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M. E. Harward

Soils developed on volcanic ash exhibit several unique properties not commonly observed in soils formed on other geologic material. Low thermal conductivities, low volumetric heat capacities, slow transport phenomena, excess macro-drainage and development of unique suites of clay minerals are some properties thought to be directly related to the vesicular nature of the parent ash. In order to establish cause and effect relationships in these soils one must first define the porous nature of the system. The purpose of this study was to obtain this basic information, particularly on Mazama ash. Since internal vesicular porosity of volcanic ash is thought to be a function of the properties of its parent melt, ejecta from other sources was included in the study.

Pore size distributions, determined by mercury intrusion methods, and microscopic analysis of pore shape and arrangement

indicate that differences between sources do exist. The percent pores between 30.0 and 0.2 microns is different for Mazama and Newberry ash. Newberry ash is more dense and exhibits a twisted knotty texture compared to Mazama's sub-parallel tubular pore arrangement.

Analysis of samples from a transect indicates that characteristic porosity of a given particle size of Mazama ash does not change with distance. As particle size increases, percent of pore space between 30.0 and 0.2 microns increases. For all particle sizes percentage of total volume between these pore diameters ranges from 80 to 95 percent. Larger particles are also more vesicular. The range of vesicularity for all particle sizes is 0.8 to 2.0 ml/gm. All median pore diameters are between 4 and 10 microns, regardless of particle size.

Analysis with depth in an ash deposit have implications to the effects of weathering as well as to differences in eruptive nature of the source. A major effect of weathering is to reduce the diameter of particles. In addition, weathering processes tend to decrease vesicularity of the particles by filling surface pores with weathering products. The fact that vesicularity in Newberry ash increases with depth indicates that the deposit represents one eruptive sequence. Data from Mazama deposit samples are consistent with the view that the ash fall was deposited under two levels of violence.

A Qualitative and Quantitative Characterization of Porosity in Volcanic Ash

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[redacted]

Professor of Soils
in charge of major

[redacted]

Head of Department of Soils

[redacted]

Dean of Graduate School

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INTRODUCTION

Soils developed from volcanic ash exhibit many unique properties. Low thermal conductivities, low volumetric heat capacities (Cochran, Boersma and Youngberg, 1967), excessive macro-drainage, and development of unique suites of clay minerals are some of the properties thought to be directly related to the vesicular nature of the parent ash. Chichester (1967) demonstrated the difficulty with which the ions of salt solutions diffuse into and out of the capillary spaces of volcanic ash particles, and suggested that the average solute concentration in these pores would be sufficiently high to promote the formation of 2:1 phyllosilicates.

The widespread distribution of volcanic ejecta in central Oregon (Williams, 1942) and its ultimate effect on the soils of that region resulted in the initiation of an expanded research program at Oregon State University. Two projects are now being pursued. The first, "Clays in volcanic ash deposits from Mt. Mazama, Oregon," concerns weathering processes and genesis of amorphous and crystalline clays. The second, "Physico-chemical properties of soils from volcanic ash," is concerned with elucidating the phenomena of ion exchange, diffusion and translocation in these systems. It is apparent that in both cases proper consideration must be given to the effects of the porous media.

A first step in establishing the relationship of porosity to processes in soils is a definition or characterization of the media under investigation. Information on shape and arrangement of pores, as well as limiting pore diameters is required. There is a scarcity of information concerning the characterization of porosity in volcanic ash. This is especially true for deposits in this region. This study was designed to obtain this basic background information.

The internal vesicular porosity of volcanic ash is a function of gas pressure, volatile content, temperature, rate of cooling and viscosity of the volcanic melt. These factors should vary between different volcanoes. The question arises as to the difference in porosity of ash from different sources. There are two implications to this. First, it may be possible to distinguish various sources of ash on the basis of pore size distribution curves. Secondly, any differences will affect the choice of material for subsequent diffusion studies.

Williams (1942) and Fisher (1964) have shown that ash particle size decreases with distance from Mt. Mazama. It is thought that both particle size and pore size distribution are related to the level of eruptive violence of a volcano. A distance transect extending northeast from Mt. Mazama was sampled to determine the relationship between pore size distribution and distance from the vent.

Field evidence, in the form of a particle size and color discontinuity, indicated two separate layers of ash from Mt. Mazama. At many sampling sites, this texture and color change occurs across an abrupt boundary. This fact has led to the soils being described as having a C1 and a C2 horizon to indicate a change in the parent material (Chichester, 1967). Fisher (1964) proposed the possibility that each lobe was formed by a single eruption or series of eruptions within a short time interval. Vesicularity measurements have been used to establish eruptive sequences in the Taupo area, New Zealand. A portion of this study was concerned with the changes in porosity and pore size distribution with depth in the ash deposit. Analyses with depth have implications to the effects of weathering as well as to the differences in the eruptive nature of the source.

REVIEW OF LITERATURE

Volcanic Ash Defined

Volcanic ash is a widely used phrase that, by virtue of its use, has developed many definitions. Heinrich (1956) defines volcanic ash as a natural glass froth in which the volume of pore space equals or even exceeds the volume of glass. Kennedy (1955) used the word ash to designate very small pyroclastic fragments, the product of extreme fragmentation of fresh lava. Such extreme fragmentation of liquid material produces large volume expansion, and in this sense ash formation and volcanic explosion are taken to be almost synonymous. For purposes of this study, volcanic ash is defined as uncemented pyroclastic ejecta of less than 4.0 mm diameter. The ash fraction of pyroclastic ejecta is divided into three sub-fractions: coarse ash (4.0 - 0.5 mm), medium ash (0.5 - 0.0625 mm), and fine ash (< 0.0625 mm).

Mechanics of Volcanic Ash Formation

Several theories have been proposed that attempt to explain the mechanics of volcanic eruption and attendent ash formation. These theories relate to porosity. The size of the ejected particles, the internal pore structure, and the total pore volume are a few of the latent pieces of evidence that may be correlated with the proposed theories of formation.

Kennedy

Kennedy (1955) has stated that water present in solution in a magma body will migrate and distribute itself so that its free energy will have the same ultimate value at every point in the melt, and its partial pressure will be approximately uniform throughout. It is probably the normal case that the confining pressure, the weight of the column of melt and rock above a certain point, will exceed the partial pressure of the water in the melt. In effect, the higher confining pressure increases the partial pressure of the water thereby squeezing it out of the melt. In order to approach equilibrium, water will diffuse toward areas of lower pressure and lower temperature, usually the upper portions, the cupolas, and upward extending apophyses. With the upward diffusion of the water, the vapor pressure would exceed the confining pressure and a violent explosion would ensue. With continued effusion of ejecta, pressure would decrease and the explosions would become less violent.

An interesting corallary results from the hypothesis that, as a volcanic eruption proceeds, volatile content decreases. Eruption will cease when the wet cap of the volcanic conduit has been discharged and a drier magma moves into place. Diffusion of water will again take place into the upper areas of the melt and the pressure in the upper chamber will steadily build up until it exceeds the confining pressure, permitting renewed eruption. Cyclic eruptions could be explained to have one major control, the diffusion rate of the water in the magma.

Verhoogen

Verhoogen (1951) states that ash formation depends essentially on the kinetics of gas evolution, the crucial factor being the number of bubbles per unit volume which may be present at a certain time. Initial water content of the magma, degree of oversaturation, rate at which oversaturation develops, cause of oversaturation, viscosity, surface tension, temperature, depth, nature and amount of crystals, are among the factors which determine the rate and mode of gas evolution.

Vesiculation begins when oversaturation becomes positive; that is when the vapor pressure exceeds the actual pressure and a certain amount of water comes out of solution. The newly formed bubbles will rise by buoyancy to the surface and the molten material will boil. If an extreme number of bubbles expand more rapidly than they rise, coalescense of these bubbles fragments the melt into shreds of liquid and glass. If the residual pressure in the bubbles is large, the fragments will be blown apart producing an explosion dependent on the magnitude of this pressure. If the residual pressure is low, the release may be in the form of a slowly expanding dust cloud.

The primary condition for ash formation is that the melt should lose its cohesion by coalescence of a large number of bubbles expanding radially faster than they can rise and escape at the surface. Verhoogen states that a violent explosion cannot occur at the surface of the melt if the bubble radius exceeds 1 micron. If the number of bubbles per cubic centimeter is less than 10^{12} the lava would vesiculate but not lose cohesion. The number of bubbles per cubic centimeter required to form ash decreases with increasing temperature and depth. If the temperature is 1000 degrees centigrade and the depth is 10^{4} centimeters, fragmentation will occur if there are more than a few hundred bubbles per cubic centimeter.

Ewart

Ewart (1963) separated the members of the Taupo deposit into ten eruptive sequences. Vesiculation of pumice from each sequence was studied quantitatively by comparing measurements of density and porosity (by modal analysis). In each sequence, there was a progressive decrease in vesiculation with time which was attributed to progressive volatile loss.

As a result of differences in nucleation of various pumices, three general textures can be recognized: fine cellular with thick intercellular walls, fine cellular with thin intercellular walls, and coarsely cellular pumice, usually with widely varying vesicle size. The fine cellular pumices show attenuation of vesicles due to streaming of the lava. The coarse cellular pumice has many vesicles as large as 500 microns in diameter and has a swirled knotty texture.

There is a marked difference in vesiculation between the younger eruptive sequences and the older ones. Ewart suggests that the older sequences erupted under conditions of lower vapor pressure and lower confining pressure than the newer sequences. The older sequences have greater bulk densities and more uniform particle and vesicle size. This feature must indicate very rapid freezing of the vesiculating magma due either to eruption from a shallow source or eruption of a relatively small volume of magma.

<u>Williams</u>

Williams (1942) hypothesizes that the culminating explosions of pumice and scoria from Mt. Mazama gradually increased in violence as activity proceeded. As more magma escaped and deeper, more gas-charged layers of the reservoir were tapped, the violence of the explosion continued to grow until the chamber was largely exhausted. The initial explosions were weak and the pumice fragments were at first small. Later, the size and volume of ejecta increased until toward the close, the pumice was no longer shot high above the cone but rose only a short distance above the rim and then falling on the flanks of the volcano, rushed down the canyons in the form of a glowing avalanche.

Generally, at any given locality the Mazama pumice becomes coarser from the bottom upward, again reflecting the growing violence of the eruptions. In the larger pumice lumps, the vesicles occupy much space, but the vesicles become progressively smaller as the size of the particles diminishes. Some of the finest dust is almost wholly devoid of pores.

Modriniak and Studt

Modriniak and Studt (1959) have proposed a mechanism of volcanism that is applicable to the geological structure of the Taupo-Tarawera district of New Zealand. Neglecting rigidity, the pressure imposed on a magmatic mass is due to the weight of the overlying solid crusts. This pressure P is evaluated as being equal to d_1h_1, where d_1 equals the density of the crust and h_1 equals the thickness. If the crust is fractured, liquid magma will rise along the fracture to a height h_2 such that $d_1h_1 = d_2h_2$, where d_2 is equal to the density of the magma. The excess head in the magma available to cause eruption is given by the following equation:

$$h_2 - h_1 = h_1(d_1 - d_2)/d_2 .$$

This is the height above the earth's surface to which magma can rise. If d_1 is less than d_2, there can be no eruption unless promoted by vesiculation in the vent. Vesiculation would reduce d_2 to a value less than d_1. Therefore, it may be seen that explosive vesiculation must be a major factor in violent effusions.

MATERIALS AND GENERAL METHODS

Porosimeter

Principals and Equipment

The Aminco-Winslow porosimeter is an instrument with which increments of pressure can be applied to a column of mercury that is in contact with a porous sample. The column is graduated to provide for measuring the cumulative volume of mercury intruded with increasing pressure.

Washburn (1921) states that the absolute pressure required to force mercury into a pore in solid material is inversely proportional to the size of the pore opening and is shown in equation form as

$$P = \frac{2\sigma \cos\theta}{r},$$

where P is the pressure, r is the limiting pore radius, σ is the surface tension of mercury, and θ is the angle of contact between the mercury and solid. Klock (1968), using a contact angle of 130 degrees and a surface tension of 473 dynes per cm for mercury, reduced the equation to

$$D = 175/p,$$

where D is the effective diameter of the pore in microns and p is the absolute pressure in pounds per square inch.

The Aminco-Winslow penetrometer assembly consists of a uniform bore graduated stem of length 23.3 cm fused to a 3.2 cm glass sample holder, which is sealed with a ground glass plate and a threaded collar. The reservoir volume of mercury in the graduated portion of the penetrometer stem is 0.20 ml and this limits the maximum size of particles that may be intruded.

Procedure

A sample of proper size is weighed, usually 0.1000 to 0.1500 gm for ash samples, and is placed in the penetrometer assembly. The penetrometer stem is placed in the vacuum chamber and evacuated to a pressure of less than 50 microns mercury. Once this pressure is reached, the vacuum chamber is rotated to allow the mercury in the chamber to come in contact with the base of the graduated stem. A valve on the vacuum chamber is opened to the atmosphere and the pressure in the chamber is allowed to come up to an indicated gauge pressure of 6.0 psi. The chamber is rotated back down and the reading on the graduated stem is recorded in column En of the data sheet (Table 1). Increments of pressure up to 14.7 pounds per square inch are allowed to enter and with each pressure increase the mercury volume intruded is recorded on the data sheet.

After atmospheric pressure is reached, the penetrometer

Table 1. Sample data sheet 35-3.

An Hg Head	Bn 0-15 Gauge	Cn 0-5000 Gauge	Dn Absolute Pressure	En Stem Reading	Fn Cumulative Volume	Gn Pore Diameter (μ)	Hn Percent Volume < Gn
5.12	6.0	0	0.88	.001	.000	198.864	100.0
5.00	7.0	0	2.00	.010	.009	87.500	94.4
4.94	8.0	0	3.06	.014	.013	57.190	92.0
4.91	9.0	0	4.09	.017	.016	42.787	90.1
4.89	10.0	0	5.11	.018	.017	34.247	89.5
4.87	11.0	0	6.13	.020	.019	28.548	88.3
4.85	12.0	0	7.15	.021	.020	24.476	87.7
4.84	13.0	0	8.16	.022	.021	21.446	87.0
4.81	14.0	0	9.19	.024	.023	19.042	85.8
4.77	14.7	0	9.93	.027	.026	17.623	84.0
4.56	14.7	5	15.14	.043	.042	11.559	74.1
4.39	14.7	10	20.31	.056	.055	8.616	66.0
4.20	14.7	15	25.50	.070	.069	6.863	57.4
3.91	14.7	25	35.79	.092	.091	4.890	43.8
3.57	14.7	50	61.13	.118	.117	2.863	27.8
3.34	14.7	90	101.36	.135	.134	1.727	17.3
3.25	14.7	125	136.45	.142	.141	1.283	13.0
3.18	14.7	175	186.52	.147	.146	.938	9.9
3.13	14.7	250	251.57	.151	.150	.669	7.4
3.09	14.7	400	411.61	.154	.153	.425	5.6

Continued on next page

Table I Continued.

An Hg Head	Bn 0-15 Gauge	Cn 0-5000 Gauge	Dn Absolute Pressure	En Stem Reading	Fn Cumulative Volume	Gn Pore Diameter (μ)	Hn Percent Volume < Gn
3.05	14.7	600	611.65	.157	.156	.286	3.7
3.02	14.7	1000	1011.68	.159	.158	.173	2.5
3.01	14.7	1600	1611.69	.160	.159	.109	1.9
3.00	14.7	2800	2811.70	.161	.160	.062	1.2
2.97	14.7	5000	5011.73	.163	.162	.035	0.0

assembly is placed in the pressure vessel. The pressure is increased by increments up to 5000 psi and each volume change in the hanging mercury column is recorded.

Calculation of Porosimeter Data

In order to apply the reduced equation of Klock (1968) one must first calculate the value of the absolute pressure applied. The absolute pressure is equal to the sum of the 0-15 psi gauge reading (Bn), and the 0-5000 psi gauge reading (Cn), minus the pressure required to hold the hanging mercury column (An).

The columns on the data sheet (Table 1) are defined as follows:

An = mercury head in psi

$A = H\ cm\ (13.6\ gm/cm^3)\ (6.452\ cm^2/in^2)/453.6\ gm/lb$

if $H = 26.5$ cm, then $A = 5.126\ lb/in^2$

if $H = 12.8$ cm, then $A = 2.476\ lb/in^2$

$A_{26.5} - A_{12.8}/0.200\ ml = 13.25\ lb/in^2/ml$

An = 5.13 - En (13.25)

Bn = 0-15 psi gauge reading

Cn = 0-5000 psi gauge reading

Dn = absolute pressure in psi

Dn = Bn + Cn - 5.13 + En (13.25)

En = indicated stem reading in ml

Fn = cumulative pore volume in ml

$Fn = En - E_1$

Gn = pore diameter in microns

$Gn = 175.0/Dn$

$Hn = (Fmax - Fn)/Fmax$

Hn is plotted on the ordinate and Gn is plotted on the abscissa of linear graph paper. The area under the curve is calculated by integration, assigned the proper units and designated mean volume pore diameter. This parameter is a mean obtained by weighting each pore diameter with the volume of mercury intruded at that diameter and is similar to the mean weight diameter of soil aggregates as described by van Bavel (1949). On the same graph, the pore diameter that corresponds to the 50 percent cumulative volume is designated median pore diameter.

The two other parameters measured are volume of mercury intruded per gram of sample, and the percent volume of pore space between 30.0 and 0.2 microns diameter. Marshall (1958) lists 30.0 and 0.2 microns as the diameter of pores which could be full of water at 0.1 bar tension (field moisture capacity), and 15.0 bars tension (permanent wilting point) respectively.

An initial pressure of approximately 6 psi is required to fill the penetrometer assembly with mercury. The pressure required to hold the hanging mercury column initially is 5.13 psi. The difference in these two values is 0.87 psi and by virtue of the equipment design this pressure establishes the maximum pore diameter measured as approximately 200 microns.

Reproducibility of Parameters

A reproducibility study was conducted to establish the inherent precision of each parameter measured by the mercury intrusion porosimeter. For this study, Mazama C2 ash taken from Antelope site (Appendix I) was used. The 833-701 micron fraction of the sample was separated by dry sieving. This fraction was separated into vesicular and non-vesicular components using a density separation with CCl_4 ($\rho = 1.6$) as the criterion for vesicularity (Borchardt, Theisen and Harward, 1968).

The vesicular component was dried at 110° C for 24 hours in an electric oven. This method of drying was shown to reduce the time required to evacuate the porosimeter system and also contributed to the reproducibility of the parameters. Drying in a vacuum oven or heating for longer than 24 hours did not affect the parameter values. The sample was placed in a desiccator over fresh $CaCl_2$ and allowed to cool. The vesicular component was divided into five subsamples on a Sepor Microsplitter and labeled 35-5-B through 35-5-F.

The samples were again stored in the desiccator and one sample was withdrawn and intruded each day for a period of five days. The four measured parameters were calculated for each subsample and the 90 percent confidence limits were established around the mean of each set of parameters.

It was demonstrated that the coefficients of variation are low and that the confidence limits are narrow (Table 2). Subsequent studies revealed that variability due to sample sites was greater than the variation of the determination. On the basis of this information, it was deemed unnecessary to run time consuming duplications on each sample.

Microscope

It is difficult to obtain a true perspective of size and shape of pores using natural particles. The index of refraction of the pumice glass is very near the index of the mounting medium, resulting in a low level of contrast. It was found that the porous nature of the ash is best observed using mercury intruded samples from the porosimeter. These samples were mounted in briquets of Scotchcast #3, a thermosetting resin.[1] The briquets were mounted on petrographic slides, lapped to the desired thickness and examined under reflected light on a standard petrographic microscope.

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[1] Minnesota Mining and Manufacturing Company, Minneapolis, Minn.

Table 2. Reproducibility study, sample 35-4, Mazama C2.

