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PRELIMINARY REPORT ON UNCONTAMINATED SOIL PROFILES
LOS ALAMOS NATIONAL LABORATORY, NEW MEXICO

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INTRODUCTION

Soils of the Pajarito Plateau, located in north-central New Mexico, are variable in terms of soil type, soil properties (such as clay and iron content, etc.) and soil-landform relationship. A variety of geomorphic settings exist on the Pajarito Plateau, generally grouped into mesa top, slope, and canyon floor. The parent material for the soils, though nearly always volcanic in origin, also varies from site to site on the plateau. Soil ages vary from (probably) late Pleistocene to late Holocene. The range in elevations within the Pajarito Plateau result in a variety of vegetative zones. The variability in factors such as vegetation, parent lithology, geomorphic setting and time, lead to a wide range of soil types and degree of soil development, reflected in the physical and chemical properties of the soil. Data on the physical and chemical properties of fourteen soils are given in this report, and serve to emphasize the variable character of soils on the plateau.

A study of soils in and around Los Alamos National Laboratory (LANL) was undertaken as a cooperative project between the Earth and Environmental Science Division (EES-1), Chemical Science and Technology Division (CST-10) at LANL and the department of Earth and Planetary Sciences at the University of New Mexico. This report fulfills the requirements of part of LANL contract 3-40771. The information presented in this report is part of an ongoing study of soil types and soil properties present in the Los Alamos area. A report submitted in 1992 also presented preliminary results of a study of uncontaminated soils, examining soil types, properties and geomorphic settings. The earlier report examined seven soil profiles. In this study, an additional fourteen soil profiles from Los Alamos County were described, sampled and characterized.

All soil samples underwent standard soil characterization analyses in the soil laboratory at the University of New Mexico, which included analyses for pH, particle-size distribution,

cation exchange capacity, carbonate content, iron content by both the citrate-bicarbonate-dithionite extraction and the oxalate extraction, organic carbon content and bulk density.

Soils require on the order of at least several centuries to several thousand years in a semi-arid climate. Relatively stable surfaces are necessary for the development of at least weakly to moderately developed soil profiles, however, soil development can occur on nearly any geomorphic surface. Alternating periods of landscape stability and landscape mobility may be recorded, or partially recorded, in a soil profile. Climatic variations may also be represented in the soil profile by a change in some pedogenic property, or change in a soil property as a function of depth (McFadden and Knuepfer, 1990). Deciphering the record of climatic or tectonic influences through the evaluation of soils requires that the impacts on some soil characteristic be registered and preserved in the soil profile. Studying soils in the context of their geomorphic setting allows construction of a more robust data base, and generates the potential for predicting probable soil type-landform relationships. In Los Alamos County, understanding this relationship is particularly crucial because of the presence of contaminants in the surface and near-surface environments. The need for environmental restoration has underscored the utility of studies that link landscape evolution, soil properties and surficial processes. Only with the integration of this data can predictions be made regarding the rate and manner in which contaminants may be redistributed in the environment.

METHODOLOGY

The approach taken in this study follows that of Jenny (1941) and others (Birkeland, 1974, Yaalon, 1975) that emphasis the effects of five factors in defining the state of a soil system; these factors are climate, organic contributions, topography, parent material and time. In this scheme, the soil state is considered a dependent variable, and the five factors independent variables. In the truest sense, no factor is completely independent of all the others, but site

selection can maximize the effect of a certain variable while minimizing the impact of the others. In each case, an attempt is made to isolate and vary one independent variable, keeping the other four as nearly constant as possible. For example, site selection can be designed so that parent lithology varies, but soil age, topographic setting and climate remain relatively constant. Alternatively, climate can be varied by selecting sites at different elevations, since these sites will differ in annual precipitation, snowfall, and maximum and minimum temperatures while the other factors are held nearly constant.

On the Pajarito Plateau there are significant variations in elevation, vegetation and topography. Although nearly all parent material for soils in the area are volcanic in origin, the rock composition and texture, and the degree to which the rocks have been modified, vary from site to site. The predominant parent lithology for Los Alamos soils is the Bandelier Tuff, a rhyolitic ignimbrite consisting of both welded and nonwelded tuff and pumice-fall deposits. The two members of the Bandelier Tuff form the mesas and prominent cliff faces of the Pajarito Plateau. The transition from mesa top to canyon floor is typically abrupt, and these topographic extremes discourage construction of a chronosequence along a catena, an approach common to several other soil studies (Berry, 1990, Birkeland and Burke, 1988, Harden, 1988). Instead, the Quaternary history of the landscape can best be reconstructed by piecing together information from a variety of soils, and noting reoccurring evidence for a change in climate or landscape stability common to several of the soils.

GENERAL GEOLOGY

Los Alamos National Laboratory is situated on the Pajarito Plateau, located on the eastern flank of the Jemez Mountains in north-central New Mexico. The plateau slopes gently eastward from an elevation of 2377 m where it adjoins the Sierra de los Valles on the west, to an elevation of 1890 m adjacent to the Rio Grande river to the east (Rogers, 1977). The plateau is dissected by numerous southeast trending canyons, cut by intermittent streams

draining the Jemez Mountains. The depth of these canyons varies from 61 to 122 m deep (Rogers, 1977).

The Jemez volcanic field is located along the western edge of the Rio Grande rift, at its intersection with the Jemez volcanic lineament (Heiken et al., 1990). Rocks of the Jemez volcanic field are compositionally diverse, ranging from basaltic through rhyolitic rock types. Eruption of the field began >13 Ma (Heiken et al., 1990) and continued to <60 Ka (Reneau et al., in press).

The predominant rock type on the Pajarito Plateau is a rhyolitic tephra, the Bandelier Tuff. In the Los Alamos area, the Bandelier Tuff is subdivided into two members, the Otowi Member and the Tshirege Member. The Otowi Member consists of a Plinian pumice-fall deposit, the Guaje Pumice, overlain by surge beds and pyroclastic flows. It is composed of both welded and nonwelded units with abundant lithic and pumice clasts. The matrix consists of vitric-crystal or crystal-vitric ash with phenocrysts primarily of sanidine and quartz (Heiken et al., 1990). The Otowi Member is assigned an age of 1.45 Ma based on K/Ar analyses of sanidine (Doell et al., 1968). The Tshirege Member, based on K/Ar, erupted 1.12 Ma (Doell, 1968). It consists of a basal pumice-fall deposit, the Tsankawi Pumice, overlain by surge beds and pyroclastic flow units. Like the Otowi Member, the Tshirege consists of welded and nonwelded, crystal-vitric to vitric-crystal tuff with phenocrysts of sanidine and quartz, and minor amounts of hornblende (Heiken et al., 1990). Clasts of Bandelier Tuff and pumice lapilli, also from the ignimbrite, are commonly incorporated into soils at Los Alamos. Many soils in the area have formed above or contain reworked El Cajete Pumice, which has a probable age of <60,000 years (Reneau et al., in press). At a few sites, reworked clasts of dacite, probably from the 7 Ma Tschicoma Formation (Heiken et al., 1990) are incorporated in the colluvium. Virtually all the soils in the Los Alamos area, whatever the geomorphic setting, are formed from weathering and reworking of volcanic units. However, at no site were soils

formed primarily by direct weathering in place of the parent material, but are formed in alluvium, colluvium, sheetwash and loess overlying the volcanic units.

CLIMATE

Los Alamos has a semiarid, temperate, continental mountain climate. The range in elevations is between 1944 and 3139 m. Prevailing winds are out of the south, but are variable depending on the location, the season and the time of day. Average annual rainfall is just over 47 cm, mostly occurring between May and October, with peak rainfall associated with August thunderstorms (Purtyman et al., 1987). The values for maximum and minimum total annual precipitation can vary markedly between wet and dry years, characteristic of arid and semiarid climates. Maximum temperatures are typically below 35°C, and minimum temperatures above -16°C. The hottest month is typically July and the coldest January (Purtyman et al., 1987).

SOIL CHARACTERIZATION

The first basic steps in the study of soils, is to describe, sample and characterize the soil. Field descriptions are particularly important for information on soil horizon depths and thicknesses, soil structure, and soil-geomorphic relationships. In this study, for any given soil profile, samples were collected based on observable changes in soil properties, reflected in the different soil horizons. In the field, information on soil horizon thickness, depth, color, texture, structure and the presence of clay films, pores and roots was recorded. Soil color value (lightness) and chroma (strength) are assigned using a Munsell Color Chart under both wet and dry conditions. Texture, which refers to the relative amount of sand, silt and clay, is also measured in the laboratory. Soil structure is the aggregation of individual soil particles into larger units, called peds, of varying size, shape and strength (Buol et al., 1989). Structure in soils tends to be more prevalent and more durable as clay content of the soil increases. Consistence, measured both wet and dry, is a measure of a soils ability to

adhere, cohere, or resist deformation (Nyhan et al., 1978). Bulk density is the ratio of the weight of a known soil volume to the weight of an equal volume of water and can be useful in calculating the total porosity of the soil (Buol et al., 1989). Bulk density is usually measured on the basis of analyses of peds collected in the field.

In soil horizon nomenclature, the 'A' horizon is a mineral horizon that contains a relatively high amount of organic material, and this loosely packed, low density organic material lowers the total bulk density of the horizon. A 'B' horizon is one in which evidence of the original sediment or rock structure is nearly absent. The 'B' horizon is recognized either by the material transported into the horizon from horizons above, or by the concentration of residual material in the horizon (Birkeland, 1984). In contrast, the 'C' horizon preserves much of the original structure and is only slightly modified by soil-forming processes. Transition horizons, such as a 'BC', have properties of both master horizons, with the properties associated with the first letter dominating (Buol et al., 1989). The relatively low bulk density values for the 'BC' horizons result from the loose nature of the 'C' component, with little clays translocated into the open spaces. The 'Bt' horizons, where the small 't' refers to the accumulation of silicate clays, or evidence of translocated clays, yielded higher bulk densities because of the presence of abundant translocated clays infilling pore spaces, and lining ped faces.

For each horizon within a profile, a single, homogenized, bulk sample of approximately 1 Kg was collected. Soil geochemical and morphological data were based on these stratified samples. Although the depth to each horizon boundary and horizon thicknesses were always noted, the sample collection scheme was based on soil properties, without regard to depth.

In the laboratory, all soil samples were subjected to standard soil analyses, which included measurements of soil pH, particle-size distribution, citrate-bicarbonate-dithionite extraction for iron oxides and oxyhydroxides, oxalate extraction for iron oxyhydroxides, calcium carbonate, organic carbon content, cation exchange capacity and bulk density. A detailed

descriptions of laboratory procedures can be found in Appendix B, pages 70 through 88.

Both the field and laboratory data was then applied towards unraveling part of the Quaternary history of the Pajarito Plateau.

SITE DESCRIPTIONS

Fourteen soil profiles were sampled at six different sites. These sites are 1) a Holocene terrace exposed along a stream cut near State Road 4 in Ancho Canyon, 2) a road cut near the back gate, along West Jemez Road, 3) a trench excavated for hydrologic studies near TA-51, 4) road cuts and soil pits adjacent to Water Canyon, 5) trenches excavated for seismic studies near TA-63, and 6) trenches at the proposed mixed waste facility at TA-67. A detailed field description of each profile is given in Appendix A, pages 56 through 69. An explanation of the symbols in the field data sheet can be found in the Appendix B, pages 90 through 93.

Ancho Canyon (1)

Ancho Canyon (1) is a young, Holocene soil located along a stream cut terrace just off State Road 4. This is a poorly developed soil, relatively low in clay content; values range between 0.70 and 10.31 wt. % clay, and low in $\text{Fe}_2\text{O}_3\%$, with values between 0.26 and 0.60 wt. % (Table 1 and 3, pages 18 and 26). Low values in these categories are generally considered reflective of a young, weakly developed soil (Ritter, 1989; Birkeland, 1984; McFadden and Weldon, 1987). Organic carbon content in this soil profile ranges from a high of 1.74 wt. % soil carbon in the A1 horizon to a low of 0.44 wt. % in the Bw3 horizon, as shown on Table 5, page 35. As a consequence of the low clay content and low iron oxide content of this profile, the cation exchange capacity values are also very low; from a high of 12.35 meq/100 g in the Btb horizon (the only Bt horizon in this profile) to a low of 2.70 meq/100 g in the A2 horizon. Since the soil is young, much of the organic material in the A horizon remains as leaf litter and rootlets and has not been broken down into humic materials, including humic and fulvic

acids, which can yield relatively high cation exchange capacities. Bulk density data on this profile is limited to the Bw1 horizon (Table 2, page 41), since most soil material was so clay-poor that no peds could be successfully extracted.

The carbonate values for this profile fall between a high of 1.17 wt. % and a low of 0.20 wt. % (Table 7, page 46). The high values are generally associated with the upper horizons, A1 and A2, probably reflecting a carbonate contribution from an eolian source (McFadden et al., 1991). The first 'C' horizon also contains relatively high amounts of carbonate, possibly the result of leaching of carbonate through the 'Bw' horizons of the upper profile and accumulation at the Bw3/C hydrologic boundary due to contrasting permeabilities of these horizons (McFadden et al., 1991).

Los Alamos (4)

Los Alamos 4 represents data from a soil profile described and sampled along West Jemez Road, near the back gate to Los Alamos National Laboratory. In contrast to Ancho Canyon 1, the LA-4 soil is both clay-rich and iron oxide-rich (Tables 1 and 3, pages 18 and 26), as demonstrated by the relatively high clay content values; 14.24 to 36.87 wt. %, and relatively high iron oxide values; 0.76 to 0.85 wt. % Fe_2O_3 . Organic carbon content for this entire profile is generally low, as shown on Table 5, page 35.

In general, the cation exchange capacity values for LA-4 are relatively high (Table 6, page 41), particularly in the 'Bt' horizons (values from 13.39 to 27.45 meq/100 g). The cation exchange capacity of the 'BCb' horizon is comparatively low, 9.33 meq/100 g. The cation exchange values consistently decrease with depth through the profile, and may be reflective of variations in clay mineralogy with depth (Birkeland, 1984), although no XRD data was analyzed from this profile.

TA - 51

The Technical Area 51 (TA-51) soil profile is developed in Holocene, mesa-top alluvial and colluvial material overlying Bandelier Tuff. The soil profile was exposed as a result of trenching operations as part of a hydrologic study. Clay content in this profile is relatively high, varying from 17.56 to 31.60 wt. % (Table 1, page 18). Iron oxide content is also moderately high, from 0.80 to 1.01 wt. % Fe_2O_3 (Table 3, page 26). Bulk density values are low, commonly <1.00 (Table 2, page 21). Organic carbon content values for this profile (Table 5, page 35), except the 'A' horizon (17.30 wt. %) are low; 4.86 to 8.13 wt. % carbon. Carbonate values are relatively low throughout this profile, but are highest in the 'A' horizon, 0.54 wt. % (Table 7, page 46), again suggesting an eolian contribution. The cation exchange capacity of this profile appears to be primarily related to pH dependent charge, since the highest values are associated with the 'A' horizon (Table 6, page 41).

TA - 63

A total of four soil profiles were described, sampled and analyzed from two trenches excavated for seismic studies near Technical Area 63. Two soil profiles were sampled from trench 1, a 149 m long trench located on the west side of Pajarito Road. These soils, labeled sites TA-63a and TA-63c, are thin Holocene soils overlying fractured Bandelier Tuff. Fractures in the tuff are prevalent, and many are infilled with clay, iron oxide or carbonate-rich material. An additional two profiles were sampled from a 213 m trench on the east side of Pajarito Road. These soils, TA-63 1A and TA-63 2, are thicker, better developed, and probably older than those on the west side.

Bulk density data for the group of soils, given in Table 2, page 22, range from a low of 1.20 to a high of 1.71 g/cc. The 'Bt' horizons tend to be the most dense, and the 'A' horizons, at this site, the least dense. Organic carbon content for these soils ranges between 5.22 and 0.27% (Table 5, page 36). The shallower soils of the side tend to be more organic-rich, reflecting

more thoroughly incorporation throughout the profile, partly due to the thin nature of the profile, and partly the result of bioturbation. The presence of organic material tends to lower the pH values of the upper horizons through the formation of humic and fulvic acids. The pH values for the TA-63 soils, given in Table 8, pages 51 and 52, range from 5.7 to 7.3. The higher pH values are associated with the 'Btk' horizons, where the 'k' indicates an accumulation of carbonates.

The difference in relative degree of development of the TA-63a and TA-63c soils compared with that associated with TA-63 1A and TA-63 2 is reflected primarily in the higher clay content of the last two profiles. The TA-63 1A and -2 soils have maximum clay-content values of 30 and 40 percent, whereas the TA-63a and -c soils barely exceed a high of 20% (Table 1, page 18).

The TA-63a and -c profiles have relatively low cation exchange capacity values (maximum of <15 meq/100 g of samples, minimum of 7.66 meq/100 g), probably reflective of their relatively low clay content (Tables 6 and 1, pages 42 and 18 respectively). Profiles TA-63 1A and -2 exhibit both higher cation exchange capacities (maximum of >22 meq/100 g and minimum of >10 meq/100 g).

The TA-63 profiles are variable in carbonate content, as indicated by Table 7, page 47. TA-63a and -c profiles are both generally low, <0.5 wt. %, while TA-63-1A and TA-63-2 both contain 'Btk' horizons ranging from 3.93 to 6.59 wt. % calcium carbonate. In both profiles, these 'Btk' horizons probably result from translocation of eolian carbonate material through the soil profile, and precipitation of the carbonate at a hydrologic boundary related to the underlying, clay rich 'Btb' horizons.

Water Canyon

Three soil profiles were sampled from three sites within Water Canyon along West Jemez Road, and labeled WC-1 (Water Canyon 1), WC-2 and WC-3. In general, the bulk density values for the Water Canyon sites are high in comparison to those of the previous sites. Values fall between 1.58 and 1.90 g/cc (Table 2, page 23), and reflect the relative maturity, and high clay content of these soils. Maximum clay content (50.09%) occurs in a 'Bt' horizon and minimum (8.44) in a 'C' horizon (Table 1, page 19). The trend in the organic carbon content in these profile reflects the generally tendency for organic carbon to decrease with depth in a profile (Table 5, page 37). The pH values mirror the presence or absence of organic material, with site WC-3 having the most organic material, and providing the most acidic pH values (Table 8, page 53).

Of the Water Canyon soils, WC-1 shows the highest cation exchange capacity values, and WC-2 the lowest, as indicated by Table 6, page. The relatively high values associated with WC-1 likely correlate with the high translocated clay content of all the horizons in this profile. The WC-3 profile also consists of primarily Bt subhorizons, although the 'BC' horizon is actually highest in % clay, and has the highest cation ion exchange capacity. The horizons in profile WC-2 which do exhibit relatively high cation exchange capacity are the Bt horizons. The carbonate content of all the Water Canyon profiles is relatively low (Table 7, page 48). Water Canyon 3 has the highest values , but all values are <1.00 wt. %. No elevation in calcium carbonate values in the upper horizons, which could be attributed to an eolian contribution, is evident in these profiles.

TA - 67 (Proposed mixed Waste Site)

Four soil profiles were described, sampled and analyzed from trenches excavated at the proposed mixed-waste site located in TA-67 on the Pajarito Mesa. A total of 1343 m of

mesa (Reneau et al. in press). These sites are referred to as TA-67 E (for east) 1 and TA-67 2 E1 from a 152 m long trench (these two are grouped as one profile), TA-67 E3 from a 140 m long trench, TA-67 W (for west) 1 from a 49 m long trench and TA-67 W5 from a 119 m long trench (Reneau et al., in press). In general, soils showed remarkable continuity in the number and types of horizons from profile to profile within the site.

Bulk density values for five soils from TA-67 (Table 2, pages 24 and 25) range from a low of 1.03 and high of 1.78 g/cc. The lowest bulk density values are typically associated with the 'BC' horizons and the highest values with the 'Bt' horizons. The organic carbon contents of the soil profiles from TA-67 are given on Table 5, pages 38 through 40. These values reflect the typical trend of decreasing organic material with increasing depth in a soil profile.

The pH values for these soils (Table 8, pages 54 and 55) range from a low of 5.3 to a high of 7.7. The most acidic horizons are associated with those highest in organic material. The horizons with the highest pH values reflect an increase in the amount of calcium carbonate content, as shown by data in Table 7, pages 49 and 50.

Results of the particle-size distribution analyses (Table 1, pages 19 and 20) demonstrate that horizons with high clay content are associated with the 'Bt' horizons, which contain abundant translocated clays. The lowest clay-content values generally occur in the 'CR' or 'E' horizons. The 'R' horizon is consolidated bedrock, and the 'E' refers to mineral horizons with a concentration of residue quartz resulting from loss of clay and other material (Buol et al., 1989). By contrast, gravel and sand content are highest in the 'C' horizons. Silt content is typically highest in the 'A' horizons and probably reflects a significant eolian contribution. The presence of silt-sized loess material in the 'A' horizon is common to many soils in the Los Alamos area.

The most profound variation in soil character between profiles from this site is the tendency for soils to thin downslope, approaching the end of the mesa.

Of the four TA-67 profiles, TA-67 E3, and especially TA-67 E5 are highest in cation exchange capacity (Table 6, pages 44 and 45), with maximum values >37 meq/100 g of sample. The higher CEC values, however, do not generally show a positive correlation with %clay, nor with high organic carbon content. The elevated cation exchange capacity values, therefore, may be related instead to iron oxide and oxyhydroxide coatings on grains, since a (visual) correlation appears to exist between %Fe₂O₃ and cation exchange capacity (Table 3, pages 28 and 29).

Carbonate content for the TA-67 profiles is variable. The TA-67 E1 profile is low in carbonate content, all values falling below 1.00 wt. %, with slight elevations associated with the 'A' horizon, the E/Btb1 and Btk1b2 horizons. However, the TA-67 E3, -W1 and -W5 profiles all contain horizons >1.00 wt. % calcium carbonate. In these profiles, elevation in the carbonate content occurs at the base of a younger soil where it overlies an older, buried soil. The boundary between the two soils is also a hydrologic boundary between the younger, more porous and permeable horizons containing El Cajete Pumice above, and the older, less permeable and denser horizons below.

CONCLUSIONS

Data from background soil profiles in and around Los Alamos National Laboratory show that soils and associated soil properties in the area vary significantly with respect to soil age and degree of soil development. Many sites, from diverse geomorphic settings such as mesa-tops, hill slopes and valley floors, contain weakly developed, young Holocene soils (TA-63a and -c). On valley floor sites, (Ancho Canyon), active geomorphic processes such as channel aggradation and erosion, preclude surface stability necessary for the formation of

clay-, iron- and carbonate-rich horizons. Lower elevation sites at Los Alamos lack the amount of precipitation required to form a substantial vegetative cover, consequently, thick 'O' or 'A' horizons do not form. As evident from the data, particularly those with relatively high clay and iron content, some soil profiles record a history of landscape stability on the order of at least several thousand years, the period of time required to develop these soil properties. Indication of prolonged landscape stability can be found in data from several sites in this report, particularly WC-1 and -2 and LA-4, and perhaps to a lesser extent, TA-63 1A and -2 and TA-67 E3. The prevalence of buried soils within many profiles from a variety of locations around the laboratory, indicates a period of landscape stability, during which the older soil formed, followed by a period of limited erosion, renewed deposition and subsequent landscape stability, during which the overlying younger soil formed. Evidence from this and other studies suggest that several such cycles have occurred in the area. These cycles may related to tectonic activity (i.e. along the Pajarito Fault), or to variations in climatic conditions. In some areas, favorable circumstances have led to the preservation of original deposits of the El Cajete Pumice, or reworked El Cajete. Soils that have formed in this deposit have characteristics quite different from those formed in reworked Bandelier Tuff.

Landscape position, or soil-geomorphic association, can influence the type of degree of soil development. Canyon floor sites commonly contain thick packets of sediment, but thin, weakly developed soils due to active reworking of sedimentary material downslope and along stream channels. Transitions between mesa tops and canyon bottoms are typically abrupt, but at sites where hillslope soils have developed, they are commonly relatively thick, cumulic soils containing abundant lithic clasts. Mesa top soils vary markedly in degree of development. Soil profiles commonly thin towards mesa edges due to active transport of soil material across the mesa surface and ultimately into adjacent canyons. Soils on mesas are typically thicker near the base of the mesa, where material is shed off adjacent slopes.

The development of soil properties such as increased clay, iron and carbonate content reflect complex interactions between the chemistry of the parent material, climate and its impact on rate of weathering and depth of wetting front, and soil age. Volcanic parent materials at Los Alamos are low in clay and carbonate material, therefore the presence of these components suggests introduction from an eolian source, or, in the case of clays, authogenic origin.

Results of this study demonstrate the diversity of soil morphology, soil chemistry, mineralogy, and stratigraphy that reflects dynamic landscape-forming processes influenced by climatic changes in the Quaternary. These climatic changes affected soils 1) directly, by altering leaching magnitude through changes in pressure, temperature, evaporation, vegetative community and 2) indirectly, by causing periods of loess deposition and by causing alternating periods of base-level fall (partly related to regional tectonics) that induced channel degradation and erosion by associated tributaries, and base-level rise, leading to alluviation and subsequent formation of buried soils.

