	18	71	10	88	927	104	309	177	21
QPS-AAF-0003	0.06	0.91	0.03	6.74	20	63	9	88	1416	117	362	168	20
QPS-AAF-0003-56	1.07	0.43	0.16	5.06	42	69	11	84	930	92	311	151	24
QPS-AAF-0003-57	0.17	0.54	0.06	4.81	30	57	9	76	1100	110	734	167	21
QPS-AAF-0003-58	0.22	0.61	0.06	5.32	31	70	9	82	1227	102	384	164	21
QPS-AAF-0003-61	0.32	0.59	0.04	4.95	30	66	9	80	1070	106	379	165	20
QPS-AAF-0003-62	0.3	0.76	0.04	6.05	30	67	9	82	1094	107	377	163	20
QPS-AAF-0005	0.02	1.17	0.03	8.03	17	61	10	86	1086	116	371	169	18
QPS-AAF-0005-56	0.25	0.22	0.03	3.2	23	52	8	72	1156	99	571	175	18
QPS-AAF-0005-57	0.12	0.26	0.02	3.47	24	59	9	83	1396	118	461	173	14
QPS-AAF-0005-58	0.09	0.64	0.02	5.47	23	64	9	83	1188	120	385	171	17
QPS-AAF-0005-61	0.06	0.59	0.03	5.37	24	62	9	82	1171	115	384	172	18
QPS-AAF-0005-62	0.06	0.71	0.05	6.52	24	64	10	88	1186	112	370	170	19
QPS-AAF-0009	0.18	1.18	0.03	6.93	11	68	10	97	933	103	380	170	18
QPS-AAF-0009-56	0.22	0.38	0.06	3.7	33	81	12	101	1264	87	530	168	17
QPS-AAF-0009-57	0.62	1.03	0.02	6.1	24	70	10	93	1028	83	338	151	14
QPS-AAF-0009-58	0.23	0.68	0.02	5.05	20	73	11	107	1015	101	319	165	16
QPS-AAF-0009-61	0.2	0.73	0.02	5.44	17	66	11	96	1024	96	345	165	17
QPS-AAF-0009-62	0.17	1.08	0.03	6.57	15	69	11	102	1014	100	346	164	17
QPS-SAN-0002	0	0.97	0.04	5.13	8	48	8	69	724	109	285	200	29
QPS-SAN-0002-57	0.08	0.48	0.02	4.69	4	37	5	44	947	111	210	230	44
QPS-SAN-0002-58	0.31	0.39	0.02	4.34	7	44	5	53	730	100	226	208	38
QPS-SAN-0002-61	0.15	0.63	0.05	5.48	6	50	8	64	790	104	299	193	31
QPS-SAN-0002-62	0.05	1.17	0.04	7.42	7	58	8	71	799	108	335	185	29
SPR-SAN-0002	0.18	0.46	0.05	4.22	62.8	106	13.8	122	1075	112.6	725	166.5	20.5
SPR-SAN-0002-57	1.28	0.08	0.07	3.93	58	121	13	123	1206	119	898	176	20
SPR-SAN-0002-58	0.79	0.1	0.03	3.31	64	106	13	115	1150	113	676	181	20
SPR-SAN-0002-61	0.49	0.19	0.06	3.9	55	99	12	107	1182	113	665	172	20
SPR-SAN-0002-62	0.23	0.51	0.15	5.7	62	106	13	110	1084	113	746	166	19

Sample	Nb	Ga	Cu	Zn	Pb	La	Ce	Th	Nd	U	F
GHN-JRM-0001	16	21	172	92	153	49	96	11	40.3	5	1646
GHN-JRM-0001-56	16	19	78	52	62	36	75	9	30.5	3.7	
GHN-JRM-0001-57	16	19	73	138	48	34	65	9	28.2	3.7	
GHN-JRM-0001-58	17	20	124	86	57	34	72	10	29.7	4.6	
GHN-JRM-0001-61	17	21	139	86	61	43	90	10	37.4	3.7	
GHN-JRM-0001-62	16	20	165	113	84	46	92	10	38.6	4.8	
GHN-JRM-0002	12	21	88	295	131	45	102	7	46	1.1	1047
GHN-JRM-0002-56	13	17	28	244	35	35	83	7	36.1	2.6	
GHN-JRM-0002-57	12	19	51	221	37	36	82	8	37.7	3.1	
GHN-JRM-0002-58	12	18	51	240	56	30	69	7	32.9	3.5	
GHN-JRM-0002-61	13	18	61	266	84	36	79	7	37.3	1.9	
GHN-JRM-0002-62	12	19	94	301	137	39	92	8	38.2	2.8	
GHN-KMD-0088	13	20	40	221	60	41	102	7	53.8	4	1015
GHN-KMD-0088-56	21	19	37	127	41	51	125	12	61.1	4.2	
GHN-KMD-0088-57	17	18	35	252	95	46	100	11	48.8	4.9	
GHN-KMD-0088-58	16	20	28	359	47	83	193	11	102	4.5	
GHN-KMD-0088-61	16	19	34	214	60	43	106	10	51.6	4.2	
GHN-KMD-0088-62	16	20	32	223	167	49	121	10	59.1	4.4	
MIN-AAF-0001	25	22	18	20	93	54	102	13	40	3	1284
MIN-AAF-0001-56	24	21	15	27	54	46	87	11	36.1	3.9	747

