Geochemical characteristics of a waste rock repository at a western gold mine
by Jason Dwayne Outlaw

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Land Rehabilitation
Montana State University
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Abstract:
This study was conducted to determine the extent of weathering in a large pyritic waste rock repository, characterize its geochemical variations, and correlate the extent of weathering with physical waste rock characteristics. Field sampling activities revealed a highly variable waste rock pile made up of distinct layers of material. Chemical characteristics of waste rock varied greatly between layers throughout the repository. To investigate the associations that may exist between waste rock chemical variables, a correlation analysis was performed on waste rock chemical data. Sample titratable acidity was correlated with soluble SO4 (r = 0.8299), soluble Fe (r - 0.7919), soluble Al (r = 0.9212) and electrical conductivity (r = 0.6720).

The weathering of pyritic waste rock occurs when it comes into contact with air and water. This study revealed that regions of the waste rock dump where this interface occurs were more highly weathered. Samples of waste rock taken from the upper portions of the repository contained greater levels of acidity, electrical conductivity, and water soluble SO4, aluminum and iron. Though weathering may be significantly decreased deep within the repository, chemical data confirmed that weathering may still be occurring at any location within this waste rock pile. The oldest waste rock was found deeper in the interior of the waste rock repository, but it showed the highest degree of weathering. This was supported by data that showed the oldest samples contained greater levels of acidity, electrical conductivity and water soluble SO4, iron and aluminum. Finally, salt formations found within the waste rock repository were found to include copper, magnesium and zinc sulfates.

GEOCHEMICAL CHARACTERISTICS OF A WASTE ROCK REPOSITORY AT A WESTERN GOLD MINE

by

Jason Dwayne Outlaw

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of

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS iv

LIST OF TABLES vi

LIST OF FIGURES ix

ABSTRACT x

INTRODUCTION 1

Investigation Objectives 3

LITERATURE REVIEW 4

Pyrite Oxidation 4
Waste Dump Observations 6

MATERIALS AND METHODS 8

Waste Rock Sample Collection 8
Analytical Procedures 10
Determination of Sample Ages 12

RESULTS AND DISCUSSION 19

Waste Rock Physicochemical Characteristics 19
Correlation Analysis of Waste Rock Chemical Data 21
Chemical Variability as a Function of Repository Age 27
Chemical Variability as a Function of Position Within Repository.. 30
Chemical Variability as a Function of Sample Particle Size 34
Scanning Electron Microscopy Analysis 37

SUMMARY AND CONCLUSIONS 38

LITERATURE CITED 42

APPENDIX A Waste Rock Chemical Data..... 45

TABLE OF CONTENTS -- Continued

Page

APPENDIX B Test Pit Field Logs 51

APPENDIX C Statistical Analysis Reports 81

LIST OF TABLES

Table		Page
1.	Chemical characteristics of waste rock materials.	20
2.	Correlation coefficients and associated p-values between various chemical characteristics in a waste rock repository	23
3.	Type of ANOVA performed for analysis based on sample age.	28
4.	One - way ANOVA results based on sample age.	29
5.	Type of ANOVA performed for analysis based on sample position...	31
6.	One - way ANOVA results based on sample elevation.	32
7.	Type of ANOVA performed for analysis based on sample particle size.	34
8.	One - way ANOVA results based on sample percent passing a 2mm sieve.	35
9.	Summary of SEM analysis.	37
10.	Waste rock chemical data.	46
11.	Test pit 1 field log.	52
12.	Test pit 2 field log.	52
13.	Test pit 3 field log.	52
14.	Test pit 4 field log.	53
15.	Test pit 5 field log.	54
16.	Test pit 6 field log.	56
17.	Test pit 7 field log.	58
18.	Test pit 8 field log.	60

LIST OF TABLES -- Continued

Table		Page
19.	Test pit 9 field log.	60
20.	Test pit 10 field log.	61
21.	Test pit 11 field log.	61
22.	Test pit 12 field log.	62
23.	Test pit 13 field log.	63
24.	Test pit 14 field log.	64
25.	Test pit 15 field log.	65
26.	Test pit 16 field log.	66
27.	Test pit 17 field log.	68
28.	Test pit 18 field log.	69
29.	Test pit 19 field log.	70
30.	Test pit 20 field log.	71
31.	Test pit 21 field log.	71
32.	Test pit 22 field log.	72
33.	Test pit 23 field log.	73
34.	Test pit 24 field log.	75
35.	Test pit 25 field log.	76
36.	Test pit 26 field log.	77
37.	Test pit 27 field log.	79

LIST OF TABLES -- Continued

Table		Page
38.	Test pit 28 field log.	80
39.	Test pit 29 field log.	80
40.	Test pit 30 field log.	80
41.	Spearman rank order correlation statistical report.	82
42.	Statistical report - ANOVA results based on sample depth.	86
43.	Statistical report - ANOVA results based on sample age.	110
44.	Statistical report - ANOVA results based on sample particle size.	129

LIST OF FIGURES

Figure		Page
1.	Location of the Golden Sunlight Mine, Whitehall, Montana.	2
2.	Overhead view of waste rock repository with test pit locations and elevations.	9
3.	Aerial view of waste rock repository showing cross-sections A, B, C and D.	14
4.	View of waste rock repository vertical plane through cross-section A - A′.	15
5.	View of waste rock repository vertical plane through cross-section B - B′.	16
6.	View of waste rock repository vertical plane through cross-section C - C′.	17
7.	View of waste rock repository vertical plane through cross-section D - D′.	18
8.	Relationships between waste rock repository pH, electrical conductivity and water extractable Fe, Al and SO_4.	24
9.	Relationships between waste rock repository titratable acidity and water extractable Fe, Al, SO_4 and pH.	25
10.	Relationships between HNO_3 extractable and total sulfur, electrical conductivity and titratable acidity, and water extractable SO_4 and Al and Fe.	26

ABSTRACT

This study was conducted to determine the extent of weathering in a large pyritic waste rock repository, characterize its geochemical variations, and correlate the extent of weathering with physical waste rock characteristics. Field sampling activities revealed a highly variable waste rock pile made up of distinct layers of material. Chemical characteristics of waste rock varied greatly between layers throughout the repository. To investigate the associations that may exist between waste rock chemical variables, a correlation analysis was performed on waste rock chemical data. Sample titratable acidity was correlated with soluble SO_4 ($r = 0.8299$), soluble Fe ($r = 0.7919$), soluble Al ($r = 0.9212$) and electrical conductivity ($r = 0.6720$).

The weathering of pyritic waste rock occurs when it comes into contact with air and water. This study revealed that regions of the waste rock dump where this interface occurs were more highly weathered. Samples of waste rock taken from the upper portions of the repository contained greater levels of acidity, electrical conductivity, and water soluble SO_4, aluminum and iron. Though weathering may be significantly decreased deep within the repository, chemical data confirmed that weathering may still be occurring at any location within this waste rock pile. The oldest waste rock was found deeper in the interior of the waste rock repository, but it showed the highest degree of weathering. This was supported by data that showed the oldest samples contained greater levels of acidity, electrical conductivity and water soluble SO_4, iron and aluminum. Finally, salt formations found within the waste rock repository were found to include copper, magnesium and zinc sulfates.

INTRODUCTION

Acidity, metal solubilization and salt generation resulting from the weathering of waste rock containing sulfide minerals are common occurrences at hardrock mining operations in western North America and throughout the world. Waste rock is that material that must be removed in order to mine an economically important ore. This waste rock often contains iron-sulfide minerals which, after removal from their oxygen deprived - chemically reduced geologic environment, are placed on site in large repositories. This material is then exposed to air and water, facilitating weathering reactions that can produce acidity, elevated levels of sulfate, and the solubilization of metals. If a sufficient amount of water comes into contact with the repository material, acid rock drainage can occur. Acid rock drainage occurs when the products of sulfide weathering are leached into the natural environment. This can be inhibitory to plant growth and negatively affect aquatic ecosystems.

Due to the large size of most waste rock repository facilities and difficulty of sampling, little is known of the geochemical processes that occur deep within a repository over long periods of time. This study to investigate the geochemical processes deep within a waste rock repository took advantage of waste rock excavation necessitated by an episode of ground movement that took place at the Golden Sunlight Mine located in southwest Montana during 1994. Due to this ground movement, approximately 15 million tons of waste rock were off-loaded from a large repository facility. This study

was conducted on the east waste rock complex that underwent excavation from July 1994 to March 1995. This provided a unique opportunity to observe materials and obtain samples from deep within a large waste rock pile.

The Golden Sunlight Mine is located in southwestern Montana approximately 8 km northeast of Whitehall along Interstate 90. (Figure 1) The mine is owned and operated by Placer Dome U.S. Inc. and has been operating since 1981, although historic mining occurred at this site beginning in the late 1800's. The site receives an average annual precipitation of 25.4 to 30.5 cm, mostly as rainfall from April to September (MAPS 1990).

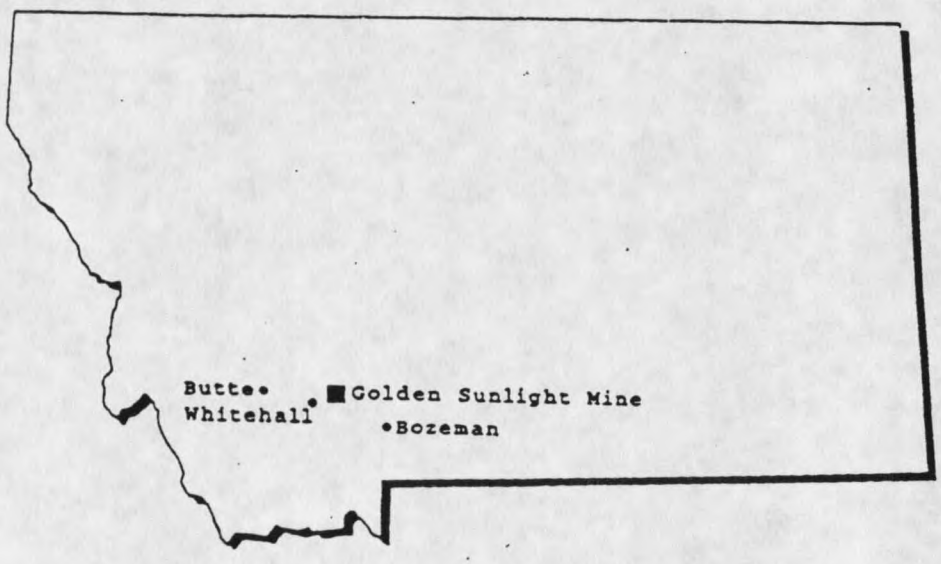


Figure 1. Location of the Golden Sunlight Mine, Whitehall, Montana.

Investigation Objectives

In order better to understand the geochemical weathering that occurs within a large waste rock repository, this investigation addressed the following research objectives:

- determine the extent of weathering in the waste rock repository;
- characterize the geochemical variations in the waste rock repository; and
- correlate the extent of weathering with waste rock particle size distribution.

LITERATURE REVIEW

Pyrite Oxidation

The oxidation of pyrite takes place when the mineral is exposed to air and water. This process involves chemical and biological reactions and is dependent on environmental conditions such as the morphology of pyrite crystals and the presence of water and oxygen.

The oxidation of pyrite by oxygen and water can be expressed in the following widely accepted reactions.

$$FeS_2 + 7/2\ O_2 + H_2O = Fe^{2+} + 2\ SO_4^{2-} + 2\ H^+ \quad [1]$$

$$Fe^{2+} + 1/4\ O_2 + H^+ = Fe^{3+} + \tfrac{1}{2}\ H_2O \quad [2]$$

$$Fe^{3+} + 3\ H_2O = Fe(OH)_3 + 3\ H^+ \quad [3]$$

These three reactions can be summarily expressed as Reaction 4.

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O = Fe(OH)_3 + 2\ SO_4^{2-} + 4\ H^+ \quad [4]$$

Reaction one indicates that the oxidation of pyrite produces ferrous iron (Fe^{2+}), sulfate (SO_4^{2-}) and hydrogen ions (H^+). Ferrous iron produced in Reaction 1 is then oxidized to yield ferric iron (Fe^{3+}) as shown in Reaction 2. Finally, the precipitate $Fe(OH)_3$ is formed from the combination of Fe^{3+} and water (Reaction 3). This third step is a reversible dissolution/precipitation reaction and can serve as a source or sink of solution Fe^{3+} (Evangelou and Zhang, 1995).

While O_2 is the major oxidant of pyrite at neutral to alkaline pH, Singer and Stumm (1970) found Fe^{3+} to be the dominant pyrite oxidant at acidic pH levels (<3.5).

This reaction at pH < 3.5 produces 16 moles of acidity per mole of FeS_2 as shown in Reaction 5.

$$FeS_2 + 14\ Fe^{3+} + 8\ H_2O = 15\ Fe^{2+} + 2\ SO_4^{2-} + 16\ H^+ \qquad [5]$$

Because Fe^{3+} is the dominant oxidant of FeS_2, Reaction 2, which shows the production of Fe^{3+} from the oxidation of Fe^{2+}, is known as the rate-limiting step in abiotic pyrite oxidation (Singer and Stumm 1970).

When iron-oxidizing bacteria are present in the waste rock dump environment, the rate-limiting step in pyrite oxidation can be bypassed. One such iron-oxidizing bacterium is *Thiobacillus ferroxidans*, an acidophilic iron-oxidizing bacterium that is ubiquitous in geologic environments containing pyrite (Ivarson et. al. 1982). Dugan (1975) and Singer and Stumm (1970) found that iron-oxidizing bacteria such as *T. ferroxidans* can accelerate the rate of Fe^{2+} oxidation by a factor of 10^6.

Other factors influencing the rate of pyrite oxidation are pyrite grain size and morphology. Shellhorn, Sobek and Rastogi (1985) used column leach testing to show an exponential increase in acidity with decreasing particle size (increased relative surface area) of pyritic sulfur refuse. Recent research has shown that pyrite particle morphology has an even greater influence on the rate of oxidation than particle size (Jennings and Dollhopf 1995).

Waste Dump Observations

Temperature profiles of a 20-year-old pyritic waste rock dump in the Northern Territory of Australia were measured by Harries and Ritchie (1980). They found that below 6m, temperatures in the dump remained essentially unchanged through their wet/dry season cycle. Since pyrite oxidation is exothermic, they concluded that this process primarily occurred in the top 5m of the dump with some regions showing oxidation down to 15m.

Harries and Ritchie (1985) also studied the pore gas composition of this Australian waste rock dump. They found that in most regions of the dump, oxygen supply was the oxidation-rate-limiting mechanism. Oxygen levels in this dump were highly variable, ranging from <1% to approximately 20% of atmospheric conditions. In some areas of the dump, oxygen content was near 20% in the top 2m but declined rapidly to <1% as depth increased, leveling off at <1% for depths greater than 5m. In other areas, oxygen content was shown to decrease from near 20% to less than 10% as depth ranged from 0 to 5m, then increased to a maximum of 19% at a depth of 13m. It was determined that the main oxygen transport mechanisms in the dump were likely to be diffusion, due to concentration gradients, and advection, caused by thermal effects and atmospheric pressure changes.

Schafer et al. (1994) performed a monitoring study on a waste rock pile at the Golden Sunlight Mine to compare reclaimed and unreclaimed waste rock dumps. They found that rock particle size gradually increased with depth due to gravity sorting in the

end-dumping sequence. Freshly shot waste rock was determined to have a volumetric water content of less than 6 percent. Residual saturation was found to vary between 8 and 12 percent within the dump with residual saturation generally lower near the base of the dump where larger particles are deposited. Fine waste rock produced by vehicle compaction at the top of each bench was found to have a residual saturation level ranging from 15 to 20 percent.

Whitney, Esposito and Sweeney (1995) conducted a study to describe the distribution of secondary alteration minerals within an excavated pyritic mine dump near Central City, Colorado. They identified four mineralogical zones distributed vertically within the dump: a surficial, relatively unaltered zone; a leached zone; a cemented zone in which pore spaces are filled with the minerals copiapite ($Fe^{2+}Fe^{3+}_4(SO_4)_6(OH)_2 \cdot 20\ H_2O$) and coquimbite ($Fe^{3+}_2(SO_4)_3 \cdot 9\ H_2O$); and an interior relatively unaltered zone.

Due to difficulty in sampling material found deep inside waste rock repositories, documentation concerning how waste rock weathers over long periods of time is nonexistent. This geochemical study, analyzing a range of samples collected throughout a large waste rock repository, is unique in this aspect.

MATERIALS AND METHODS

Waste Rock Sample Collection

The field sampling program was conducted simultaneously with excavation of the east waste rock complex. Excavation using electric shovels and 175 ton haul trucks began at the top of the waste rock pile at 1682 m (5520 ft) elevation and continued downward in approximately 12 to 18 m benches to the 1588 m (5210 ft) elevation level. Sampling occurred in 30 test pits that were located along two north-south and two east-west transect lines. The locations of these test pits with elevations are shown in Figure 2. Overall, 121 waste rock samples were collected for geochemical analysis.

Prior to the removal of each bench, transect lines were located by Golden Sunlight Mine survey staff and test pits were excavated to permit sampling. In this manner, sampling occurred along established transect lines at approximately 18 m vertical intervals throughout the portion of the east waste rock dump that was excavated.

Test pits were excavated to depths ranging from 3 to 4.6 m. One wall of each test pit was left vertical for logging and sampling while the other was sloped for safety concerns. Distinct layering of waste rock material was observed in the waste rock pile and was defined by changes in particle size and/or Munsell color. Each layer within a test pit was given a unique sample number (for example, TP10GS3 refers to test pit number 10 layer 3). The logs for each test pit are presented in Appendix B. A bulk sample was taken from each layer and transported to Montana State University for analysis. Sample

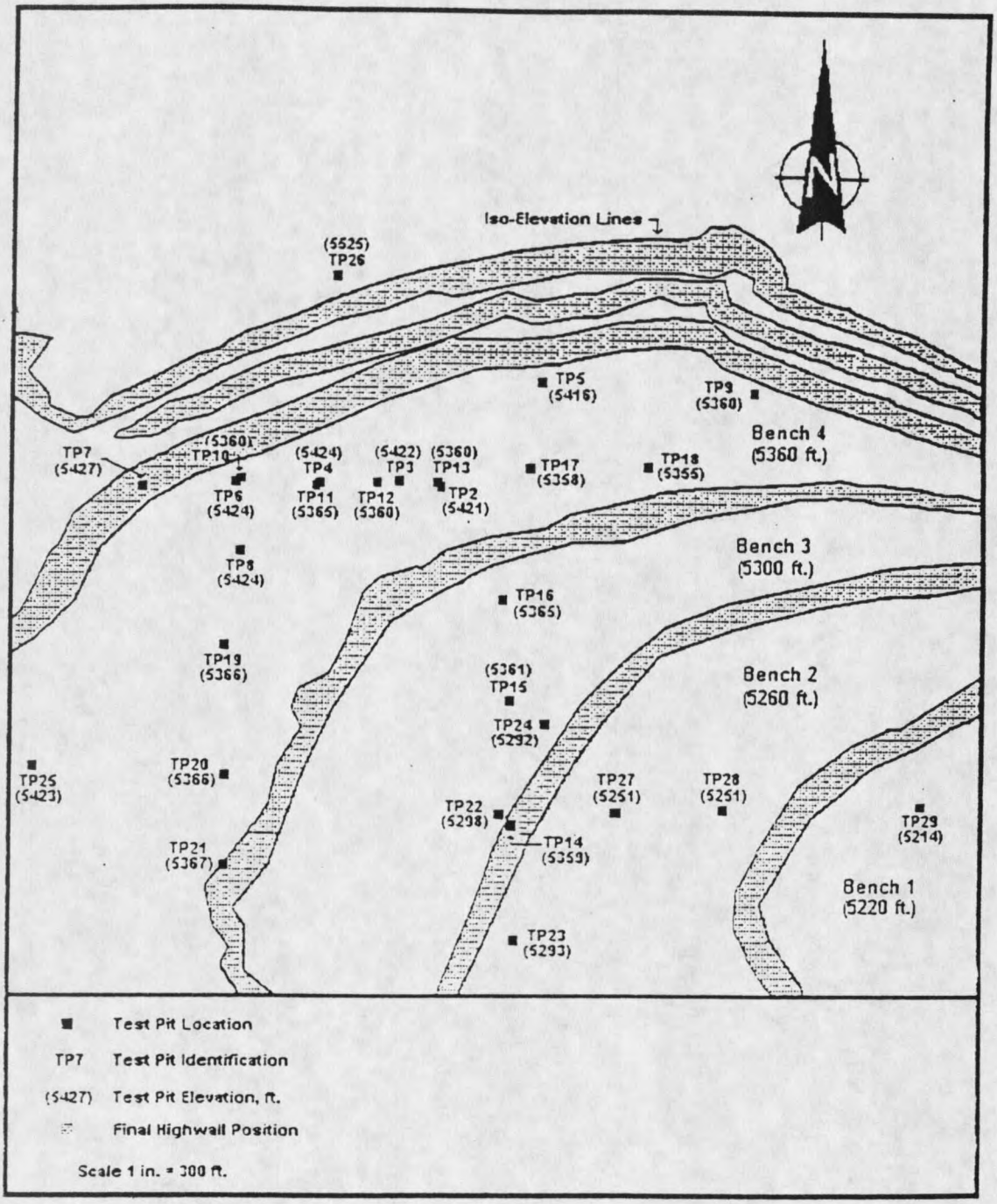


Figure 2. Overhead view of waste rock repository with test pit locations and elevations.

collection occurred concurrently with sample collection by researchers from the University of Saskatchewan who were performing a hydrogeologic study of this waste rock dump. Identical sample identification numbers were used by each university to facilitate data sharing and collaboration.

Analytical Procedures

Bulk samples were analyzed for particle size (ASTM D421-85). Aggregates were broken with a mortar and rubber-tipped pestle, then sieved by hand using metal sieves to obtain a <2mm diameter size fraction. It should be noted that while coarse layers were encountered in the waste rock pile, sampling of very coarse materials (>20 cm diameter) was prohibitive for practical reasons. A portion of the <2 mm diameter size fraction from each bulk sample was used for a 1:1 paste extraction (Methods of Soil Analysis, 1983, Method 10-2.3.2). Due to the low porosity of waste rock samples, a 1:1 paste extraction was chosen to ensure the collection of sufficient extract to analyze the entire suite of chemical variables. In addition, a 1:1 paste ensures that each sample is extracted at the same soil to water ratio, as opposed to the subjective variability involved in preparing a saturated paste. This water extract was analyzed for pH (Methods of Soil Analysis, 1965, Method 60-3.1.2), electrical conductivity (EC) (Methods of Soil Analysis, 1965, Method 62-2.2.3), soluble iron (Fe), aluminum (Al), manganese (Mn) and sulfate (SO_4) (Methods of Soil Analysis, 1965, Method 62-1.3.2.1) and titratable acidity (TA) to pH 7 (Standard Methods for the Examination of Water and Wastewater, p. 2-30). Waste rock of <2mm size was analyzed for potential acidity and sulfur fractionation, including total sulfur

(TS), hot water extractable sulfur (H_2O-S), HCl extractable sulfur (HCl-S), HNO_3 extractable sulfur (HNO_3-S), residual sulfur (Res-S) and neutralization potential (NP) (Modified Sobek et. al., 1978). The hot water extraction is intended to remove sulfur from the readily soluble calcium, magnesium and sodium sulfates. Sulfate sulfur existing in less soluble minerals such as Jarosite ($KFe_3(SO_4)_2(OH)_6$) is removed with the HCl extraction. The HNO_3 extraction serves to extract the sulfide sulfur that exists as pyrite and the residual sulfur is a measure of the organic sulfur in the sample.

The parameters pH, EC, titratable acidity and soluble Fe, Al, Mn and SO_4 were measured by the Soil Analytical Laboratory at Montana State University. To monitor the precision of analysis, laboratory replicates were entered into the sample set at a 10 percent rate. Replicate relative percent difference (RPD) averaged 2.2% pH, 9.1% EC, 5.6% titratable acidity, 8.2% soluble Al, 5.8% soluble Fe, 7.1% soluble Mn, and 4.1% soluble SO_4.

Neutralization potential and the sulfur fractionation parameters were measured by Energy Laboratories, Inc. in Billings, MT. Laboratory replicates were entered into the sample set at a 10 percent rate. Replicate RPD averaged 11.3% neutralization potential, 1.8% total sulfur, 19.9% hot water extractable sulfur, 12.1% HCl extractable sulfur, 2.4% HNO_3 extractable sulfur, and 11.1% residual sulfur.

In order to analyze the data based on age, position, and percent passing a 2mm sieve, the data were divided into three age categories, four elevation categories, and four

particle size separation categories. Achieving relatively uniform sample sizes was the basis for the delineation of categories. Measurements below analytical detection limits were adjusted for inclusion in the development of all categories. This adjustment multiplied respective analytical detection limits by a factor of 0.7 to obtain a numerical value (Severson 1979).

In cases where data populations were normal or where data transformations could be applied to normalize populations, a one-way analysis of variance (ANOVA) was conducted using a 95 percent confidence interval. Where the p-value for the observed F statistic was less than or equal to 0.05, the hypothesis of equality of means was rejected. Data sets with unequal means were then subjected to the Student-Newman-Keuls means separation procedure at the 0.05 level of significance.

In cases where data populations could not be normalized through transformation, a one-way ANOVA on ranks was performed using a 95 percent confidence interval. Where the p-value for the observed H statistic was less than or equal to 0.05, the hypothesis of equality of medians was rejected. Data sets with unequal medians were then subjected to the Dunn's separation procedure at the 0.05 level of significance. Results were reported with respect to sample means.

Determination of Sample Ages

Sample ages were determined using drawings supplied by Golden Sunlight Mines, Inc. Drawings for the years 1987, 1988, 1989, 1990, 1992 and 1993 were provided which document the crest and toe position of the repository for each year. Figure 3 shows the

waste rock dump study area areal view with the locations of cross-sections. Figures 4, 5, 6 and 7 show cross-sections A-A′, B-B′, C-C′ and D-D′, respectively. These cross-sections show the crest and toe positions of the repository for each year along with the locations of test pits. Test pit 29 was excavated in material placed in 1994. The location of test pit 29 in Figure 5 is shown outside the last toe and crest position due to the unavailability of toe and crest positions for 1994.

Since new material is placed on the repository by end-dumping from the edge, the oldest aged material is found not at the lowest elevations of the repository but farther toward the interior from the edge. This can be seen by examining Figures 4 through 7. Thus, sampling at higher elevations in the waste rock pile encountered not just new material, but materials of varying ages. To support this, a correlation analysis was performed on test pit elevations vs. material age. While the correlation was significant ($p = 0.007$), a low r-squared value of 0.24 hinders interpretation because only 24 percent of the variability in age can be attributed to elevation.