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Table 1

PARTICLE-SIZE DISTRIBUTION ANALYSES

Sample Number	Horizon	Flask wt.	Flask	Sple. wt.	Beaker wt.	Beaker	Clay wt.	Sand	Sand wt.	Dsprst. wt.	SUMMARY					Gravel (%)	
			+ sple. wt.			+ clay wt.		+ flask wt.			Sand (%)	Silt (%)	Clay >2mm (%)	<2mm (gm)			
Ancho Canyon (1)																	
A1		98.79	120.94	22.15	28.7635	28.8302	0.0667	115.42	16.63	0.0394	75.08	17.53	7.40	5.9	130.1	4.3	
A2		98.78	121.71	22.93	30.2012	30.2609	0.0597	119.05	20.27	0.0479	88.40	8.51	3.09	12.1	172.9	6.5	
Bw1		94.19	116.63	22.44	30.3706	30.4534	0.0828	104.84	10.65	0.0479	47.46	43.21	9.33	26.9	269.6	9.1	
Bw2		98.43	119.43	21.00	30.0992	30.1753	0.0761	112.27	13.84	0.0479	65.90	26.04	8.06	24.4	163.3	13.0	
Bw3		93.95	116.39	22.44	27.0405	27.1008	0.0603	113.77	19.82	0.0479	88.32	8.36	3.32	16.5	342.5	4.6	
Blb		96.21	118.30	22.09	27.9079	27.9905	0.0826	110.25	14.04	0.0479	63.56	27.02	9.43	61.0	163.8	27.1	
Bwb		94.52	126.71	32.19	28.0925	28.1872	0.0947	115.80	21.28	0.0394	66.11	23.58	10.31	48.4	180.1	21.2	
Ckq		94.44	118.52	24.08	29.0224	29.0756	0.0532	117.00	22.56	0.0479	93.69	4.99	1.32	113.7	166.1	40.6	
C'		98.27	122.15	23.88	27.5577	27.6084	0.0507	121.02	22.75	0.0479	95.27	4.03	0.70	29.3	236.8	11.0	
C		91.38	112.23	20.85	28.2620	28.3180	0.0560	110.74	19.36	0.0479	92.85	4.82	2.33	19.5	229.5	7.8	
Los Alamos (4)																	
Bl4b		96.09	114.17	18.08	27.8465	28.0055	0.1590	100.10	4.01	0.0479	22.18	40.95	36.87	14.6	135.4	9.7	
Bl5b		96.83	123.53	26.70	26.7854	26.9183	0.1329	103.57	6.74	0.0479	25.24	55.66	19.10	14.9	108.6	12.1	
Bl6b		80.00	106.37	26.37	27.2022	27.3127	0.1105	87.66	7.66	0.0479	29.05	56.71	14.24	31.1	252.9	11.0	
Bl7b		75.17	100.18	25.01	27.2490	27.3888	0.1398	82.72	7.55	0.0394	30.19	45.73	24.09	40.4	99.2	28.9	
Bl8b		82.35	102.81	20.46	28.1472	28.2491	0.1019	88.97	6.62	0.0479	32.36	51.81	15.84	18.5	143.3	11.4	
Bl9b		93.89	114.02	20.13	30.1134	30.2095	0.0961	98.14	4.25	0.0479	21.11	64.52	14.37	11.1	231.8	4.6	
BCb		94.19	117.58	23.39	30.1374	30.2406	0.1032	100.19	6.00	0.0394	25.65	57.98	16.37	3.9	182.3	2.1	
TA-51																	
A		82.16	100.37	18.21	30.0610	30.1537	0.0927	86.89	4.73	0.0394	25.97	56.46	17.56	1.8	59.7	2.9	
BA		96.86	120.41	23.55	29.9408	30.0658	0.1250	100.10	3.24	0.0479	13.76	66.60	19.64	0.6	99.4	0.6	
Bw		98.16	118.38	20.22	27.0357	27.1901	0.1544	101.92	3.76	0.0479	18.60	49.80	31.60	3.9	101.5	3.7	
BC		81.35	102.14	20.79	27.8259	27.9543	0.1284	87.93	6.58	0.0479	31.65	45.12	23.23	25.7	92.2	21.8	
TA-63a																	
A		85.14	107.10	21.96	28.9027	28.9935	0.0908	90.95	5.81	0.0336	26.46	57.91	15.63	3.0	121.7	2.4	
Bw1		78.61	103.43	24.82	30.7197	30.8228	0.1031	85.41	6.80	0.0300	27.40	54.93	17.67	1.1	98.9	1.1	
Bw2		87.69	112.07	24.38	30.8813	30.9970	0.1157	94.08	6.39	0.0336	26.21	53.58	20.21	7.2	196.1	3.5	
TA-63c																	
A1		82.03	106.56	24.53	28.2604	28.3392	0.0788	87.45	5.42	0.0336	22.10	66.85	11.06	2.5	116.0	2.1	
A2		82.05	107.33	25.28	30.0140	30.1170	0.1030	87.71	5.66	0.0300	22.39	60.28	17.33	0.7	134.8	0.5	
Bw1		84.84	107.15	22.31	30.9468	31.0250	0.0782	90.52	5.68	0.0336	25.46	62.55	11.99	0.5	150.8	0.3	
Bw2		98.79	124.32	25.53	30.9901	31.0686	0.0785	107.59	8.80	0.0300	34.47	54.13	11.40	0.5	81.3	0.6	
Bw3		81.89	107.13	25.24	29.0771	29.1780	0.1009	91.48	9.59	0.0336	38.00	46.01	16.00	1.8	104.0	1.7	
TA-63-1A																	
A1		89.61	114.60	24.99	27.4210	27.5168	0.0958	94.02	4.41	0.0394	17.65	68.81	13.54	1.3	132.6	1.0	
A2		91.39	109.45	18.06	27.0156	27.1135	0.0979	94.13	2.74	0.0394	15.17	65.39	19.44	3.3	145.8	2.2	
Bw		93.88	114.79	20.91	29.9615	30.0817	0.1202	96.80	2.92	0.0394	13.96	62.85	23.19	5.0	133.2	3.6	
Blh		82.03	101.55	19.52	27.9990	28.1310	0.1320	85.90	3.87	0.0394	19.83	51.71	28.46	17.4	171.7	9.2	
Blk1		94.45	114.97	20.52	30.1137	30.2279	0.1142	98.82	4.37	0.0394	21.30	56.83	21.87	2.0	103.0	1.9	
Blk2		82.42	103.66	21.24	30.3530	30.4956	0.1426	85.95	3.53	0.0394	16.62	54.23	29.15	2.8	135.1	2.0	
Blb		81.94	104.29	22.35	27.0360	27.2342	0.1982	83.81	1.87	0.0394	8.37	49.00	42.63	3.9	167.1	2.3	
TA-63-2																	
Bw		96.82	119.53	22.71	28.1099	28.2661	0.1562	100.15	3.33	0.0414	14.66	55.01	30.33	13.6	111.3	10.9	
Blh		80.10	100.08	19.98	30.3843	30.5100	0.1257	83.65	3.55	0.0414	17.77	56.92	25.32	7.5	128.7	5.5	
Blhk		94.19	111.78	17.59	30.8620	30.9630	0.1010	97.82	3.63	0.0414	20.64	59.03	20.33	3.0	127.7	2.3	
Blk1		82.43	102.63	20.20	30.0123	30.1103	0.0980	87.25	4.82	0.0414	23.86	59.33	16.81	1.3	73.8	1.7	
Blk2		82.31	100.90	18.59	27.5305	27.6592	0.1287	86.48	4.17	0.0414	22.43	49.39	28.18	5.8	128.2	4.3	
Blkb1		96.19	117.07	20.88	29.3125	29.4791	0.1666	98.49	2.30	0.0414	11.02	53.01	35.98	9.5	124.3	7.1	
Blkb2		98.43	117.45	19.02	31.7840	31.9231	0.1391	100.20	1.77	0.0414	9.31	59.87	30.82	12.0	123.8	8.8	
Blb1		79.10	98.03	18.93	28.1225	28.2411	0.1186	82.07	2.97	0.0414	15.69	59.84	24.47	12.4	141.1	8.1	
Blb2		82.44	102.66	20.22	29.9400	30.0766	0.1366	87.78	5.34	0.0414	26.41	45.34	28.25				

Table 1

PARTICLE-SIZE DISTRIBUTION ANALYSES CONT.

ARTICLE SIZE DISTRIBUTION ANALYSIS CONT.																
Sample Number	Horizon	Flask	Flask	Spie.	Beaker	Beaker	Clay	Sand	Sand	Deprst.	SUMMARY					Gravel
		wt.	+ sple. wt.	wt.	wt.	+ clay wt.	wt.	+ flask wt.	wt.		Sand (%)	Silt (%)	Clay (%)	>2mm (gm)	<2mm (gm)	
Water Canyon - 1																
	Bt1b2	75.08	94.79	19.71	26.9539	27.1230	0.1691	81.51	6.43	0.0414	32.62	28.50	38.87	101.2	63.2	61.6
	Bt2b2	75.17	98.00	22.83	27.1333	27.3653	0.2320	80.46	5.29	0.0414	23.17	26.74	50.09	76.8	93.0	45.2
	Bt3b2	93.89	116.06	22.17	29.7520	29.9237	0.1717	102.26	8.37	0.0414	37.75	26.98	35.26			
	Bt4b2	94.45	115.59	21.14	28.0188	28.2040	0.1852	103.68	9.23	0.0414	43.66	15.53	40.81	132.8	76.2	63.5
	Bt5b2	89.61	113.19	23.58	30.1125	30.3192	0.2067	100.32	10.71	0.0414	45.42	12.52	42.06			
Water Canyon - 2																
	C1b1a	98.28	116.87	18.59	28.9251	28.9932	0.0681	105.06	6.78	0.0414	36.47	54.91	8.62	192.7	62.1	75.6
	C2b1a															
	C3b1a	96.84	118.29	21.45	27.9069	27.9983	0.0914	104.51	7.67	0.0414	35.76	50.26	13.99			
	Bt1b1b	98.16	118.35	20.19	30.3030	30.4286	0.1256	104.93	6.77	0.0414	33.53	41.45	25.02	40.9	122.7	25.0
	Bt2b1b	81.66	101.39	19.73	29.2265	29.3453	0.1188	89.53	7.87	0.0414	39.89	36.57	23.54			
	Bt1b1c	82.07	103.53	21.46	27.8694	27.9996	0.1302	90.72	8.65	0.0414	40.31	34.86	24.83			
	Bt2b1c	81.31	101.23	19.92	29.8241	29.9506	0.1265	89.89	8.58	0.0414	43.07	31.30	25.63	131.6	80.5	62.0
	Bt3b1c	93.93	115.41	21.48	29.0205	29.1544	0.1339	103.13	9.20	0.0414	42.83	31.33	25.84	77.5	98.0	44.2
Water Canyon - 3																
	Ap	97.55	117.54	19.99	28.9042	28.9825	0.0783	104.35	6.80	0.0394	34.02	54.31	11.68	40.4	135.2	23.0
	Bt1	95.12	120.84	25.72	30.9870	31.1994	0.2124	100.44	5.32	0.0479	20.68	40.94	38.37	63.1	113.4	35.8
	Bt2	96.11	117.88	21.77	28.0195	28.0974	0.0779	101.05	4.94	0.0414	22.69	67.25	10.06	4.4	157.1	2.7
	Bt3	80.09	100.37	20.28	28.9524	29.0661	0.1137	84.59	4.50	0.0479	22.19	58.34	19.47	13.2	237.2	5.3
	Bt4	95.99	115.97	19.98	27.0270	27.1362	0.1092	100.21	4.22	0.0479	21.12	60.47	18.41	8.7	161.0	5.1
	BC	98.06	119.10	21.04	29.9612	30.1003	0.1391	103.91	5.85	0.0479	27.80	46.19	26.01	22.6	209.9	9.7
	2C	96.75	117.57	20.82	30.9867	31.0554	0.0687	112.63	15.88	0.0394	76.27	15.28	8.44	151.8	119.4	56.0
TA-67 E1																
	A	80.79	106.99	26.20	29.1264	29.2150	0.0886	87.49	6.70	0.0300	25.57	61.01	13.42	9.5	195.8	4.6
	BA	78.77	104.77	26.00	30.3254	30.4147	0.0893	86.16	7.39	0.0300	28.42	57.89	13.68	21.4	350.6	5.8
	Bw	79.10	104.25	25.15	30.2627	30.3762	0.1135	85.05	5.95	0.0315	23.66	56.78	19.56	11.3	488.1	2.3
	Bt1	82.40	109.33	26.93	27.4203	27.5445	0.1242	86.70	4.30	0.0315	15.97	63.38	20.65	7.6	540.5	1.4
	Bt2	98.43	123.67	25.24	27.7974	27.9118	0.1144	103.39	4.96	0.0300	19.65	60.29	20.06	5.9	386.2	1.5
	2Bwb	82.01	107.69	25.68	26.9377	27.0512	0.1135	88.05	6.04	0.0315	23.52	57.32	19.16	22.6	399.3	5.4
	2BCb	80.61	106.74	26.13	29.2257	29.3154	0.0897	89.47	8.86	0.0300	33.91	52.38	13.71	49.8	505.4	9.0
TA-67-2 E1																
	Btkb1	82.36	107.62	25.26	28.0001	28.0952	0.0951	92.86	10.50	0.0300	41.57	42.97	15.46	29.7	441.0	6.3
	Bt1b1	82.87	108.01	25.14	27.8249	27.9556	0.1307	89.80	6.93	0.0315	27.57	48.76	23.68	4.2	444.5	0.9
	Bt2b1	93.89	119.11	25.22	28.8672	28.9827	0.1155	101.57	7.68	0.0300	30.45	49.21	20.34	12.5	730.4	1.7
	Bt3b2	83.19	108.13	24.94	27.6194	27.7242	0.1048	97.10	13.91	0.0300	55.77	26.23	18.00	23.4	290.0	7.5
	Btk1b2	97.75	122.93	25.18	30.8928	31.0778	0.1850	107.73	9.98	0.0315	39.63	23.79	36.58	6.5	465.1	1.4
	Btk2b2	82.00	107.41	25.41	29.0389	29.1529	0.1140	92.24	10.24	0.0300	40.30	39.87	19.83	61.3	524.1	10.5
	E/Bt1b1	81.46	106.42	24.96	27.8612	27.9285	0.0673	89.65	8.19	0.0300	32.81	58.22	8.97	4.5	350.5	1.3
	E/Bt2b1	93.24	118.19	24.95	28.2602	28.3616	0.1014	100.90	7.66	0.0300	30.70	52.13	17.17	16.9	385.5	4.2
	CR	81.90	107.04	25.14	30.0050	30.0577	0.0527	100.65	18.75	0.0300	74.58	20.00	5.42	20.8	242.1	7.9
TA-67 E3																
	A	82.14	103.64	21.50	26.7352	26.8673	0.1321	86.51	4.37	0.0336	20.33	52.19	27.49	8.8	213.8	4.0
	2BAb1	82.03	102.69	20.66	29.0384	29.1722	0.1338	85.17	3.14	0.0336	15.20	55.70	29.10	8.7	169.9	4.9
	2Bt1b1	95.11	116.33	21.22	27.5574	27.6775	0.1201	98.52	3.41	0.0336	16.07	59.47	24.46	35.8	183.2	16.3
	2Bt2b1	82.05	106.37	24.32	30.1993	30.3042	0.1049	88.88	6.83	0.0336	28.08	54.33	17.59	23.1	185.0	11.1
	2BC1b1	83.06	104.84	21.78	29.5235	29.6036	0.0801	89.64	6.58	0.0336	30.21	56.98	12.81	18.1	162.6	10.0
	2BC2b1	92.87	115.28	22.41	28.0929	28.1727	0.0798	100.72	7.85	0.0336	35.03	52.60	12.37	18.0	154.4	10.4
	3Bt1b2	82.29	101.10	18.81	28.0392	28.1071	0.0679	88.69	6.40	0.0336	34.02	55.03	10.94	9.7	153.7	5.9
	3Bt2b2	94.44	115.50	21.06	31.1894	31.2777	0.0883	101.40	6.96	0.0336	33.05	51.37	15.58	5.5	246.9	2.2
	3Bt3b2	97.54	121.42	23.88	27.8101	27.9323	0.1222	105.65	8.11	0.0336	33.96	43.78	22.26	18.6	199.1	8.5

Table 1

PARTICLE-SIZE DISTRIBUTION ANALYSES CONT.

											SUMMARY					
Sample Number	Horizon	Flask	Flask	Sple.	Beaker	Beaker	Clay	Sand	Sand	Dsprst.	Sand	Silt	Clay >2mm	<2mm	Gravel	
		wt.	+ sple. wt.			wt.		+ clay wt.			wt.	+ flask wt.	wt.	wt.		(%)
TA-67 W1																
A1		84.20	103.76	19.56	29.2535	29.3286	0.0751	91.14	6.94	0.0336	35.48	51.79	12.73	8.8	120.1	6.8
A2		94.50	114.08	19.58	27.8693	27.9450	0.0757	99.73	5.23	0.0336	26.71	60.39	12.90	15.6	136.4	10.3
A3		80.81	102.86	22.05	28.2601	28.3521	0.0920	86.85	6.04	0.0336	27.39	56.72	15.89	21.6	171.6	11.2
BA		81.16	101.45	20.29	27.0292	27.1221	0.0929	86.15	4.99	0.0336	24.59	57.87	17.54	18.4	156.2	10.5
Bw1		93.95	120.91	26.96	28.9035	29.0848	0.1813	99.30	5.35	0.0336	19.84	47.28	32.87	53.3	327.5	14.0
Bl1		80.01	101.25	21.24	29.2255	29.3054	0.0799	84.22	4.21	0.0336	19.82	67.10	13.08	10.0	208.7	4.6
Bl2		80.90	101.87	20.97	29.7633	29.8527	0.0894	86.91	6.01	0.0336	28.66	55.37	15.97	43.8	197.6	18.1
Blkb		79.19	97.68	18.49	27.5386	27.7001	0.1615	90.04	10.85	0.0336	58.68	-0.18	41.50	2.0	162.7	1.2
E/Bb		78.63	101.97	23.34	27.7154	27.7753	0.0599	86.47	7.84	0.0336	33.59	59.65	6.76	11.6	227.4	4.9
Bl/CR		84.44	107.61	23.17	31.7831	31.8592	0.0761	99.13	14.69	0.0336	63.40	25.59	11.01	1.4	173.9	0.8
TA-67 W5																
A		81.26	106.95	25.69	27.9060	27.9939	0.0879	88.61	7.35	0.0315	28.61	58.22	13.17	18.9	267.2	6.6
BA		83.06	108.59	25.53	30.0985	30.2130	0.1145	88.41	5.35	0.0315	20.96	59.54	19.51	5.7	355.5	1.6
2Bl1b1		78.08	102.05	23.97	27.7155	27.8370	0.1215	82.45	4.37	0.0315	18.23	59.24	22.53	6.2	181.9	3.3
2Bl2b1		80.94	106.95	26.01	29.0196	29.1397	0.1201	85.81	4.87	0.0315	18.72	60.84	20.44	142.8	302.6	32.1
2Bl3b1		75.78	104.96	29.18	27.6325	27.7403	0.1078	85.24	9.46	0.0315	32.42	51.89	15.69	70.5	249.1	22.1
2BC1sb1		81.78	107.93	26.15	29.2533	29.4161	0.1628	92.02	10.24	0.0315	39.16	30.72	30.13	60.2	266.1	18.4
2BC2sb1		81.38	107.06	25.68	28.0185	28.1086	0.0901	93.00	11.62	0.0315	45.25	41.06	13.69	158.8	285.7	35.7
3BAb2		92.88	117.71	24.83	30.8618	30.9264	0.0646	101.55	8.67	0.0315	34.92	57.08	8.00	30.3	677.8	4.3
3Blb2		81.99	106.94	24.95	26.9537	27.0751	0.1214	90.04	8.05	0.0315	32.26	46.12	21.62	62.0	368.9	14.4
4CBt1b3		80.54	103.88	23.34	27.6283	27.7198	0.0915	96.89	16.35	0.0315	70.05	14.52	15.42	0.7	483.8	0.1
4CBt2b3		95.41	120.19	24.78	29.5233	29.6155	0.0922	113.41	18.00	0.0315	72.64	12.66	14.70	98.3	327.2	23.1
4Clb3		79.19	104.43	25.24	30.3691	30.4635	0.0944	97.76	18.57	0.0315	73.57	11.47	14.95	123.4	140.1	46.8
4C2b3		97.37	122.06	24.69	28.0660	28.1639	0.0979	115.14	17.77	0.0315	71.97	11.89	16.14	286.6	145.7	66.3

Table 2

BULK DENSITY OF PEDS

Sample #	Horizon	Oven-dry wt.	Waxed-ped wt. in air	Waxed-ped wt. in water	Wax wt.	Bulk Density	Gravel wt.
Ancho Canyon 1 (AC - 1)							
	Bw1	26.04	29.17	2.30	3.13	1.11	
		19.07	21.91	1.49	2.84	1.10	
		95.07	107.00	13.33	11.93	1.18	
		83.81	90.09	9.27	6.28	1.13	
		131.63	146.96	18.85	15.33	1.19	
Los Alamos 4 (LA - 4)							
	Bt1b	34.34	36.49	10.51	2.15	1.46	2.62
		97.71	102.10	36.86	4.39	1.62	4.64
		209.18	220.80	80.80	11.62	1.65	7.86
	Bt2b	146.11	153.62	58.26	7.51	1.68	5.29
		67.37	72.09	28.48	4.72	1.76	3.20
		112.80	118.77	46.08	5.97	1.71	1.89
	Bt3b	13.92	15.89	5.31	1.97	1.66	0.41
		15.12	16.45	6.43	1.33	1.77	0.06
		13.68	15.03	5.68	1.35	1.74	0.08
		8.12	9.00	3.48	0.88	1.79	0.10
	Bt4b	106.55	112.65	41.63	6.10	1.66	6.81
		34.58	36.96	13.93	2.38	1.70	0.92
		45.82	49.11	18.36	3.29	1.69	1.27
	Bt5b	32.76	35.21	12.31	2.45	1.62	0.51
		48.77	51.58	18.34	2.81	1.62	1.23
		67.29	71.43	25.35	4.14	1.62	7.11
		28.89	34.80	10.47	5.91	1.63	0.74
	Bt6b	116.98	123.82	43.11	6.84	1.60	4.98
		94.19	101.01	35.13	6.82	1.62	3.35
		72.47	77.44	27.34	4.97	1.63	0.90
	Bt7b	186.80	195.97	74.05	9.17	1.67	17.42
		206.63	217.00	79.46	10.37	1.64	11.33
		191.95	202.09	73.21	10.14	1.63	13.98
	Bt8b	90.94	96.43	32.41	5.49	1.57	7.88
		52.67	55.95	19.51	3.28	1.61	0.55
		63.05	66.97	23.76	3.92	1.62	4.29
	Bt9b	119.89	128.77	44.65	8.88	1.61	4.66
		47.29	50.57	16.73	3.28	1.57	0.89
		33.00	38.17	11.42	5.17	1.57	0.77
		36.75	39.28	13.67	2.53	1.61	0.61
TA - 51							
	BA	14.33	17.04	0.99	2.71	<1.10	
		40.04	46.51	0.99	6.47	<1.04	
		27.72	33.08	0.99	5.36	<1.06	
	Bw	13.71	16.81	0.99	3.10	<1.11	
		30.60	37.53	0.99	6.93	<1.06	
		69.94	76.01	9.78	6.07	1.18	
	BC	3.23	4.74	0.99	1.51	<1.56	
		8.24	9.16	2.87	0.92	1.56	
		3.45	4.81	0.99	1.36	<1.49	
		10.20	14.31	0.99	4.11	<1.17	

Table 2

BULK DENSITY CONT.

Sample #	Horizon	Oven-dry wt.	Waxed-ped wt. in air	Waxed-ped wt. in water	Wax wt.	Bulk Density	Gravel wt.
TA - 63a							
	A	24.33	28.56	4.93	4.23	1.29	0.91
		45.11	51.96	11.03	6.85	1.35	1.02
		104.03	122.27	24.93	18.24	1.35	2.85
	Bw1	39.13	42.42	12.68	3.29	1.50	0.88
		78.89	88.63	24.04	9.74	1.47	1.69
		152.52	166.89	49.18	14.37	1.50	2.29
	Bw2	19.77	23.76	5.97	3.99	1.48	0.17
		18.62	20.66	6.21	2.04	1.53	0.49
		20.54	22.32	7.34	1.78	1.58	0.16
TA - 63c							
	A2	62.11	67.41	19.81	5.30	1.49	0.75
		73.1	83.18	20.93	10.08	1.43	0.63
		104.61	119.14	29.96	14.53	1.43	0.88
	Bw1	39.51	45.83	10.71	6.32	1.41	0.42
		154.58	167.75	43.44	13.17	1.41	1.18
		85.31	93.92	24.58	8.61	1.43	0.80
		75.55	82.32	21.98	6.77	1.43	1.30
	Bw2	2.90	3.51	0.81	0.61	1.43	0.01
		15.86	18.83	4.11	2.97	1.39	0.28
		14.31	16.25	3.78	1.94	1.39	0.10
	Bw3	4.17	4.77	1.27	0.60	1.47	0.12
		7.98	9.33	2.31	1.35	1.45	0.33
		9.79	11.87	3.14	2.08	1.53	0.28
TA - 63 1A							
	A1	7.71	9.64	1.58	1.93	1.30	0.12
		7.67	9.03	1.26	1.36	1.23	0.33
		5.55	6.37	1.32	0.82	1.34	0.28
		27.68	31.98	6.11	4.30	1.31	0.03
		11.95	14.16	2.68	2.21	1.32	0.00
		25.23	30.17	3.57	4.94	1.20	0.03
	A2	170.26	185.49	47.64	15.23	1.41	0.68
		89.98	96.58	26.83	6.60	1.44	0.19
		123.70	135.42	38.52	11.72	1.47	0.44
		121.49	135.25	36.63	13.76	1.46	0.24
	Bw	17.12	19.05	6.27	1.93	1.61	0.15
		25.48	28.28	9.04	2.80	1.58	0.03
		8.60	10.41	2.81	1.81	1.54	0.01
	Bth	50.52	55.46	17.88	4.94	1.57	0.21
		75.62	81.28	30.72	5.66	1.71	0.95
		78.01	85.31	29.72	7.30	1.64	0.78
		91.36	99.43	34.24	8.07	1.62	1.62
		69.11	75.62	26.27	6.51	1.64	1.28
	Btk1	43.72	47.76	17.74	4.04	1.71	0.68
		20.04	22.21	7.61	2.17	1.64	0.29
		15.01	17.59	5.37	2.58	1.60	0.19
	Btk2	23.91	26.29	9.29	2.38	1.67	0.70
		102.94	114.29	39.33	11.35	1.65	1.84
		22.96	26.76	8.51	3.80	1.64	0.46
TA - 63 2							
	Btb1	108.44	122.78	41.81	14.34	1.67	
		187.16	196.92	66.18	9.76	1.56	
		81.50	86.89	29.96	5.39	1.60	
	Btk1	79.85	85.25	28.35	5.40	1.57	
		151.83	165.68	53.49	13.85	1.57	
		131.39	142.02	46.31	10.63	1.57	
		170.91	180.07	61.97	9.16	1.58	
		147.59	160.30	54.37	12.71	1.61	
		113.94	120.39	41.31	6.45	1.58	

Table 2

BULK DENSITY CONT.

Sample #	Horizon	Oven-dry wt.	Waxed-ped wt. in air	Waxed-ped wt. in water	Wax wt.	Bulk Density	Gravel wt.
Water Canyon 1 (WC - 1)							
	Bt1b2	50.61	57.16	20.53	6.55	1.72	8.07
		35.83	42.45	14.43	6.62	1.73	2.70
		22.28	25.97	9.33	3.69	1.78	6.15
	Bt2b2	15.68	17.83	6.26	2.15	1.71	2.34
		121.06	134.84	48.96	13.78	1.72	24.39
		41.46	45.71	15.72	4.25	1.64	5.60
	Bt3b2	56.55	62.01	20.81	5.46	1.61	7.11
		64.63	75.99	22.43	11.36	1.58	12.45
		84.04	91.02	35.52	6.98	1.76	32.03
	Bt4b2	54.84	61.78	21.97	6.94	1.71	21.81
		82.54	97.70	32.30	15.16	1.70	34.04
		95.28	104.56	41.01	9.28	1.79	51.06
		145.49	154.00	63.58	8.51	1.80	50.85
		117.74	129.38	50.00	11.64	1.77	55.60
Water Canyon 2 (WC - 2)							
	C3b1a	37.53	42.72	17.23	5.19	1.90	
		159.37	168.14	73.04	8.77	1.87	
		27.37	31.08	11.84	3.71	1.81	
		190.59	209.42	81.17	18.83	1.78	
	Bt1b1b	196.38	219.20	84.24	22.82	1.79	
		81.37	90.53	32.72	9.16	1.71	3.93
		67.45	71.89	27.95	4.44	1.73	12.40
	Bt2b1b	43.67	50.04	17.38	6.37	1.71	5.04
		136.50	148.86	53.23	12.36	1.67	
		175.87	198.39	68.78	22.52	1.68	
		133.25	148.58	54.85	15.33	1.74	
		150.54	165.07	61.23	14.53	1.72	

Table 2

BULK DENSITY CONT.