Sample	Nb	Ga	Cu	Zn	Pb	La	Ce	Th	Nd	U	F
MIN-AAF-0001-57	29	24	27	19	176	56	105	12	47.1	4	924
MIN-AAF-0001-58	28	24	12	17	51	47	96	12	36.2	3.5	1098
MIN-AAF-0001-61	27	22	16	22	83	54	111	12	43.1	4	1098
MIN-AAF-0001-62	27	20	16	20	91	53	102	13	40.2	4.7	1057
MIN-AAF-0004	26	23	23	21			124	16		2	1258
MIN-AAF-0004-56	23	21	13	27	39	38	76	11	28	3.3	913
MIN-AAF-0004-57	21	19	18	32	56	45	82	10	31.1	3.9	1044
MIN-AAF-0004-58	29	22	12	18	70	43	89	12	34.5	5.1	1071
MIN-AAF-0004-61	25	21	21	21	74	53	97	11	37.2	4.2	1089
MIN-AAF-0004-62	26	21	19	21	92	49	95	12	36.7	3	958
MIN-SAN-0002	25	22	25	19			88	13		3.9	1092
MIN-SAN-0002-57	24	21	45	22	117	41	80	13	34.5	3.3	
MIN-SAN-0002-58	23	21	14	16	62	45	90	13	36.4	4.4	
MIN-SAN-0002-61	26	22	14	19	59	50	98	12	37.7	3.4	
MIN-SAN-0002-62	25	21	19	19	92	51	98	13	37.5	3.9	
QPS-AAF-0001	15	21	39	64			47	11		3.8	
QPS-AAF-0001-56	14	20	44	39	25	34	69	9	28.5	3	801
QPS-AAF-0001-57	18	21	25	54	40	40	73	10	32.4	2	907
QPS-AAF-0001-58	16	20	31	44	44	36	75	9	29.2	4.9	1829
QPS-AAF-0001-61	15	21	35	46	44	34	67	7	30.5	4.4	982
QPS-AAF-0001-62	14	19	37	50	59	38	69	9	29.1	2.4	1220
QPS-AAF-0003	13	21	44	82			55	11		3	1291
QPS-AAF-0003-56	10	16	64	108	52	29	66	6	33.1	1.6	3373
QPS-AAF-0003-57	12	19	50	91	33	34	65	9	31.5	4	2354
QPS-AAF-0003-58	12	20	41	87	44	35	65	8	30.7	1.9	1090
QPS-AAF-0003-61	12	20	51	85	40	33	65	8	29.8	2.7	2145
QPS-AAF-0003-62	13	19	46	85	46	33	61	7	27.5	2.6	1453
QPS-AAF-0005	12	20	43	73			58	10		2	1164
QPS-AAF-0005-56	12	16	28	69	28	25	48	11	24.3	2.1	599
QPS-AAF-0005-57	11	18	26	63	30	24	43	9	21	1.6	745
QPS-AAF-0005-58	14	19	36	76	48	29	58	9	24.6	2.3	1801
QPS-AAF-0005-61	12	20	39	77	54	30	57	8	22.8	0.6	937
QPS-AAF-0005-62	14	19	41	81	54	35	60	8	24.6	0.9	997
QPS-AAF-0009	11.5	19	29	29	40	37	67	9	29	3	940
QPS-AAF-0009-56	11	20	41	55	26	39	77	8	32.1	1.1	872
QPS-AAF-0009-57	10	17	19	45	71	32	64	6	28.6	3.5	765
QPS-AAF-0009-58	11	20	25	37	24	38	69	6	29.1	2.7	918
QPS-AAF-0009-61	10	20	31	35	26	36	67	5	27.8	3.3	961
QPS-AAF-0009-62	11	19	30	31	36	34	67	6	27.3	3.7	885
QPS-SAN-0002	19	23	34	34			33	11		5.1	1070
QPS-SAN-0002-57	28	22	32	31	47	66	108	13	37.4	5.1	
QPS-SAN-0002-58	23	21	27	31	24	56	105	11	41.3	4.3	
QPS-SAN-0002-61	19	21	30	37	33	52	93	11	29	5	
QPS-SAN-0002-62	18	22	38	42	50	42	76	10	29.8	3.7	
SPR-SAN-0002	10.9	18.7	139	47.9	20.7	46.6	89.3	8	37.5	3	2498
SPR-SAN-0002-57	11	19	132	42	8	43	83	9	36	3.6	
SPR-SAN-0002-58	12	19	147	49	20	42	84	9	36	2.1	
SPR-SAN-0002-61	12	18	123	62	24	44	87	9	38	2.7	
SPR-SAN-0002-62	10	18	150	64	30	50	92	9	38.9	4.1	

TABLE 2-4. Mineral composition of samples and different particle size fractions in weight percent.

Sample	Quartz	K-feldspar	Plagioclase	Epidote	Calcite	Pyrite	Fe Oxides	Rutile
GHN-JRM-0001	35	7	15	0.01	0.4	3	0.01	0.5
GHN-JRM-0001-56	33	21	12	0.01	0.09	5	0.01	0.5
GHN-JRM-0001-57	32	18	21	0.01	0.01	4	0.7	0.5
GHN-JRM-0001-58	34	21	14	0.01	0.09	4	1	0.5
GHN-JRM-0001-61	35	18	12	0.01	0.09	3	0.3	0.5
GHN-JRM-0001-62	35	14	13	0.01	0.09	3	0.2	0.5
GHN-JRM-0002	26	18	19	0.3	0.6	0.3	7	0.5
GHN-JRM-0002-56	24	24	26	4	0.3	0.01	4	0.6
GHN-JRM-0002-57	26	25	18	2	0.2	0.2	4	0.7
GHN-JRM-0002-58	26	22	22	2	0.2	0.09	5	0.7
GHN-JRM-0002-61	27	22	19	2	0.09	0.09	6	0.6
GHN-JRM-0002-62	27	20	18	0.01	0.09	0.01	7	0.5
GHN-KMD-0088	29	23	19	0.01	0.01	0.9	3	0.5
GHN-KMD-0088-56	33	30	16	0.01	0.4	1	2	0.3
GHN-KMD-0088-57	28	28	20	0.01	0.2	1	3	0.4
GHN-KMD-0088-58	31	23	19	0.01	0.6	1	2	0.4
GHN-KMD-0088-61	30	24	18	0.01	0	0.9	3	0.4
GHN-KMD-0088-62	31	23	17	0.01	0	0.6	3	0.4
MIN-AAF-0001	47	15	0	0.01	0.1	0.01	2	0.3
MIN-AAF-0001-56	38	36	2	0.01	0.6	0.1	1	0.4
MIN-AAF-0001-57	45	19	4	0.01	0.8	0.09	2	0.3
MIN-AAF-0001-58	45	18	0.6	0.01	0.7	0.01	2	0.4
MIN-AAF-0001-61	47	21	0.01	0.01	0.2	0.01	2	0.3
MIN-AAF-0001-62	48	16	0.01	0.01	0.8	0.01	2	0.3
MIN-AAF-0004	43	22	0.01		0.4	0.01	3	0.2
MIN-AAF-0004-56	40	22	8		0.9	0.01	3	0.3
MIN-AAF-0004-57	41	21	4		1	0.09	2	0.5
MIN-AAF-0004-58	50	15	1		0.5	0.01	0.9	0.3
MIN-AAF-0004-61	47	18	0.01		0.6	0.09	1	0.4
MIN-AAF-0004-62	47	15	0.01		0.7	0.09	2	0.3
MIN-SAN-0002	48	4	10		0.2		0.8	0.4
MIN-SAN-0002-57	48	11	6		0.6	0.09	2	0.4
MIN-SAN-0002-58	49	14	0.8		0.4	0.09	1	0.4
MIN-SAN-0002-61	51	10	2		0.5	0.09	1	0.3
MIN-SAN-0002-62	47	13	0.2		0.2	0.01	2	0.3
QPS-AAF-0001	38	12	13	0.01	0.7	0.2	2	0.5
QPS-AAF-0001-56	39	11	15	0.01	0.01	0.6	3	0.6
QPS-AAF-0001-57	38	10	15	0.01	0.3	0.3	3	0.5
QPS-AAF-0001-58	40	8	10	0.01	0.2	0.2	2	0.5
QPS-AAF-0001-61	40	10	11	0.01	0.09	0.2	2	0.6
QPS-AAF-0001-62	39	8	11	0.01	0.4	0.09	3	0.6
QPS-AAF-0003	34	10	14		0.1	0.1	3	0.5
QPS-AAF-0003-56	38	14	13	0.01	1	2	2	0.6