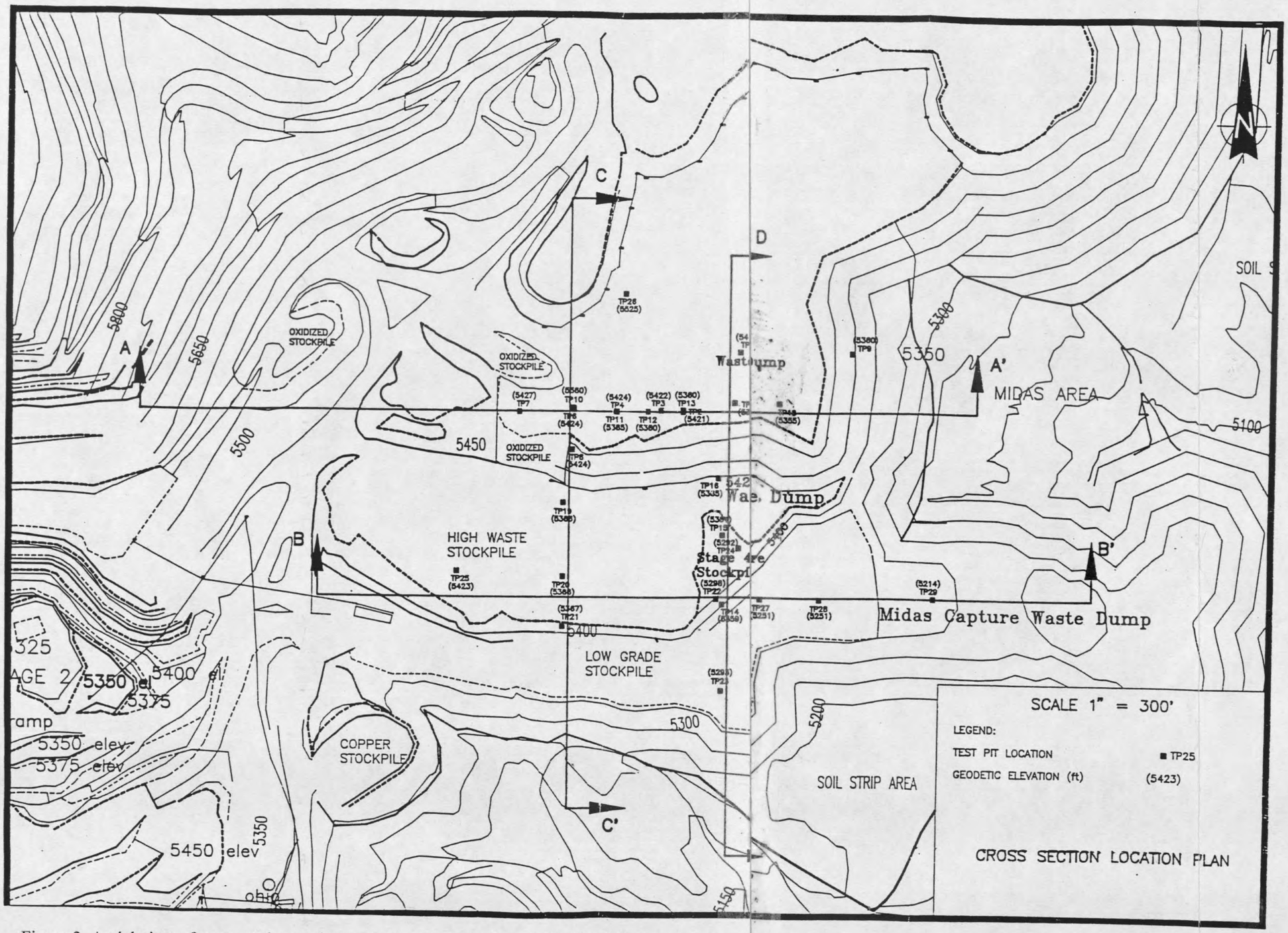


Figure 3. Aerial view of waste rock repository showing cross-sections A, B, C and D.

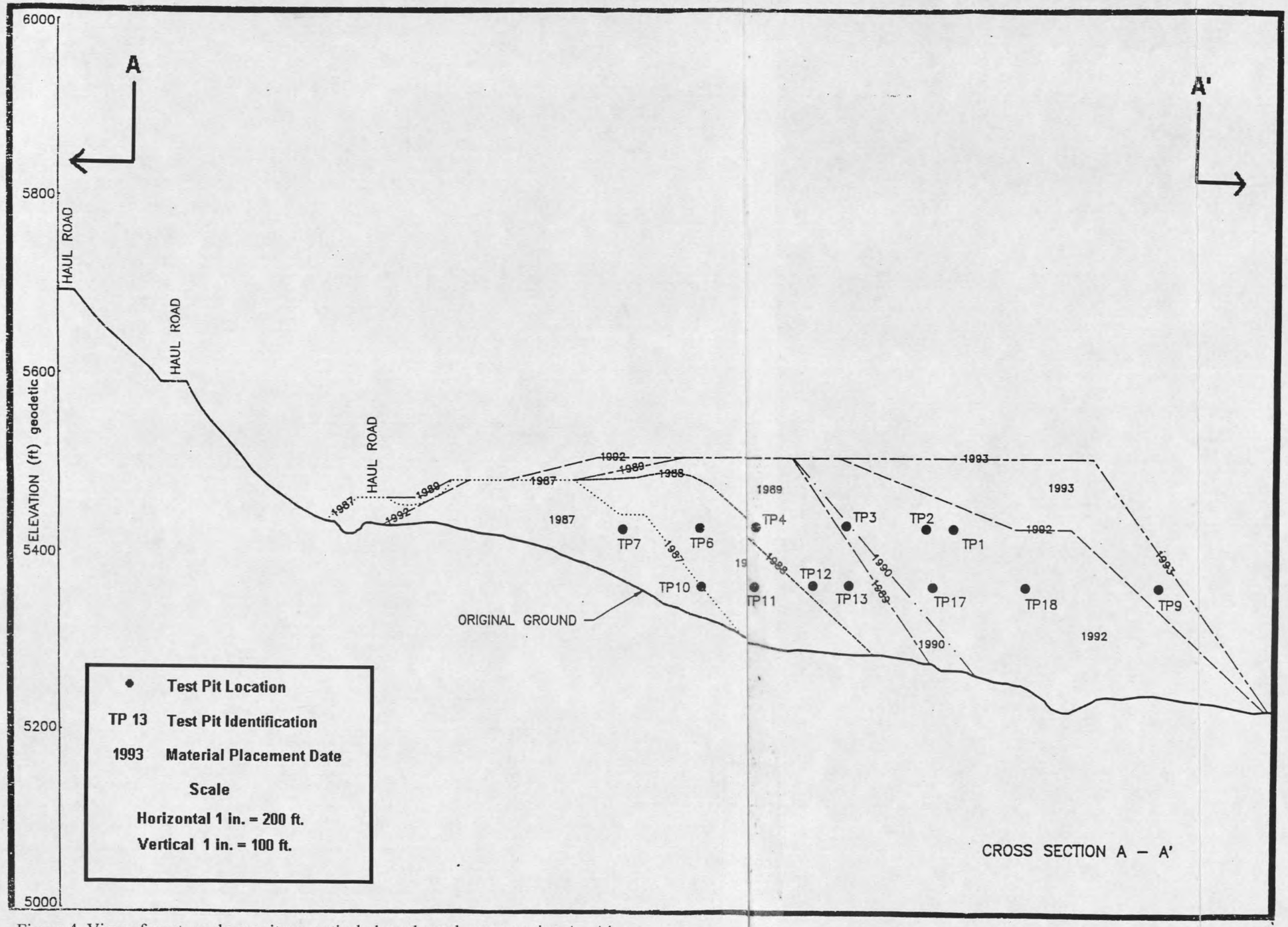


Figure 4. View of waste rock repository vertical plane through cross section A - A´.

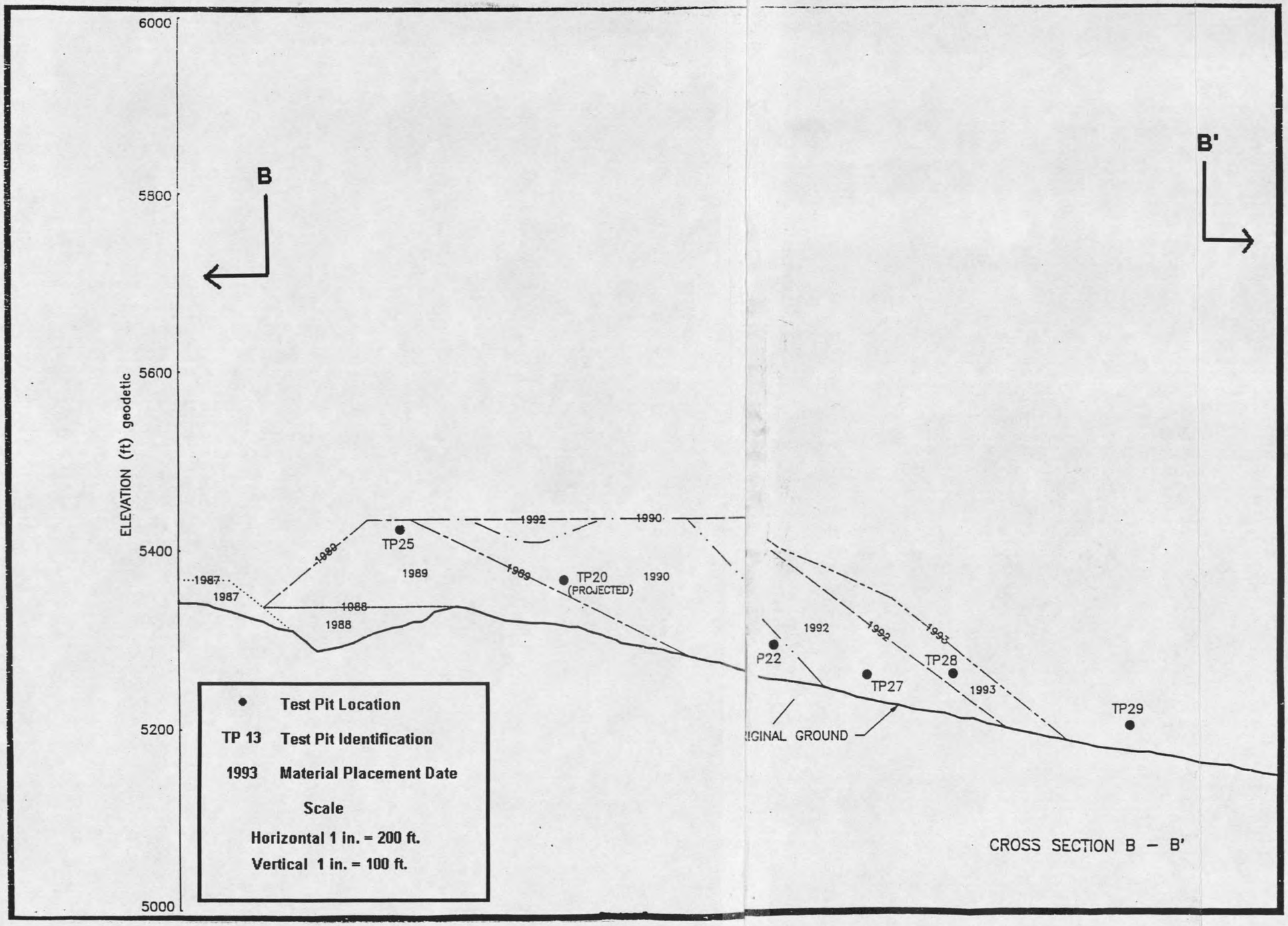


Figure 5. View of waste rock repository vertical plane through cross section B - B′.

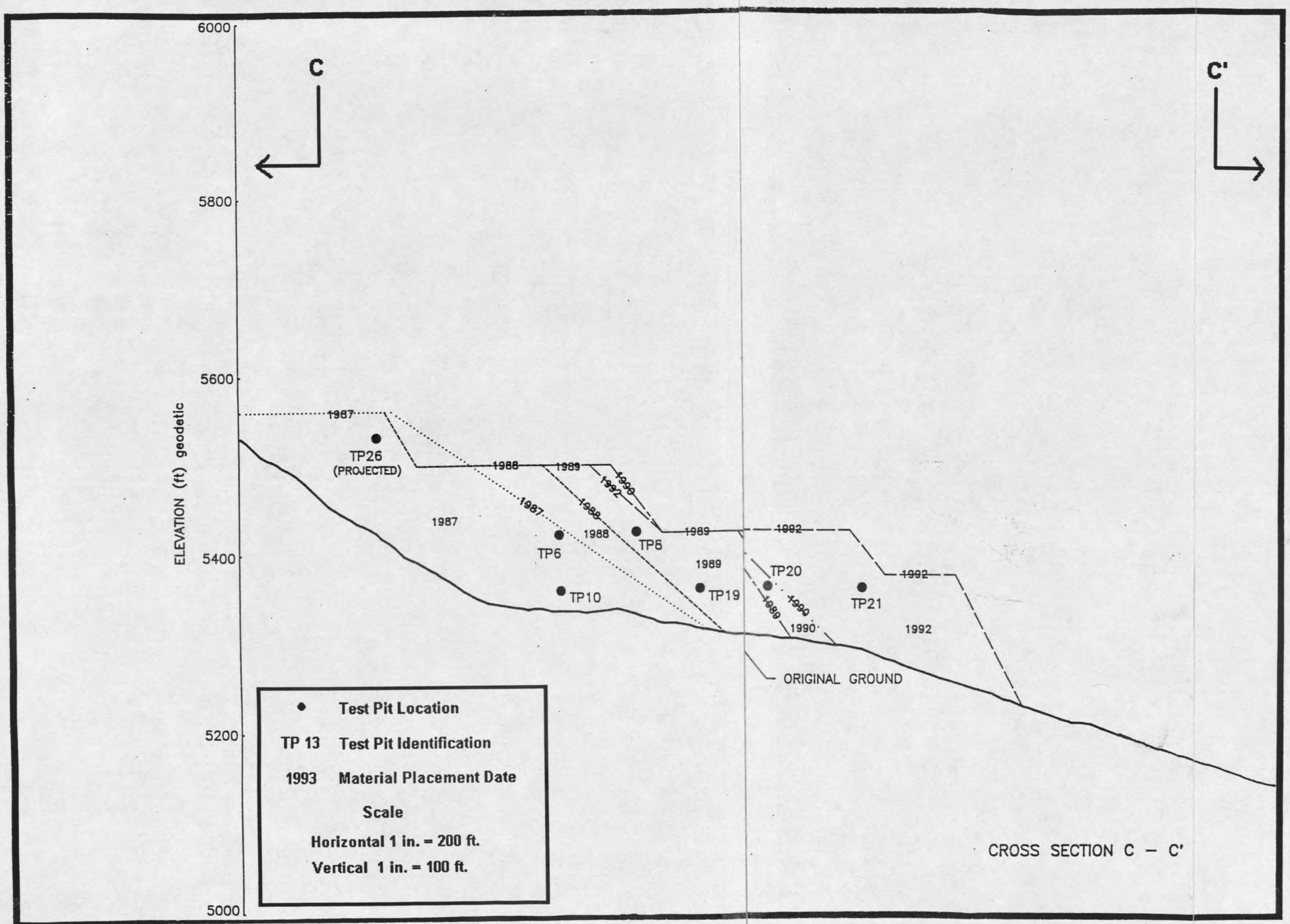


Figure 6. View of waste rock repository vertical plane through cross section C - C′.

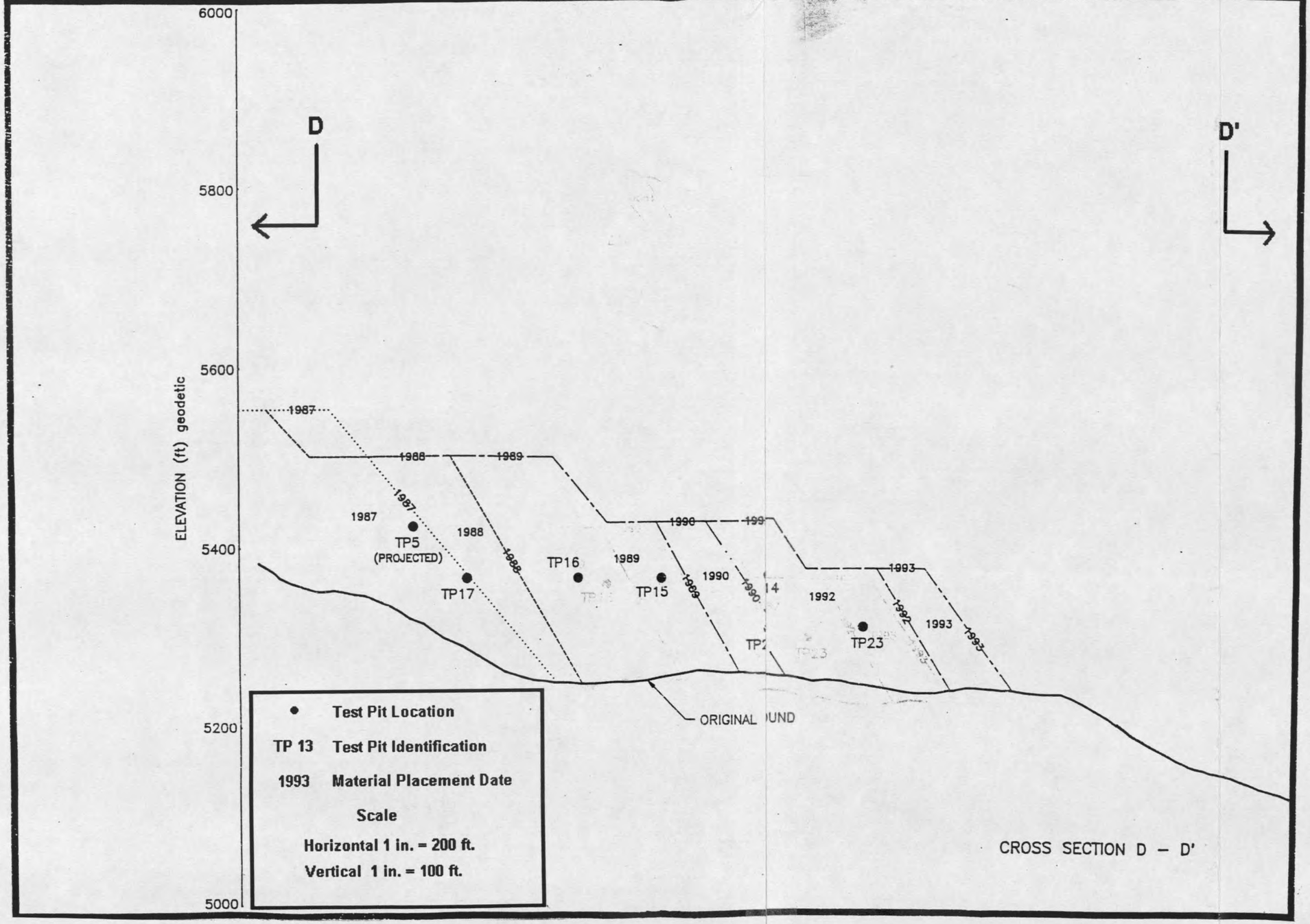


Figure 7. View of waste rock repository vertical plane through cross section D - D′.

RESULTS AND DISCUSSION

Waste Rock Physicochemical Characteristics

Field sampling activities revealed a highly variable waste rock pile made up of distinct layers of material. Layers of waste rock ranging from 10 cm to several meters in width were found to be dipping at an angle of approximately 40°. These layers of waste rock were comprised of either shale (sedimentary) or latite (igneous) rock types or a combination of the two. Both shale and latite rock types were found to contain massive and disseminated sulfide mineralization, with pyrite being the dominant sulfide mineral found. Often, color differences were sharply defined between layers. Munsell colors of waste rock ranged from red to reddish yellow to yellow - olive. Grain size differences between layers were observed, ranging from coarse "rubble layers" consisting of > 20 cm diameter particles with larger open interparticle voids to fine layers where voids between coarse particles were filled with silt and sand sized particles. A coarse rubble zone was found to exist at the base of the repository, most likely due to gravity sorting during pile construction.

Chemical characteristics of waste rock varied greatly between layers throughout the pile. A complete listing of chemical data can be found in Appendix A. A general overview of chemical data including means, standard deviations, minimum and maximum values are presented in Table 1. A mean value for neutralization potential is not presented because most layers had little or no neutralization potential. The 1:1 paste

Table 1. Chemical characteristics of waste rock materials.

Chemical Variable	n	Mean	Standard Deviation	Minimum	Maximum
Neutralization Potential (t $CaCO_3$/1000t)	121	--------	--------	<1	56.0
pH	121	3.6	1.4	2.0	7.6
EC (mmhos/cm)	121	8.09	3.89	0.85	17.73
SO_4 (mg/L)	121	11466	7793	417	40335
Al (mg/L)	121	572	649	< 1	2925
Fe (mg/L)	121	1157	1979	< 1	10363
Mn (mg/L)	121	35	42	< 1	201
Titratable Acidity (mg $CaCO_3$/L)	107	6806	6239	2.0	26615
Total Sulfur (%)	121	8.22	4.43	0.64	34.40
H_2O-S (%)	121	0.65	0.62	< 0.01	2.5
HCl-S (%)	121	0.47	0.74	< 0.01	5.3
HNO_3-S (%)	121	6.58	3.88	0.3	30.0
Residual-S (%)	121	0.52	0.44	.03	4.39

pH values ranged from 2.0 to 7.6 with a mean value of 3.6. Higher pH values (above 5.0) were associated with layers that contained a significant amount of neutralization potential due to the presence of chemical constituents capable of neutralizing acidity. The presence of neutralizing materials in some layers can also explain the wide range of titratable acidity data - from 2 to 26615 mg $CaCO_3$/L. In turn, the wide ranges of soluble SO_4, Fe, Al and Mn data can be attributed to the variability of acidity in the waste rock dump because high acidity and associated low pH results in the solubilization of these metals

and SO_4. Likewise, the high variability in electrical conductivity data can be attributed to varying levels of SO_4 solubilization due to varying levels of acidity. While the presence of neutralizing materials explains why the ranges of the chemical data are so great, it should be noted that only 22 out of the 121 samples contained a neutralization potential of 5 t $CaCO_3$/ 1000 t or greater. This explains why the means of the acidity influenced variables (EC, SO_4, Fe, Al and Mn) are much greater than the minimum values. In summary, the presence of neutralizing materials in some layers of the dump can cause soluble metal levels to be quite low (below detection limit), but the overall effects of these layers are negligible as shown by the higher mean values of the soluble metals and other acidity influenced variables.

Total sulfur values for waste rock samples ranged from 0.64 to 34.4% with a mean of 8.22%. Nitric acid (HNO_3) extractable sulfur exhibited the highest mean as compared to water and hydrochloric acid extractable sulfur. This suggests that a majority of the sulfur in this waste rock dump exists as sulfide sulfur, most likely in the form of pyrite (FeS_2).

Correlation Analysis of Waste Rock Chemical Data

In an effort to investigate the associations that exist between waste rock chemical variables, a Spearman Rank Order Correlation analysis was performed. Raw rank correlation results output including sample size are presented in Appendix C. A Spearman Rank Order Correlation is used to measure the strength of association between

pairs of variables without specifying which variable is dependent or independent. Results of this analysis are presented in Table 2. The Spearman correlation coefficient quantifies the strength of the association between the variables and varies between -1 and +1. A correlation coefficient near +1 indicates a strong positive relationship between the two variables, with both increasing together. A correlation coefficient near -1 indicates a strong negative relationship, with one variable decreasing as the other increases. A correlation coefficient near zero indicates no relationship between the two variables. A true association was assumed to exist if the p-value was less than 0.05.

Graphs illustrating the strongest relationships between waste rock variables are presented in Figures 8, 9 and 10. The production of hydrogen ions as shown previously in reactions one through three is greater for those samples that have undergone a higher degree of chemical weathering. Production of hydrogen ions causes a decrease in sample pH. In addition to hydrogen ions, weathering reaction products include Fe and SO_4, as shown in reactions one through three. Since H^+, Fe and SO_4 are all weathering reaction products, samples with a low pH (<4.0) also contain higher concentrations of water extractable Fe and SO_4 (Figure 8.) Increased acidity can also cause the solubilization of minerals found within a waste rock repository that may contain metals such as Al. These minerals become soluble at low pH levels, causing an increase in water extractable Al for those samples with a pH below 4.0 (Figure 8.) Since electrical conductivity (EC) is a measure of the amount of soluble salt in a sample, those samples with high EC measurements also have higher water extractable SO_4 values (Figure 8.)

Table 2. Correlation coefficients and associated p-values between various chemical characteristics in a waste rock repository.