Sample #	Horizon	Oven-dry wt.	Waxed-ped wt. in air	Waxed-ped wt. in water	Wax wt.	Bulk Density	Gravel wt.
TA - 67 E1							
	BA	34.55	37.25	7.92	2.70	1.31	1.58
		15.64	17.23	2.65	1.59	1.22	0.61
		29.52	31.51	5.24	1.99	1.23	1.54
	Bw	54.53	59.40	6.53	4.87	1.15	2.97
		48.64	54.03	6.44	5.39	1.17	1.43
		26.81	29.97	4.13	3.16	1.20	0.41
		43.24	47.20	6.94	3.96	1.21	1.56
	Bt1	129.79	139.41	39.59	9.62	1.46	1.17
		67.00	72.55	22.60	5.55	1.53	0.93
		96.39	104.38	28.17	7.99	1.43	0.62
		69.84	75.34	23.16	5.50	1.52	0.90
		90.31	94.86	29.35	4.55	1.49	0.57
	Bt2	172.50	180.28	52.96	7.78	1.45	1.68
		53.29	63.52	19.50	10.23	1.63	0.77
	2BCb	35.70	38.17	3.35	2.47	1.11	3.36
		77.82	82.99	6.22	5.17	1.10	9.57
		55.47	58.84	5.96	3.37	1.13	6.01
TA - 67 E3							
	A	74.35	80.52	19.43	6.17	1.37	0.51
		31.74	34.03	8.13	2.29	1.36	0.25
		64.17	69.22	16.00	5.05	1.35	0.48
	2BAb1	6.30	7.02	2.18	0.72	1.56	0.04
		10.55	11.50	3.67	0.95	1.56	0.02
		11.57	12.43	3.86	0.86	1.52	0.01
	2Bt1b1	24.30	27.44	8.52	3.14	1.57	0.23
		37.36	41.01	13.18	3.65	1.57	0.31
		37.54	41.86	12.48	4.32	1.53	0.30
	2Bt2b1	28.66	31.05	5.14	2.39	1.23	1.56
		30.96	33.70	6.55	2.74	1.28	1.99
		90.26	99.61	17.14	9.35	1.25	6.33
	2BC1b1	19.59	21.25	2.24	1.66	1.14	2.71
		37.79	41.29	6.15	3.50	1.21	5.55
		28.11	31.02	4.53	2.91	1.21	2.91
	2BC2b1	54.68	58.91	10.92	4.23	1.26	7.52
		85.64	93.43	11.74	7.79	1.17	12.76
		55.70	61.14	10.55	5.44	1.25	4.51
	3Bt1b2	72.45	78.88	11.00	6.43	1.19	13.02
		101.56	109.69	20.34	8.13	1.26	20.76
		49.74	55.60	9.87	5.86	1.27	4.62
	3Bt2b2	51.62	56.97	22.26	5.35	1.79	0.17
		43.41	48.42	17.75	5.01	1.73	0.68
		66.10	71.43	27.73	5.33	1.75	1.03
	3Bt3b2	51.84	56.67	21.95	4.83	1.77	0.89
		72.86	80.23	29.27	7.37	1.70	1.44
		56.16	61.21	23.96	5.05	1.78	1.17

Table 2

BULK DENSITY CONT.

Sample #	Horizon	Oven-dry wt.	Waxed-ped wt. in air	Waxed-ped wt. in water	Wax wt.	Bulk Density	Gravel wt.
TA - 67 W1							
	BA	102.68	112.52	14.61	9.84	1.18	5.73
		15.27	16.69	1.67	1.42	1.14	0.82
		130.65	136.59	17.71	5.94	1.16	10.77
	Bw1	46.23	50.73	2.82	4.50	1.08	4.19
		106.53	111.87	14.20	5.34	1.16	12.49
	Bt1	33.65	38.50	3.74	4.85	1.15	2.22
		49.12	53.08	12.77	3.96	1.37	0.57
		132.37	146.79	27.42	14.42	1.28	2.00
	Bt2	70.46	79.96	10.63	9.50	1.20	1.69
		59.71	64.23	11.91	4.52	1.26	1.68
		69.88	76.28	11.76	6.40	1.22	2.47
TA - 67 W5							
	A	24.34	26.61	3.45	2.27	1.18	1.29
		19.02	20.82	3.07	1.80	1.21	0.75
		13.57	14.74	2.03	1.17	1.19	0.80
	BA	37.69	40.55	5.56	2.86	1.18	1.40
		54.41	58.78	13.05	4.37	1.33	0.38
		65.26	70.13	15.28	4.87	1.32	0.47
	2Bt1b1	23.12	26.43	5.62	3.31	1.35	0.29
		52.79	56.35	12.21	3.56	1.31	0.47
		55.67	59.50	13.40	3.83	1.33	0.62
	2Bt2b1	25.59	29.01	7.33	3.42	1.43	0.21
		33.30	35.83	8.33	2.53	1.35	0.60
		77.12	81.90	23.85	4.78	1.46	0.52
	2Bt3b1	106.38	113.96	18.57	7.58	1.22	12.64
		111.82	117.39	22.93	5.57	1.27	12.80
		86.16	92.49	19.56	6.33	1.31	6.84
	2BC1sb1	19.52	21.84	0.71	2.32	1.05	4.67
		14.82	16.55	0.18	1.73	1.03	3.39
	2BC2sb1	8.53	9.60	0.91	1.07	1.14	0.64
		66.78	71.99	2.08	5.21	1.04	13.29
	3BAb2	54.24	57.06	22.23	2.82	1.71	1.11
		42.92	46.74	17.75	3.82	1.73	4.17
		60.36	63.19	25.28	2.83	1.74	2.87
	3Bt1b2	33.22	35.99	12.64	2.77	1.64	1.64
		56.75	59.82	20.73	3.07	1.59	4.44
	4CBt1b3	72.03	76.79	17.54	4.76	1.33	0.40
		17.95	20.10	4.64	2.15	1.37	0.12
		17.30	18.85	4.72	1.55	1.39	0.00
		21.12	24.74	6.04	3.62	1.44	0.04

Table 3

IRON DITHIONITE EXTRACTION

Sample Number	Horizon	Sample wt.(g)	Fe (ug/mL)	Fe2O3 %
Ancho Canyon 1 (AC - 1)				
	A1	0.5001	15.37	0.44
	A2	0.5002	16.84	0.48
	Bw1	0.4999	21.13	0.60
	Bw2	0.4998	18.36	0.53
	Bw3	0.5001	16.38	0.47
	C	0.5001	11.32	0.32
	Ckq	0.4999	9.80	0.28
	C'	0.5002	8.98	0.26
	Btb	0.5001	15.29	0.44
	Bwb	0.5002	17.30	0.49
Los Alamos 4 (LA - 4)				
	Bt4b	0.5002	29.78	0.85
	Bt5b	0.5000	28.62	0.82
	Bt6b	0.4998	26.70	0.76
	Bt7b	0.5002	29.56	0.84
	Bt8b	0.5000	27.49	0.79
	Bt9b	0.4999	28.33	0.81
	BCb	0.5002	27.36	0.78
TA - 51				
	A	0.5002	27.95	0.80
	BA	0.5002	29.97	0.86
	Bw	0.5002	33.65	0.96
	BC	0.5002	35.28	1.01

Table 3

Fe DITHIONITE EXTRACTION CONT.

Sample Number	Horizon	Sample wt.(g)	Fe (ug/mL)	Fe2O3 %
TA - 63a				
	A	0.5000	37.72	1.08
	Bw1	0.5001	38.00	1.09
	Bw2	0.5000	34.69	0.99
	CB	0.5000	40.53	1.16
	FF (80 cm)	0.5000	49.32	1.41
	FF (110 cm)	0.5001	29.02	0.83
TA - 63b				
	FF (90 cm)	0.5002	38.54	1.10
	FF (150 cm)	0.5000	36.80	1.05
TA - 63c				
	A1	0.5000	33.59	0.96
	A2	0.5000	35.58	1.02
	Bw1	0.5001	34.89	1.00
	Bw2	0.4999	34.54	0.99
	Bw3	0.5000	33.50	0.96
	FF (80 cm)	0.4999	31.70	0.91
	FF (110 cm)	0.5001	22.13	0.63
TA - 63 - 1A				
	A1	0.5001	32.18	0.92
	A2	0.4998	37.99	1.09
	Bw	0.4998	35.11	1.00
	Bth	0.5002	30.97	0.89
	Btk1	0.5002	25.04	0.72
	Btk2	0.5000	28.50	0.81
	Btb	0.5001	33.07	0.95
TA - 63 - 2				
	Bw	0.5000	41.03	1.17
	Bth	0.4999	41.56	1.19
	Bthk	0.5001	38.29	1.09
	Btk1	0.4999	33.13	0.95
	Btk2	0.5001	35.59	1.02
	Btkb1	0.5000	41.51	1.19
	Btkb2	0.4998	37.05	1.06
	Btb1	0.5000	41.63	1.19
	Btb2	0.4998	34.17	0.98

Table 3

Fe DITHIONITE EXTRACTION CONT.

Sample Number	Horizon	Sample wt.(g)	Fe (ug/mL)	Fe2O3 %
Water Canyon 1 (WC - 1)				
	Bt1b2	0.5002	34.67	0.99
	Bt2b2	0.4998	39.46	1.13
	Bt3b2	0.5002	32.03	0.92
	Bt4b2	0.4999	31.10	0.89
	Bt5b2	0.5000	31.75	0.91
Water Canyon 2 (WC - 2)				
	C1b1a	0.4998	20.35	0.58
	C2b1a	0.5000	49.27	1.41
	C3b1a	0.5000	32.06	0.92
	Bt1b1b	0.4999	36.15	1.03
	Bt2b1b	0.5000	32.42	0.93
	Bt1b1c	0.5000	33.70	0.96
	Bt2b1c	0.5001	31.16	0.89
	Bt3b1c	0.5002	29.83	0.85
Water Canyon 3 (WC - 3)				
	Ap	0.5000	22.57	0.65
	Bt1	0.5000	32.60	0.93
	Bt2	0.4999	36.79	1.05
	Bt3	0.4999	30.97	0.89
	Bt4	0.5001	31.95	0.91
	BC	0.5001	28.20	0.81
	2C	0.5000	12.26	0.35
TA - 67 E1				
	A	0.4998	29.45	0.84
	BA	0.5001	29.49	0.84
	Bw	0.5002	33.07	0.95
	Bt1	0.5000	34.48	0.99
	Bt2	0.5000	36.76	1.05
	2Bwb	0.5001	34.37	0.98
	2BCb	0.5001	29.53	0.84
TA - 67 2 E1				
	E/Btb1	0.5001	34.18	0.98
	E/Bt2b1	0.5000	38.78	1.11
	Bt1b1	0.5001	44.08	1.26
	Bt2b1	0.5002	37.59	1.07
	Btkb1	0.5000	31.03	0.89
	Btk1b2	0.5000	31.66	0.91
	Btk2b2	0.5002	32.90	0.94
	Bt3b2	0.4999	27.97	0.80
	CR	0.5000	17.44	0.50
TA - 67 E3				
	A	0.5000	31.76	0.91
	2BAb	0.5000	39.32	1.12
	2Bt1b1	0.5000	40.77	1.17
	2Bt2b1	0.5000	34.20	0.98
	2BC1b1	0.5000	31.59	0.90
	2BC2b1	0.5000	32.70	0.94
	3Bt1b2	0.5000	29.29	0.84
	3Bt2b2	0.5000	35.59	1.02
	3Bt3b2	0.5000	37.88	1.08

Table 3

Fe DITHIONITE EXTRACTION CONT.

Sample Number	Horizon	Sample wt.(g)	Fe (ug/mL)	Fe ₂ O ₃ %
TA - 67 W1				
	A1	0.5000	29.11	0.83
	A2	0.5000	29.86	0.85
	A3	0.5000	31.04	0.89
	BA	0.5000	32.29	0.92
	Bw	0.5001	33.92	0.97
	Bt1	0.5000	37.99	1.09
	Bt2	0.5000	34.46	0.99
	Btkb	0.5000	28.60	0.82
	Bt/CR	0.5000	32.39	0.93
	E/Bb	0.5000	32.25	0.92
TA - 67 W5				
	A	0.4998	26.13	0.75
	BA	0.4998	30.72	0.88
	2Bt1b1	0.4999	35.41	1.01
	2Bt2b1	0.5001	37.49	1.07
	2Bt3b1	0.5001	31.19	0.89
	2BC1b1	0.5001	29.26	0.84
	2BC2b1	0.4998	26.86	0.77
	3BAb2	0.5002	22.21	0.63
	3Btb2	0.5000	21.18	0.61
	4CBt1b3	0.5001	14.57	0.42
	4CBt2b3	0.5002	14.62	0.42
	4C1b3	0.5000	20.79	0.59
	4C2b3	0.5001	21.98	0.63

Table 4

IRON OXALATE EXTRACTION

Sample #	Horizon	Sample Wt. (g)	Fe (ug/mL)	Fe2O3 %	Mean % Fe2O3
Fe standard	Fe2O3	0.0050	2.27	1.30	1.29
Fe standard	Fe2O3	0.0050	2.27	1.30	
Fe standard	Fe2O3	0.0050	2.24	1.28	

Sample #	Horizon	Sample Wt. (g)	Fe (ug/mL)	Fe2O3 %	Mean % Fe2O3
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Ancho Canyon 1 (AC - 1)

A1	0.5002	68.68	0.39	0.42
	0.5001	77.39	0.44	
A2	0.5000	53.43	0.31	0.31
Bw1	0.5002	60.22	0.34	0.35
	0.4998	62.50	0.36	
Bw2	0.5002	70.47	0.40	0.38
	0.5001	61.08	0.35	
Bw3	0.5001	39.17	0.22	0.22
C	0.5002	59.75	0.34	0.34
Ckq	0.5002	59.09	0.34	0.32
	0.5002	54.21	0.31	
C'	0.5000	28.90	0.17	0.17
Btb	0.4999	77.40	0.44	0.44
	0.5001	76.53	0.44	
Bwb	0.5000	70.33	0.40	0.43
	0.4999	79.32	0.45	

Los Alamos 4 (LA - 4)

Bt4b	0.5001	33.44	0.19	0.18
	0.5002	28.45	0.16	
Bt5b	0.5001	41.63	0.24	0.22
	0.5001	36.89	0.21	
Bt6b	0.5002	34.71	0.20	0.19
	0.5000	31.88	0.18	
Bt7b	0.5002	34.40	0.20	0.19
	0.5001	31.35	0.18	
Bt8b	0.5002	34.81	0.20	0.19
	0.4999	30.44	0.17	
Bt9b	0.5001	36.40	0.21	0.20
	0.5002	34.71	0.20	
BCb	0.5000	43.27	0.25	0.25
	0.4998	43.25	0.25	

TA - 51

A	0.5001	69.30	0.40	0.41
	0.5000	72.54	0.41	
BA	0.5001	88.29	0.50	0.51
	0.5000	90.58	0.52	
Bw	0.5000	108.08	0.62	0.64
	0.4999	115.53	0.66	
BC	0.5001	102.41	0.59	0.60
	0.5000	106.69	0.61	

Table 4

Fe OXALATE EXTRACTION CONT.

Sample #	Horizon	Sample Wt. (g)	Fe (ug/mL)	Fe2O3 %	Mean % Fe2O3
TA - 63a	A	0.5000	42.80	0.24	0.26
		0.5000	46.64	0.27	
	Bw1	0.5002	56.33	0.32	0.32
	Bw2	0.5000	44.78	0.26	0.26
		0.5000	45.51	0.26	
	CB	0.5000	45.24	0.26	0.23
		0.5000	33.45	0.19	
	FF(80)	0.5001	48.02	0.27	0.27
	FF(110)	0.5002	33.33	0.19	0.19

Sample #	Horizon	Sample Wt. (g)	Fe (ug/mL)	Fe2O3 %
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TA - 63b	FF(90)	0.4999	28.50	0.16
	FF(150)	0.4999	32.46	0.19

TA - 63c	A1	0.5002	40.97	0.23
	A2	0.5001	46.71	0.27
	Bw1	0.5000	49.91	0.29
	Bw2	0.5001	47.50	0.27
	Bw3	0.5002	46.68	0.27
	FF(80)	0.5000	48.53	0.28
	FF(110)	0.5002	110.00	0.63

Sample #	Horizon	Sample Wt. (g)	Fe (ug/mL)	Fe2O3 %	Mean % Fe2O3
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TA - 63 - 1A	A1	0.5001	90.43	0.52	0.55
		0.4891	98.65	0.58	
	A2	0.5000	125.01	0.71	0.71
		0.5001	122.52	0.70	
	Bw	0.5001	140.56	0.80	0.77
		0.5001	128.37	0.73	
	Bth	0.5002	119.22	0.68	0.67
		0.4999	115.74	0.66	
	Btk1	0.4999	80.51	0.46	0.47
		0.5001	82.32	0.47	
	Btk2	0.5000	66.03	0.38	0.38
		0.4919	66.67	0.39	

TA - 63 - 2	Bw	0.5000	64.68	0.37	0.37
		0.5000	64.04	0.37	
	Bth	0.4999	65.36	0.37	0.37
	Bthk	0.5001	75.83	0.43	0.43
	Btk1	0.5001	46.36	0.27	0.27
	Btk2	0.5000	39.14	0.22	0.22
	Btkb1	0.5000	52.64	0.30	0.30
	Btkb2	0.5002	58.77	0.34	0.34
	Btb1	0.4998	85.05	0.49	0.49
	Btb2	0.5000	57.14	0.33	0.33

Table 4

Fe OXALATE EXTRACTION CONT.

Sample #	Horizon	Sample Wt. (g)	Fe (ug/mL)	Fe ₂ O ₃ %	Mean % Fe ₂ O ₃
Water Canyon 1 (WC - 1)					
	Bt1b2	0.4998	22.18	0.13	0.13
	Bt2b2	0.5001	28.12	0.16	0.16
	Bt3b2	0.5001	23.22	0.13	0.13
	Bt4b2	0.4999	25.45	0.15	0.15
	Bt5b2	0.5000	12.90	0.07	0.08
		0.5002	14.80	0.08	
Water Canyon 2 (WC - 2)					
	C1b1a	0.4999	27.77	0.16	0.16
	C2b1a	0.4998	81.35	0.47	0.47
		0.4999	81.32	0.47	
	C3b1a	0.5001	19.21	0.11	0.11
		0.5000	18.50	0.11	
	Bt1b1b	0.4999	20.34	0.12	0.12
	Bt2b1b	0.4998	17.48	0.10	0.10
		0.4998	16.36	0.09	
	Bt1b1c	0.5001	15.97	0.09	0.09
		0.5000	15.55	0.09	
	Bt2b1c	0.4999	22.55	0.13	0.13
	Bt3b1c	0.4998	22.46	0.13	0.13
Water Canyon 3 (WC - 3)					
	Ap	0.5002	41.20	0.24	0.24
		0.5000	42.27	0.24	
	Bt1	0.4998	36.40	0.21	0.20
		0.4999	34.33	0.20	
	Bt2	0.4998	56.63	0.32	0.32
	Bt3	0.5002	49.19	0.28	0.26
		0.4998	40.42	0.23	
	Bt4	0.5002	47.81	0.27	0.25
		0.5002	40.09	0.23	
	BC	0.5002	35.28	0.20	0.19
		0.4999	32.51	0.19	
	2C	0.4999	42.36	0.24	0.24
		0.4998	40.33	0.23	

Table 4

Fe OXALATE EXTRACTION CONT.

Sample #	Horizon	Sample Wt. (g)	Fe (ug/mL)	Fe ₂ O ₃ %	
TA - 67 E1					
	A	0.5000	34.84	0.20	
	BA	0.5000	32.27	0.18	
	Bw	0.5002	34.54	0.20	
	Bt1	0.5002	42.09	0.24	
	Bt2	0.4999	36.97	0.21	
	2Bwb	0.5001	33.32	0.19	
	2BCb	0.5000	25.81	0.15	
TA - 67 - 2 E1					
	E/Btb1	0.4998	38.18	0.22	
	E/Bt2b1	0.5002	28.00	0.16	
	Bt1b1	0.4998	33.75	0.19	
	Bt2b1	0.5002	26.44	0.15	
	Btkb1	0.5001	29.17	0.17	
	Btk1b2	0.5001	29.22	0.17	
	Btk2b2	0.5002	26.39	0.15	
	Bt3b2	0.5001	30.35	0.17	
	CR	0.5002	38.31	0.22	
Sample #	Horizon	Sample Wt. (g)	Fe (ug/mL)	Fe ₂ O ₃ %	Mean % Fe ₂ O ₃
TA - 67 E3					
	A	0.5001	50.82	0.29	0.28
		0.5000	48.38	0.28	
	2BAb1	0.5002	50.00	0.29	0.31
		0.5002	57.62	0.33	
	2Bt1b1	0.5002	60.65	0.35	0.34
		0.5001	57.59	0.33	
	2Bt2b1	0.5002	51.10	0.29	0.28
		0.5000	47.58	0.27	
	2BC1b1	0.4998	51.37	0.29	0.30
		0.5000	53.32	0.30	
	2BC2b1	0.5001	51.37	0.29	0.29
		0.5002	50.27	0.29	
	3Bt1b2	0.5000	43.40	0.25	0.24
		0.5001	41.88	0.24	
	3Bt2b2	0.4998	42.39	0.24	0.22
		0.5000	36.26	0.21	
	3Bt3b2	0.5002	51.92	0.30	0.30
		0.5002	54.74	0.31	

Table 4

Fe OXALATE EXTRACTION CONT.

Sample #	Horizon	Sample Wt. (g)	Fe (ug/mL)	Fe ₂ O ₃ %	Mean % Fe ₂ O ₃
TA - 67 W1	A1	0.5000	24.14	0.14	0.15
		0.5000	29.27	0.17	
	A2	0.5000	30.78	0.18	0.16
		0.5000	23.77	0.14	
	A3	0.5000	28.68	0.16	0.18
		0.5000	33.59	0.19	
	BA	0.5000	27.83	0.16	0.17
		0.5000	30.62	0.18	
	Bw	0.5000	40.54	0.23	0.23
	Bt1	0.5000	38.59	0.22	0.21
		0.5000	34.03	0.19	
	Bt2	0.5000	27.50	0.16	0.16
		0.5000	26.71	0.15	
	E/Btb	0.5000	30.39	0.17	0.18
		0.5000	31.64	0.18	
	Btkb	0.5000	16.86	0.10	0.11
		0.5000	21.06	0.12	
	Bt/CR	0.5000	24.10	0.14	0.13
		0.5000	20.96	0.12	

Sample #	Horizon	Sample Wt. (g)	Fe (ug/mL)	Fe ₂ O ₃ %
TA - 67 W5	A	0.4999	31.35	0.18
	BA	0.5001	33.52	0.19
	2Bt1b1	0.5000	43.20	0.25
	2Bt2b1	0.5001	38.35	0.22
	2Bt3b1	0.4999	32.40	0.19
	2BC1b1	0.5000	32.54	0.19
	2BC2b1	0.5001	35.88	0.21
	3BAb2	0.4998	27.76	0.16
	3Btb2	0.4999	24.96	0.14
	4CBt1b3	0.5000	16.34	0.09
	4CBt2b3	0.5000	19.84	0.11
	4C1b3	0.5000	23.07	0.13
	4C2b3	0.5000	25.63	0.15

Table 5

ORGANIC CARBON ANALYSES

	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Calc.soil C (mg)	Diff. sqrd	Soil C (%)
Sucrose standards						
1	0	0.000	0.000	0.00	0.0000	0.00
2	0.0233	0.260	20.000	20.28	0.0792	2.00
3	0.0463	0.484	40.000	39.65	0.1195	4.00
4	0.0693	0.700	60.000	60.00	0.0000	6.00
sum stds. 1 thru 4					0.1987	

$$a \cdot x^2 + b \cdot x + c$$

a	17.515232
b	73.454977
c	-0.000948

Sample #	Horizon	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Soil C (%)
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Ancho Canyon 1 (AC - 1)

A1	0.50	0.116	8.756	1.75
A2	0.50	0.032	2.368	0.47
Bw1	0.50	0.132	10.000	2.00
Bw2	0.50	0.056	4.167	0.83
Bw3	0.50	0.031	2.293	0.46
C	0.50	0.041	3.040	0.61
Ckq	0.50	0.050	3.716	0.74
C'	0.50	0.038	2.816	0.56
Btb	0.50	0.048	3.565	0.71
Bwb	0.50	0.070	5.227	1.05

	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Calc.soil C (mg)	Diff. sqrd	Soil C (%)
Sucrose standards						
1	0	0.000	0.000	0.00	0.0000	0.00
2	0.0233	0.222	20.000	19.99	0.0002	2.00
3	0.0463	0.443	40.000	40.01	0.0002	4.00
4	0.0693	0.662	60.000	60.00	0.0000	6.00
sum stds. 1 thru 4					0.0004	

$$a \cdot x^2 + b \cdot x + c$$

a	1.3953688
b	89.696578
c	0.00463

Sample #	Horizon	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Soil C (%)
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Los Alamos 4 (LA - 4)

Bt4b	0.50	0.029	2.607	0.52
Bt5b	0.50	0.013	1.171	0.23
Bt6b	0.50	0.023	2.068	0.41
Bt7b	0.50	0.010	0.902	0.18
Bt8b	0.50	0.010	0.902	0.18
Bt9b	0.50	0.012	1.081	0.22
BCb	0.50	0.025	2.248	1.12

Sample #	Horizon	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Soil C (%)
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TA - 51

A	0.50	0.950	86.476	17.30
BA	0.50	0.386	34.835	6.97
Bw	0.50	0.270	24.324	4.86
BC	0.50	0.450	40.651	8.13

Table 5

ORGANIC CARBON CONTENT CONT.

Sample #	Horizon	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Soil C (%)	Mean Soil C (%)
TA - 63a						
	A	0.50	0.104	8.845	1.77	1.79
	Bw1	0.50	0.107	9.101	1.82	
	Bw2	0.50	0.062	5.267	1.05	1.21
		0.50	0.080	6.800	1.36	

TA - 63c						
	A1	0.50	0.290	24.792	4.96	5.22
		0.50	0.320	27.380	5.48	
	A2	0.50	0.179	15.256	3.05	2.59
		0.50	0.125	10.638	2.13	
	Bw1	0.50	0.086	7.311	1.46	1.60
		0.50	0.102	8.675	1.73	
	Bw2	0.50	0.110	9.357	1.87	1.95
		0.50	0.119	10.125	2.03	
	Bw3	0.50	0.138	11.748	2.35	2.62
		0.50	0.170	14.485	2.90	

Sample #	Horizon	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Soil C (%)
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TA - 63 - 1A					
	A1	0.50	0.167	15.023	3.00
	A2	0.50	0.069	6.200	1.24
	Bw	0.50	0.043	3.864	0.77
	Bth	0.50	0.023	2.068	0.41
	Btk1	0.50	0.025	2.248	0.45
	Btk2	0.50	0.025	2.248	0.45
	Btb	0.50	0.042	3.774	0.75

Sample #	Horizon	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Soil C (%)	Mean Soil C (%)
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TA - 63 - 2						
	Bw	0.50	0.082	6.416	1.28	1.02
		0.50	0.049	3.829	0.77	
	Bth	0.50	0.015	1.170	0.23	0.34
		0.50	0.028	2.186	0.44	
	Bthk	0.50	0.042	3.281	0.66	0.49
		0.50	0.021	1.638	0.33	
	Btk1	0.50	0.032	2.498	0.50	0.44
		0.50	0.024	1.873	0.37	
	Btk2	0.50	0.031	2.420	0.48	0.41
		0.50	0.022	1.717	0.34	
	Btkb1	0.50	0.032	2.498	0.50	0.37
		0.50	0.015	1.170	0.23	
	Btkb2	0.50	0.025	1.951	0.39	0.42
		0.50	0.029	2.264	0.45	
	Btb1	0.50	0.020	1.560	0.31	0.39
		0.50	0.030	2.342	0.47	
	Btb2	0.50	0.021	1.638	0.33	0.30
		0.50	0.018	1.404	0.28	

Table 5

ORGANIC CARBON CONTENT CONT.

