CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
1520 West Adams St.
Phoenix, AZ 85007
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

TABLE 2 - PROXIMATE POROSITY PER CENT VIA VISUAL ESTIMATE OF BOTH HAND SAMPLE AND MICROSCOPIC ROCK THIN SECTION ANALYSIS.

SAMPLE IDENTIFICATION	PROXIMATE POROSITY IN VOLUME PER CENT
WILLIAMS SITE B	40 - 50
WILLIAMS SITE A	40 - 50
TUFFLITE	45 - 55
OREGON, CASCADE PROVINCE	65 - 70
GREEK TYPE "H"	60 - 65
EQUADORIAN TYPE "F"............	70
GREEK TYPE "B"	65 - 70
TURKISH TYPE "D"	60 - 65
MEXICO ASW - WHITE	70 - 75
MEXISO ASG - GRAY	75 - 80

TABLE 3 – MEASUREMENTS OF SPECIFIC GRAVITY AND DENSITY OF THE TEN SAMPLES OF ROCK PUMICE

SAMPLE IDENTIFICATION	SPECIFIC GRAVITY	DENSITY
WILLIAMS SITE B	....	
WILLIAMS SITE A	....	
TUFFLITE	....	
OREGON, CASCADE PROVINCE....	....	
GREEK TYPE "H"	....	
EQUADORIAN TYPE "F"	....	
GREEK TYPE "B"	....	
TURKISH TYPE "D"	....	
MEXICO ASW – WHITE	....	
MEXICO ASG – GRAY	....	

TABLE 4 - ROCK CLASSIFICATION BASED ON HAND SAMPLE AND MICROSCOPIC ROCK THIN SECTION ANALYSIS.

SAMPLE IDENTIFICATION	ROCK NAME
WILLIAMS SITE B	CRYSTAL-VITRIC TUFFACEOUS PUMICE
WILLIAMS SITE A	CRYSTAL - - VITRIC TUFFACEOUS PUMICE
TUFFLITE	VESICULAR PARTLY DEVITRIFIED PUMICE
OREGON, CASCADE PROVINCE..	VESICULAR PARTLY DEVITRIFIED PUMICE
GREEK TYPE "H"	VESICULAR PARTLY DEVITRIFIED PUMICE
EQUADORIAN TYPE "F"	VESICULAR WELL-COMPACTED PUMICE
GREEK TYPE "B"	VESICULAR CRYSTAL-VITRIC PUMICE
TURKISH TYPE "D"..........	VESICULAR COMPACTED PUMICE
MEXICO ASW - WHITE	VESICULAR COMPACTED PUMICE
MEXICO ASG - GRAY	VESICULAR COMPACTED CRYSTAL-VITRIC PUMICE

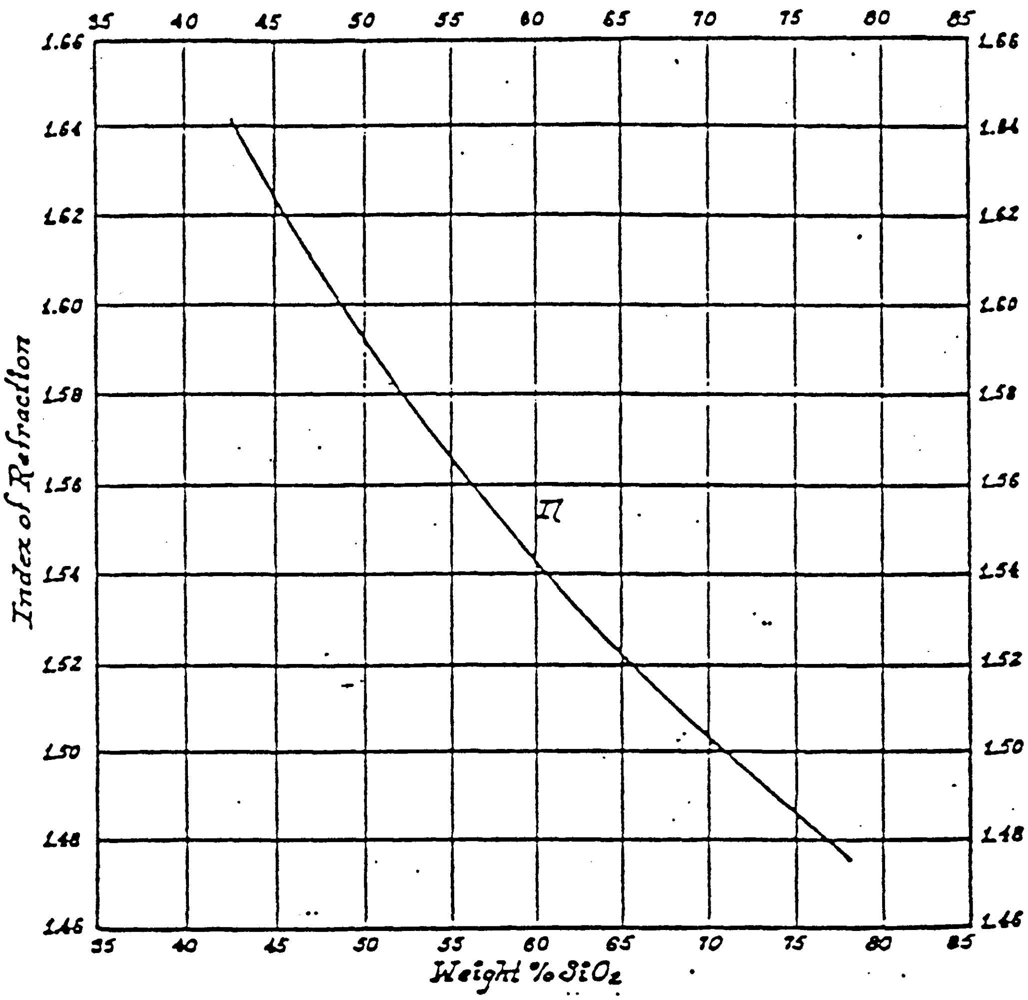


FIGURE 7-9. Variation of index of refraction with silica content in volcanic glasses. (Modified from Huber and Rinehart, 1966)

SAMPLE #1 - WILLIAMS SITE B

OIL IMMERSION INDEX OF REFRACTION ANALYSIS

$n > 1.490$ white into fragt.

$n > 1.494$ weak blue into fragt.

$n > 1.498$ white line into fragt.

$n \gtrsim 1.502$ very close match, no distinct Becke Line movement, perhaps moves into fragt. slightly.

$n \approx 1.506$ inclusions in glass blot Becke Line.

$n < 1.514$ white into the oil   n 1.510 white out into oil

n glass = 1.502-1.506 ± 0.002

SAMPLE #2 - WILLIAMS SITE A

$n < 1.514$ white out into oil

$n < 1.510$ white out into oil

$n < 1.506$ white out into oil

$n \lesssim 1.502$ - probably slightly less than 1.502

$n = 1.498$ good match. Becke Line not move

n glass = 1.498 ± 0.002

SAMPLE #33- TUFFLITE

OIL IMMERSION INDEX OF REFRACTION ANALYSIS

$n < 1.510$ good white line out into oil

$n < 1.506$ good white line out into oil

$n \simeq 1.502$ no Becke Line visible

$n \simeq 1.498$ no Becke Line visivle, no movement

$n > 1.494$ faint movement white into fragment

$n \text{ glass} = 1.498 - 1.502 \pm 0.002$

SAMPLE #4 - OREGON, CASCADE PROVINCE

OIL IMMERSION INDEX OF REFRACTION ANALYSIS

$n < 1.510$ white Becke Line out into oil

$n < 1.506$ pale bluish white out into oil

$n = 1.502$ no Becke Line visible in that glass that contains elliptical higher index inclusions

$n > 1.498$

n glass $= 1.502 \pm 0.002$

SAMPLE #5 - GREEK TYPE H

OIL IMMERSION INDEX OF REFRACTION ANALYSIS

$n < 1.510$ white out into oil

$n < 1.506$ white out into oil

$n < 1.502$ weak to moderate white out into oil

$n \approx 1.498$ no Becke Line visible

$n > 1.494$ very pale yellowish white into fragment

$$n \text{ glass} = 1.498 \pm 0.002$$

SAMPLE #6 – EQUADORIAN TYPE "F"