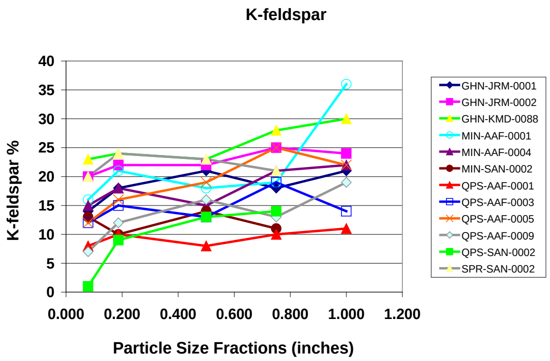
Sample	Quartz	K-feldspar	Plagioclase	Epidote	Calcite	Pyrite	Fe Oxides	Rutile
QPS-AAF-0003-57	31	19	18	0.01	0.4	0.3	4	0.4
QPS-AAF-0003-58	33	13	19	0.01	0.4	0.4	3	0.5
QPS-AAF-0003-61	34	15	15	0.01	0.2	0.6	3	0.5
QPS-AAF-0003-62	34	12	15	0.01	0.2	0.6	3	0.5
QPS-AAF-0005	34	6	14	0.01	0.09		3	0.5
QPS-AAF-0005-56	25	22	30	0.01	0.09	0.5	4	0.4
QPS-AAF-0005-57	29	25	23	0.01	0	0.2	3	0.5
QPS-AAF-0005-58	30	19	17	0.01	0.01	0.2	3	0.5
QPS-AAF-0005-61	32	16	17	0.01	0.09	0.09	3	0.5
QPS-AAF-0005-62	33	12	16	0.01	0.3	0.09	3	0.5
QPS-AAF-0009	35	17	6	0.01	0.3	0.3	3	0.6
QPS-AAF-0009-56	27	19	14	3	0.5	0.4	3	0.6
QPS-AAF-0009-57	33	13	12	0.01	0.01	1	4	0.4
QPS-AAF-0009-58	32	16	8	0.01	0.01	0.4	4	0.5
QPS-AAF-0009-61	36	12	9	0.01	0.01	0.4	3	0.5
QPS-AAF-0009-62	37	7	8	0.01	0.09	0.3	3	0.5
QPS-SAN-0002	42	4	10		0.2		0.8	0.4
QPS-SAN-0002-57	44	14	5	0.01	0.09	0.09	2	0.3
QPS-SAN-0002-58	44	13	7	0.01	0.09	0.6	1	0.4
QPS-SAN-0002-61	42	9	9	0.01	0.3	0.3	1	0.5
QPS-SAN-0002-62	41	1	10	0.01	0.2	0.09	2	0.4
SPR-SAN-0002	25	21	18	2	0.5	0.3	4	0.6
SPR-SAN-0002-57	24	21	20	7	0.6	2	0.6	0.7
SPR-SAN-0002-58	23	23	21	5	0.2	1	2	0.6
SPR-SAN-0002-61	25	24	19	5	0.5	0.8	2	0.7
SPR-SAN-0002-62	25	20	18	0.8	1	0.4	4	0.5

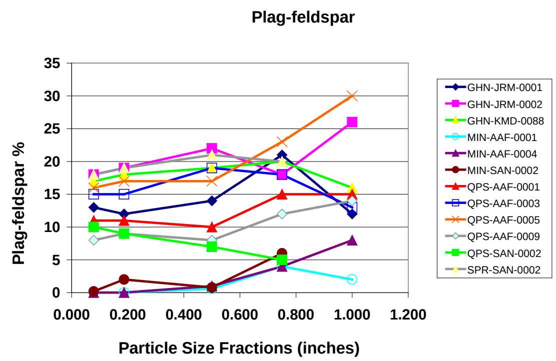
Sample	Gypsum	Apatite	Kaolinite	Chlorite	Illite	Smectite	Jarosite	Zircon
GHN-JRM-0001	1	0.2	0.9	3	27	2	4	0.03
GHN-JRM-0001-56	0.3	0.4	0.9	3	21	2	1	0.03
GHN-JRM-0001-57	0.5	0.3	0.9	3	16	2	1	0.03
GHN-JRM-0001-58	0.4	0.4	0.9	3	17	2	0.9	0.03
GHN-JRM-0001-61	0.7	0.3	0.9	3	22	2	2	0.03
GHN-JRM-0001-62	1	0.2	0.9	3	24	2	3	0.03
GHN-JRM-0002	1.6	0.9		6	16	4	0.01	0.03
GHN-JRM-0002-56	0.6	0.8	0	6	6	4	0.01	0.03
GHN-JRM-0002-57	1	0.7	0	7	12	4	0.01	0.03
GHN-JRM-0002-58	1	0.8	0	6	11	4	0.01	0.03
GHN-JRM-0002-61	0.8	0.8	0	6	12	4	0.01	0.03
GHN-JRM-0002-62	2	0.7	0	6	15	4	0.01	0.03
GHN-KMD-0088	2	0.4	2	4	14	2	0.01	0.03
GHN-KMD-0088-56	1.09	0.2	2	3	9	2	0.01	0.03
GHN-KMD-0088-57	1.07	0.5	2	4	10	2	0	0.03
GHN-KMD-0088-58	0.96	0.3	2	4	14	2	0.5	0.03
GHN-KMD-0088-	2.1	0.3	2	4	14	2	0	0.03

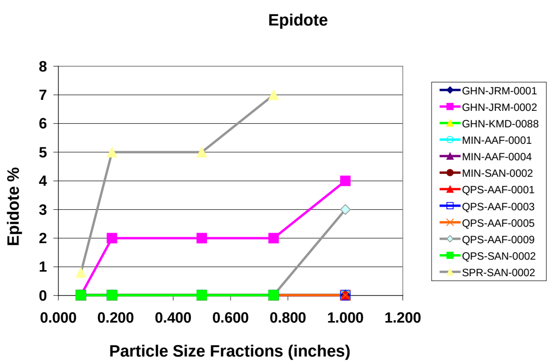
Sample	Gypsum	Apatite	Kaolinite	Chlorite	Illite	Smectite	Jarosite	Zircon
61								
GHN-KMD-0088-62	1.09	0.3	2	4	15	2	0.3	0.03
MIN-AAF-0001	0.1	0.1	2	2	29	1	2	0.04
MIN-AAF-0001-56	0.01	0.01	2	2	16	1	0.7	0.04
MIN-AAF-0001-57	0.01	0.01	2	1	24	0.9	1	0.04
MIN-AAF-0001-58	0.01	0.01	2	2	28	0.9	1	0.04
MIN-AAF-0001-61	0.01	0.09	2	2	24	0.9	1	0.04
MIN-AAF-0001-62	0.01	0.01	0.9	2	28	0.9	2	0.04
MIN-AAF-0004	0.01	0.01	2	1	25	0.9	2	0.04
MIN-AAF-0004-56	0.4	0.3	2	2	20	1		0.04
MIN-AAF-0004-57	0.01	0.01	2	2	24	0.9	1	0.04
MIN-AAF-0004-58	0	0.01	2	1	27	0.9	0.7	0.04
MIN-AAF-0004-61	0	0.01	2	2	27	0.9	1	0.04
MIN-AAF-0004-62	0.01	0.01	2	2	28	0.9	2	0.04
MIN-SAN-0002	1	0.2	1	3	31	3	4	0.04
MIN-SAN-0002-57	0.01	0.01	3	2	26	0.9	0.9	0.04
MIN-SAN-0002-58	0.01	0.01	3	2	27	0.9	1	0.04
MIN-SAN-0002-61	0.01	0.01	3	2	28	0.9	1	0.04
MIN-SAN-0002-62	0.01	0.09	3	2	29	0.9	2	0.04
QPS-AAF-0001	0.9	0.4		3	27		2	0.03
QPS-AAF-0001-56	0.4	0.6		3	27		0.6	0.03
QPS-AAF-0001-57	0.9	0.4		3	27		2	0.03
QPS-AAF-0001-58	1	0.4		3	31		3	0.03
QPS-AAF-0001-61	0.9	0.4		3	30		2	0.03
QPS-AAF-0001-62	1	0.4		3	31		3	0.03
QPS-AAF-0003	2	0.4	1	4	28	1	2	0.03
QPS-AAF-0003-56	2	0.5	0.9	6	19	0.9		0.03
QPS-AAF-0003-57	2	0.4	0.9	4	18	0.9	0.7	0.03
QPS-AAF-0003-58	1	0.4	0.9	5	21	0.9	2	0.03
QPS-AAF-0003-61	2	0.4	0.9	4	22	0.9	1	0.03
QPS-AAF-0003-62	2	0.4	0.9	4	25	0.9	2	0.03
QPS-AAF-0005	2	0.4	3	4	29	0.9	3	0.03
QPS-AAF-0005-56	0.7	0.3	3	2	10	0.9	0.4	0.03
QPS-AAF-0005-57	0.6	0.3	3	3	11	0.9	0.7	0.03
QPS-AAF-0005-58	2	0.4	3	4	19	0.9	1	0.03
QPS-AAF-0005-61	1	0.4	3	4	20	0.9	2	0.03
QPS-AAF-0005-62	1	0.4	3	4	24	0.9	2	0.03
QPS-AAF-0009	0.9	0.7	1	3	28	1	3	0.03
QPS-AAF-0009-56	2	0.7	0.9	5	22	2		0.03
QPS-AAF-0009-57	5	0.4	2	4	25	0.9		0.03
QPS-AAF-0009-58	3	0.4	2	3	29	0.9	0.3	0.03
QPS-AAF-0009-61	2	0.4	2	3	29	0.9	1	0.03
QPS-AAF-0009-62	3	0.4	0.9	3	34	0.9	2	0.03
QPS-SAN-0002	1	0.2	1	3	31	3	4	0.04
QPS-SAN-0002-57	0.8	0.3	0.9	2	25	3	2	0.04
QPS-SAN-0002-58	0.8	0.3	0.9	2	26	3	1	0.04
QPS-SAN-0002-61	0.8	0.3	0.9	2	28	3	2	0.04
QPS-SAN-0002-62	1	0.4	0.9	3	33	3	4	0.04