Sample #	Horizon	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Soil C (%)	Mean Soil C (%)
Water Canyon 1 (WC - 1)						
Bt1b2		0.50	0.082	6.970	1.39	1.55
		0.50	0.100	8.504	1.70	
Bt2b2		0.50	0.028	2.377	0.48	0.59
		0.50	0.041	3.482	0.70	
Bt3b2		0.50	0.020	1.698	0.34	0.42
		0.50	0.030	2.547	0.51	
Bt4b2		0.50	0.059	5.012	1.00	0.85
		0.50	0.041	3.482	0.70	
Bt5b2		0.50	0.023	1.953	0.39	0.43
		0.50	0.028	2.377	0.48	

Water Canyon 2 (WC- 2)

C1b1a		0.50	0.061	5.182	1.04	0.85
		0.50	0.039	3.312	0.66	
C2b1a		0.50	0.032	2.717	0.54	0.46
		0.50	0.022	1.868	0.37	
C3b1a		0.50	0.039	3.312	0.66	0.58
		0.50	0.029	2.462	0.49	
Bt1b1b		0.50	0.001	0.086	0.02	0.03
		0.50	0.002	0.171	0.03	
Bt2b1b		0.50	0.021	1.783	0.36	0.31
		0.50	0.016	1.358	0.27	
Bt1b1c		0.50	0.010	0.849	0.17	0.15
		0.50	0.008	0.680	0.14	
Bt2b1c		0.50	0.048	4.077	0.82	0.52
		0.50	0.013	1.104	0.22	
Bt3b1c		0.50	0.089	7.567	1.51	1.00
		0.50	0.029	2.462	0.49	

Sample #	Horizon	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Soil C (%)
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Water Canyon 3 (WC - 3)

Ap		0.50	0.076	6.830	1.37
Bt1		0.50	0.051	4.583	0.92
Bt2		0.50	0.043	3.652	0.73
Bt3		0.50	0.026	2.338	0.47
Bt4		0.50	0.022	1.979	0.40
BC		0.50	0.010	0.902	0.18
2C		0.50	0.012	1.081	0.22

Table 5

ORGANIC CARBON CONTENT CONT.

	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Calc. soil C (mg)	Diff. sqrd	Soil C (%)	a*x ² + b*x + c
Sucrose standards							
1	0	0.000	0.000	0.01	0.0002	0.00	a -0.410395
2	0.0233	0.229	20.000	19.96	0.0015	2.00	b 87.201713
3	0.0463	0.460	40.000	40.04	0.0015	4.00	c 0.0131472
4	0.0693	0.690	60.000	59.99	0.0002	6.00	
				sum stds.			
				1 thru 4			
				0.0034			

Sample #	Horizon	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Soil C (%)	Mean Soil C (%)
TA - 67 E1						
	A	0.50	0.105	9.165	1.83	1.89
		0.50	0.112	9.775	1.95	
	BA	0.50	0.085	7.422	1.48	1.79
		0.50	0.120	10.471	2.09	
	Bw	0.50	0.063	5.505	1.10	1.28
		0.50	0.084	7.335	1.47	
	Bt1	0.50	0.089	7.771	1.55	1.82
		0.50	0.120	10.471	2.09	
	Bt2	0.50	0.025	2.193	0.44	0.64
		0.50	0.048	4.198	0.84	
	2Bwb	0.50	0.062	5.418	1.08	0.97
		0.50	0.049	4.285	0.86	
	2BCb	0.50	0.079	6.900	1.38	1.39
		0.50	0.080	6.987	1.40	

TA - 67 - 2 E1

	E/Btb1	0.50	0.082	7.161	1.43	1.78
		0.50	0.122	10.646	2.13	
	E/Bt2b1	0.50	0.011	0.972	0.19	0.21
		0.50	0.013	1.147	0.23	
	Bt1b1	0.50	0.062	5.418	1.08	1.08
		0.50	0.062	5.418	1.08	
	Bt2b1	0.50	0.039	3.413	0.68	0.41
		0.50	0.008	0.711	0.14	
	Btkb1	0.50	0.017	1.495	0.30	0.49
		0.50	0.039	3.413	0.68	
	Btk1b2	0.50	0.019	1.670	0.33	0.31
		0.50	0.016	1.408	0.28	
	Btk2b2	0.50	0.010	0.885	0.18	0.34
		0.50	0.029	2.542	0.51	
	Bt3b2	0.50	0.013	1.147	0.23	0.23
		0.50	0.013	1.147	0.23	
	CR	0.50	0.016	1.408	0.28	0.97
		0.50	0.095	8.294	1.66	

Table 5

ORGANIC CARBON CONTENT CONT.

Sample #	Horizon	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Soil C (%)	Mean Soil C (%)
TA - 67 E3						
A		0.50	0.061	5.182	1.04	0.86
		0.50	0.040	3.397	0.68	
2BAb1		0.50	0.071	6.033	1.21	1.27
		0.50	0.078	6.630	1.33	
2Bt1b1		0.50	0.043	3.652	0.73	0.73
		0.50	0.043	3.652	0.73	
2Bt2b1		0.50	0.030	2.547	0.51	0.42
		0.50	0.020	1.698	0.34	
2BC1b1		0.50	0.071	6.033	1.21	0.94
		0.50	0.040	3.397	0.68	
2BC2b1		0.50	0.010	0.849	0.17	0.20
		0.50	0.014	1.189	0.24	
3Bt1b2		0.50	0.042	3.567	0.71	0.47
		0.50	0.013	1.104	0.22	
3Bt2b2		0.50	0.002	0.171	0.03	0.03
		0.50	0.001	0.086	0.02	
3Bt3b2		0.50	0.015	1.274	0.25	0.27
		0.50	0.017	1.443	0.29	

Table 5

ORGANIC CARBON CONTENT CONT.

	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Calc. soil C (mg)	Diff. sqrd	Soil C (%)
Sucrose standards						
1	0	0.000	0.000	0.00	0.0000	0.00
2	0.0233	0.230	20.000	19.63	0.1369	2.00
3	0.0463	0.470	40.000	40.38	0.1462	4.00
4	0.0693	0.694	60.000	60.00	0.0000	6.00
					sum stds. 1 thru 4	
					0.2831	

$$a \cdot x^2 + b \cdot x + c$$

a	2.3942458
b	84.792019
c	0.0011837

TA - 67 W1

A1	0.50	0.200	17.055	3.41	3.37
	0.50	0.195	16.627	3.33	
A2	0.50	0.125	10.638	2.13	2.00
	0.50	0.110	9.357	1.87	
A3	0.50	0.095	8.078	1.62	1.65
	0.50	0.099	8.419	1.68	
BA	0.50	0.060	5.097	1.02	0.99
	0.50	0.056	4.757	0.95	
Bt1	0.50	0.051	4.332	0.87	0.87
	0.50	0.051	4.332	0.87	
Bt2	0.50	0.042	3.567	0.71	1.16
	0.50	0.095	8.078	1.62	
Btkb	0.50	0.082	6.970	1.39	0.88
	0.50	0.022	1.868	0.37	
E/Bb	0.50	0.008	0.680	0.14	0.23
	0.50	0.019	1.613	0.32	
Bt/CR	0.50	0.030	2.547	0.51	0.58
	0.50	0.038	3.227	0.65	

Sample #	Horizon	Sample wt. (gm)	Absorb- ance	Soil C (mg)	Soil C (%)	Mean Soil C (%)
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TA - 67 W5

A	0.50	0.121	10.296	2.06	1.97
	0.50	0.110	9.357	1.87	
BA	0.50	0.075	6.374	1.27	1.10
	0.50	0.055	4.672	0.93	
2Bt1b1	0.50	0.062	5.267	1.05	1.10
	0.50	0.068	5.778	1.16	
2Bt2b1	0.50	0.038	3.227	0.65	0.87
	0.50	0.065	5.523	1.10	
2Bt3b1	0.50	0.088	7.481	1.50	1.05
	0.50	0.035	2.972	0.59	
2BC1b1	0.50	0.013	1.104	0.22	0.37
	0.50	0.031	2.632	0.53	
2BC2b1	0.50	0.023	1.953	0.39	0.43
	0.50	0.028	2.377	0.48	
3BAb2	0.50	0.020	1.698	0.34	0.31
	0.50	0.016	1.358	0.27	
4CBt1b3	0.50	0.020	1.698	0.34	0.42
	0.50	0.030	2.547	0.51	
4CBt2b3	0.50	0.038	3.227	0.65	0.51
	0.50	0.022	1.868	0.37	
4C1b3	0.50	0.025	2.122	0.42	0.37
	0.50	0.018	1.528	0.31	
4C2b3	0.50	0.081	6.885	1.38	0.93
	0.50	0.029	2.462	0.49	

Table 6

CATION EXCHANGE CAPACITY

Site & Horizon	ug/mL Ca	meq Ca per 100 g	ug/mL Mg	meq Mg per 100 g	ug/mL Na	meq Na per 100 g	ug/mL K	meq K per 100 g	Total cation conc. in meq/100 g	Ave. cation conc. in meq/100 g
Ancho Canyon 1 (AC - 1)										
A1	15.76	3.93	1.51	0.62	2.29	0.50	3.01	0.39	5.44	5.44
A2	8.57	2.14	1.01	0.42	0.00	0.00	1.17	0.15	2.70	2.70
Bw1	36.80	9.18	3.15	1.30	1.39	0.30	6.07	0.78	11.56	11.56
Bw2	23.99	5.99	2.67	1.10	10.12	2.20	4.14	0.53	9.82	9.82
Bw3	11.40	2.84	1.28	0.53	0.13	0.03	2.20	0.28	3.68	3.68
C	10.78	2.69	0.61	0.25	0.13	0.03	1.75	0.22	3.19	3.19
Ckq	6.26	1.56	0.78	0.32	4.59	1.00	1.16	0.15	3.03	3.03
C'	8.58	2.14	0.56	0.23	1.28	0.28	1.78	0.23	2.88	2.88
Btb	36.48	9.10	3.70	1.52	5.57	1.21	3.99	0.51	12.35	12.35
Bwb	26.29	6.56	3.40	1.40	5.97	1.30	3.68	0.47	9.73	9.73
Los Alamos 4 (LA - 4)										
Bt4b	81.96	20.45	12.40	5.10	3.58	0.78	8.78	1.12	27.45	27.45
Bt5b	57.71	14.40	8.69	3.58	2.85	0.62	7.58	0.97	19.56	19.56
Bt6b	57.14	14.26	7.68	3.16	5.00	1.09	7.70	0.99	19.49	19.49
Bt7b	51.58	12.87	6.31	2.60	3.19	0.69	6.72	0.86	17.02	17.02
Bt8b	41.75	10.42	5.33	2.19	3.61	0.79	5.55	0.71	14.11	14.11
Bt9b	41.72	10.41	4.86	2.00	1.52	0.33	5.07	0.65	13.39	13.39
BCb	26.65	6.65	4.18	1.72	2.06	0.45	4.02	0.51	9.33	9.33
TA - 51										
A	150.44	37.53	10.70	4.40	1.35	0.29	6.35	0.81	43.04	43.04
BA	96.51	24.08	6.02	2.48	0.00	0.00	5.83	0.75	27.30	27.30
Bw	89.61	22.36	4.87	2.00	1.29	0.28	4.35	0.56	25.20	25.20
BC	104.27	26.02	5.88	2.42	0.22	0.05	3.64	0.47	28.95	28.95

Table 6

CATION EXCHANGE CAPACITY CONT.

Site & Horizon	ug/mL Ca	meq Ca per 100 g	ug/mL Mg	meq Mg per 100 g	ug/mL Na	meq Na per 100 g	ug/mL K	meq K per 100 g	Total cation conc. in meq/100 g	Ave. cation conc. in meq/100 g
TA - 63a										
A	28.78	7.18	4.20	1.73	1.05	0.23	5.14	0.66	9.80	9.85
	29.19	7.28	4.06	1.67	1.69	0.37	4.49	0.57	9.90	
Bw	32.54	8.12	5.45	2.24	0.17	0.04	4.08	0.52	10.92	10.86
	32.19	8.03	5.35	2.20	0.25	0.05	3.93	0.50	10.79	
Bw2	31.93	7.97	6.32	2.60	0.91	0.20	2.99	0.38	11.15	11.05
	31.48	7.85	6.15	2.53	0.84	0.18	2.97	0.38	10.95	
CB	28.09	7.01	6.06	2.49	0.07	0.02	2.13	0.27	9.79	10.61
	32.71	8.16	7.20	2.96	0.00	0.00	2.43	0.31	11.43	
TA - 63c										
A1	44.06	10.99	5.34	2.20	0.00	0.00	8.99	1.15	14.34	14.35
	44.19	11.03	5.37	2.21	0.00	0.00	8.80	1.13	14.36	
A2	35.50	8.86	5.84	2.40	0.36	0.08	6.57	0.84	12.18	12.24
	35.74	8.92	5.85	2.41	0.35	0.08	7.04	0.90	12.30	
Bw1	25.02	6.24	4.13	1.70	0.72	0.16	3.72	0.48	8.57	8.57
Bw2	20.77	5.18	4.64	1.91	0.38	0.08	2.92	0.37	7.55	7.66
	21.02	5.24	4.69	1.93	0.91	0.20	3.13	0.40	7.77	
Bw3	23.89	5.96	5.08	2.09	0.49	0.11	3.21	0.41	8.57	8.92
	25.21	6.29	5.48	2.26	0.72	0.16	4.53	0.58	9.28	
TA - 63 - 1A										
A1	33.97	8.48	4.00	1.65	0.00	0.00	6.42	0.82	10.94	10.94
A2	35.84	8.94	4.03	1.66	0.00	0.00	2.57	0.33	10.93	10.93
Bw	42.39	10.58	6.27	2.58	0.34	0.07	1.35	0.17	13.40	13.40
Bth (1)	59.67	14.89	8.30	3.42	3.18	0.69	1.89	0.24	19.24	19.00
Btk1	57.33	14.30	8.55	3.52	3.34	0.73	1.62	0.21	18.76	
	70.78	17.66	7.41	3.05	1.62	0.35	1.53	0.20	21.26	21.26
TA - 63 - 2										
Bw	33.27	8.30	6.25	2.57	0.12	0.03	2.64	0.34	11.24	11.24
Bth	48.64	12.14	8.62	3.55	1.79	0.39	2.07	0.26	16.34	16.34
Bthk(1)	70.64	17.62	9.45	3.89	4.01	0.87	1.75	0.22	22.61	22.05
	68.58	17.11	9.11	3.75	1.77	0.38	1.97	0.25	21.50	
Btk1	63.35	15.81	7.81	3.21	2.12	0.46	1.42	0.18	19.66	19.66
Btk2	49.91	12.45	5.86	2.41	1.97	0.43	1.23	0.16	15.45	15.45
Btkb1	67.23	16.77	9.22	3.79	4.32	0.94	3.07	0.39	21.90	21.90
Btkb2	62.14	15.50	8.57	3.53	4.70	1.02	2.69	0.34	20.40	20.40
Btb1	67.31	16.79	11.73	4.83	3.27	0.71	2.73	0.35	22.68	22.68
Btb2	46.16	11.52	7.35	3.02	3.10	0.67	2.65	0.34	15.55	15.55

Table 6

CATION EXCHANGE CAPACITY CONT.

Site & Horizon	ug/mL Ca	meq Ca per 100 g	ug/mL Mg	meq Mg per 100 g	ug/mL Na	meq Na per 100 g	ug/mL K	meq K per 100 g	Total cation conc. in meq/100 g	Ave. cation conc. in meq/100 g
Water Canyon 1 (WC - 1)										
Bt1b2	67.31	16.79	9.68	3.98	5.04	1.10	6.15	0.79	22.66	22.66
Bt2b2	47.25	11.79	5.92	2.44	3.17	0.69	3.39	0.43	15.35	15.35
Bt3b2	90.42	22.56	11.35	4.67	5.92	1.29	7.37	0.94	29.46	29.46
Bt4b2	57.33	14.30	8.46	3.48	6.52	1.42	5.59	0.72	19.92	19.92
Bt5b2	77.98	19.46	8.72	3.59	5.28	1.15	5.71	0.73	24.92	24.92
Water Canyon 2 (WC - 2)										
C1b1a	16.79	4.19	3.57	1.47	1.03	0.22	4.48	0.57	6.46	6.46
C2b1a	25.32	6.32	3.60	1.48	0.00	0.00	4.53	0.58	8.38	8.38
C3b1a	20.15	5.03	2.66	1.09	0.00	0.00	2.52	0.32	6.44	6.44
Bt1b1b	43.86	10.94	7.22	2.97	2.02	0.44	6.19	0.79	15.15	15.15
Bt1b1c	40.77	10.17	6.04	2.49	2.52	0.55	4.75	0.61	13.81	13.81
Bt2b1b	33.30	8.31	6.04	2.49	0.26	0.06	3.90	0.50	11.35	11.35
Bt2b1c	0.74	0.18	4.71	1.94	0.11	0.02	0.18	0.02	2.17	2.17
Bt3b1c	37.97	9.47	6.20	2.55	2.76	0.60	4.63	0.59	13.22	13.22
Water Canyon 3 (WC - 3)										
Ap	18.78	4.69	2.56	1.05	1.30	0.28	3.50	0.45	6.47	6.47
Bt1	41.39	10.33	10.10	4.16	6.44	1.40	12.92	1.65	17.54	17.54
Bt2	38.12	9.51	10.61	4.37	7.18	1.56	13.23	1.69	17.13	17.19
	38.26	9.55	10.60	4.36	7.26	1.58	13.74	1.76	17.25	
Bt3	38.96	9.72	10.63	4.37	10.98	2.39	12.12	1.55	18.03	18.03
Bt4	41.17	10.27	10.29	4.23	23.95	5.21	8.67	1.11	20.83	20.83
BC	45.9	11.45	10.73	4.42	28.34	6.16	10.52	1.35	23.38	23.38
2C	20.38	5.08	3.2	1.32	8.36	1.82	3.37	0.43	8.65	8.65

Table 6

CATION EXCHANGE CAPACITY CONT.

Site & Horizon	ug/mL Ca	meq Ca per 100 g	ug/mL Mg	meq Mg per 100 g	ug/mL Na	meq Na per 100 g	ug/mL K	meq K per 100 g	Total cation conc. in meq/100 g	Ave. cation conc. in meq/100 g
TA-67 E1										
A	29.43	7.34	3.97	1.63	0.00	0.00	5.90	0.76	9.73	9.73
	29.36	7.33	3.93	1.62	0.00	0.00	6.10	0.78	9.72	
BA	27.71	6.91	4.02	1.65	0.00	0.00	5.78	0.74	9.31	9.29
	27.37	6.83	4.02	1.65	0.00	0.00	6.20	0.79	9.28	
Bt1	31.47	7.85	5.66	2.33	0.06	0.01	6.40	0.82	11.01	11.09
	32.19	8.03	5.54	2.28	0.00	0.00	6.61	0.85	11.16	
Bt2	45.63	11.38	7.95	3.27	0.04	0.01	8.73	1.12	15.78	15.74
	44.62	11.13	8.08	3.32	0.59	0.13	8.69	1.11	15.70	
2Bwb	46.44	11.59	7.82	3.22	0.40	0.09	8.42	1.08	15.97	15.71
	44.62	11.13	7.69	3.16	0.27	0.06	8.63	1.10	15.46	
2BCb	38.37	9.57	5.85	2.41	1.43	0.31	6.25	0.80	13.09	13.02
	36.37	9.07	6.41	2.64	1.50	0.33	7.14	0.91	12.95	
TA-67-2 E1										
E/Bt1	39.89	9.95	3.58	1.47	0.59	0.13	3.14	0.40	11.96	11.86
	39.05	9.74	3.43	1.41	0.87	0.19	3.31	0.42	11.77	
E/Bt2b1	37.96	9.47	6.16	2.53	0.82	0.18	4.81	0.62	12.80	13.32
	41.37	10.32	6.23	2.56	1.23	0.27	5.39	0.69	13.84	
Bt1b1	42.59	10.63	7.25	2.98	3.22	0.70	6.73	0.86	15.17	15.59
	45.04	11.24	7.85	3.23	3.11	0.68	6.75	0.86	16.01	
Bt2b1	37.40	9.33	7.39	3.04	2.11	0.46	5.87	0.75	13.58	13.39
	36.01	8.98	7.34	3.02	2.22	0.48	5.48	0.70	13.19	
Btkb1	28.43	7.09	6.12	2.52	2.28	0.50	4.56	0.58	10.69	10.65
	28.11	7.01	5.84	2.40	2.59	0.56	4.90	0.63	10.61	
Btk2b2	38.56	9.62	7.17	2.95	7.14	1.55	5.41	0.69	14.82	14.82
Bt3b2	40.25	10.04	6.95	2.86	4.74	1.03	5.48	0.70	14.63	14.54
	39.51	9.86	7.02	2.89	4.61	1.00	5.37	0.69	14.44	
TA-67 E3										
A	20.75	5.18	4.16	1.71	1.27	0.28	4.87	0.62	7.79	7.79
	21.09	5.26	3.69	1.52	1.70	0.37	4.94	0.63	7.78	
2BAb1	43.82	10.93	9.74	4.01	4.97	1.08	8.22	1.05	17.07	17.06
	43.92	10.96	10.09	4.15	4.40	0.96	7.72	0.99	17.06	
2Bt1b1	51.65	12.89	12.14	5.00	3.40	0.74	10.44	1.34	19.96	19.85
	50.76	12.66	12.13	4.99	3.45	0.75	10.43	1.34	19.74	
2Bt2b1	46.05	11.49	9.82	4.04	5.25	1.14	9.61	1.23	17.90	17.90
2BC1b1	35.66	8.90	9.02	3.71	7.33	1.59	8.84	1.13	15.33	15.47
	36.21	9.03	8.96	3.69	8.17	1.78	8.60	1.10	15.60	
2BC2b1	45.35	11.31	8.93	3.67	8.10	1.76	9.03	1.16	17.91	18.15
	46.14	11.51	9.14	3.76	8.91	1.94	9.19	1.18	18.39	
3Bt1b2	120.32	30.02	8.40	3.46	8.58	1.87	7.88	1.01	36.35	36.35
3Bt2b2	110.53	27.58	8.76	3.60	5.69	1.24	5.93	0.76	33.18	32.53
	105.38	26.29	8.66	3.56	5.69	1.24	6.13	0.78	31.88	
3Bt3b2	73.71	18.39	12.14	5.00	11.69	2.54	8.48	1.09	27.01	25.41
	60.65	15.13	12.41	5.11	11.10	2.41	8.95	1.15	23.80	

Table 6

CATION EXCHANGE CAPACITY CONT.