OIL IMMERSION INDEX OF REFRACTION ANALYSIS

$n < 1.510$ white line out into oil

$n < 1.506$ faint white line out into oil

$n \approx 1.502$ movement of Becke Line inconclusive, probably about equal to 1.502

$n \gtrsim 1.498$ same as 1.502 but probably closer to 1.498

$n > 1.494$ white Becke Line into fragment

$$n \text{ glass} = 1.498 - 1.502 \pm 0.002$$

SAMPLE #7 - GREEK TYPE "B"

OIL IMMERSION INDEX OF REFRACTION ANALYSIS

$n < 1.510$ white out into oil

$n < 1.506$ moderate white out into oil

$n \approx 1.502$ difficult to see any Becke Line or any movement

$n > 1.498$ faint whitish line into fragmants

$n > 1.494$ whitish line into fragments

n glass $= 1.502 \pm 0.002$

SAMPLE #8 - TURKISH TYPE "D"

OIL IMMERSION INDEX OF REFRACTION ANALYSIS

$n < 1.510$ white ~~out into oil~~

$n < 1.506$ white out into oil

$n \approx 1.502$ Becke Line difficult to see, no movement

$n \approx 1.498$ Becke Line difficult to see, no movement

$n > 1.494$ faint yellowish white line into fragment

$$n \text{ glass} = 1.498 - 1.502 \pm 0.002$$

SAMPLE #9 - MEXICO ASW - WHITE

OIL IMMERSION INDEX OF REFRACTION ANALYSIS

$n <$	1.510	white line out into oil
$n <$	1.506	white out into oil
$n \approx$	1.502	no Becke Line visible
$n >$	1.498	slight movement of faint line into fragment
$n >$	1.494	yellowish white Becke Line into fragment

$$n \text{ glass} = 1.500 - 1.502 \pm 0.002$$

SAMPLE #10 - MEXICO ASG - GRAY

OIL IMMERSION INDEX OF REFRACTION ANALYSIS

$n < 1.514$ strong white line out into oil

$n < 1.510$ moderately strong white line out into oil

$n < 1.506$ moderate white line out into oil.

$n \approx 1.502$ no Becke Line visible

$n > 1.498$ very slight movement of pale white line into fragment

$n > 1.494$ weak yellowish white line into fragment

$$n \text{ glass} = 1.502 \pm 0.002$$

SAMPLE #1 - WILLIAMS SITE B

TEXTURE - Igneous, pyroclastic, vitroclastic with angular crystal fragments variously fractured and broken that are scattered irregularly throughout a matrix (groundmass) of densely packed volcanic glass that has been attenuated (stretched out) with smaller crystal fragments throughout. There has been physical and chemical corrosion as well as gas-charged reaction of the larger crystal fragments which are feldspar (variety plagioclase), biotite mica and to a lesser extent hornblende. These three minerals are each well fragmented and broken.

Larger plagioclase fragments vary .4 x .5mm - .7x2.3mm to 1.5 x 2.5 mm. Biotite varies .02 x .05 mm up to .9 x 1.3 mm, and hornblende varies .08 x .20 to 0.6 x 1.2 mm. The smaller broken fragments vary .005 x .01 mm - .02 x .05 mm - .4 x .5 mm - .06 x .13 mm.

MINERAL COMPOSITION -

Plagioclase Feldspar ~~Fragments~~	8-10%
Biotite Mica Fragments	5%
Hornblende Fragments	10%
High Temperature Quartz (corroded).	1%
Magnetite (in Biotite and Hblde)...	2-3%
Volcanic Glass	75-80%
	100%

COMMENTARY ON THIS SAMPLE - This rock type is unusual in that it has about 20 - 25 volume % crystal fragments that are varyingly scattered and mixed throughout a glassy matrix. The glassy matrix (groundmass) shows a moderate fluidal flow-banding to which the crystal fragments have aligned themselves more or less parallel, as much as possible, along the planes of fluidal flow.

ROCK NAME - In attempting to properly name this volcanic rock one must needfully take into consideration the large amount of fragmented crystal fragments that are suspended in volcanic glass. The rock originally, when hot and fluid, was mainly a vesicular, gaseous siliceous lava but with many suspended broken crystal fragments engulfed in the siliceous lava. Hence the best probable classification of this rock is: CRYSTAL VITRIC (TUFFACEOUS) PUMICE OR TUFFACEOUS CRYSTAL VITRIC PUMICE.

SAMPLE #2 - WILLIAMS SITE A

TEXTURE - Igneous, pyroclastic, vitroclastic with angular crystal fragments variously broken and fractured that are scattered irregularly throughout a matrix of densely packed volcanic glass that has been stretched or flattened with smaller crystal fragments throughout. There has been physical and chemical corrosion as well as gas-charged reaction of the larger crystal fragments, especially the feldspar and to a lesser degree biotite mica and hornblende.

Augitic pyroxene is rimmed by brown hornblende and is .8 x .9 mm. Brown hornblende is .4 x 1.0 to ,04 x .08mm to .2 x .6 mm. Plagioclase feldspar fragments vary .02 x .06 mm to .08 x .3 mm to .5 x 1.0mm to .9 x 1.4 mm to 1.2 x 1.4 mm. Magnetite is .03 x .03 mm.

MINERAL COMPOSITION -

Plagioclase Feldspar Fragments	10-12%
Pyroxene (Augite) Fragments	1
Brown Hornblende Fragments	8-10%
Biotite Fragments	2-3%
Magnetite Fragments	1-2%
Volcanic Glass	75-80%
	100%

COMMENTARY ON THIS SAMPLE - This rock, just like Sample #1, WILLIAMS SITE B, is unusual in that it has about 20-25% crystal fragments varyingly scattered throughout a glassy groundmass or matrix. The glassy matrix shows a moderate fluidal flow-banding to which the crystal fragments have aligned themselves more or less parallel.

ROCK NAME - This sample, similar to Sample #1, WILLIAMS SITE B, is best classified as a CRYSTAL VITRIC (TUFFACEOUS) PUMICE OR TUFFACEOUS CRYSTAL VITRIC PUMICE.

SAMPLE #3 - TUFFLITE

TEXTURE - Igneous, vesicular, volcanic. This sample is composed 100% of extremely vesicular volcanic glass. Some of the glass is partly devitrified (recrystallized) to microcrystalline centers averaging about .01 x .01 mm to .01 x .03 mm. About 30-35% of the glass is devitrified. The microcrystalline material is probably a feldspar and high temperature quartz or silica (SiO_2).

MINERAL COMPOSITION - As mentioned above the rock is entirely volcanic glass which is 30-35% recrystallized to microcrystalline centers of feldspar and/or quartz (SiO_2).

ROCK NAME - PARTLY DEVITRIFIED VESICULAR (RHYOLITIC) PUMICE.

SAMPLE #4 - OREGON, CASCADE PROVINCE

TEXTURE - Igneous, volcanoclastic, vitroclastic, vesicular, with well-developed fluidal alignment of elongated and stretched glass plates and vesicles. Both the air bubbles (vesicles) as well as the glass are drawn out in subparallel wavey lines or planes. Broken phenocrysts of plagioclase and a trace of brown hornblende make up about 1 to 1.5% of the total rock. The remaining 98.5 - 99% is volcanic glass. Microlites and crystallites are also aligned subparallel to parallel to the fluidal planes and lines of the volcanic glass.

MINERAL COMPOSITION -

Plagioclase Feldspar Fragments 1-1½%

Brown Hornblende .... trace

Volcanic Glass 98.25-99%

100 %

Plagioclase crystals vary .12 x .25 mm to .08 x .23 mm to .07 x .20 mm to .005 x .01 mm.

Brown Hornblende is .03 x .12 mm.

ROCK NAME - VESICULAR PARTLY DEVITRIFIED (RHYOLITIC) PUMICE.

SAMPLE # 5 - GREEK TYPE H

TEXTURE - Igneous, volcanic, vitroclastic, vesicular with well-developed fluidal alignment of elontaed and stretched volcanic glass with gas bubbles (vesicles). Both the air bubbles as well as the glassy material are drawn out into parallel to subparallel wavey planar-linear patterns. A few broken crystals of plagioclase feldspar and a single elongate fragment of a rock (lithic) fragment have their longer dimensions parallel to the flow lines.