Sample	Mean Volume (μ)	Median Pore Diam. (μ)	Pore Volume (ml Hg/gm)	% Volume Between 30.0-0.2 micron (%)
35-4-B	23.876	7.053	0.873	76.9
35-4-C	21.015	7.067	0.854	79.5
35-4-D	21.123	7.131	0.892	79.0
35-4-E	19.508	6.834	0.822	78.7
35-4-F	20.333	6.663	0.842	79.2
Mean	21.171	6.950	0.857	78.7
C.V. %	7.77	2.81	3.09	1.31

Confidence Limits

Mean Volume Diam. (μ)	$p(19.604 < X < 22.738)$	= 90%
Median Pore Diam. (μ)	$p(6.760 < X < 7.140)$	= 90%
Pore Volume (ml Hg/gm)	$p(0.849 < X < 0.865)$	= 90%
% Volume 30.0-0.2 μ (%)	$p(77.7 < X < 79.7)$	= 90%

DIFFERENCES BETWEEN SOURCES

The internal porosity of volcanic ash is believed to be a function of various factors such as gas pressure, volatile content, temperature, rate of cooling and viscosity of the parent magma. These factors may be expected to vary between different sources. Therefore, the hypothesis was developed that different volcanic sources produce characteristic differences in the porous nature of the ejecta.

Questions of this type require some estimate of the degree to which a difference is to be accepted as real. This requires an estimate of error associated with sampling and deposit variability. The study was designed to take this into account and permit the establishment of a confidence interval around each parameter mean of different sources.

Materials and Methods

Three sites each (Table 3 and Appendix I) were sampled in the Mazama, Glacier Peak and Newberry Crater areas. The sites in the Mazama area were sampled in the C1 and C2 horizons. These horizons were considered as separate deposits in accordance with the suggestion of Fisher (1964) that the final effusion from Mt. Mazama was composed of two or more eruptions separated by a

Table 3. Locations and samples used in source-variability study.

Source	Location	Sample No.	Horizon
Mazama	Antelope Sec. 1, T.28S. R.10E.	35-3 35-4	C1 C2
	Walker Rim Sec. 18, T.26S. R.9E.	WRC1 WRC2	C1 C2
	Royce Mt. Sec. 3, T.24S. R.7E.	RMC1 RMC2	C1 C2
Newberry	China Hat Sec. 9, T.22S. R.14E.	23-1	C
	Pumice Butte Sec. 1, T.22S. R.13E.	38-1	C
	Weasel Butte Sec. 2, T.22S. R.13E.	39-1	C
Glacier Peak	Grand Coulee Sec. 15, T.23N. R.26E.	25-1	
	Phelps Creek Sec. 27, T.30N. R.16E.	45-6	IIIC2
	N. Sugarloaf Sec. 34, T.27N. R.18E.	46-4	C1

short period of time. The sites in the Glacier Peak and Newberry Crater areas were sampled only in the C horizon. The C horizons were chosen to minimize the effects of weathering on the pore size distribution.

The vesicular components of the 833-701 micron fraction were separated and pore size distributions determined in the manner previously described. The four parameters were calculated and the 90 percent confidence limits were established around the mean of each parameter for each source: Mazama, Glacier Peak and Newberry (Tables 4 and 5). The shape and arrangement of pores was evaluated on Hg-intruded samples using microscopic techniques as outlined in the general methods section.

Results

A graphical representation of the confidence limits around each parameter (Figure 1) shows the relationship between the sources. Mean volume diameter shows Glacier Peak to be different from Mazama C2 and Newberry. Median pore diameter values overlap for all sources. Pore volume separates Mazama C1 from Mazama C2 and Newberry. Percent volume between 30.0-0.2 microns overlaps only between Glacier Peak and Mazama C1.

The data suggest that the percent volume between 30.0-0.2 microns may be useful in distinguishing sources. While it is true

Table 4. Characteristics of porosity within and between different sources of ejecta, 833-701 micron fractions.

Source	Sample	Mean Volume Diam. (μ)	Median Pore Diam. (μ)	Pore Volume (ml Hg/gm)	% Volume Between 30.0-0.2μ (%)
Mazama C1	WRC1	18.2	7.5	1.15	84.1
	RMC1	20.2	8.9	1.00	83.2
	35-3	14.2	5.5	1.01	86.4
	Mean	17.5	7.3	1.05	84.7
	C.V. %	17.5	23.0	8.0	2.59
Mazama C2	WRC2	20.0	6.6	0.81	79.0
	RMC2	21.7	8.7	0.75	77.3
	35-4	21.2	7.0	0.83	78.7
	Mean	21.0	7.4	0.80	78.3
	C.V. %	4.3	18.1	4.9	1.16
Newberry C	38-1	24.4	10.0	0.80	74.3
	23-1	21.0	6.1	0.63	72.5
	39-1	22.5	8.5	0.68	74.1
	Mean	22.6	8.2	0.70	73.6
	C.V. %	7.6	24.2	13.5	1.34
Glacier Peak	46-4	11.8	5.8	0.87	88.9
	45-6	16.7	7.5	1.22	86.8
	25-1	14.6	3.9	1.04	83.3
	Mean	14.3	5.8	1.04	86.3
	C.V. %	17.2	31.7	16.6	3.28

Table 5. Confidence limits around parameters for each source.

Source	Mean Volume Diam. (μ)	Median Pore Diam. (μ)	Pore Volume (ml Hg/gm)	% Volume Between 30.0-0.2μ (%)
Mazama C1	$(12.37 < X < 22.69)$	$(4.46 < X < 10.11)$	$(0.912 < X < 1.192)$	$(81.0 < X < 88.4)$
Mazama C2	$(19.46 < X < 22.48)$	$(5.46 < X < 9.36)$	$(0.718 < X < 0.876)$	$(76.8 < X < 79.8)$
Newberry C	$(19.74 < X < 25.54)$	$(4.84 < X < 11.51)$	$(0.544 < X < 0.860)$	$(72.0 < X < 75.2)$
Glacier Peak	$(10.19 < X < 18.48)$	$(2.68 < X < 8.82)$	$(0.752 < X < 1.336)$	$(81.5 < X < 91.1)$

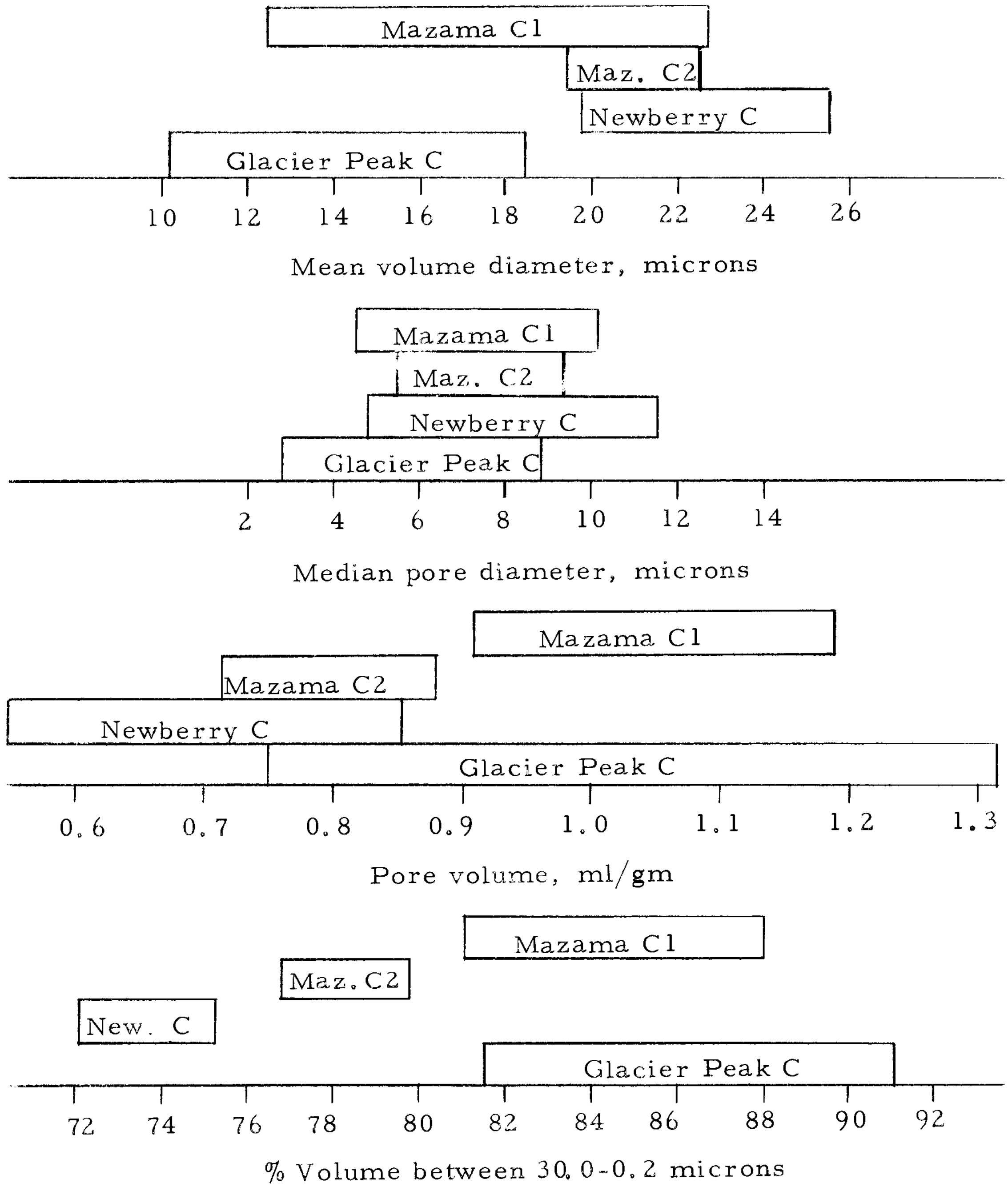
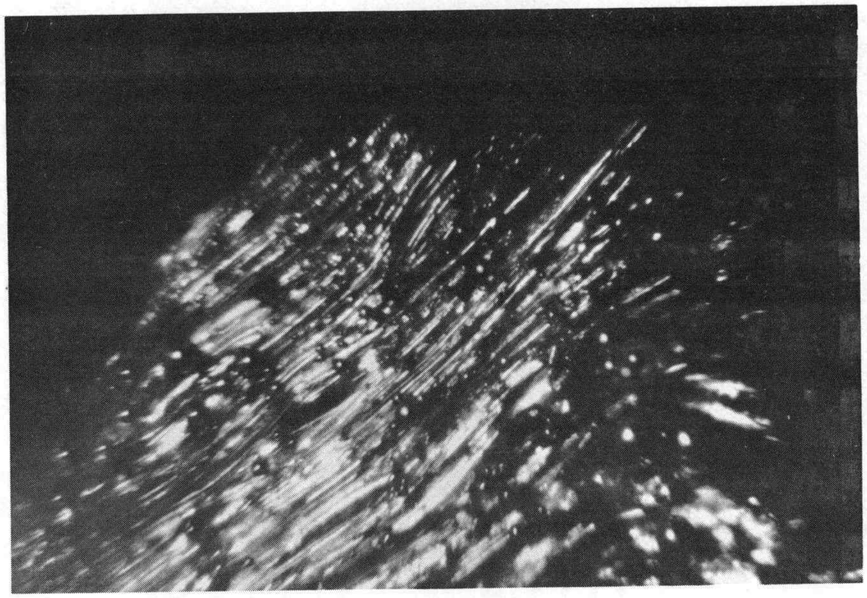


Figure 1. Graphical representation of confidence limits around parameters for each source.

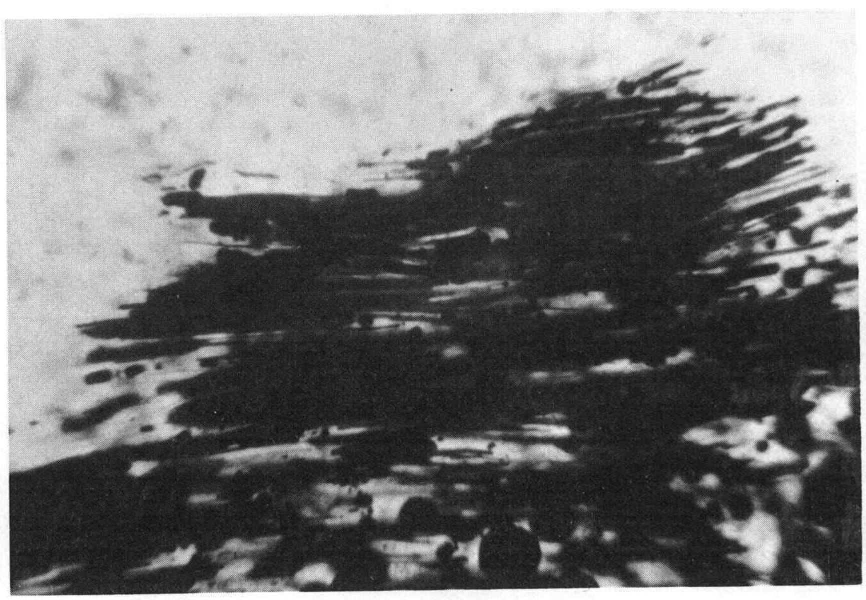
that Mazama C1 is not statistically different from Glacier Peak C at the 90 percent confidence level, field mapping and data by other investigators (Fryxell, 1965) indicates that Glacier Peak deposits overlap our study area only in northeastern Oregon. These deposits are not surfacial and are not widespread in Oregon; therefore, the question of separating these two sources is somewhat academic. Since the area of Newberry deposition is limited, the pore volume per gram of sample may also be used to differentiate Mazama C1 from Mazama C2.

Mercury intrusion by the porosimeter provided valuable information on pore volumes and limiting pore sizes. However these data do not provide information on shape and arrangement of pores. The nature of the porous matrix is revealed by examination of Hg-intruded samples with reflected light. Sample 35-4 is typical of the Mazama C2 ash in the 833-701 micron size range and is shown to be dominated by sub-parallel tubular pores (Plate 1). Approximately 80 percent of the total pore volume exists in pores between 30.0-0.2 microns diameter. These tubular pores appear as continuous threads of mercury after intrusion indicating that the pores often run the full length of the particle without constriction or deadend pockets.

The Mazama C1 (Sample 35-3) has the characteristic of very few sub-parallel pores (Plate 2). It has a very uniform texture with no large spheroidal openings or pockets. The Newberry C (Sample

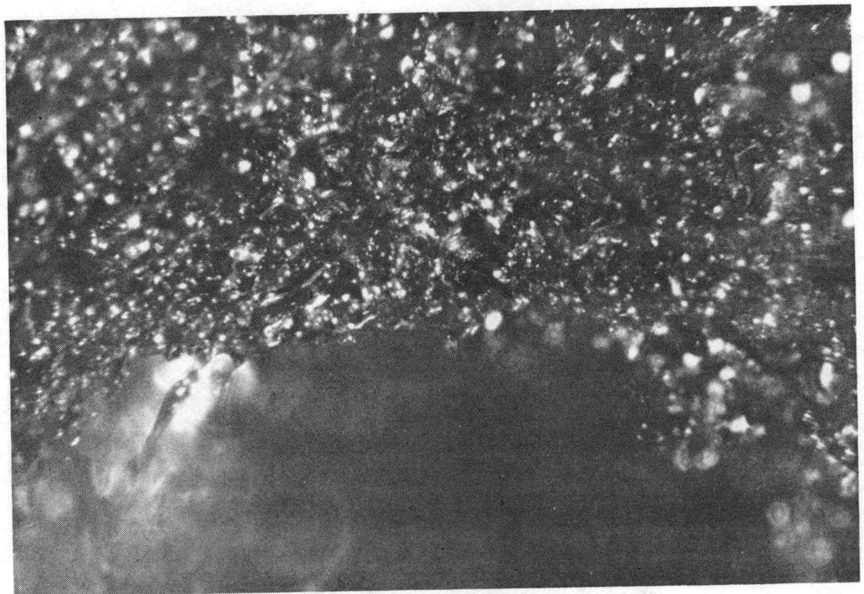


Reflected light

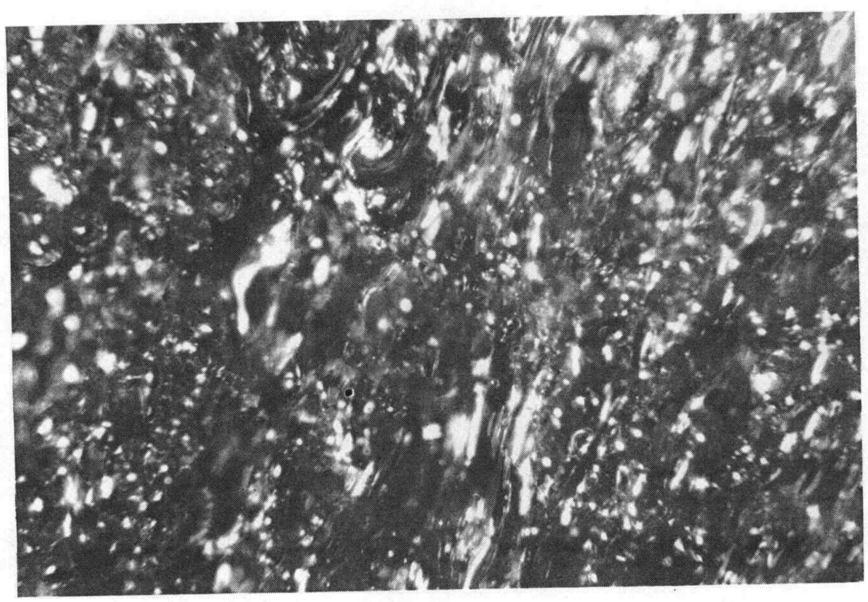


Transmitted light

Plate 1. Mazama C2, sample 35-4, Hg intruded, 833-701 micron particles, X100.



Sample 35-3, 1-2 mm.



Sample 39-1, 1.0-0.5 mm.

Plate 2. Mazama Cl, sample 35-3 and Newberry C, sample 39-1, Hg intruded, X100.

39-1) characteristically shows few sub-parallel pores and has many open cavities and large spheroidal pores in the 100-50 micron size class (Plate 2). The general texture is knotty and it has a swirled tortuous appearance.

To test for this apparent difference in tortuosity, samples 35-3 and 39-1 were intruded with Microfil MV-118, a silicon rubber injection compound having a blend viscosity of 20 centipoises.[2] The samples were suspended over the rubber compound in a vacuum chamber and the chamber was evacuated to a pressure of 500 microns mercury. The samples were allowed to drop into the injection compound and the vessel was brought to atmospheric pressure. A positive pressure of 15 psi was applied. After one hour the samples were removed and the rubber was allowed to set for 24 hours at room temperature. The samples were cut into halves and examined under the microscope.

Sample 35-3, Mazama C1, was uniformly filled with rubber while 39-1, the Newberry C sample with a similar median pore diameter (Table 4), was dominated by unfilled space in the center of the particle (Plate 3). The Newberry sample shows many large pores but it appears that these may not be connected to the surface of the particle. The more dense appearing Mazama C1 sample must have a significantly less tortuous diffusion route.