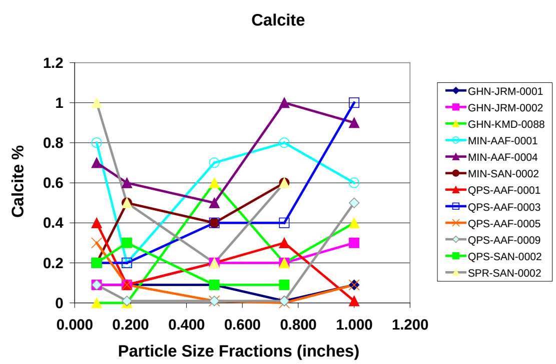
Sample	Gypsum	Apatite	Kaolinite	Chlorite	Illite	Smectite	Jarosite	Zircon
SPR-SAN-0002	2	0.9	1	8	14	3		0.03
SPR-SAN-0002-57	0.4	0.7	0.9	8	11	3		0.03
SPR-SAN-0002-58	0.5	0.8	0.9	8	11	3		0.03
SPR-SAN-0002-61	0.9	0.8	0.9	8	10	3		0.03
SPR-SAN-0002-62	2	0.8	0.9	8	15	3		0.03

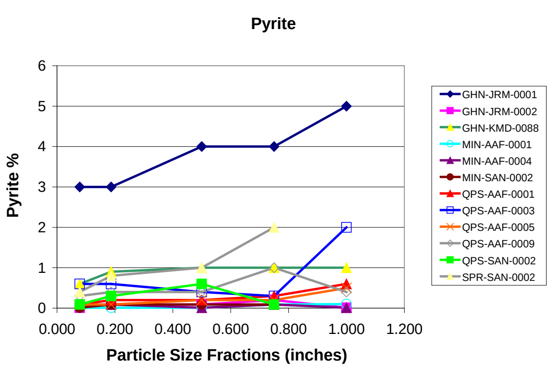
DISTRIBUTION OF SIZE FRACTIONS WITH MINERALOGY