Of the few broken crystals present (1-1½%) the plagioclase feldspar varies in size .03 x .12 mm to .16 x .17 mm to .5 x .7 mm. The lithic fragment is .03 x 2 mm or slightly larger.

The volcanic glass is partly recrystallized (de-vitrified) into microscopic sized centers averaging about .01 x .01 mm.

MINERAL COMPOSITION -

Plagioclase Feldspar Fragments	1-1½%
Lithic (Rock) Fragment	trace
Volcanic Glass partly recrystallized.....	98.5-99%
	100%

ROCK NAME - VESICULAR PARTLY DEVITRIFIED (RHYOLITIC) PUMICE.

SAMPLE # 6 - EQUADORIAN TYPE "F"

<u>TEXTURE</u> - Igneous, volcanic, pyroclastic, vitroclastic, vesicular-compacted with well-developed fluidal alignment of elongate stretched glass shards and broken gas bubbles (vesicles). The vesicles as well as the glassy material is drawn out into parallel to subparallel wavey planes and lines. Broken crystals pf plagioclase feldspar and biotite make up about 2% of the rock. Plagioclase is .25 x .4 mm to 1 x 1.8 mm. Biotite is .01 x .07 mm to .25 x .4 mm.

<u>MINERAL COMPOSITION</u> -

Plagioclase Feldspar Fragments	1%
Biotite Mica Fragments	1%
Volcanic Glass	98%
	100%

<u>ROCK NAME</u> - VESICULAR WELL-COMPACTED (RHYOLITIC) PUMICE.

SAMPLE # 7 - GREEK TYPE "B"

<u>TEXTURE</u> - Igneous, pyroclastic, vitroclastic, vesicular with moderate compaction layering. The rock is a mixture of about 12 - 15% broken crystals and 85 - 88% volcanic glass. Plagioclase feldspar fragments vary .1 x 1.0 mm to .6 x .8 mm to .7 x 1.1 mm. Hornblende is .05 x .38mm to .2 x .7mm to .4 x .8 mm. Pyroxene (augite) is .3 x .5 mm to .6 x 1 mm. Magnetite is .4 x .4 mm average and a single rock fragment is 1.2 x 2 mm. There has been considerable gas corrosion of the plagioclase feldspar fragments.

<u>MINERALS COMPOSITION</u> -

Plagioclase Feldspar Fragments 5-7%

Hornblende Fragments 2%

Pyroxene (augite) fragments 1%

Magnetite Grains 1-2%

Rock (lithic) Fragment .... trace

<u>ROCK NAME</u> - VESICULAR CRYSTAL-VITRIC (RHYOLITIC) PUMICE.

SAMPLE # 8 - TURKISH TYPE "D"

TEXTURE - Igneous, volcanic, holohyaline (100% volcanic glass with vesicles all compacted into fluidal flow lines and planes. The ratio of vesicles to volcanic glass varies greatly throughout the rock sample, i.e., vesicls : glass ratio varies 50-70:30-50.

MINERAL COMPOSITION - As mentioned above there are no broken crystals present. The rock is 100% volcanic glass with stretched vesicles.

ROCK NAME - VESICULAR COMPACTED (RHYOLITIC) PUMICE.

SAMPLE #9 - MEXICO ASW - WHITE

TEXTURE - Igneous, volcanic, vitroclastic, pyroclastic, vesicular, strongly compacted. Fragments of biotite mica and plagioclase feldspar make up less than 2% of the rock. Biotite fragments vary .1 x .5 mm to .2 x .35 mm to .5 x .7 mm. Feldspars are .18 x .23mm to .2 x .2mm to .6 x 1 mm. Vesicular bubbles and the volcanic glass are drawn and stretched into parallel and subparallel planes and lines.

MINERAL COMPOSITION -

Plagioclase Feldspar Fragments	about 1%
Biotite Mica Fragments	about 1%
Vesiculated Volcanic Glass	98%
	100%

ROCK NAME - VESICULAR COMPACTED (RHYOLITIC) PUMICE.

SAMPLE #10 - MEXICO ASG - GRAY

TEXTURE - Igneous, volcanic, pyroclastic, vitroclastic, vesicular..strongly compacted The gas bubbles (vesicles) as well as the glassy (vitric) material have been strongly compressed and intensely drawn out into parallel and sub-parallel lines and planes. Fragments of broken crystals (phenocrysts) are scattered non-uniformly throughout the rock. Plagioclase feldspar fragments are 1-2%, biotite about 1%, hematite flakes about a trace as is also apatite. Several of the vesicles appear to have been partially filled with native copper.

Plagioclase fragments are .04 x .26 mm to .3 x .45 mm Biotite is .03 x .12 mm to .3 x .32 mm to .4 x 1.1 mm. Hematite flakes are .12 x .22m. Copper fillings in vesicles are .29 x .37 average mm.

MINERAL COMPOSITION -

Plagioclase Feldspar Fragments	1-2%
Biotite Mica Fragments	1%
Copper filling vesicles	trace
Hematite flakes	trace
Apatite + Pyrite (?)	trace
Volcanic Glass	95% ±
	100%

ROCK NAME - VESICULAR COMPACTED CRYSTAL VITRIC (RHYOLITIC) PUMIC

DEL TIERRA ENGINEERING & MINING CORP.
HARVEY W. SMITH, E.M. PRESIDENT

Registered Mining Engineer
U.S. Approved Title Abstracter

U.S. Mineral Surveyor
Registered Land Surveyor

4310 North Brown Avenue / Suite 3 Scottsdale, Arizona 85251
Tel. 602 / 946-3996

February 12, 1990

Robin Strathy
U. S. Forest Service
Arizona Zone Office
2324 E. McDowell
Phoenix, AZ 85006-2497

Dear Robin:

Enclosed is some supplemental information pertaining to the Hutchinson Report which I submitted to you in December, 1989.

If you have any questions, please do not hesitate to call me.

Sincerely,

Harvey W. Smith, E.M.
President

HM/hm
Enclosure

CONTENTS

ILLUSTRATIONS, TABLES AND FIGURES

EXECUTIVE STATEMENT

Ten separate pumice rock samples have been analyzed for Apparent (In-Place) Specific Gravity, True Specific Gravity, Void Volume Percent, Mineralogical and Chemical Purity. Chem-Stone, Inc. reports that of the ten varieties of pumice stone there are three which best meet the requirments for a successful "Stone-Washing" process. These are the Tufflite, Williams Site "B", and the Williams Site "A".

Tufflite has a Calculated Void Volume Percent of 67.9%, Williams Site "B" is 59.7% and Williams Site "A" is 59.3%. All other samples, except for the Greek Type "B", have Calculated Void Volume Percents greater than Tufflite, Williams Site "B" and Williams Site "A". Greek Type "B" is 43.1%.

Apparent (In Place) Specific Gravity for Tufflite is 0.667, Williams Site "B" is 0.997, and Williams Site "A" is 1.00. Density values are Tufflite 0.667 gm/cm^3 (41.62 lb/ft^3), Williams Site "B" 1.00 gm/cm^3, (62.4 lb/ft.^{3}), and Williams Site "A" is 0.997 gm. cm^3 (62.21 lb/ft^3).

Analytical accuracy of the Calculated Void Volume Percent is greater than 95.0%. Analytical accuracy of the Specific Gravity and Density measurements is greater than 99.9%.

PREPARATION OF MATERIAL FOR ANALYSIS

Determination of the physical, mineralogical and chemical properties of ten rock pumice samples required two different and separate methods of laboratory analysis. Determination of Apparent Specific Gravity (*"In Place"* Specific Gravity), True Specific Gravity and Volume percent of voids (pore spaces) necessitated design of special laboratory equipment for analysis. This was accomplished with the help of Hazen Research, Inc. of Golden, Colorado. Mineralogical and chemical purity of the samples was accomplished using rock thin sections and examining and analyzing them with the petrographic microscope. Forty pumice rock thin sections were made by Petrographic Services, Inc., Montrose, Colorado.