Site & Horizon	ug/mL Ca	meq Ca per 100 g	ug/mL Mg	meq Mg per 100 g	ug/mL Na	meq Na per 100 g	ug/mL K	meq K per 100 g	Total cation conc. in meq/100 g	Ave. cation conc. in meq/100 g
TA - 67 W1										
A1	34.28	8.55	4.09	1.68	0.00	0.00	6.25	0.80	11.04	11.04
A2	36.81	9.18	4.59	1.89	0.00	0.00	7.00	0.90	11.97	11.94
	36.31	9.06	4.61	1.90	0.35	0.08	6.79	0.87	11.90	
A3	37.12	9.26	5.15	2.12	0.00	0.00	8.03	1.03	12.41	12.45
	37.26	9.30	5.14	2.12	0.00	0.00	8.46	1.08	12.49	
BA	34.16	8.52	4.42	1.82	1.22	0.27	8.02	1.03	11.63	12.18
	36.98	9.23	5.65	2.32	0.37	0.08	8.48	1.09	12.72	
Bw1	31.19	7.78	5.42	2.23	1.32	0.29	9.06	1.16	11.46	11.31
	30.22	7.54	5.29	2.18	1.49	0.32	8.82	1.13	11.17	
Bt1	35.48	8.85	6.13	2.52	0.00	0.00	8.68	1.11	12.49	12.46
	35.62	8.89	6.11	2.51	0.21	0.05	7.78	1.00	12.44	
Bt2	35.80	8.93	5.43	2.23	0.55	0.12	8.86	1.13	12.42	12.58
	35.04	8.74	6.48	2.67	0.55	0.12	9.54	1.22	12.75	
E/Bb	31.39	7.83	4.49	1.85	0.00	0.00	4.97	0.64	10.32	10.30
	31.25	7.80	4.51	1.86	0.00	0.00	4.97	0.64	10.29	
Btkb										
B/CR	46.46	11.59	8.07	3.32	0.46	0.10	7.40	0.95	15.96	16.78
	50.43	12.58	8.72	3.59	1.70	0.37	8.26	1.06	17.60	
TA - 67 W5										
A	30.62	7.64	3.95	1.63	0.00	0.00	6.15	0.79	10.05	13.81
	60.60	15.12	3.94	1.62	0.00	0.00	6.39	0.82	17.56	
BA	33.76	8.42	5.92	2.44	0.15	0.03	7.30	0.93	11.83	11.84
	34.22	8.54	5.91	2.43	0.02	0.00	6.86	0.88	11.85	
2Bt1b1	40.93	10.21	6.93	2.85	0.79	0.17	7.87	1.01	14.24	14.33
	41.76	10.42	6.85	2.82	0.65	0.14	8.12	1.04	14.42	
2Bt2b1	51.14	12.76	8.17	3.36	0.75	0.16	10.99	1.41	17.69	17.65
	51.06	12.74	8.21	3.38	0.73	0.16	10.48	1.34	17.62	
2Bt3b1	69.08	17.24	8.24	3.39	0.86	0.19	10.96	1.40	22.22	21.94
	66.97	16.71	8.06	3.32	0.80	0.17	11.45	1.47	21.67	
2BC1sb1	99.58	24.85	7.21	2.97	1.89	0.41	9.17	1.17	29.40	30.18
	105.21	26.25	8.04	3.31	1.38	0.30	8.69	1.11	30.97	
2BC2sb1	112.22	28.00	7.34	3.02	3.34	0.73	8.28	1.06	32.81	30.08
	90.50	22.58	6.55	2.70	4.52	0.98	8.54	1.09	27.35	
3BAb2	46.84	11.69	4.60	1.89	3.89	0.85	5.46	0.70	15.12	15.13
	47.53	11.86	4.53	1.86	3.49	0.76	5.04	0.65	15.13	
3Btb2	82.85	20.67	17.73	7.30	9.47	2.06	14.98	1.92	31.94	32.00
	84.27	21.03	17.49	7.20	9.02	1.96	14.68	1.88	32.06	
4CBt1b3	46.19	11.52	9.20	3.79	5.17	1.12	8.42	1.08	17.51	17.26
	44.35	11.07	8.99	3.70	5.17	1.12	8.68	1.11	17.00	
4CBt2b3	64.46	16.08	8.45	3.48	7.20	1.57	9.37	1.20	22.33	22.76
	68.09	16.99	8.83	3.63	6.46	1.41	9.14	1.17	23.20	
4C1b3	78.23	19.52	10.06	4.14	8.71	1.89	12.20	1.56	27.11	25.31
	62.08	15.49	12.49	5.14	7.45	1.62	9.79	1.25	23.50	
4C2b3	104.10	25.97	17.79	7.32	12.92	2.81	15.81	2.02	38.13	37.88
	102.10	25.47	16.91	6.96	14.06	3.06	16.80	2.15	37.64	

Table 7

CHITTICK ANALYSES FOR CARBONATE

Sample #	Horizon	Sample Wt. (gm)	CO2 Evolved (mL)	HCl mL	Corrected CO2	Correction Factor	Adjusted CF	% CaCO3	Mean % CaCO3
Ancho Canyon 1 (AC - 1)									
A1		7.7251	24.0	10.0	24.0	0.9900	0.8207	0.82	1.17
		5.8198	33.5	10.0	33.5	0.9900	0.8207	1.52	
A2		6.3020	38.5	10.0	38.5	0.9900	0.8207	1.61	0.90
		7.2507	5.0	10.0	5.0	0.9900	0.8207	0.18	
Bw1		7.1312	7.0	10.0	7.0	0.9930	0.8231	0.26	0.27
		6.6091	7.0	10.0	7.0	0.9930	0.8231	0.28	
Bw2		5.5766	7.0	10.0	7.0	1.0010	0.8298	0.33	0.34
		5.9176	7.5	10.0	7.5	1.0010	0.8298	0.34	
Bw3		5.1292	5.0	10.0	5.0	0.9790	0.8115	0.25	0.23
		6.8646	5.5	10.0	5.5	0.9790	0.8115	0.21	
C		6.8541	24.0	10.0	24.0	0.9900	0.8207	0.92	1.10
		5.4471	26.5	10.0	26.5	0.9900	0.8207	1.28	
Ckq		3.7630	4.5	10.0	4.5	0.9790	0.8115	0.31	0.47
		2.5547	6.0	10.0	6.0	0.9930	0.8231	0.62	
C'		6.9830	6.5	10.0	6.5	1.0010	0.8298	0.25	0.30
		5.2656	7.0	10.0	7.0	0.9900	0.8207	0.35	
Btb		6.6688	8.0	10.0	8.0	0.9900	0.8207	0.32	0.36
		5.1970	8.0	10.0	8.0	0.9900	0.8207	0.41	
Bwb		8.6934	4.5	10.0	4.5	0.9900	0.8207	0.14	0.20
		7.3464	7.5	10.0	7.5	0.9900	0.8207	0.27	
Los Alamos 4 (LA - 4)									
Bt4b		5.1182	6.5	10.0	6.5	1.0260	0.8505	0.35	0.30
		6.5566	6.0	10.0	6.0	1.0260	0.8505	0.25	
Bt5b		7.0332	4.0	10.0	4.0	1.0520	0.8721	0.16	0.18
		6.2289	4.5	10.0	4.5	1.0520	0.8721	0.20	
Bt6b		7.1830	5.5	10.0	5.5	0.9870	0.8182	0.20	0.24
		6.4524	6.5	10.0	6.5	0.9870	0.8182	0.27	
Bt7b		7.2245	6.5	10.0	6.5	0.9840	0.8157	0.24	0.30
		5.0885	7.0	10.0	7.0	0.9840	0.8157	0.36	
Bt8b		5.8962	5.0	10.0	5.0	1.0520	0.8721	0.24	0.22
		7.1455	5.0	10.0	5.0	1.0520	0.8721	0.20	
Bt9b		7.8414	5.5	10.0	5.5	0.9840	0.8157	0.19	0.25
		6.2341	7.5	10.0	7.5	0.9840	0.8157	0.32	
BCb		9.6960	11.0	15.0	6.0	0.9840	0.8157	0.16	0.16
TA- 51									
A		6.1662	10.5	10.0	10.5	0.9840	0.8157	0.45	0.54
BA		6.0976	3.0	10.0	3.0	1.0520	0.8721	0.14	0.23
		4.9072	5.5	10.0	5.5	1.0520	0.8721	0.32	
Bw		5.9125	4.5	10.0	4.5	1.0520	0.8721	0.22	0.22
		6.8617	5.5	10.0	5.5	1.0520	0.8721	0.23	
BC		4.8407	7.0	10.0	7.0	0.9840	0.8157	0.38	0.32
		6.6430	6.5	10.0	6.5	0.9840	0.8157	0.26	

Table 7

CHITTICK ANALYSES FOR CARBONATE CONT.

Sample #	Horizon	Sample Wt. (gm)	CO2 Evolved (ml)	mL HCl	Corrected CO2 value	Correction Factor	Adjusted CF	% CaCO3	Mean % CaCO3
TA-63a									
	Bw1	10.0580	9.0	15.0	4.0	1.0135	0.8401	0.13	0.30
		8.7497	15.0	12.0	13.0	1.0135	0.8401	0.48	
	Bw2	9.3959	9.0	15.0	4.0	1.0345	0.8575	0.14	0.14
	CB	3.8306	4.0	10.0	4.0	1.0345	0.8575	0.34	0.34
TA-63c									
	A1	9.8330	13.0	15.0	8.0	1.0219	0.8471	0.22	0.27
		7.0312	11.0	13.0	8.0	1.0219	0.8471	0.31	
	A2	10.0342	14.0	15.0	9.0	1.0219	0.8471	0.25	0.26
		8.1560	10.0	12.0	8.0	1.0219	0.8471	0.27	
	Bw1	9.9188	13.0	15.0	8.0	1.0219	0.8471	0.22	0.22
	Bw2	10.0526	11.0	15.0	6.0	1.0135	0.8401	0.16	0.18
		8.6656	9.0	13.0	6.0	1.0135	0.8401	0.19	
	Bw3	9.7553	11.0	15.0	6.0	1.0135	0.8401	0.17	0.17
TA - 63 - 1A									
	A1	9.4786	10.0	15.0	5.0	1.0345	0.8575	0.15	0.15
	A2	9.8827	9.0	15.0	4.0	1.0345	0.8575	0.11	0.11
	Bw	9.4856	9.0	15.0	4.0	1.0345	0.8575	0.12	0.12
	Bth	9.4571	11.0	15.0	6.0	0.9870	0.8182	0.37	0.37
	Btk1	1.6114	20.0	10.0	20.0	1.0345	0.8575	4.12	6.09
		1.1934	29.0	10.0	29.0	1.0345	0.8575	8.07	
	Btk2	1.2171	23.0	10.0	23.0	1.0345	0.8575	6.27	6.59
		1.1549	24.0	10.0	24.0	1.0345	0.8575	6.90	
	Btkb	2.1551	25.5	10.0	25.5	1.0345	0.8575	3.93	3.93
TA - 63 - 2									
	Bw	9.4670	12.0	15.0	7.0	1.0345	0.8575	0.20	0.20
	Bth	9.7665	11.0	15.0	6.0	1.0345	0.8575	0.17	0.17
	Bthk	9.6376	17.0	15.0	12.0	1.0345	0.8575	0.34	0.34
	Bt	8.3382	21.0	15.0	16.0	1.0345	0.8575	0.52	0.52
	Btk	1.3965	27.5	15.0	22.5	1.0345	0.8575	4.35	4.40
		1.5462	30.5	15.0	25.5	1.0345	0.8575	4.45	
	Bt1b	8.5075	12.0	15.0	7.0	1.0345	0.8575	0.22	0.22
	Bt2b	9.2302	11.0	15.0	6.0	1.0345	0.8575	0.18	0.18
	Bt3b	9.7852	10.0	15.0	5.0	1.0345	0.8575	0.14	0.14
	Bt4b	9.5728	10.0	15.0	5.0	1.0345	0.8575	0.14	0.14

Table 7

CHITTICK ANALYSES FOR CARBONATE CONT.

Sample #	Horizon	Sample Wt. (gm)	CO2 Evolved (ml)	mL HCl	Corrected CO2 value	Correction Factor	Adjusted CF	% CaCO3	Mean % CaCO3
Water Canyon 1 (WC - 1)									
	Bt1b2	9.7492	10.0	15.0	5.0	1.0372	0.8598	0.14	0.14
	Bt2b2	10.0031	11.0	15.0	6.0	1.0372	0.8598	0.17	0.17
	Bt3b2	9.7260	11.0	15.0	6.0	1.0372	0.8598	0.17	0.17
	Bt4b2	9.3951	12.0	15.0	7.0	1.0427	0.8643	0.21	0.21
	Bt5b2	9.5433	10.0	15.0	5.0	1.0372	0.8598	0.15	0.15
Water Canyon 2 (WC - 2)									
	C1b1a	9.4481	9.0	15.0	4.0	1.0345	0.8575	0.12	0.12
	C2b1a	6.3292	3.0	10.0	3.0	1.0345	0.8575	0.13	0.13
	C3b1a	9.8669	10.0	15.0	5.0	1.0345	0.8575	0.14	0.14
	Bt1b1b	9.5874	10.0	15.0	5.0	1.0345	0.8575	0.15	0.15
	Bt2b1b	9.6786	9.0	15.0	4.0	1.0345	0.8575	0.12	0.12
	Bt1b1c	9.5768	10.0	15.0	5.0	1.0345	0.8575	0.15	0.15
	Bt2b1c	9.4435	11.0	15.0	6.0	1.0345	0.8575	0.18	0.18
	Bt3b1c	6.3072	9.0	10.0	9.0	1.0345	0.8575	0.40	0.40
Water Canyon 3 (WC - 3)									
	Ap	6.6549	2.0	10.0	2.0	1.0570	0.8762	0.09	0.15
		5.0562	4.0	10.0	4.0	1.0520	0.8721	0.22	
	Bt1	5.0420	4.0	10.0	4.0	1.0520	0.8721	0.22	0.22
		6.5632	5.0	10.0	5.0	1.0520	0.8721	0.22	
	Bt2	9.7909	9.0	15.0	4.0	1.0372	0.8598	0.11	0.11
	Bt3	6.4667	7.5	10.0	7.5	0.9910	0.8215	0.31	0.28
		5.4826	5.0	10.0	5.0	0.9910	0.8215	0.24	
	Bt4	7.1310	10.0	10.0	10.0	1.0260	0.8505	0.39	0.36
		5.1276	6.0	10.0	6.0	1.0260	0.8505	0.32	
	BC	4.8407	8.0	10.0	8.0	0.9970	0.8265	0.44	0.38
		6.6430	8.0	10.0	8.0	0.9970	0.8265	0.32	
	2C	6.7051	9.0	10.0	9.0	1.0120	0.8389	0.37	0.34
		5.3469	6.0	10.0	6.0	1.0120	0.8389	0.31	

Table 7

CHITTICK ANALYSES FOR CARBONATE CONT.

Sample #	Horizon	Sample Wt. (gm)	CO2 Evolved (ml)	mL HCl	Corrected CO2 value	Correction Factor	Adjusted CF	% CaCO3	Mean % CaCO3
TA - 67 E1									
	A	9.8428	41.0	14.0	37.0	1.0148	0.8412	0.99	0.60
		8.7232	10.0	13.0	7.0	1.0148	0.8412	0.21	
	BA	10.1758	13.0	15.0	8.0	1.0274	0.8517	0.21	0.23
		8.2680	10.0	12.0	8.0	1.0274	0.8517	0.26	
	Bw	10.2304	12.0	15.0	7.0	1.0148	0.8412	0.18	0.20
		9.3403	11.0	13.0	8.0	1.0148	0.8412	0.23	
	Bt1	10.4103	12.0	15.0	7.0	1.0232	0.8482	0.18	0.22
		8.0154	11.0	13.0	8.0	1.0232	0.8482	0.27	
	Bt2	10.0537	13.0	15.0	8.0	1.0148	0.8412	0.21	0.22
		9.0943	11.0	13.0	8.0	1.0148	0.8412	0.23	
	2Bwb	10.0335	12.0	15.0	7.0	1.0288	0.8528	0.19	0.21
		9.0109	11.0	13.0	8.0	1.0288	0.8528	0.24	
	2BCb	10.2011	13.0	15.0	8.0	1.0274	0.8517	0.21	0.24
		8.2115	10.0	12.0	8.0	1.0274	0.8517	0.26	
TA - 67 - 2 E1									
	E/Bt1b1	9.8968	20.0	15.0	15.0	1.0261	0.8505	0.41	0.41
		8.5038	15.0	12.0	13.0	1.0261	0.8505	0.41	
	E/Bt2b1	10.0118	12.0	15.0	7.0	1.0261	0.8505	0.19	0.20
		9.1614	10.0	13.0	7.0	1.0261	0.8505	0.20	
	Bt1b1	9.9095	11.0	15.0	6.0	1.0135	0.8401	0.16	0.19
		8.7102	9.0	12.0	7.0	1.0135	0.8401	0.21	
	Bt2b1	10.1554	9.0	15.0	4.0	1.0385	0.8608	0.11	0.11
		9.2206	7.0	13.0	4.0	1.0385	0.8608	0.12	
	Bt3b1	10.1057	13.0	15.0	8.0	1.0385	0.8608	0.21	0.21
		8.9987	10.0	13.0	7.0	1.0385	0.8608	0.21	
	Btk1b2	10.0632	17.0	15.0	12.0	1.0274	1.0274	0.39	0.39
	Btk2b2	9.8292	11.0	15.0	6.0	1.0385	0.8608	0.17	0.19
		8.4449	7.0	10.0	7.0	1.0385	0.8608	0.22	
	CR	9.9698	10.0	15.0	5.0	1.0135	0.8401	0.13	0.16
		8.3651	8.0	12.0	6.0	1.0135	0.8401	0.19	
TA - 67 E3									
	A	10.0632	12.0	15.0	7.0	1.0274	0.8517	0.19	0.25
		6.0386	7.0	10.0	7.0	1.0274	0.8517	0.31	
	2BAb1	9.5510	14.0	15.0	9.0	1.0274	0.8517	0.25	0.25
	2Bt1b1	8.9734	8.0	12.0	6.0	1.0149	0.8413	0.18	0.18
	2Bt2b1	8.6707	10.0	12.0	8.0	1.0149	0.8413	0.24	0.24
	2BC1b1	9.3514	13.0	15.0	8.0	1.0149	0.8413	0.23	0.23
	2BC2b1	9.0728	16.0	15.0	11.0	1.0149	0.8413	0.32	0.32
	3Bt1b2	9.6708	66.0	15.0	61.0	1.0149	0.8413	1.67	1.67
	3Bt2b2	9.8106	57.0	15.0	52.0	1.0149	0.8413	1.40	1.40
	3Bt3b2	8.5847	22.0	13.0	19.0	1.0149	0.8413	0.59	0.59

Table 7

CHITTICK ANALYSES FOR CARBONATE CONT.

Sample #	Horizon	Sample Wt. (gm)	CO2 Evolved (ml)	mL HCl	Corrected CO2 value	Correction Factor	Adjusted CF	% CaCO3	Mean % CaCO3
TA - 67 W1									
	A1	10.0594	13.0	15.0	8.0	1.0330	0.8563	0.21	0.21
	A2	10.0915	13.0	15.0	8.0	1.0330	0.8563	0.21	0.28
		6.9546	9.0	10.0	9.0	1.0330	0.8563	0.35	
	A3	9.8492	13.0	15.0	8.0	1.0330	0.8563	0.22	0.22
	BA	9.9812	13.0	15.0	8.0	1.0330	0.8563	0.22	0.22
	Bw1	10.0434	14.0	15.0	9.0	1.0079	0.8355	0.24	0.25
		7.9546	11.0	13.0	8.0	1.0079	0.8355	0.26	
	Bt1	9.8842	12.0	15.0	7.0	1.0330	0.8563	0.19	0.20
		9.9302	8.0	10.0	8.0	1.0330	0.8563	0.22	
	Bt2	9.9471	13.0	15.0	8.0	1.0287	0.8527	0.22	0.22
	E/Bb	9.8338	17.0	15.0	12.0	1.0287	0.8527	0.33	0.33
	Btkb	4.9887	19.0	10.0	19.0	1.0287	0.8527	1.02	1.11
		3.7975	17.0	10.0	17.0	1.0287	0.8527	1.20	
	BV/CR	9.8623	21.0	15.0	16.0	1.0287	0.8527	0.44	0.71
		5.4518	20.0	10.0	20.0	1.0287	0.8527	0.98	
TA - 67 W5									
	A	10.3008	12.0	15.0	7.0	1.0148	0.8412	0.18	0.20
		8.6538	10.0	13.0	7.0	1.0148	0.8412	0.21	
	BA	10.2025	11.0	15.0	6.0	1.0079	0.8355	0.15	0.19
		8.0519	9.0	12.0	7.0	1.0079	0.8355	0.23	
	2Btb1	10.0535	11.0	15.0	6.0	1.0288	0.8528	0.16	0.16
	2Bt2b1	10.1011	10.0	12.0	8.0	1.0288	0.8528	0.21	0.24
		8.0474	10.0	12.0	8.0	1.0288	0.8528	0.27	
	2Bt3b1	10.0268	20.0	15.0	15.0	1.0288	0.8528	0.40	0.42
		8.5162	16.0	12.0	14.0	1.0288	0.8528	0.44	
	2BC1sb1	10.0809	39.0	15.0	34.0	1.0288	0.8528	0.90	0.90
	2BC2sb1	10.2189	52.0	15.0	47.0	1.0274	0.8517	1.23	1.23
	3BAb2	10.1222	26.0	15.0	21.0	1.0274	0.8517	0.56	0.56
	3Btb2	9.9764	13.0	15.0	8.0	1.0274	0.8517	0.21	0.21
	4CBt1b3	10.8749	12.0	15.0	7.0	1.0079	0.8355	0.17	0.23
		7.2135	13.0	15.0	8.0	1.0079	0.8355	0.29	
	4CBt2b3	10.6837	24.0	15.0	19.0	1.0135	0.8402	0.47	0.52
		7.4716	21.0	15.0	16.0	1.0135	0.8402	0.57	
	4C1b3	10.5179	17.0	15.0	12.0	1.0135	0.8402	0.30	0.31
		8.5387	12.0	12.0	10.0	1.0135	0.8402	0.31	
	4C2b3	10.7473	22.0	15.0	17.0	1.0135	0.8402	0.42	0.43
		7.6062	17.0	14.0	13.0	1.0135	0.8402	0.45	

Table 8

pH ANALYSES

Sample Site	Horizon	pH
Ancho Canyon	A1	5.51
	A2	5.69
	Bw1	5.42
	Bw2	6.39
	Bw3	6.94
	C	6.76
	Ckq	6.62
	C'	6.76
	Btb	6.98
	Bwb	6.97

Los Alamos (4)

Bt4b	6.33
Bt5b	6.53
Bt6b	6.50
Bt7b	6.58
Bt8b	6.52
Bt9b	6.29
BCb	6.65

TA - 51

A	6.36
BA	6.01
Bw	6.01
BC	6.18

Sample Site	Horizon	pH	average pH
TA - 63a	A	5.69	5.7
		5.65	
	Bw1	5.70	5.7
	Bw2	5.62	
		5.81	5.8
TA - 63c	A1	5.81	
	A2	6.08	6.1
		6.13	
	A2	6.14	6.1
		6.13	
	Bw1	6.03	6.0
	Bw2	6.03	
		5.93	5.9
	Bw3	5.77	
		6.09	6.0
		5.81	

Table 8

pH ANALYSES CONT.

Sample Site	Horizon	average	
		pH	pH
TA - 63 - 1A			
	A1	5.73	5.8
		5.87	
	A2	6.46	6.2
		5.85	
	Bw	6.78	6.8
		6.80	
	Bth	6.84	6.8
		6.80	
	Btk1	6.99	7.0
		7.05	
	Btk2	7.08	7.1
		7.06	
	Btb	7.13	7.1
		7.10	
TA - 63 - 2			
	Bw	6.07	6.1
		6.04	
	Bth	6.49	6.5
		6.48	
	Bthk	7.23	7.2
		7.21	
	Btk1	7.31	7.3
		7.31	
	Btk2	7.34	7.3
		7.33	
	Btkb1	7.17	7.2
		7.16	
	Btkb2	7.03	7.0
		7.03	
	Btb1	6.91	7.0
		7.01	
	Btb2	7.08	7.1
		7.08	

Table 8

pH ANALYSES CONT.

Sample Site	Horizon	pH	average pH
Water Canyon (1)			
	Bt1b2	6.91 6.95	6.9
	Bt2b2	7.17 7.19	7.2
	Bt3b2	7.14 7.16	7.2
	Bt4b2	7.01 7.02	7.0
	Bt5b2	7.10 7.11	7.1
Water Canyon (2)			
	C1b1a	7.00 7.06	7.0
	C2b1a	6.68 6.81	6.7
	C3b1a	6.60 6.55	6.6
	Bt1b1b	6.60 6.66	6.6
	Bt2b1b	6.55 6.59	6.6
	Bt1b1c	6.62 6.60	6.6
	Bt2b1c	6.32 6.75	6.5
	Bt3b1c	6.58 6.50	6.5

Sample Site	Horizon	pH
Water Canyon (3)		
	Ap	5.00
	Bt1	5.66
	Bt2	6.86
	Bt3	7.06
	Bt4	7.08
	BC	6.75
	2C	7.00

Table 8

pH ANALYSES CONT.

Sample Site	Horizon	average	
		pH	pH
TA- 67 E1	A	5.86	5.8
		5.82	
	BA	5.74	5.7
		5.74	
	Bw	5.99	6.0
		5.97	
	Bt1	6.18	6.2
		6.14	
	Bt2	6.49	6.5
	2Bwb	6.97	6.9
		6.91	
	2BCb	6.74	6.7
		6.67	
TA-67-2 E1	E/Btb1	7.34	7.4
		7.39	
	E/Bt2b1	7.26	7.5
		7.74	
	Bt1b1	7.26	7.3
		7.24	
	Bt2b1	7.21	7.2
		7.26	
	Btkb1	7.17	7.2
		7.23	
	Btk1b2	7.27	7.3
	Btk2b2	7.24	7.3
		7.38	
	Bt3b2	7.27	7.3
		7.30	
	CR	7.06	7.1
TA- 67 E3	A	6.12	6.1
		5.98	
	2BAb1	6.05	6.1
		6.24	
	2Bt1b1	6.47	6.5
		6.43	
	2Bt2b1	7.14	7.1
		7.09	
	2BC1b1	6.85	6.9
		6.95	
	2BC2b1	7.01	7.0
		7.08	
	3Bt1b2	7.21	7.2
		7.22	
	3Bt2b2	7.76	7.5
		7.30	
	3Bt3b2	7.24	7.2
		7.24	

Table 8

pH ANALYSES CONT.

Sample Number	Horizon	average	
		pH	pH
TA - 67 W1			
	A1	5.56 5.06	5.3
	A2	6.00 5.75	5.9
	A3	6.31 6.18	6.2
	BA	6.27 6.24	6.3
	Bw1	6.43 6.46	6.4
	Bt1	6.57 6.56	6.6
	Bt2	6.73 6.68	6.7
	E/Btb	7.09 7.16	7.1
	Btkb	7.30 7.31	7.3
	Bt/CR	7.31 7.31	7.3
TA- 67 W5			
	A	6.20 6.27	6.2
	BA	6.78 6.66	6.7
	2Bt1b1	7.00 6.93	7.0
	2Bt2b1	6.74 6.68	6.7
	2Bt3b1	7.54 7.60	7.6
	2BC1b1	7.32 7.34	7.3
	2BC2b1	7.36 7.40	7.4
	3BAb2	7.42 7.74	7.6
	3Btb2	7.21 7.24	7.2
	4CBt1b3	7.45 7.39	7.4
	4CBt2b3	7.61 7.60	7.6
	4C1b3	7.32 7.36	7.3
	4C2b3	7.67 7.67	7.7

Appendix A

FIELD SOIL DESCRIPTION

Location: Ancho Canyon

Site: 1

Date: 6/25/93

Vegetation: Juniper, pinyon, cactus, grasses

Approx. Elevation:

Geomorphic surface: Holocene terrace

Approx. Slope: 2 - 4 degrees

Aspect:

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSISTENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL % estimate	BOUND- ARIES	NOTES
0 - 4	A1	10YR3/2 10YR5/2	1 m sbk 1 m crb	so,ss so	L	0	2 v f t	1-2 v f	2-4	a, s	
4 - 12	A2	10YR3/3 10YR4.5/2	1 f, m sbk 1 f, m crb	so, po so, ps	LS-SL	v pat. silans on gr.	1 v f t 2 v f lv	1-2 v f v f f	2-4	a, s	
12 - 27	Bw1	10YR3/2 10YR4/2	1-2 m pr 1-2 f, m sbk	ss, ps sh	SIL-L	pat. f silans on gr.	2 v f t 1 f t	1-2 v f 1 m	5-10	c, s	
27 - 56	Bw2	10YR4/3 10YR5/4	1 m, c sbk	so, ps sh	L	pat. f d silans on gr.	1-2 v f t 1 f t	2 v f 1 f, m	10-15	a, w	
56 - 69	Bw3	10YR3/3 10YR5/3	sg	so, ps-po lo	SL	0	1 v f t 2 v f lv	2-3 v f v f f	5-10	a, s	
69 - 90	C	10YR3/3 10YR5/2	sg	so, po lo	LS	0	2 v f lv 1 f lv	1 v f	5-10	c, w	
90 - 109	Ckq	10YR3/3 10YR5/2	sg	so, po lo	LS-S	0	2-3 v f, f lv v f m lv	1 v f	15-25	c, s	
109 - 130	C'	10YR4/3 10YR5/2	sg	so, po lo	LS-S	0	2-3 v f, f lv v f m lv	v f v f	10-15	a, s	

Appendix A

FIELD SOIL DESCRIPTION

Location: Los Alamos

Site #: 4 Date: 6/17/93

Vegetation: Juniper, pinyon, Ponderosa pine, shrubs, grasses

Approx. Elevation:

Geomorphic surface: dissected fan

Approx. Slope:

Aspect:

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSIS- TENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL % estimate	BOUND- ARIES	NOTES
94 - 110	Bl4b	7.5YR4/4 7.5YR5/6	2 m, c pr 2 f, m, c abk	ss, p h-vh	SiCL	ncd-p pft 2d pbr pint pres-fac	1-2 vft lv pf	1 f, m	5-8	c, s	
110 - 134	Bl5b	7.5YR4/4 7.5YR5/4	1-2 m, c pr 1-2 f, m, c abk	s, ps h-vh	SiCL	ncd p pf nc pf, m po	2 vft 1 ft	vf m	10-15	g, s	
134 - 186	Bl6b	7.5YR4/6 7.5YR4/6	1 m, c pr 1 m, c abk	ss, ps vh	SIL+	nc f-p pr, pf pat f-d abk, pf nc f-p po	2-3 vft 2 ft	0	10-20	g, s	
186 - 234	Bl7b	7.5YR4/6 7.5YR4/4	1 f, m, c abk, sbk	ss, ps h-vh	SIL-L		2 vft 1-2 ft vf m t	0	25-30	g, s	
234 - 264	Bl8b	7.5YR4/6 7.5YR5/6	1 m, c sbk nrly massive	ss, ps h-vh	SIL	pat nc f-d pf nc f-d f+, m po	2-3 vft 1-2 ft vf m t	0	20-25	g, s	
264 - 354	Bl9b	7.5YR4/4 10YR5/4	1 m, c sbk, abk nrly massive	ss, ps h-vh	SIL	nc pat f pf nc pat f po	2-3 vft 1-2 ft 1 m t	0	5-10	g, s	
354+	BCb	10YR4/4 10YR6/3	massive	ss, ps h-vh	SIL-L	pat f po, br	3 vft 2 ft 1 m t	0	15-20		

Appendix A

FIELD SOIL DESCRIPTION

Location: TA - 51

Site #

Date: 7/9/93

Vegetation: Juniper, pinyon, cactus, grasses

Approx. Elevation: 6700'

Geomorphic surface:

Approx. Slope: 2 - 4 degrees

Aspect: E

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSISTENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	EFFERVE- SCENCE	BOUND- ARIES	NOTES
0 - 3	A	10YR2/2 10YR3/3	sg, 1 fgr	so, ps so	SIL	0	1 vff 2 f v	1-2 vff	0	a, s	
3 - 6	BA	10YR3/2 10YR4/2	1 c pl ^ m+1 f+m sbk	ss, ps sh	SIL	vff pl, po silans	1 f f 1 f v, 1 hor. t	1-2 vff	0	a, s	
6 - 18	Bw	10YR3/2 10YR4/3	1 m+c sbk	ss, ps sh	SIL	1 f pl, po, co	1-2 f v 1 f f	1 vff+m	0	a, s	
18 - 25	BC	10YR4/2 10YR4/2	1 m+c sbk	ss+, ps+ sh+h	SICL	1 f pl, co	1-2 m t 1 f v	1-2 m, 1 f	0	a, s	
25+	BT										

Appendix A

FIELD SOIL DESCRIPTION

Location: TA - 63

Site #: a

Date: 6/29/93

Vegetation: Juniper, pinyon, cactus, grasses

Approx. Elevation: 6800'

Geomorphic surface:

Approx. Slope: 2 - 4 degrees

Aspect:

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSISTENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL % estimate	BOUND- ARIES	NOTES
0 - 5	Ap	10YR3/3 10YR5/3	sg, 1 vf+f sbk	ss, ps sh	SIL		2 m lv	2 f	<10	c, w	disturbed by trenching
5 - 12	A	10YR3/4 10YR4/4	2 c sbk	ss, ps h	SIL		vf f lv 1 ft	1 f	10	a, w	
12 - 25	Bw1	10YR3/4 10YR4/4	1 m+c sbk	ss+, ps+ h+sh	SIL			1 f; vf vf	10	c, w	
25 - 35	Bw2	10YR4/3 10YR4/3	1 f+m+c sbk	s, p h	SIL		1 vf t	1 vf; 1 m	25	c, w	
35 - 47	CB										altered grey BT
at 80											Fe oxide/clay, young hor. fracture, follows root (?)
at 110											CO3/Fe oxide/clay fracture fill, older?