Chemical Variable	pH	Electrical Conductivity (mmhos/cm)	Titratable Acidity (mg $CaCO_3$/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	SO_4 (mg/L)	Total Sulfur (%)	H_2O Sulfur (%)	HCL Sulfur (%)	HNO_3 Sulfur (%)
pH	------	-0.6702 <0.05	-0.8110 <0.05	-0.8342 <0.05	-0.8125 <0.05	-0.1376 0.1323	-0.7296 <0.05	-0.1486 0.1037	-0.1783 0.0504	-0.0064 0.9443	-0.1043 0.2543
Electical Conductivity	-0.6702 <0.05	------	0.6720 <0.05	0.7314 <0.05	0.6257 <0.05	0.4977 <0.05	0.8437 <0.05	0.2670 <0.05	0.1647 0.0710	0.0194 0.8324	0.2349 <0.05
Titratable Acidity	-0.8110 <0.05	0.6720 <0.05	------	0.7919 <0.05	0.9212 <0.05	-0.0069 0.9434	0.8299 <0.05	0.2679 <0.05	0.0770 0.4298	0.1216 0.2119	0.2353 <0.05
Fe (mg/L)	-0.8342 <0.05	0.7314 <0.05	0.7919 <0.05	------	0.7066 <0.05	0.3430 <0.05	0.7913 <0.05	0.3569 <0.05	0.2032 <0.05	0.0303 0.7408	0.3136 <0.05
Al (mg/L)	-0.8125 <0.05	0.6257 <0.05	0.9212 <0.05	0.7066 <0.05	------	0.1865 <0.05	0.7814 <0.05	0.1185 0.1951	0.1106 0.2267	0.0583 0.5249	0.0854 0.3513
Mn (mg/L)	-0.1376 0.1323	0.4977 <0.05	-0.0069 0.9434	0.3430 <0.05	0.1865 <0.05	------	0.5253 <0.05	0.1653 0.0700	0.1603 0.0790	-0.0266 0.7717	0.1628 0.0745
SO_4 (mg/L)	-0.7296 <0.05	0.8437 <0.05	0.8299 <0.05	0.7913 <0.05	0.7814 <0.05	0.5253 <0.05	------	0.2693 <0.05	0.2063 <0.05	0.0338 0.7123	0.2355 0.0094
Total Sulfur (%)	-0.1486 0.1037	0.2670 <0.05	0.2679 <0.05	0.3569 <0.05	0.1185 0.1951	0.1653 0.0700	0.2693 <0.05	------	0.1131 0.2165	0.0892 0.3303	0.9797 <0.05
H_20 Sulfur (%)	-0.1783 0.0504	0.1647 0.0710	0.0770 0.4298	0.2032 <0.05	0.1106 0.2267	0.1603 0.0790	0.2063 <0.05	0.1131 0.2165	------	-0.5509 <0.05	0.0360 0.6949
HCL Sulfur (%)	-0.0064 0.9443	0.0194 0.8324	0.1216 0.2119	0.0303 0.7408	0.0583 0.5249	-0.0266 0.7717	0.0338 0.7123	0.0892 0.3303	-0.5509 <0.05	------	0.0359 0.6951
HNO_3 Sulfur (%)	-0.1043 0.2543	0.2349 <0.05	0.2353 <0.05	0.3136 <0.05	0.0854 0.3513	0.1628 0.0745	0.2355 0.0094	0.9797 <0.05	0.0360 0.6949	0.0359 0.6951	------
Residual Sulfur (%)	-0.0284 0.7568	0.1332 0.1451	0.1007 0.3013	0.2036 <0.05	0.0256 0.7800	0.0242 0.7921	0.1111 0.2247	0.7712 <0.05	-0.1144 0.2113	0.1365 0.1354	0.7562 <0.05

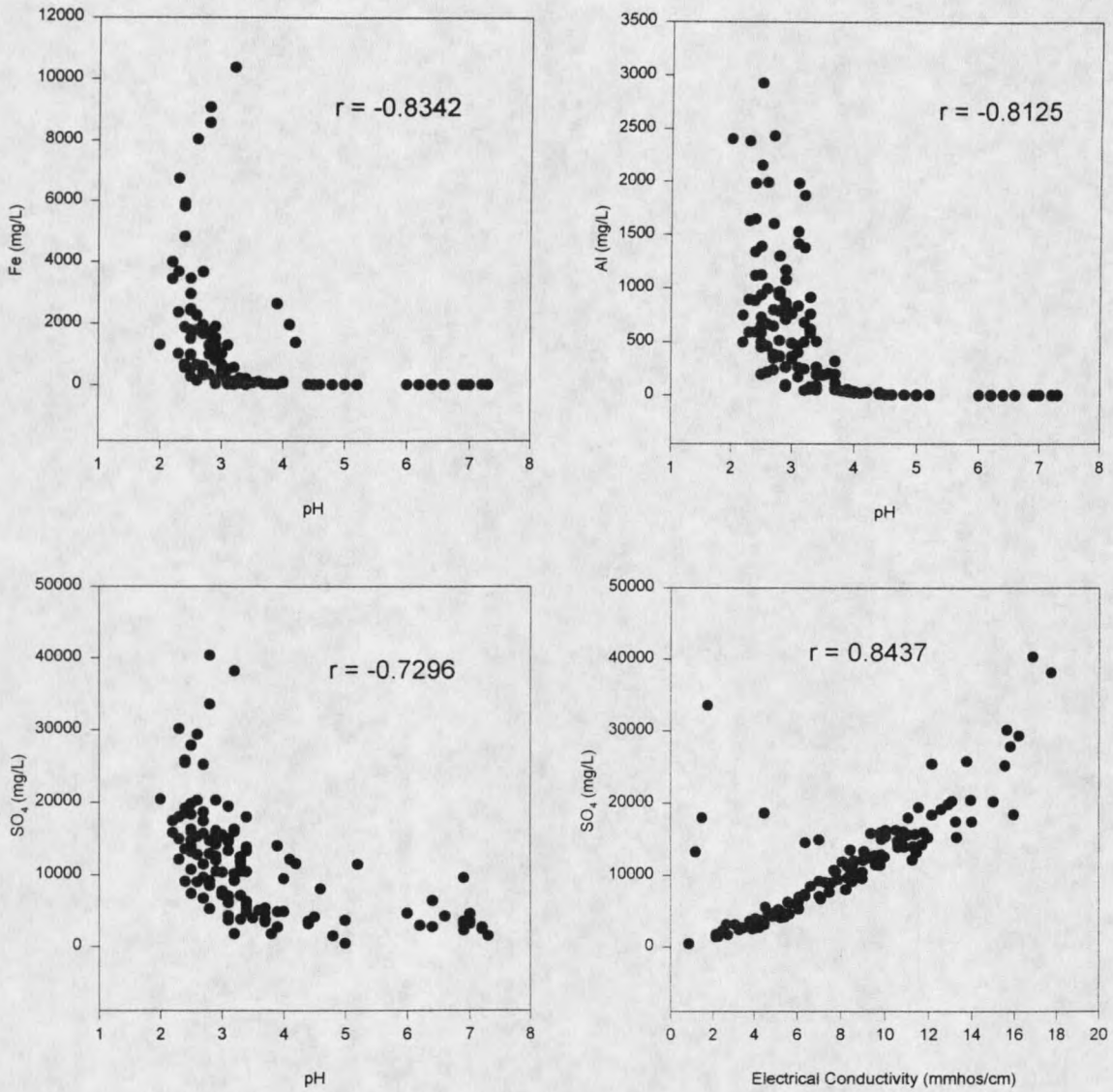


Figure 8. Relationships between waste rock repository pH, electrical conductivity and water extractable Fe, Al and SO_4.

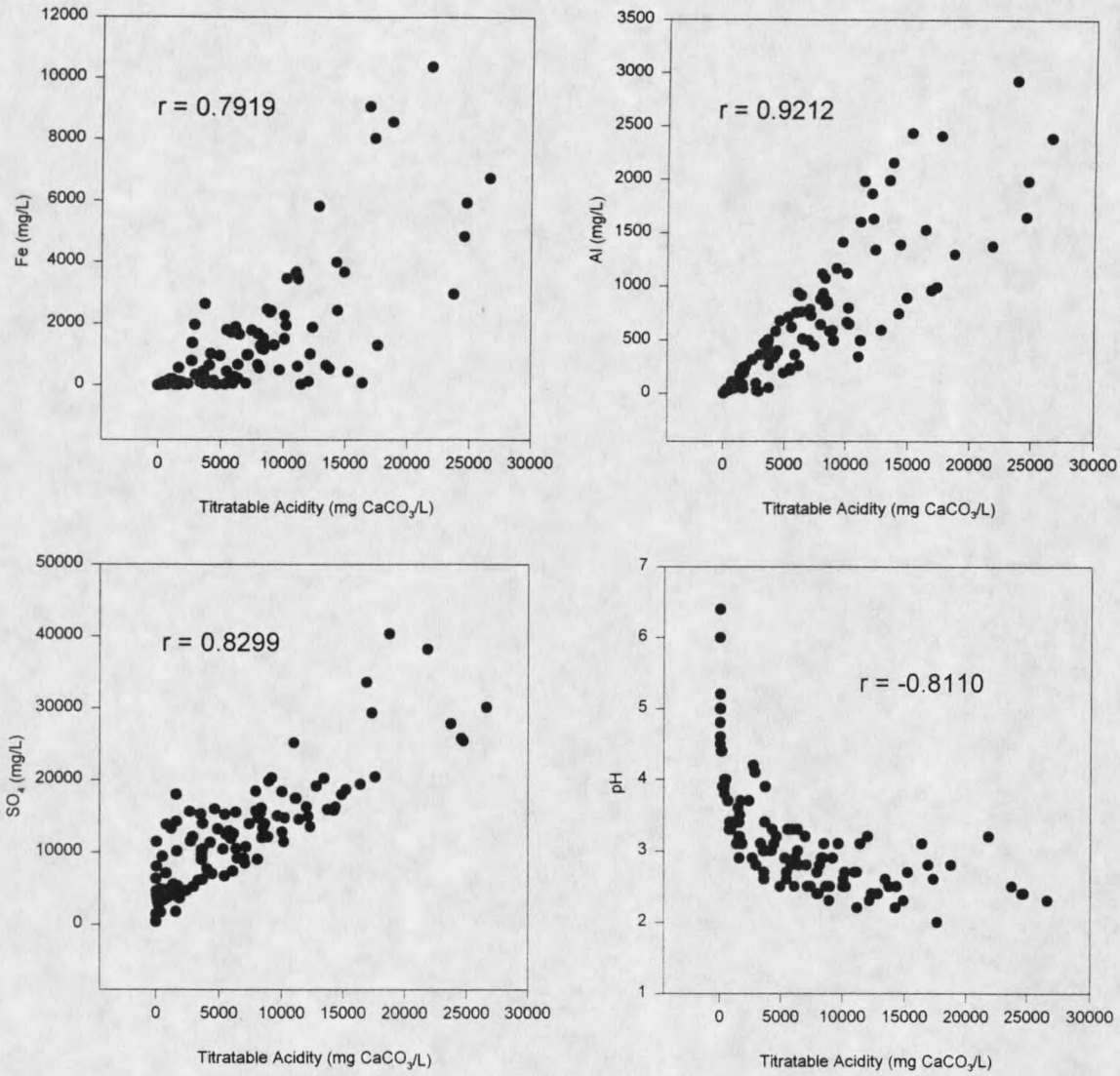


Figure 9. Relationships between waste rock repository titratable acidity and water extractable Fe, Al, SO_4 and pH.

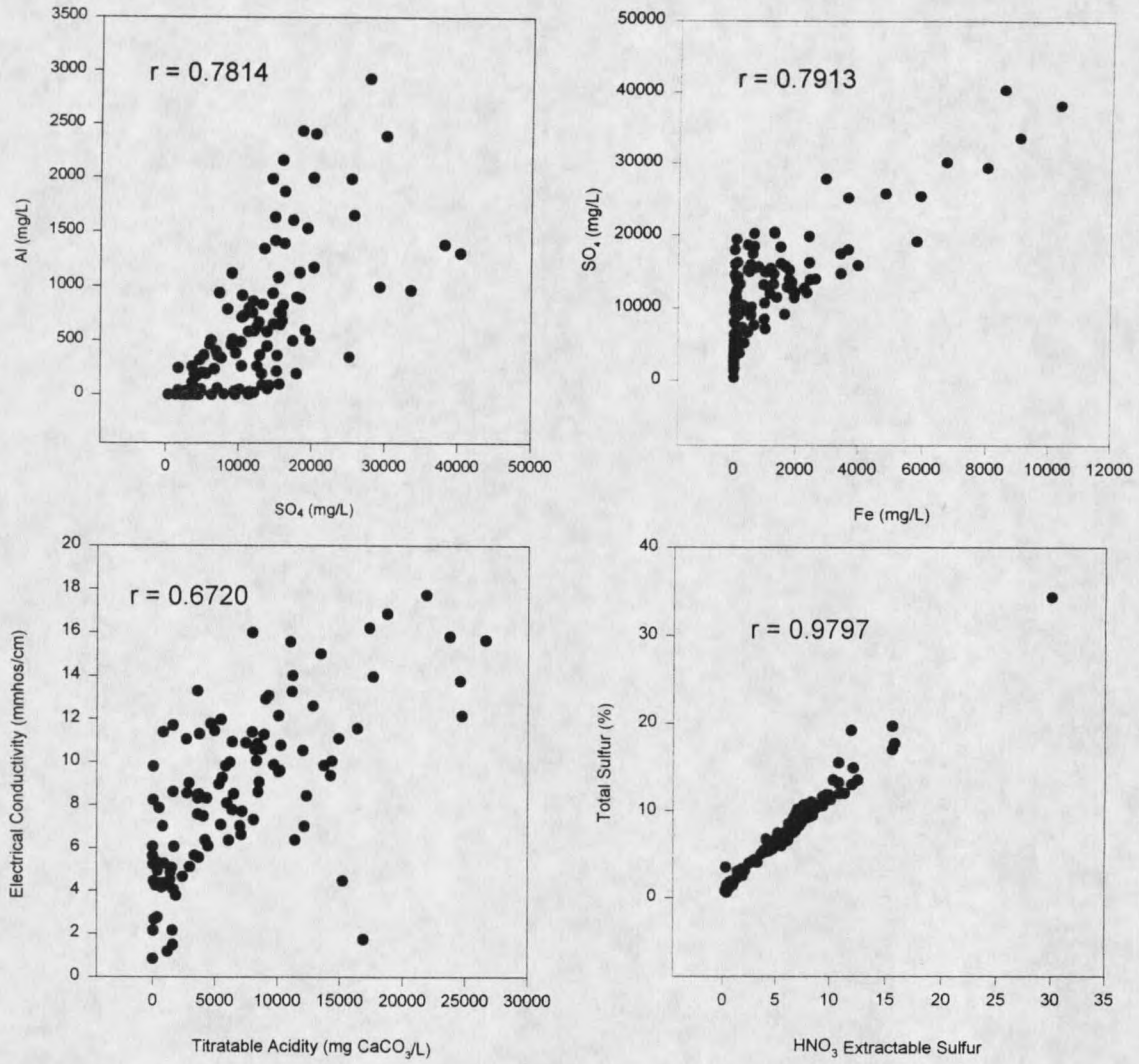


Figure 10. Relationships between HNO_3 extractable and total sulfur, electrical conductivity and titratable acidity, and water extractable SO_4 and Al and Fe.

Low pH values are correlated with high titratable acidity values as shown in Figure 9 due to increased acidity requiring the addition of more base to raise the sample pH to 7.0. This relationship appears to be exponential. For the same reasons as discussed for pH above, water extractable Fe, Al and SO_4 increase with titratable acidity (Figure 9.)

Because samples that contain high acidity have been shown to possess high concentrations of water extractable Fe, Al and SO_4, water extractable SO_4 is correlated with water extractable Fe ($r = 0.7913$) and Al ($r = 0.7814$) as shown in Figure 10. Due to SO_4 concentration being strongly correlated with titratable acidity ($r = 0.8299$), titratable acidity is also correlated with EC ($r = 0.6720$) as shown in Figure 10. The fourth graph contained in Figure 10 shows the strongly positive relationship between total sulfur and HNO_3 extractable sulfur. Total sulfur is more strongly related to HNO_3 extractable sulfur than any of the other extractable sulfur data ($r = 0.9797$). This graph illustrates that as total sulfur increases, so does HNO_3 extractable sulfur in a co-linear relationship. Since HNO_3 extractable sulfur is an indicator of sulfide-sulfur in a sample and sulfide-sulfur generally yields the most acid production, total sulfur contents can be used as a good predictor of the amount of acid a sample will produce.

Chemical Variability as a Function of Repository Age

In order to investigate how waste rock material undergoes weathering over time, one-way ANOVA analysis of waste rock chemical data was conducted based on sample

age. Table 3 summarizes the type of ANOVA used to analyze these data based on sample age.

Table 3. Type of ANOVA performed for analysis based on sample age.

Chemical Variable	One-way ANOVA	One-way ANOVA on transformed data[1]	One-way ANOVA on ranks
pH			X
Titratable Acidity		X (square root)	
EC	X		
SO_4		X (square root)	
Fe			X
Al		X (square root)	
Mn			X
Total Sulfur			X
H_2O Extractable S			X
HCL Extractable S			X
HNO_3 Extractable S			X
Residual Sulfur			X

[1] Transformations applied.

Table 4 contains the one-way ANOVA results for chemical data based on sample age. Samples were grouped in three age classes for this analysis. The first group contains the oldest samples, placed on the pile prior to or during 1988. The second grouping contains data from samples placed on the pile during the years 1989 and 1990. The third grouping contains data from the youngest samples, placed on the pile during 1992, 1993 or 1994.

Table 4. One-way ANOVA results based on sample age.

Depository Placement	N	Mean pH	Mean Titratable Acidity (mg $CaCO_3$/L)	Mean EC (mmhos/cm)	Mean SO_4 (mg/L)	Mean Fe (mg/L)	Mean Al (mg/L)	Mean Mn (mg/L)
≤ 1988	39	3.05 ± 0.89a[1]	9912 ± 6876 a	9.92 ± 4.44 a	15648 ± 9646 a	2197 ± 2839 a	901 ± 703 a	37 ± 40 a
1989 - 1990	52	3.45 ± 1.33 a	6054 ± 5561 b	7.40 ± 3.42 b	9915 ± 6350 b	821 ± 1269 a b	524 ± 585 b	28 ± 37 a
1992 - 1994	28	4.65 ± 1.68 b	3047 ± 3623 c	7.04 ± 3.14 b	8954 ± 4862 b	414 ± 759 b	216 ± 484 c	47 ± 52 a

Depository Placement	N	Mean Total Sulfur (%)	Mean H_20 Extractable Sulfur (%)	Mean HCl Extractable Sulfur (%)	Mean HNO_3 Extractable Sulfur (%)	Mean Residual Sulfur (%)
≤ 1988	39	8.81 ± 5.79 a	0.68 ± 0.59 a	0.32 ± 0.54 a	7.22 ± 5.18 a	0.60 ± 0.68 a
1989 - 1990	52	7.47 ± 3.93 a	0.76 ± 0.68 a	0.53 ± 0.94 a	5.73 ± 3.20 a	0.45 ± 0.26 a
1992 - 1994	28	8.84 ± 2.99 a	0.46 ± 0.51 a	0.53 ± 0.50 a	7.30 ± 2.72 a	0.56 ± 0.26 a

[1] Means in the same column followed by the same letter are not significantly different ($p \leq 0.05$)

Because acidity, Fe and SO_4 are waste rock weathering products, waste rock that is highly weathered will contain greater concentrations of these products. Each is significantly greater for samples taken from waste rock that has resided in the repository for longer periods of time and thus has been exposed to environmental conditions for longer periods of time. Due to increased acidity in the older aged samples, the solubilization of Al bearing minerals is increased. This results in higher water extractable Al concentrations in older portions of the repository. Mean water soluble Mn concentrations were not shown to vary significantly with respect to sample age. As previously mentioned, low Mn concentrations may point to random variability as a reason for uniform Mn distribution and the non-dependence on acidity. Mean total sulfur, residual sulfur and the extractable sulfur data do not vary significantly with respect to sample age. This suggests that sulfur content of waste rock material does not vary significantly from year to year due to uniformity of sulfur in the waste rock.

Chemical Variability as a Function of Position within Repository

In order to investigate the influence of geographical position within the waste rock pile on the extent of weathering, a one-way analysis of variance (ANOVA) analysis of waste rock chemical data was conducted based on sample elevation. Table 5 summarizes the type of ANOVA used to analyze these data based on sample depth.

Table 5. Type of ANOVA performed for analysis based on sample position.

Chemical Variable	One-way ANOVA	One-way ANOVA on transformed data[1]	One-way ANOVA on ranks
pH			X
Titratable Acidity		X (square root)	
EC	X		
SO_4		X (square root)	
Fe			X
Al			X
Mn			X
Total Sulfur			X
H_2O Extractable S		X (square root)	
HCL Extractable S			X
HNO_3 Extractable S			X
Residual Sulfur			X

[1] Transformations applied.

Table 6 contains the one-way ANOVA results for chemical data based on sample elevations. Depth class 1 refers to the uppermost portions of the dump, greater than 1661m (5450 ft) in elevation. Depth classes 2 and 3 contain those samples located on the 1634 m (5360 ft) and 1615 m (5300 ft) bench elevations, respectively. Depth class 4 contains those samples located nearest the bottom of the dump facility, at elevation 1603 m (5260 ft) and below.

From this analysis, it can easily be seen that the samples taken from the upper portions of the repository have significantly higher concentrations of waste rock

Table 6. One-way ANOVA results based on sample elevation.

Depth Class[1]	N	Mean pH	Mean Titratable Acidity (mg $CaCO_3$/L)	Mean EC (mmhos/cm)	Mean SO_4 (mg/L)	Mean Fe (mg/L)	Mean Al (mg/L)	Mean Mn (mg/L)
1	14	2.75 ± 1.03a[2]	12360 ± 4752 a	11.07 ± 3.78 a	16091 ± 5621 a	1602 ± 1425 a	1242 ± 851 a	24 ± 21 a b
2	35	3.23 ± 1.35 a	9870 ± 7446 a	8.98 ± 3.95 a b	13973 ± 9301 a	2048 ± 2875 a	810 ± 688 a	38 ± 48 a b
3	52	3.68 ± 1.12 b	4138 ± 4004 b	7.83 ± 3.59 b	10478 ± 6843 b	822 ± 1431 a b	331 ± 354 b	44 ± 47 b
4	20	4.62 ± 1.83 b	3767 ± 4048 b	5.13 ± 2.40 c	6413 ± 4954 c	159 ± 297 b	314 ± 563 b	16 ± 13 a

Depth Class	N	Mean Total Sulfur (%)	Mean H_20 Extractable Sulfur (%)	Mean HCl Extractable Sulfur (%)	Mean HNO_3 Extractable Sulfur (%)	Mean Residual Sulfur (%)
1	14	9.26 ± 8.41 a	0.34 ± 0.39 a	0.87 ± 0.81 a	7.33 ± 7.47 a	0.73 ± 1.09 a
2	35	8.78 ± 4.32 a	0.80 ± 0.53 b	0.38 ± 1.00 b	7.08 ± 3.65 a	0.52 ± 0.28 a
3	52	8.06 ± 2.75 a	0.83 ± 0.70 b	0.32 ± 0.40 b	6.44 ± 2.33 a	0.47 ± 0.20 a
4	20	6.94 ± 4.30 a	0.16 ± 0.25 a	0.71 ± 0.70 a	5.56 ± 4.08 a	0.52 ± 0.35 a

[1] Depth Class 1 = uppermost depths, 4 = lowest depth.

[2] Means in the same column followed by the same letter are not significantly different ($p \leq 0.05$)

weathering products. This may be because the upper portions of the dump are more likely to come into contact with air and precipitation, both of which are needed to drive the waste rock weathering reactions. For example, mean sample pH values are significantly lower and mean titratable acidity values are significantly higher in the upper portions of the dump. Since more oxidation is occurring in the upper portions of the repository, water extractable Fe and SO_4, both weathering reaction products, are significantly higher in these regions. Because increased acidity is generated in these areas that are more exposed to air and precipitation, conditions are more favorable for the dissolution of Al bearing minerals resulting in significantly higher concentrations of water extractable Al. EC is also higher in the upper portions of the repository because SO_4 is a weathering reaction product and EC and SO_4 are strongly correlated as shown previously. Mean soluble Mn concentrations were not found to follow the same trend as the other soluble metals. Since Mn concentrations were at lower levels than the other metals, it's infrequent occurrence at detectable levels in the repository may point to random variability in the overburden materials as a reason for it's non-dependence on acidity. For instance, certain portions of the waste rock repository may contain more or less Mn primarily due to overburden variability. Mean total sulfur, residual sulfur and HNO_3 extractable sulfur values did not vary significantly throughout the waste rock pile. This supports the fact that the waste rock pile is homogeneous with respect to sulfur content. Mean H_2O and HCl extractable sulfur values were found to vary within the waste rock repository with respect to position,

but this variation can be attributed to random variability in sulfide mineral solubility and composition.

Chemical Variability as a Function of Sample Particle Size

In an attempt to associate waste rock particle size with waste rock chemical data, one-way ANOVA analysis of waste rock chemical data was performed based on percent passing a 2mm sieve by weight. Table 7 summarizes the type of ANOVA used to analyze this data based on sample particle size.

Table 7. Type of ANOVA performed for analysis based on sample particle size.

Chemical Variable	One-way ANOVA	One-way ANOVA on transformed data[1]	One-way ANOVA on ranks
pH			X
Titratable Acidity		X (square root)	
EC	X		
SO_4		X (square root)	
Fe			X
Al		X (square root)	
Mn		X (natural log)	

[1] Transformation applied

Table 8 contains the one-way ANOVA results for chemical data based on percent passing a 2mm sieve by weight. Particle size data were obtained from Greg Herasymuik at the University of Saskatchewan. Waste rock samples were divided into groups based on percent passing a 2 mm sieve. No samples were determined to have greater than 40

Table 8. One-way ANOVA results based on sample percent passing a 2mm sieve.

% Passing 2mm Sieve	N	Mean pH	Mean Titratable Acidity (mg $CaCO_3$/L)	Mean EC (mmhos/cm)	Mean SO_4 (mg/L)	Mean Fe (mg/L)	Mean Al (mg/L)	Mean Mn (mg/L)
≤ 10	31	4.02 ± 1.65a[1]	5347 ± 5860 a	7.34 ± 3.99 a	8870 ± 6996 a	705 ± 1329 a	428 ± 571 a	24 ± 23 a
11 - 20	30	3.22 ± 1.20 a	9211 ± 7342 a	9.52 ± 3.66 a	14670 ± 7948 b c	1674 ± 2067 a	785 ± 759 a	36 ± 37 a
21 - 30	20	3.30 ± 1.16 a	8657 ± 6284 a	9.46 ± 4.35 a	14640 ± 8845 b c	1836 ± 2805 a	781 ± 706 a	53 ± 63 a
31 - 40	12	3.44 ± 1.26 a	5585 ± 5496 a	6.80 ± 3.55 a	12083 ± 7909 a c	1109 ± 2597 a	501 ± 605 a	57 ± 64 a

[1] Means in the same column followed by the same letter are not significantly different ($p \leq 0.05$)

percent passing a 2 mm sieve. Data presented in Table 8 shows no significant differences in waste rock chemical variables based on sample particle size. These data do not show a trend as anticipated. Observations were made while sampling this waste rock repository of some large waste rock particles that would crumble easily when agitated with hand pressure. This indicates that increased physical breakdown of waste rock particles could be associated with a high degree of chemical weathering. This would result in samples with finer particle sizes containing more waste rock weathering products. Data presented in Table 8 do not support this association, but do indicate that sample particle size is independent of sample chemistry. For example, a sample with < 10% of its mass passing a 2 mm sieve might contain more acidity (indicating a higher degree of weathering) than a sample with 31 - 40% of its mass passing a 2 mm sieve. One possible explanation of these data is that sample chemistry depends more on mineralogy than the degree of physical weathering. For example, a sample might be broken down into fine particles which would indicate a high degree of weathering, yet this sample would contain less waste rock weathering products than a sample made up of larger particle sizes because the larger particle-sized sample contained minerals that were more likely to produce acidity, Fe and SO_4.