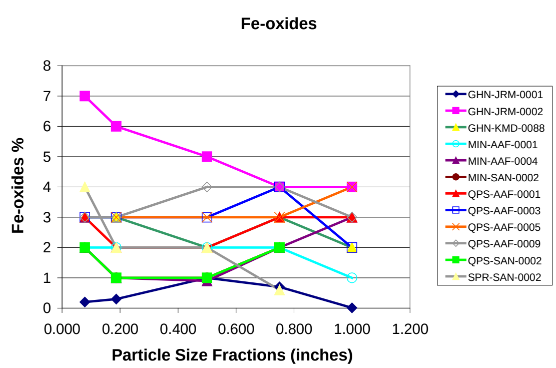


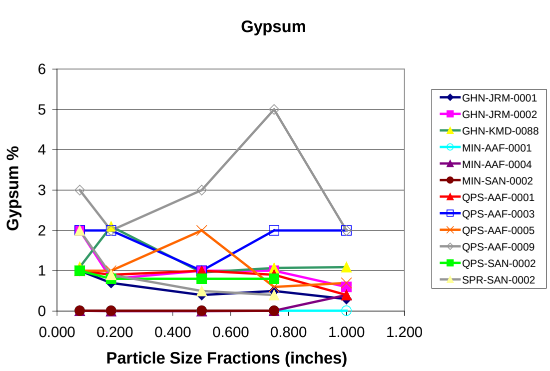


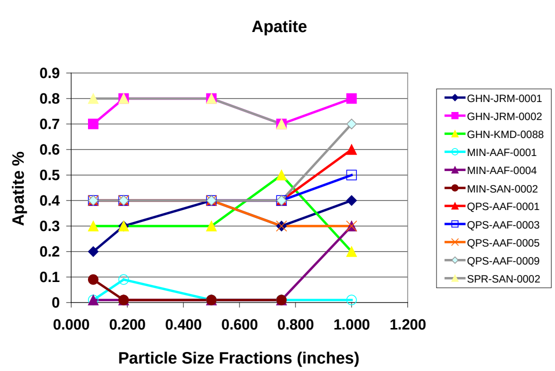


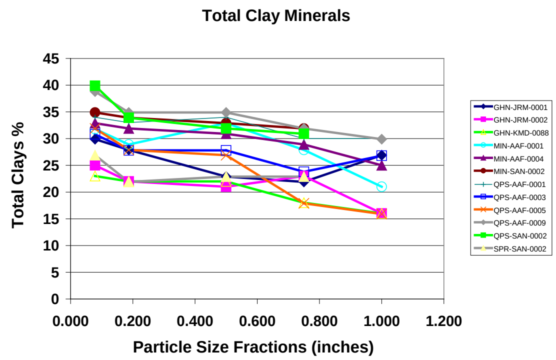


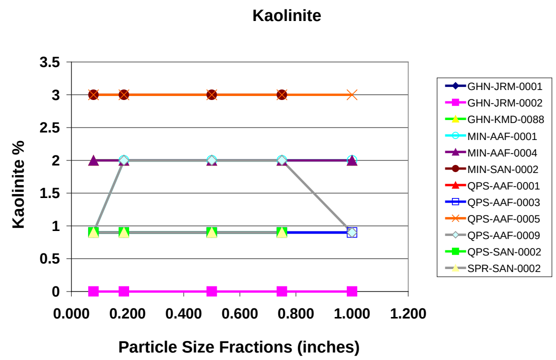


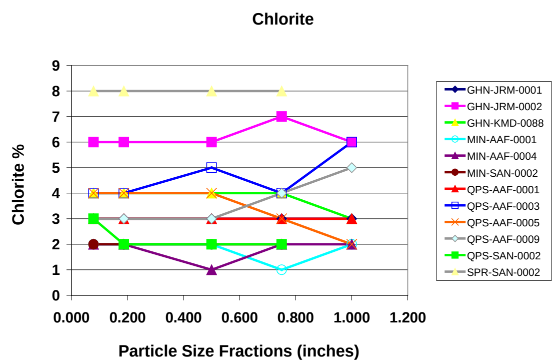


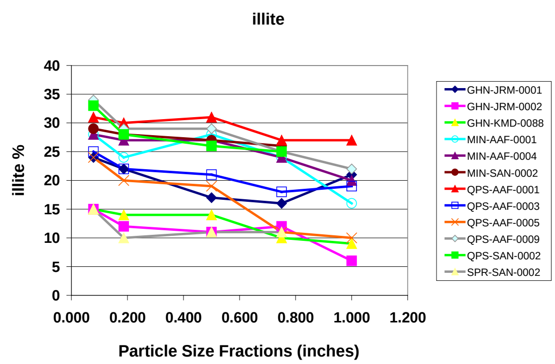


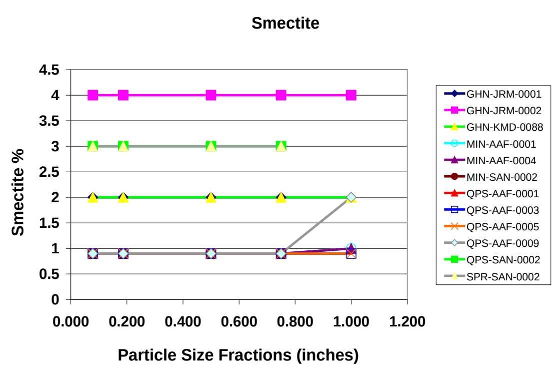


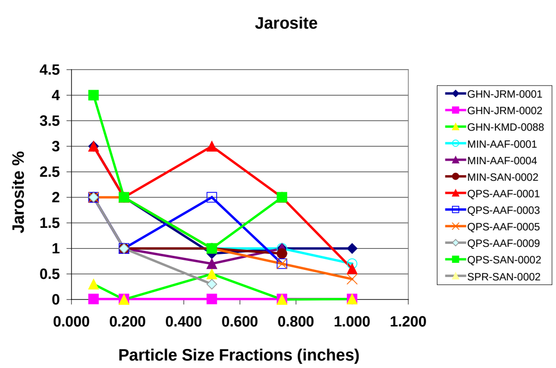

Total Clay Minerals
Total Clays %
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

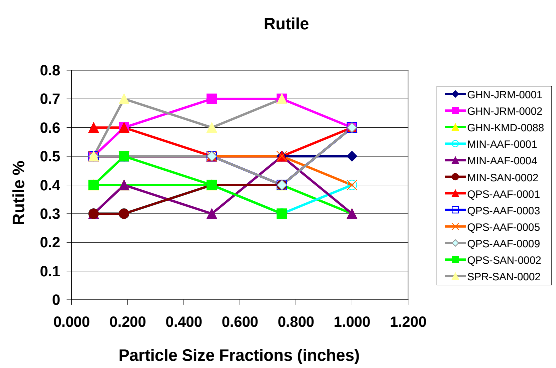

Kaolinite
Kaolinite %
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002


Chlorite
Chlorite %
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

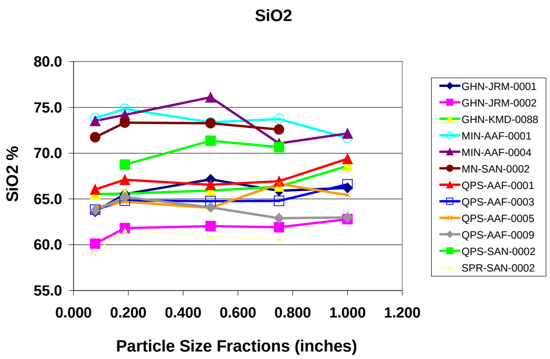

illite
illite %
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

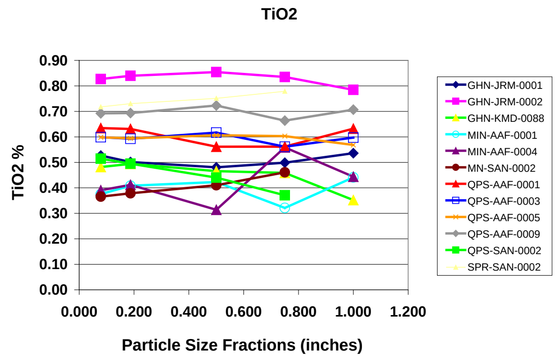

Smectite
Smectite %
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

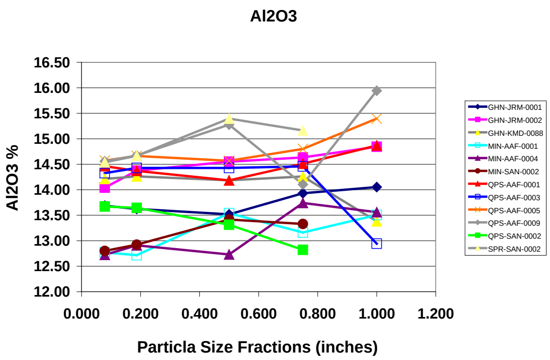

Jarosite
Jarosite %
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

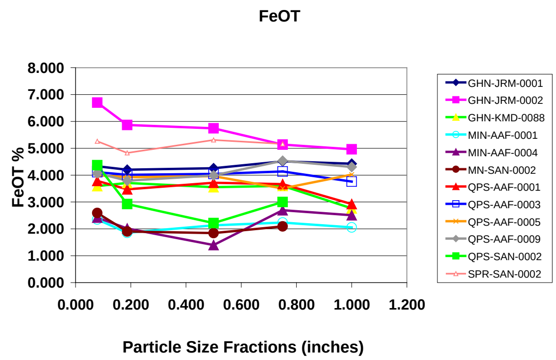

Rutile
Rutile %
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

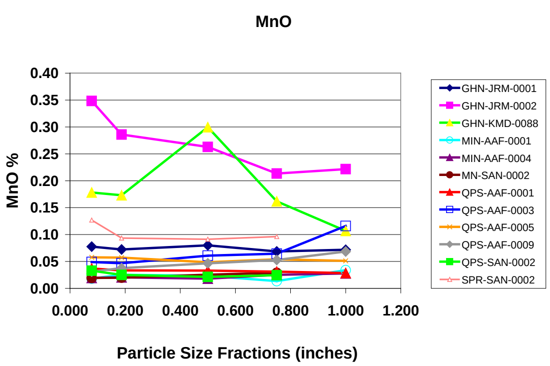
CHEMICAL COMPOSITION OF DIFFERENT SIZE FRACTIONS