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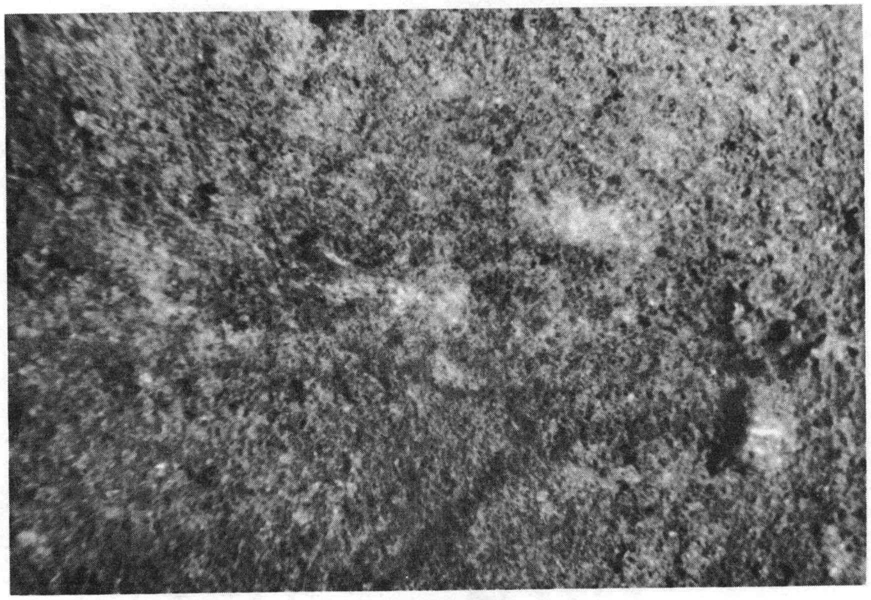
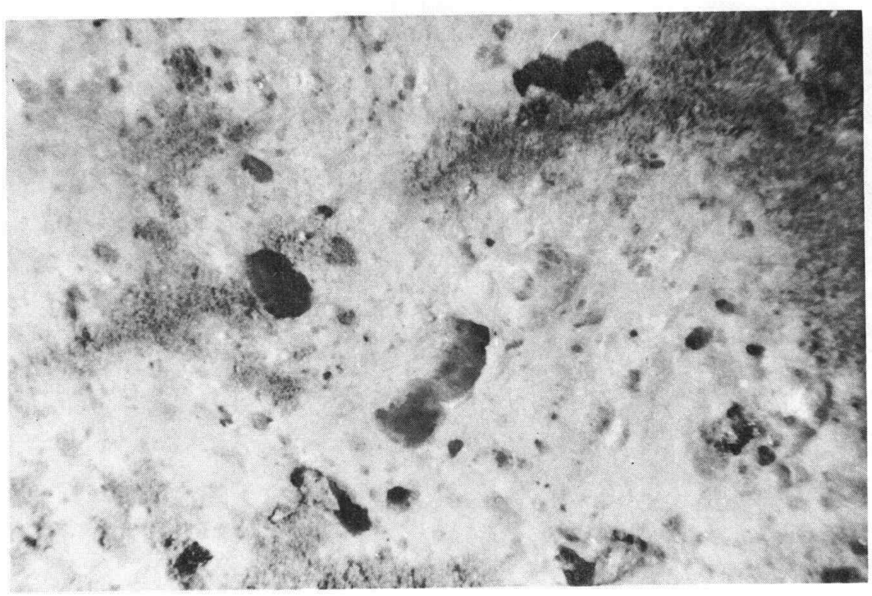
[2] Canton Bio-Medical Products, Swarthmore, Penn.



Sample 35-3



Sample 39-1

Plate 3. Mazama Cl, sample 35-3 and Newberry C, sample 39-1, rubber intruded, X6.6.

DIFFERENCES WITH DISTANCE FROM MT. MAZAMA

It has been shown that the modal particle size of the ash deposit decreases with distance from Mt. Mazama (Williams, 1942; Fisher, 1964). Both particle size and pore size distribution probably are related to the explosivity of the source (Verhoogen, 1951). In order to establish the relationship between distance and the characteristics of vesicularity, a distance transect beginning in the vicinity of Crater Lake, Oregon and extending about 445 air kilometers to the northeast corner of the state was established. This transect follows the axis of the northeast lobe on Williams (1942) isopachs map of the Mazama deposit.

The relationship of porosity with distance is of interest from another viewpoint. Chichester (1967) has shown that in addition to a predominance of amorphous component, the < 2 micron fraction from the coarse Mazama pumice contains a complex suite of 2:1 type phyllosilicates. One of the hypotheses for formation of these clay minerals concerned the poorly drained microenvironment of the porous matrix. Any differences in porosity across a distance transect has implications toward hypotheses of clay mineral genesis. Studies of clay minerals in the Mazama deposit are being pursued by another research project. Results on porosity obtained in this study will ultimately be used for correlation with clay mineral data.

Materials and Methods

Five sample sites (Table 6 and Appendix I) were chosen on broad upland topography of forest vegetation to minimize the possibility of post-depositional mixing, sorting and contamination. Samples were taken from the middle of the AC, C1 and C2 horizons at the first four sites. The AC and C horizons were sampled at the Dick Spring site as there was no good field evidence, such as a color or texture change, to indicate the presence of two C horizons (Appendix I).

From each sample the 1.0-0.5 mm size fraction was extracted by dry sieving and prepared by the methods described previously. The Dick Spring site (445 kilometers) did not yield any component with a density of less than 1.6 gm/cm^3; therefore, the non-vesicular material was collected for mercury intrusion and microscopic analysis. The sites nearer the source yielded sufficient vesicular material for mercury intrusion. The four parameters relating to porosity were calculated and the values compared to those from the Mazama variability study. In order to determine the effect of weathering on the vesicular nature of the ash, the theoretical plant available moisture in particles of this size class has been calculated for each soil horizon. These data will be discussed in the section concerned with weathering effects.

Table 6. Mazama transect samples.

Location	No.	Horizon	Depth (cm)	Distance from Crater Lake, Oregon (km)
Antelope	35-2	AC	5.1-27.9	54
Sec. 1, T.28S. R.10E.	35-3	C1	27.9-71.0	
	35-4	C2	71.0-134.5	
South Ice Cave	37-1	AC	5.1-30.5	107
Sec. 13, T.23S. R.13E.	37-2	C1	30.5-40.5	
	37-3	C2	40.5-63.5	
South Ochoco Butte	50-2	AC	18.5-45.0	222
Sec. 11, T.13S. R.20E.	50-3	C1	45.0-68.0	
	50-4	C2	68.0-85.0	
Day Creek	49-2	AC	25.0-45.0	304
Sec. 24, T.11S. R.30E.	49-3	C1	45.0-60.0	
	49-4	C2	60.0-72.0	
Dick Spring	47-2	AC	22.0-50.0	445
Sec. 11, T.3N. R.37E.	47-3	C	50.0-68.0	

Results

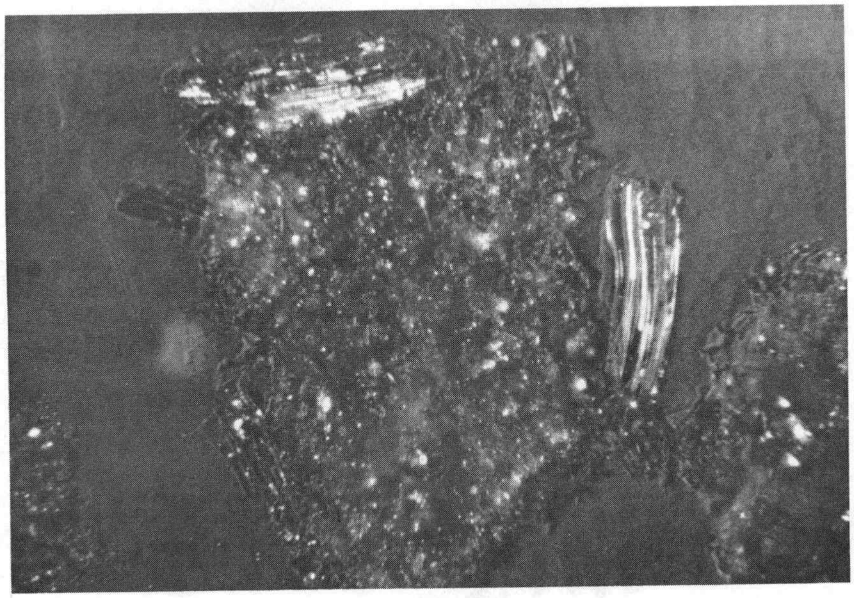
With the exception of the South Ochoco Butte C2 sample (50-4), all C1 and C2 horizons have values of percent volume between 30.0-0.2 micron that lie within the confidence limits for Mazama C1 and C2 respectively (Tables 5 and 7). Sample 50-4, described in the field as Mazama C2 on the basis of color difference (Appendix I), should possibly be changed to Mazama C1. Other data such as mechanical analysis or primary mineral distribution are needed to make the final decision.

Approximately 50 percent of the 1.0-0.5 mm size fraction from Day Creek site (49) and all of this size fraction from Dick Spring site (47) was found to have a density greater than 1.6 gm/cm^3. Plate 4 shows this dense internal structure; note the tangentially oriented material on the surface of the particle. These particles are believed to be aggregate lapilli. They are described by Pratt (1916) as having been formed around raindrops as they fell through dust-laden air. These aggregates are not uncommon and have been described by Perret (1913) and Enlows (1955). The second print on Plate 4 contrasts the vesicularity of the aggregate (left) with the vesicular ash (right). Each spot of reflected light indicates a mercury filled pore. Mercury intrusion methods show the aggregates to have only one-half the pore volume per gram

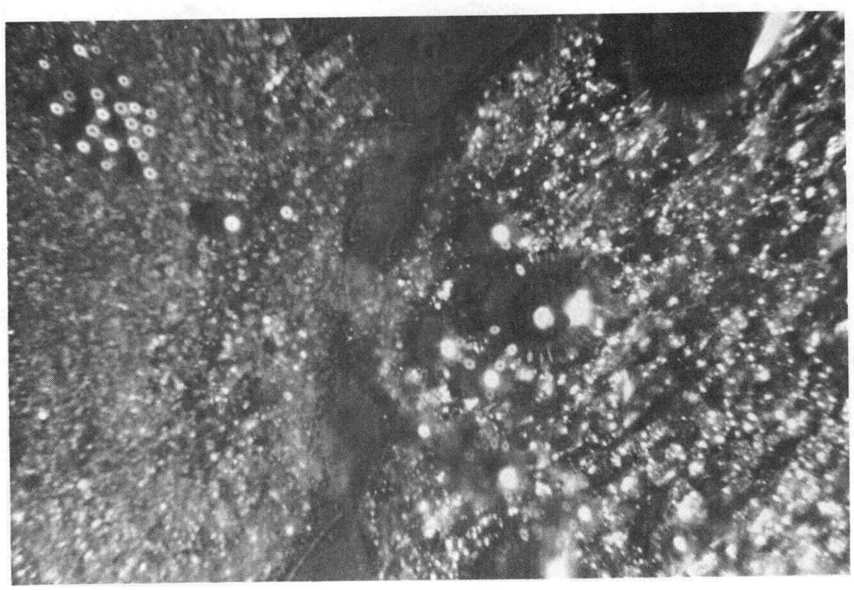
Table 7. Distance transect data from Mt. Mazama.

Site	km from source	Sample	Total Pore Volume (ml/gm)	Percent Volume			Plant Avail. Moisture (gm/gm ash)
				% < 30μ (%)	% < 0.2μ (%)	% 30-.2μ (%)	
35	(54)	2	1.197	92.1	3.2	88.9	1.06
		3	1.080	88.6	2.7	85.9	0.93
		4	0.849	81.0	4.1	76.9	0.65
37	(107)	1	1.005	87.1	3.6	83.5	0.84
		2	1.012	86.9	3.0	83.9	0.85
		3	1.033	80.1	3.5	76.6	0.79
50	(222)	2	1.117	87.5	2.9	84.6	0.85
		3	1.257	85.1	2.5	82.6	1.04
		4	1.294	90.0	1.6	88.4	1.14
49	(304)	2	1.090	84.1	3.0	81.1	0.81
		3	1.036	85.8	2.6	83.2	0.86
		4	0.744	77.7	3.7	74.0	0.55
47[1/]	(445)	2	0.428	82.3	8.1	74.2	0.32
		3	0.762	80.7	4.2	76.5	0.58

[1/] Aggregate particles (density > 1.6 gm/cm^3).



Aggregate lapilli



Aggregate (left) and vesicular (right)

Plate 4. Aggregate lapilli and vesicular material from Day Creek site (49-4), 1.0-0.5 mm, Hg intruded, X100.

expected for vesicular ash (Table 7) of this particular size.

The data indicate that vesicular coarse ash particles of a given size class have essentially the same characteristic vesicularity parameters regardless of the distance from the source (Table 7). This seems to indicate that characteristic vesicularity is strongly related to the eruptive condition under which the ash is formed. The modal particle size decreases with distance from Mt. Mazama (Williams, 1942) but the characteristic vesicularity of a given particle size does not. Applying this, it should be possible to identify the source of ejected material in any area that contains particles of a size previously used to establish limits of variability. For Mazama ash in the 1.0-0.5 mm size class, this distance is a maximum of 322 kilometers.

DIFFERENCES WITH DEPTH: WEATHERING AND ERUPTIVE SEQUENCES

Physical and chemical weathering are two processes that act on geological material when soil is formed. Vesicular volcanic ash, characterized by its large specific surface, should be extremely susceptible to weathering processes. It is important to know what effect weathering has on the internal vesicular porosity of volcanic ash. Without this information it would be impossible to define relationships to physico-chemical properties of soils developed on these materials.

Field evidence in the form of a particle size and color discontinuity indicates the possibility of two separate layers of ash from Mt. Mazama. Ewart (1963) used vesicularity measurements to establish eruptive sequences in the Taupo ash, New Zealand. A similar study of Mt. Mazama ash should produce evidence relating to the theory of two eruptive sequences.

The results obtained on transect samples demonstrate that for a given particle size, the characteristic vesicularity parameters do not vary with distance from the source. Since the mean weight particle diameter decreases with distance across a deposit, the question of relationships between particle size and vesicularity arises. This was evaluated in this study.

Materials and Methods

In order to determine the effects of weathering, the presence of eruptive sequences and relationships to particle size, sites were sampled in the Newberry and Mazama deposits (Table 8 and Appendix I). These two sites were chosen close to their respective sources in order to have sufficient depth for minimal influence of weathering in the lower horizons. The samples were taken at 10 cm intervals through the entire depth of the deposits with care being exercised that no sample was taken across a soil horizon boundary. The Huckleberry Spring site (Mazama) was 224 cm in depth and yielded 22 samples. The Red Hill site (Newberry) was 115 cm in depth yielding 11 samples. Particles in each sample were separated into seven size classes (Appendix III) by dry sieving. These size classes were prepared by the method described in the general methods section. A statistical index of particle size (mean weight diameter) for each 10 cm interval was calculated by the method of van Bavel (1949). Parameters relating to porosity were determined as previously described. The essential numerical data are recorded in Appendix III. Graphs of the more pertinent data appear in this section.

Table 8. Weathering and eruptive sequence samples.

Name	Site No.	Sample No.	Horizon
Huckleberry Spring (Mazama)	62	1	AC
	62	2 through 7	C1
	62	8 through 22	C2
Red Hill (Newberry)	65	1 and 2	AC
	65	3 through 11	C

Results

Weathering

For the Mazama (Huckleberry Spring) ash the strongest effect of weathering was to reduce the mean weight diameter. This can be seen by comparing the AC and C horizon values (Figure 3). In addition to decreasing the number of larger particles, the weathering process has reduced the volume of pores per gram of ash (Figures 2 and 3) of the remaining particles by filling the pores with weathering products. This pore filling is shown in Plate 5 to extend 200 microns into the larger vesicular particles. Beyond this distance the material appears to be fresh and unaffected by weathering.

This decrease in pore volume (ml/gm) in AC relative to C horizons is consistent with observations made on the majority of samples from the Mazama distance transect (Table 7). As C1

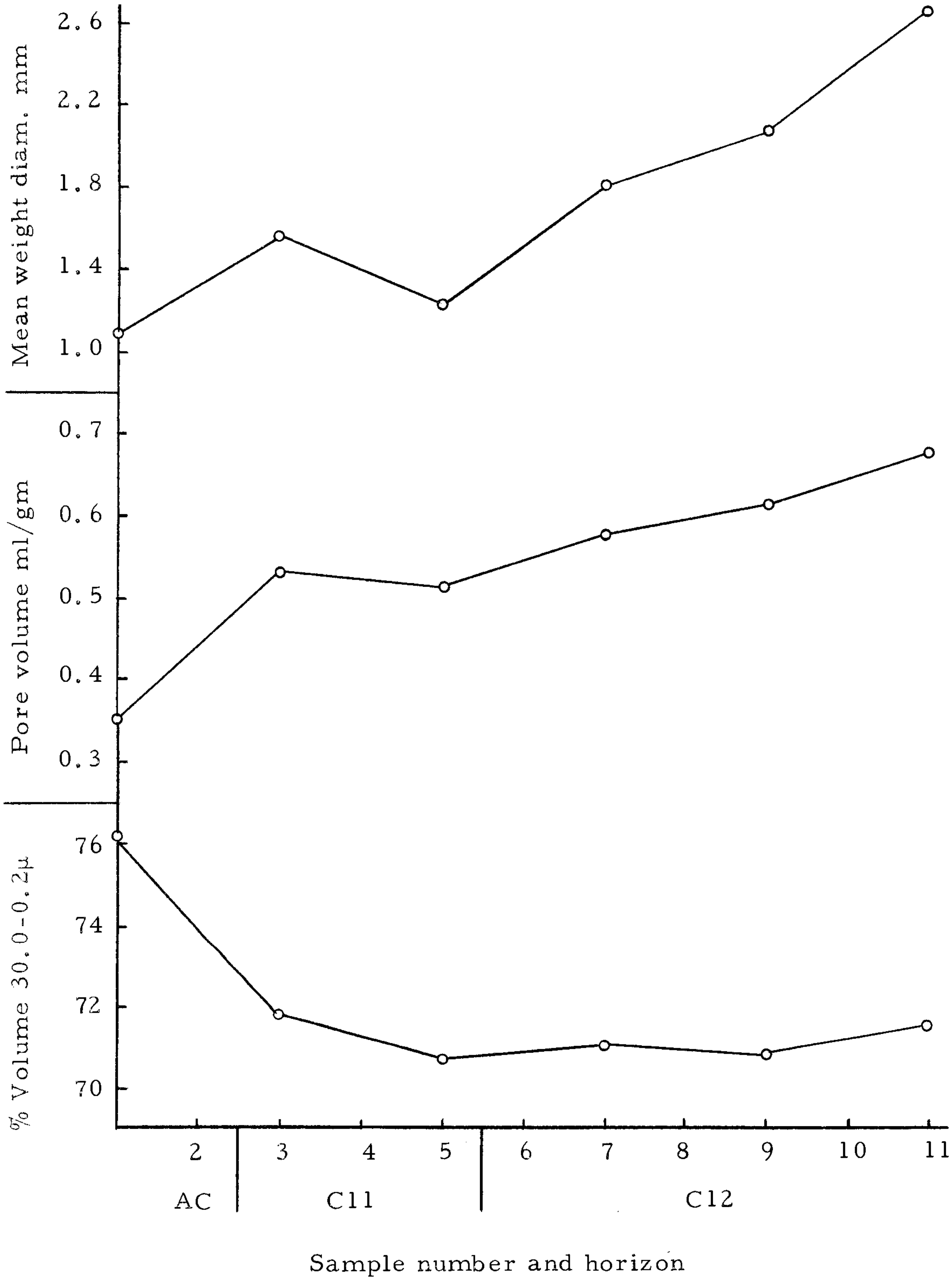


Figure 2. Parameter differences with increasing depth, Red Hill site (65), Newberry ash.