Scanning Electron Microscopy Analysis

While sampling in the waste rock pile, occasionally salt formations and other secondary mineral formation were noticed. These often occurred in areas of the dump where steam venting was evident. Salts were often crystalline in structure and were collected for scanning electron microscopy analysis. This analysis was performed to determine the chemical makeup of these substances. A summary of this analysis can be found in Table 9.

Table 9. Summary of SEM Analysis.

Sample Location	Sample Appearance	Possible Chemical Makeup
Test Pit 3 GS4	turquoise blue, crystalline	copper sulfate
Test Pit 6 GS1	white salt precipitates	magnesium, zinc sulfates
Test Pit 15, near moist venting	crystalline	magnesium sulfate
Test Pit 15 GS2, near vent	clay-like deposits	aluminum compound
Test Pit 20 GS1	black hard deposits	copper sulfate
Test Pit 21 GS1	yellow salt deposits	magnesium sulfate

SUMMARY AND CONCLUSIONS

This study was conducted to document and understand chemical weathering within a large pyritic waste rock repository. Thirty test pits were excavated and 121 waste rock samples were collected for geochemical and physical analysis, including particle size, pH, titratable acidity, electrical conductivity, soluble iron, aluminum, manganese and sulfate, sulfur fractionation and neutralization potential. Data from waste rock samples were compiled and analyzed to determine the extent of weathering in the waste rock repository, characterize the geochemical variations in the waste rock repository and correlate the extent of weathering with physical waste rock characteristics.

Field sampling activities showed a highly variable waste rock pile made up of distinct layers of material. Chemical characteristics of waste rock varied greatly within layers throughout the repository. Mean pH was 3.6 with a mean titratable acidity of 6806 mg $CaCO_3$/L. Mean electrical conductivity was 8.09 mmhos/cm and mean soluble SO_4 was 11466 mg/L. Mean soluble Fe was 1157 mg/L, soluble Al was 572 mg/L and soluble Mn was 35 mg/L. Mean total sulfur content was 8.22 % with most (6.58 %) existing as HNO_3 extractable sulfur. This suggests that a majority of the sulfur in this repository exists as sulfide sulfur, most likely in the form of pyrite (FeS_2).

In an effort to investigate the associations that exist between waste rock chemical variables, a correlation analysis was performed on waste rock chemical data. Low sample pH and high sample titratable acidity were shown to be correlated with high levels of soluble SO_4, Fe and Al. Additionally, soluble SO_4 was shown to be correlated with both

soluble Fe ($r = 0.7913$) and Al ($r = 0.7814$). Finally, increased sample titratable acidity was shown to be correlated with an increased sample electrical conductivity ($r = 0.6720$). These correlations exist because acidity, SO_4 and Fe are all waste rock weathering products and increase together. In the case of Al, it is released when conditions are acidic enough to cause the solubilization of minerals containing Al.

The weathering of pyritic waste rock occurs when it comes into contact with air and water. This study revealed that regions of the waste rock dump where this interface occurred was more highly weathered. For instance, samples of waste rock taken from the upper portions of the dump contained greater levels of acidity, electrical conductivity, and water soluble SO_4, aluminum and iron. These data support the interpretation that this waste rock pile was undergoing chemical weathering where it was exposed to atmospheric conditions, but that weathering may be significantly decreased at locations where the influx of air and water into the dump were impeded.

Though weathering may be significantly decreased deep within the dump, data support that weathering may still be occurring at all locations within this waste rock pile. The oldest aged samples (placed on the repository in 1988 or earlier) found deep in the interior of the waste rock dump showed the highest degree of weathering. This was supported by data that show the oldest aged samples contain greater levels of acidity, electrical conductivity and water soluble SO_4, iron and aluminum. Possibly, waste rock was exposed to conditions favorable to weathering when it was first placed on the

repository, then overlain by subsequent additions to the pile. Even though the oldest samples were farther away from the interface of oxygen and water, some degree of weathering must still be occurring in order for these samples to show a significantly higher degree of weathering than the younger aged samples (placed in 1992 or later).

Some confusion may result by the fact that samples taken from the upper portions of the repository and the oldest aged samples (which inherently reside deeper within the repository) both contained greater levels of waste rock weathering products. This apparent contradiction can be explained by examining the way in which the waste rock repository was constructed. Since new material is placed on the repository by end-dumping from the edge, the oldest aged samples reside not only at the deepest vertical positions but also deeper toward the interior of the repository from the edge. Thus, these two conclusions are not inconsistent. Samples taken from the upper portions of the repository, where the interface with the environment is greater, are shown to contain more weathering products as compared with those samples taken from the lower portions of the repository. Additionally, that material which has resided in the repository for longer periods of time contains more weathering products than the younger aged material, irrespective of its vertical position in the repository.

Sample chemistry was not shown to vary significantly with sample particle size. It was thought that a highly weathered sample would contain smaller particle sizes and higher concentrations of weathering products. This was shown to be false, possibly due

to sample mineralogy having more influence on chemistry than the amount of physical breakdown the waste rock has undergone.

Scanning electron microscopy analysis was used to estimate the chemical makeup of secondary minerals found within the waste rock repository. Since secondary mineral formation was noticed in areas where water vapor movement was evident, the chemical composition of these minerals may give an indication of the types of substances contained in and transported by these moisture migration pathways. Secondary minerals identified include copper, magnesium and zinc sulfates.

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APPENDIX A

Waste Rock Chemical Data

Table 10. Waste rock chemical data.

Sample	NP	Total Sulfur	Hot H2O S	HCL S	HNO3 S	Residual S	EC	SO4	Acidity	Al	Fe	Mn	pH
ID	t/1000t	%	%	%	%	%	mhos/c	mg/L	mg CaCO3/	mg/L	mg/L	mg/L	
TP1GS1	35.0	6.050	1.420	<0.01	4.340	0.290	5.63	4620.0	15.0	<1	6.0	25.0	6.0
TP2GS1	6.0	5.620	0.640	<0.01	4.720	0.260	6.07	5319.0	1717.0	197.0	17.0	23.0	3.7
TP3GS1	<1	2.580	0.300	<0.01	1.940	0.340	2.15	1764.0	1584.0	244.0	10.0	1.0	3.2
TP3GS2	1.0	5.380	0.760	<0.01	4.390	0.230	7.08	6702.0	5452.0	237.0	452.0	9.0	2.7
TP3GS3	<1	5.290	1.000	<0.01	3.990	0.300	11.70	14256.0	1624.0	83.0	123.0	158.0	2.9
TP3GS4	<1	6.560	1.220	0.040	4.900	0.400	11.55	19416.0	16395.0	1528.0	70.0	14.0	3.1
TP4GS1	<1	19.200	0.900	5.300	11.900	1.090	15.64	30135.0	26615.0	2385.0	6733.0	5.0	2.3
TP4GS2	<1	4.120	0.270	<0.01	3.330	0.520	5.12	5241.0	2981.0	363.0	342.0	8.0	2.8
TP4GS3	<1	2.880	0.570	<0.01	2.010	0.300	3.78	3645.0	1867.0	259.0	102.0	7.0	3.1
TP4GS4	<1	8.820	1.570	<0.01	6.750	0.500	6.37	7164.0	4218.0	359.0	1031.0	16.0	3.0
TP4GS5	<1	7.250	1.200	<0.01	5.720	0.330	11.46	13209.0	4924.0	194.0	965.0	61.0	2.5
TP5GS1	<1	10.400	1.670	0.370	7.800	0.560	1.74	33564.0	16900.0	962.0	9069.0	142.0	2.8
TP5GS2	<1	9.740	1.430	<0.01	8.010	0.300	16.20	29346.0	17331.0	991.0	8030.0	181.0	2.6
TP5GS3	<1	9.460	0.580	<0.01	8.240	0.640	12.58	19161.0	12828.0	592.0	5815.0	103.0	2.4
TP5GS4	<1	10.600	0.300	0.410	9.400	0.490	10.76	14766.0	10256.0	650.0	3453.0	80.0	2.5
TP5GS5	<1	11.000	2.180	<0.01	8.340	0.480	11.39	15711.0	7967.0	646.0	1678.0	77.0	2.7
TP5GS6	<1	9.560	0.670	<0.01	8.330	0.560	17.73	38163.0	21842.0	1376.0	10363.0	102.0	3.2
TP6GS1	<1	12.000	<0.01	<0.01	11.300	0.690	12.15	18375.0	10069.0	1120.0	1511.0	36.0	2.5
TP6GS2	<1	6.740	0.910	<0.01	5.410	0.420	11.97	15237.0	5465.0	216.0	1799.0	25.0	2.6
TP6GS3	<1	11.300	0.600	<0.01	10.100	0.620	10.58	14712.0	8162.0	932.0	1294.0	35.0	2.8
TP6GS4	<1	9.380	0.520	<0.01	8.250	0.610	9.86	15021.0	9688.0	1412.0	502.0	63.0	3.1
TP6GS5	<1	4.220	0.910	<0.01	2.950	0.360	6.63	8493.0	7091.0	786.0	992.0	9.0	2.8
TP7GS1	<1	17.000	0.500	<0.01	15.600	0.930	13.76	25782.0	24588.0	1647.0	4828.0	2.0	2.4
TP7GS2	<1	6.780	0.740	0.600	5.090	0.350	6.36	7368.0	6103.0	936.0	268.0	2.0	2.5
TP7GS3	<1	2.510	0.720	0.060	1.550	0.180	9.83	15939.0	13737.0	2155.0	537.0	6.0	2.5
TP7GS4	<1	9.000	1.550	<0.01	6.860	0.590	8.43	13545.0	12329.0	1339.0	1878.0	<1	2.4
TP7GS5	<1	3.150	0.740	<0.01	2.160	0.250	7.32	9045.0	8080.0	1114.0	561.0	1.0	2.4
TP7GS6	<1	19.700	<0.01	2.500	15.600	1.600	12.15	25425.0	24743.0	1983.0	5928.0	2.0	2.4
TP7GS7	<1	10.600	1.300	<0.01	8.650	0.650	10.04	16257.0	14357.0	1387.0	2437.0	18.0	2.5

Table 10. Waste rock chemical data.

Sample	NP	Total Sulfur	Hot H2O S	HCL S	HNO3 S	Residual S	EC	SO4	Acidity	Al	Fe	Mn	pH
ID	t/1000t	%	%	%	%	%	mhos/c	mg/L	mg CaCO3/	mg/L	mg/L	mg/L	
TP7GS8	<1	4.400	0.330	0.750	3.070	0.250	10.53	16263.0	12032.0	1866.0	113.0	46.0	3.2
TP8GS1	<1	13.000	0.300	<0.01	12.000	0.730	7.49	7671.0	4069.0	338.0	659.0	26.0	3.0
TP8GS2	3.0	9.410	1.120	1.040	6.810	0.440	7.02	7080.0	794.0	56.0	102.0	39.0	3.3
TP9GS1	35.0	11.000	1.140	<0.01	9.370	0.490	4.36	3492.0	N/A	<1	<1	2.0	7.0
TP9GS2	14.0	13.200	<0.01	1.500	10.800	0.870	5.43	4524.0	N/A	<1	6.0	20.0	7.0
TP9GS3	37.0	9.500	<0.01	0.700	8.170	0.630	3.47	2658.0	N/A	<1	<1	1.0	7.2
TP10-F	3.0	9.490	1.240	<0.01	7.700	0.550	4.25	3783.0	959.0	74.0	184.0	10.0	3.3
TP10-C	<1	6.820	<0.01	0.590	5.700	0.530	7.78	10485.0	6375.0	912.0	218.0	28.0	3.3
TP11GS1	2.0	0.640	0.150	<0.01	0.450	0.040	0.85	417.0	15.0	<1	<1	3.0	5.0
TP11GS2	3.0	0.790	0.220	<0.01	0.300	0.270	2.14	1437.0	29.0	2.0	<1	5.0	4.8
TP11GS3	<1	7.460	1.090	0.780	5.260	0.330	15.55	25188.0	11005.0	346.0	3665.0	37.0	2.7
TP11GS4	<1	2.930	0.900	<0.01	1.730	0.300	9.82	12900.0	5832.0	366.0	1717.0	22.0	2.8
TP11GS5	<1	8.080	1.040	<0.01	6.700	0.340	16.85	40335.0	18756.0	1298.0	8563.0	35.0	2.8
TP12GS1	N/A	8.350	<0.01	0.700	7.260	0.390	4.85	4266.0	1414.0	172.0	136.0	10.0	3.1
TP12GS2	<1	7.540	0.610	0.570	5.960	0.400	8.33	9633.0	3623.0	383.0	317.0	21.0	2.7
TP12GS3	<1	6.990	0.820	<0.01	5.760	0.410	7.58	8973.0	3623.0	461.0	142.0	17.0	2.6
TP12GS4	4.0	10.200	2.200	<0.01	7.080	0.920	9.98	12543.0	6171.0	264.0	1891.0	20.0	2.9
TP12GS5	2.0	9.560	0.370	0.630	8.120	0.440	9.06	13320.0	8525.0	831.0	1292.0	26.0	3.1
TP12GS6	<1	9.180	1.210	<0.01	7.330	0.640	8.61	12024.0	8448.0	860.0	1174.0	27.0	2.9
TP13GS1	<1	10.300	<0.01	1.110	8.730	0.460	4.06	3984.0	1661.0	190.0	70.0	15.0	3.5
TP13GS2	<1	13.500	2.500	<0.01	10.310	0.690	4.95	4872.0	397.0	26.0	69.0	49.0	4.0
TP13GS3	9.0	6.120	0.490	0.060	5.340	0.230	5.07	5028.0	1521.0	203.0	103.0	28.0	3.6
TP13GS4	3.0	6.350	0.500	0.170	5.360	0.320	2.75	1719.0	388.0	39.0	20.0	6.0	3.8
TP14GS1	40.0	6.720	0.960	<0.01	5.410	0.350	4.08	3450.0	N/A	<1	<1	2.0	6.9
TP14GS2	6.0	10.700	1.760	0.600	7.650	0.690	7.87	9432.0	513.0	31.0	95.0	73.0	4.0
TP14GS3	11.0	8.670	0.740	<0.01	7.430	0.500	5.24	4092.0	39.0	2.0	6.0	24.0	4.5
TP14GS4	11.0	8.430	0.860	<0.01	7.120	0.450	8.24	8016.0	48.0	3.0	7.0	61.0	4.6
TP15GS1	<1	1.900	0.870	0.120	0.860	0.050	11.78	15975.0	4650.0	680.0	27.0	88.0	3.2
TP15GS2	<1	3.330	1.010	0.340	1.890	0.090	1.48	17988.0	1615.0	191.0	12.0	94.0	3.4

Table 10. Waste rock chemical data.

Sample	NP	Total Sulfur	Hot H2O S	HCL S	HNO3 S	Residual S	EC	SO4	Acidity	Al	Fe	Mn	pH
ID	t/1000t	%	%	%	%	%	mhos/c	mg/L	mg CaCO3/	mg/L	mg/L	mg/L	
TP15GS3	<1	4.020	0.870	0.410	2.580	0.160	12.92	19839.0	9010.0	498.0	2418.0	41.0	2.5
TP15GS4	16.0	8.520	1.810	<0.01	6.250	0.460	5.41	4176.0	N/A	<1	<1	8.0	6.6
TP16GS1	<1	9.030	1.760	0.150	6.680	0.440	8.52	9174.0	6471.0	510.0	1653.0	17.0	2.8
TP16GS2	<1	9.770	2.430	<0.01	6.950	0.390	9.59	11451.0	10192.0	798.0	1944.0	8.0	2.7
TP16GS3	<1	8.880	1.170	0.620	6.670	0.420	11.26	12138.0	8913.0	589.0	2366.0	18.0	2.3
TP16GS4	<1	7.170	1.010	<0.01	5.760	0.400	10.93	15519.0	6355.0	761.0	673.0	96.0	3.0
TP16GS5	<1	9.040	0.500	1.370	6.690	0.480	10.85	16092.0	8390.0	825.0	1528.0	78.0	2.9
TP16GS6	<1	6.720	1.200	<0.01	5.110	0.410	10.05	15438.0	8312.0	1075.0	1189.0	36.0	2.9
TP16GS7	<1	10.400	1.640	<0.01	8.300	0.460	13.08	20292.0	9242.0	1167.0	1317.0	187.0	2.9
TP17GS1	<1	9.030	1.450	<0.01	7.100	0.480	9.27	12474.0	5561.0	618.0	89.0	37.0	3.3
TP17GS2	<1	9.880	1.550	<0.01	7.930	0.400	8.50	10422.0	3701.0	263.0	49.0	30.0	3.4
TP17GS3	2.0	8.970	1.260	<0.01	6.910	0.800	5.31	4809.0	378.0	43.0	8.0	17.0	3.9
TP17GS4	1.0	8.400	1.200	<0.01	6.590	0.610	4.32	3495.0	203.0	24.0	3.0	14.0	4.4
TP17GS5	12.0	7.790	0.110	0.200	6.900	0.580	4.45	3633.0	68.0	4.0	1.0	16.0	5.0
TP18GS1	1.0	10.500	0.650	0.780	8.490	0.580	8.48	10350.0	3643.0	487.0	314.0	82.0	3.0
TP18GS2	1.0	9.340	1.020	<0.01	7.880	0.440	11.38	13815.0	823.0	81.0	69.0	201.0	3.4
TP18GS3	20.0	6.020	0.020	<0.01	5.560	0.440	8.98	9558.0	N/A	<1	<1	9.0	6.9
TP18GS4	3.0	9.200	0.820	<0.01	7.920	0.460	1.18	13275.0	1207.0	88.0	196.0	110.0	3.4
TP18GS5	<1	10.000	0.620	1.270	7.750	0.360	10.60	13914.0	8680.0	582.0	2463.0	45.0	2.5
TP18GS6	<1	7.670	<0.01	0.680	6.680	0.310	13.30	15282.0	3572.0	361.0	450.0	192.0	3.0
TP18GS7	10.0	6.290	0.060	0.620	5.080	0.530	9.79	11433.0	48.0	2.0	9.0	112.0	5.2
TP19GS1	8.0	10.500	<0.01	0.800	9.020	0.680	4.37	3411.0	635.0	52.0	44.0	12.0	3.7
TP19GS2	<1	11.800	<0.01	1.100	9.940	0.760	7.02	9189.0	6995.0	498.0	57.0	6.0	3.2
TP20GS1	<1	6.550	<0.01	0.100	6.040	0.410	5.28	4851.0	911.0	47.0	70.0	35.0	3.4
TP20GS2	<1	7.740	0.100	0.670	6.410	0.560	6.09	6987.0	4437.0	400.0	152.0	18.0	3.1
TP20GS3	<1	14.900	2.200	<0.01	12.100	0.650	6.06	6351.0	2.0	<1	<1	21.0	6.4
TP21GS1	9.0	8.380	<0.01	0.720	6.530	1.130	8.55	11526.0	2751.0	27.0	1385.0	66.0	4.2
TP21GS2	2.0	9.190	0.310	1.070	7.060	0.750	11.30	13995.0	3724.0	53.0	2639.0	49.0	3.9
TP21GS3	12.0	9.510	<0.01	0.460	8.470	0.580	9.01	12117.0	2916.0	20.0	1966.0	42.0	4.1

Table 10. Waste rock chemical data.

Sample	NP	Total Sulfur	Hot H2O S	HCL S	HNO3 S	Residual S	EC	SO4	Acidity	Al	Fe	Mn	pH
ID	t/1000t	%	%	%	%	%	mhos/c	mg/L	mg CaCO3/	mg/L	mg/L	mg/L	
TP22GS1	<1	5.860	<0.01	0.670	4.640	0.550	5.66	6096.0	3362.0	465.0	106.0	12.0	3.1
TP22GS2	<1	7.540	0.140	0.130	6.680	0.590	7.71	10740.0	7169.0	728.0	993.0	20.0	2.5
TP22GS3	<1	3.560	0.030	3.030	0.330	0.170	4.17	3708.0	736.0	111.0	19.0	12.0	3.7
TP22GS4	<1	3.050	0.030	0.410	1.420	1.190	4.24	2703.0	233.0	31.0	8.0	7.0	3.9
TP22GS5	7.0	10.600	0.100	0.650	9.130	0.720	4.48	3120.0	N/A	<1	<1	7.0	6.9
TP23GS1	<1	17.700	0.900	0.100	15.800	0.940	11.05	15636.0	2693.0	96.0	805.0	33.0	2.9
TP23GS2	<1	10.600	<0.01	1.310	8.090	1.200	8.62	10152.0	1657.0	46.0	569.0	28.0	3.2
TP23GS3	<1	7.870	<0.01	0.990	6.360	0.520	8.32	11352.0	4301.0	582.0	73.0	45.0	3.3
TP23GS4	<1	5.110	<0.01	1.150	3.720	0.240	8.09	11910.0	5948.0	757.0	54.0	39.0	3.3
TP23GS5	<1	13.500	<0.01	0.100	12.500	0.950	4.48	18675.0	15249.0	2432.0	445.0	8.0	2.7
TP23GS6	<1	2.230	0.160	0.360	1.370	0.340	4.51	5556.0	1395.0	196.0	11.0	15.0	3.4
TP24GS1	<1	0.840	0.270	0.070	0.430	0.070	2.45	2235.0	N/A	<1	<1	1.0	6.9
TP24GS2	<1	1.210	0.340	0.080	0.760	0.030	3.93	2568.0	N/A	<1	<1	2.0	7.2
TP24GS3	<1	1.510	0.250	0.100	1.060	0.100	2.65	3159.0	131.0	11.0	12.0	23.0	4.4
TP24GS4	8.0	7.350	<0.01	0.550	6.360	0.440	3.09	3159.0	N/A	<1	<1	7.0	7.0
TP25GS1	<1	1.470	0.790	0.150	0.450	0.080	6.38	14553.0	11432.0	1983.0	22.0	13.0	3.1
TP25GS2	<1	1.800	0.730	0.220	0.710	0.140	7.01	14958.0	12168.0	1629.0	1017.0	9.0	2.3
TP25GS3	<1	11.600	1.300	0.520	9.360	0.420	9.37	15819.0	14260.0	749.0	3990.0	5.0	2.2
TP25GS4	<1	15.500	0.700	3.100	10.800	0.920	9.54	12771.0	10074.0	667.0	2265.0	13.0	2.6
TP25GS5	<1	6.840	0.250	0.870	5.410	0.310	11.07	18006.0	14900.0	893.0	3676.0	17.0	2.3
TP25GS6	<1	6.760	0.280	1.470	4.170	0.840	13.96	20454.0	17632.0	2405.0	1306.0	6.0	2.0
TP26GS1	<1	34.400	<0.01	<0.01	30.000	4.390	14.00	17469.0	11180.0	496.0	3444.0	29.0	2.2
TP26GS2	<1	6.810	0.030	1.030	5.320	0.430	15.97	18450.0	7944.0	883.0	661.0	83.0	2.4
TP26GS3	<1	11.800	<0.01	1.600	9.670	0.530	15.81	27795.0	23745.0	2925.0	2955.0	30.0	2.5
TP26GS4	<1	5.460	0.090	1.020	3.960	0.390	15.01	20232.0	13447.0	1991.0	650.0	40.0	2.6
TP26GS5	<1	12.000	0.200	0.200	10.900	0.750	13.26	17451.0	11141.0	1602.0	617.0	36.0	2.7
TP26GS6	<1	1.280	0.270	0.240	0.640	0.130	8.98	10458.0	5319.0	713.0	33.0	28.0	2.9
TP26GS7	<1	5.160	0.060	0.940	3.850	0.310	10.88	13935.0	7440.0	448.0	1786.0	23.0	2.5
TP26GS8	28.0	8.810	<0.01	0.880	7.390	0.540	3.76	2919.0	N/A	<1	<1	2.0	6.2

Table 10. Waste rock chemical data.

Sample	NP	Total Sulfur	Hot H2O S	HCL S	HNO3 S	Residual S	EC	SO4	Acidity	Al	Fe	Mn	pH
ID	t/1000t	%	%	%	%	%	mhos/c	mg/L	mg CaCO3/	mg/L	mg/L	mg/L	
TP27GS1	4.0	10.100	0.730	1.290	7.420	0.660	3.42	2703.0	N/A	<1	<1	6.0	6.4
TP28GS1	12.0	6.650	<0.01	0.190	6.170	0.290	2.27	1452.0	N/A	<1	<1	<1	7.3
TP29GS1	17.0	7.810	<0.01	0.840	6.540	0.430	3.29	2412.0	N/A	<1	<1	3.0	7.2
TP30-16	2.0	7.770	0.040	1.080	6.180	0.470	4.66	4674.0	2403.0	319.0	39.0	20.0	3.7
TP30-18	1.0	7.840	0.070	1.070	6.220	0.480	5.57	6243.0	3691.0	502.0	49.0	27.0	3.4

APPENDIX B

Test Pit Field Logs

Table 11. Test Pit 1 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP1GS1	0 - 0.8	Coarse grained, black shale (80%). Some medium to coarse grained, light grey to white intrusive rocks (latite). Shale contains disseminated pyrite. Some silt interparticle spaces open. Little to no weathering, material appears very fresh, some particles show oxidation along original joint surfaces. No sorting of material, unit is dry, dusty.

Table 12. Test Pit 2 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP2GS1	not available	No description available.

Table 13. Test Pit 3 Field Log

Sample Identification	Depth Increment (m)	Description of Layer
TP3GS1	3.4 - 2.1	Large boulders to silt size particle range, reddish yellow (7.5YR6/8) color, some degree of sorting, fining upwards. Primarily composed of medium to coarse grained latite. Moderate degree of oxidation. Higher degree of oxidation noted in matrix and smaller particles. Level of oxidation in coarse particles minor, restricted to particle surfaces.
TP3GS2	2.1 - 1.8	Coarse boulder to silt size particles. Pale olive, yellow color (5Y7/3) matrix and dusting on larger particles. Poorly sorted, oxidation is low to moderate. Unit composed primarily of coarse grained latite. Some particles show oxidation along original joint surfaces which are dark red to black in color.
TP3GS3	1.8 - 1.2	Composed primarily of gravel to silt sized particles, some boulders. Color reddish yellow (7.5YR6/8). Primarily composed of medium to coarse grained latite. Moderate degree of oxidation. Unit similar to TP3GS1 layer previously described.

Table 13. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP3GS4	LOG 2 2.9 - surface	Gravel to silt sized particles, some boulders. Matrix and dusting on particles is a yellow (5Y8/3) color. Layer contains both shale and latite particles. Occasional pockets and lenses of dusky red particles in matrix. Turquoise blue secondary minerals precipitated on some particle surfaces. Layer is dry to slightly moist, slightly cemented. Level of oxidation low to moderate. Interparticle spaces filled with fine matrix.