Appendix A

FIELD SOIL DESCRIPTION

Location: TA - 63

Site #: c

Date: 6/29/93

Vegetation: Juniper, pinyon, cactus, grasses

Approx. Elevation: 6800'

Geomorphic surface:

Approx. Slope: 2 - 4 degrees

Described by: P. Walt

Aspect:

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSISTENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL % estimate	BOUND- ARIES	NOTES
0 - 10	A1	10YR3/3 10YR5/3	1 f+m sbk^ 2 m pl	ss, ps h	SIL		2 m lv; w ft	2 f	<10	a, w	
10 - 14	A2	10YR3/3 10YR5/2	1+ c pl^ 1 c abk	ss, ps h+vh	SIL		2 m t hor.+vert.	1 f; 1 m	<10	a, w	
14 - 38	Bw1	10YR4/3 10YR5/3	1 c abk	ss, ps sh	SIL		1 ft	vf vf; 1 f	<10	a, w	
38 - 49	Bw2	10YR4/3 10YR5/3	1 m abk	ss, ps sh	SIL		1 ft	vf vf; 1 f	<10	a, w	
49 - 57	Bw3	10YR3/3 10YR4/3	1 m pl+sbk	ss, ps	SIL		1 ft; 1 f lv	vf vf; 1 f	10	c, w	contains reworked lithics of BT & dacite
57+	R										grey BT
at 80	FF	7.5YR4/3	1 f gr+sbk	ss, ps sh	L				10+		fracture fill in ~vert. CaCO3 & Fe oxides
at 110	FF										

Appendix A

FIELD SOIL DESCRIPTION

Location: TA - 63

Site #: 1A

Vegetation: Juniper, Ponderosa pine, grasses

Geomorphic surface: thin colluvial, eolian wedge over BT

Date: 6/15/93

Approx. Elevation:

Approx. Slope:

Aspect:

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSIS- TENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL % estimate	BOUND- ARIES	NOTES
0 - 5	A1	10YR3/3 10YR4/4	2 vf, f, m pl	so, ps so-sh	SIL-L	0	1-2 vf t	2 f vf	<5	a-c, s	
5 - 19	A2	10YR3/4 10YR4/4	3 m, c pl 2-3 m, c abk	ss, ps-p sh-h	SIL	0	1 vf, f t 1-2 lv pf	1 vf pf	<5	a, s	
19 - 40	Bw	7.5YR3/4 7.5YR5/3	2 c sbk 2 f, m sbk	so-ss, ps h	L	pat f silans pat f-d skel both on pf	3 vf t 1-2 f t vf m t	1 vf vf m	<5	a, s	
40 - 66	Bth	7.5YR5/4	2 m, c, vc pr 2-3 f, m abk	ss, p h	SIL	nc p-d argil pr pf	2-3 vf t 1-2 lv pf	1-2 vf pf	5-10	c-g, s	
66 - 72	Btk1		2 m, c pr 2 m pl	ss, ps-p h	SIL	nc-pat f-d arg on pf, br	1 vf t 1-2 lv pf	vf vf pf	<5	a, s	
72 - 77	Btk2C		2 c pr 2 vf, f, m pl	h-vh	SCL	nc-pat f-d arg on pf, br	1 vf t 1-2 lv pf	vf vf pf	<5	a, s	

Appendix A

FIELD SOIL DESCRIPTION

Location: TA - 63

Site #: 2

Date: 6/15/93

Vegetation: Juniper, pinyon, Ponderosa pine, grasses

Approx. Elevation:

Geomorphic surface: Quaternary sediments, fines over BT

Approx. Slope:

Aspect:

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSIS- TENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL % estimate	BOUND- ARIES	NOTES
0 - 26	Bw	10YR3/4 10YR5/4	2 m,c pl 3 f,m,c abk 2 vc pr	ss, ps vh	SIL	vpaf f skel pf	2 vf lv vf vft	0	<5	c, s	
26 - 40	Bth	7.5YR4/4 7.5YR5/4	2 m,c pr 1-2 m,c abk	ss, ps-p vh	SIL-SICL	nc d-p arg on pf,pr nc-pat f-d pf	3 vf t 1-2 ft 1 m t	0	<5	c, s	
40 - 53	Bthk	7.5YR4/4 7.5YR6/4	1-2 m,c pr 1 m,c abk nmassive	so, ps h-vh	SIL	nc-pat f-d on pf,po 1-2 p po	3 vf t 1-2 ft 1 m t	0	5-10	a, s	
53 - 60	Blk1	7.5YR4/3 7.5YR5/4	2 c pr m	ss, ps vh	SIL	nc d-p pr,pf nc-pat f-p po	2-3 vf t 1-2 ft vf m t	0	5-10	a, s	
60 - 65	Blk2	7.5YR4/3 7.5YR6/4	2 c pr 2 f pl	ss, ps vh	SIL-L	nc d-p pf pat f-d po	2-3 vf t 1-2 ft vf m t	0	<5	a, s	
65 - 88	Blkb1	5YR4/4 7.5YR5/4	2-3 m,c pr 3 f,m,c abk	ss, p h-vh	SICL	nc d-p pf	1-2 vf t 1-2 ft	0	<5	c, s	
88 - 118	Blkb2	5YR3/3 5YR5/4	2 m,c pr 1-2 f,m,c abk	ss, p h-vh	SICL	nc p pf	1-2 vf t 1-2 ft	0	<5	c, s	
118 - 150	Btb1	7.5YR4/3 7.5YR5/3	2 c pr 3 f,m pl	so-ss, ps h-vh	SIL-L	pat f pf nc-pat f-d on pr,pf	1-2 vf t 1 ft vf m t	0	<5	c, s	
136 - 145	Btb2	7.5YR4/3 7.5YR6/3	2 m,c pr 1-2 m,c sbk	ss, ps h-vh	SIL	nc-pat f-d on pr,pf f bk pf	1-2 vf t 1 ft vf m t	0	<5	c, w	

Appendix A

FIELD SOIL DESCRIPTION

Location: Water Canyon Site #: 1

Date: 6/16/93

Vegetation: Juniper, pinyon, Ponderosa pine, shrubs, grasses

Approx. Elevation:

Geomorphic surface: colluvial wedge off scarp

Approx. Slope:

Aspect:

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSIS- TENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL % estimate	BOUND- ARIES	NOTES
0 - 13	Bt1b2		2-3 f, m abk 2-3 f, m sbk	s-vsm o h	CL+	>2mm nc p co nc p pf	1 vf t 1-2 lv pf	0	25-35	c, s	
13 - 48	Bt2b2		2 m, c pr 1 f, m, c sbk, abk	ss-s, p h	SiCL	nc vp pr, pf >2mm nc p co nc p pf	1-2 vf t 1-2 lv pf	vf f	30-40	g, s	
48 - 75	Bt3b2		1 c pr 1-2 f, m, c sbk 1-2 f, m, c abk	ss, p sh-h	SiCL	nc d-p co gr nc d-p pf	1-2 vf t 1-2 lv pf	0	35-45	c, s	
75 - 108	Bt4b2		1 m, c sbk	ss-s, p sh-h	CL	nc pat on pf nc f-p co gr nc f-p br pf	2 vf t 1-2 lv pf	0	35-45	c, s	
108 - 138	Bt5b2		1 m, c sbk	s, p sh-h	CL+	nc pat f-d co gr pat d-p br pf	2 vf t 1-2 lv pf	vf m	50-70	c, s	

Appendix A

FIELD SOIL DESCRIPTION

Location: Water Canyon Site #: 2

Vegetation: Juniper, pinyon, Ponderosa pine, shrubs, grasses

Geomorphic surface:

Date: 6/16/93

Approx. Elevation:

Approx. Slope:

Aspect:

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSIS- TENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL % estimate	BOUND- ARIES	NOTES
0 - 11	C1b1a		m	s, ps sh-h	SCL	pat f silans pat d-p co	2 vf ft 1 m t	0	>80	a, w	
11 - 16	C2b1a		m	s, ps sh-h	SCL	pat f argil	2 vf ft 1 m t	0	>80	a, w	
16 - 53	C3b1a		m	so-ss, ps h	SIL-L	0	2 vf, f, m t	0	50-60	a, s-w	
53 - 70	Bt1b1b		2 m pr 2 f, m sbk	ss-s, p h	SICL	nc f-d br pf pat d pr, pf pat f-d co gr	2-3 vf t 1 f, m t 1-2 lv pf	0	25-35	c, s	
70 - 99	Bt2b1b		1 c pr 1-2 m, c sbk	ss-s, ps-p sh-h	CL	pat f-p co gr pat f-p br pf	1-2 vf, f t 2 m t 1-2 f, m lv, pf	0	45-55	c, s	
99 - 110	Bt1b1c		2 m pr 1-2 f, m sbk	s, ps-p h	CL	nc f-p br pf nc d-p po nc f-p co gr	1-2 vf t 2 f, m t	0	40-60	c, w	
110 - 135	Bt2b1c		1-2 f, m, c sbk	ss-s, p sh-h	CL	pat f-p br pf pat d-p po pat-nc f-d co, gr	2-3 vf, f t 1-2 m t 2 vf, f lv	0	60-75	c, w	
135 - 156	Bt3b1c		m-1 m, c sbk	s-vs, p h-vh	CL	pat-nc f-p br, pf co gr pat-nc f-d po	2-3 vf, f t 1-2 m t 2 vf, f lv	0	60-75	c, s	

Appendix A

FIELD SOIL DESCRIPTION

Location: Water Canyon Site #: 3

Vegetation: Juniper, pinyon, Ponderosa pine

Geomorphic surface: Post El Cajete fluvial/slopewash

Date: 6/25/93

Approx. Elevation:

Approx. Slope:

Aspect:

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSIS- TENSE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL BOUND- % ARIES estimate	NOTES
0 - 8	Ap	10YR4/2 10YR5/2	2 f, m pl 2 f, m abk	ss, ps sh-h	SIL	pat. silans co on gr	3 v f t 1-2 f t	1-2 v f f	<5	a, s
8 - 21	Bt1	7.5YR3/3 7.5YR5/3	1-2 m pr 2-3 m, c abk	ss-s, ps-p h-vh	SICL	nc f-d pf, po	2-3 v f t 1-2 f t v f m t	1 v f f v f m	5	c, s
21 - 39	Bt2	7.5YR4/4 7.5YR5/4	1-2 m, c pr 1-2 m, c abk	ss-s, p h-vh	SICL	nc p pr pf nc pat f-d pf, pd	3 v f t 1 f t	1-2 v f pf 1 f m	5	c, s
39 - 70	Bt3	7.5YR4/4 7.5YR5/4	1 c pr 1 m, c sbk, abk	s, po-p sh-h	CL	nc f pr, pf pat f-d po	3 v f t 1-2 f t v f m t	1-2 v f pf v f f	5-10	c, s
70 - 107	Bt4	7.5YR4/4 7.5YR5/4	1 m, c pr 1 m, c abk, sbk	ss, ps sh-h	SIL	pat f pr, pf pat f-d po	2-3 v f t 1 f t, v f m t	1 v f pr	5-10	c, s
107 - 159	BC	7.5YR4/4 7.5YR5/4	0-1 c pr 0-1 m, c sbk	ss, ps sh-h	SIL	pat f pf, pr pat f-d po	2-3 v f t 1-2 f t, 1 m t	v f f	20-30	g, s
159 - 187	2C	7.5YR4/3 7.5YR5/3	m to sg	so, ps sh	SL-L	0	1 v f t 1-2 v f f iv	0	25-35	

Appendix A

FIELD SOIL DESCRIPTION

Location: TA-67 Site # E1

Vegetation: Juniper, pinyon, ponderosa pine, cactus, grasses

Geomorphic surface:

Described by: P. Watt

Date: 10/7/93

Approx. Elevation: 7200'

Approx. Slope: 3 - 5 degrees

Aspect: North

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSISTENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL % estimate	BOUND- ARIES	NOTES
0 - 7	A		1 f, m gr	ss, ps lo, so	SIL	0	2 lv; 1 t	1-2 f; 1-2 m	<10	a, s	
7 - 16	BA		1+ f, m gr -1+ f, m sbk	ss, ps lo, so, sh	SIL	0	2 lv; 1 t	1-2 f; 1-2 m	<10	a, s	
16 - 38	Bw		2- m abk, sbk	ss+, p- sh	SICL	0	1-2 lv	1 f; 1 c	<10	c, s	
38 - 62	Bl		2+ m, c abk	s-, p- h, vh	SICL	2- d po 1 d co; 2 p pf	1-2 lv	1 f; 1 c	10	c, s	
62 - 98	2Bwb		1 m sbk -1 f, m gr +sbk	ss+, ps+ sh	L	0	1 lv	1 f, m, c	25	c, w	
98 - 110	2BCb		1 m, c abk -1 m gr +sg	ss, ps sh	L	0	1 lv	1 f, m, c	25+		

Appendix A

FIELD SOIL DESCRIPTION

Location: TA-67 Site # E3

Vegetation: Juniper, pinyon, ponderosa pine, cactus, grasses

Geomorphic surface:

Date: 10/15/93

Approx. Elevation: 7200'

Approx. Slope: 3 - 5 degrees

Aspect: North

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSISTENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL % estimate	BOUND- ARIES	NOTES
0 - 14	A		1 m, c, vc sbk	ss, ps sh	SIL		2 t, lv	2f; 1 m, c	<10	a, s	
14 - 22	2BAb1		1 f, pl ~2 f, m abk	s, p vh	CL	3 p pf 2 d po, co	2 t	2 m, f; 1 c	<10	a, s	
22 - 40	2Bt1b1		2+ c pr ~2+ m abk	s, p vh	CL	3 p pl 2 d po, co	2 t	2 m, f; 1 c	<10	c, s	
40 - 50	2Bt2b1		2 m, c, vc sbk	ss+, ps+ h, vh	L	1+ d pf pat. 2 d po	2 t	1 f, m	10	c, s	
50 - 57	2BC1b1		1 v, m sbk	ss, ps	SCL	2 d pf, po	2 lv; 1 t	1 f, m	25+	c, s	
57 - 67	2BC2b1		1+ m, c sbk ~1 f, m gr	ss+, ps+ h, vh	L	pat. 1 d- pf	2 lv; 1 t	1 f, m	50 pumice	c, s	
67 - 76	3Bt1b2		2 m, c abk ~1 f, m gr	s, p- sh, h	SCL	2 d pf, po	2 lv; 1 t	1 f, m	25+ pumice	a, s	
76 - 87	3Bt2b2		2 f, m abk	s, p h	CL	2 d pf, po	2 lv; 1 t	1 f, m	<10	c, w	
87 - 101	3Bt3b2		1+ m pr ~2 m, c abk	s, ps+ h, vh	SCL	2 d pf, po	1+ t; 1 lv	vf f, m	10+	a, w	
101+	R										Bandelier Tuff

Appendix A

FIELD SOIL DESCRIPTION

Location: TA - 67

Site #: W1

Date: 9/16/93

Vegetation: Juniper, pinyon, Ponderosa pine, shrubs, grasses

Approx. Elevation: 7200'

Geomorphic surface: mesa top

Approx. Slope:

Aspect:

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSIS- TENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL % estimate	BOUND- ARIES	NOTES
0 - 6	A1	10YR3/2 10YR4/2	1-2 f,m pl 2 f,m cr	ss, ps so	SIL-L	0	m vf is	m vf, f	<5	a, w	
6 - 13	A2	10YR3/2 7.5YR4/2	1-2 m,c pl 2 f,m cr 1-2 m sbk	ss, ps sh-h	SIL-	pat f br, po silans	1-2 vf t 3 vf is	3 vf, f	5	c, s	
13 - 23	A3	10YR3/2 7.5YR4/2	1-2m,c sbk 1 f,m cr	ss, ps sh	SIL+	v pat f silan sbk, pf	1 vf t 1-2 vf is	2 vf 1 f	5	c, s	
23 - 39	BA	7.5YR3/3 7.5YR4/3	1 m,c sbk 1 f,m cr	ss, ps so	SIL	v pat silan br, sbk, pf	1 vf t 2 vf is	1 vf, f	5-10	w, s	highly bioturbated El Cajete only weakly weathered
39 - 65	Bw	7.5YR3/3 7.5YR5/3	1-2 m pr 1 f,m sbk	ss-s, ps sh	SIL+	v pat f br on pf	2 vf t	1 vf	10-20	c, s	highly bioturbated El Cajete only weakly weathered
65 - 86	Bt1	7.5YR4/3 7.5YR5/4	1-2 m,c pr 1-2 f,m sbk	ss, ps sh-h	SIL	pat f-d pr, pf pat f br on sbk, pf	2 vf t 1 ft	vf f	15-30	c, s	
86 - 109	Bt2	7.5YR3/3 7.5YR5/3	1 m pr 1 m,c sbk	ss, ps so-sh	SIL	pat f-d pr, pf pat f-d br,sbk	2 vf t	vf vf, f	25-45	a, w	
109 - 120	E/Bb	7.5YR4/3 7.5YR6/3	massive	vh	L	pat-nc f-p po pat d on vert. fracture	2 vf, f t 1 m t		10-15	a, s-w	
120 - 142	Btkb	7.5YR4/3 7.5YR6/3	1-2 f,m sbk 1-2 f,m abk	ss, ps h-vh	L	pat d br on pf pat d pf, po	1-2 vf t	vf, vf	15-25	c, w	
142 - 163	Bt/CR										

Appendix A

FIELD SOIL DESCRIPTION

Location: TA - 67 Site # W5

Vegetation: Juniper, pinyon, cactus, grasses

Geomorphic surface:

Date: 6/29/93

Approx. Elevation: 6800'

Approx. Slope: 2 - 4 degrees

Aspect:

DEPTH (cm.)	HORI- ZON	COLOR wet/dry	STRUCTURE	CONSISTENCE wet/dry	TEXTURE estimate	CLAY FILMS	PORES	ROOTS	GRAVEL %	BOUND- ARIES	NOTES
0 - 8	A	10YR3/2 10YR4/2	1 m, c sbk ~1+ m pl	ss-, ps- sh-	SIL	0	2- 2; 2+ iv	2 f, m	10	a, s	
8 - 26	BA	7.5YR4/3 7.5YR5/3	2- m, c, v, sbk	ss+, ps+ sh+	SIL	0	1 t	1 m, c	<10	a, s	
26 - 44	2Bt1b1	7.5YR4/4 7.5YR5/3	1+ m abk	s-, p- h	SICL	1 f+ po vf f pf	1 t	1 m, c	<10	c, s	
44 - 69	2Bt2b1	7.5YR4/4 7.5YR6/4	1 m, c sbk	s, p h	CL	1+ d pf pat. 1 f po	1 t	1 f, m	<10	c, w	
69 - 79	2Bt3b1	7.5YR4/3 7.5YR6/3	1 m, c pr	s-, p- vh	L	1 f+ pf pat. 1 d- po	1 t	1 f, m	25+	c, w	
79 - 107	2Bc1b1	7.5YR4/4 7.5YR5/3	sg & 1 c sbk	ss, ps lo, sh	L	0	1 iv	1 m, c	75	c, w	pat. Si redeposited thru horizon, but not cementing it
107 - 124	2Bc2b1	7.5YR4/4 7.5YR5/3	sg & 1- m, c sbk	ss, ps lo, sh	SL	0	1 iv	1 f, m	50	a, w	
124 - 136	3BAb2	7.5YR4/3 7.5YR6/3	1 m sbk	ss, ps h, vh	SL	2 d po	2 t	1 m	25	a, w	Si & clays line pores Si 'cemented' layer ?
136 - 145	3Btb2	7.5YR4/4 7.5YR6/3	2 c pr -2 f, m sbk	s, p vh	CL	2+ p pf 1 d- co pat.	1- t	1 m	10	a, w	
145 - 168	4CBt1b3	7.5YR5/6 7.5YR6/4	1 m, c sbk	so, po h	LS	1 d co	1+ t	1- m	<10	c, w	
168 - 186	4CB2b3	7.5YR5/6 7.5YR6/4	1 m, c sbk	so, po h	LS	v1 d co	1+ t	1- m	25	c, w	
186 - 194	4C1b3	7.5YR5/6 7.5YR6/4	sg & 1- m sbk	so, po sh	LS	1- d co	0	1- c	75	c, w	
194 - 211	4C2b3	7.5YR4/6 7.5YR5/4	m & sg	so, po lo	S		0	0	>75	a, w	
211+	R										Bandelier Tuff

INITIAL SPLIT

BULK SPLIT

All samples must be recorded in soil file book and air dried prior to splitting. The standard analyses, pH, soluble salts, gypsum, particle size, CaCO_3 , dithionite and oxalate extractable iron, silica, and organic carbon require approximately 150 grams of < 2mm soil. It is most efficient to split out a 'run' of 20 to 30 samples at one time.

EQUIPMENT

Large splitter and containers
2mm sieve
Small ziplock sample bags
Permanent marking pen
Balance (analytical)

PROCEDURE

- (1) To air dry samples, place the sample on a sheet of paper for one or two days. If the sample has a high clay content, break up large clasts by hand while the soil is still moist.
- (2) If required, remove peds for bulk density determinations and soil micromorphologic examination.
- (3) Using the large splitter, split out 200-300 grams of bulk sample.
- (4) Sieve sample through the 2mm sieve. If the sample has a high clay content, it may be difficult to sieve, and wet sieving of the sample may be necessary.
- (5) Label sample bags with pedon name, horizon designation, sample number, horizon depth, and size fraction.
- (6) Weigh the > and < 2mm fractions and record weight in the initial splits file (Figure 2.1).
- (7) Place splits in labeled bags with the > 2mm fraction bag rolled up and placed inside the other bag.
- (8) Label the remaining unsieved sample, bulk sample, and remove from the lab.

FINE SPILT

The $\approx$ 150 grams of < 2mm soil can be further split for individual analyses. The following amounts are required for the standard analyses:

pH		2 * 10 grams
Soluble salts and gypsum		2 * 10 grams
PSDA		20 - 40 grams
CaCO_3	up to	2 * 10 grams
Feo		2 * 0.5 gram
Fed		2 * 0.5 gram
Organic carbon		2 * 0.5 gram
Silica		2 * 1 gram

It is easier to split out all the fine fractions at one time.

EQUIPMENT

Small splitter and containers
Film containers
Beakers for analyses (for analyses to be started immediately)

PROCEDURE

- (1) Split fine fraction into appropriate weights for analyses.
- (2) Store samples not required immediately in appropriately labeled film containers and store in drawers in the splitting room.
- (3) pH and digestion for particle size are usually started immediately.

PARTICLE SIZE ANALYSIS - SETTLING TUBES

(Modified from Day, 1965, and Jackson 1969)

The particle size analysis procedure is used to determine the percentage of sand, silt and clay in the sample. This procedure is based on Stoke's Law that spherical particles settle in a fluid at a rate proportional to their radius and mass (Janitzky, 1987). Prior to the actual particle size procedure, any organic matter or carbonate must be removed from the sample. These procedures are located under the heading of organic matter digestion and carbonate digestion.

EQUIPMENT

Balance (analytical)	Sieve (63 μ m)
125 ml erlenmeyer flasks	Funnel
50 ml graduated cylinder or pipet	1200 ml fleakers and caps
No. 5 stoppers	Marble platform
Shaker table	Pipet (20 or 15 ml)
Water bottle (deionized)	Aluminum sample dishes

REAGENTS

Dispersing agent: 10% Sodium Pyrophosphate

Dissolve 53.52 g of Sodium Pyrophosphate ($\text{Na}_2\text{P}_2\text{O}_7$) and 4.24g of Sodium Bicarbonate ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$) into one (1) liter of deionized water.