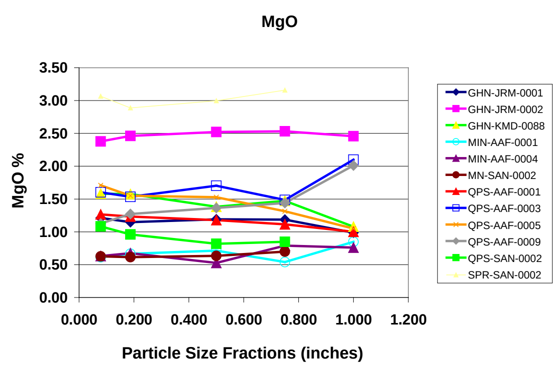


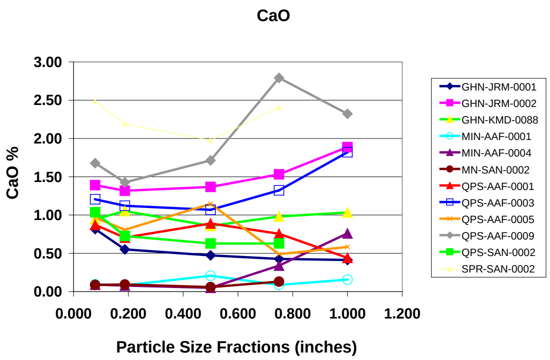


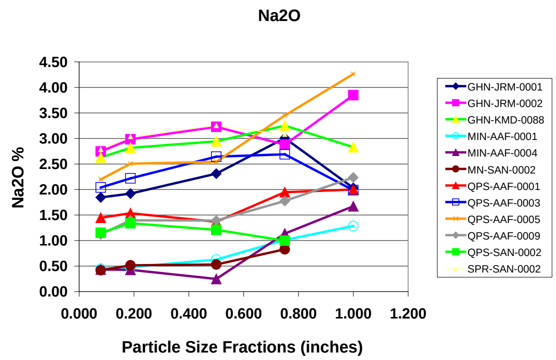


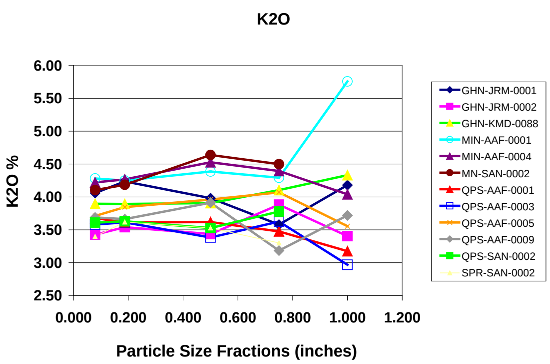


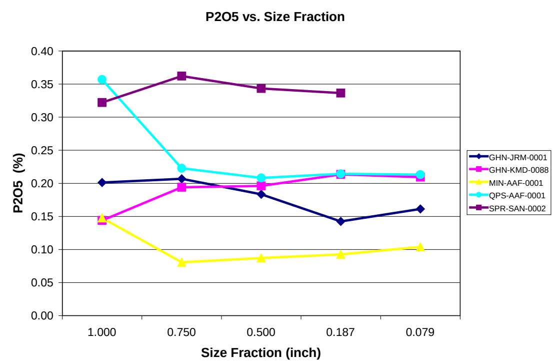


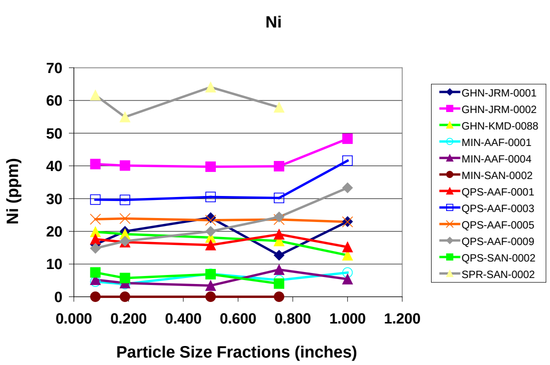


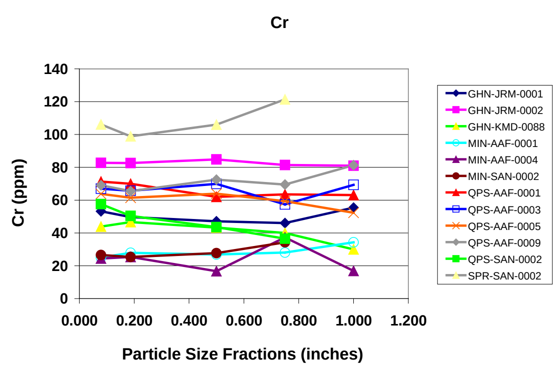

CaO
CaO %
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.000 0.200 0.400 0.600 0.800 1.000 1.200
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

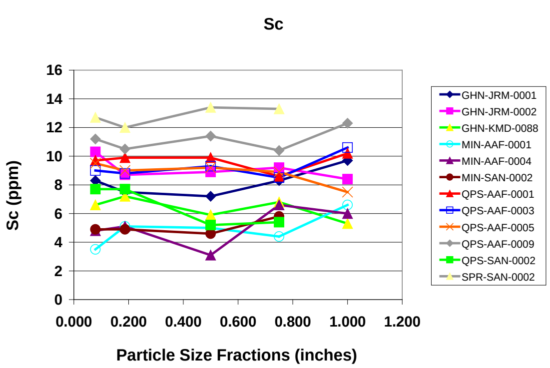

Na2O
Na2O %
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.000 0.200 0.400 0.600 0.800 1.000 1.200
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

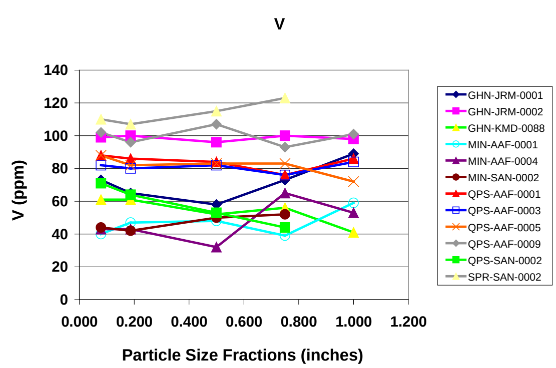

K2O
K2O %
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
0.000 0.200 0.400 0.600 0.800 1.000 1.200
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

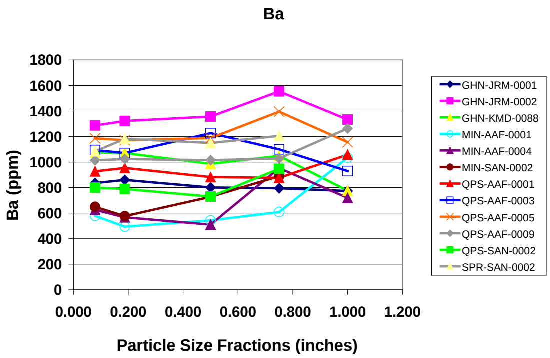

P2O5 vs. Size Fraction
P2O5 (%)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1.000 0.750 0.500 0.187 0.079
Size Fraction (inch)
GHN-JRM-0001
GHN-KMD-0088
MIN-AAF-0001
QPS-AAF-0001
SPR-SAN-0002

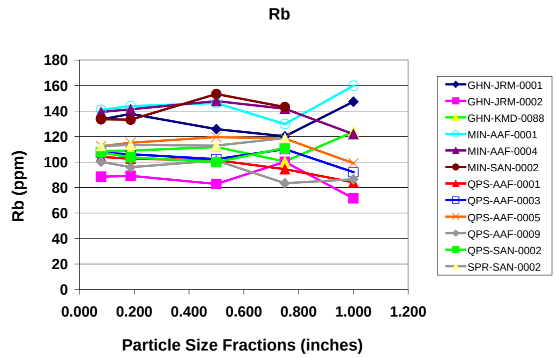

Ni
Ni (ppm)
70
60
50
40
30
20
10
0
0.000 0.200 0.400 0.600 0.800 1.000 1.200
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

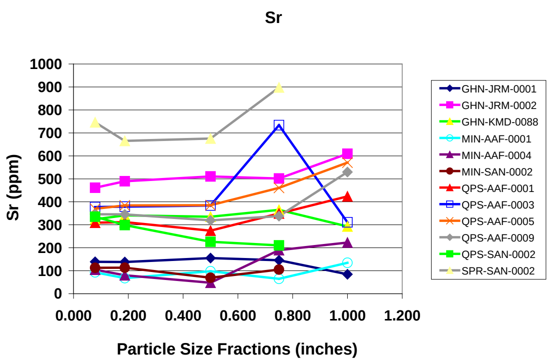

Cr
Cr (ppm)
140
120
100
80
60
40
20
0
0.000 0.200 0.400 0.600 0.800 1.000 1.200
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