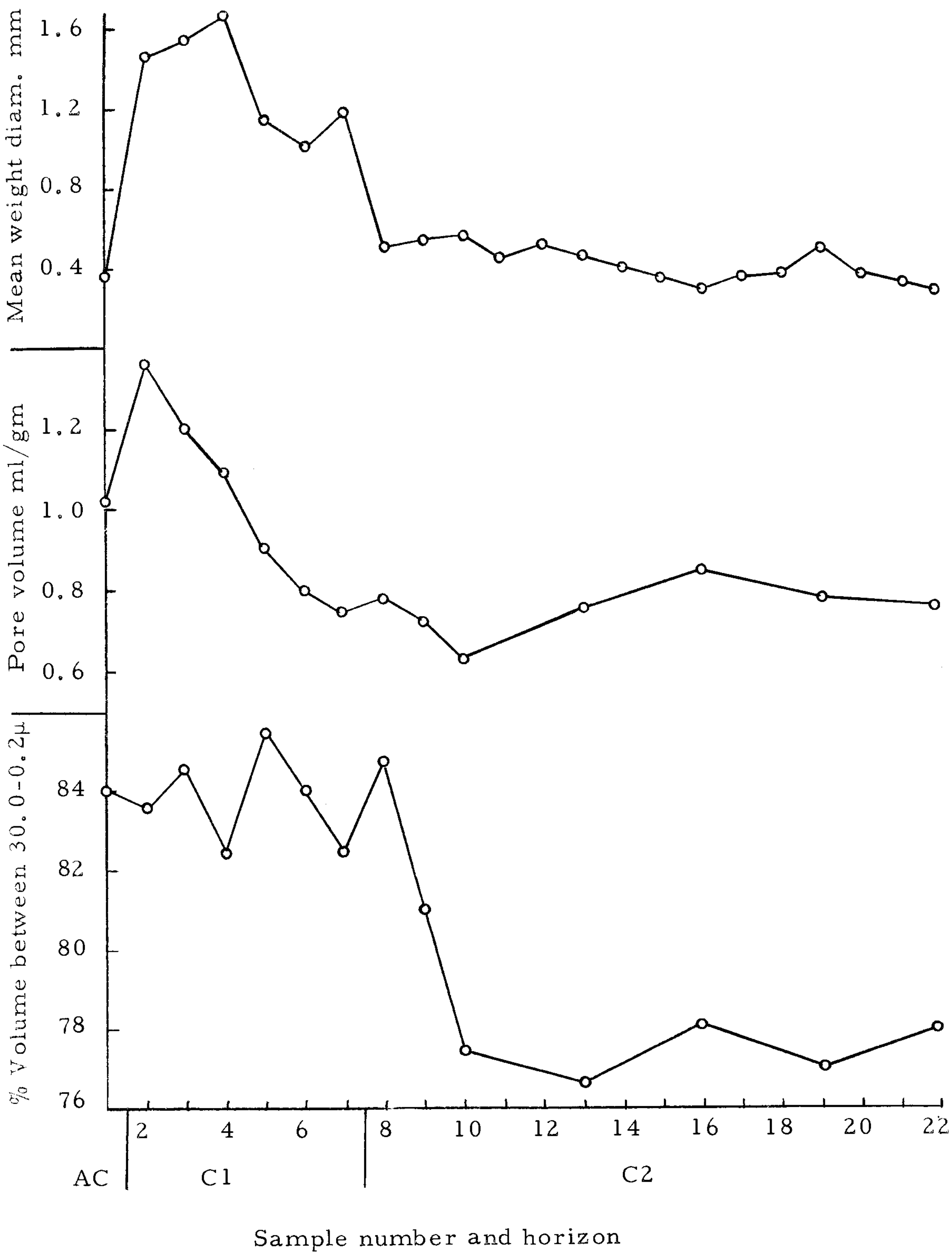


Figure 3. Parameter differences with increasing depth, Huckleberry Spring site (62) Mazama ash.

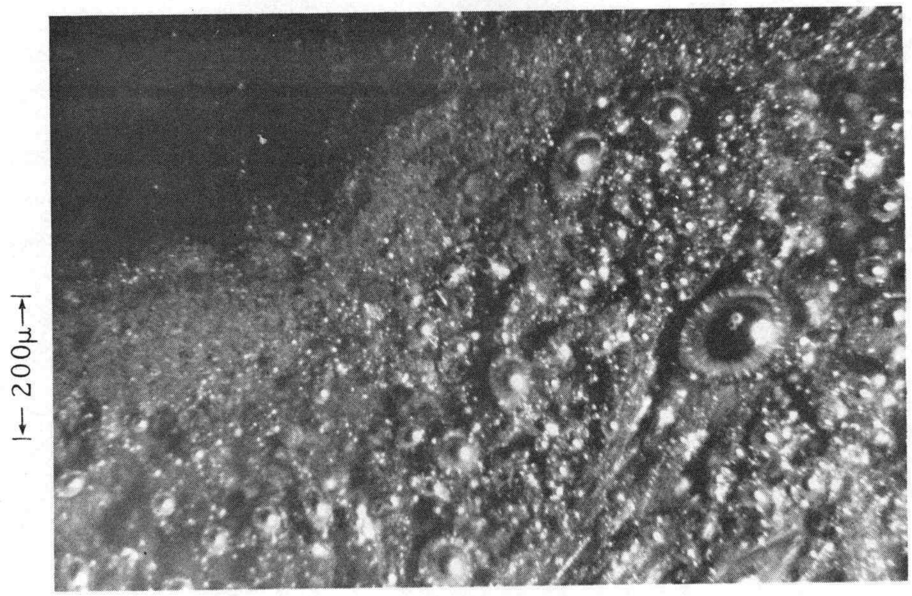


Plate 5. Weathered vesicular particle, Mazama C2, sample 35-4, Hg intruded, X100.

material is weathered and an AC horizon developed, there is an increase in the percent pore volume contained in the less than 30.0 micron diameter pores (Table 7). There is also an increase in the volume of pores smaller than 0.2 microns. The increase in the less than 0.2 micron size is not as great as the increase in the less than 30.0 micron size. This indicates that weathering processes fill the larger pores to a greater extent than the smaller pores, leading to an increase in the percent volume between 30.0 and 0.2 microns. This increase is offset by the decrease in total pore volume (ml/gm) with weathering. The theoretical plant available moisture (Table 7) tends to decrease as the 1.0-0.5 mm fraction of the deposit is weathered.

Eruptive Sequences

The Red Hill site (Newberry) yielded no evidence, based on porosity, of more than one eruptive sequence. This is consistent with field observations. The particulate mean weight diameter increases with depth (Figure 2). Below the AC horizon (65-1), the volume percent pore space between 30.0-0.3 micron does not change with increasing depth for particles in the same size class (1.0-0.5 mm). Pore volume per gram of the Newberry ash increases with depth (Figure 2). This relationship holds for both the 2.0-1.0 mm and 1.0-0.5 mm size fraction. This corresponds to a decrease in vesicularity with time in a given eruptive sequence. In many respects the Red Hill site follows the pattern of the Taupo ash deposits of New Zealand as reported by Ewart (1963). He observed a progressive decrease in vesicularity with time, hence with decreasing depth in a given eruptive layer. Ewart has also reported that higher bulk densities and tortuous knotty texture are characteristic of rapid freezing of the vesiculating magma and may be due to eruption of a small volume of magma from a shallow source.

Deposits of Newberry ash are quite localized in comparison to deposits of Mazama ash (Williams, 1942). The limited area of deposition and the characteristic porosity (smaller pore volume) and texture of the ash tend to support the premise that the Newberry eruption was less violent than the eruption of Mt. Mazama.

The Huckleberry Spring site (Mazama), as indicated previously, shows a particle size discontinuity (C1-C2 boundary) at a depth of 74 cm. Above this boundary the deposit is dominated by large yellow particles; below it the particles are smaller and grey in color (Appendix I). This boundary is commonly found in a number of areas except where post-depositional disturbance has occurred. Williams (1942) suggests that the culminating eruptions initially were mild and the fine pumice was drifted eastward by the wind. The effusion then became more violent, the pumice lumps increased in size and the wind veered toward the northeast. Such a pattern of eruption might have resulted in the particle size discontinuity observed at Huckleberry Spring site.

Particle mean weight diameter decreases between sample 62-4 and 62-8 with the sharpest decrease occurring between 62-7 and 62-8, a distance of 10 cm (Figure 3). The pore volume does not show an increase with depth as would be expected in a single eruptive sequence (Figure 3). The pore volume decreases down to 62-7 and then levels off.

The percent pore volume between 30.0-0.2 micron decreases from sample 62-8 to 62-10, a distance of 20 cm (Figure 3). The break in the curve occurs below its C1-C2 boundary. The mean value of this percent for samples 65-1, 2, 3, 4, 5, 6, 7 and 8 are significantly different at the 99.5 percent level (Appendix IV) from the mean percent of samples 65-10, 13, 16, 19 and 22.

The measured parameters for porosity do not change abruptly at the 74 cm particle size boundary. Instead, they change gradually over a 30 cm section between sample 62-7 and sample 62-10. This indicates that the column of Mazama Ash sampled at Huckleberry Spring was not deposited by two eruptions, separated by a short period of time as proposed by Fisher (1964), but was deposited by a single effusion that changed character and became more violent as eruptive activity proceeded. The abrupt boundary between the C1 and C2 ash may be a product of this increase in violence coupled with a change in wind velocity or direction as suggested by Williams (1942).

Particle Size

Both sites, Huckleberry Spring (Figure 4) and Red Hill (Figure 5) show a relationship between the diameter of the ash particles and the value of the parameters measured by mercury intrusion. There is a decrease in vesicularity (measured as milliliters of pore space per gram of ash) with decreasing particle size. There is also a decrease in the volume percent of pores in the 30.0-0.2 micron range with decreasing particle size. Pores in this size range hold moisture at 0.1 bar tension and 15 bars tension respectively (Marshall, 1958). Youngberg and Dyrness (1964) have shown that moisture held at these tensions is available to the native vegetation (ponderosa pine and snowbrush). The volume percent of pores in this size class is invariably greater in the Mazama deposit than in the Newberry, leading to the conclusion that soils developed on Mazama ash should provide better moisture relations for plants than soils developed on Newberry ash.

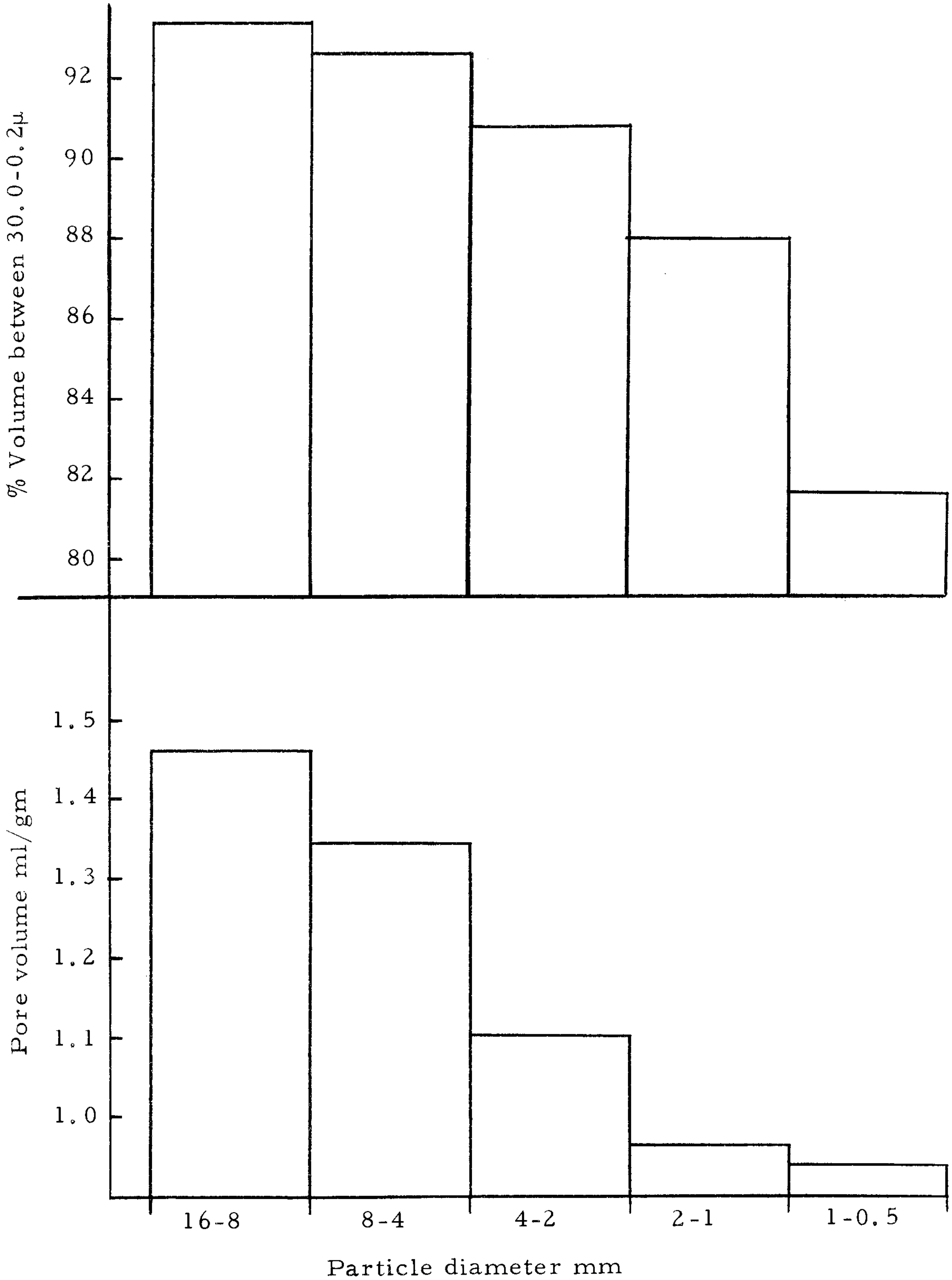


Figure 4. Parameter differences with particle size, Huckleberry Spring site (62) Mazama ash.

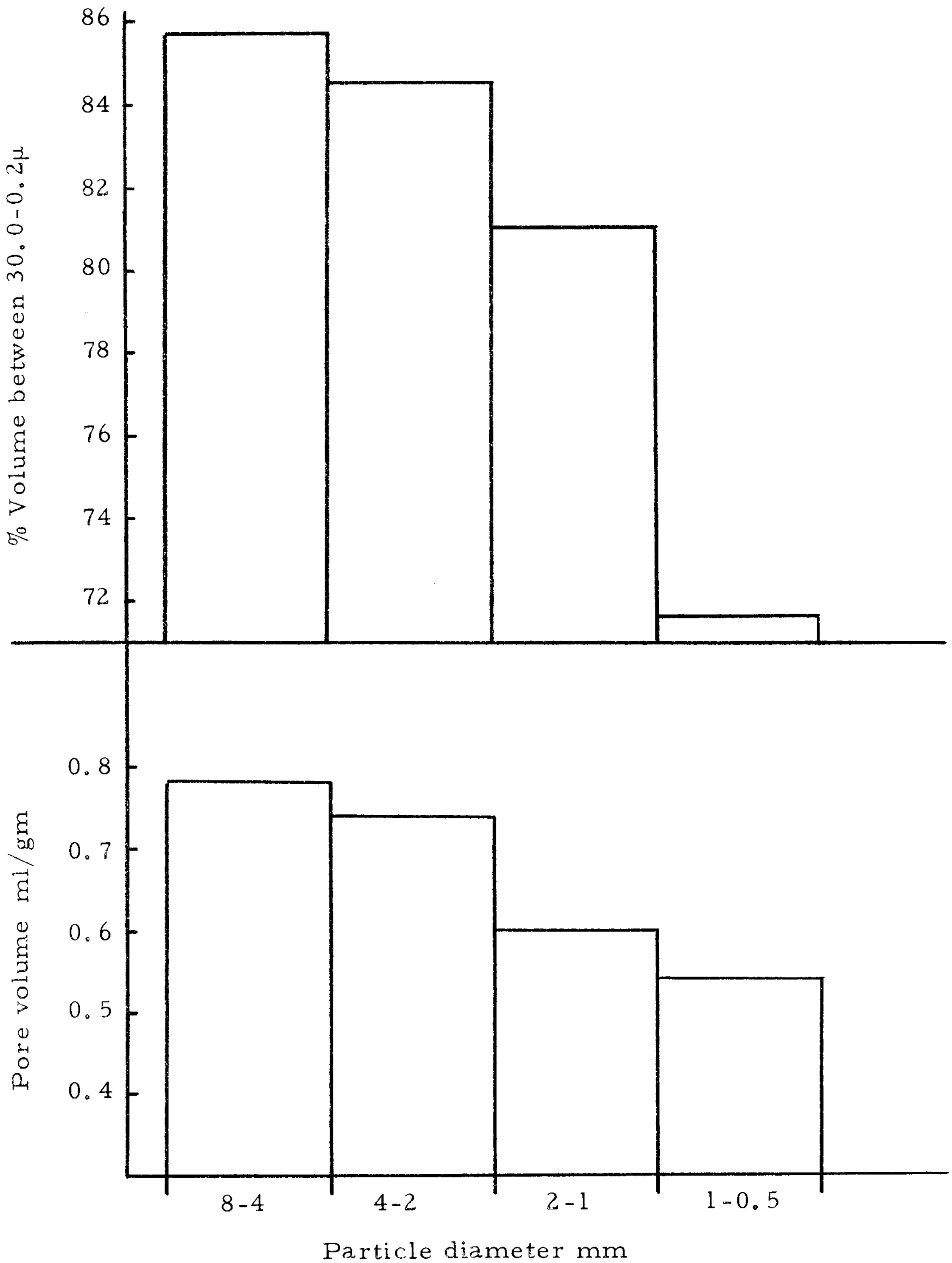


Figure 5. Parameter differences with particle size, Red Hill site (65) Newberry ash.

SUMMARY AND CONCLUSION

The mercury intrusion porosimeter provides a relatively rapid method of determining pore size distributions in porous material such as volcanic ash. The four parameters (mean volume diameter, median pore diameter, pore volume, and percent volume between 30.0-0.2 microns) used to characterize the porosity were shown to have a high level of reproducibility.

The 90 percent confidence limits for the percent volume intruded in pores between 30.0-0.2 micron diameter do not overlap for Mazama C1, Mazama C2, or Newberry deposits. This provides a property which may assist in identifying these deposits at any site sufficiently coarse to yield a vesicular component in the 1.0-0.5 mm size range.

The Newberry ash shows few sub-parallel pores. Generally, it has many large spheroidal pores in a dense, swirled, knotty matrix characteristic of eruption from a small or shallow source of magma.

Mazama C2 ash is dominated by fine tubular pores and is less vesicular than the Mazama C1 deposit. The Mazama C1 and the Glacier Peak ash are the most vesicular, indicating that they were erupted under more explosive conditions. The porosity and texture of these two sources are so nearly the same they are indistinguishable on this basis.

In all ash deposits vesicularity decreased with decreasing particle size. Also, the percent volume between 30.0-0.2 microns decreased resulting in a decrease in theoretical plant available moisture. In all size classes Mazama C1 ash should provide better moisture relations for plants than Mazama C2 or Newberry.

Data on samples of the Newberry ash suggests that the deposit represents a single eruptive sequence as defined by Ewart (1963). Data from the Huckleberry Spring site is consistent with the view that the Mazama ash fall consisted of two levels of explosivity. The C2 ash was effused under less violent conditions and then slowly over 30 cm of the column, violence increased until larger more vesicular material characterizing the C1 deposit began to fall on the site.

The major effect of weathering on volcanic ash is to reduce the mean weight particle diameter of the weathered horizon. In addition, weathering processes tend to decrease the vesicularity of the particles by filling the pores near the surface with weathering products.

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APPENDICES

APPENDIX I

SAMPLING SITE DESCRIPTIONS

Antelope Unit: Site 35

This site (Sec. 1, T.28S., R.10E.) is approximately 37 miles from the source at Crater Lake, Oregon. It is located in the coarse Mazama pumice area. The soil is mapped as Lapine and exhibits the typical profile sequence for this area: A1, AC, C1, C2. The location and details of the profile description are given by Chicester (1967). Samples were obtained from horizons adjacent to his previous sampling site.