Table 14. Test Pit 4 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP4GS1	3.5 - 1.8	Layer contains boulder to silt sized latite and shale particles. Poorly sorted, dry, weakly cemented in places. Particles are highly angular. Some particle surfaces have a pale yellow dusting. Overall oxidation is low, much of the pyrite on particle surfaces show very little alteration. Material is grey (7.5RN5). Some fine grained salts are visible on some particle surfaces. Interparticle voids partly filled with fine matrix.
TP4GS2	1.8 - 1.7	Coarse boulder to gravel particle size range. Material is composed of highly angular latite particles. Reddish yellow (7.7YR7/8) dusting on particle surfaces. Little fine matrix filling interparticle voids. Level of oxidation low overall. Material is very loose and poorly sorted.
TP4GS3	1.7 - 1.3	Gravel to silt sized particle range. Material is yellow (10YR7/6). Highly angular latite particles show a low degree of weathering and oxidation restricted to particle surfaces. Material is dry, loose, warm. Some particles show red to dusky red stain which appears to be original joint surfaces. Fine matrix infilling all interparticle voids.

Table 14. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP4GS4	LOG 2 1.8 - 1.2	Coarse gravel to silt sized particle range. Fine silt and sand matrix infills most interparticle spaces, however some interparticle voids around larger particles remain open. Unit is a reddish yellow (7.5YR7/8) color with fine reddish yellow dusting on particle surfaces. Level of oxidation appears low overall. Material is dry, poorly sorted and loose. Layer is composed primarily of coarse to medium grained latite. Some fine thin bands locally define weak sorting.
TP4GS5	1.2 - surface	Highly angular boulder to silt particle size range. Unit shows some sorting with material becoming fine near top of layer. Particles are highly angular and very loosely packed. Layer composed primarily of shale particle types. Most particles appear to have broken along pre-existing joint surfaces or bedding planes. Unit is a reddish yellow (7.5YR6/8) to strong brown (7.5YR5/8) color. Fine layer near top of unit and surface. Strong brown particles are possibly oxide material. Some particles show areas of dusky red (7.5YR2.5/4) staining. All interparticle voids are infilled with fine matrix. Unit is dry and warm. Level of oxidation appears to be low to moderate.

Table 15. Test Pit 5 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP5GS1	2.9 - 2.6	Coarse boulders to silt sized particle range. Unit is a pale olive yellow color with occasional pockets or lenses of reddish yellow stain. Material is primarily composed of latite particles. Layer is dry, warm and poorly sorted. Interparticle voids are infilled with fine matrix. Degree of oxidation appears low with fine pale olive yellow dusting on surface of particles with occasional patches of reddish yellow stain where sulphide minerals are exposed on particle surfaces. Pyrite with little or no alteration visible. Layer is very weakly cemented.

Table 15. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP5GS2	2.4 - 1.7	Boulder to silt sized particle range. Layer is composed of intrusive varieties (latite most common). Reddish yellow (7.5YR6/8) color of matrix and dusting of particle surfaces. Layer is dry and warm. Air in void spaces feels moist to the touch. Fine grained matrix infills most of the interparticle voids. Material is loose and poorly consolidated. Some fine matrix and small grains are cemented to some larger particles. Degree of oxidation low to moderate.
TP5GS3	1.7 - 0.91	Coarse boulder to gravel particle range. Layer composed of latite particle types. Reddish yellow stain along some particle surfaces. Overall latite particles have undergone minor alteration. Degree of oxidation low. Little infilling of interparticle voids by fine grained matrix. Hot moist air venting through open voids. Some condensation occurring as hot moist air vents through pit wall. Rock particles poorly sorted with an edge to face framework.
TP5GS4	0.91 - 0.61	Boulder to silt sized particle range. Reddish yellow (7.5YR6/8) color. Composed primarily of latite particles. Layer is dry, warm and dusty. Level of oxidation low to moderate (matrix appears moderately oxidized). Reddish yellow dusting on particle surfaces. Particles relatively unaltered below surface.
TP5GS5	0.61 - 0.5	Boulder to sand sized particle range. Unit composed of latite particles. Interparticle voids partly infilled with fine matrix. Material is poorly sorted. Layer is warm and slightly moist, moisture possibly due to condensation. Movement of hot moist air occurring through open void spaces. Level of oxidation is low.

Table 15. Continued

Sample Identification	Depth Increment (m)	Description of Layer
TP5GS6	LOG 2 1.7 - 0.5	Highly angular gravel to silt sized particle range. Layer is a yellowish red (5YR5/8) color. Yellowish red color of fine silt matrix and fine dusting on particles. Material composed of shale particle types and coarse to medium grained latite. Some very dusky red (7.5R2.5/4) patches on shale particle surfaces. Layer is warm, very dry, loose and poorly consolidated. Interparticle spaces infilled with fine matrix. Level of oxidation low to moderate.

Table 16. Test Pit 6 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP6GS1	3.2 - 2.0	Gravel to silt sized particle range with occasional boulder sized particles. Layer is a light grey (5Y7/2) to pale yellow (5Y8/3) color. Material primarily composed of highly angular sulfide bearing shale with some latite. Particles are covered with a light yellow dusting with areas of brownish yellow stain where sulfides appear to be oxidizing. Layer is cool, dry. Fine white salt precipitates on some particle surfaces. Material is slightly cemented. Oxidation is low to moderate in places. Material is poorly sorted with fine matrix infilling interparticle voids.
TP6GS2	2.0 - 1.1	Material composed of reddish yellow (7.5YR6/8) gravel to silt sized particles with occasional boulder sized particles. Material primarily composed of highly angular sulfide bearing shale with some latite. Lower contact is sharp defined by color change. Unit is slightly cemented in nature with fine white salts precipitated on particle surfaces and in fine matrix. All interparticle voids are infilled with fine matrix. Reddish yellow dusting over most particles with areas or spots of dark dusky red stain on particle surfaces. Material is cool and dry. Level of oxidation low to moderate.

Table 16. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP6GS3	1.1 - 0.8	Boulder to silt sized particle range, composed of both shale and latite particle types. 75% of interparticle voids infilled with fine matrix. Material is a pale yellow (5Y8/3) color. Areas or spots of dark dusky red stain on particle surfaces. Overall level of oxidation is low and restricted to particle surfaces where present. White "powdery" salts visible on particle surfaces and in matrix. Unit is dry, warm and slightly cemented in places.
TP6GS4	0.8 - surface	Layer is a pale yellow (5Y8/3) color. Material is composed primarily of gravel to silt sized particles with occasional boulders. Layer is composed primarily of highly angular sulfide bearing shale with some latite. Patches or spots of dusky red with reddish yellow halos visible on particle surfaces. Interparticle voids infilled with fine matrix. Layer is slightly cemented. Fine grained white salts found on particle surfaces and within matrix. Material is dry, warm and poorly sorted. Level of oxidation low overall.
TP6GS5	LOG 2 0.7 - surface	Material consists of highly angular gravel to silt sized sulfide bearing shale with some latite (<20%) and occasional boulders. Layer is weakly cemented. Fine, white salt precipitates on particle surfaces and in matrix. Layer is reddish yellow (7.5YR6/8) color. Material is dry, warm and poorly sorted. Level of oxidation low.

Table 17. Test Pit 7 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP7GS1	2.7 - 2.1	Gravel to silt sized particles. Unit is a light olive grey (5Y6/2) changing laterally into a strong brown (7.5YR5/8) color. Material is moist, warm, well compacted with interparticle voids infilled with fine matrix. Some cementing of fine particles to larger particles. Layer composed of latite. Oxidation appears to be restricted to the surface of particles. Latite particles have a light pale yellow (5Y8/4) dusting on the surface. Level of oxidation low to moderate. Sample TP7GS1 consists of material from grey unit.
TP7GS2	2.7 - 2.1	See description for TP7GS1. Sample TP7GS2 consists of material from brown unit.
TP7GS3	2.1 - 1.7	Boulder to silt sized particle range. Material is primarily a yellowish red (5YR5/8) with abundant patches of red (2.5YR4/8) in the matrix. Layer consists of both shale and latite. Unit contains some pale yellow clay which appears to be a product of weathering. Some (generally smaller) latite particles appear to be weathered both on the surface and within the particle. Removal of sulfide minerals in sulfide bearing shales evident, leaving a dark dusky red to black stained cavity in the particle. Fine grained white salts present in matrix and on particle surfaces. Unit is warm, moist and poorly sorted with interparticle spaces infilled with fine matrix. Level of oxidation moderate to high.
TP7GS4	1.7 - 1.5	Layer is a grey (5Y5/1) color with pale yellow (5Y8/4) dusting of fines on some particles. Layer is composed primarily of latite with some shale. Particles range from boulders to silt size. Interparticle voids infilled with fine matrix. Material is warm, moist and poorly sorted. Smaller particles show moderate degree of weathering. Larger particles appear less altered. Oxidation low to moderate.

Table 17. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP7GS5	1.5 - 0.4	Consists primarily of gravel to silt particle sizes with occasional boulders. Material is primarily a red (2.5YR4/8) color with a lens in the middle of red (10R4/8) clay. All interparticle voids are infilled with fine matrix. Degree of oxidation moderate to high with sulfide bearing shale particles showing complete removal of sulfide minerals leaving deep red stained cavities. Some shale particles completely weathered to a buff brown (2.5Y7/8) colored clay. Latite appears less altered than shale varieties. Fine white salts visible on particle surfaces and in matrix. Layer is warm, moist and appears to be weakly cemented.
TP7GS6	LOG 2 2.2 - 0.75	Material consists of light olive grey (5Y6/2) matrix with pale yellow (5Y8/4) dusting on particles. Layer composed of latite particles. Smaller particles show higher degree of weathering. Layer is warm and moist. Matrix contains pyrite grains or crystals possibly released during weathering of sulfide bearing latite particles. Pyrite on particle surfaces and in the matrix appears fresh indicating a low degree of oxidation. Weathering is moderate to high in places. Fine matrix has infilled all interparticle voids with the exception of the center of the unit where coarse boulder material has open void spaces.
TP7GS7	0.75 - surface	See description of TP7GS6.
TP7GS8	LOG 3 1.2 - 0.8	Particles range from boulder to silt sizes. Interparticle voids infilled with fine matrix. Layer ranges from a reddish yellow (7.5YR6/8) to a dusk red (7.5R3/4) color. Patches of dark red clay observed in matrix. Layer composed primarily of latite with some shale particle types. Layer is warm, moist, poorly sorted and weakly cemented. Degree of oxidation moderate to high.

Table 18. Test Pit 8 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP8GS1	2.7 - 1.2	Coarse boulder to silt particle sizes. Layer composed of latite and shale particle types. Very little fines infilling interparticle voids. Material is dry, loose and poorly sorted. Latite particles have a light pale yellow (5Y8/4) dusting on surface. Level of oxidation appears low and confined to particle surfaces.
TP8GS2	1.2 - surface	Gravel to silt sized particles with occasional boulders. Layer is composed of highly angular sulfide bearing shale. Material has a reddish yellow (7.5YR6/8) matrix and dusting on particle surfaces. Matrix has infilled approximately 80% of interparticle voids. Material is dry, warm and loose. Oxidation overall is weak.

Table 19. Test Pit 9 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP9GS1	2.8 - 0.8	Material composed of boulder to gravel with some sand and silt sized particles. Layer composed of light grey to dark grey sulfide bearing shale material with minor porphyritic intrusive varieties. Material appears relatively unweathered. The material is dry and loose with >50% of the interparticle voids open. Thin stringers of fines possibly indicating some minor degree of sorting locally. Level of oxidation very low.
TP9GS2	0.8 - 0.5	Layer composed of gravel to silt sized particle range with >75% of interparticle voids infilled with fine matrix. Layer is a reddish yellow (7.5YR6/8) color of matrix and particle surfaces. Material is dry, slightly compacted, cool and poorly sorted. Layer composed primarily of shale particle types. Level of oxidation low however higher than unit below.
TP9GS3	0.65 - 0.4	See description of TP9GS1.

Table 20. Test Pit 10 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP10-F	not available	No description available.
TP10-C	not available	No description available.

Table 21. Test Pit 11 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP11GS1	1.8 - 0.8	Material ranges from very pale brown (10YR7/4) to brown (10YR5/3) with occasional streaks of reddish yellow (7.5YR7/8). Layer is composed primarily of shale with <10% latite. Material is highly angular, dry, warm and poorly sorted. Interparticle void spaces are infilled with fine matrix. Overall level of oxidation is low and restricted to particle surfaces.
TP11GS2	0.8 - 0.5	Particles range from gravel to silt sizes with fine matrix infilling interparticle voids. Layer is a light reddish brown (5YR6/4) with occasional patches of dusky red (2.5YR3/2) to reddish yellow (7.5YR7/8). Layer is dry, warm, poorly sorted with a moderate degree of cementing. All particles have a reddish brown stain and dusting of fines. Layer is composed primarily of shale with minor amounts of latite. Degree of oxidation is high. Some particles show advanced degree of weathering to clay. Matrix contains both fine white and pale yellow salt precipitates.

Table 21. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP11GS3	LOG 2 1.5 - 1.1	Particles range from gravel to silt sizes with few boulders. Layer is a yellow (5Y8/4) color and comprised of 90% shale and 10% latite particle types. Shale particles have a reddish yellow (7.5YR6/8) stain on particle surfaces. Occasional particles have a black mineral on surface. Fine matrix infilling approximately 90% of interparticle voids. Moderate degree of cementing. White and yellow mineral precipitate found on some particle surfaces. Layer is dry, warm and poorly sorted. Level of oxidation low to moderate.
TP11GS4	not available	Description not available.
TP11GS5	0.8 - 0.6	Layer is a reddish yellow (7.5YR6/8) color. Particles range from gravel to silt sizes with few boulders. Layer is comprised of 90% shale and 10% latite varieties. Some particles exhibit dusky red staining on particle surfaces. Layer has a moderate degree of cementing. Fine matrix infilling approximately 90% of interparticle voids. White and yellow precipitates found on some particle surfaces. Layer is dry, warm, poorly sorted. Level of oxidation low to moderate.

Table 22. Test Pit 12 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP12GS1	3.2 - 2.9	Description not available.
TP12GS2	2.9 - 2.1	Description not available.
TP12GS3	2.1 - 1.8	Description not available.
TP12GS4	1.8 - 1.7	Description not available.
TP12GS5	1.7 - 0.8	Description not available.
TP12GS6	0.8 - 0.6	Description not available.

Table 23. Test Pit 13 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP13GS1	2.5 - 1.4	Layer composed of boulder to gravel sized particles with some sand and silt sized particles. Layer is composed of highly angular shale with <10% latite rock types. Layer is cool, moist, poorly sorted and loose. Interparticle voids open. Some fine white salts seen on particle surfaces. Very low level of oxidation.
TP13GS2	1.4 - 0.5	Layer composed primarily of gravel to silt sized particles with occasional boulders. Material ranges from reddish yellow (7.5YR7/8) to dark yellowish brown (10YR4/6). Layer comprised primarily of shale (85%) with some latite and other intrusive varieties. All particles covered with a reddish yellow to yellowish brown stain and dusting of fines. Level of oxidation low to moderate. Interparticle voids only partly infilled with fine matrix.
TP13GS3	LOG 2 1.4 - 0.8	Coarse boulder and gravel material with some sand and silt sized particles. Layer composed primarily of latite (80-90%) with some shale. Latite particles commonly have light pale yellow (2.5Y8/4) color on surface with zones of reddish yellow (7.5YR6/8) stain on surface. Some stain appears to occur along previous joint or fracture surfaces. Level of oxidation low overall. Material is cool, poorly sorted and interparticle voids remain open.
TP13GS4	0.8 - 0.4	Material composed primarily of coarse gravel to boulder sized particles with some sand and silt. Layer is composed of highly angular shale with <10% latite rock types. Most interparticle voids >75% open. Layer is cool, moist, poorly sorted, loose and unstable. Particles have some reddish yellow stain on particle surfaces otherwise shake has light to dark grey color. Particles are unaltered overall showing a very low degree of oxidation.

Table 24. Test Pit 14 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP14GS1	2.1 - 1.6	Layer composed of boulders to silt sized particles. Layer is dark yellowish brown (10YR4/4) color. Silt matrix infills all interparticle voids. Layer is composed mainly of shale particle types with minor intrusive varieties. Material is loose, poorly sorted, moist and cool. Moisture is most likely due to watering for dust control. Level of oxidation is low overall.
TP14GS2	1.6 - 1.45	Layer composed of gravel to silt sized particles. Inter-particle voids infilled with fine silt matrix. Material is an olive (5Y5/4) color. Material is moderately consolidated, moist and poorly sorted. Relatively unaltered fine grained pyrite found in matrix. Low to moderate degree of oxidation.
TP14GS3	1.45 - 1.1	Layer is composed of boulder to silt sized particles. Fine matrix infills interparticle voids. Layer is a yellowish brown (10YR4/4) color with yellowish red and reddish yellow mottling of particle surfaces and matrix. Material is loose, poorly sorted, moist and cool. Level of oxidation moderate.
TP14GS4	1.1 - 0.4	Layer contains boulder to silt sized particles with fine matrix infilling interparticle voids. Material is yellowish red to reddish yellow which grades into a strong brown color near top of layer. Material is composed of both shale and latite particle types. Layer is moist, cool and poorly sorted. Level of oxidation moderate.

Table 25. Test Pit 15 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP15GS1	1.5 - 0.5	Pale yellow (5Y8/4) color of matrix and particle surfaces with some surfaces showing dark dusky red. Layer composed of boulders to silt sized particles with interparticle voids open. Layer composed of equal amounts of shale and intrusive varieties. Some small latite particles breaking down producing a sandy matrix of feldspar grains. Some particle surfaces show a reddish yellow (7.5YR6/8) and strong brown (7.5YR5/8) stain. Material is warm, moist and poorly sorted. Level of oxidation moderate to high.
TP15GS2	0.5 - surface	Layer composed of gravel to silt sized particles with occasional boulders. Interparticle voids infilled with fine matrix. Material is a strong brown (7.5YR5/8) color with some particles having a very dusky red (10R2.5/2) color. Layer is moist, warm, poorly sorted. Layer composed primarily of shale particle types with minor igneous varieties. Oxidation of some particles extends below particle surfaces. Some shale varieties, primarily white colored (10YR8/1) have weathered to clay. In places matrix contains a pale yellowish clay (5Y8/4) which is soft, moist and plastic. Level of oxidation moderate to high.
TP15GS3	LOG 2 1.4 - 1.3	Layer composed of gravel to silt sized particles with occasional boulders. Interparticle voids infilled with fine matrix. Material is a strong brown (7.5YR5/8) color with some particles having a very dusky red (10R2.5/2) color. Layer composed primarily of shale. Layer is moist, warm and poorly sorted. Oxidation of some particles extends below their surface. Some shale varieties, primarily white (10YR8/1) colored have weathered to clay. Level of oxidation moderate to high. In places matrix contains a pale yellowish (5Y8/4) colored clay which is soft, moist and plastic. Strong brown to dusky red salts visible on particle surfaces. Layer is weakly cemented. Surface between this layer and the one above appears to represent a previous dump surface with relatively fresh waste rock placed on top.

Table 25. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP15GS4	1.3 - 0.3	Highly angular boulder to sand sized material with little silt. Layer consists of light to dark grey shale particles. Interparticle void spaces open. Material is moist, cool and poorly sorted. Little to no oxidation.

Table 26. Test Pit 16 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP16GS1	2.6 - 1.4	Layer composed primarily of boulder to gravel sized particles with minor amounts of sand and silt. Layer composed of 80% latite and 20% shale rock types. Interparticle voids are open with minor infilling of fine silt matrix. Matrix and particles have a pale yellow (5Y8/4) color. Some particle surfaces show a reddish yellow (7.5YR6/8) color. Layer is warm, dry and poorly sorted with noticeable air flow venting through interparticle void spaces. Level of oxidation low overall.
TP16GS2	1.4 - 0.9	Unit is composed of boulders and gravel sized material grading upwards into a fine sand with some silt near the top of the layer. Layer is a pale yellow (5Y8/4) to green (5G7/2) color. Some particles have a yellowish brown (10YR5/4) stain. Material composed of 60% shale and 40% latite rock types. Unit is dry, loose and warm. Some fine white salts observed on particle surfaces. Lower portion of layer has open interparticle void spaces, spaces in upper half are filled with fine matrix. Some hard black secondary mineral on some particle surfaces.

Table 26. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP16GS3	0.9 - 0.1	Layer consists of small boulders to gravel with minor sand and silt fining upwards to gravel to silt material at top of layer. Layer composed of 80 - 90% shale particles with the remainder being latite. Interparticle voids are open at the bottom and filled with fine matrix near the top. Material is loose and dry. Layer is a reddish yellow (7.5YR6/8) color. Some fine white and pale green salts visible on particle surfaces. Level of oxidation low overall and restricted to particle surfaces.
TP16GS4	LOG 2 2.0 -1.4	Layer composed primarily of boulder and gravel sized particles and consists of latite particle types. Interparticle voids are open with minor infilling of fine silt matrix. Matrix and particles have a pale yellow (5Y8/4) color. Some particle surfaces have a reddish yellow (7.5YR6/8) color. Layer is warm, dry and poorly sorted. Thin (10cm) layer of reddish yellow material, sand and silt to gravel sized particles, divides this layer. Upper half of unit is the same however large boulders less common. Level of oxidation low overall.
TP16GS5	1.4 - 0.9	See description of TP16GS4.
TP16GS6	LOG 3 1.4 - 0.9	Layer composed of gravel to silt sized particles with interparticle voids infilled with fine matrix. Layer composed of 60% shale and 40% latite particle types. Layer is a pale yellow brown (10YR7/4) color. Unit is dry, warm, loose, poorly sorted and very weakly cemented. Level of oxidation is low and restricted to particle surfaces, showing reddish yellow to strong brown halo around sulfide grains.
TP16GS7	0.9 - 0.4	Layer composed of gravel to silt sized particles with occasional boulders. Interparticle voids infilled with fine matrix. Layer is a reddish yellow (7.5YR6/8) color. Layer composed of 60% shale and 40% latite particle types. Unit is dry, loose, poorly sorted and very weakly cemented. Level of oxidation low overall.

Table 27. Test Pit 17 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP17GS1	2.7 - 1.7	Layer consists of boulder to sand sized particles with little silt, approximately 60% latite and 40% shale particle types. Interparticle void spaces open (up to 5cm). Latite particles range from grey to pale yellow (5Y8/4) while shale ranges from grey to brownish yellow (10YR6/8). Some yellow clay found in some interparticle voids. Weathering of particles moderate with loose feldspar grains contributing to matrix from the breakdown of latite particles.
TP17GS2	1:7 - 1.3	Layer is a light pale green (5GY7/1) color with mottled yellowish brown patches grading into a yellowish brown (10YR5/8) color with pale green mottling at the top of unit. Layer consists of gravel to sand sized particles with occasional boulders. Interparticle voids infilled with fine matrix. Level of oxidation low to moderate. Layer consists of 40 - 60% latite particles with remainder being shale. Fine white and blue salts visible on particle surfaces.
TP17GS3	1.3 - 1.15	Gravel to sand sized particles with little silt. Layer composed of shale and latite particle types in equal amounts. Interparticle voids open. Material is a reddish yellow (7.5YR6/8) to yellowish brown (10YR5/8) color. Some breakdown of latite particles evident. Layer is slightly moist, weakly cemented, loosely compacted and poorly sorted. Fine white salts visible on particle surfaces.
TP17GS4	1.15 - 0.9	Gravel to sand sized particles with occasional boulders. Layer composed of 70% shale and 30% latite. Layer is a dark yellowish brown (10YR4/6) color. Interparticle voids filled with fine matrix. Layer is cool, moist and poorly sorted. Level of oxidation low to moderate.
TP17GS5	0.9 - surface	Boulder to sand sized particles with some silt. Layer composed primarily of black to grey shale with minor latite (30%) particle types. Interparticle voids open. Overall level of oxidation is low to moderate. One rock type (<5%) highly weathered to a dusk red colored particle which breaks apart easily. Material is slightly moist, cool and poorly sorted. Moisture likely due to dust control efforts.

Table 28. Test Pit 18 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP18GS1	2.3 - 1.9	Boulder to silt sized particles. Layer composed of >85% latite rock type. Interparticle voids infilled with fine matrix. Layer is a pale olive (5Y6/3) to pale yellow (5Y7/3) color. Layer is dry, warm and poorly sorted. Level of oxidation low and restricted to particle surfaces.
TP18GS2	1.9 - 1.7	Gravel to silt sized particles with occasional boulders. Material is a strong brown (7.5YR5/8) color and composed of >85% shale particle types. Layer is dry, loose and poorly sorted. Interparticle voids infilled with fine matrix. Level of oxidation moderate. Fine white salts visible on surfaces.
TP18GS3	1.7 - 1.5	Gravel to silt sized particles with occasional boulders. Layer is a light reddish grey (5YR6/3) to reddish grey (5YR5/2) color and comprised of 90% shale particle types. Interparticle voids infilled with fine matrix. Layer is warm, dry and poorly sorted. Level of oxidation moderate.
TP18GS4	1.5 - 1.2	Gravel to silt sized particles with occasional boulders. Matrix is primarily a reddish yellow color. Interparticle voids infilled with fine matrix. Layer is loose, dry, poorly sorted and slightly warm. Level of oxidation moderate to high in places. Some particles have completely broken down to fine matrix.
TP18GS5	1.2 - 1.1	Boulder to silt sized particles. Pale yellow (5Y7/3) to pale olive (5Y6/2) color. Layer composed of 95% latite and minor shale particle types. Interparticle voids infilled with fine matrix. Level of oxidation low to moderate overall. Some reddish yellow to dusky red stain on particle surfaces where disseminated pyrite grains are exposed. Remainder of particle surfaces have a pale yellow dusting. Layer is slightly warm, dry, loose and poorly sorted.

Table 28. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP18GS6	1.1 - 0.8	Gravel to silt sized particles with occasional boulders. Layer is a reddish yellow (7.5YR7/8) to yellowish red (5YR5/8) color and composed primarily of shale particle types. Red to dusky red stain on some particle surfaces. Level of oxidation low to moderate. Layer is dry, loose and slightly warm.
TP18GS7	0.8 - 0.7	Gravel to silt sized material with occasional boulders. Matrix is primarily a yellowish red (5YR6/8) to red (2.5YR4/8) color. Layer composed primarily of shale particle types. Interparticle voids infilled with fine matrix. Level of oxidation moderate to high in places. Layer is dry, loose, poorly sorted and slightly warm.