The ten different pumice rock samples were cut and trimmed to 22 x 44 mm with a diamond rock saw and 40 microscopic thin sections ground to a thickness of 30 microns (0.03 mm). Four thin sections were made for each type of rock pumice sample. Two of the thin sections were not stained and two were stained with Orasol Blue Green Dye in order to emphasize the pore spaces (voids) throughout the rock sample. In order to carry out the index of refraction measurements of the glass, fragments of the volcanic glass were scraped off each rock sample with a sharp pointed dissecting needle. These broken grains varied from 0.03 to 0.23 mm average size and were very sharp and angular.

Index of Refraction measurements were made in white polarized light using the petrographic microscope and a series of immersion oils with indices of refraction ranging from 1.498 to 1.510. These measurements and the Index of Refraction determinations are given in Table 1.

Microscopic analysis of the rock pumice thin sections was made also using plane polarized white light and five different microscopic lens objectives of magnifications 1X, 2.5X, 3.2X, 5.6X, and 10X. The eyepiece (ocular) had a magnification of 10X.

With the microscopic analysis it was possible to (1) identify the components of each rock, i.e., volcanic glass, crystals of different minerals, pore spaces (voids), chemical alteration of the glass and/or the crystals, (2) estimate the proximate volume percent porosity of each rock sample, (3) identify and describe the internal fabric, structural arrangement, shape and orientation of both crystals and pore spaces, (4) classify each of the rock samples in terms of volume percentage ratios of crystals to volcanic glass to pore spaces. A photographic record has been made for each of the ten rock pumice samples (See Figures 1-21).

SIGNIFICANCE OF INDEX OF REFRACTION MEASUREMENTS

There is a systematic relationship between the amount of the Index of Refraction and the weight percent of the silica (SiO_2) that makes up the volcanic glass for that particular index of refraction or range of indices of refraction (See Illustration 1). As mentioned previously, the indices of refraction for the ten rock samples ranged from 1.498 to 1.510 (See Table 1). Referring to the variation graph shown in Illustration 1, the content weight percent of the silica for each rock sample has been obtained.

Silica (SiO_2) content for the volcanic glass of the ten rock samples ranges from 69 wt.% up to 71.5 wt.%. This is a very narrow and restricted range indicating that all ten rock samples are derived from a compositionally similar lava type or types.

All volcanic glasses derive from silicate melts and may vary in composition over the range of the common igneous rocks (silica ranges from about 40 to over 77 percent), excluding the ultramafic types. Only from chemical analysis or refractive index determinations can we equate a glass to its crystalline analog and designate it as a rhyolite glass, andesitic glass, basaltic glass, and so on. A given volcanic rock may be entirely glass, glass with crystallites, glass with broken or perfect crystals (phenocrysts), or largely crystalline, with only minor glass filling interstices. Most rocks that are largely glass are rhyolitic. And this is the case with the ten samples herein analyzed. They are all compositionally rhyolitic to trachytic glass.

Characteristic and typical index of refraction values for the different rock glass types are as follows:

Rhyolitic glass ~ 1.49
Trachytic glass ~ 1.51
Andesitic glass ~ 1.52
Leucite tephrite glass ~ 1.55
Basaltic glass ~ 1.60

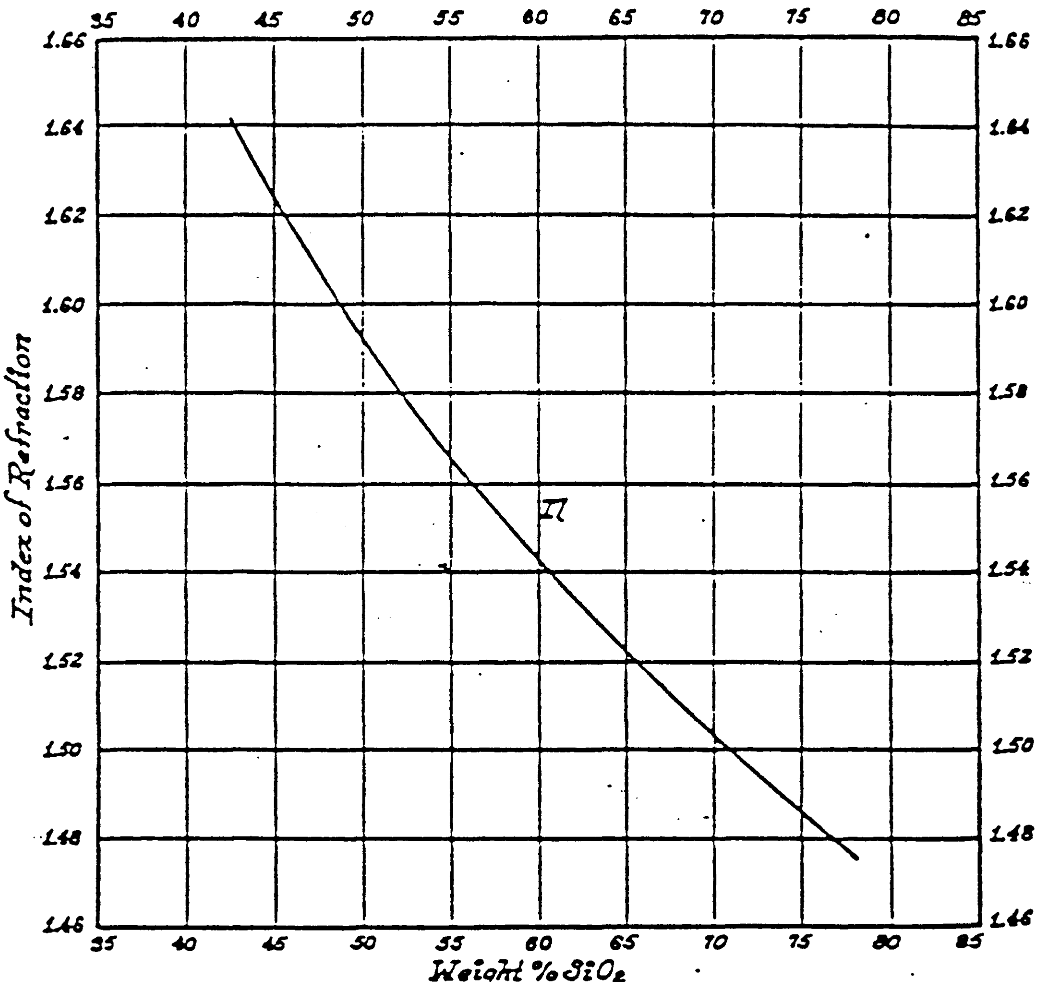


Illustration 1 -

Variation of index of refraction with silica content in volcanic glasses. (Modified from Huber and Rinehart, 1966)

SIGNIFICANCE OF MICROSCOPIC ANALYSIS OF THIN SECTIONS

As shown in Table 2 all ten rock samples have been classified as PUMICE and have the proper characteristics. Pumice is properly defined and must have the following features and properties:

PUMICE - A rock-froth which forms crusts on more compact lava or occurs in the form of volcanic ejectamenta. It is glass so filled with air bubbles (voids) that the pore space may be much greater than the glassy material. Usually, the bubbles are drawn out in parallel or wavy lines, which bend around the rare broken crystals and phenocrysts. Microlites and crystallites are common. The word is very old. It is mentioned by Pliny, but it was known long before and was mentioned by Theophrastis.

As shown by microscopic analysis, each of the rock thin sections indicates that the ten different pumice rock samples are of high to very high mineralogical and chemical purity. The analytical results are given on pages 17-35. Sample numbers 3-10 are about 85%-100% volcanic glass. Samples Numbers 1 and 2, Williams Site "B" and Williams Site "A" have varying amounts of crystal fragments and pieces varying from about 10%-20%

The following comments and observations can be made from the microscopic examination and analysis of the samples:

(1) Williams Site B rock has more or less circular pore spaces and is non-compacted. Proximate porosity is 40%-50% (See Figs. 1, 2, 3).

(2) Williams Site A rock shows moderate compaction with pores elongate to subcircular. Proximate pore porosity is 40%-50% (See Figs. 4, 5).

(3) Tufflite shows pore spaces with moderate compression with proximate porosity 45%-55% (See Figs. 6, 7).