PROCEDURE

- (1) If sample contains abundant organic matter or carbonate it must be removed before proceeding with this procedure.
- (2) Weigh 125 ml erlenmeyer flask to the nearest 0.01 g. Weigh out and record 20 grams of the fine fraction ($< 2\text{mm}$) and place in the erlenmeyer flasks. (Use 40 grams of sample if texture is sandy or sandy loam, and 10 to 15 grams for clays)
- (3) The weight of the dispersant must be known. Prepare a blank using a 125 ml erlenmeyer flask.
- (4) Pipet 50 ml of 10% sodium pyrophosphate solution into the flask. Add approximately 30 ml of deionized water to flask. Place flask on a mechanical shaker table. Shake for 4 hours in order to disperse the clays.
- (5) Wet sieve the clay and silt fraction, using a 63 μ m sieve, into 1200 ml fleakers. DO NOT fill past the 1200 ml mark. (If more than 1200 mls is required to complete sieving a sample then collect the sample in a large beaker and dry off the excess water in the oven.) Wash the sand back into the erlenmeyer flask. Oven dry the sand sample. Weight the sand fraction and record. Pour solution from Blank flask into fleaker and fill to the 1200 ml mark.
- (6) Fill fleakers to the 1200 ml mark. Cap fleakers. Shake each fleaker vigorously for 30-45 seconds. Place on marble platform. Fleakers must be shaken at distinct intervals (2 minutes) and the time recorded. Note the room temperature.
- (7) Wait the required duration of time to allow all the greater-than -2 μ m. particles to settle below the 10 cm depth (see Table 3.1 for settling times.) In the mean time, label, weigh and record the weight of the aluminum sample dishes to the nearest 0.0001 gram.
- (8) At the appropriate time extract a 20 or 25 ml aliquot of clay suspension using a pipet and pump apparatus. Collect the sample at 10 cm depth. Empty pipet into the appropriate aluminum clay sample dish. At this time, an additional clay sample may be collected for

analysis by x-ray diffraction. Oven dry clay sample dish. Allow the dish to cool in a desiccator before weighing the clay sample.

- (9) DISPOSAL OF WASTE: empty the still suspended sediment in the fleakers into the sink and wash the silt that has settled out into a separate container. Allow the water to evaporate then empty the container into the trash can.

CALCULATIONS

Type data into the PSDA spread sheet (Figure 3.1). The spreadsheet will automatically do the calculations listed below.

Calculation of the ratio of fleaker vol./aliquot vol.

aliquot vol.	fleaker vol.	
	1200	1000
20 ml	60	50
25 ml	48	40

$\text{SAND PERCENT} = (\text{Sand and flask weight (g)} - \text{flask weight (g)}) / \text{total sample wt.})$

CLAY PERCENT:

$\text{CLAY WEIGHT} = (\text{clay+dish weight}) - (\text{dish weight})$

$\text{CLAY PERCENT} = [(\text{clay weight-dispersant weight}) * (\text{fleaker volume/aliquot vol.})] / (\text{total sample weight})$

$\text{SILT PERCENT} = 100 - (\text{sand percent} + \text{clay percent})$

NOTE: If carbonate or organic digestion is carried out, the total sample wt = digested sample wt.

Table 3.1. Settling Time for 10-cm Fall of a 2 μ (clay) Particle

Particle Size, in μ

Temp. C°	<u>2 μ</u> (hr.min)	
5	12	05
6	11	45
7	11	20
8	11	00
9	10	45
10	10	25
11	10	10
12	9	50
13	9	35
14	9	20
15	9	05
16	8	50
17	8	35
18	8	25
19	8	10
20	8	00*
21	7	50
22	7	40
23	7	25
24	7	15
25	7	05
26	6	55
27	6	45
28	6	40
29	6	30
30	6	25

*International Standard Definition of 2 μ by sedimentation velocity

BULK DENSITY-PARAFFIN CLOD METHOD

(Blake, 1965 and modified by Singer, 1986)

PRINCIPLE

In this method, an intact clod is removed from the soil for volume and weight measurement. soils with coarse fragments present a special problem. Clod size must be increased proportionately as gravel size and soil volume occupied by gravel increases. For some soils with very high gravel content, a visual estimate of volumetric gravel content may be used. For nongravelly soils, a 200-250 g sample is convenient. The paraffin becomes a significant part of the total weight of smaller samples.

An undisturbed soil sample is weighed and its volume calculated by determining the volume of water it displaces after the sample is coated with a water proof material. Bulk density is calculated as the weight per unit volume, normally on an oven dry basis.

EQUIPMENT

Beam balance

String

Paraffin

Warming container for the paraffin

Oven

Balance (two decimal)

PROCEDURE

- (1) Tie each ped by fine thread, oven dry for 24 hours, and weigh. A fine thread of twine works well for all but the weakest clods.
- (2) Briefly immerse the clod in 48 °C paraffin. A brief immersion at the temperature slightly above the paraffin melting point helps to retard paraffin penetration into soil pores. One coating should be sufficient to waterproof the clod.
- (3) Dip coated ped in beaker of cold water to check for leaks and to help cool the sample.
- (4) After the paraffin is solid, weigh the coated clod in air and in water.
- (5) If gravel free bulk density is desired, remove wax from ped, soak in water overnight and wash through a 2mm sieve. The gravel-free weight of the ped is calculated using the weight and volume of the gravel as a correction factor.
- (6) WASTE DISPOSAL: Collect the coarse material from the washing in a water bath set beneath the sieve. Allow the water to evaporate and put the dry soil in the trash.

CALCULATION

$$< 2mm \text{ BD} = \frac{(\text{Oven Dry Ped Wt.}) - (> 2mm \text{ Wt.})}{(\text{Ped+Wax Wt.}) - (\text{Ped+Wax Wt. H}_2\text{O}) - (\text{Wax Wt.} \cdot 1/0.9) - (> 2mm \text{ wt. } 2.65)}$$

pH

Measurement of soil pH in 0.01 M CaCl_2 is the preferred method for most purposes because of advantages pointed out by Peech (1965).

- (1) The pH is almost independent of dilution over a wide range.
- (2) The pH measured is almost independent of the concentration of soluble salt present in non-saline soils.
- (3) It provides a good approximation of the pH of the soil solution under field conditions.

pH in 0.01 M CaCl_2 (Peech, 1965)

REAGENTS

0.01 M CaCl_2 - If large volumes are required, make a stock solution of 3.6 M CaCl_2 (1059 g of $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ to 2ℓ with distilled water, and dilute 50 ml of this stock solution to 18ℓ with distilled water). For a smaller amount, add 1.11 g solid CaCl_2 to 1ℓ of deionized H_2O . Check the pH; it should be between 5.0 and 6.5. If it is not, adjust by adding $\text{Ca}(\text{OH})_2$ or HCl . To check the concentration of the solution, measure its conductivity; the specific conductivity should be 232 ± 0.08 millisiemens per cm (ms/cm) at 25°C.

PROCEDURE

- (1) Place about 10 g of soil into a 50 ml beaker, add about 20 ml of 0.01 M CaCl_2 solution and stir the suspension several times during the next 30 minutes. For organic soils that absorb all of the solution use a 4 to 1 solution:soil ratio.
- (2) Let the suspension stand for 30 minutes to allow most of the sediment to settle.
- (3) Measure the pH by immersing the combination electrode into the partly settled suspension (do not immerse it to the bottom of the container). The pH meter is adjusted by setting it to the pH of buffer solutions at the same temperature as the soil suspension. The meter should be checked against two buffers one of which has a pH at the lower and the other at the upper end of the range of pH of the soils being measured.
- (4) Record the pH in CaCl_2 to one decimal place.
- (5) WASTE DISPOSAL: Wash the soil into a large container, allow the water to evaporate and place the dry soil in the trash.

pH in water

- (1) To 10 g of soil in a 50 ml beaker or plastic cup, add 20 ml of distilled water and stir the suspension several times during the next 30 minutes. For samples with a high content of organic matter, use a 1:2 or a 1:4 soil:water ratio.
- (2) Allow the suspension to settle for 30 minutes.
- (3) Measure the pH as outlined in step 3 of the preceding procedure.

There is no point in measuring the pH of most soils containing free carbonates of Ca or Mg as the value obtained depends upon the partial pressure of CO_2 , which is generally uncontrolled during pH measurements (Turner and Clark, 1956). It is, however, useful to measure the pH of saline, calcareous soils as values above about 8.5 indicate sodium carbonate (Richards, 1954).

CALCIUM AND MAGNESIUM CARBONATE

(Dreimanis, 1962; modified by Machette, 1986, and Association of Official Analytical Chemists, 1950)

PRINCIPLE

Soil samples containing calcium and (or) magnesium carbonates are oven dried and crushed to pass an 80-mesh sieve (0.18 mm), although crushing to pass a 200-mesh sieve (0.075 mm) will improve the precision of the analysis. The sample is placed in a flask, attached to the Chittick apparatus, and digested with 6 N hydrochloric acid. The evolved gas is collected under monitored conditions of temperature and pressure. Carbonate content is calculated from the volume of evolved gas (corrected to conditions of standard temperature and pressure), dry sample weight, and the molecular weight of the carbonate mineral being analyzed. Calcium and magnesium carbonates are differentiated by the rate at which they dissolve and generate gas. This analysis is modified from Dreimanis (1962) to accept variable sample weight and incorporates minor changes to improve the quality of the analyses.

EQUIPMENT

Chittick apparatus (see Figure 6.1):

- Decomposition flask (A) with 2- or 3-hole stopper
- Pipette, 25 ml size (B)
- Stopcock (C)
- Gas measuring tube, 200 ml capacity (D)
- Leveling bulb (E)
- Glass and tygon tubing
- Mounting rack
- Magnetic stirring apparatus (F)
- Ring stand for magnetic stirrer (F)

- Mortar and pestle
- Mechanical sample splitter
- Wash bottle for acid
- Sieves (2 mm, 0.18 mm, 0.075 mm)
- Desiccator
- Vented oven, 110°C
- Analytical balance
- 11-19 extra flasks
- Six magnetic stirring bars
- Thermometer, Celsius
- Barometer, millimeter type
- Timer

REAGENTS

Hydrochloric acid. 50 percent (approximately 6 N HCl). Reagent grade HCl is 12 N. Dilute to 6 N by adding equal volume of acid to water.

Methyl orange indicator. Dissolve 0.5 g indicator in 1 l distilled water.

Displacement solution. Dissolve 100 g of sodium chloride or sodium sulfate decahydrate in 350 ml distilled water. Add about 1 g of sodium bicarbonate and 2 ml of methyl orange indicator. After the bicarbonate is dissolved, add sufficient dilute sulfuric acid to make the solution acid (definite

pink color). The solution, used in the gas measuring tube and leveling bulb, seldom needs replacement. Occasional addition of distilled water to replace that which is lost by evaporation will prevent crystallization of salt.

Figure 6.1. Chittick apparatus and accessory equipment used to analyze calcium and magnesium carbonates in soils (modified from Dreimanis, 1962). A. decomposition glass; B. pipette; C. stopcock; D. gas measuring tube; E. leveling bulb; F. magnetic stirring device; G. ring stand (From Machette, 1986, Fig. 12).

PROCEDURE

Sample Preparation

- (1) To optimize the precision of the analysis, use an 80- or 200-mesh dry sample which will produce the maximum volume of the measuring burette (200 ml). Individual Chittick analyses require a maximum of 0.75 g for samples containing 100 percent carbonate and 7.5 g for sample containing 10 percent carbonate.
- (2) Weigh sample on Sartorius balance to 0.0005g accuracy. Record this as sample wt (w).

DETERMINATION

Modified slightly from Chittick apparatus instructions and description by Dreimanis (1962).

- (1) Place a magnetic stirring bar in the flask with the sample and attach the flask to the Chittick apparatus (Fig. 6.1). Make sure that the seal is airtight by slightly wetting the rubber stopper.
- (2) Open stopcock (C) and, by means of the leveling bulb (E), bring the displacement solution in the gas measuring tube up the -10 ml graduation mark, above the zero mark. (This 10 ml is equal in volume to that of the acid which is used to decompose the sample. If more acid is used (that is, with large samples), then the level of the displacement solution must be adjusted accordingly.)
- (3) Allow apparatus to stand 1-2 minutes so that the pressure within the apparatus equilibrates with that of the room. Measure room temperature and pressure at this time. Additional measurements are necessary only if conditions change during the course of the analyses.
- (4) Turn on magnetic stirring device (F), thereby agitating the contents of the flask. Close stopcock (C) and lower the leveling bulb (E) several centimeters to reduce pressure in the apparatus. Fill the pipette (B) with acid and record its level. Open the pipette, slowly introducing acid into the decomposition flask (A). From this point on in the analysis, gas that is being liberated can escape up through the pipette or cause the displacement solution to overtop the leveling bulb. Thus, the gas measuring tube (D) must be kept at equal levels by progressively lowering the leveling bulb; some acid must be kept in the pipette. Close the stopcock when 10 ml of acid have entered the flask. If you introduce too much acid, adjust the measure of final gas volume by subtracting the volume of excess acid.
- (5) Most of the calcite in soil samples will be dissolved within the first minute of the reaction, yet one should wait 5 minutes to read the final volume in the measuring tube, especially if the sample has not been ground to 200-mesh size. During digestion of the CaCO_3 , there may be a slight increase in the temperature within the flask. A good rule of thumb is to add 1°C to the temperature reading for each 50 ml of gas generated in excess of 50 ml. Such changes, usually $1\text{--}2^\circ\text{C}$, can be measured with a thermometer inserted into the flask through a three-hole stopper. Dreimanis (1962, p. 521) recommends using the air temperature within the flask when calculating the gas volume at standard conditions of temperature and pressure.
- (6) If the sample volume of gas continues to increase during this interval, the sample may contain dolomite. In such cases, Dreimanis (1962, p. 521) recommends making both a first reading at 30 seconds to 1 minute, which is used to determine calcite content, and a second reading 15-45 minutes after beginning the analysis, which is used to determine dolomite content. Samples that contain dolomite should be crushed to pass a 200-mesh sieve.
- (7) When the reaction has stopped, open the stopcock, return the leveling bulb to the -10ml level, and remove the flask with decomposed sample.

- (8) **WASTE DISPOSAL:** Pour the soil and acid mix into a large beaker containing limestone situated in the fume cupboard. Leave for at least a day so that neutralisation of the acid will be complete. When no more bubbles are observed, and there is still some limestone remaining, pour the neutralised mixture down the sink. Run tap water at the same time.

CALCULATIONS

The Chittick apparatus is designed primarily for determination of the volume of CO_2 evolved from carbonates reacting with acid. The operating procedures supplied by the manufacturer of the apparatus (Sargent-Welch Scientific Company) are written for the determination from baking powder; nevertheless, the volume of CO_2 can be converted to calcite (A) or dolomite (B) content:

- A. Weight percent of CaCO_3 = weight percentage of CO_2 x $100.09/44.01$, where 100.09 is the molecular weight of CaCO_3 and 44.01 is the molecular weight of CO_2 .
- B. Weight percent of $\text{CaMg}(\text{CO}_3)_2$ = weight percentage of CO_2 x $144.40/88.02$, where 144.40 is the molecular weight of $\text{CaMg}(\text{CO}_3)_2$ and 88.02 is the weight of two moles of CO_2 .
- (1) For convenience, the records of the analyses are kept in tabular form from left to right: sample weight (W, in grams), gas volume (V, in milliliters), temperature (in degree Celsius) and pressure (in inches), correction factor (Cf) for standard temperature and pressure (see Table 6.1, pages 38-42, for correction factors from the Association of Analytical Chemists, 1950, p. 821-875), corrected volume (Vc is milliliters; $V_c = V \times \text{Cf}$), and percent calcium carbonate or magnesium carbonate.
- (2) The following calculations are for percent calcium carbonate; percent magnesium carbonate is calculated using the appropriate molecular weights. Percent CaCO_3 = $1.7 \text{ g/W} \times (100.09/44.01) \times \text{Cf} \times (V/10) \times 0.83$.
- NOTE: The factor of .83 is a calibration factor included for our instrument. For example, $1.7 \text{ g}/4.0 \text{ g} \times (2.27) \times 0.90 \times (185/10) \times 0.83 = 13.2 \text{ percent}$.

ADDITIONAL REMARKS

Dreimanis (1962, p. 525) found that the probable errors (not exceeded in half the samples analyzed) for the results of the Chittick apparatus were ± 0.1 for calcite content and ± 0.3 for dolomite content. By modifying the procedure to accept variable sample weight and using sample weights which produce the maximum allowable volume of gas (200 ml), the probable errors can be reduced.

The analyses of pure calcite have a standard deviation (s) of about 2 percent, which is attributable to the Chittick method itself. Analyses of soil samples have relatively higher standard deviations, which range from a low of 1.5 percent to a maximum of 3 percent of the reported mean value X; (this is termed the coefficient of variability). The slightly higher error limits for soil samples are attributable to their natural inhomogeneity and to inadequacies of the splitting process. Still, on the basis of our tests, we would expect that two-thirds of analyses (the population within one standard deviation) of soil samples with 50% CaCO_3 , would be accurate with ± 1.0 percent CaCO_3 .

The method of analyzing calcium and magnesium carbonates using the Chittick analyses were found to have the following advantages (Dreimanis, 1962):

- (1) The procedure is simple, clean, and uses equipment that requires little space and is relatively inexpensive. The analyses can be done even in a field laboratory.

- (2) Preparation of the sample is similar to that of particle size determinations and handling the apparatus requires only a few minutes per sample. When set up for production work, one analyst can perform as many as 30-40 analyses per day, thereby affording an inexpensive measure of soil carbonates content.
- (3) The precision and accuracy of the analyses are on par with methods using atomic absorption spectrometry, X-ray fluorescence, and colorimetric titration. Carbonate coatings, which remain on gravel clasts after sieving, must be dissolved to determine their contribution to the total mass of soil CaCO_3 . This process involves weighing oven-dry gravel, dissolving the coatings with 6NHCl , decanting the acidic solution, and washing the gravels free of any CaCl_2 (the residue from digestion of CaCO_3). The gravels are dried and reweighed; the net loss is the weight of CaCO_3 coatings on the gravel.

Table 6.1. Correction factors for the gasometric determination of carbon dioxide.

°C.	19.0°	19.5°	20.0°	20.5°	21.0°	21.5°	22.0°	22.5°	
mm.									inches
700	0.97335	0.97055	0.96815	0.96564	0.96294	0.96023	0.95753	0.95509	27.56
702	.97019	.97368	.97116	.96850	.96582	.96311	.96041	.95794	27.64
704	.97206	.97653	.97400	.97132	.96865	.96597	.96329	.96082	27.72
706	.98183	.97933	.97683	.97420	.97153	.96885	.96624	.96371	27.80
708	.98474	.98224	.97971	.97701	.97435	.97173	.96912	.96656	27.87
710	.98759	.98508	.98253	.97988	.97724	.97459	.97195	.96938	27.95
712	.99041	.98788	.98533	.98273	.98012	.97747	.97483	.97227	28.03
714	.99329	.99073	.98819	.98556	.98294	.98032	.97771	.97512	28.11
716	.99612	.99358	.99106	.98844	.98582	.98323	.98065	.97800	28.19
718	.99900	.99644	.99389	.99126	.98865	.98606	.98348	.98093	28.27
720	1.00182	.99925	.99671	.99412	.99153	.98894	.98636	.98371	28.35
722	.00465	1.00209	.99953	.99694	.99435	.99176	.98918	.98653	28.43
724	.00753	.00497	1.00241	.99982	.99724	.99462	.99200	.98932	28.50
726	.01035	.00779	.00524	1.00265	1.00006	.99746	.99483	.99215	28.58
728	.01324	.01068	.00806	.00547	.00288	1.00027	.99763	.99497	28.66
730	.01606	.01347	.01089	.00829	.00571	.00306	1.00041	.99781	28.74
732	.01888	.01629	.01371	.01112	.00853	.00588	.00324	1.00056	28.82
734	.02176	.01919	.01659	.01397	.01135	.00870	.00606	.00338	28.90
736	.02459	.02200	.01941	.01679	.01418	.01153	.00888	.00620	28.98
738	.02747	.02486	.02224	.01962	.01699	.01435	.01171	.00900	29.06
740	.03029	.02768	.02506	.02244	.01982	.01717	.01453	.01182	29.13
742	.03318	.03056	.02794	.02532	.02265	.02000	.01735	.01464	29.21
744	.03600	.03338	.03076	.02811	.02547	.02279	.02012	.01742	29.29
746	.03888	.03624	.03359	.03094	.02829	.02561	.02294	.02024	29.37
748	.04171	.03906	.03641	.03376	.03112	.02844	.02576	.02306	29.45
750	.04453	.04189	.03924	.03659	.03394	.03126	.02858	.02589	29.53
752	.04741	.04477	.04212	.03944	.03676	.03408	.03141	.02868	29.61
754	.05024	.04759	.04494	.04226	.03959	.03691	.03424	.03150	29.69
756	.05306	.05041	.04776	.04508	.04241	.03973	.03706	.03433	29.76
758	.05594	.05329	.05065	.04797	.04529	.04261	.03993	.03715	29.84
760	.05876	.05613	.05347	.05079	.04812	.04543	.04275	.03999	29.92
762	.06165	.05897	.05629	.05361	.05094	.04821	.04547	.04274	30.00
764	.06447	.06179	.05912	.05644	.05376	.05103	.04829	.04556	30.08
766	.06729	.06462	.06194	.05926	.05659	.05386	.05112	.04839	30.16
768	.07013	.06745	.06478	.06212	.05941	.05668	.05394	.05118	30.24
770	.07300	.07032	.06765	.06494	.06224	.05950	.05676	.05400	30.31
°F.	66.2°	67.1°	68.0°	68.9°	69.8°	70.7°	71.5°	72.5°	

°C.	23.0°	23.5°	24.0°	24.5°	25.0°	25.5°	26.0°	26.5°	
mm.									inches
700	0.95265	0.95020	0.94776	0.94508	0.94241	0.93973	0.93706	0.93432	27.56
702	.95547	.95303	.95059	.94791	.94518	.94250	.93982	.93708	27.64
704	.95835	.95585	.95335	.95067	.94800	.94532	.94265	.93993	27.72
706	.96118	.95865	.95612	.95344	.95076	.94808	.94541	.94267	27.80
708	.96400	.96147	.95894	.95626	.95359	.95091	.94824	.94544	27.87
710	.96682	.96429	.96176	.95905	.95635	.95364	.95094	.94820	27.95
712	.96971	.96712	.96453	.96182	.95912	.95644	.95376	.95100	28.03
714	.97253	.96991	.96729	.96461	.96194	.95923	.95653	.95376	28.11
716	.97535	.97273	.97012	.96741	.96471	.96200	.95929	.95655	28.19
718	.97818	.97556	.97294	.97023	.96753	.96482	.96212	.95935	28.27
720	.98106	.97848	.97581	.97300	.97029	.96758	.96483	.96213	28.35
722	.98388	.98120	.97853	.97582	.97312	.97038	.96765	.96488	28.43
724	.98665	.98397	.98129	.97858	.97583	.97314	.97041	.96764	28.50
726	.98947	.98679	.98412	.98141	.97871	.97594	.97318	.97041	28.58
728	.99229	.98961	.98694	.98420	.98147	.97870	.97594	.97319	28.66
730	.99512	.99241	.98971	.98697	.98424	.98147	.97871	.97594	28.74
732	.99788	.99517	.99247	.98973	.98700	.98423	.98147	.97871	28.82
734	1.00071	.99799	.99529	.99255	.98982	.98705	.98429	.98153	28.90
736	.00353	1.00083	.99812	.99538	.99265	.98993	.98715	.98438	28.98
738	.00639	.00369	1.00053	.99781	.99508	.99231	.98952	.98673	29.06
740	.00912	.00643	.00371	1.00025	.99751	.99473	.99195	.98916	29.13
742	.01194	.00923	.00653	.00377	1.00000	.99720	.99441	.99158	29.21
744	.01471	.01200	.00929	.00653	.00378	1.00000	.99718	.99435	29.29
746	.01753	.01482	.01212	.00936	.00659	.00378	1.00000	.99715	29.37
748	.02035	.01764	.01494	.01218	.00943	.00663	.00377	1.00000	29.45
750	.02318	.02045	.01771	.01492	.01212	.00936	.00659	.00377	29.53
752	.02594	.02321	.02047	.01771	.01494	.01211	.00929	.00644	29.61
754	.02876	.02603	.02329	.02050	.01771	.01483	.01206	.00921	29.69
756	.03159	.02885	.02610	.02338	.02059	.01774	.01482	.01197	29.76
758	.03441	.03165	.02890	.02615	.02339	.02054	.01765	.01477	29.84
760	.03718	.03442	.03167	.02894	.02616	.02333	.02041	.01753	29.92
762	.04000	.03724	.03447	.03164	.02882	.02600	.02318	.02030	30.00
764	.04282	.04005	.03723	.03444	.03165	.02882	.02600	.02318	30.08
766	.04565	.04288	.04005	.03723	.03441	.03158	.02875	.02593	30.16
768	.04841	.04564	.04282	.04000	.03718	.03435	.03152	.02870	30.24
770	.05123	.04846	.04564	.04282	.04000	.03718	.03435	.03152	30.31
°F.	73.4°	74.3°	75.2°	76.1°	77.0°	77.9°	78.8°	79.7°	

°C.	27.0°	27.5°	28.0°	28.5°	29.0°	29.5°	30.0°	30.5°	inches
700	0.93159	0.93385	0.93612	0.93832	0.94063	0.94277	0.94494	0.94703	27.56
702	93435	93461	93488	93515	93542	93569	93596	93623	27.64
704	93712	93738	93765	93792	93819	93846	93873	93900	27.72
706	93994	94021	94048	94075	94102	94129	94156	94183	27.80
708	94371	94398	94425	94452	94479	94506	94533	94560	27.87
710	94747	94774	94801	94828	94855	94882	94909	94936	27.95
712	95124	95151	95178	95205	95232	95259	95286	95313	28.03
714	95500	95527	95554	95581	95608	95635	95662	95689	28.11
716	95882	95909	95936	95963	95990	96017	96044	96071	28.19
718	96269	96296	96323	96350	96377	96404	96431	96458	28.27
720	96659	96686	96713	96740	96767	96794	96821	96848	28.35
722	97041	97068	97095	97122	97149	97176	97203	97230	28.43
724	97423	97450	97477	97504	97531	97558	97585	97612	28.50
726	97805	97832	97859	97886	97913	97940	97967	97994	28.58
728	98187	98214	98241	98268	98295	98322	98349	98376	28.66
730	98569	98596	98623	98650	98677	98704	98731	98758	28.74
732	98941	98968	98995	99022	99049	99076	99103	99130	28.82
734	99313	99340	99367	99394	99421	99448	99475	99502	28.90
736	99685	99712	99739	99766	99793	99820	99847	99874	28.98
738	100067	100094	100121	100148	100175	100202	100229	100256	29.06
740	100449	100476	100503	100530	100557	100584	100611	100638	29.13
742	100831	100858	100885	100912	100939	100966	100993	101020	29.21
744	101203	101230	101257	101284	101311	101338	101365	101392	29.29
746	101585	101612	101639	101666	101693	101720	101747	101774	29.37
748	101967	101994	102021	102048	102075	102102	102129	102156	29.45
750	102349	102376	102403	102430	102457	102484	102511	102538	29.53
752	102731	102758	102785	102812	102839	102866	102893	102920	29.61
754	103113	103140	103167	103194	103221	103248	103275	103302	29.69
756	103495	103522	103549	103576	103603	103630	103657	103684	29.76
758	103877	103904	103931	103958	103985	104012	104039	104066	29.84
760	104259	104286	104313	104340	104367	104394	104421	104448	29.92
762	104641	104668	104695	104722	104749	104776	104803	104830	30.00
764	105023	105050	105077	105104	105131	105158	105185	105212	30.08
766	105405	105432	105459	105486	105513	105540	105567	105594	30.16
768	105787	105814	105841	105868	105895	105922	105949	105976	30.24
770	106169	106196	106223	106250	106277	106304	106331	106358	30.31
°F.	80.6°	81.5°	82.4°	83.3°	84.2°	85.1°	86.0°	86.9°	