Table 29. Test Pit 19 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP19GS1	2.3 - 1.1	Gravel to sand sized particles with little silt. Coarse boulder layer between 1.8 and 1.6m with gravel to sand sized matrix. Layer composed of highly angular shale particles. Particles have a pale yellow (5Y8/4) to yellowish brown (10YR5/6) dusting or coating. Material is dry, poorly sorted and loose with little infilling of interparticle voids. Level of oxidation low overall.
TP19GS2	0.7 - 0.2	Coarse boulder to gravel sized particles with little sand or silt. Layer is composed of 75% intrusive and 25% shale particle types. Interparticle voids open. Some intrusive rock types (latite and lamprophyre) show extensive weathering. Other particles show little alteration. Fine royal blue salt crystals precipitated on particle surfaces. Some particles have a pale yellow to yellowish brown stain on some particle surfaces. Layer is dry, loose and poorly sorted.

Table 30. Test Pit 20 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP20GS1	1.6 -1.2	Gravel to silt sized particles with 10% boulders. Interparticle voids infilled with fine matrix. Layer composed primarily of shale with 10 - 20% latite particle types. Matrix and coatings on particles are primarily a brownish yellow (10YR6/8) color. Some particles are a dark brown to very dusky red (10R2.5/2) color and may be oxide cap material. Layer is cool, dry, poorly sorted and weakly cemented. Level of oxidation low to moderate.
TP20GS2	1.2 - 0.3	Layer composed of coarse boulders and gravel with little silt or sand. Composed of equal amounts of latite and shale particle types. Large open interparticle void spaces. Some shale particles showing breakdown to clay and some latite particles are weathering and contributing feldspar grains to matrix. Layer is dry and poorly sorted. Some royal blue and black precipitate on particle surfaces.
TP20GS3	LOG 2 1.1 - 0.6	Gravel to silt sized particles with occasional boulders. Layer composed of >90% shale particle types. Layer is a dark brown to brown (7.5YR4/4) color. Layer is moist (from watering) and cool with some sorting of finer material into bands. Some interparticle void spaces remain open around gravel sized particles but majority are infilled with fine matrix. Level of oxidation low overall.

Table 31. Test Pit 21 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP21GS1	1.9 - 1.3	Gravel to silt sized particles with occasional boulders. Light reddish brown (5YR6/4) to reddish yellow (5YR6/8) color. Layer composed of 60% shale and 40% intrusive rock types. Unit is loose, dry and poorly sorted. Level of oxidation low. Some particle surfaces dusky red in color.

Table 31. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP21GS2	1.3 - 0.9	Gravel to silt sized particles. Layer is a light grey (2.5Y7/2) color and composed of 60% shale and 40% intrusive rock types. Interparticle voids infilled with fine matrix. Some sorting is visible where thin bands of gravel with little silt are present. Lower boundary is sharply marked by color change from reddish yellow below to grey above. Oxidation low overall.
TP21GS3	0.9 - 0.4	Coarse boulder to gravel sized particles with little silt and sand. Layer is loose, dry, poorly sorted and slightly warm. Interparticle void spaces are open. Material is composed of 60% breccia, 10% shale and 30% intrusive rock types. Some fine yellow salt precipitates noted. Level of oxidation low overall.

Table 32. Test Pit 22 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP22GS1	2.6 - 1.7	Gravel to boulder sized particles with little sand or silt. Layer composed of 75% intrusive rock types. Particle surfaces are red (2.5YR4/8) to reddish yellow (5YR6/8) and pale yellow (5Y8/4) color. Interparticle void spaces open. Unit is loose, slightly moist and poorly sorted. Level of weathering moderate to high.
TP22GS2	1.7 - 1.5	Boulder to clay sized particles. Layer consists of significant clay (yellow and grey) which is moist and plastic. Layer moderately consolidated. Interparticle voids infilled with fine silt and clay matrix. Layer appears to be composed of 60% breccia and 40% shale. Level of oxidation appears to be low to moderate but material is highly weathered. Layer is a mixture of dark olive grey (5Y3/2) and pale yellow (5Y8/4) color. In places dark grey, moist, highly plastic clay present possibly due to the extensive breakdown of shale particles.

Table 32. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP22GS3	1.5 - 0.8	Boulder to gravel sized particles with little silt and sand. Layer composed primarily of latite particle types. Layer has a pink (7.5YR7/4) to red yellow (7.5YR7/6) to pale yellow (5Y8/4) color on particle surfaces. Material is loose, dry, poorly sorted with interparticle void spaces open. Level of oxidation low.
TP22GS4	0.8 - 0.5	Primarily gravel sized particles with little silt or sand. Layer composed primarily of highly angular shale particles. Layer has a pink (7.5YR7/4) to red yellow (7.5YR7/6) to pale yellow (5Y8/4) color on particle surfaces. Material is loose, dry to slightly moist, poorly sorted with interparticle voids open. Level of oxidation low.
TP22GS5	LOG 2 2.7 - 0.9	Boulder to sand sized particles with little silt. Layer composed of 70% shale and 30% intrusive rock types. Material is loose, dry and poorly sorted with interparticle void spaces open. Level of oxidation low.

Table 33. Test Pit 23 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP23GS1	2.6 - 1.75	Gravel to boulder sized particles with little sand or silt. Layer composed of shale particles types. Interparticle void spaces open. Material is loose, poorly sorted, dry and slightly warm. Level of oxidation low overall. Particles contain both fresh pyrite grains and some dark reddish brown (5YR3/4) stain where pyrite grains are exposed on particle surfaces. Pale yellow (5Y8/4) dusting on particle surfaces common.
TP23GS2	1.75 - 1.65	Gravel to silt sized particles. Layer composed primarily of shale (90%) with some latite. Layer is a yellowish red (7.5YR6/8) to reddish yellow (5Y6/8) color. Material is loose, dry and poorly sorted. Interparticle voids infilled with fine silt matrix. Level of oxidation low to moderate.

Table 33. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP23GS3	1.65 - 1.2	Gravel to silt sized particles with occasional boulders. Layer composed of 75 - 80% shale and 20 - 25% latite and intrusive varieties. Layer is pale olive (5Y7/4) to pale yellow (5Y6/3) color. Fine matrix infills most interparticle voids, however some remain open. Layer is dry, loose, cool and poorly sorted. Overall level of oxidation low to moderate.
TP23GS4	1.2 - 0.7	Gravel to silt sized particles with occasional boulders. Layer composed of 85% shale and 15% intrusive varieties. Layer is pale olive (5Y7/4) to pale yellow (5Y6/3) color. Fine matrix infills most interparticle voids, however some remain open. Layer is dry to slightly moist, poorly sorted and moderately consolidated. Overall level of oxidation low to moderate.
TP23GS5	0.8 - 0.55	Gravel to silt sized particles. Layer is composed of 75% shale and 25% intrusive rock types. Interparticle voids infilled with fine matrix. Layer is a yellow (10YR7/8) to strong brown (7.5YR5/8) color. No visible pyrite in matrix. Layer is slightly moist, poorly sorted and cool. Level of oxidation moderate.
TP23GS6	0.55 - 0.2	Fine grained layer of gravel, sand and silt. Layer is a red (10R4/6) color and composed of both shale and intrusive particle types. Some shale particles show deep red color throughout the particle. Some shale particles have completely altered to clay. Level of oxidation high.

Table 34. Test Pit 24 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP24GS1	1.8 - 1.4	Boulder to silt sized particles. Layer composed of 70% intrusive and 30% shale rock types. Matrix has infilled most interparticle voids. Layer is a yellowish red (5YR5/8) color with some light grey to white (7.5YRN8) shale particles. Some shale particles altered to a yellowish (10YR7/8) silty clay. Layer is moist, cool and poorly sorted. Level of oxidation moderate to high.
TP24GS2	1.4 - 0.3	Coarse boulder to gravel sized particles with little silt or sand. Layer composed of 70% intrusive and 30% shale particle types. Interparticle voids open or partially infilled with coarse gravel and sand. Most particle surfaces have a reddish yellow (7.5YR6/8) dusting of fines on surface. Some intrusive varieties have oxidized to a red (5R4/6) color. Layer is moist (probably due to watering), poorly sorted and cool. Level of oxidation low to moderate.
TP24GS3	LOG 2 1.4 - 0.9	Boulder and coarse sized particles with little silt. Layer composed of 75% intrusive and 25% shale particle types. Most particles covered with a dark brown (10YR3/3) fine grained material. Layer is cool, moist and poorly sorted. Level of oxidation low to moderate.
TP24GS4	0.9 - 0.3	Coarse boulder to gravel sized particles with little silt or sand. Layer is composed of equal amounts of shale and intrusive rock types. Layer is dry, poorly sorted and cool. Interparticle voids open. Pyrite exposed on many particle surfaces appears unoxidized. Material appears relatively fresh with little alteration visible.

Table 35. Test Pit 25 Field Log

Sample Identification	Depth Increment (m)	Description of Layer
		Test pit was warm and moist when excavated. Steam made it difficult to see pit walls during excavation. Once pit walls cooled, fine layers stopped steaming however coarse boulder layer (at far end of pit) continued to vent for days afterward.
TP25GS1	2.9 - 2.6	Gravel to clay sized particles. Layer has a high percentage of fine material. Layer is a yellowish red (5YR5/8) to red (10R4/8) color. Layer composed of shale and intrusive particle types. Many particles show deep oxidation and removal of sulfide minerals. Patches of yellowish red and red colored clay in matrix. Some particles broken down into a silty clay but maintain original particle shape. Layer is moist, warm and poorly sorted. Level of oxidation high.
TP25GS2	2.6 - 2.3	Gravel to silt sized particles with occasional boulders. Layer composed of 90% shale particle types. Overall layer ranges from a yellow (2.5YR8/4) to a yellowish red (7.5YR5/8) color. Interparticle voids infilled with fine matrix. Some shale particles show extensive breakdown but still retain original particle shape. Other varieties of shale seem only slightly weathered. Some yellowish clay in matrix. Layer is warm, moist and poorly sorted.
TP25GS3	2.3 - 1.5	Gravel to silt sized particles with occasional boulders. Layer is composed of highly weathered latite particles and minor (5%) shale. Layer is a grey (5Y6/1) to light grey (5Y7/2) color. Interparticle voids infilled with fine matrix. Layer is moist, warm and poorly sorted. Level of oxidation low to moderate with a high degree of weathering.
TP25GS4	1.5 - 1.4	Similar to TP25GS3. Layer composed entirely of latite particles. Layer is an olive grey (5Y4/2) color. Interparticle voids infilled with fine matrix. Layer is moist, warm and poorly sorted. Level of oxidation low to moderate with a high degree of weathering. Fine white salts precipitating as excavation face cools and dries.

Table 35. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP25GS5	1.4 - 0.4	Gravel to silt sized particles with occasional boulders. Layer is a pale olive (5Y6/4) to yellowish red (5YR5/8) color. Layer composed of 95% latite and 5% shale rock types. Matrix appears to contain some clay. Interparticle voids infilled with fine matrix. Level of oxidation low to moderate. Some shale particles show extensive alteration to clay but not common overall. Some pyrite minerals exposed on particle surfaces show little alteration.
TP25GS6	not available	Sample taken from opposite side of pit than was logged. This material consisted of clay sized particles which were wet, steaming and plastic. Most likely this material is the product of extensive weathering and breakdown.

Table 36. Test Pit 26 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP26GS1	5.3 - 4.7	Gravel to silt sized particles with occasional boulders and clay. Layer composed of 75% intrusive and 25% sedimentary (primarily shale) particle types. Layer is a dark grey (5Y3/1) color with mottled areas of pale yellow (5Y7/4) clay associated with the breakdown of some light grey shale fragments. Sandy to silty matrix has a high percentage of pyrite grains. Level of oxidation overall appears low however the level of weathering is moderate to high. Interparticle voids infilled with fine matrix. Layer is loose, warm, moist and steaming when first opened. Latite particles showing significant breakdown.

Table 36. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP26GS2	4.7 - 4.1	Boulder to clay sized particles. Layer ranges from pale yellow (5Y8/4) to reddish yellow (7.5YR6/8) color. Layer is composed of 90% light grey sulfide bearing shale and 10% latite rock types. Fine matrix not completely infilling interparticle voids. Layer is moist, warm and poorly sorted. Some shale particles completely altered to clay but maintaining original particle shape. Some dusk red (10R3/2) color on some particle surfaces. Level of oxidation moderate to high. Latite, where present, is altered in most particles adding feldspar grains to matrix. Some fine pale yellow, reddish yellow and white salts present.
TP26GS3	4.1 - 3.55	Boulder to silt sized particles. Layer composed primarily of latite with approximately 10% shale. Layer is a mixture of pale yellow (5Y8/4) and dark grey (5Y4/1) colors, giving a mottled texture. Interparticle voids infilled with fine matrix. Level of oxidation low to moderate. Latite particles showing significant breakdown adding feldspar minerals to matrix. Layer is warm, moist and poorly sorted.
TP26GS4	3.55 - 3.45	Boulder to clay sized particles. Unit composed primarily of latite with minor amounts of shale. Layer is a yellowish red (5YR5/8) color. Some particles show signs of removal of sulfide minerals from particle surfaces. No pyrite (unaltered) is visible in matrix. Layer is moist, warm, moderately compacted and poorly sorted. Interparticle voids infilled with fine matrix. Matrix appears to be a sandy silt with some clay. Level of oxidation moderate.
TP26GS5	3.45 - 3.1	Boulder to clay sized particles. Layer composed of highly angular shale. Interparticle voids partially infilled with fine matrix. Most particles have a pale yellow color on surface and in matrix. Some preferential oxidation along bedding planes and joint surfaces of shale particles. Some pale yellow clay present. Layer is moist, warm and poorly sorted. Overall level of oxidation low to moderate.

Table 36. Continued.

Sample Identification	Depth Increment (m)	Description of Layer
TP26GS6	3.1 - 2.7	Boulder to clay sized particles. Layer composed primarily of latite with minor amounts of shale. Latite particles are covered with yellowish red to dusk red fines. Some particles show signs of removal of sulfide crystals from particle surfaces. No pyrite visible in matrix. Interparticle voids infilled with fine matrix. Layer is moist, warm and moderately compacted. Matrix appears to be a sandy silt with some clay. Level of oxidation moderate.
TP26GS7	2.7 - 2.3	Boulder to clay sized particles. Layer composed of equal amounts of shale and intrusive rock types. Layer is a pale yellow with some yellowish red stain. Interparticle voids infilled with fine matrix. Some shale particles are completely altered to clay. Layer is moist, loose and warm. Salts began to precipitate on pit surface after opening. Level of oxidation moderate to high.
TP26GS8	2.3 - surface	Coarse boulder to gravel sized material with little sand or silt. Layer composed of equal amounts of shale and intrusive rock types. Some boulders have a pale yellow to reddish yellow stain on surfaces. Layer is cool, dry and poorly sorted. Interparticle void spaces remain open. Level of oxidation low.

Table 37. Test Pit 27 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP27GS1	2.2 - surface	Occasional boulder to coarse gravel with very little silt or sand sized particles. Interparticle void spaces open. Layer composed of grey shale with minor intrusive rocks. Both fresh and stained pyrite grains are visible on particle surfaces. Material is slightly moist to dry, cool and loose. Level of oxidation low.

Table 38. Test Pit 28 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP28GS1	2.4 - 0.1	Gravel to cobble sized particles with occasional boulders. Material is highly angular and blocky. Rock appears fresh. Level of oxidation very low. Layer composed of 95% shale and 5% intrusive particle types. Material is cool, loose, slightly moist and contains very little silt and sand. Interparticle void spaces open.

Table 39. Test Pit 29 Field Log.

Sample Identification	Depth Increment (m)	Description of Layer
TP29GS1	1.3 - 0.8	Gravel to cobble and boulder sized particles with little sand and silt. Layer composed of 95% shale and 5% intrusive rock types. Layer is cool, slightly moist and loose. Interparticle void spaces open. Waste rock has a fresh, unweathered appearance. Level of oxidation low. Some particle surfaces show patches of reddish yellow stain on particle surfaces.

Table 40. Test Pit 30 Field Log

Sample Identification	Depth Increment (m)	Description of Layer
		This test pit was located in an area where as-built dump plans indicated the original ground surface was 3.0 to 4.5m below the 5260 ft. excavation bench.
TP30-16		Sample taken at 4.8 m below pit top.
TP30-18		Sample taken at 5.2 m below pit top.

APPENDIX C

Statistical Analysis Reports

Table 41. Spearman rank order correlation statistical report for correlation analysis.

Spearman Rank Order Correlation

Cell Contents:
Correlation Coefficient
P Value
Number of Samples

	H2O-S	HCL-S	HNO3-S
TS	0.11307	0.089155	0.9797
	0.21650	0.330286	0.0000
	121	121	121
	RES-S	EC	SO4
TS	0.7712	0.2669598	0.2693468
	0.0000	0.0031536	0.0028867
	121	121	121
	Acidity	Al	Fe
TS	0.2678516	0.11851	0.3569
	0.0053914	0.19512	0.0000
	107	121	121
	Mn	pH	
TS	0.165300	-0.14859	
	0.070010	0.10374	
	121	121	
	H2O-S	HCL-S	HNO3-S
H2O-S		-0.5509	0.035965
		0.0000	0.694880
		121	121
	RES-S	EC	SO4
H2O-S	-0.11436	0.164710	0.206329
	0.21131	0.071026	0.023301
	121	121	121
	Acidity	Al	Fe
H2O-S	0.077009	0.11063	0.203163
	0.429794	0.22666	0.025544
	107	121	121
	Mn	pH	
H2O-S	0.160327	-0.178331	
	0.078956	0.050415	
	121	121	

Table 41. Continued.

	H2O-S	HCL-S	HNO3-S
HCL-S			0.035941
			0.695075
			121
	RES-S	EC	SO4
HCL-S	0.13645	0.019410	0.033808
	0.13543	0.832368	0.712349
	121	121	121
	Acidity	Al	Fe
HCL-S	0.12156	0.058270	0.030330
	0.21188	0.524948	0.740824
	107	121	121
	Mn	pH	
HCL-S	-0.026607	-0.0064095	
	0.771701	0.9442601	
	121	121	
HNO3-S			
	RES-S	EC	SO4
HNO3-S	0.7562	0.2348953	0.2354703
	0.0000	0.0096217	0.0094421
	121	121	121
	Acidity	Al	Fe
HNO3-S	0.235336	0.085362	0.3136
	0.014825	0.351338	0.0000
	107	121	121
	Mn	pH	
HNO3-S	0.162758	-0.10434	
	0.074473	0.25429	
	121	121	
RES-S			
	RES-S	EC	SO4
RES-S		0.13318	0.11111
		0.14510	0.22465
		121	121
	Acidity	Al	Fe
RES-S	0.10074	0.025607	0.203574
	0.30127	0.780054	0.025243
	107	121	121

Table 41. Continued.

	Mn	pH	
RES-S	0.024168	-0.028394	
	0.792124	0.756832	
	121	121	
EC			

	RES-S	EC	SO4
EC			0.8437
			0.0000
			121

	Acidity	Al	Fe
EC	0.6720	0.6257	0.7314
	0.0000	0.0000	0.0000
	107	121	121

	Mn	pH	
EC	0.4977	-0.6702	
	0.0000	0.0000	
	121	121	
SO4			

	Acidity	Al	Fe
SO4	0.8299	0.7814	0.7913
	0.0000	0.0000	0.0000
	107	121	121

	Mn	pH	
SO4	0.5253	-0.7296	
	0.0000	0.0000	
	121	121	
Acidity			

	Acidity	Al	Fe
Acidity		0.9212	0.7919
		0.0000	0.0000
		107	107

	Mn	pH	
Acidity	-0.0069227	-0.8110	
	0.9434449	0.0000	
	107	107	
Al			

Table 41. Continued.

	Acidity	Al	Fe
Al			0.7066
			0.0000
			121
	Mn	pH	
Al	0.186548	-0.8125	
	0.040581	0.0000	
	121	121	
Fe			
	Mn	pH	
Fe	0.3430	-0.8342	
	0.0000	0.0000	
	121	121	
Mn			
	Mn	pH	
Mn		-0.13756	
		0.13226	
		121	

The pair(s) of variables with positive correlation coefficients and P values below 0.050000 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050000, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050000, there is no significant relationship between the two variables.

Table 42. Statistical Report - ANOVA results, analysis on sample depth.

One Way Analysis of Variance - pH

Normality Test:	Failed	(P = <0.0001)
Equal Variance Test:	Failed	(P = 0.0212)

Group	N	Missing
PH1	14	0
PH2	35	0
PH3	52	0
PH4	20	0

Group	Mean	Std Dev	SEM
PH1	2.7500	1.0346	0.27651
PH2	3.2314	1.3499	0.22817
PH3	3.6827	1.1231	0.15575
PH4	4.6200	1.8341	0.41011

Power of performed test with alpha = 0.1000: 0.9827

Source of Variance	DF	SS	MS
Between Treatments	3	36.033	12.0110
Residual	117	204.117	1.7446
Total	120	240.150	

Source of Variance	F	P
Between Treatments	6.8847	0.0003
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00026060).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
PH4 vs PH1	1.87000	4	5.7458
PH4 vs PH2	1.38857	3	5.3040
PH4 vs PH3	0.93731	2	3.8142
PH3 vs PH1	0.93269	3	3.3167
PH3 vs PH2	0.45126	2	2.2099
PH2 vs PH1	0.48143	2	1.6300

Comparison	P<0.05

Table 42. Continued.

PH4 vs PH1	Yes
PH4 vs PH2	Yes
PH4 vs PH3	Yes
PH3 vs PH1	No
PH3 vs PH2	Do Not Test
PH2 vs PH1	Do Not Test

Kruskal-Wallis One Way Analysis of Variance on Ranks - pH

Normality Test: Failed (P = <0.0001)

Group	N	Missing
PH1	14	0
PH2	35	0
PH3	52	0
PH4	20	0

Group	Median	25%	75%
PH1	2.5000	2.3000	2.7000
PH2	2.8000	2.5000	3.1750
PH3	3.3500	2.9000	4.0500
PH4	3.7000	3.2500	6.9000

H = 34.227 with 3 degrees of freedom. (P = <0.0001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00000017745)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	p	Q
PH4 vs PH1	59.175	4	4.8478
PH4 vs PH2	39.439	3	4.0167
PH4 vs PH3	14.358	2	1.5578
PH3 vs PH1	44.817	3	4.2492
PH3 vs PH2	25.082	2	3.2749
PH2 vs PH1	19.736	2	1.7816

Table 42. Continued.

Comparison	P<0.05
PH4 vs PH1	Yes
PH4 vs PH2	Yes
PH4 vs PH3	No
PH3 vs PH1	Yes
PH3 vs PH2	Yes
PH2 vs PH1	No

One Way Analysis of Variance - Titratable Acidity

Normality Test: Failed (P = 0.0054)

Equal Variance Test: Failed (P = 0.0080)

Group	N	Missing
ACID1	14	1
ACID2	35	3
ACID3	52	3
ACID4	20	7

Group	Mean	Std Dev	SEM
ACID1	12360.2	4751.7	1317.88
ACID2	9869.5	7446.1	1316.29
ACID3	4137.7	4004.1	572.02
ACID4	3766.8	4047.7	1122.64

Power of performed test with alpha = 0.1000: 1.0000

Source of Variance	DF	SS	MS
Between Treatments	3	1170300053.1	390100017.7
Residual	103	2955894058.4	28698000.6
Total	106	4126194111.5	

Source of Variance	F	P
Between Treatments	13.593	<0.0001
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00000015404).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method)
:

Table 42. Continued.

Comparison	Diff of Means	p	q
ACID1 vs ACID4	8593.38	4	5.78376
ACID1 vs ACID3	8222.46	3	6.95769
ACID1 vs ACID2	2490.69	2	1.99916
ACID2 vs ACID4	6102.70	3	4.89837
ACID2 vs ACID3	5731.77	2	6.65746
ACID3 vs ACID4	370.92	2	0.31387

Comparison	P<0.05
ACID1 vs ACID4	Yes
ACID1 vs ACID3	Yes
ACID1 vs ACID2	No
ACID2 vs ACID4	Yes
ACID2 vs ACID3	Yes
ACID3 vs ACID4	No

One Way Analysis of Variance - Titratable Acidity

Normality Test:	Passed	(P = 0.8432)
Equal Variance Test:	Passed	(P = 0.0789)

Group	N	Missing
sqrt(-ACID1-)	14	1
sqrt(-ACID2-)	35	3
sqrt(-ACID3-)	52	3
sqrt(-ACID4-)	20	7

Group	Mean	Std Dev	SEM
sqrt(-ACID1-)	109.348	20.900	5.7965
sqrt(-ACID2-)	91.115	40.226	7.1111
sqrt(-ACID3-)	54.847	33.956	4.8508
sqrt(-ACID4-)	54.031	30.298	8.4033

Power of performed test with alpha = 0.1000: 1.0000

Source of Variance	DF	SS	MS
Between Treatments	3	48433.9	16144.6
Residual	103	121764.7	1182.2
Total	106	170198.6	

Source of Variance	F	P
Between Treatments	13.657	<0.0001
Residual		
Total		

Table 42. Continued.

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00000014414).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
sqrt(-ACID1-) vs sqrt(-ACID4-)	55.31650	4	5.80075
sqrt(-ACID1-) vs sqrt(-ACID3-)	54.50062	3	7.18535
sqrt(-ACID1-) vs sqrt(-ACID2-)	18.23332	2	2.28023
sqrt(-ACID2-) vs sqrt(-ACID4-)	37.08318	3	4.63757
sqrt(-ACID2-) vs sqrt(-ACID3-)	36.26729	2	6.56324
sqrt(-ACID3-) vs sqrt(-ACID4-)	0.81589	2	0.10757

Comparison	P<0.05
sqrt(-ACID1-) vs sqrt(-ACID4-)	Yes
sqrt(-ACID1-) vs sqrt(-ACID3-)	Yes
sqrt(-ACID1-) vs sqrt(-ACID2-)	No
sqrt(-ACID2-) vs sqrt(-ACID4-)	Yes
sqrt(-ACID2-) vs sqrt(-ACID3-)	Yes
sqrt(-ACID3-) vs sqrt(-ACID4-)	No

One Way Analysis of Variance - Electrical Conductivity

Normality Test:	Passed	(P = 0.3487)
Equal Variance Test:	Passed	(P = 0.1301)

Group	N	Missing
EC1	14	0
EC2	35	0
EC3	52	0
EC4	20	0

Table 42. Continued.