(4) Oregon, Cascade Province rock has strong compaction layering with hollow tube-like pore spaces and some suboptical extremely microscopic-sized dusty material (clay?). Proximate porosity is 65%-70% (See Figs. 8, 9).

(5) Greek Type "H" shows extreme compaction along with tubular openings which seem to be partly interconnected. Proximate porosity is 60%-65% (See Figs. 10, 11).

(6) Equadorian Type "F" has strong compaction and flow lines with hollow tubular pore spaces varyingly connected. Proximate porosity is 70% (See Figs. 12, 13).

(7) Greek Type "B" proximate porosity is 65%-75% and similar to Williams Site B rock, the openings are not compressed and are somewhat connected. Combination of the high porosity and the sub-optical dustlike material lowers the quality of the rock (See Figs. 14, 15).

(8) Turkish Type "D" has moderate compaction with large oval to crudely circular pore spaces. Proximate porosity varies 60%-70% (See Figs. 16, 17).

(9) Both Mexico ASW-White and Mexico ASG-Gray have very high proximate porosity of 75%-80% and moderate to moderately strong compaction. (See Figs. 18, 19 and Figs. 20, 21, respectively.)

MEASUREMENTS OF SPECIFIC GRAVITY,
DENSITY AND CALCULATED VOID VOLUME PERCENT

The engineering suitability of pumice rock for use in the "stone-washing" process is closely tied to and dependent upon the properties of specific gravity, density, void volume percent, coupled with the mineralogical and chemical purity of the rock. As shown by microscopic analysis all ten of the rock samples are of high to very high purity.

SPECIFIC GRAVITY is defined as the ratio of the mass of a body to the mass of an equal volume of a standard substance. For solids and liquids the standard substance is usually water at the temperature of its maximum density, 3.8°C. to 4.2°C., at which temperature its density is .999973 gm/cm^3. The standard substance for gases is usually hydrogen or air. It should be observed in this connection that the expression "specific gravity" is something of a scientific misnomer, since it does not refer to gravity in any way. Specific gravity should likewise not be confused with density; in the metric system they are numerically the same but in the English system they are quite different. Specific gravity is an abstract, or pure, number while denisty has dimensions and units. Consider the specific gravity and the density of lead. *Mass* and *weight* are, for the present purpose, regarded as identical, but their difference in terms of physical concept should be clearly distinguished. Let the mass of the sample be 340.2 gms., equivalent to .750 lb., and the mass of an equal volume of water be .066 lb., equal to 29.94 gms; then the specific gravity of lead will be:

$$S.G. = .750 \div .066 = 11.36; \text{ or}$$
$$S.G. = 340.2 \div 29.94 = 11.36.$$

Thus the specific gravity is simply a ratio and is independent of the units used. But the density of lead in the English system is $62.4\ lb/ft^3 \times 11.36 = 708\ lb/ft^3$ or $11.36\ gm/cm^3$. (Ordinarily we call the density of water in the metric system 1 gm/cm^3 at 0^oC., while in reality it is .999973 $gm/cm.^3$.

As referred to earlier special laboratory equipment was prepared to measure (1) the *"In Place"* Apparent Specific Gravity, (2) the True Specific Gravity, and (3) the Calculated Void Volume Percent. The sketch on the next page shows the essentials of the laboratory setup, excluding the beam balance.

The Apparent Specific Gravity is essentially the density of the rock on the "as-received" basis, i.e., the *"in place"* or natural, unaltered specific gravity. To obtain this number the rock sample was weighed then coated with a clear plastic and its volume measured by enclosing it in a mesh cage and submerging it in water held in an overflow tank. The amount of overflow water represented the volume of the rock.

The plastic coating was then removed from the surface of the rock by burning it off in a muffle furnace set at 750 deg. C. The rock was then pulverized to minus 100 mesh, and the True Specific Gravity was determined on the pulverized material using an air-comparison pycnometer.

The difference between the two specific gravity numbers was used to calculate the void space on a volume percent basis of the original uncoated rock. The equation used is as follows:

CALCULATED VOID VOLUME % = (1 - Apparent S.G/True S.G.) x 100.

Table 3 gives the numerical results of the laboratory measurements, i.e., Apparent Specific Gravity (In Place Specific Gravity), True Specific Gravity, and the Calculated Void Volume %.

Sample #7, Greek Type "B", was the only rock sample that did not show a tendency to float. It sank due to the fact its Apparent Specific Gravity is greater than that of water. Since

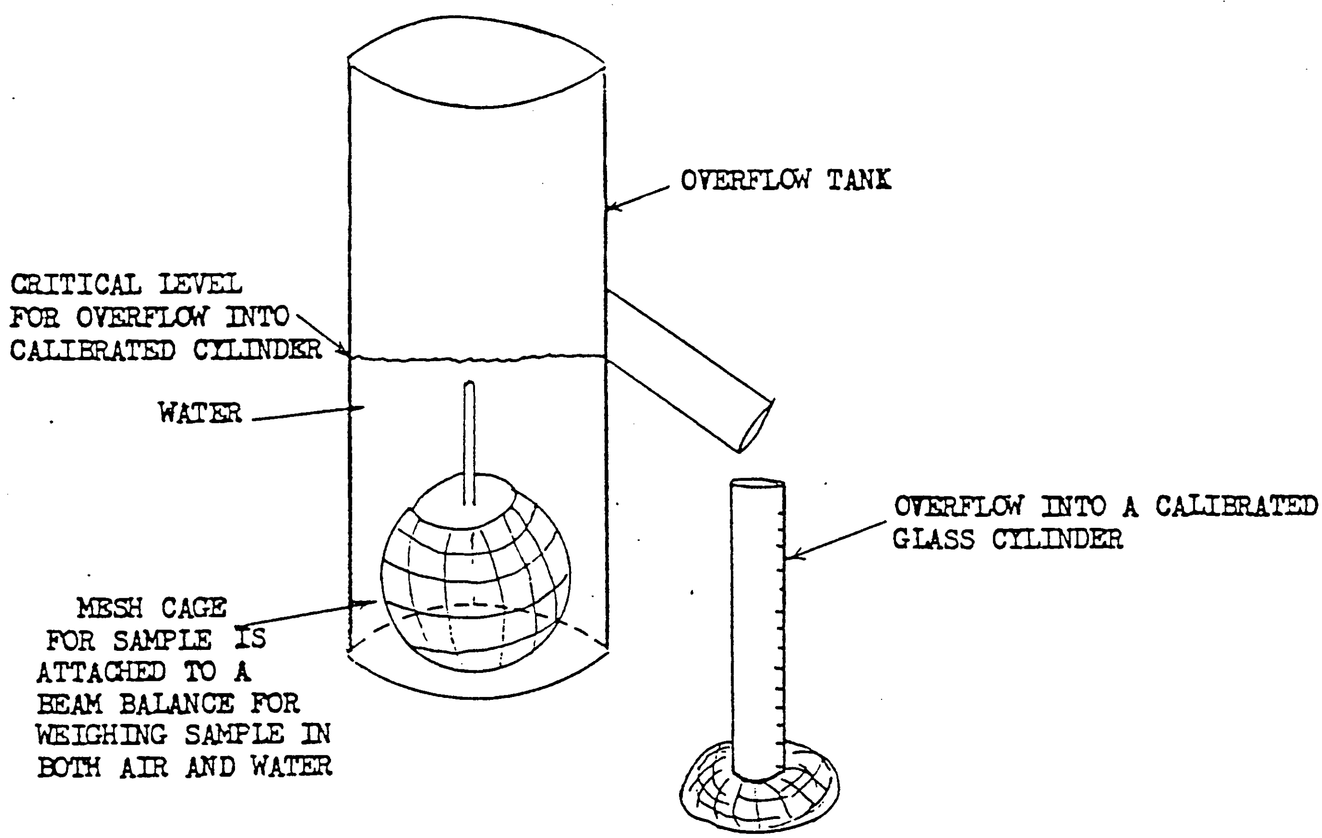


Illustration 2. -
LABORATORY SET-UP FOR MEASURING THE
APPARENT SPECIFIC GRAVITY AND DENSITY
OF PUMICE ROCK SAMPLES #1 TO # 10.

the specific gravity of water at 4.2 deg. C is 0.999973 gm/cm^3 all the other rock samples showed a tendency to float in the water. Sample #1, Williams Site "B", both floated and was partly submerged. It has an Apparent Specific Gravity = 1.00. As expected, the 10%-20% crystal fragments in Sample Numbers #1 and #2, Williams Site "B" and "A" caused the Apparent Specific Gravity, coupled with the lower calculated void volume percent, to be higher than all other samples, except for Sample #7, Greek Type "B".