Walker Rim: Site WR

This site (Sec. 18, T.26S., R.10E.) was sampled and described by Chichester (1967). The deposit at this location is almost identical with that at the Antelope Unit except for greater depth. The C1 layer is 61 cm thick and the C2 extends below the C1 in excess of 137 cm. Samples were available from Chichester's previous sampling and these were used in this study.

Royce Mountain: Site RM

This site, sampled and described by Chichester (1967) is located in Sec. 3, T.24S., R.7E., Klamath County, Oregon. This site is essentially the same as Antelope Unit. At the Royce Mountain site the C1 horizon is of greater thickness than the C2; just the reverse of the situation found in the Antelope Unit site. The C1 horizon dry color is more yellow (10 YR 7/8) and the C2 ash is not as grey as at Walker Rim, tending to pale yellow (2.5 Y 7/4) when moist. Samples from this site were also available from Chichester's previous study and these were used.

China Hat: Site 23

Sampled 10/26/66, by A. A. Theisen, G. A. Borchardt, and C. T. Youngberg.
Deschutes County, Oregon, Newberry area, NE 1/4, NE 1/4, sec. 9, T.22S., R.14E.
About 5100 feet elevation, 2% NW slope, well drained soil from Newberry pumice over Mazama pumice over buried soil.
Vegetation of lodgepole pine, bitterbrush, *Ribes* sp., *Carex rossii*, *Sitanion hystrix*, *Fragaria cuneifolia*, and penstemon.

Soil Profile (depths in inches)

A1 0-2	Very dark brown (10YR 2/2) gravelly loamy coarse sand; weak very fine granular structure; loose, very friable, nonplastic, nonsticky; abundant roots; boundary abrupt, smooth.
AC 2-7	Dark grayish brown (10YR 4/2) gravelly coarse sand; structureless; loose, very friable, nonplastic, nonsticky, abundant roots; boundary gradual and wavy.
C 7-28 (23-I)	Very pale brown (10YR 7/3) gravel, white (1CYR 8/1) dry, with coatings of brownish yellow (10YR 6/6) moist and yellow (10YR 8/6) dry; structureless; loose; few roots; boundary abrupt, smooth.
IIACb 28-42 (23-II)	Dark yellowish brown (10YR 4/4) loamy coarse sand; structureless; loose, very friable, nonplastic, nonsticky; common roots; boundary gradual, wavy.
IIC 42-50 (23-III)	White (10YR 8/1) when dry, coarse sand, with coatings of yellow (10YR 8/6 and 7/6); structureless; loose, nonplastic, nonsticky; few roots; boundary abrupt, smooth.
IIIB1b 50-65 (23-IV)	Dark brown (7.5YR 4/4) sandy loam, light yellowish brown (10YR 6/4) dry; massive; very friable, slightly plastic, nonsticky; few fine tubular pores; common roots; boundary gradual, wavy.
IIIB2b 65-74 (23-V)	Dark brown (10YR 4/3) loam, pale brown (10YR 6/3) dry; weak medium subangular blocky structure; friable, slightly plastic, slightly sticky; few roots; common fine tubular pores; thin patchy clay flows on peds and pores; boundary gradual, wavy.

Soil Profile (depths in inches)

IIIC 74+	Very dark grayish brown (10YR 3/2) coarse sandy loam, grayish brown (10YR 5/2) dry; massive, very friable, slightly plastic, nonsticky; few roots; few fine tubular pores.

Pumice Butte: Site 38

Sampled 11/20/67, by C. T. Youngberg.
Deschutes County, Oregon, Newberry area, NE 1/4, SE 1/4, sec. 1; T.22S., R.13E.; 25 feet north of China Hat - East Lake Road, F.S. road 2129.
About 5700 feet elevation, 4% E slope, well drained soil from Newberry pumice.
Vegetation of lodgepole pine, bitterbrush, and sparse ground cover of sedge and needle grass.

Soil Profile (depths in inches)

A1 C-2	Gravelly coarse sand.
AC 2-12	Gravelly coarse sand.
C1 12-22	Gravel
C2 22-30+ (38-I)	Gravel (sample from 39 inch depth)

Weasel Butte: Site 39

Sampled 11/20/67, by C. T. Youngberg.
Deschutes County, Oregon, Newberry area, SW 1/4, SW 1/4, sec. 2, T.22S., R.13E.; borrow pit on China Hat - East Lake Road, F. S. road 2129.
About 6200 feet elevation, 5% S slope, well drained soil from Newberry pumice.
Vegetation of ponderosa pine, lodgepole pine, mat manzanita, Ross sedge, and Stipa sp.

Soil Profile (depths in inches)

A1 O2	Gravelly coarse sand.
AC 2-17	Gravelly coarse sand.
C 17-46+ (39-I)	Gravel. (Sample from 44 to 46 inches)

Lower Grand Coulee: Site 25

This sample was provided through the courtesy of Roald Fryxell, of the Anthropology Dept., Washington State University, Pullman, Washington. This material was reported to be from Glacier Peak and corresponds to his sample L-65-1, layer G. This material had been stream deposited in what is now a dry canyon. It contained shells of fresh water mollusks which were separated during the specific gravity separation outlined under Methods.

Phelps Creek: Site 45

Sampled 8/4/67 by David Wooldridge, U. S. Forest Service, Wenatchee, Washington; M. E. Harward; A. A. Theisen; C. T. Youngberg; and E. G. Knox.
Chelan County, Washington, Wenatchee area, NW 1/4, sec. 27, T.30N., R.16E.; 75 feet southeast of F. S. road on southeast side of Phelps Creek, about 1/4 mile from end of road at edge of wilderness area.
About 3500 feet elevation, 5% west slope, well drained soil from ash, on bench below steep slopes.
Vegetation of lodgepole pine and species of Vaccanium and Gaultheria.

Soil Profile (depths in cm, colors for moist soil unless indicated otherwise, brief description)

01 2-0	
C 0-8 (45-I)	Dark gray (10YR 4/1) loamy very fine sand, gray (10YR 6/1) dry; structureless, soft, nonplastic, nonsticky; 5% dark crystals.

Soil Profile (depths in cm, colors for moist soil unless indicated otherwise, brief description)

IIBb 8-20 (45-II)	Dark yellowish brown (10YR 4/4) fine sandy loam, light yellowish brown (10YR 6/4) dry, common distinct fine mottles; structureless; very friable, nonplastic, nonsticky; 5% 1 to 3 mm particles.
IIC 20-50 (45-III)	Light brownish gray (2.5Y 6/2) loamy fine sand, mottled with light yellowish brown (2.5Y 6/4); structureless; firm, nonplastic, nonsticky; 5% 2 to 5 mm particles; boundary abrupt.
IIIBb 50-90 (45-IV)	Yellowish brown (10YR 5/6) fine sandy loam; structureless; friable, nonplastic, nonsticky; 10% 2 to 10 mm pumice particles; boundary diffuse.
IIIC1 90-100+ (45-V)	Light gray (2.5Y 7/2) pumice gravel with dominantly yellowish brown coatings (10YR 5/6, 2.5 Y 6/6, 7.5YR 5/8); 5% dark minerals. In road cut, grades to layer below.

Samples were obtained from this site because of previous work by Fryxell (1965). It is not known how close this sample site was to their original sample site although it was in the same general area. Examination of the profile in relation to topography suggested movement and redeposition of at least the upper layers. Samples of the uncoated pumice gravel were used in this study to minimize problems of contamination and on the assumption that they would most closely represent pumice from Glacier Peak.

North Sugarloaf: Site 46

Sampled 8/4/67, by David Wooldridge, U. S. Forest Service, Wenatchee, Washington; A. A. Theisen, C. T. Youngberg, M. E. Harward, and E. G. Knox.
Chelan County, Washington, Wenatchee area, probably sec. 34, T.27N., R.18E., F. S. road 2723, Entiat Mountains, ridge between Entiat River and Wenatchee River.
About 5500 feet elevation, 7% E slope, well drained soil from ash over colluvium (?); several hundred feet or more from ridge top.
Vegetation of fir, *Vaccinium scoparium*, lupine, etc.

Soil Profile (depths in cm, colors for moist soil, brief description)
01 and 02
5-0

A1 C-20 (46-I)	Dark yellowish brown (10YR 4/4) fine sandy loam; weak very fine granular structure; soft, very friable, slightly plastic, nonsticky.
B2 20-40 (46-II)	Dark yellowish brown (10YR 4/6) fine sandy loam; weak very fine granular structure; very friable, slightly plastic, nonsticky; 3% 2 to 5 mm (pumice?) particles.
B3 40-55 (46-III)	Dark yellowish brown (10YR 4/4) fine sandy loam; 5% 2 to 5 mm yellowish brown (10YR 5/4, 5/6, 5/8) pumice particles; otherwise as above.
C1 55-75 (46-IV)	Yellowish brown (10YR 5/4) loamy sand; structureless; very friable, nonplastic, nonsticky; 15% 2 to 10 mm yellow (10YR 7/6) and brownish yellow (10YR 6/6) pumice particles.
IIC2 75-90+ (46-V)	Micaceous sandy loam material with 10% of more pebbles.

This site was believed to represent ash from Glacier Peak although this was not previously established. The stratigraphic position of the C1 horizon on top of the micaceous sandy loam (possibly alluvium or glacial outwash) suggested that Glacier Peak material would most likely be in this layer. The possibility of material from other sources being present in upper horizons was recognized. The sample from the C1 horizon was therefore used in these studies.

South Ice Cave: Site 37

Sampled 11/20/67, by C. T. Youngberg.
Lake County, Oregon, Newberry area, NE 1/4, SE 1/4 sec. 13, T. 23 S., R.13E.; about 25 feet south of F.S. road 2226 at line between sections 13 and 18.
About 5100 feet elevation, level, well drained soil from Mazama pumice ash, Lapine series.
Vegetation of ponderosa pine, bitterbrush, and Idaho fescue.

Soil Profile (depths in inches)

A1 0-2	Loamy coarse sand; boundary abrupt, smooth.
AC 2-12 (37-I)	Very gravelly loamy coarse sand; boundary clear, wavy.
C1 12-16 (37-II)	Gravel; boundary clear, broken. There are inclusions of layer below in this depth range.
C2 16-27 (37-III)	Gravel; intermittent. There are inclusions of layer above in this depth range.
IIA1b 27-30+	Sandy loam.

South Ochoco Butte: Site 50

Sampled 9/15/67, by A. A. Theisen, D. P. Rai, W. H. Doak, and E. G. Knox.
Wheeler County, Oregon, Ochoco area, center of SE 1/4, sec. 11, T.13S., R.20E.; SE of Ochoco Butte, about 400 feet SE of F.S. road 127, 100 feet west of scabland boundary, on aerial photograph EJL-7-140.
About 5720 feet elevation, 2% W slope, well drained soil from ash over buried soil, on the southeast gentle side slope of a major drainage divide, about 1000 feet from the summit.
Vegetation of fir and few ponderosa pine with sparse pine grass understory.

Upper Soil Profile (depths in cm)

01 and 02 5-0	Partially decomposed litter.
A1 0-18 (50-I)	Dark brown (10YR 3/3) fine sandy loam, yellowish brown (10YR 5/4) dry, few pumice sand grains brownish yellow (10YR 6/6) when moist and very pale brown (10YR 7/3) when dry; structureless; soft, very friable, nonplastic, nonsticky; abundant interstitial pores; boundary gradual.

Upper Soil Profile (depths in cm)

AC 18-45 (50-II)	Dark yellowish brown (10YR 4/4) fine sandy loam, pale brown (10YR 6/3) dry, few pumice sand grains colored as above; structureless; soft, nonplastic, nonsticky; abundant interstitial pores; boundary gradual.
C1 45-68 (50-III)	As above but with more pumice sand grains colored as above; boundary clear, wavy.
C2 68-85 (50-IV)	Light yellowish brown (10YR 6/4) fine sandy loam, very pale brown (10YR 7/3) dry; structureless; soft, nonplastic, nonsticky; abundant interstitial pores; common black crystals; abundant medium sand pumice; boundary abrupt, wavy, extending to 85 cm in deepest parts.
IIBb 85-95+ (50-V)	Dark brown (7.5YR 3/3) loam; weak fine and very fine subangular blocky structure; hard, slightly plastic, slightly sticky; abundant very fine tubular pores.

Day Creek: Site 49

Sampled 9/14/67, by A. A. Theisen, D. P. Rai, W. H. Doak, and E. G. Knox.

Grant County, Oregon, Beech Creek area, SE 1/4, NE 1/4, sec. 24, T.11S., R.30E.; About 200 feet E of F.S. road 1130 from point on road about 200 feet S of edge of scabland, on aerial photograph EPK 8-12.

About 5840 feet elevation, 2% S slope, well drained soil from ash over buried soil, on a broad, level to gently sloping summit, cut off by side drainages from the main area of the summit.

Vegetation, severely disturbed by logging in 1967, of fir, Douglas-fir, larch, ponderosa pine, lodgepole pine, *Vaccinium scoparium* and another *V.* species.

Upper Soil Profile (depths in cm)

01 2-0	Partially decomposed litter; variable in thickness; boundary abrupt, smooth.

Upper Soil Profile (depths in cm)

A1 0-25 (49-I)	Could be designated B2. Dark brown (7.5YR 4/4) loam, light yellowish brown (10YR 6/4) dry; weak very fine granular or massive; very friable, nonplastic, nonsticky; abundant very fine interstitial pores; few black crystals; 5 to 10% soft, mostly 10YR 7/3 when moist, medium and fine sand grains (pumice); boundary clear, smooth. At upper boundary, nearly black, intermittent horizon less than 1 cm thick.
AC 25-45 (49-II)	Yellowish brown (10YR 5/4) loam, very pale brown (10YR 7/3) dry; massive; very friable, nonplastic, nonsticky; abundant very fine interstitial pores; few black crystals, 10% sand grains as above; boundary clear, wavy.
C1 45-60 (49-III)	Yellowish brown (10YR 5/4) loam, very pale brown (10YR 8/3) dry; massive; very friable, nonplastic, nonsticky; abundant very fine interstitial pores; few black crystals, 10% sand grains as above; intermittent and variable in thickness with fragments similar to horizon below in places; boundary abrupt, irregular. This boundary apparently due to mechanical disturbance. Charcoal was sampled from lower part of this horizon.
C2 60-72 (49-IV)	Very pale brown (10YR 7/3) very fine sandy loam, white (10YR 8/2) dry; massive; slightly hard, friable, brittel nonplastic, nonsticky; abundant very fine interstitial pores; few black crystals; 10% sand grains as above but without color contrast with groundmass.
IIBb 72-80+ (49-V)	Dark brown (7.5YR 3/3) loam; moderate very fine subangular blocky structure; friable, slightly plastic, slightly sticky; abundant very fine tubular pores.

Dick Spring: Site 47

Sampled 9/13/67, by A. A. Theisen, W. H. Doak, and C. G. Knox; with M. E. Harward, C. T. Youngberg, D. P. Rai, J. L. Young, and E. M. Taylor.

Umatilla County, Oregon, Tollgate area, SE 1/4, NW 1/4, sec. 11, T.3N., R.37E.; Blalock Mountain 7-1/2' top. sheet, 2.2 miles south

of Oregon 204 on dirt road, 130 feet east of road, from point on road 100 feet north of curve to east and drop in elevation, at top of slight rise.
About 4500 feet elevation, 1% slope, well drained soil from ash over a buried soil, on a broad, level ridge top.
Vegetation of grand fir, Engelmann spruce, western larch, twinflower, vanilla leaf, Vaccinium sp., oceanspray, Ribes sp. and violet.

Upper Soil Profile (depths in cm)

01 and 02 2-0	Needles and twigs, partially decomposed.
A1 0-22 (47-I)	Dark yellowish brown (10YR 4/4) silt loam, brown (10YR 5/3) dry; weak very fine granular structure or massive; soft, very friable, nonplastic, nonsticky; abundant roots; abundant very fine interstitial pores; common black particles, 0.5 to 3 mm across, mostly elongated (some, at least, are charcoal.); few, yellowish, soft, medium and fine sand grains; less than 5% dark minerals; boundary gradual, smooth. At upper boundary, intermittent horizon, less than 1 cm thick, 10YR 2/1 or 3/1, moist, and 10YR 5/1 or 6/1, dry.
AC 22-50 (47-II)	Yellowish brown (10YR 5/4) silt loam, light yellowish brown (10YR 6/4) dry; massive; soft, very friable, nonplastic, nonsticky; common roots; abundant very fine interstitial pores; common, yellowish, soft, fine and medium sand grains; less than 5% dark minerals; some portions with colors like horizon below; boundary abrupt, irregular. Form of this boundary apparently due to mechanical disturbance.
C 50-68 (47-III)	Light yellowish brown (10YR 6/4) silt loam, very pale brown (10YR 7/3) dry, with variations of 1 or 2 units of value and chroma within 20 cm laterally; massive; soft but brittle, very friable, nonplastic, nonsticky; abundant very fine interstitial pores; soft sand grains as above absent or the same color as the groundmass; less than 5% dark mineral; boundary abrupt. This may be a remnant of an ash layer older than the ash dominant in the horizons above.

Upper Soil Profile (depths in cm)

IIBb 68-90+ (47-IV)	Dark brown (7.5YR 3/4) silt loam, brown (7.5YR 5/4) dry; moderate fine and very fine subangular blocky structure; hard, friable, slightly plastic, slightly sticky abundant very fine tubular pores; about 5% pebbles; common ped coats of clean silt and sand; few small clay skins in some parts only.

Red Hill: Site 65

Sampled by M. E. Harward, W. H. Doak and J. Norgren.
This site is located in W 1/2, sec. 35, R.13E., T.21S. just east of Newberry Crater on a 5% east facing slope; approximately 1.5 miles north of Newberry-China Hat Road on F.S. road 1942.
A well drained soil on Newberry Crater pumice.

Soil Profile (depth in inches)

A1 0-2	Coarse sand.
AC 2-9	Gravelly coarse sand.
CII 9-21	Gravelly coarse sand; 40% pumice gravel > 4 mm.
C12 21-45	Gravelly coarse sand; 50% pumice gravel > 4 mm.
IIBb 45+	Loamy sand.

Huckleberry Spring: Site 62

Sampled by W. H. Doak, M. E. Haward, D. P. Rai, G. A. Borchardt and N. Christensen.
Located in an open stand of ponderosa pine in the Winema National Forest NE 1/4, sec. 36, R.9E., T.27S. Slope is SW 2-3%, well drained soil from Mazama pumice over buried soil.

Soil Profile (depth in inches)

A1 0-2	Sandy loam.
AC 2-4	Loamy coarse sand.
C1 4-29	Gravelly coarse sand; 40% pumice gravel > 8 mm.
C2 29-88	Gravelly coarse sand; 40% pumice gravel > 4 mm.
IIBb 88-95+	Fine sandy loam.