°C.	31.0°	31.5°	32.0°	32.5°	33.0°	33.5°	34.0°	34.5°	35.0°	inches
700	0.90912	0.90620	0.90329	0.90038	0.89747	0.89456	0.89165	0.88874	0.88583	27.56
702	91198	90894	90590	90286	89982	89678	89374	89070	88766	27.64
704	91485	91181	90877	90573	90269	89965	89661	89357	89053	27.72
706	91773	91469	91165	90861	90557	90253	89949	89645	89341	27.80
708	92060	91756	91452	91148	90844	90540	90236	89932	89628	27.87
710	92347	92043	91739	91435	91131	90827	90523	90219	89915	27.95
712	92635	92331	92027	91723	91419	91115	90811	90507	90203	28.03
714	92922	92618	92314	92010	91706	91402	91098	90794	90490	28.11
716	93210	92906	92602	92298	91994	91690	91386	91082	90778	28.19
718	93497	93193	92889	92585	92281	91977	91673	91369	91065	28.27
720	93785	93481	93177	92873	92569	92265	91961	91657	91353	28.35
722	94073	93769	93465	93161	92857	92553	92249	91945	91641	28.43
724	94360	94056	93752	93448	93144	92840	92536	92232	91928	28.50
726	94648	94344	94040	93736	93432	93128	92824	92520	92216	28.58
728	94936	94632	94328	94024	93720	93416	93112	92808	92504	28.66
730	95224	94920	94616	94312	94008	93704	93400	93096	92792	28.74
732	95512	95208	94904	94600	94296	93992	93688	93384	93080	28.82
734	95800	95496	95192	94888	94584	94280	93976	93672	93368	28.90
736	96088	95784	95480	95176	94872	94568	94264	93960	93656	28.98
738	96376	96072	95768	95464	95160	94856	94552	94248	93944	29.06
740	96664	96360	96056	95752	95448	95144	94840	94536	94232	29.13
742	96952	96648	96344	96040	95736	95432	95128	94824	94520	29.21
744	97240	96936	96632	96328	96024	95720	95416	95112	94808	29.29
746	97528	97224	96920	96616	96312	96008	95704	95400	95096	29.37
748	97816	97512	97208	96904	96600	96296	95992	95688	95384	29.45
750	98104	97800	97496	97192	96888	96584	96280	95976	95672	29.53
752	98392	98088	97784	97480	97176	96872	96568	96264	95960	29.61
754	98680	98376	98072	97768	97464	97160	96856	96552	96248	29.69
756	98968	98664	98360	98056	97752	97448	97144	96840	96536	29.76
758	99256	98952	98648	98344	98040	97736	97432	97128	96824	29.84
760	99544	99240	98936	98632	98328	98024	97720	97416	97112	29.92
762	99832	99528	99224	98920	98616	98312	98008	97704	97400	30.00
764	100120	99816	99512	99208	98904	98600	98296	97992	97688	30.08
766	100408	100104	99800	99496	99192	98888	98584	98280	97976	30.16
768	100696	100392	100088	99784	99480	99176	98872	98568	98264	30.24
770	100984	100680	100376	100072	99768	99464	99160	98856	98552	30.31
°F.	87.8°	88.7°	89.6°	90.5°	91.4°	92.3°	93.2°	94.1°	95.0°	

EXTRACTION OF FE OXYHYDROXIDES USING THE CITRATE-DITHIONITE BICARBONATE METHOD

(Hendricks, written communication,
McKeague and Day, 1966, Mehra and Jackson, 1960)

Dithionite-citrate treatment is thought to remove the total free iron that is not included in silicate minerals; these are the crystalline oxides (goethite and hematite), amorphous hydrous oxides, and organic-bound iron.

EQUIPMENT

Centrifuge

Hot plate

30 ml repipette

190 x 100 mm pyrex dish

Centrifuge tube rack to fit pyrex dish

Thermometer

Stir rods

Spatula

50 ml centrifuge tubes with rack

100 ml or 150 ml volumetric flasks (250 ml flasks necessary for samples with >2% iron)

Semi-logarithmic paper (1 cycle x 70 Divisions)

REAGENTS

Sodium Citrate - Bicarbonate buffer:

Add 90 ml 0.3 M Na Citrate (88.23 g/l) to 10 ml 1 M NaHCO₃ (84.01 g/l)

For 2250 ml of Citrate-Bicarbonate buffer solution, add 178.67 g of Na Citrate to 2025 ml DI water, add 18.9 g of NaHCO₃ to 225 ml of DI water, and mix together.

Sodium dithionite Fe-standard

PROCEDURE

- (1) Weigh 0.5 g ground (100-mesh) soil into 50 ml centrifuge tubes (2 samples for each horizon).
- (2) Label 8 empty centrifuge tubes for standards.
- (3) Add 30 ml citrate-bicarbonate buffer to each centrifuge tube.
- (4) Place tubes in H₂O bath and bring temperature to about 80°C.
- (5) Add about 0.2 g Na₂S₂O₄. Stir for 1 minute, and then occasionally for 15 minutes.
- (6) Remove from bath. Cool solution by adding ≈ 15 ml cool distilled H₂O to tube.
- (7) Centrifuge at 1500-2000 RPM for 10 minutes (Blanks do not need to be centrifuged).
- (8) Transfer supernatant to 100 ml volumetric flask.
- (9) Repeat steps 3-8, with original sample.
- (10) Set blanks aside for preparation of standards.
- (11) Dilute to 100 ml.
- (12) Measure μg Fe in sample using atomic absorption.
- (13) Warm up the atomic absorption spectrophotometer and follow instructions for setting up recorder and lighting flame (Page 47).
 - A. To run samples place aspirator tube in sample, wait until recorder peaks and stabilizes, remove aspirator tube from sample and place in distilled water. Label peak with appropriate sample number.

- B. Run a few samples on the AA to estimate the range of iron content. Sometimes the range of the samples is outside the range (too high or too low) for the standards, or the samples fall too high on the standard curve (Fig. 8.1.)

There are two alternatives:

- (1) Change the wavelength to increase or reduce the sensitivity (Figs. 8.2 & 8.3).
 - (2) Dilute the samples. If using this option then the calculations in the spreadsheet must be changed to allow for this.
- C. Make up standards to cover this range (see standards handbook in the lab). Usually standards of 0, 10, 20, 40, 60, 80, and 120 $\mu\text{g/ml}$ are sufficient. The highest standard should fall at approximately the 80 % line on the recorder chart (Figure 8.2).
- D. Run standards, run samples, and then rerun standards. Rerun standards in middle of samples if more than 20 samples.
- E. Burner may need to be cleaned after 40 or 50 samples. To clean burner, follow shutdown procedures on page 48, through step 4. Let burner cool, remove burner and sand top and between slits with fine sand paper. Replace burner and light.

CALCULATIONS

- (1) Plot standards on semi-logarithmic paper (1 cycle x 70 divisions) (Turn paper upside-down, on bottom have $\mu\text{g/ml}$, on side have absolute value as read off of graph (Fig. 8.3)).
- (2) Use graph to determine $\mu\text{g/ml}$ of each sample.
- (3) Percent Fe = $\frac{\text{Fe}(\mu\text{g/ml}) \cdot 1.4297}{\text{Sample Wt.}}$

REMOVAL OF THE MAGNETIC FRACTION

(From Janitzky, 1986)

Magnetite must be removed from all samples prior to extraction of iron by ammonium oxalate. This procedure is performed because magnetite is soluble in ammonium oxalate, and extraction of Fe^{3+} from magnetite is not desired.

EQUIPMENT

Analytical balance

Magnetic stirrer

magnetic stirring rod (long rod with magnetic tip)

Glass plate, approximately 30 x 20 cm

tongs or tweezers, stainless steel

Crucible, porcelain or glass, 4 cm tall, 4.5 cm diameter

Small artist's paint brush, camel's hair, round tip, size 3-5

Weighing tin

PROCEDURE

- (1) Weigh 2-5 grams of soil sample ground to pass an 100-mesh sieve.
- (2) Transfer the sample quantitatively into a crucible.
- (3) Stir sample with long magnetic stirring rod. Magnetic particles will attach themselves to the tip of the rod. As they also carry along some soil particles, knock the bar against the inner walls of the crucible a few times to remove excess soil from the magnetic material.
- (4) Position a clean glass plate over a magnetic stirrer such that its right half will be located over the stirrer center.
- (5) Gently rub the stirring bar with the tongs until it appears clean.
- (6) Tap the material adhering to the tongs on the glass plate near its right edge.
- (7) Repeat steps 3-6 until no more visible accumulation of particles occurs on the stirring bar.
- (8) Turn on the magnetic stirrer. Slowly increase the stirrer to a medium setting. The magnetic particles on the plate will separate from the soil and migrate toward a spot above the center of the stirrer.
- (9) Gently stir the remaining soil with a camel hair brush while slowly moving the glass plate to the right.
- (10) Let particles collect to a whirl. Carefully stir it with the brush and move the plate farther to the right while brushing together any visible "outsiders" circling on more distant courses. By now the material should be free of any adhering soil.
- (11) When the whirl has come within approximately 5 cm of the left edge of the glass plate, turn off the stirrer and remove the plate (vertically away from the stirrer at first).
- (12) Brush material carefully into pre-weighed tin.
- (13) Record the weight of magnetic material and tin.
- (14) The sample in the crucible is saved for Fe-oxalate analysis.

CALCULATIONS

$$\% \text{ Magnetics} = \frac{(\text{Wt. of magnetic material of tin}) \text{ Wt. of tin}}{\text{Sample Wt.}}$$

EXTRACTION OF FE OXYHYDROXIDE WITH OXALATE (Figure 9.1) -
(From Hendricks, written communication, and McKeague and Day, 1966)

Oxalate treatment removes the amorphous hydrous oxides (much of which probably is ferrihydrite) and some of the organic-bound Fe.

EQUIPMENT

Scale
50 ml centrifuge tubes
20 ml repipet
Shaking table (in dark place)
Centrifuge

REAGENTS

0.4M NH_4Ox extracting solution: Dissolve 56.8g NH_4Ox in 1 liter of water. Dissolve 50.4g oxalic acid in 1 liter of water. Mix 350 ml of 0.4M NH_4Ox with 218 ml of 0.4M Oxalic acid.

0.2M NH_4Ox extracting solution: Dilute 0.4M solution for extraction.

STANDARDS

Standards must be made to duplicate the solution in the centrifuge tubes. This method makes a 0.4M solution which is then diluted by half before adding it to the centrifuge tubes. This allows for greater accuracy and less change for contamination. The problem with this method is that to create a 0.4 M solution the solutions must be heated slightly to attain total solubility. Therefore, after the extracting solution is mixed and added to the volumetrics, add enough water to bring the solution to below the 100 ml line. Let the solution cool to room temperature then top off to 100 ml.

To make 100 ml of 20, 50, 100, 200, 300 $\mu\text{g/ml}$ standards pipet 1, 5, 10, 20, 30 ml of 1000 ppm Fe standard into 100 ml volumetric flasks. Repipet 50 ml of 0.4M extracting solution to each volumetric and fill to the 100 ml mark. Shake the solution well.

PROCEDURE

- (1) Sample must be demagnetized. See Procedure for Removal of the Magnetic Fraction.
- (2) Weigh out 0.500 grams of 80-100 mesh crushed and de-magnetized sample and place in a 50 ml centrifuge tube.
- (3) Add 20 ml of 0.2 M NH_4 oxalate extracting solution.
- (4) Shake samples for 4 hours on a covered shaking table. The extracting solution is light sensitive and therefore should be covered and stored in a dark cabinet.
- (5) Centrifuge samples for 10 minutes at 1300-2000 rpm.
- (6) Analyze for Fe on the AA directly from centrifuge tube. (See for operation of AA).
- (7) Plot standards on semi-log paper, absorbance on log scale. Read values for samples off of graph.

CALCULATIONS

$$\text{Percent Iron} = \frac{\text{Fe}(\mu\text{.ml}) \cdot 20 \cdot 100 \cdot 1.4297}{\text{Sample Wt.} \cdot 1000000.}$$

STANDARD CONDITIONS FOR IRON ANALYTICAL SOLUTION

Stock solution - 1000 $\mu\text{g/ml}$ iron in aqueous solution

Iron Standard - 25ml solutions containing 10,20,30 and 40 $\mu\text{g/ml}$ iron

Optimum Working Range - 5 to 40 $\mu\text{g/ml}$ (in aqueous solution)

OPERATING CONDITIONS

Instruction Settings

Model 303

Wavelength - 2483 A

RANGE - UV
WAVELENGTH - 248

Slit

SLIT - 3 (0.3 mm, 2 A)

Source - Hollow cathode

SOURCE - Use current given on lamp.

Fuel - Acetylene
(Oxidizing flame)

FLOW¹ - 9.0

Oxidizer - (Air)

FLOW² - 9.0

Footnotes:

¹On fuel flowmeters having two float balls, flow is indicated by the upper (plastic) ball when the oxidant is air.

²Oxidant flow is the sum of the flows through the nebulizer and the auxiliary orifice.

Acetylene pressure should be 8 psig. Oxidant pressure should be set to 30 psig at the burner regulator for the Model 303, when either air or nitrous oxide is used.

ADDITIONAL ANALYTICAL INFORMATION

Sensitivity and Detection Limit - The sensitivity for iron at the 2483 A line is 0.15 $\mu\text{g/ml}$ for 1% absorption. When using the Model 303 a detection limit of 0.01 $\mu\text{g/ml}$ Fe in aqueous solutions can be achieved.

TEXTURAL ABBREVIATIONS:				MODIFIER ABBREVIATIONS:	
C	Clay	SCL	Sandy Clay Loam	vf	very fine
CL	Clay Loam	SL	Sandy Loam	f	fine
L	Loam	Si	Silt	co	coarse
LS	Loamy Sand	SiC	Silty Clay	vco	very coarse
S	Sand	SiCL	Silty Clay Loam	g	gravelly
SC	Sandy Clay	SiL	Silt Loam		

Figure A-2. Textural names and abbreviations of names versus sand-silt-clay contents.

Texture—Use established names from the textural triangle (Fig A-2). Determine the textural class of the less than 2-mm fraction by noting the grittiness and wet consistence in a rating chart (Table A-5). Broad guidelines are given in the rating chart, but for more accuracy, one should calibrate the tactile response by texturing samples with known particle-size distribution.

pH—Record specific value, using field kit.

Clay films—These are described by recording their amount, distinctness, and locations. Study with a hand lens in the field, or with a microscope in the laboratory.

Amount

v1—very few. Occupies less than 5% of the total area of the kind of surface described.

1—few. Occupies 5-25% of the total area of the kind of surface described.

2—common. Occupies 25-50% of the total area of the kind of surface described.

3—many. Occupies more than 50% of the total area of the kind of surface described.

The same classes are used to describe the amount of bridges connecting particles of structureless soil bodies. The amount is judged on the basis of the percentage of particles of the size designated that are joined to adjacent particles of similar size by bridges at contact points.

Distinctness: Distinctness refers to the ease and degree of certainty with which a surface feature can be identified. Distinctness is related to thickness, color contrast with the adjacent material, and other properties but is not itself a measure of any one of them. Some thick films, for example, are faint, whereas some thin ones are prominent. The distinctness of some surface features changes markedly as

Structure—Describe type, grade, structure size.

Type of structure: Use Table A-3 to define the type of soil structure.

Grade

m—massive. Enough aggregation to maintain a vertical face but no formation of structure type.

sg—single grain. No aggregation.

1—weak. Peds barely observable in place, and when disturbed, few entire peds are observed; much of the material is unaggregated.

2—moderate. Peds easily observable but not distinct in place, and when disturbed, many entire peds.

3—strong. Peds are distinctly visible in place, and when disturbed, nearly the entire mass consists of entire peds.

Size: Size differs with the kind of structure as shown in Table A-4.

Gravel content—Estimate volume percent occupied by gravel (>2 mm). Weight percent can be determined in the field with a screen (we use 3-mm door screen) and a hand-held portable scale. Be watchful for shape and lithologic changes during the screening process, as they may indicate parent materials of more than one origin.

Consistence—This is a measure of the adherence of the soil particles to the fingers, the cohesion of soil particles to one another, and the resistance of the soil mass to deformation. Because this property varies with moisture content, it is taken when the soil is dry, moist, and wet. The wet consistence (natural or artificial wetness) is useful in determining texture classes in the field.

Dry consistence

lo—loose. Noncoherent.

so—weakly coherent. Easily crushes to powder or single grain.

sh—slightly hard. Easily broken between thumb and forefinger.

h—hard. Can be broken in the hands without difficulty; difficult to break between thumb and forefinger.

vh—very hard. Can be broken in hands with difficulty.

eh—extremely hard. Cannot be broken in hands.

Moist consistence

lo—loose. Noncoherent.

vfr—very friable. Crushes under gentle pressure.

fr—friable. Crushes easily under gentle to moderate pressure between thumb and forefinger.

fi—firm. Crushes under moderate pressure between thumb and forefinger but resistance is distinctly noticeable.

vfi—very firm. Crushes under strong pressure, barely crushable between thumb and forefinger.

efi—extremely firm. Crushes under very strong pressure, cannot be crushed between thumb and forefinger.

Wet consistence

Stickiness is measured by pressing the wet soil between the thumb and forefinger and noting its adherence.

so—nonsticky. Practically no adherence when pressure released.

ss—slightly sticky. After pressure, soil adheres to both thumb and finger but comes off one rather cleanly. Does not appreciably stretch.

s—sticky. After pressure soil adheres to both thumb and finger and tends to stretch somewhat before pulling apart from either digit.

vs—very sticky. After pressure, soil adheres strongly to both digits and is markedly stretched when they are separated.

Plasticity is measured by rolling the wet soil between the thumb and finger and observing whether or not a wire or thin rod can be formed.

po—nonplastic. No thread can be formed.

ps—slightly plastic. Thread can be formed and mass is deformed by very slight force.

p—plastic. Thread can be formed and mass is deformed by slight force.

vp—very plastic. Thread can be formed and mass is deformed by moderate or strong force.

Table A-4.—Classes of soil structures

SIZE CLASS	DIAMETER OF GRANULES (mm)	THICKNESS OF PLATES (mm)	DIAMETER OF BLOCKS (mm)	DIAMETER OF PRISMS (mm)
vf—very fine	<1	<1	<5	<10
f—fine	1-2	1-2	5-10	10-20
m—medium	2-5	2-5	10-20	20-50
c—coarse	5-10	5-10	20-50	50-100
vc—very coarse	>10	>10	>50	>100

Table A-5.—Field criteria useful for determining major textural classes
[Modified from Foss and others (1975)]

Soil textural classes	FIELD CHARACTERISTICS							
	Feel (moist)	Ability to:		(wet consistence)			Consistence	
		Form stable ball	Ribbon out	"Soils Hands"	Plasticity	Stickiness	Moist	Dry
Sand	Very gritty	No	No	No	No	No	Loose	Loose
Loamy sand	Very gritty	No	No	Yes (slight)	No	No	Loose	Loose
Sandy loam	Gritty	Yes (easily deformed)	Yes (dull surface; poorly formed)	Yes	No	No	Very friable	Weakly coherent
Loam	Gritty	Yes	Yes (dull surface; poorly formed)	Yes	Yes (slight)	Yes (slight to sticky)	Friable	Weakly coherent
Silt loam	Velvety	Yes	Yes (dull surface; poorly formed)	Yes	Yes (slight to plastic)	Yes (slight to sticky)	Friable	Weakly coherent
Silty clay loam	Velvety and sticky	Yes (very stable)	Yes (shiny surface; well formed)	Yes	Yes (plastic)	Yes (sticky)	Friable to firm	Slightly hard
Clay loam	Gritty and sticky	Yes (very stable)	Yes (shiny surface; well formed)	Yes	Yes (plastic)	Yes (sticky)	Firm	Slightly hard to hard
Sandy clay loam	Very gritty and sticky	Yes (very stable)	Yes (shiny surface; well formed)	Yes	Yes (plastic)	Yes (sticky)	Friable to firm	Slightly hard to hard
Silty clay	Extremely sticky and very smooth	Yes (very resistant to molding)	Yes (very shiny surface; very well formed)	Yes	Yes (very)	Yes (very)	Firm to very firm	Hard to very hard
Clay	Extremely sticky	Yes (very resistant to molding)	Yes (very shiny surface; very well formed)	Yes	Yes (very)	Yes (very)	Firm to very firm	Hard to very hard

Note: All criteria, except for the right two columns, are for soil in the wet state, but not so wet that it flows off one's hand. These criteria can be used as a "general guide" to determine field textures, but local variations in organic matter, clay mineralogy, carbonate, parent material, and other factors would require adjustments before their use in a given area.

the amount of moisture changes; therefore, the soil-water state is specified. These distinctness classes are used.

f—faint. Evident only on close examination with 10X magnification and cannot be identified positively in all places without greater magnification. The contrast with the adjacent material in color, texture, and other properties is small.

d—distinct. Can be detected without magnification, although magnification or tests may be needed for positive identification. The feature contrasts enough with the adjacent material that a difference in color, texture, or other properties is evident.

p—prominent. Conspicuous without magnification when compared with a surface broken through the soil. Color, texture, or some other property or combination of properties contrasts sharply with properties of the adjacent material, or the feature is thick enough to be conspicuous.

Location of clay films: Oriented clay is present as films on peds, inside of pores, or as bridges between grains and coats on grains.

pf—clay films occur on ped faces. Where the structure grade is weak or the soil is structureless, ped faces are indistinct or absent. It is probable that only when the structure grade is moderate or strong are the clay films on ped faces discernible.

po—clay films line tubular or interstitial pores.

br—oriented clay occurs as bridges holding mineral

grains together. (This is probably an initial step that occurs before clay films coat grains and is best observed in coarse-textured soils.)

co—colloid coats mineral grains.

cob—coats and bridges are present (probably more common than coats or bridges alone).

In describing clay films, care must be exercised not to confuse pressure faces with clay films. Pressure faces may arise because of slickensides (caused by soil slip), swelling that pushes structural aggregates together and makes their sides look smooth (in places reflective) and striated, and enlargement of roots in tubular pores.

Examples of clay-film descriptions

3d po—many distinct clay films in pores.

2f pf & po—common faint clay films on peds and in pores.

3p pf, 2f po—many prominent clay films on ped faces, common faint clay films in pores.

It is important to record clay films because their presence is strong evidence for pedogenically illuvial clay. However, be warned that in places clay films can be original depositional (parent-material) features. Waters charged with fine sediment that infiltrate a flood plain can produce clay films at depth (Walker and others, 1978), as can similar waters infiltrating till at the base of a glacier. If these latter parent-material films are present below the main soil-forming zone, their color will be closer to that of the parent material than to that of the soil.

Horizon boundaries—Describe the lower boundary of each horizon, indicating distinctness and general topography.

Distinctness

- a—abrupt. Transition is less than 2 cm.
- c—clear. Transition is 2-5 cm thick.
- g—gradual. Transition is 5-15 cm thick.
- d—diffuse. Transition is more than 15 cm thick.

Topography: The modifiers sl (slightly) and v (very) may be used in combination with the following abbreviations.

- s—smooth. Boundary is parallel to surface of the soil.
- w—wavy. If pockets are wider than their depth.
- i—irregular. If irregular pockets are deeper than their width.
- b—broken. If parts of the horizon are unconnected with other parts.

Stages of carbonate morphology—Describe the stage of morphology with respect to the texture of the parent materials

as described in Tables A-6 and A-7. In some places, there may not be stage II morphology in a sequence of nongravelly soils; rather, filaments of stage I become so common that the horizon meets the approximate percent requirements for stage II. Holliday (1982) suggests that these latter occurrences be termed II_f to point out their filamentous morphology.

We want to inject a word of caution on the recognition of carbonate morphological stages. In places, carbonate can be deposited on vertical faces by laterally seeping waters and thereby mask the pedogenic carbonate morphology (Lattman, 1973). In addition, Machette and R.E. Anderson (USGS) have observed strong lateral (on contour) variations in carbonate morphology and accumulation along natural arroyos in arid parts of the eastern Great Basin. Hence, to study the morphology of pedogenic carbonate and avoid surficial cementation, one may have to dig back a meter or more.

Table A-6.—Stages of carbonate morphology in gravelly and nongravelly parent materials
[Modified from Gile and others (1966); Bachman and Machette (1977); R.R. Shroba (written commun., 1982); and Machette (1985a)]

STAGE	GRAVELLY PARENT MATERIAL	NONGRAVELLY PARENT MATERIAL
I	Thin discontinuous clast coatings; some filaments; matrix can be calcareous next to stones; about 4% CaCO ₃ .	Few filaments or coatings on sand grains; <10% CaCO ₃ .
I+	Many or all clast coatings are thin and continuous.	Filaments are common.
II	Continuous clast coatings; local cementation of few to several clasts; matrix is loose and calcareous enough to give somewhat whitened appearance.	Few to common nodules; matrix between nodules is slightly whitened by carbonate (15-50% by area), and the latter occurs in veinlets and as filaments; some matrix can be noncalcareous; about 10-15% CaCO ₃ .
II+	Same as stage II, except carbonate in matrix is more pervasive.	Common nodules; 50-90% of matrix is whitened; about 15% CaCO ₃ .
<i>Continuity of fabric high in carbonate</i>		
III	Horizon has 50-90% of grains coated with carbonate, forming an essentially continuous medium; color mostly white; carbonate-rich layers more common in upper part; about 20-25% CaCO ₃ .	Many nodules, and carbonate coats so many grains that over 90% of horizon is white; carbonate-rich layers more common in upper part; about 20% CaCO ₃ .
III+	Most clasts have thick carbonate coats; matrix particles continuously coated with carbonate or pores plugged by carbonate; cementation more or less continuous; > 40% CaCO ₃ .	Most grains coated with carbonate; most pores plugged; >40% CaCO ₃ .
<i>Partly or entirely cemented (irrespective of parent material)</i>		
IV	Upper part to K horizon is nearly pure cemented carbonate (75-90% CaCO ₃) and has a weak platy structure due to the weakly expressed laminar depositional layers of carbonate; the rest of the horizon is plugged with carbonate (50-75% CaCO ₃).	
V	Laminar layer and platy structure are strongly expressed; incipient brecciation and pisolith (thin, multiple layers of carbonate surrounding particles) formation.	
VI	Brecciation and recementation (multiple generations), as well as pisoliths, are common.	