It is interesting to note the true volume of the volcanic glass including any crystal fragments in Samples #1 - #10. These numbers are given in Table 4. The two volume percent values should add up to 100% total volume, i.e, Actual Volume % of Volcanic Glass + Crystal Fragments added to the Calculated Void Volume percent = 100 volume %.

DENSITY

In view of the fact that the "stone-washing" process makes use of the pumice rock in its natural, untreated state, the (1) Apparent Specific Gravity (In Place" Specific Gravity), (2) Apparent Density (*"In Place" Density*), and (3) the calculated True Void Volume % are all critical to the laundering process. Table 5 gives the numbers for the "In Place" Density for both Metric System and the English System. This *"In Place" Density* of course is the actual working density when the pumice rock is actively used during the "stone-washing" process.

TABLE 1. INDEX OF REFRACTION AND WEIGHT PERCENT OF SIO_2 OF THE PUMICE ROCK SAMPLES.

SAMPLE NO.	SAMPLE IDENTIFICATION	INDEX OF REFRACTION	WT % SiO_2
#1	Williams Site B	1.502-1.506	69-70
#2	Williams Site A	1.498	71.5
#3	Tufflite	1.498-1.502	70-71.5
#4	Oregon, Cascade Province	1.502	70
#5	Greek Type "H"	1.498	71.5
#6	Equadorian Type "F"	1.498-1.502	70-71.5
#7	Greek Type "B"	1.502	70
#8	Turkish Type "D"	1.498-1.502	70-71.5
#9	Mexico ASW-White	1.500-1.502	70-71
#10	Mexico ASG-Gray	1.502	70

TABLE 2. ROCK CLASSIFICATION BASED ON HAND SAMPLE AND MICROSCOPIC ROCK THIN SECTION ANALYSIS.

SAMPLE NO.	SAMPLE IDENTIFICATION	ROCK NAME
#1	Williams Site B	Crystal-Vitric Tuffaceous Pumice
#2	Williams Site A	Crystal--Vitric Tuffaceous Pumice
#3	Tufflite	Vesicular Partly Devitrified Pumice
#4	Oregon, Cascade Province ..	Vesicular Partly Devitrified Pumice
#5	Greek Type "H"	Vesicular Partly Devitrified Pumice
#6	Equadorian Type "F"	Vesicular Well-Compacted Pumice
#7	Greek Type "B"	Vesicular Crystal-Vitric Pumice
#8	Turkish Type "D"	Vesicular Compacted Pumice
#9	Mexico ASW-White	Vesicular Compacted Pumice
#10	Mexico ASG-Gray	Vesicular Compacted Crystal-Vitric Pumice

TABLE 3. APPARENT SPECIFIC GRAVITY, TRUE SPECIFIC GRAVITY, AND CALCUALTED VOID VOLUME % OF PUMICE ROCK SAMPLES.

SAMPLE NO.	SAMPLE IDENTIFICATION	APPARENT SPECIFIC GRAVITY (with void spaces)	TRUE SPECIFIC GRAVITY (without void spaces)	CALCULATED VOID VOLUME %
#1	Williams Site B	1.00	2.48	59.7
#2	Williams Site A	0.997	2.45	59.3
#3	Tufflite	0.667	2.08	67.9
#4	Oregon, Cascade Province	0.674	2.27	70.3
#5	Greek Type "H"	0.592	2.26	73.8
#6	Equadorian Type "F"	0.596	2.09	71.5
#7	Greek Type "B"	1.36	2.39	43.1
#8	Turkish Type "D"	0.684	2.25	69.6
#9	Mexico ASW-White	0.622	2.32	73.2
#10	Mexico ASG-Gray	0.584	2.36	75.2

Calculated Void Volume % = (1 - A.S.G/T.S.G.) x 100

TABLE 4. VOLUME % OF VOLCANIC GLASS AND CRYSTAL FRAGMENTS IN SAMPLES #1-#10 AND CALCULATED VOID VOLUME % IN SAMPLES #1-#10.

SAMPLE NO.	SAMPLE IDENTIFICATION	VOLUME % GLASS + CRYSTAL FRAGMENTS IN EACH SAMPLE	CALCULATED VOID VOLUME % IN EACH SAMPLE
		$\frac{A.S.G.}{T.S.G.} \times 100$	(1-A.S.G/T.S.G.) x 100
#1	Williams Site B	$\frac{1.00}{2.48} \times 100 = 40.3\%$	59.7%
#2	Williams Site A	$\frac{0.997}{2.45} \times 100 = 40.7\%$	59.3%
#3	Tufflite	$\frac{0.667}{2.08} \times 100 = 32.1\%$	67.9%
#4	Oregon, Cascade Province	$\frac{0.674}{2.27} \times 100 = 29.7\%$	70.3%
#5	Greek Type "H"	$\frac{0.592}{2.26} \times 100 = 26.2\%$	73.8%
#6	Equadorian Type "F"	$\frac{0.596}{2.09} \times 100 = 28.5\%$	71.5%
#7	Greek Type "B"	$\frac{1.36}{2.39} \times 100 = 56.9\%$	43.1%
#8	Turkish Type "D"	$\frac{0.684}{2.25} \times 100 = 30.4\%$	69.6%
#9	Mexico ASW-White	$\frac{0.622}{2.32} \times 100 = 26.8\%$	73.2%
#10	Mexico ASG-Gray	$\frac{0.584}{2.36} \times 100 = 24.8\%$	75.2%

TABLE 5. CALCULATION OF *"IN PLACE" DENSITY* OF TEN ROCK SAMPLES BY BOTH METRIC SYSTEM AND THE ENGLISH SYSTEM.

SAMPLE NO.	SAMPLE IDENTIFICATION	METRIC SYSTEM	ENGLISH SYSTEM
#1	Williams Site B	1.00 gm/cm^3	1.00 gm/cm^3 x 62.4 lb/ft^3 = 62.4 lb/ft^3
#2	Williams Site A	0.997 gm/cm^3	0.997 gm/cm^3 x 62.4 lb/ft^3 = 62.21 lb/ft^3
#3	Tufflite	0.667 gm/cm^3	0.667 gm/cm^3 x 62.4 lb/ft^3 - 41.62 lb/ft^3
#4	Oregon, Cascade Province	0.674 gm/cm^3	0.674 gm/cm^3 x 62.4 lb/ft^3 = 42.06 lb/ft^3
#5	Greek Type "H"	0.592 gm/cm^3	0.592 gm/cm^3 x 62.4 lb/ft^3 = 36.94 lb/ft^3
#6	Equadorian Type "F"	0.596 gm/cm^3	0.596 gm/cm^3 x 62.4 lb/ft^3 = 37.19 lb/ft^3
#7	Greek Type "B"	1.36 gm/cm^3	1.36 gm/cm^3 x 62.4 lb/ft^3 = 84.86 lb/ft^3
#8	Turkish Type "D"	0.684 gm/cm^3	0.684 gm/cm^3 x 62.4 lb/ft^3 = 42.68 lb/ft^3
#9	Mexico ASW-White	0.622 gm/cm^3	0.622 gm/cm^3 x 62.4 lb/ft^3 = 38.81 lb/ft^3
#10	Mexico ASG-Gray	0.584 gm/cm^3	0.584 gm/cm^3 x 62.4 lb/ft^3 = 36.44 lb/ft^3

ADEYE MINE file

DEL TIERRA ENGINEERING & MINING CORP.

HARVEY W. SMITH, E.M. PRESIDENT

Registered Mining Engineer
U.S. Approved Title Abstracter

U.S. Mineral Surveyor
Registered Land Surveyor

4310 North Brown Avenue / Suite 3 Scottsdale, Arizona 85251
Tel. 602 / 946-3996

September 14, 1990

Mr. David Bellaire
Chem-Stone, Inc.
2215 W. Mountain View Rd.
Phoenix, AZ 85021

Dear Dave:

I have reviewed the "Mineral Classification Report" by Robin Strathy and believe the following comments may be pertinent.