APPENDIX II. POROSIMETER DATA

Reproducability Study

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
35-4-B		35-4-C		35-4-D		35-4-E		35-4-F	
Sample Wt. 0.1580		Sample Wt. 0.1580		Sample Wt. 0.1580		Sample Wt. 0.1580		Sample Wt. 0.1580	
0	192.361	0	198.132	0	195.204	0	189.599	0	189.599
.014	83.522	.010	86.816	.011	85.690	.009	85.690	.010	85.137
.017	66.414	.013	68.480	.014	67.777	.011	68.127	.012	67.777
.019	55.353	.015	56.781	.016	56.297	.013	56.538	.014	56.297
.023	41.523	.019	42.322	.019	42.186	.016	42.322	.017	42.186
.025	33.391	.021	33.905	.022	33.732	.018	33.905	.020	33.732
.027	27.922	.023	28.281	.024	28.160	.020	28.281	.022	28.160
.029	23.992	.025	24.257	.026	24.168	.022	24.257	.024	24.168
.031	21.032	.027	21.235	.028	21.167	.024	21.235	.026	21.167
.037	17.327	.034	17.441	.035	17.395	.032	17.418	.034	17.372
.059	8.582	.057	8.604	.060	8.582	.054	8.604	.053	8.610
.087	4.293	.086	4.297	.091	4.289	.082	4.299	.083	4.297
.100	2.872	.098	2.874	.104	2.870	.094	2.875	.096	2.874
.107	2.160	.106	2.161	.112	2.158	.101	2.162	.103	2.161
.112	1.731	.111	1.732	.116	1.730	.106	1.732	.107	1.732
.117	1.285	.114	1.286	.121	1.285	.110	1.286	.114	1.286
.122	.940	.120	.940	.125	.940	.115	.940	.117	.940
.125	.670	.123	.670	.129	.670	.118	.670	.118	.670
.128	.425	.126	.426	.131	.425	.121	.426	.123	.426
.130	.286	.128	.286	.133	.286	.123	.286	.125	.286
.133	.173	.130	.173	.135	.173	.125	.173	.127	.173
.134	.109	.132	.109	.137	.109	.127	.109	.129	.109
.136	.062	.133	.062	.139	.062	.129	.062	.131	.062
.137	.044	.134	.044	.140	.044	.130	.044	.132	.044
.138	.035	.135	.035	.141	.035	.131	.035	.133	.035

Source Variability

35-3 Sample Wt. 0.1580		RM-C1 Sample Wt. 0.1580		WR-C1 Sample Wt. 0.1580		WR-C2 Sample Wt. 0.1580		RM-C2 Sample Wt. 0.1580		23-1 Sample Wt. 0.1580	
FN	GN	FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
0	195.204	0	195.204	0	189.599	0	195.204	0	195.204	0	198.132
.008	87.391	.011	85.690	.011	84.592	.009	86.816	.009	86.816	.007	88.563
.011	57.523	.016	56.297	.019	41.919	.014	56.781	.013	57.026	.012	57.523
.014	34.435	.021	33.818	.022	33.560	.019	33.992	.018	34.480	.017	34.257
.016	28.649	.023	28.220	.024	28.040	.021	28.341	.020	28.402	.019	28.525
.017	24.573	.026	24.168	.026	24.080	.023	24.301	.023	24.301	.020	24.482
.018	21.512	.028	21.167	.028	21.100	.024	21.304	.025	21.269	.021	21.442
.020	17.746	.034	17.418	.036	17.327	.030	17.511	.031	17.487	.025	17.651
.050	8.638	.081	8.466	.079	8.466	.052	8.627	.060	8.582	.041	8.695
.092	4.288	.117	4.253	.128	4.235	.077	4.309	.082	4.302	.055	4.341
.112	2.865	.129	2.855	.145	2.843	.089	2.879	.090	2.879	.062	2.897
.123	2.154	.136	2.150	.154	2.143	.095	2.164	.095	2.164	.067	2.175
.130	1.727	.139	1.725	.159	1.720	.100	1.734	.098	1.734	.071	1.741
.137	1.283	.144	1.282	.164	1.279	.105	1.287	.101	1.287	.075	1.291
.140	.939	.147	.938	.168	.937	.110	.941	.104	.941	.079	.943
.146	.669	.149	.669	.171	.668	.114	.670	.106	.670	.082	.671
.150	.425	.151	.425	.174	.425	.117	.426	.108	.426	.086	.426
.153	.286	.153	.286	.175	.286	.120	.286	.110	.286	.088	.287
.155	.173	.154	.173	.176	.173	.122	.173	.112	.173	.091	.173
.156	.109	.155	.109	.178	.109	.124	.109	.114	.109	.093	.109
.158	.062	.156	.062	.179	.062	.126	.062	.116	.062	.096	.062
.159	.044	.157	.044	.180	.044	.127	.044	.117	.044	.098	.044
.160	.035	.158	.035	.181	.035	.128	.035	.119	.035	.099	.035

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
38-1		39-1		25-1		45-6		46-6	
Sample Wt. 0.1580		Sample Wt. 0.1580		Sample Wt. 0.1580		Sample Wt. 0.1580		Sample Wt. 0.1580	
0	195.204	0	195.204	0	195.204	0	201.149	0	201.149
.011	85.690	.008	87.391	.009	86.816	.008	88.563	.004	91.004
.016	56.297	.013	57.026	.013	57.026	.015	57.026	.007	59.067
.021	41.919	.016	42.595	.015	42.732	.019	42.458	.009	43.868
.024	33.450	.018	34.080	.016	34.257	.022	33.905	.010	34.983
0.27	27.981	.021	28.341	.018	28.525	.024	28.281	.011	29.090
.031	23.949	.023	24.301	.019	24.482	.026	24.257	.011	24.944
.033	20.999	.024	21.304	.020	21.442	.028	21.235	.012	21.796
.041	17.259	.032	17.464	.026	17.604	.034	17.464	.014	17.939
.068	8.538	.053	8.621	.039	8.701	.082	8.472	.042	8.695
.088	4.293	.070	4.318	.076	4.310	.148	4.214	.084	4.302
.096	2.875	.077	2.887	.097	2.874	.165	2.834	.101	2.873
.100	2.163	.082	2.169	.112	2.158	.171	2.138	.108	2.160
.103	1.733	.085	1.737	.121	1.729	.178	1.717	.113	1.732
.107	1.287	.088	1.289	.128	1.284	.182	1.278	.118	1.286
.110	.941	.091	.942	.137	.939	.184	.936	.122	.940
.112	.670	.093	.671	.142	.669	.187	.668	.126	.670
.114	.426	.095	.426	.147	.425	.188	.425	.130	.425
.118	.286	.097	.286	.151	.286	.190	.286	.132	.286
.121	.173	.100	.173	.155	.173	.191	.173	.134	.173
.122	.109	.102	.109	.158	.109	.192	.109	.135	.109
.124	.062	.104	.062	.162	.062	.193	.062	.136	.062
.126	.044	.106	.044	.163	.044			.137	.044
.127	.035	.107	.035	.164	.035			.138	.035

Distance Transect

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
35-2		35-3		35-4		37-1		37-2		37-3	
Sample Wt. 0.1470		Sample Wt. 0.1500		Sample Wt. 0.1565		Sample Wt. 0.1533		Sample Wt. 0.1472		Sample Wt. 0.1520	
0	201.149	0	198.132	0	195.204	0	198.132	0	198.132	0	195.204
.007	89.161	.009	87.391	.012	85.137	.013	85.137	.009	87.391	.018	81.967
.010	58.285	.013	57.274	.018	55.821	.016	56.538	.014	57.026	.023	54.666
.012	43.435	.016	42.732	.021	41.919	.018	42.458	.016	42.732	.027	41.135
.013	34.707	.017	34.257	.024	33.560	.019	34.080	.018	34.168	.030	33.056
.014	28.899	.019	28.525	.026	28.040	.020	28.463	.020	28.463	.032	27.688
.015	24.757	.020	24.482	.028	24.080	.021	24.436	.021	24.436	.035	23.776
.016	21.653	.021	21.442	.030	21.100	.022	21.407	.023	21.373	.038	20.833
.017	19.241	.023	19.047	.032	18.776	.023	19.047	.025	18.992	.040	18.565
.022	17.746	.026	17.627	.035	17.395	.027	17.604	.031	17.511	.051	17.036
.048	11.509	.042	11.559	.051	11.459	.044	11.539	.052	11.459	.074	11.235
.072	8.527	.055	8.616	.060	8.582	.062	8.576	.069	8.538	.090	8.418
.089	6.796	.069	6.863	.070	6.856	.076	6.839	.084	6.810	.100	6.751
.108	4.861	.091	4.890	.083	4.902	.094	4.884	.101	4.872	.114	4.847
.127	2.857	.117	2.863	.098	2.874	.110	2.867	.116	2.863	.126	2.856
.141	1.725	.134	1.727	.109	1.732	.122	1.729	.126	1.728	.135	1.726
.149	1.292	.141	1.283	.114	1.286	.128	1.284	.131	1.284	.139	1.283
.155	.938	.146	.938	.118	.940	.133	.939	.135	.939	.142	.938
.159	.669	.150	.669	.121	.670	.138	.669	.138	.669	.145	.669
.164	.425	.153	.425	.124	.426	.143	.425	.141	.425	.148	.425
.168	.286	.156	.286	.126	.286	.146	.286	.143	.286	.150	.286
.171	.173	.158	.173	.128	.173	.149	.173	.145	.173	.152	.173
.173	.109	.159	.109	.129	.109	.151	.109	.147	.109	.154	.109
.174	.062	.160	.062	.131	.062	.153	.062	.148	.062	.156	.062
.176	.035	.162	.035	.133	.035	.154	.035	.149	.035	.157	.035

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
50-2 Sample Wt. 0.1065		50-3 Sample Wt. 0.1400		50-4 Sample Wt. 0.1538		49-2 Sample Wt. 0.1348		49-3 Sample Wt. 0.1274		49-4 Sample Wt. 0.1250	
0	198.132	0	192.361	0	198.132	0	198.132	0	198.132	0	201.149
.007	88.563	.017	81.967	.009	87.391	.012	85.690	.006	89.161	.011	86.816
.010	58.029	.021	54.893	.014	57.026	.018	56.058	.012	57.523	.016	56.781
.011	43.435	.024	41.393	.017	42.595	.020	42.186	.015	42.871	.018	42.595
.014	34.525	.025	33.391	.019	34.080	.022	33.818	.018	34.168	.020	34.080
.015	28.773	.027	27.922	.020	28.463	.024	28.220	.019	28.525	.021	28.463
.016	24.664	.028	24.036	.022	24.391	.026	24.212	.020	24.482	.022	24.436
.017	21.582	.029	21.100	.023	21.373	.027	21.235	.021	21.442	.023	21.407
.018	19.185	.031	18.776	.025	18.992	.029	18.883	.022	19.074	.024	19.047
.019	17.794	.034	17.395	.029	17.557	.030	17.534	.025	17.651	.026	17.651
.029	11.692	.054	11.419	.059	11.390	.051	11.469	.038	11.600	.035	11.640
.044	8.678	.078	8.477	.089	8.429	.070	8.532	.051	8.638	.041	8.701
.057	6.906	.098	6.755	.116	6.700	.082	6.817	.064	6.881	.048	6.943
.076	4.917	.121	4.833	.144	4.796	.099	4.875	.082	4.906	.059	4.950
.091	2.879	.141	2.847	.165	2.833	.114	2.864	.100	2.873	.070	2.893
.100	1.734	.154	1.722	.179	1.716	.124	1.729	.110	1.732	.078	1.740
.105	1.287	.159	1.280	.184	1.277	.129	1.284	.115	1.286	.081	1.290
.108	.941	.163	.937	.188	.935	.132	.939	.119	.940	.084	.942
.110	.670	.165	.668	.190	.668	.136	.670	.122	.670	.086	.671
.112	.426	.168	.425	.193	.425	.139	.425	.125	.426	.087	.426
.114	.286	.170	.286	.195	.286	.141	.286	.127	.286	.088	.287
.116	.173	.172	.173	.196	.173	.143	.173	.129	.173	.090	.173
.117	.109	.173	.109	.197	.109	.145	.109	.130	.109	.091	.109
.118	.062	.174	.062	.198	.062	.146	.062	.131	.062	.092	.062
.119	.035	.176	.035	.199	.035	.147	.035	.132	.035	.093	.035

FN	GN
47-2	
Sample Wt. 0.1564	
0	201.149
.005	90.381
.008	58.804
.010	43.723
.011	34.890
.012	29.026
.013	24.850
.014	21.724
.015	19.297
.016	17.890
.021	11.786
.024	8.799
.028	7.017
.032	5.001
.039	2.912
.045	1.747
.048	1.294
.051	.945
.054	.672
.057	.426
.060	.287
.062	.173
.064	.109
.066	.062
.067	.035

FN	GN
47-3	
Sample Wt. 0.1010	
0	201.149
.006	89.767
.010	58.285
.012	43.435
.014	34.616
.015	28.836
.016	24.711
.017	21.618
.018	19.213
.020	17.794
.029	11.702
.036	8.729
.042	6.965
.052	4.963
.061	2.898
.066	1.742
.069	1.292
.070	.943
.071	.672
.072	.426
.073	.287
.074	.173
.075	.109
.076	.062
.077	.035

Red Hill site, Newberry Crater

65-1-C
Sample Wt. 0.1120

FN	GN
0	201.149
.001	92.924
.002	60.418
.003	44.760
.004	25.278
.005	19.583
.006	18.136
.016	11.839
.022	8.811
.027	7.020
.033	4.999
.040	2.912
.049	1.746
.054	1.294
.057	.944
.060	.672
.064	.426
.067	.287
.069	.173
.071	.109
.072	.062
.073	.035

65-1-D
Sample Wt. 0.1543

FN	GN
0	201.149
.001	92.924
.002	60.418
.003	44.760
.004	35.547
.005	29.480
.006	25.182
.007	21.977
.008	19.496
.017	17.866
.025	11.744
.035	8.735
.042	6.965
.053	4.961
.065	2.896
.074	1.740
.078	1.291
.081	.943
.085	.671
.088	.426
.091	.287
.093	.173
.095	.109
.097	.062
.099	.035

65-1-E
Sample Wt. 0.1348

FN	GN
0	201.149
.001	92.924
.002	60.418
.004	44.760
.004	22.088
.006	18.136
.009	11.913
.012	8.870
.015	7.065
.021	5.022
.029	2.919
.036	1.749
.039	1.295
.042	.945
.045	.673
.047	.427
.050	.287
.052	.173
.053	.109
.056	.035
.056	.035

65-1-F
Sample Wt. 0.1704

FN	GN
0	201.149
.005	90.381
.007	59.067
.009	43.868
.010	34.983
.011	29.090
.012	19.382
.013	17.963
.016	11.839
.019	8.829
.021	7.043
.025	5.014
.032	2.917
.039	1.748
.044	1.295
.047	.945
.049	.673
.052	.427
.055	.287
.057	.173
.058	.109
.059	.062
.060	.035

65-3-C
Sample Wt. 0.1647

FN	GN
0	201.149
.001	92.924
.003	60.143
.004	44.609
.005	35.452
.006	25.182
.007	21.977
.008	19.496
.009	18.061
.021	11.786
.037	8.724
.051	6.932
.073	4.924
.093	2.878
.105	1.733
.110	1.287
.113	.941
.116	.670
.119	.426
.123	.286
.126	.173
.129	.109
.133	.062
.136	.035

65-3-D
Sample Wt. 0.1795

FN	GN
0	201.149
.002	92.275
.003	60.143
.005	44.459
.006	35.357
.007	29.349
.008	25.086
.009	21.904
.010	19.439
.011	18.012
.022	11.775
.030	8.764
.038	6.979
.048	4.971
.058	2.900
.067	1.742
.072	1.291
.075	.943
.079	.671
.083	.426
.087	.287
.091	.173
.094	.109
.098	.062
.103	.035

65-3-E — Sample Wt. 0.1775

FN	GN
0	201.149
.001	92.924
.003	60.143
.005	44.459
.006	35.357
.008	29.284
.009	25.038
.010	21.868
.011	19.410
.014	17.939
.028	11.713
.034	8.741
.042	6.965
.049	4.969
.059	2.900
.067	1.742
.071	1.291
.074	.943
.076	.672
.079	.426
.082	.287
.084	.173
.087	.109
.090	.062
.093	.035

65-3-F — Sample Wt. 0.1828

FN	GN
0	201.149
.009	87.973
.014	57.274
.017	42.732
.019	34.168
.021	28.463
.022	24.436
.024	21.373
.026	18.992
.029	17.580
.041	11.579
.047	8.666
.051	6.932
.060	4.948
.067	2.895
.075	1.740
.078	1.291
.082	.943
.084	.671
.087	.426
.089	.287
.091	.173
.093	.109
.095	.062
.097	.035

65-5-C — Sample Wt. 0.1380

FN	GN
0	201.149
.001	92.924
.002	60.418
.003	44.760
.004	29.546
.005	19.583
.006	18.136
.011	11.892
.019	8.829
.027	7.020
.037	4.991
.047	2.907
.056	1.745
.060	1.293
.064	.944
.066	.672
.070	.426
.072	.287
.075	.173
.079	.109
.082	.062
.086	.035

65-5-D — Sample Wt. 0.1812

FN	GN
0	201.149
.003	91.635
.005	59.600
.007	44.161
.009	35.075
.010	29.155
.011	24.944
.012	21.796
.013	19.354
.018	17.842
.040	11.589
.050	8.649
.061	6.896
.075	4.921
.091	2.879
.103	1.734
.109	1.287
.113	.941
.118	.670
.123	.426
.127	.286
.133	.173
.137	.109
.141	.062
.146	.035

65-5-E — Sample Wt. 0.1640

FN	GN
0	201.149
.003	91.635
.006	59.332
.008	44.014
.010	34.983
.011	29.090
.012	24.897
.014	21.724
.015	19.297
.018	17.842
.028	11.713
.034	8.741
.039	6.976
.047	4.973
.059	2.900
.069	1.742
.073	1.291
.077	.943
.081	.671
.085	.426
.088	.287
.091	.173
.094	.109
.097	.062
.099	.035

65-5-F — Sample Wt. 0.1655

FN	GN
0	201.149
.009	87.973
.013	57.523
.016	42.871
.017	34.346
.019	28.587
.020	24.527
.021	21.477
.023	19.074
.027	17.627
.033	11.661
.037	8.724
.040	6.972
.048	4.971
.053	2.903
.060	1.744
.064	1.292
.068	.944
.071	.672
.073	.426
.076	.287
.078	.173
.080	.109
.082	.062
.084	.035

65-7-C
Sample Wt. 0.1578

FN	GN
0	198.132
.003	91.004
.005	59.332
.008	43.868
.010	34.890
.011	29.026
.013	24.803
.014	21.689
.016	19.241
.021	17.746
.051	11.469
.062	8.576
.071	6.856
.081	4.908
.093	2.878
.102	1.734
.107	1.287
.111	.941
.114	.670
.118	.426
.121	.286
.125	.173
.127	.109
.130	.062
.133	.035

65-7-D
Sample Wt. 0.2295

FN	GN
0	198.132
.003	91.004
.005	59.332
.008	43.868
.009	34.983
.010	29.090
.012	24.850
.013	21.724
.015	19.269
.019	17.794
.042	11.559
.063	8.571
.071	6.856
.088	4.895
.106	2.869
.121	1.729
.127	1.284
.133	.939
.138	.669
.143	.425
.147	.286
.151	.173
.155	.109
.160	.062
.164	.035

65-7-E
Sample Wt. 0.2237

FN	GN
0	198.132
.007	88.563
.011	57.775
.015	42.871
.017	34.257
.019	28.525
.021	24.436
.023	21.373
.025	18.992
.033	17.464
.047	11.509
.056	8.610
.064	6.881
.075	4.919
.089	2.880
.101	1.734
.106	1.287
.111	.941
.115	.670
.119	.426
.123	.286
.126	.173
.130	.109
.134	.062
.139	.035

65-7-F
Sample Wt. 0.2075

FN	GN
0	198.132
.012	85.690
.017	56.297
.021	42.052
.024	33.646
.026	28.100
.029	24.080
.031	21.100
.032	18.803
.037	17.372
.050	11.479
.056	8.610
.061	6.892
.070	4.928
.081	2.885
.092	1.736
.096	1.288
.100	.941
.103	.671
.106	.426
.109	.286
.111	.173
.114	.109
.117	.062
.120	.035

65-9-C
Sample Wt. 0.1695

FN	GN
0	201.149
.003	91.635
.006	59.332
.008	44.014
.009	35.075
.011	29.090
.013	24.850
.014	21.724
.016	19.269
.022	17.746
.043	11.559
.062	8.582
.072	6.856
.091	4.892
.110	2.868
.123	1.729
.127	1.284
.132	.939
.135	.670
.140	.425
.143	.286
.148	.173
.151	.109
.155	.062
.159	.035