Group	Mean	Std Dev	SEM
EC1	11.0714	3.7753	1.00898
EC2	8.9809	3.9539	0.66833
EC3	7.8273	3.5913	0.49802
EC4	5.1330	2.4048	0.53774

Power of performed test with alpha = 0.1000: 0.9972

Source of Variance	DF	SS	MS
Between Treatments	3	330.69	110.229
Residual	117	1484.46	12.688
Total	120	1815.15	

Source of Variance	F	P
Between Treatments	8.6879	<0.0001
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.000029856).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
EC1 vs EC4	5.9384	4	6.7660
EC1 vs EC3	3.2441	3	4.2777
EC1 vs EC2	2.0906	2	2.6248
EC2 vs EC4	3.8479	3	5.4502
EC2 vs EC3	1.1535	2	2.0948
EC3 vs EC4	2.6943	2	4.0656

Comparison	P<0.05
EC1 vs EC4	Yes
EC1 vs EC3	Yes
EC1 vs EC2	No
EC2 vs EC4	Yes
EC2 vs EC3	No
EC3 vs EC4	Yes

Table 42. Continued.

One Way Analysis of Variance - SO_4

Normality Test: Failed (P = 0.0024)

Equal Variance Test: Failed (P = 0.0203)

Group	N	Missing
SO41	14	0
SO42	35	0
SO43	52	0
SO44	20	0

Group	Mean	Std Dev	SEM
SO41	16090.7	5621.2	1502.33
SO42	13973.4	9300.5	1572.08
SO43	10478.2	6843.3	948.99
SO44	6412.7	4954.3	1107.80

Power of performed test with alpha = 0.1000: 0.9811

Source of Variance	DF	SS	MS
Between Treatments	3	1080945279.3	360315093.1
Residual	117	6206453677.9	53046612.6
Total	120	7287398957.2	

Source of Variance	F	P
Between Treatments	6.7924	0.0003
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00029167).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
SO41 vs SO44	9678.1	4	5.3928
SO41 vs SO43	5612.5	3	3.6194
SO41 vs SO42	2117.3	2	1.3001
SO42 vs SO44	7560.8	3	5.2374
SO42 vs SO43	3495.2	2	3.1041
SO43 vs SO44	4065.5	2	3.0002

Table 42. Continued.

Comparison	P<0.05
SO41 vs SO44	Yes
SO41 vs SO43	Yes
SO41 vs SO42	No
SO42 vs SO44	Yes
SO42 vs SO43	Yes
SO43 vs SO44	Yes

One Way Analysis of Variance - SO_4

Normality Test: Passed (P = 0.3714)

Equal Variance Test: Passed (P = 0.0894)

Group	N	Missing
sqrt(-SO41-)	14	0
sqrt(-SO42-)	35	0
sqrt(-SO43-)	52	0
sqrt(-SO44-)	20	0

Group	Mean	Std Dev	SEM
sqrt(-SO41-)	124.452	25.472	6.8076
sqrt(-SO42-)	111.653	39.387	6.6576
sqrt(-SO43-)	97.087	32.756	4.5424
sqrt(-SO44-)	75.004	28.784	6.4363

Power of performed test with alpha = 0.1000: 0.9922

Source of Variance	DF	SS	MS
Between Treatments	3	25980.0	8660.0
Residual	117	131641.7	1125.1
Total	120	157621.7	

Source of Variance	F	P
Between Treatments	7.6968	<0.0001
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.000097440).

Table 42. Continued.

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method)
:

Comparison	Diff of Means	p	q
sqrt(-SO41-) vs sqrt(-SO44-)	49.448	4	5.9827
sqrt(-SO41-) vs sqrt(-SO43-)	27.365	3	3.8317
sqrt(-SO41-) vs sqrt(-SO42-)	12.799	2	1.7064
sqrt(-SO42-) vs sqrt(-SO44-)	36.649	3	5.5124
sqrt(-SO42-) vs sqrt(-SO43-)	14.566	2	2.8088
sqrt(-SO43-) vs sqrt(-SO44-)	22.083	2	3.5386

Comparison	P<0.05
sqrt(-SO41-) vs sqrt(-SO44-)	Yes
sqrt(-SO41-) vs sqrt(-SO43-)	Yes
sqrt(-SO41-) vs sqrt(-SO42-)	No
sqrt(-SO42-) vs sqrt(-SO44-)	Yes
sqrt(-SO42-) vs sqrt(-SO43-)	Yes
sqrt(-SO43-) vs sqrt(-SO44-)	Yes

One Way Analysis of Variance - Fe

Normality Test:	Failed	(P = <0.0001)
Equal Variance Test:	Failed	(P = 0.0023)

Group	N	Missing
FE1	14	0
FE2	35	0
FE3	52	0
FE4	20	0

Table 42. Continued.

Group	Mean	Std Dev	SEM
FE1	1601.62	1425.46	380.970
FE2	2047.87	2875.09	485.979
FE3	822.39	1431.48	198.510
FE4	159.40	296.63	66.329

Power of performed test with alpha = 0.1000: 0.9290

Source of Variance	DF	SS	MS
Between Treatments	3	56271738.6	18757246.2
Residual	117	413641675.1	3535398.9
Total	120	469913413.6	

Source of Variance	F	P
Between Treatments	5.3056	0.0018
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.0018286).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
FE2 vs FE4	1888.47	4	5.0673
FE2 vs FE3	1225.48	3	4.2158
FE2 vs FE1	446.25	2	1.0614
FE1 vs FE4	1442.23	3	3.1129
FE1 vs FE3	779.23	2	1.9465
FE3 vs FE4	662.99	2	1.8952

Comparison	P<0.05
FE2 vs FE4	Yes
FE2 vs FE3	Yes
FE2 vs FE1	No
FE1 vs FE4	No
FE1 vs FE3	Do Not Test
FE3 vs FE4	Do Not Test

Table 42. Continued.

Kruskal-Wallis One Way Analysis of Variance on Ranks - Fe

Normality Test: Failed (P = <0.0001)

Group	N	Missing
FE1	14	0
FE2	35	0
FE3	52	0
FE4	20	0

Group	Median	25%	75%
FE1	1161.500	617.00000	2955.000
FE2	659.000	104.75000	2297.250
FE3	139.000	16.00000	1351.000
FE4	15.500	0.70000	89.500

H = 20.996 with 3 degrees of freedom. (P = 0.0001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00010549)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	p	Q
FE1 vs FE4	45.2000	4	3.70260
FE1 vs FE3	21.6058	3	2.04829
FE1 vs FE2	5.1643	2	0.46616
FE2 vs FE4	40.0357	3	4.07703
FE2 vs FE3	16.4415	2	2.14657
FE3 vs FE4	23.5942	2	2.55967

Comparison	P<0.05
FE1 vs FE4	Yes
FE1 vs FE3	No
FE1 vs FE2	Do Not Test
FE2 vs FE4	Yes
FE2 vs FE3	Do Not Test
FE3 vs FE4	No

Table 42. Continued.

One Way Analysis of Variance - Al

Normality Test: Failed (P = <0.0001)

Equal Variance Test: Failed (P = 0.0004)

Group	N	Missing
AL1	14	0
AL2	35	0
AL3	52	0
AL4	20	0

Group	Mean	Std Dev	SEM
AL1	1241.76	850.63	227.341
AL2	810.17	687.52	116.212
AL3	330.97	354.45	49.154
AL4	314.05	562.75	125.834

Power of performed test with alpha = 0.1000: 1.0000

Source of Variance	DF	SS	MS
Between Treatments	3	12617227.9	4205742.6
Residual	117	37902385.5	323952.0
Total	120	50519613.5	

Source of Variance	F	P
Between Treatments	12.983	<0.0001
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00000022270).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
AL1 vs AL4	927.719	4	6.61501
AL1 vs AL3	910.793	3	7.51602
AL1 vs AL2	431.599	2	3.39121
AL2 vs AL4	496.121	3	4.39774
AL2 vs AL3	479.195	2	5.44581
AL3 vs AL4	16.926	2	0.15984

Table 42. Continued.

Comparison	P<0.05
AL1 vs AL4	Yes
AL1 vs AL3	Yes
AL1 vs AL2	Yes
AL2 vs AL4	Yes
AL2 vs AL3	Yes
AL3 vs AL4	No

Kruskal-Wallis One Way Analysis of Variance on Ranks - Al

Normality Test: Failed (P = <0.0001)

Group	N	Missing
AL1	14	0
AL2	35	0
AL3	52	0
AL4	20	0

Group	Median	25%	75%
AL1	888.000	667.00000	1983.00
AL2	650.000	221.25000	1366.75
AL3	197.000	26.50000	546.00
AL4	71.000	0.70000	483.50

H = 25.575 with 3 degrees of freedom. (P = <0.0001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.000011704)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	p	Q
AL1 vs AL4	48.9500	4	4.0107
AL1 vs AL3	39.5962	3	3.7547
AL1 vs AL2	16.0500	2	1.4491
AL2 vs AL4	32.9000	3	3.3511
AL2 vs AL3	23.5462	2	3.0748
AL3 vs AL4	9.3538	2	1.0150

Table 42. Continued.

Comparison	P<0.05
AL1 vs AL4	Yes
AL1 vs AL3	Yes
AL1 vs AL2	No
AL2 vs AL4	Yes
AL2 vs AL3	Yes
AL3 vs AL4	No

One Way Analysis of Variance - Mn

Normality Test: Failed (P = <0.0001)

Equal Variance Test: Passed (P = 0.0892)

Group	N	Missing
MN1	14	0
MN2	35	0
MN3	52	0
MN4	20	0

Group	Mean	Std Dev	SEM
MN1	23.857	20.836	5.5686
MN2	38.449	47.689	8.0610
MN3	44.308	46.994	6.5169
MN4	15.785	13.115	2.9326

Power of performed test with alpha = 0.1000: 0.5720

The power of the performed test (0.5720) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	3	14009.5	4669.8
Residual	117	198866.2	1699.7
Total	120	212875.7	

Source of Variance	F	P
Between Treatments	2.7474	0.0460
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.046040).

Table 42. Continued.

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
MN3 vs MN4	28.5227	4	3.71851
MN3 vs MN1	20.4505	3	2.32984
MN3 vs MN2	5.8591	2	0.91925
MN2 vs MN4	22.6636	3	2.77347
MN2 vs MN1	14.5914	2	1.58280
MN1 vs MN4	8.0721	2	0.79461

Comparison	P<0.05
MN3 vs MN4	Yes
MN3 vs MN1	No
MN3 vs MN2	Do Not Test
MN2 vs MN4	No
MN2 vs MN1	Do Not Test
MN1 vs MN4	Do Not Test

Kruskal-Wallis One Way Analysis of Variance on Ranks - Mn

Normality Test: Failed (P = <0.0001)

Group	N	Missing
MN1	14	0
MN2	35	0
MN3	52	0
MN4	20	0

Group	Median	25%	75%
MN1	20.000	9.0000	30.000
MN2	20.000	5.2500	57.250
MN3	27.500	15.5000	55.000
MN4	12.000	6.5000	25.000

H = 9.7256 with 3 degrees of freedom. (P = 0.0210)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.021049)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Table 42. Continued.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	p	Q
MN3 vs MN4	27.5192	4	2.98292
MN3 vs MN1	14.3764	3	1.36175
MN3 vs MN2	13.1621	2	1.71695
MN2 vs MN4	14.3571	3	1.46080
MN2 vs MN1	1.2143	2	0.10952
MN1 vs MN4	13.1429	2	1.07568

Comparison	P<0.05
MN3 vs MN4	Yes
MN3 vs MN1	No
MN3 vs MN2	Do Not Test
MN2 vs MN4	No
MN2 vs MN1	Do Not Test
MN1 vs MN4	Do Not Test

One Way Analysis of Variance - Total Sulfur (%)

Normality Test:	Failed	(P = <0.0001)
Equal Variance Test:	Failed	(P = 0.0091)

Group	N	Missing
TS1	14	0
TS2	35	0
TS3	52	0
TS4	20	0

Group	Mean	Std Dev	SEM
TS1	9.2636	8.4123	2.24828
TS2	8.7829	4.3197	0.73017
TS3	8.0627	2.7536	0.38186
TS4	6.9350	4.3049	0.96260

Power of performed test with alpha = 0.1000: 0.1068

The power of the performed test (0.1068) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Table 42. Continued.

Source of Variance	DF	SS	MS
Between Treatments	3	60.645	20.215
Residual	117	2293.215	19.600
Total	120	2353.860	

Source of Variance	F	P
Between Treatments	1.0314	0.3814
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.38143).

Kruskal-Wallis One Way Analysis of Variance on Ranks - Total Sulfur (%)

Normality Test: Failed (P = <0.0001)

Group	N	Missing
TS1	14	0
TS2	35	0
TS3	52	0
TS4	20	0

Group	Median	25%	75%
TS1	6.8250	5.1600	11.8000
TS2	9.3800	5.4400	10.9000
TS3	8.4750	6.7700	9.5350
TS4	7.4450	3.3050	8.9850

H = 2.9267 with 3 degrees of freedom. (P = 0.4031)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.40307)

Table 42. Continued.

One Way Analysis of Variance - H_20 Extractable Sulfur (%)

Normality Test: Passed (P = 0.1184)

Equal Variance Test: Passed (P = 0.0611)

Group	N	Missing
sqrt(-H2OS1-)	14	0
sqrt(-H2OS2-)	35	0
sqrt(-H2OS3-)	52	0
sqrt(-H2OS4-)	20	0

Group	Mean	Std Dev	SEM
sqrt(-H2OS1-)	0.47751	0.34292	0.091650
sqrt(-H2OS2-)	0.82364	0.35746	0.060421
sqrt(-H2OS3-)	0.79264	0.45788	0.063496
sqrt(-H2OS4-)	0.29883	0.26458	0.059162

Power of performed test with alpha = 0.1000: 0.9997

Source of Variance	DF	SS	MS
Between Treatments	3	4.8604	1.62012
Residual	117	17.8955	0.15295
Total	120	22.7559	

Source of Variance	F	P
Between Treatments	10.592	<0.0001
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.0000032511).

Table 42. Continued.

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method)
:

Comparison	Diff of Means	p	q
sqrt(-H2OS2-) vs sqrt(-H2OS4-)	0.524819	4	6.77037
sqrt(-H2OS2-) vs sqrt(-H2OS1-)	0.346130	3	3.95800
sqrt(-H2OS2-) vs sqrt(-H2OS3-)	0.031001	2	0.51273
sqrt(-H2OS3-) vs sqrt(-H2OS4-)	0.493817	3	6.78660
sqrt(-H2OS3-) vs sqrt(-H2OS1-)	0.315129	2	3.78458
sqrt(-H2OS1-) vs sqrt(-H2OS4-)	0.178688	2	1.85426

Comparison	P<0.05
sqrt(-H2OS2-) vs sqrt(-H2OS4-)	Yes
sqrt(-H2OS2-) vs sqrt(-H2OS1-)	Yes
sqrt(-H2OS2-) vs sqrt(-H2OS3-)	No
sqrt(-H2OS3-) vs sqrt(-H2OS4-)	Yes
sqrt(-H2OS3-) vs sqrt(-H2OS1-)	Yes
sqrt(-H2OS1-) vs sqrt(-H2OS4-)	No

One Way Analysis of Variance - HCL Extaractable Sulfur (%)

Normality Test:	Failed	(P = <0.0001)
Equal Variance Test:	Failed	(P = 0.0011)

Group	N	Missing
HCLS1	14	0
HCLS2	35	0
HCLS3	52	0
HCLS4	20	0

Table 42. Continued.

Group	Mean	Std Dev	SEM
HCLS1	0.87479	0.81205	0.217030
HCLS2	0.38394	1.00347	0.169617
HCLS3	0.32433	0.40093	0.055600
HCLS4	0.70850	0.70364	0.157339

Power of performed test with alpha = 0.1000: 0.6497

The power of the performed test (0.6497) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	3	4.7941	1.59802
Residual	117	60.4138	0.51636
Total	120	65.2079	

Source of Variance	F	P
Between Treatments	3.0948	0.0297
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.029663).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
HCLS1 vs HCLS3	0.550459	4	3.59798
HCLS1 vs HCLS2	0.490843	3	3.05480
HCLS1 vs HCLS4	0.166286	2	0.93915
HCLS4 vs HCLS3	0.384173	3	2.87354
HCLS4 vs HCLS2	0.324557	2	2.27876
HCLS2 vs HCLS3	0.059616	2	0.53663

Comparison	P<0.05
HCLS1 vs HCLS3	No
HCLS1 vs HCLS2	Do Not Test
HCLS1 vs HCLS4	Do Not Test
HCLS4 vs HCLS3	Do Not Test
HCLS4 vs HCLS2	Do Not Test
HCLS2 vs HCLS3	Do Not Test

Table 42. Continued.

Kruskal-Wallis One Way Analysis of Variance on Ranks - HCL Extractable S

Normality Test: Failed (P = <0.0001)

Group	N	Missing
HCLS1	14	0
HCLS2	35	0
HCLS3	52	0
HCLS4	20	0

Group	Median	25%	75%
HCLS1	0.8750000	0.2200000	1.03000
HCLS2	0.0070000	0.0070000	0.29250
HCLS3	0.0800000	0.0070000	0.62500
HCLS4	0.6000000	0.1150000	1.07500

H = 26.030 with 3 degrees of freedom. (P = <0.0001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.0000093997)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	p	Q
HCLS1 vs HCLS2	42.0214	4	3.92998
HCLS1 vs HCLS3	31.4657	3	3.09065
HCLS1 vs HCLS4	3.8964	2	0.33069
HCLS4 vs HCLS2	38.1250	3	4.02251
HCLS4 vs HCLS3	27.5692	2	3.09881
HCLS3 vs HCLS2	10.5558	2	1.42786

Comparison	P<0.05
HCLS1 vs HCLS2	Yes
HCLS1 vs HCLS3	Yes
HCLS1 vs HCLS4	No
HCLS4 vs HCLS2	Yes
HCLS4 vs HCLS3	Yes
HCLS3 vs HCLS2	No

Table 42. Continued.

One Way Analysis of Variance - HNO_3 Extractable Sulfur (%)

Normality Test: Failed (P = <0.0001)

Equal Variance Test: Failed (P = 0.0027)

Group	N	Missing
HNO3S1	14	0
HNO3S2	35	0
HNO3S3	52	0
HNO3S4	20	0

Group	Mean	Std Dev	SEM
HNO3S1	7.3307	7.4700	1.99644
HNO3S2	7.0814	3.6480	0.61662
HNO3S3	6.4385	2.3255	0.32249
HNO3S4	5.5590	4.0795	0.91220

Power of performed test with alpha = 0.1000: 0.0985

The power of the performed test (0.0985) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	3	38.580	12.860
Residual	117	1769.881	15.127
Total	120	1808.461	

Source of Variance	F	P
Between Treatments	0.85012	0.4692
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.46923).

Table 42. Continued.

Kruskal-Wallis One Way Analysis of Variance on Ranks

Normality Test: Failed (P = <0.0001)

Group	N	Missing
HNO3S1	14	0
HNO3S2	35	0
HNO3S3	52	0
HNO3S4	20	0

Group	Median	25%	75%
HNO3S1	5.3650	3.8500	9.6700
HNO3S2	6.8600	4.3525	9.1900
HNO3S3	6.6950	5.6300	7.7250
HNO3S4	6.2000	1.3950	7.0500

H = 3.4080 with 3 degrees of freedom. (P = 0.3329)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.33290)

One Way Analysis of Variance - Residual Sulfur (%)

Normality Test: Failed (P = <0.0001)

Equal Variance Test: Failed (P = 0.0409)

Group	N	Missing
RESS1	14	0
RESS2	35	0
RESS3	52	0
RESS4	20	0

Group	Mean	Std Dev	SEM
RESS1	0.72714	1.08505	0.289991
RESS2	0.52143	0.28145	0.047573
RESS3	0.47154	0.20170	0.027971
RESS4	0.51900	0.34502	0.077150

Power of performed test with alpha = 0.1000: 0.1688

The power of the performed test (0.1688) is below the desired power of 0.8000.

Table 42. Continued.

You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	3	0.72154	0.24051
Residual	117	22.33517	0.19090
Total	120	23.05671	

Source of Variance	F	P
Between Treatments	1.2599	0.2915
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.29145).

Kruskal-Wallis One Way Analysis of Variance on Ranks

Normality Test: Failed (P = <0.0001)

Group	N	Missing
RESS1	14	0
RESS2	35	0
RESS3	52	0
RESS4	20	0

Group	Median	25%	75%
RESS1	0.42500	0.31000	0.75000
RESS2	0.49000	0.30750	0.62750
RESS3	0.44500	0.37500	0.58000
RESS4	0.47500	0.26500	0.69000

H = 0.20596 with 3 degrees of freedom. (P = 0.9766)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.97662)

Table 43. Statistical Report - ANOVA results, analysis on sample age.

One Way Analysis of Variance - pH

Normality Test:	Failed	(P = <0.0001)
Equal Variance Test:	Failed	(P = 0.0131)

Group	N	Missing
pH1	39	0
pH2	52	0
pH3	28	0

Group	Mean	Std Dev	SEM
pH1	3.0513	0.89115	0.14270
pH2	3.4462	1.32775	0.18413
pH3	4.6500	1.67962	0.31742

Power of performed test with alpha = 0.1000: 0.9993

Source of Variance	DF	SS	MS
Between Treatments	2	43.843	21.9217
Residual	116	196.257	1.6919
Total	118	240.100	

Source of Variance	F	P
Between Treatments	12.957	<0.0001
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.0000083382).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
pH3 vs pH1	1.59872	3	7.0174
pH3 vs pH2	1.20385	2	5.5839
pH2 vs pH1	0.39487	2	2.0268

Comparison	P<0.05
pH3 vs pH1	Yes
pH3 vs pH2	Yes
pH2 vs pH1	No

Table 43. Continued.

Kruskal-Wallis One Way Analysis of Variance on Ranks - pH

Normality Test:	Failed	(P = <0.0001)

Group	N	Missing
pH1	39	0
pH2	52	0
pH3	28	0

Group	Median	25%	75%
pH1	2.7000	2.5000	3.2750
pH2	3.1000	2.7000	3.5500
pH3	4.0500	3.3000	6.6500

H = 25.619 with 2 degrees of freedom. (P = <0.0001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.0000027353)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	p	Q
pH3 vs pH1	42.804	3	5.0158
pH3 vs pH2	29.236	2	3.6203
pH2 vs pH1	13.567	2	1.8591

Comparison	P<0.05
pH3 vs pH1	Yes
pH3 vs pH2	Yes
pH2 vs pH1	No

One Way Analysis of Variance - Titratable Acidity

Normality Test:	Failed	(P = 0.0039)

Equal Variance Test:	Failed	(P = 0.0211)

Group	N	Missing
ACID1	39	1
ACID2	52	5
ACID3	28	8

Table 43. Continued.

Group	Mean	Std Dev	SEM
ACID1	9912.3	6876.1	1115.45
ACID2	6053.6	5561.0	811.15
ACID3	3047.0	3622.6	810.03

Power of performed test with alpha = 0.1000: 0.9932

Source of Variance	DF	SS	MS
Between Treatments	2	675335347.8	337667673.9
Residual	102	3421233991.2	33541509.7
Total	104	4096569339.0	

Source of Variance	F	P
Between Treatments	10.067	0.0001
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00010230).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
ACID1 vs ACID3	6865.3	3	6.0684
ACID1 vs ACID2	3858.6	2	4.3190
ACID2 vs ACID3	3006.7	2	2.7500

Comparison	P<0.05
ACID1 vs ACID3	Yes
ACID1 vs ACID2	Yes
ACID2 vs ACID3	No

One Way Analysis of Variance - Titratable Acidity

Normality Test:	Passed	(P = 0.6648)
Equal Variance Test:	Passed	(P = 0.4265)

Group	N	Missing
sqrt(-ACID1-)	39	1
sqrt(-ACID2-)	52	5
sqrt(-ACID3-)	28	8

Table 43. Continued.

Group	Mean	Std Dev	SEM
sqrt(-ACID1-)	90.675	41.666	6.7591
sqrt(-ACID2-)	69.006	36.330	5.2992
sqrt(-ACID3-)	46.420	30.645	6.8524

Power of performed test with alpha = 0.1000: 0.9900

Source of Variance	DF	SS	MS
Between Treatments	2	26729.1	13364.6
Residual	102	142788.6	1399.9
Total	104	169517.7	

Source of Variance	F	P
Between Treatments	9.5469	0.0002
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00015827).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
sqrt(-ACID1-) vs sqrt(-ACID3-)	44.255	3	6.0551
sqrt(-ACID1-) vs sqrt(-ACID2-)	21.668	2	3.7543
sqrt(-ACID2-) vs sqrt(-ACID3-)	22.587	2	3.1978

Comparison	P<0.05
sqrt(-ACID1-) vs sqrt(-ACID3-)	Yes
sqrt(-ACID1-) vs sqrt(-ACID2-)	Yes
sqrt(-ACID2-) vs sqrt(-ACID3-)	Yes

Table 43. Continued.

One Way Analysis of Variance - Electrical Conductivity

Normality Test: Passed (P = 0.7726)

Equal Variance Test: Passed (P = 0.1611)

Group	N	Missing
EC1	39	0
EC2	52	0
EC3	28	0

Group	Mean	Std Dev	SEM
EC1	9.9172	4.4381	0.71066
EC2	7.4038	3.4193	0.47417
EC3	7.0361	3.1418	0.59374

Power of performed test with alpha = 0.1000: 0.9313

Source of Variance	DF	SS	MS
Between Treatments	2	185.48	92.739
Residual	116	1611.25	13.890
Total	118	1796.73	

Source of Variance	F	P
Between Treatments	6.6767	0.0018
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.0018008).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
EC1 vs EC3	2.88111	3	4.41364
EC1 vs EC2	2.51333	2	4.50222
EC2 vs EC3	0.36777	2	0.59536

Comparison	P<0.05
EC1 vs EC3	Yes
EC1 vs EC2	Yes
EC2 vs EC3	No

Table 43. Continued.

One Way Analysis of Variance - SO_4

Normality Test:	Passed	(P = 0.1525)
Equal Variance Test:	Failed	(P = 0.0171)

Group	N	Missing
SO4-1	39	0
SO4-2	52	0
SO4-3	28	0

Group	Mean	Std Dev	SEM
SO4-1	15647.7	9645.9	1544.57
SO4-2	9914.7	6349.7	880.54
SO4-3	8954.1	4862.3	918.89

Power of performed test with alpha = 0.1000: 0.9869

Source of Variance	DF	SS	MS
Between Treatments	2	982549500.7	491274750.4
Residual	116	6230210812.4	53708713.9
Total	118	7212760313.1	

Source of Variance	F	P
Between Treatments	9.1470	0.0002
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00020477).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
SO4-1 vs SO4-3	6693.55	3	5.21462
SO4-1 vs SO4-2	5732.98	2	5.22260
SO4-2 vs SO4-3	960.57	2	0.79078

Comparison	P<0.05
SO4-1 vs SO4-3	Yes
SO4-1 vs SO4-2	Yes
SO4-2 vs SO4-3	No

Table 43. Continued.