1. The report limits itself to pumice being used as an abrasive in the garment industry. Its use as an abrasive would appear to me to be a unique characteristic when compared to pumice used in the aggregate business and other miscellaneous uses. The aggregate business and miscellaneous uses consume over 90% of the pumice used in the United States. In McClarty v. Secretary of Interior; 408 F2d 907 (9th Cir 1969) the courts stated ...(1) there must be a comparison of the mineral deposit in question with other deposits of such <u>minerals generally</u>, ... Thus, Ms. Strathy's report would appear to me to be flawed because of this lack of comparison.

2. On page 13 of Ms. Strathy's report, paragraph five, she contends that the Chem-Stone pumice is not unique because of the porosity unless it is conceded that all other pumices are unique. She states: "I doubt that such is the case." However, it is the porosity combined with the abrasiveness and right hardness that makes all pumice used in the garment industry unique. If it were not unique, then some other material could be used, but such is not the case.

3. Again, on page 13 of Ms. Strathy's report, paragraph four, she states that there are, "A wide range of rock types and compositions in any volcanic field. These compositional differences can have a marked effect on such characteristics such as porosity." The implication here is that just because we may have good porosity in any given sample, it may be quite different elsewhere, but she hasn't shown this to be true.

4. Her tests for block pumice are quite prejudiced. The three channel samples couldn't possibly have any pieces over 2 inches and two grab samples are hardly representative. Secondly, the regulations do not state any percentage of block pumice for being a locateable mineral. The regulation, Sec. 3711.1 Public Law 167, states "Common Varieties ... does not include so-called block-pumice which occurs in nature in pieces having one dimension of two inches or more." Your videotape showing the surface with large pieces of pumice should be good evidence at any hearing.

5. On page 16 of Ms. Strathy's report she attempts to relate IBLA 70-46 decision to the instant case. The former refers to claims covering the same ground that we are attempting to mine. However, there is a considerable difference between that case and our position. The previous owners were trying to patent the material on pre-1955 claims and as an aggregate. Their case was shot down on the marketability test. However, apparently during the hearing none of the witnesses referred to the material as "block-pumice" thus the court concluded that none had been shown to exist on the claims. However, on page 216 of IBLA 70-46, the last paragraph would seem to indicate that material from these claims, if marketed as an abrasive, would be an uncommon variety regardless of much of it being less than 2 inches in size.

6. Referring once again to the McClarty v. Secretary of the Interior case, certain guidelines were established. One of these guidelines is the price received for a certain material to assist in establishing its uncommonality. Here again, Ms. Strathy's report is flawed. All of her price comparisons are to pumice used in the garment stone-washing industry. But, guideline No. 1 in the McClarty v. Secretary of the Interior states that there must be a comparison of the mineral deposit with other deposits of such minerals generally. A comparison of the price received for your material with a variety used for aggregate will show that your material meets the higher price required for an uncommon variety.

7. Ms. Strathy has attempted to muddy the waters of this case by making statements on "hearsay evidence." Verbal communications are usually meaningless unless backed by documentary evidence. Additionally, I don't believe we are trying to prove that we have a corner on the market.

In conclusion, it is my belief Ms. Strathy's report is flawed because of its lack of comparison with other pumice (mineral) deposits generally. A proper dissertation would have shown that most pumice is used in the aggregate business and that when used as an abrasive, it is a very special and unique use. Additionally, the price paid for abrasive material is much higher than that used for aggregate. And, if a 2-inch piece of pumice used as an abrasive is uncommon - why not a 1½-inch piece - or even smaller?

Furthermore, I believe we should file a complaint with the Secretary of Agriculture that because we didn't receive a copy of the "Classification Report" in a timely manner, we were unable to respond to it in our reply to Regional Forester's Responsive Statement.

Sincerely,

Harvey W. Smith, E.M.
President

HWS/hm

cc: Ralph Sievwright

CULTURAL RESOURCE SURVEY OF A PROPOSED PUMICE MINE, BILL WILLIAMS MOUNTAIN WATERSHED, KAIBAB NATIONAL FOREST, COCONINO COUNTY, ARIZONA

Submitted to

Del Tierra Engineering and Mining Corporation
4310 North Brown Avenue, Suite 3
Scottsdale, Arizona 85251
(602) 946-3996

Prepared by

Mark L. Chenault
Archaeologist

SWCA, Inc.
Environmental Consultants
804 North Beaver Street
Flagstaff, Arizona 86001

June 26, 1989

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT: A cultural resource survey was requested for an area covering approximately 800 acres for a proposed pumice mine on the east side of Bill Williams Mountain in the Kaibab National Forest, Arizona. A site file search at the Kaibab National Forest indicated that approximately half of the project area had previously been surveyed, reducing the actual acreage to be surveyed under this project to 420 acres. Two sites and one isolated occurrence were found and recorded during the current survey. During the previous archaeological surveys eight sites were recorded. Those eight sites were revisited and re-examined as requested by the Kaibab National Forest archaeologist, and they are described in this report.

INTRODUCTION

A cultural resource survey of a proposed pumice mine on the east side of Bill Williams Mountain, Coconino County, Arizona, was requested by Mr. Harvey W. Smith of the Del Tierra Engineering and Mining Corporation. That survey was undertaken on June 12, 13 and 14, 1989, by SWCA personnel. The project area incorporated all of Section 16, the south 1/2 of the south 1/2 of Section 9, and the north 1/2 of the northwest 1/4 Section 15, Township 21 North, Range 2 East (USGS 15 minute quadrangle, Bill Williams Mountain, Arizona). SWCA was contracted to complete an archaeological survey of previously unsurveyed lands in the project area, amounting to approximately 420 acres (Figure 1). The remainder of the project area had already been surveyed by National Forest Service personnel. Eight sites were recorded in the areas previously surveyed (Figure 2), and these sites were re-examined and re-flagged by SWCA personnel.