65-9-D
Sample Wt. 0.1620

FN	GN
0	198.132
.003	91.004
.005	59.332
.007	44.014
.008	35.075
.009	29.155
.010	24.944
.011	21.796
.012	19.354
.013	17.939
.026	11.723
.037	8.718
.047	6.943
.063	4.941
.080	2.886
.091	1.736
.096	1.288
.100	.941
.103	.671
.107	.426
.110	.286
.113	.173
.116	.109
.119	.062
.122	.035

65-9-E
Sample Wt. 0.1840

FN	GN
0	201.149
.002	92.275
.005	59.600
.008	44.014
.010	34.983
.012	29.026
.013	24.850
.014	21.724
.016	19.269
.021	17.770
.035	11.640
.044	8.684
.053	6.925
.065	4.939
.077	2.888
.086	1.738
.090	1.289
.093	.942
.096	.671
.099	.426
.102	.286
.105	.173
.108	.109
.111	.062
.115	.035

65-9-F
Sample Wt. 0.1700

FN	GN
0	198.132
.012	85.690
.016	56.538
.019	42.322
.021	33.905
.022	28.341
.024	24.301
.025	21.304
.027	18.937
.031	17.511
.044	11.539
.050	8.644
.056	6.910
.064	4.939
.074	2.890
.082	1.738
.085	1.290
.088	.942
.090	.671
.093	.426
.094	.286
.096	.173
.099	.109
.101	.062
.104	.035

65-11-C
Sample Wt. 0.1690

FN	GN
0	201.149
.002	92.275
.004	59.870
.005	44.459
.006	35.357
.007	29.349
.008	25.086
.009	21.904
.010	19.439
.012	17.987
.029	11.702
.040	8.706
.049	6.939
.059	4.950
.072	2.891
.088	1.737
.099	1.288
.107	.941
.113	.670
.119	.426
.124	.286
.130	.173
.134	.109
.138	.062
.142	.035

65-11-D
Sample Wt. 0.1720

FN	GN
0	198.132
.004	90.381
.007	58.804
.010	43.578
.012	34.707
.014	28.836
.015	24.711
.017	21.582
.020	19.129
.029	17.557
.044	11.539
.062	8.576
.076	6.839
.095	4.883
.115	2.864
.128	1.728
.134	1.283
.138	.939
.142	.669
.146	.425
.150	.286
.154	.173
.158	.109
.161	.062
.165	.035

65-11-E
Sample Wt. 0.2000

FN	GN
0	198.132
.008	87.973
.013	57.274
.017	42.595
.020	33.992
.022	28.341
.025	24.257
.028	21.201
.030	18.856
.036	17.395
.056	11.419
.067	8.549
.079	6.828
.096	4.881
.115	2.864
.127	1.728
.133	1.284
.138	.939
.142	.669
.146	.425
.149	.286
.153	.173
.157	.109
.160	.062
.164	.035

65-11-F
Sample Wt. 0.1566

FN	GN
0	201.149
.010	87.391
.015	57.026
.018	42.595
.021	33.992
.023	28.341
.025	24.301
.026	21.304
.029	18.910
.033	17.487
.045	11.539
.051	8.644
.058	6.906
.066	4.937
.076	2.889
.084	1.738
.087	1.289
.090	.942
.092	.671
.095	.426
.097	.286
.099	.173
.101	.109
.103	.062
.106	.035

Huckleberry Spring Site, Mazama

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
62-1-B		62-1-C		62-1-D		62-1-E		62-1-F		62-2-B	
Sample Wt. 0.1353		Sample Wt. 0.1540		Sample Wt. 0.1438		Sample Wt. 0.1294		Sample Wt. 0.1436		Sample Wt. 0.2748	
0	198.132	0	198.132	0	198.132	0	198.132	0	198.132	0	198.132
0	92.924	.001	92.275	.004	90.381	.002	91.635	.010	86.816	.001	92.275
0	60.695	.002	60.143	.006	59.067	.004	59.600	.014	57.026	.001	60.418
0	45.065	.002	44.760	.007	44.014	.005	44.309	.017	42.595	.001	44.912
0	35.837	.002	35.643	.008	35.075	.005	35.357	.018	34.168	.001	35.740
0	29.745	.002	29.612	.009	29.155	.006	29.349	.019	28.525	.002	29.612
0	25.424	.003	25.278	.010	24.944	.007	25.086	.020	24.482	.002	25.327
.001	22.162	.003	22.088	.011	21.796	.008	21.904	.021	21.442	.003	22.088
.002	19.641	.003	19.612	.012	19.354	.009	19.439	.022	19.074	.003	19.612
.005	18.136	.004	18.161	.014	17.914	.012	17.963	.024	17.675	.004	18.161
.089	11.102	.010	11.892	.022	11.765	.026	11.723	.046	11.519	.005	11.946
.122	8.255	.021	8.811	.031	8.753	.043	8.684	.059	8.593	.006	8.900
.139	6.623	.032	6.998	.037	6.979	.060	6.896	.070	6.860	.009	7.084
.155	4.777	.047	4.971	.044	4.976	.075	4.919	.081	4.908	.019	5.024
.167	2.832	.079	2.886	.005	2.902	.087	2.881	.095	2.876	.049	2.905
.176	1.717	.105	1.733	.067	1.742	.095	1.735	.108	1.732	.117	1.730
.180	1.278	.114	1.286	.073	1.291	.099	1.288	.116	1.286	.147	1.282
.184	.936	.120	.940	.079	.943	.103	.941	.124	.940	.164	.937
.187	.668	.125	.670	.083	.671	.105	.671	.130	.670	.175	.668
.190	.425	.130	.425	.087	.426	.108	.426	.136	.425	.185	.425
.192	.286	.134	.286	.090	.287	.110	.286	.140	.286	.190	.286
.194	.173	.137	.173	.092	.173	.112	.173	.143	.173	.194	.173
.195	.109	.138	.109	.094	.109	.113	.109	.145	.109	.197	.109
.196	.062	.139	.062	.095	.062	.114	.062	.146	.062	.198	.062
.197	.035	.140	.035	.096	.035	.115	.035	.147	.035	.199	.035

62-2-C
Sample Wt. 0.1300

FN	GN
0	198.132
.001	92.275
.003	59.870
.005	44.309
.007	35.169
.008	29.219
.011	24.897
.013	21.724
.014	19.297
.021	17.746
.055	11.429
.092	8.413
.119	6.690
.150	4.785
.173	2.828
.185	1.715
.190	1.276
.192	.935
.194	.668
.195	.425
.196	.286
.197	.173
.198	.109
.199	.062

62-2-D
Sample Wt. 0.1065

FN	GN
0	198.132
.003	91.004
.004	59.600
.005	44.309
.006	35.263
.007	29.284
.008	25.038
.009	21.868
.010	19.410
.012	17.963
.021	11.775
.033	8.741
.043	6.957
.070	4.928
.104	2.871
.123	1.729
.129	1.284
.133	.939
.136	.670
.139	.425
.140	.286
.142	.173
.143	.109
.144	.062
.145	.035

62-2-E
Sample Wt. 0.1448

FN	GN
0	198.132
.005	89.767
.007	58.804
.009	43.723
.011	34.798
.012	28.963
.013	24.803
.015	21.653
.016	19.241
.021	17.746
.045	11.529
.067	8.549
.086	6.803
.113	4.850
.138	2.850
.151	1.723
.157	1.281
.161	.937
.163	.669
.166	.425
.168	.286
.170	.173
.171	.109
.172	.062
.173	.035

62-2-F
Sample Wt. 0.1412

FN	GN
0	198.132
.014	84.592
.020	55.586
.024	41.654
.026	33.475
.029	27.922
.031	23.992
.034	20.999
.037	18.670
.045	17.191
.086	11.130
.111	8.312
.127	6.663
.146	4.792
.164	2.834
.175	1.717
.180	1.278
.184	.936
.187	.668
.190	.425
.191	.286
.193	.173
.195	.109
.196	.062
.197	.035

62-3-B
Sample Wt. 0.1269

FN	GN
0	201.149
.004	91.004
.008	58.804
.011	43.578
.012	34.798
.016	28.773
.020	24.527
.023	21.407
.026	18.992
.032	17.511
.066	11.331
.084	8.461
.103	6.748
.128	4.825
.145	2.846
.156	1.722
.161	1.280
.165	.937
.168	.668
.171	.425
.173	.286
.176	.173
.177	.109
.179	.062
.181	.035

62-3-C
Sample Wt. 0.1547

FN	GN
0	201.149
.002	92.275
.003	60.143
.004	44.609
.006	35.357
.007	29.349
.008	25.086
.009	21.904
.010	19.439
.011	18.012
.018	11.818
.022	8.811
.025	7.028
.039	4.988
.072	2.891
.103	1.734
.116	1.286
.122	.940
.130	.670
.133	.425
.136	.286
.137	.173
.139	.109
.140	.062
.141	.035

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
62-3-D		62-3-E		62-3-F		62-4-B		62-4-C		62-4-D	
Sample Wt. 0.1524		Sample Wt. 0.1500		Sample Wt. 0.1205		Sample Wt. 0.1357		Sample Wt. 0.1252		Sample Wt. 0.1421	
0	201.149	0	201.149	0	201.149	0	198.132	0	198.132	0	198.132
.002	92.275	.003	91.635	.010	87.391	.002	91.635	.001	92.275	.002	91.635
.003	60.143	.005	59.600	.014	57.274	.003	59.870	.002	60.143	.005	59.332
.004	44.609	.007	44.161	.016	42.871	.004	44.459	.003	44.609	.006	44.161
.005	35.452	.008	35.169	.018	34.257	.005	35.357	.003	35.547	.007	35.169
.006	29.414	.009	29.219	.020	28.525	.005	29.414	.004	29.480	.008	29.219
.007	25.134	.010	24.991	.021	24.482	.005	25.182	.005	25.182	.009	24.991
.008	21.941	.011	21.832	.023	21.407	.006	21.977	.005	22.014	.009	21.868
.009	19.468	.012	19.382	.024	19.047	.007	19.496	.006	19.525	.010	19.410
.011	18.012	.013	17.963	.028	17.604	.008	18.061	.007	18.086	.011	17.987
.025	11.744	.033	11.661	.051	11.479	.014	11.849	.021	11.775	.019	11.796
.037	8.724	.052	8.638	.066	8.560	.028	8.770	.037	8.718	.032	8.747
.052	6.928	.070	6.863	.081	6.824	.055	6.914	.060	6.896	.051	6.928
.074	4.923	.093	4.888	.099	4.877	.104	4.866	.095	4.883	.083	4.904
.108	2.869	.116	2.864	.117	2.863	.139	2.849	.122	2.859	.117	2.863
.129	1.728	.131	1.727	.128	1.728	.156	1.722	.134	1.727	.133	1.727
.137	1.283	.137	1.283	.132	1.284	.161	1.280	.138	1.283	.139	1.283
.143	.939	.141	.939	.135	.939	.165	.937	.141	.939	.142	.939
.148	.669	.143	.669	.138	.669	.168	.668	.143	.669	.145	.669
.151	.425	.146	.425	.140	.425	.170	.425	.145	.425	.147	.425
.153	.286	.148	.286	.142	.286	.172	.286	.147	.286	.149	.286
.154	.173	.149	.173	.143	.173	.174	.173	.148	.173	.150	.173
.155	.109	.150	.109	.144	.109	.175	.109	.149	.109	.151	.109
.156	.062	.151	.062	.145	.062	.177	.062	.151	.062	.153	.062
.157	.035	.153	.035	.146	.035	.179	.035	.152	.035	.154	.035

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
62-4-E		62-4-F		62-5-B		62-5-C		62-5-D		62-5-E	
Sample Wt. 0.1457		Sample Wt. 0.1218		Sample Wt. 0.1059		Sample Wt. 0.1178		Sample St. 0.1514		Sample Wt. 0.1562	
0	201.149	0	198.132	0	186.916	0	198.132	0	201.149	0	201.149
.003	91.635	.012	85.690	.003	88.563	.001	92.275	.002	92.275	.003	91.635
.004	59.870	.015	56.781	.005	58.285	.002	60.143	.004	59.870	.005	59.600
.006	44.309	.017	42.595	.006	43.578	.003	44.609	.005	44.459	.006	44.309
.007	35.263	.019	34.080	.007	34.798	.003	35.547	.006	35.357	.007	35.263
.008	29.284	.020	28.463	.009	28.899	.004	29.480	.006	29.414	.008	29.284
.009	25.038	.022	24.391	.011	24.711	.004	25.230	.007	25.134	.009	25.038
.009	21.904	.023	21.373	.012	21.618	.004	22.051	.008	21.941	.010	21.868
.010	19.439	.024	19.019	.013	19.213	.004	19.583	.009	19.468	.011	19.410
.011	18.012	.028	17.580	.014	17.818	.005	18.136	.010	18.037	.012	17.987
.022	11.775	.042	11.559	.021	11.734	.033	11.651	.024	11.754	.025	11.744
.034	8.741	.056	8.610	.035	8.706	.041	8.695	.038	8.718	.039	8.712
.045	6.954	.067	6.871	.074	6.831	.087	6.800	.052	6.928	.054	6.921
.066	4.937	.082	4.906	.131	4.811	.112	4.852	.080	4.912	.082	4.908
.087	2.882	.100	2.873	.159	2.834	.131	2.854	.110	2.868	.111	2.867
.101	1.734	.112	1.732	.170	1.718	.139	1.725	.129	1.728	.127	1.728
.106	1.287	.117	1.286	.173	1.278	.143	1.282	.137	1.283	.133	1.284
.110	.941	.121	.940	.175	.936	.147	.938	.142	.939	.139	.939
.112	.670	.124	.670	.176	.668	.149	.669	.147	.669	.142	.669
.115	.426	.126	.426	.178	.425	.152	.425	.150	.425	.145	.425
.117	.286	.128	.286	.179	.286	.155	.286	.153	.286	.148	.286
.118	.173	.130	.173	.180	.173	.159	.173	.155	.173	.150	.173
.119	.109	.131	.109	.181	.109	.162	.109	.157	.109	.151	.109
.121	.062	.132	.062	.182	.062	.167	.062	.158	.062	.153	.062
.122	.035	.133	.035	.183	.035	.171	.035	.160	.035	.154	.035

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
62-5-F		62-6-B		62-6-C		62-6-D		62-2-E		62-6-F	
Sample Wt. 0.1227		Sample Wt. 0.1279		Sample Wt. 0.0659		Sample Wt. 0.1217		Sample Wt. 0.1321		Sample Wt. 0.1484	
0	201.149	0	198.132	0	198.132	0	201.149	0	201.149	0	198.132
.006	89.767	.001	92.275	.001	92.275	.002	92.275	.003	91.635	.007	88.563
.009	58.543	.002	60.143	.003	59.870	.004	59.870	.005	59.600	.010	58.029
.010	43.723	.003	44.609	.003	44.609	.006	44.309	.006	44.309	.011	43.435
.011	34.890	.004	35.452	.003	35.547	.008	35.169	.007	35.263	.012	34.707
.012	29.026	.005	29.414	.004	29.480	.010	29.155	.008	29.284	.013	28.899
.013	24.850	.007	25.086	.004	25.230	.012	24.897	.008	25.086	.014	24.757
.014	21.724	.008	21.904	.004	22.051	.014	21.724	.009	21.904	.015	21.653
.015	19.297	.009	19.439	.004	19.583	.016	19.269	.009	19.468	.016	19.241
.016	17.890	.012	17.963	.006	18.111	.022	17.746	.010	18.037	.017	17.842
.022	11.775	.028	11.702	.012	11.871	.045	11.539	.017	11.828	.021	11.775
.028	8.776	.052	8.632	.025	8.788	.068	8.549	.027	8.782	.025	8.788
.034	6.994	.072	6.853	.051	6.928	.086	6.807	.037	6.983	.030	7.005
.049	4.969	.098	4.877	.087	4.897	.107	4.863	.058	4.952	.043	4.978
.070	2.893	.119	2.861	.106	2.869	.124	2.859	.083	2.884	.064	2.896
.084	1.738	.128	1.728	.113	1.731	.132	1.727	.097	1.735	.081	1.739
.091	1.289	.132	1.284	.115	1.286	.138	1.283	.103	1.287	.089	1.289
.095	.942	.134	.939	.116	.940	.141	.939	.108	.941	.096	.942
.100	.671	.136	.670	.118	.670	.143	.669	.110	.670	.101	.671
.103	.426	.138	.425	.119	.426	.145	.425	.113	.426	.105	.426
.105	.286	.140	.286	.120	.286	.147	.286	.115	.286	.108	.286
.107	.173	.141	.173	.122	.173	.148	.173	.116	.173	.110	.173
.108	.109	.142	.109	.124	.109	.150	.109	.117	.109	.112	.109
.109	.062	.143	.062	.126	.062	.151	.062	.118	.062	.113	.062
.110	.035	.144	.035	.128	.035	.152	.035	.120	.035	.115	.035

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
62-7-B	Sample Wt. 0.0806	62-7-C	Sample Wt. 0.1262	62-7-D	Sample Wt. 0.1421	62-7-E	Sample Wt. 0.1535	62-7-F	Sample Wt. 0.1335	62-8-B	Sample Wt. 0.0665
0	198.132	0	201.149	0	198.132	0	201.149	0	201.149	0	198.132
.001	92.275	.002	92.275	.002	91.635	.004	91.004	.006	89.767	.001	92.275
.002	60.143	.003	60.143	.003	59.870	.006	59.332	.009	58.543	.002	60.143
.003	44.609	.004	44.609	.004	44.459	.007	44.161	.011	43.578	.004	44.459
.004	35.452	.005	35.452	.005	35.357	.008	35.169	.012	34.798	.005	35.357
.005	25.182	.006	29.414	.005	29.414	.009	29.219	.013	28.963	.009	29.155
.008	21.904	.007	25.134	.006	25.134	.010	24.991	.014	24.803	.010	24.944
.010	19.410	.009	21.904	.007	21.941	.011	21.832	.015	21.689	.011	21.796
.013	17.939	.010	19.439	.008	19.468	.012	19.382	.016	19.269	.012	19.354
.075	11.235	.013	17.963	.010	18.012	.015	17.914	.017	17.866	.016	17.866
.109	8.322	.043	11.559	.022	11.765	.022	11.775	.024	11.754	.091	11.084
.130	6.653	.067	8.554	.033	8.741	.031	8.758	.029	8.770	.125	8.239
.149	4.787	.087	6.803	.044	6.954	.043	6.961	.034	6.994	.135	6.636
.161	2.836	.114	4.850	.072	4.924	.064	4.941	.044	4.978	.142	4.799
.165	1.720	.135	2.852	.107	2.869	.088	2.881	.059	2.900	.146	2.845
.167	1.279	.146	1.724	.125	1.729	.104	1.734	.072	1.741	.148	1.723
.168	.937	.150	1.282	.132	1.284	.111	1.286	.078	1.291	.149	1.282
.169	.668	.153	.938	.138	.939	.116	.940	.082	.943	.150	.938
.170	.286	.156	.669	.140	.669	.120	.670	.086	.671	.151	.669
.171	.109	.158	.425	.143	.425	.123	.426	.090	.426	.152	.286
.172	.062	.160	.286	.145	.286	.125	.286	.092	.287	.153	.173
.173	.035	.161	.173	.147	.173	.126	.173	.094	.173	.154	.062
		.163	.109	.148	.109	.128	.109	.095	.109	.155	.035
		.165	.062	.150	.062	.129	.062	.096	.062		
		.166	.035	.151	.035	.130	.035	.098	.035		