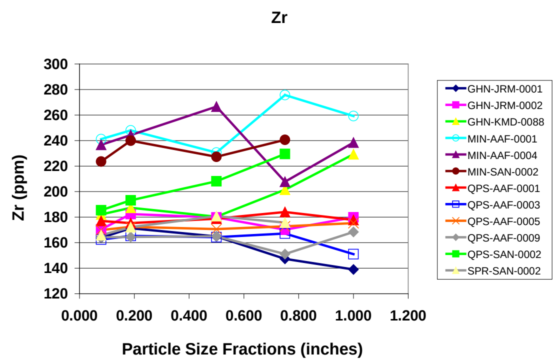

Sc
Sc (ppm)
16
14
12
10
8
6
4
2
0
0.000 0.200 0.400 0.600 0.800 1.000 1.200
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

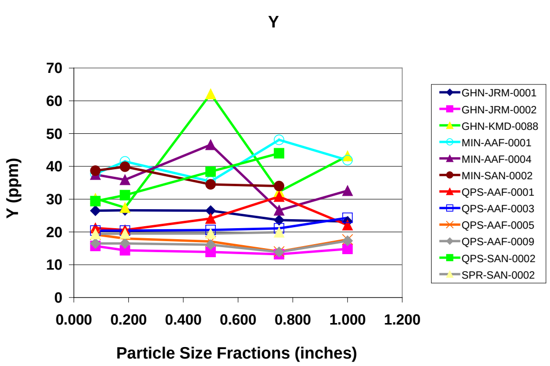

V
V (ppm)
140
120
100
80
60
40
20
0
0.000 0.200 0.400 0.600 0.800 1.000 1.200
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