One Way Analysis of Variance - SO_4

Normality Test: Passed (P = 0.4389)

Equal Variance Test: Passed (P = 0.2959)

Group	N	Missing
sqrt(-SO4-1-)	39	0
sqrt(-SO4-2-)	52	0
sqrt(-SO4-3-)	28	0

Group	Mean	Std Dev	SEM
sqrt(-SO4-1-)	118.206	41.462	6.6392
sqrt(-SO4-2-)	94.323	32.215	4.4674
sqrt(-SO4-3-)	90.591	27.841	5.2614

Power of performed test with alpha = 0.1000: 0.9452

Source of Variance	DF	SS	MS
Between Treatments	2	16889.1	8444.6
Residual	116	139179.5	1199.8
Total	118	156068.6	

Source of Variance	F	P
Between Treatments	7.0382	0.0013
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.0013034).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
sqrt(-SO4-1-) vs sqrt(-SO4-3-)	27.6153	3	4.55177
sqrt(-SO4-1-) vs sqrt(-SO4-2-)	23.8829	2	4.60316
sqrt(-SO4-2-) vs sqrt(-SO4-3-)	3.7324	2	0.65011

Table 43. Continued.

Comparison	P<0.05
sqrt(-SO4-1-) vs sqrt(-SO4-3-)	Yes
sqrt(-SO4-1-) vs sqrt(-SO4-2-)	Yes
sqrt(-SO4-2-) vs sqrt(-SO4-3-)	No

One Way Analysis of Variance - Fe

Normality Test: Failed (P = <0.0001)

Equal Variance Test: Failed (P = 0.0002)

Group	N	Missing
FE1	39	0
FE2	52	0
FE3	28	0

Group	Mean	Std Dev	SEM
FE1	2197.46	2838.66	454.55
FE2	820.60	1268.93	175.97
FE3	413.93	758.87	143.41

Power of performed test with alpha = 0.1000: 0.9867

Source of Variance	DF	SS	MS
Between Treatments	2	63521473.7	31760736.8
Residual	116	403870722.0	3481644.2
Total	118	467392195.7	

Source of Variance	F	P
Between Treatments	9.1223	0.0002
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00020919).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
FE1 vs FE3	1783.54	3	5.4573
FE1 vs FE2	1376.86	2	4.9264
FE2 vs FE3	406.68	2	1.3149

Table 43. Continued.

Comparison	P<0.05
FE1 vs FE3	Yes
FE1 vs FE2	Yes
FE2 vs FE3	No

Kruskal-Wallis One Way Analysis of Variance on Ranks

Normality Test: Failed (P = <0.0001)

Group	N	Missing
FE1	39	0
FE2	52	0
FE3	28	0

Group	Median	25%	75%
FE1	992.000	130.7500	3321.75
FE2	139.000	24.5000	1240.50
FE3	35.500	3.3500	447.50

H = 14.644 with 2 degrees of freedom. (P = 0.0007)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00066071)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	p	Q
FE1 vs FE3	32.458	3	3.8033
FE1 vs FE2	16.263	2	2.2283
FE2 vs FE3	16.195	2	2.0053

Comparison	P<0.05
FE1 vs FE3	Yes
FE1 vs FE2	No
FE2 vs FE3	No

Table 43. Continued.

One Way Analysis of Variance - Al

Normality Test:	Failed	(P = <0.0001)
Equal Variance Test:	Failed	(P = 0.0068)

Group	N	Missing
AL1	39	0
AL2	52	0
AL3	28	0

Group	Mean	Std Dev	SEM
AL1	900.50	703.42	112.637
AL2	523.89	584.75	81.090
AL3	216.05	484.33	91.529

Power of performed test with alpha = 0.1000: 0.9960

Source of Variance	DF	SS	MS
Between Treatments	2	7875571.9	3937785.9
Residual	116	42574147.8	367018.5
Total	118	50449719.7	

Source of Variance	F	P
Between Treatments	10.729	<0.0001
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.000053047).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
AL1 vs AL3	684.45	3	6.4504
AL1 vs AL2	376.61	2	4.1503
AL2 vs AL3	307.84	2	3.0657

Comparison	P<0.05
AL1 vs AL3	Yes
AL1 vs AL2	Yes
AL2 vs AL3	Yes

Table 43. Continued.

One Way Analysis of Variance - Al

Normality Test: Passed (P = 0.4259)

Equal Variance Test: Passed (P = 0.2722)

Group	N	Missing
sqrt(-AL1-)	39	0
sqrt(-AL2-)	52	0
sqrt(-AL3-)	28	0

Group	Mean	Std Dev	SEM
sqrt(-AL1-)	26.6780	13.919	2.2289
sqrt(-AL2-)	19.1697	12.628	1.7513
sqrt(-AL3-)	9.4196	11.491	2.1715

Power of performed test with alpha = 0.1000: 0.9999

Source of Variance	DF	SS	MS
Between Treatments	2	4857.1	2428.55
Residual	116	19060.7	164.32
Total	118	23917.8	

Source of Variance	F	P
Between Treatments	14.780	<0.0001
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.0000019153).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
sqrt(-AL1-) vs sqrt(-AL3-)	17.2584	3	7.6868
sqrt(-AL1-) vs sqrt(-AL2-)	7.5083	2	3.9105
sqrt(-AL2-) vs sqrt(-AL3-)	9.7501	2	4.5890

Table 43. Continued.

Comparison	P<0.05
sqrt(-AL1-) vs sqrt(-AL3-)	Yes
sqrt(-AL1-) vs sqrt(-AL2-)	Yes
sqrt(-AL2-) vs sqrt(-AL3-)	Yes

One Way Analysis of Variance - Mn

Normality Test: Failed (P = <0.0001)

Equal Variance Test: Passed (P = 0.1843)

Group	N	Missing
MN1	39	0
MN2	52	0
MN3	28	0

Group	Mean	Std Dev	SEM
MN1	37.326	40.219	6.4401
MN2	28.462	37.150	5.1518
MN3	47.025	52.453	9.9126

Power of performed test with alpha = 0.1000: 0.2774

The power of the performed test (0.2774) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	2	6418.6	3209.3
Residual	116	206138.1	1777.1
Total	118	212556.8	

Source of Variance	F	P
Between Treatments	1.8060	0.1689
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.16890).

Table 43. Continued.

Kruskal-Wallis One Way Analysis of Variance on Ranks - Mn

Normality Test:	Failed	(P = <0.0001)

Group	N	Missing
MN1	39	0
MN2	52	0
MN3	28	0

Group	Median	25%	75%
MN1	28.000	9.2500	39.250
MN2	16.500	8.0000	27.500
MN3	30.500	8.5000	63.500

H = 3.7051 with 2 degrees of freedom. (P = 0.1568)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.15684)

One Way Analysis of Variance

Normality Test:	Failed	(P = <0.0001)
Equal Variance Test:	Passed	(P = 0.1919)

Group	N	Missing
TS1	39	0
TS2	52	0
TS3	28	0

Group	Mean	Std Dev	SEM
TS1	8.8087	5.7872	0.92670
TS2	7.4681	3.9265	0.54451
TS3	8.8414	2.9864	0.56438

Power of performed test with alpha = 0.1000: 0.1767

The power of the performed test (0.1767) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Table 43. Continued.

Source of Variance	DF	SS	MS
Between Treatments	2	53.717	26.858
Residual	116	2299.785	19.826
Total	118	2353.501	

Source of Variance	F	P
Between Treatments	1.3547	0.2621
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.26207).

Kruskal-Wallis One Way Analysis of Variance on Ranks - Total Sulfur

Normality Test: Failed (P = <0.0001)

Group	N	Missing
TS1	39	0
TS2	52	0
TS3	28	0

Group	Median	25%	75%
TS1	8.9700	5.7800	10.5500
TS2	7.3000	4.7050	9.6650
TS3	8.9300	6.6850	10.3000

H = 3.2027 with 2 degrees of freedom. (P = 0.2016)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.20162)

One Way Analysis of Variance - H_2O Extractable Sulfur

Normality Test: Failed (P = <0.0001)

Equal Variance Test: Passed (P = 0.4804)

Group	N	Missing
H2OS1	39	0
H2OS2	52	0
H2OS3	28	0

Table 43. Continued.

Group	Mean	Std Dev	SEM
H2OS1	0.68082	0.58702	0.093999
H2OS2	0.76421	0.68114	0.094457
H2OS3	0.46025	0.51242	0.096839

Power of performed test with alpha = 0.1000: 0.3736

The power of the performed test (0.3736) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	2	1.6954	0.84770
Residual	116	43.8457	0.37798
Total	118	45.5411	

Source of Variance	F	P
Between Treatments	2.2427	0.1108
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.11075).

Kruskal-Wallis One Way Analysis of Variance on Ranks - H_2O Extractable Sulfur

Normality Test: Failed (P = <0.0001)

Group	N	Missing
H2OS1	39	0
H2OS2	52	0
H2OS3	28	0

Group	Median	25%	75%
H2OS1	0.60000	0.1200000	1.17250
H2OS2	0.65500	0.2500000	1.18500
H2OS3	0.23500	0.0070000	0.84000

H = 5.1568 with 2 degrees of freedom. (P = 0.0759)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.075895)

Table 43. Continued.

One Way Analysis of Variance - HCl Extractable Sulfur

Normality Test:	Failed	(P = <0.0001)
Equal Variance Test:	Passed	(P = 0.3476)

Group	N	Missing
HCLS1	39	0
HCLS2	52	0
HCLS3	28	0

Group	Mean	Std Dev	SEM
HCLS1	0.31618	0.53795	0.086141
HCLS2	0.52781	0.94439	0.130963
HCLS3	0.52832	0.50193	0.094855

Power of performed test with alpha = 0.1000: 0.1152

The power of the performed test (0.1152) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	2	1.1762	0.58812
Residual	116	63.2842	0.54555
Total	118	64.4604	

Source of Variance	F	P
Between Treatments	1.0780	0.3437
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.34365).

Kruskal-Wallis One Way Analysis of Variance on Ranks - HCl Extractable Sulfur

Normality Test:	Failed	(P = <0.0001)

Group	N	Missing
HCLS1	39	0
HCLS2	52	0
HCLS3	28	0

Table 43. Continued.

Group	Median	25%	75%
HCLS1	0.0070000	0.0070000	0.54500
HCLS2	0.1400000	0.0070000	0.66000
HCLS3	0.5300000	0.0070000	0.91500

H = 5.6009 with 2 degrees of freedom. (P = 0.0608)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.060781)

One Way Analysis of Variance - HNO_3 Extractable Sulfur

Normality Test:	Failed	(P = <0.0001)
Equal Variance Test:	Passed	(P = 0.1044)

Group	N	Missing
HNO3S1	39	0
HNO3S2	52	0
HNO3S3	28	0

Group	Mean	Std Dev	SEM
HNO3S1	7.2233	5.1756	0.82876
HNO3S2	5.7298	3.1999	0.44375
HNO3S3	7.3000	2.7203	0.51409

Power of performed test with alpha = 0.1000: 0.3805

The power of the performed test (0.3805) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	2	68.234	34.117
Residual	116	1739.929	14.999
Total	118	1808.163	

Source of Variance	F	P
Between Treatments	2.2746	0.1074
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.10741).

Table 43. Continued.

Kruskal-Wallis One Way Analysis of Variance on Ranks

Normality Test:	Failed	(P = <0.0001)

Group	N	Missing
HNO3S1	39	0
HNO3S2	52	0
HNO3S3	28	0

Group	Median	25%	75%
HNO3S1	6.9100	4.2425	8.3375
HNO3S2	6.0000	3.6600	7.2950
HNO3S3	7.2700	5.8650	8.1300

H = 4.6734 with 2 degrees of freedom. (P = 0.0966)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.096647)

One Way Analysis of Variance - Residual Sulfur

Normality Test:	Failed	(P = <0.0001)
Equal Variance Test:	Passed	(P = 0.5190)

Group	N	Missing
RES-S1	39	0
RES-S2	52	0
RES-S3	28	0

Group	Mean	Std Dev	SEM
RES-S1	0.59564	0.67557	0.108178
RES-S2	0.45135	0.25783	0.035754
RES-S3	0.56000	0.25876	0.048901

Power of performed test with alpha = 0.1000: 0.1678

The power of the performed test (0.1678) is below the desired power of 0.8000.

You should interpret the negative findings cautiously.

Table 43. Continued.

Source of Variance	DF	SS	MS
Between Treatments	2	0.51093	0.25547
Residual	116	22.54096	0.19432
Total	118	23.05190	

Source of Variance	F	P
Between Treatments	1.3147	0.2725
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.27253).

Kruskal-Wallis One Way Analysis of Variance on Ranks - Residual Sulfur

Normality Test: Failed (P = <0.0001)

Group	N	Missing
RES-S1	39	0
RES-S2	52	0
RES-S3	28	0

Group	Median	25%	75%
RES-S1	0.49000	0.33250	0.61000
RES-S2	0.42000	0.30500	0.57500
RES-S3	0.49500	0.35500	0.67500

H = 3.1320 with 2 degrees of freedom. (P = 0.2089)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.20888)

Table 44. Statistical Report - ANOVA results,analysis on sample particle size.

One Way Analysis of Variance - pH

Normality Test:	Failed	(P = <0.0001)
Equal Variance Test:	Passed	(P = 0.3450)

Group	N	Missing
pH1	31	0
pH2	30	0
pH3	20	0
pH4	12	0

Group	Mean	Std Dev	SEM
pH1	4.0226	1.6476	0.29591
pH2	3.2167	1.1983	0.21878
pH3	3.3000	1.1571	0.25874
pH4	3.4417	1.2602	0.36379

Power of performed test with alpha = 0.1000: 0.3961

The power of the performed test (0.3961) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	3	11.618	3.8727
Residual	89	165.985	1.8650
Total	92	177.603	

Source of Variance	F	P
Between Treatments	2.0765	0.1090
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.10898).

Table 44. Continued.

Kruskal-Wallis One Way Analysis of Variance on Ranks - pH

Normality Test:	Failed	(P = <0.0001)	
Group	N	Missing	
pH1	31	0	
pH2	30	0	
pH3	20	0	
pH4	12	0	
Group	Median	25%	75%
pH1	3.3000	2.8250	4.8500
pH2	2.8000	2.4000	3.4000
pH3	2.9000	2.6500	3.1500
pH4	3.1500	2.6500	3.4000

H = 6.7541 with 3 degrees of freedom. (P = 0.0802)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.080164)

One Way Analysis of Variance - Titratable Acidity

Normality Test:	Failed	(P = 0.0211)	
Equal Variance Test:	Passed	(P = 0.5480)	
Group	N	Missing	
ACID1	31	6	
ACID2	30	2	
ACID3	20	1	
ACID4	12	1	
Group	Mean	Std Dev	SEM
ACID1	5347.4	5859.5	1171.9
ACID2	9211.0	7341.8	1387.5
ACID3	8656.5	6284.2	1441.7
ACID4	5585.2	5496.4	1657.2

Power of performed test with alpha = 0.1000: 0.4028

The power of the performed test (0.4028) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Table 44. Continued.

Source of Variance	DF	SS	MS
Between Treatments	3	263249631.4	87749877.1
Residual	79	3292314615.5	41674868.6
Total	82	3555564246.9	

Source of Variance	F	P
Between Treatments	2.1056	0.1062
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.10615).

One Way Analysis of Variance - Titratable Acidity

Normality Test:	Passed	(P = 0.1408)
Equal Variance Test:	Passed	(P = 0.9980)

Group	N	Missing
sqrt(-ACID1-)	31	6
sqrt(-ACID2-)	30	2
sqrt(-ACID3-)	20	1
sqrt(-ACID4-)	12	1

Group	Mean	Std Dev	SEM
sqrt(-ACID1-)	61.924	39.697	7.9394
sqrt(-ACID2-)	86.398	42.557	8.0424
sqrt(-ACID3-)	84.259	40.538	9.3002
sqrt(-ACID4-)	65.277	38.164	11.5070

Power of performed test with alpha = 0.1000: 0.4067

The power of the performed test (0.4067) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	3	10535.6	3511.9
Residual	79	130865.1	1656.5
Total	82	141400.8	

Table 44. Continued.

Source of Variance	F	P
Between Treatments	2.1200	0.1043
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.10429).

One Way Analysis of Variance - Electrical Conductivity

Normality Test:	Passed	(P = 0.4453)
Equal Variance Test:	Passed	(P = 0.8117)

Group	N	Missing
EC1	31	0
EC2	30	0
EC3	20	0
EC4	12	0

Group	Mean	Std Dev	SEM
EC1	7.3400	3.9873	0.71614
EC2	9.5150	3.6625	0.66869
EC3	9.4590	4.3547	0.97373
EC4	6.7992	3.5506	1.02496

Power of performed test with alpha = 0.1000: 0.5627

The power of the performed test (0.5627) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	3	125.24	41.747
Residual	89	1364.94	15.336
Total	92	1490.17	

Source of Variance	F	P
Between Treatments	2.7221	0.0491
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.049075).

Table 44. Continued.

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
EC2 vs EC4	2.715833	4	2.871334
EC2 vs EC1	2.175000	3	3.066831
EC2 vs EC3	0.056000	2	0.070054
EC3 vs EC4	2.659833	3	2.630505
EC3 vs EC1	2.119000	2	2.668061
EC1 vs EC4	0.540833	2	0.574453

Comparison	P<0.05
EC2 vs EC4	No
EC2 vs EC1	Do Not Test
EC2 vs EC3	Do Not Test
EC3 vs EC4	Do Not Test
EC3 vs EC1	Do Not Test
EC1 vs EC4	Do Not Test

One Way Analysis of Variance - SO_4

Normality Test:	Failed	(P = 0.0024)
Equal Variance Test:	Failed	(P = 0.0203)

Group	N	Missing
SO41	14	0
SO42	35	0
SO43	52	0
SO44	20	0

Group	Mean	Std Dev	SEM
SO41	16090.7	5621.2	1502.33
SO42	13973.4	9300.5	1572.08
SO43	10478.2	6843.3	948.99
SO44	6412.7	4954.3	1107.80

Power of performed test with alpha = 0.1000: 0.9811

Source of Variance	DF	SS	MS
Between Treatments	3	1080945279.3	360315093.1
Residual	117	6206453677.9	53046612.6
Total	120	7287398957.2	

Table 44. Continued.

Source of Variance	F	P
Between Treatments	6.7924	0.0003
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.00029167).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
SO41 vs SO44	9678.1	4	5.3928
SO41 vs SO43	5612.5	3	3.6194
SO41 vs SO42	2117.3	2	1.3001
SO42 vs SO44	7560.8	3	5.2374
SO42 vs SO43	3495.2	2	3.1041
SO43 vs SO44	4065.5	2	3.0002

Comparison	P<0.05
SO41 vs SO44	Yes
SO41 vs SO43	Yes
SO41 vs SO42	No
SO42 vs SO44	Yes
SO42 vs SO43	Yes
SO43 vs SO44	Yes

One Way Analysis of Variance - SO_4

Normality Test:	Passed	(P = 0.4802)
Equal Variance Test:	Passed	(P = 0.7617)

Group	N	Missing
sqrt(-SO4-1-)	31	0
sqrt(-SO4-2-)	30	0
sqrt(-SO4-3-)	20	0
sqrt(-SO4-4-)	12	0

Group	Mean	Std Dev	SEM
sqrt(-SO4-1-)	87.659	34.997	6.2856
sqrt(-SO4-2-)	116.691	33.012	6.0272
sqrt(-SO4-3-)	114.833	39.115	8.7464
sqrt(-SO4-4-)	104.820	34.571	9.9798

Power of performed test with alpha = 0.1000: 0.8185

Table 44. Continued.

Source of Variance	DF	SS	MS
Between Treatments	3	15355.3	5118.4
Residual	89	110564.1	1242.3
Total	92	125919.4	

Source of Variance	F	P
Between Treatments	4.1202	0.0087
Residual		
Total		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.0087312).

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method):

Comparison	Diff of Means	p	q
sqrt(-SO4-2-) vs sqrt(-SO4-1-)	29.0313	4	4.54826
sqrt(-SO4-2-) vs sqrt(-SO4-4-)	11.8709	3	1.39449
sqrt(-SO4-2-) vs sqrt(-SO4-3-)	1.8575	2	0.25818
sqrt(-SO4-3-) vs sqrt(-SO4-1-)	27.1738	3	3.80157
sqrt(-SO4-3-) vs sqrt(-SO4-4-)	10.0134	2	1.10031
sqrt(-SO4-4-) vs sqrt(-SO4-1-)	17.1603	2	2.02519

Comparison	P<0.05
sqrt(-SO4-2-) vs sqrt(-SO4-1-)	Yes
sqrt(-SO4-2-) vs sqrt(-SO4-4-)	No
sqrt(-SO4-2-) vs sqrt(-SO4-3-)	Do Not Test
sqrt(-SO4-3-) vs sqrt(-SO4-1-)	Yes
sqrt(-SO4-3-) vs sqrt(-SO4-4-)	Do Not Test
sqrt(-SO4-4-) vs sqrt(-SO4-1-)	No

Table 44. Continued.

One Way Analysis of Variance - Fe

Normality Test:	Failed	(P = <0.0001)
Equal Variance Test:	Passed	(P = 0.2925)

Group	N	Missing
FE1	31	0
FE2	30	0
FE3	20	0
FE4	12	0

Group	Mean	Std Dev	SEM
FE1	704.58	1329.3	238.75
FE2	1674.45	2066.9	377.35
FE3	1835.79	2805.3	627.28
FE4	1109.03	2597.4	749.80

Power of performed test with alpha = 0.1000: 0.2578

The power of the performed test (0.2578) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	3	21360140.9	7120047.0
Residual	89	400628621.6	4501445.2
Total	92	421988762.5	

Source of Variance	F	P
Between Treatments	1.5817	0.1994
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.19940).

Table 44. Continued.

Kruskal-Wallis One Way Analysis of Variance on Ranks - Fe

Normality Test: Failed (P = <0.0001)

Group	N	Missing
FE1	31	0
FE2	30	0
FE3	20	0
FE4	12	0

Group	Median	25%	75%
FE1	70.000	2.7500	1138.25
FE2	991.000	73.0000	2366.00
FE3	505.500	86.0000	2538.00
FE4	169.000	32.5000	494.50

H = 8.1094 with 3 degrees of freedom. (P = 0.0438)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.043804)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	p	Q
FE2 vs FE1	17.3511	4	2.51282
FE2 vs FE4	13.8417	3	1.50305
FE2 vs FE3	1.4583	2	0.18737
FE3 vs FE1	15.8927	3	2.05527
FE3 vs FE4	12.3833	2	1.25784
FE4 vs FE1	3.5094	2	0.38285

Comparison	P<0.05
FE2 vs FE1	No
FE2 vs FE4	Do Not Test
FE2 vs FE3	Do Not Test
FE3 vs FE1	Do Not Test
FE3 vs FE4	Do Not Test
FE4 vs FE1	Do Not Test

Table 44. Continued.

One Way Analysis of Variance - Al

Normality Test: Failed (P = 0.0004)

Equal Variance Test: Passed (P = 0.2466)

Group	N	Missing
AL1	31	0
AL2	30	0
AL3	20	0
AL4	12	0

Group	Mean	Std Dev	SEM
AL1	427.84	571.15	102.58
AL2	784.68	758.50	138.48
AL3	781.37	706.35	157.94
AL4	500.73	605.36	174.75

Power of performed test with alpha = 0.1000: 0.3643

The power of the performed test (0.3643) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	3	2643320.3	881106.8
Residual	89	39981168.7	449226.6
Total	92	42624489.0	

Source of Variance	F	P
Between Treatments	1.9614	0.1255
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.12554).

Table 44. Continued.

One Way Analysis of Variance - Al

Normality Test: Passed (P = 0.0896)

Equal Variance Test: Passed (P = 0.7661)

Group	N	Missing
sqrt(-AL1-)	31	0
sqrt(-AL2-)	30	0
sqrt(-AL3-)	20	0
sqrt(-AL4-)	12	0

Group	Mean	Std Dev	SEM
sqrt(-AL1-)	15.806	13.563	2.4360
sqrt(-AL2-)	23.657	15.257	2.7855
sqrt(-AL3-)	23.923	14.834	3.3171
sqrt(-AL4-)	18.553	13.066	3.7718

Power of performed test with alpha = 0.1000: 0.3867

The power of the performed test (0.3867) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	3	1261.7	420.57
Residual	89	18327.8	205.93
Total	92	19589.5	

Source of Variance	F	P
Between Treatments	2.0423	0.1137
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.11367).

Table 44. Continued.

One Way Analysis of Variance - Mn

Normality Test: Failed (P = <0.0001)

Equal Variance Test: Failed (P = 0.0149)

Group	N	Missing
MN1	31	0
MN2	30	0
MN3	20	0
MN4	12	0

Group	Mean	Std Dev	SEM
MN1	23.903	23.306	4.1858
MN2	36.057	37.384	6.8253
MN3	53.100	62.537	13.9838
MN4	56.667	64.059	18.4921

Power of performed test with alpha = 0.1000: 0.5145

The power of the performed test (0.5145) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	3	15005.0	5001.7
Residual	89	176270.2	1980.6
Total	92	191275.2	

Source of Variance	F	P
Between Treatments	2.5254	0.0626
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.062612).

Table 44. Continued.

One Way Analysis of Variance - Mn

Normality Test: Passed (P = 0.0620)

Equal Variance Test: Passed (P = 0.3373)

Group	N	Missing
ln(-MN1-)	31	0
ln(-MN2-)	30	0
ln(-MN3-)	20	0
ln(-MN4-)	12	0

Group	Mean	Std Dev	SEM
ln(-MN1-)	2.7021	1.0709	0.19233
ln(-MN2-)	2.9542	1.3962	0.25492
ln(-MN3-)	3.1215	1.5178	0.33940
ln(-MN4-)	3.3478	1.2946	0.37372

Power of performed test with alpha = 0.1000: 0.0985

The power of the performed test (0.0985) is below the desired power of 0.8000.
You should interpret the negative findings cautiously.

Source of Variance	DF	SS	MS
Between Treatments	3	4.3889	1.4630
Residual	89	153.1460	1.7207
Total	92	157.5349	

Source of Variance	F	P
Between Treatments	0.85020	0.4701
Residual		
Total		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.47012).

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