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
62-8-C		62-8-D		62-8-E		62-8-F		62-9-B		62-9-C	
Sample Wt. 0.1092		Sample Wt. 0.1155		Sample Wt. 0.1371		Sample Wt. 0.1399		Sample Wt. 0.1347		Sample Wt. 0.1355	
0	198.132	0	201.149	0	201.149	0	201.149	0	198.132	0	201.149
.001	92.275	.002	92.275	.004	91.004	.006	89.767	.001	92.275	.002	92.275
.002	60.143	.003	60.143	.006	59.332	.009	58.543	.003	59.870	.003	60.143
.003	44.609	.004	44.609	.007	44.161	.010	43.723	.005	44.309	.004	44.609
.003	35.547	.005	35.452	.008	35.169	.011	34.890	.007	35.169	.005	35.452
.003	29.546	.006	29.414	.009	29.219	.012	29.026	.009	29.155	.006	29.414
.004	25.230	.007	25.134	.010	24.991	.013	24.850	.009	24.991	.007	25.134
.005	22.014	.008	21.941	.011	21.832	.014	21.724	.010	21.832	.008	21.941
.005	19.554	.009	19.468	.012	19.382	.015	19.297	.012	19.354	.009	19.468
.006	18.111	.011	18.012	.013	17.963	.016	17.890	.17	17.842	.017	17.866
.022	11.765	.026	11.734	.023	11.765	.023	11.765	.031	11.671	.039	11.600
.041	8.695	.041	8.701	.032	8.753	.030	8.764	.047	8.661	.073	8.521
.062	6.888	.057	6.910	.042	6.965	.036	6.987	.066	6.874	.100	6.758
.091	4.890	.075	4.921	.058	4.952	.050	4.967	.096	4.881	.124	4.833
.109	2.868	.093	2.878	.078	2.888	.066	2.895	.123	2.859	.142	2.848
.118	1.730	.102	1.734	.091	1.737	.080	1.739	.136	1.726	.151	1.723
.120	1.285	.106	1.287	.096	1.288	.086	1.290	.141	1.283	.155	1.281
.123	.940	.110	.941	.100	.941	.091	.942	.144	.938	.158	.938
.125	.670	.122	.670	.104	.671	.095	.671	.147	.669	.161	.669
.126	.426	.115	.426	.107	.426	.099	.426	.149	.425	.163	.425
.128	.286	.116	.286	.110	.286	.101	.286	.151	.286	.165	.286
.130	.173	.118	.173	.111	.173	.103	.173	.152	.173	.167	.173
.131	.109	.119	.109	.113	.109	.104	.109	.154	.109	.168	.109
.133	.062	.120	.062	.114	.062	.106	.062	.156	.062	.169	.062
.134	.035	.121	.035	.116	.035	.108	.035	.157	.035	.170	.035

62-9-D
Sample Wt. 0.1526

FN	GN
0	198.132
.002	91.635
.004	59.600
.005	44.309
.006	35.263
.007	29.284
.008	25.038
.009	21.868
.010	19.410
.014	17.914
.032	11.661
.055	8.616
.078	6.831
.104	4.866
.130	2.855
.145	1.724
.150	1.281
.156	.938
.160	.669
.163	.425
.166	.286
.168	.173
.170	.109
.173	.062
.175	.035

62-9-E
Sample Wt. 0.1540

FN	GN
0	201.149
.004	91.004
.008	59.067
.009	43.868
.010	34.983
.011	29.090
.012	24.897
.013	21.760
.014	19.325
.016	17.890
.025	11.744
.035	8.735
.047	6.946
.069	4.932
.094	2.878
.110	1.732
.120	1.285
.125	.940
.130	.670
.134	.425
.136	.286
.139	.173
.141	.109
.143	.062
.146	.035

62-9-F
Sample Wt. 0.1242

FN	GN
0	198.132
.006	89.161
.008	58.543
.009	43.723
.010	34.890
.011	29.026
.012	24.850
.016	11.828
.019	8.823
.023	7.032
.031	5.001
.044	2.909
.057	1.744
.065	1.292
.071	.943
.076	.672
.080	.426
.082	.287
.084	.173
.086	.109
.088	.062
.090	.035

62-10-B
Sample Wt. 0.0932

FN	GN
0	201.149
.003	91.635
.005	59.600
.007	44.161
.009	35.075
.011	29.090
.013	24.850
.014	21.724
.016	19.269
.020	17.794
.044	11.549
.062	8.582
.080	6.828
.100	4.875
.118	2.863
.127	1.728
.131	1.284
.134	.939
.136	.670
.139	.425
.141	.286
.143	.173
.144	.109
.146	.062
.148	.035

62-10-C
Sample Wt. 0.0831

FN	GN
0	198.132
.001	92.275
.002	60.143
.003	44.609
.004	35.452
.004	29.480
.005	25.182
.005	22.014
.006	19.525
.008	18.061
.018	11.807
.027	8.776
.044	6.954
.077	4.915
.104	2.871
.116	1.731
.120	1.285
.123	.940
.126	.670
.128	.426
.130	.286
.132	.173
.134	.109
.136	.062
.137	.035

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
62-10-D		62-10-E		62-10-F		63-13-B		62-13-C	
Sample Wt. 0.1400		Sample Wt. 0.1540		Sample Wt. 0.1450		Sample Wt. 0.1446		Sample Wt. 0.0873	
0	201.149	0	201.149	0	201.149	0	198.132	0	198.132
.003	91.635	.003	91.635	.007	89.161	.001	92.275	.002	91.635
.005	59.600	.005	59.600	.010	58.285	.002	60.143	.004	59.600
.006	44.309	.006	44.309	.012	43.435	.003	44.609	.006	44.161
.007	35.263	.007	35.263	.013	34.707	.004	35.452	.008	35.075
.008	29.284	.008	29.284	.014	38.899	.009	29.155	.010	29.090
.009	25.038	.009	25.038	.015	21.689	.009	24.991	.011	24.897
.010	21.868	.010	21.868	.016	19.269	.010	21.832	.013	21.724
.011	19.410	.011	19.410	.017	17.866	.011	19.382	.017	19.213
.013	17.963	.012	17.987	.021	11.786	.012	17.963	.023	17.698
.026	11.734	.018	11.818	.025	8.793	.019	11.796	.039	11.589
.035	8.735	.023	8.805	.029	7.013	.042	8.689	.053	8.627
.047	6.946	.029	7.013	.037	4.991	.092	6.782	.061	6.892
.067	4.935	.040	4.986	.048	2.907	.132	4.817	.074	4.921
.094	2.878	.055	2.902	.058	1.744	.155	2.839	.084	2.883
.113	1.732	.067	1.742	.065	1.292	.164	1.720	.091	1.736
.121	1.285	.072	1.291	.069	.943	.167	1.279	.094	1.288
.128	.940	.076	.943	.075	.672	.169	.937	.096	.942
.133	.670	.080	.671	.079	.426	.171	.668	.098	.671
.138	.425	.084	.426	.082	.287	.173	.425	.099	.426
.142	.286	.086	.287	.085	.173	.175	.286	.100	.286
.145	.173	.088	.173	.087	.109	.176	.173	.101	.173
.147	.109	.090	.109	.089	.062	.178	.109	.103	.109
.150	.062	.093	.062	.091	.035	.179	.062	.104	.062
.152	.035	.095	.035			.180	.035	.105	.035

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
62-13-D		62-13-E		62-13-F		62-16-C		62-16-D	
Sample Wt. 0.0966		Sample Wt. 0.1340		Sample Wt. 0.1606		Sample Wt. 0.1110		Sample Wt. 0.1289	
0	198.132	0	198.132	0	198.132	0	198.132	0	201.149
.003	91.004	.005	89.767	.009	87.391	.002	91.635	.003	91.635
.007	58.804	.008	58.543	.014	57.026	.003	59.870	.006	59.332
.008	43.868	.010	43.578	.017	42.595	.004	44.459	.008	44.014
.010	34.890	.012	34.707	.020	33.992	.005	35.357	.009	35.075
.011	29.026	.013	28.899	.021	28.402	.006	29.349	.011	29.090
.012	24.850	.014	24.757	.023	24.346	.007	25.086	.012	24.897
.014	21.689	.015	21.653	.025	21.304	.088	21.904	.013	21.760
.016	19.241	.017	19.213	.027	18.937	.010	19.410	.015	19.297
.021	17.746	.020	17.770	.030	17.534	.016	17.866	.020	17.794
.041	11.569	.040	11.579	.041	11.569	.041	11.569	.037	11.620
.055	8.616	.053	8.627	.050	8.644	.065	8.560	.048	8.661
.066	6.874	.064	6.881	.058	6.903	.085	6.807	.058	6.906
.081	4.908	.079	4.912	.070	4.928	.111	4.854	.075	4.921
.092	2.878	.095	2.876	.083	2.884	.128	2.856	.093	2.878
.099	1.734	.195	1.733	.094	1.736	.136	1.726	.105	1.733
.103	1.287	.109	1.287	.099	1.288	.139	1.283	.110	1.287
.105	.941	.113	.940	.103	.941	.141	.939	.113	.941
.106	.671	.116	.670	.106	.671	.143	.669	.116	.670
.108	.426	.119	.426	.110	.426	.145	.425	.119	.426
.109	.286	.121	.286	.112	.286	.147	.286	.121	.286
.111	.173	.123	.173	.115	.173	.150	.173	.123	.173
.112	.109	.125	.109	.117	.109	.152	.109	.125	.109
.113	.062	.127	.062	.120	.062	.154	.062	.127	.062
.114	.035	.128	.035	.122	.035	.156	.035	.128	.035

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
62-16-E		62-16-F		62-19-C		62-19-D		62-19-E	
Sample Wt. 0.1238		Sample Wt. 0.1530		Sample Wt. 0.1141		Sample Wt. 0.1497		Sample Wt. 0.1564	
0	198.132	0	198.132	0	201.149	0	198.132	0	195.204
.004	90.381	.011	86.249	.002	92.275	.004	90.381	.007	87.973
.006	59.067	.016	56.538	.004	59.870	.008	58.543	.010	57.775
.008	43.868	.020	42.186	.006	44.309	.010	43.578	.012	43.151
.009	34.983	.022	33.818	.010	34.983	.012	34.707	.014	34.435
.010	29.090	.024	28.220	.014	38.899	.013	28.899	.016	28.649
.010	24.944	.027	24.168	.019	24.573	.015	24.711	.017	24.573
.011	21.796	.029	21.167	.029	21.201	.017	21.582	.019	21.477
.012	19.354	.031	18.829	.039	18.643	.020	19.129	.020	19.102
.014	17.914	.035	17.418	.052	17.058	.026	17.627	.024	17.651
.021	11.775	.049	11.489	.078	11.215	.054	11.439	.045	11.519
.028	8.770	.059	8.593	.088	8.439	.069	8.538	.058	8.593
.035	6.991	.069	6.863	.099	6.762	.083	6.814	.068	6.863
.045	4.974	.082	4.906	.120	4.840	.107	4.861	.084	4.901
.057	2.900	.097	2.875	.140	2.849	.133	2.853	.106	2.869
.066	1.742	.109	1.732	.151	1.723	.150	1.723	.120	1.729
.069	1.292	.113	1.286	.156	1.281	.158	1.280	.128	1.284
.072	.943	.117	.940	.159	.937	.163	.937	.134	.939
.074	.672	.120	.670	.162	.669	.168	.668	.139	.669
.077	.426	.123	.426	.164	.425	.173	.425	.143	.425
.078	.287	.125	.286	.165	.286	.176	.286	.146	.286
.079	.173	.128	.173	.167	.173	.180	.173	.150	.173
.080	.109	.130	.109	.168	.109	.183	.109	.153	.109
.082	.062	.132	.062	.170	.062	.185	.062	.156	.062
.083	.035	.133	.035	.171	.035	.187	.035	.158	.035

FN	GN	FN	GN	FN	GN	FN	GN	FN	GN
62-19-F		62-22-C		62-22-D		62-22-E		62-22-F	
Sample Wt. 0.1600		Sample Wt. 0.1250		Sample Wt. 0.1353		Sample Wt. 0.1250		Sample Wt. 0.1334	
0	198.132	0	201.149	0	198.132	0	195.204	0	201.149
.010	86.816	.001	92.924	.002	91.635	.009	86.816	.006	89.767
.014	57.026	.002	60.418	.004	59.600	.012	57.274	.010	58.285
.017	42.595	.003	44.760	.006	44.161	.014	42.871	.012	43.435
.019	34.080	.003	35.643	.008	35.075	.017	34.168	.013	34.707
.021	28.402	.004	29.546	.010	29.090	.019	28.463	.015	28.836
.023	24.346	.004	25.278	.012	24.850	.021	24.391	.016	24.711
.024	21.338	.005	22.051	.013	21.724	.023	21.338	.017	21.618
.025	18.992	.006	19.554	.015	19.269	.026	18.937	.019	19.185
.029	17.557	.007	18.111	.024	17.675	.032	17.464	.021	17.770
.041	11.569	.026	11.734	.062	11.360	.068	11.292	.035	11.640
.049	8.649	.045	8.678	.080	8.477	.080	8.472	.045	8.678
.056	6.910	.063	6.888	.095	6.772	.089	6.789	.052	6.928
.067	4.934	.090	4.893	.112	4.852	.100	4.872	.062	4.945
.078	2.887	.111	2.867	.126	2.857	.110	2.866	.074	2.890
.090	1.737	.123	1.729	.135	1.726	.116	1.730	.081	1.739
.096	1.288	.126	1.285	.138	1.283	.119	1.285	.085	1.290
.101	.941	.129	.939	.141	.939	.121	.940	.088	.942
.106	.671	.132	.670	.143	.669	.123	.670	.909	.671
.110	.426	.136	.425	.146	.425	.125	.426	.092	.426
.112	.286	.139	.286	.148	.286	.127	.286	.094	.287
.115	.173	.143	.173	.150	.173	.129	.173	.096	.173
.118	.109	.146	.109	.151	.109	.130	.109	.097	.109
.120	.062	.149	.062	.153	.062	.132	.062	.099	.062
.122	.035	.152	.035	.155	.035	.133	.035	.101	.035

Appendix III. Red Hill and Huckleberry Spring Site Data

Sample No.	Mean Diam (mm)	Mean (μ)	Median (μ)	Volume (ml/gm)	Volume 30-0.2(%)	Mean (μ)	Median (μ)	Volume (ml/gm)	Volume 30-0.2(%)
		Huckleberry Spring Site, 62-X							
		C(8-4mm)				D(4-2mm)			
x= 1	0.376	5.66	2.95	0.91	96.0	13.80	3.03	0.67	86.1
x= 2	1.470	10.61	7.93	1.53	95.0	9.75	4.78	1.36	92.9
x= 3	1.548	7.69	2.99	0.91	92.2	8.68	3.99	1.03	94.3
x= 4	1.646	7.89	5.98	1.21	94.7	9.25	5.28	1.08	92.2
x= 5	1.158	7.41	6.86	1.45	90.3	8.59	4.91	1.06	92.9
x= 6	1.027	7.74	6.31	1.94	92.2	12.12	7.81	1.25	90.9
x= 7	1.201	10.37	7.15	1.32	93.4	8.38	4.72	1.06	93.8
x= 8	0.519	8.46	6.55	1.23	94.5	10.68	6.52	1.05	92.3
x= 9	0.565	10.56	7.73	1.26	94.7	9.50	6.11	1.15	91.9
x=10	0.581	7.74	5.44	1.65	93.2	9.65	4.25	1.09	89.8
x=13	0.458	14.36	8.74	1.20	86.8	15.28	8.29	1.18	87.5
x=16	0.309	10.78	7.42	1.40	92.1	13.08	6.21	0.99	87.3
x=19	0.528	13.96	9.15	1.50	89.7	12.19	5.96	1.25	88.9
x=22	0.284	7.74	5.92	1.22	90.9	12.72	8.87	1.15	89.1
		E(2-1mm)				F(1-0.5mm)			
x= 1	0.376	11.14	7.16	0.89	91.8	18.29	6.24	1.02	84.0
x= 2	1.470	13.01	6.77	1.20	91.3	21.08	9.72	1.40	83.6
x= 3	1.548	11.07	6.31	1.02	91.5	19.82	7.75	1.21	84.5
x= 4	1.646	11.02	5.42	0.84	90.2	21.97	6.96	1.09	82.5
x= 5	1.158	10.07	5.26	0.99	92.2	15.38	4.37	0.90	86.1
x= 6	1.027	10.47	4.78	0.91	89.5	15.34	3.54	0.78	84.2
x= 7	1.201	11.72	4.85	0.85	90.0	17.13	4.29	0.74	82.3
x= 8	0.519	12.54	4.95	0.85	87.8	15.65	4.45	0.77	84.9
x= 9	0.565	11.47	4.60	0.95	87.4	20.20	2.82	0.73	80.8
x=10	0.581	11.97	3.94	0.62	83.8	20.00	3.38	0.63	77.4
x=13	0.458	15.28	6.88	0.95	85.7	20.88	6.40	0.76	76.7
x=16	0.309	15.73	5.62	0.67	83.2	22.42	7.30	0.87	78.2
x=19	0.528	14.73	5.51	1.01	84.6	21.19	6.01	0.76	77.0
x=22	0.284	21.30	11.54	1.06	82.8	19.27	7.31	0.76	80.0

Appendix III (continued)

Sample No.	Mean Diam (mm)	Mean (µ)	Median (µ)	Volume (ml/gm)	Volume 30-0.2(%)	Mean (µ)	Median (µ)	Volume (ml/gm)	Volume 30-0.2(%)
		Red Hill Site, 65-X							
		C(8-4mm)				D(4-2mm)			
x= 1	1.078	14.86	3.96	0.65	88.7	9.97	5.59	0.64	88.4
x= 3	1.579	10.41	5.38	0.83	88.5	10.26	4.25	0.57	80.7
x= 5	1.249	13.69	3.74	0.62	81.7	11.27	5.21	0.81	83.4
x= 7	1.805	13.46	7.72	0.84	85.1	11.02	5.59	0.72	85.5
x= 9	2.046	11.78	6.08	0.94	85.6	11.46	5.19	0.75	84.7
x=11	2.696	8.91	3.05	0.84	85.7	12.73	6.18	0.96	84.4
		E(2-1mm)				F(1-0.5mm)			
x= 1	1.078	17.09	3.18	0.42	85.5	23.35	3.51	0.35	76.2
x= 3	1.579	11.30	5.69	0.52	81.5	25.11	8.03	0.53	71.9
x= 5	1.249	13.94	4.55	0.60	82.5	26.27	6.46	0.51	70.8
x= 7	1.805	17.20	5.90	0.62	76.9	25.15	7.23	0.58	71.0
x= 9	2.046	12.93	6.18	0.63	80.6	26.95	8.09	0.61	70.9
x=11	2.696	17.24	6.49	0.82	79.7	25.26	8.14	0.68	71.5

APPENDIX IV

STATISTICAL COMPARISON OF PERCENT VOLUME OF PORE SPACE BETWEEN 30.0-0.2 MICRONS FOR MAZAMA C1 AND C2, HUCKLEBERRY SPRING, 1.0-0.5 MM PARTICLE SIZE

	C1		C2
Sample	% 30-0.2μ	Sample	% 30-0.2μ
62-1	84.0	62-10	74.4
2	83.6	13	76.7
3	84.5	16	78.2
4	82.5	19	77.0
5	86.1	22	80.0
6	84.2		
7	82.3		
8	84.9		

$\bar{X}_1 = 84.0, \quad s_1^2 = 1.54$ $\qquad \bar{X}_2 = 77.2, \quad s_2^2 = 4.24$

null hypothesis $\quad H_o: \mu_1 - \mu_2 = 0$

alternative hypothesis $\quad H_a: \mu_1 > \mu_2$

Test statistic

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s\,(\bar{X}_1 - \bar{X}_2)}$$

$t = 7.51$

Critical statistic

For $\alpha = 0.005$, 11 d.f.

$t_c = 3.12$

$7.51 > 3.12$ reject null hypothesis ($\mu_1 - \mu_2 = 0$)
do not reject alternative hypothesis ($\mu_1 > \mu_2$)