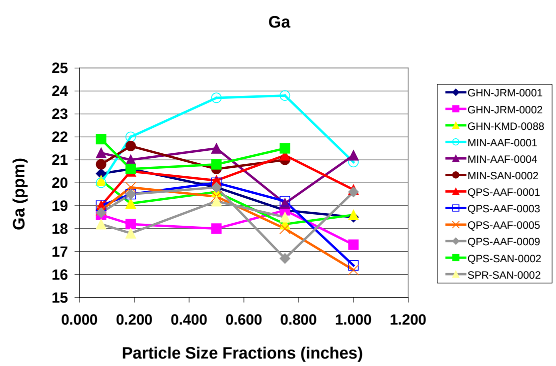

Ba
Ba (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

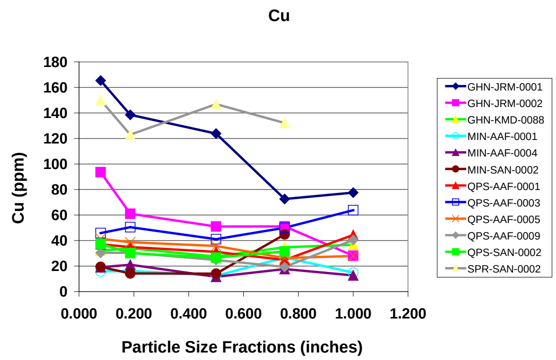

Rb
Rb (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

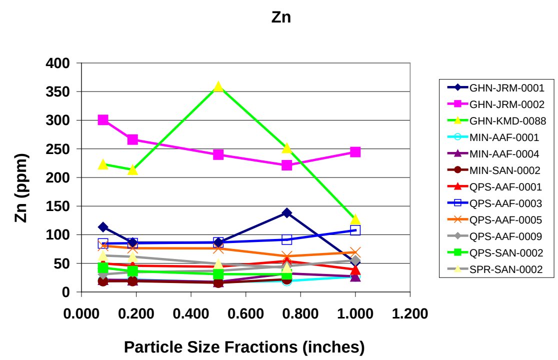

Sr
Sr (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

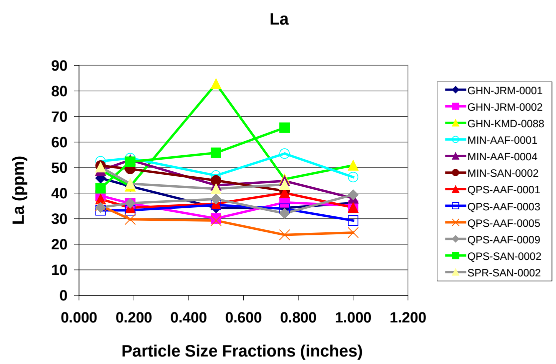

Zr
Zr (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

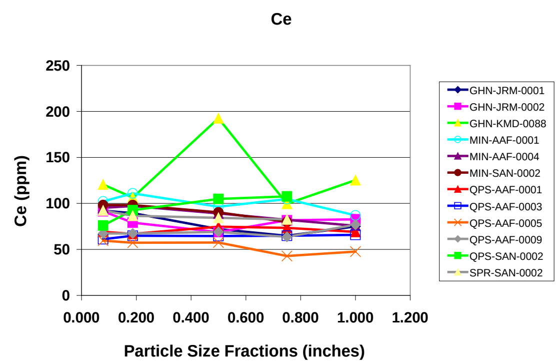

Y
Y (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

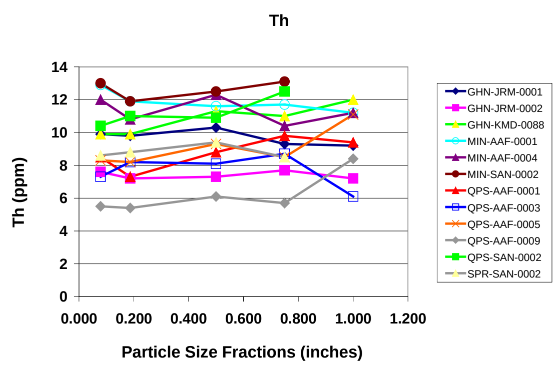

Ga
Ga (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

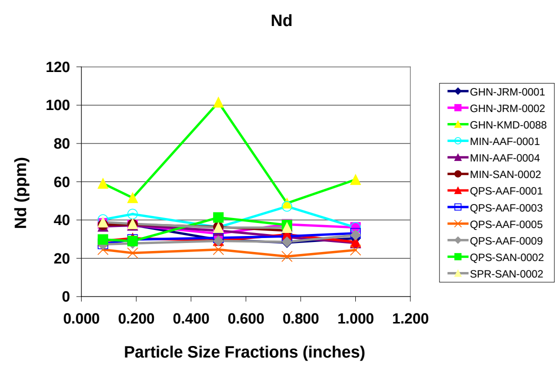

Cu
Cu (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

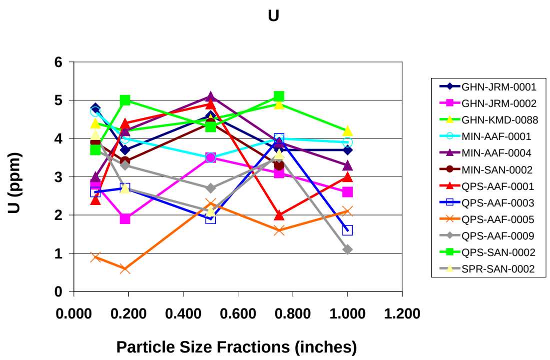

Zn
Zn (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

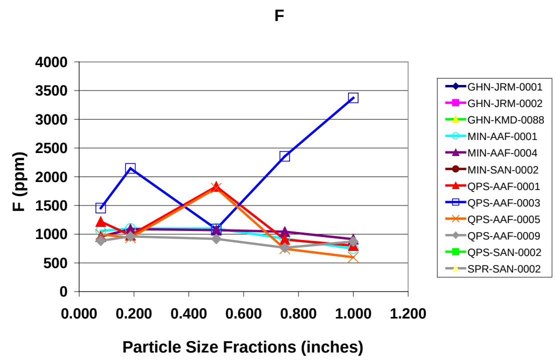

La
La (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

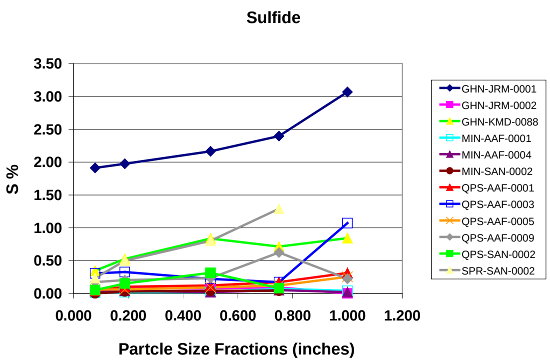

Ce
Ce (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

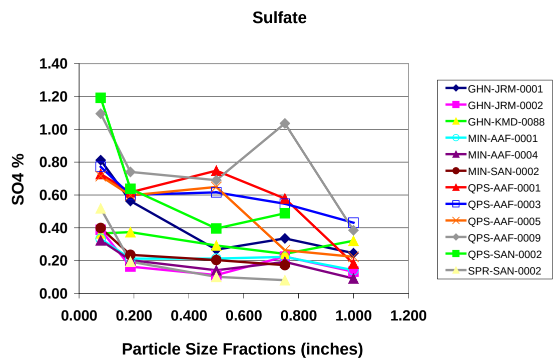

Th
Th (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

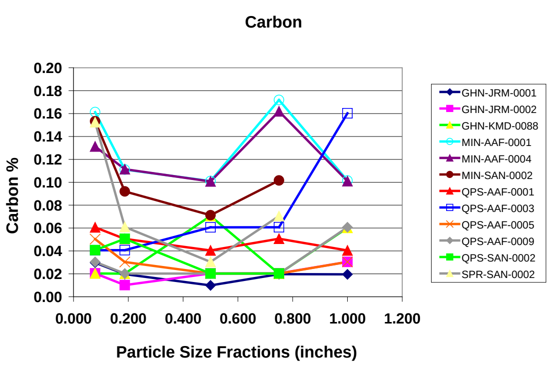

Nd
Nd (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

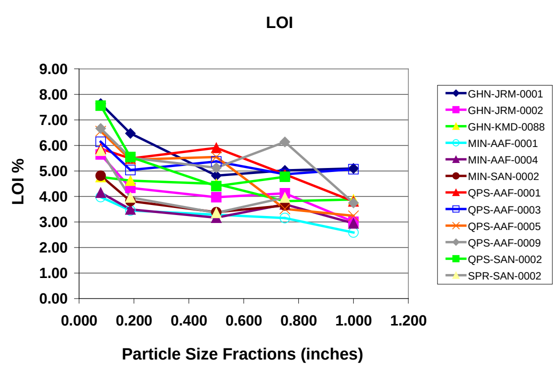

U
U (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

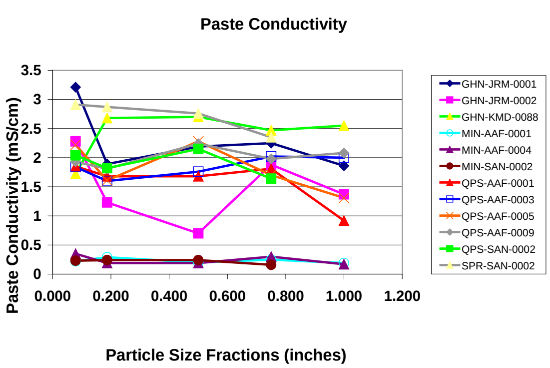

F
F (ppm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002


Sulfide
S %
Partcle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002


Sulfate
SO4 %
Partcle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002


Carbon
Carbon %
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002


LOI
LOI %
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002


Paste Conductivity
Paste Conductivity (mS/cm)
Particle Size Fractions (inches)
GHN-JRM-0001
GHN-JRM-0002
GHN-KMD-0088
MIN-AAF-0001
MIN-AAF-0004
MIN-SAN-0002
QPS-AAF-0001
QPS-AAF-0003
QPS-AAF-0005
QPS-AAF-0009
QPS-SAN-0002
SPR-SAN-0002

CLAY MINERALOGY FOR EACH SIZE FRACTION

TABLE 2-5.Clay mineralogy (X-Ray diffraction data and scans of size fractions, units in part per tens, ppt).

Sample ID	Sample Type	Kaolinite	Chlorite	Illite	Smectite	Mixed_layered
GHN-JRM-0001	Bulk Sample	1	2	3	2	2
GHN-JRM-0001-92	Fine Material	1	1	4	2	2
GHN-JRM-0002	Bulk Sample	0	2	1	4	3
GHN-JRM-0002-92	Fine Material	2	2	1	4	1
GHN-KMD-0088	Bulk Sample	2	3	1	2	2
GHN-KMD-0088-92	Fine Material	1	3	2	3	1
MIN-AAF-0001-56	1inch size	2	0	5	2	1
MIN-AAF-0001-62	0.0787inch size	1	0	6	1	2
MIN-AAF-0004	Bulk Sample	2	0	5	1	2
MIN-AAF-0004-56	1inch size	2	0	6	1	2
MIN-AAF-0004-62	0.0787inch size	2	0	5	1	2
MIN-SAN-0002	Bulk Sample	3	0	5	1	1
QPS-AAF-0001	Bulk Sample	2	0	3	3	2
QPS-AAF-0001-56	1inch size	1	1	4	1	3
QPS-AAF-0001-57	0.75inch size	2	0	6	1	1
QPS-AAF-0001-58	0.5inch	1	1	4	1	3
QPS-AAF-0001-61	0.187inch size	1	1	5	1	2
QPS-AAF-0001-62	0.0787inch size	1	1	5	1	2
QPS-AAF-0003	Bulk Sample	1	2	4	3	0
QPS-AAF-0003-56	1inch size	1	2	2	3	2
QPS-AAF-0003-62	0.0787inch size	1	1	5	2	1
QPS-AAF-0005	Bulk Sample	3	0	3	1	3
QPS-AAF-0005-56	1inch size	2	0	3	4	1
QPS-AAF-0005-58	0.5inch	1	2	4	2	1
QPS-AAF-0005-62	0.0787inch size	1	1	3	3	2
QPS-AAF-0008	Bulk Sample	1	1	5	1	2
QPS-AAF-0009	Bulk Sample	2	0	5	1	2
QPS-AAF-0009-56	1inch size	1	0	6	2	1
QPS-AAF-0009-62	0.0787inch size	1	0	5	1	2
QPS-SAN-0002	Bulk Sample	1	0	5	3	1
SPR-VTM-0001	Bulk Sample	1	6	2	1	0
SSW-SAN-0002	Bulk Sample	1	1	2	5	1
SSW-SAN-0006	Bulk Sample	1	1	5	1	2

Sample: QPS-AAF-0001, QPS-AAF-0001