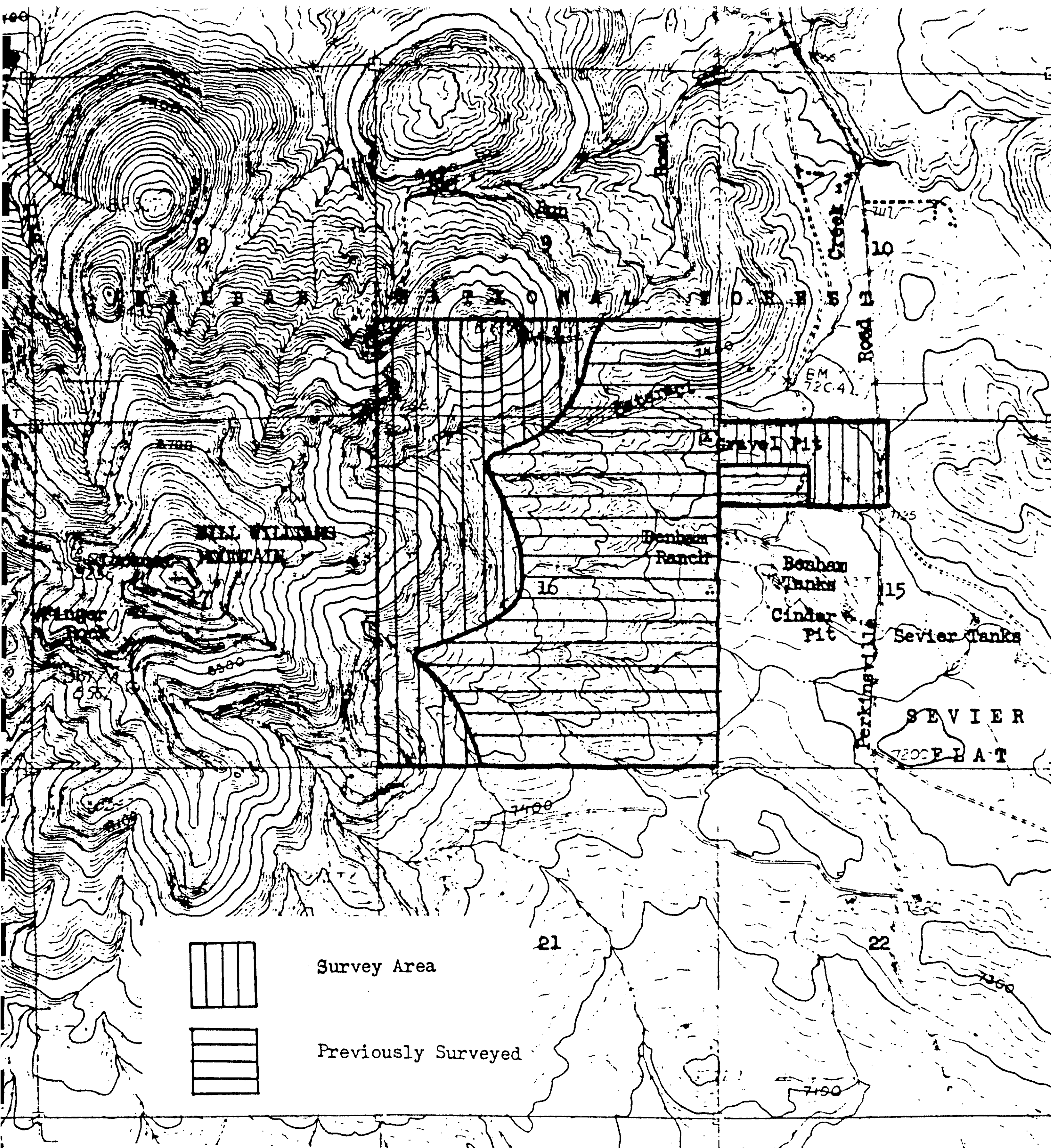
The project was administered by Mr. Harvey W. Smith, Del Tierra Engineering and Mining Corporation, and David H. Greenwald, SWCA. Field work was directed by Mark L. Chenault, and the crew consisted of Kirk Anderson, Greg Seymour, and Karen Wigglesworth. Site files were examined at the Kaibab National Forest prior to initiating the survey, and Mr. John Hanson, Archaeologist, Kaibab National Forest, was consulted as to specific requirements and procedures.

ENVIRONMENTAL SETTING

The survey area is located in an area of foothills and ridges on the east slope of Bill Williams Mountain, a 9856 ft peak. The dominant vegetation in the area is ponderosa pine (*Pinus ponderosa*). Scattered among the ponderosa are an occasional oak (*Quercus gambelli*), juniper (*Juniperus* sp.), and pinyon (*Pinus edulis*). Numerous small drainages separate the ridges extending down the slope of Bill Williams Mountain; however, no continuous, naturally occurring water source is to be found in the general project area.

PREVIOUS SURVEYS

Two previous archaeological surveys by Kaibab National Forest personnel covered portions of the project area. These surveys resulted in the finding and recording of eight archaeological sites (described below) within the project area (Cartledge 1978; 1984).



Base Map: Preliminary 7.5 minute U.S.G.S. Williams NW.

1 mile

Figure 1. Location of Project Area within the Kaibab National Forest, T21N, R2E.

Base Map: Preliminary 7.5 minute U.S.G.S. Williams NW.

1 mile

Figure 2. Location of all recorded sites in the Project Area.

CULTURE HISTORY

The primary prehistoric culture group occupying the region around Williams, Arizona, was the Cohonina. The Cohonina culture was first defined by Hargrave (1937), and later assigned as a branch of the Patayan root by Colton (1938). The area occupied by the Cohonina is the lower Colorado Plateau (Wigglesworth and Greenwald 1989), basically defined as the extent of the dominant Cohonina pottery, San Francisco Mountain Gray Ware (Cartledge 1979). The ware is distributed over the area south of the Grand Canyon to the Ash Fork/Williams area, and from the Peach Springs area on the west to Flagstaff on the east (Colton 1958; Wigglesworth and Greenwald 1989).

McGregor (1949, 1951, 1967), who did some of the most extensive early work with the Cohonina culture, agreed with the designation of the Cohonina as a branch of the Patayan. McGregor (1951) summarizes the Cohonina as an agricultural people who also hunted and gathered; had villages which were not internally planned and were apparently randomly placed throughout the region; lacked ceremonial structures; built mainly surface structures of very low, crude masonry walls; and, due to a lack of human remains, must have cremated the dead.

More recently, Cartledge (1979) has argued against some of McGregor's findings, citing settlement pattern data indicating Cohonina sites were not "scattered haphazardly about the landscape" (Cartledge 1979:308). He also states that there is strong evidence for the presence of ceremonial architecture; that pit houses were common during the early period of the Cohonina sequence, followed by the common Southwestern transition to masonry surface structures; and that Cohonina burials have been found. Cartledge also sees a stronger tie between the Cohonina and the Sinagua and Anasazi, than between the Cohonina and the Patayan.

Cartledge describes research questions current to the study of the Cohonina:

> "...the origin of Cohonina tradition, its relation to preceramic groups on the Coconino Plateau, its relationships and interaction with other contemporaneous groups, and its demise and disappearance. We need to know much more about the distribution of Cohonina populations through space and time; we need much more refined chronological control; and we need a better understanding of types and site functions in conjunction with more data on the relative importance of hunting, gathering, and agriculture in Cohonina subsistence practices" (1979:312).

Cartledge (1979), Jennings (1971), and Wigglesworth and Greenwald (1989) have addressed the question of Cohonina origins, and the transition from archaic to early Cohonina. Still, much work remains to be done before this issue can be settled. The same is true for the other research questions. Excavation of Cohonina sites throughout the Lower Colorado Plateau is needed for information on structure type and construction methods. Even settlement pattern data are incomplete, with more being known about the Cohonina in the higher elevations, than in the lower elevations (Cartledge 1979). Fortunately, several small surveys (D.H. Greenwald 1985: D.M. Greenwald 1986; Stebbins 1984, 1985; and Wigglesworth 1988 a & b) have added to our knowledge of Cohonina settlement patterns.

METHODOLOGY

During the period of June 12-14, 1989, a cultural resource survey was performed in the Bill Williams Mountain Watershed for Del Tierra Engineering and Mining Corporation by SWCA staff. The survey was performed to identify cultural resources which occur in the proposed pumice mine location.

In keeping with U.S. Forest Service standards, this was a non-collection survey. The method of coverage consisted of walking parallel transects spaced 15 to 20 meters apart, providing 100% coverage of previously unsurveyed lands in the project area. In most sections of the project area, transects were oriented north-south. All cultural remains, excluding modern trash, were treated as either sites or isolated occurrences. Forest Service guidelines were adhered to in determining if cultural remains constituted sites, as follows:

Sites

A. One or more features.
B. One formal tool if associated with other cultural materials, or more than one formal tool.
C. An occurrence of cultural materials (such as pottery sherds, chipped stone or historic items) that contains one of the following:

    1. Three or more types of artifacts or materials.
    2. Two types of artifacts or material in a density of at least 10 items per 100 square meters.
    3. A single type of artifact or material in a density of at least 25 items per 100 square meters.

Newly discovered sites were recorded on "Cultural Resources Automated Information System" site forms, provided by the Kaibab Forest Service office. Isolated occurrences were also recorded on forms provided by the Forest Service. Site boundaries were determined by visual examination of the site area, and marked with fluorescent pink flagging tape. In portions of the project area previously surveyed, sites were revisited, re-examined, and their boundaries reflagged with pink flagging tape. In all cases, the boundaries of previously recorded sites were still clearly marked with white paint.

Project area boundaries were not marked in the field. Therefore, a USGS 15 minute topographic map, and preliminary USGS 7.5 minute topographic map (provided by the Kaibab National Forest), were used to determine the limits of the survey area.

RESULTS

A total of 420 acres was surveyed, resulting in the finding and recording of two previously unknown sites and one isolated occurrence. Eight previously recorded sites were relocated and re-examined at the request of the Kaibab National Forest. All 10 sites and the one isolated occurrence are described below.

Newly Recorded Sites

AR-03-07-01-1165

This site is a small U-shaped rock feature located in a high saddle on the northeast side of Bill Williams Mountain. It is in the NE 1/4 of the SW 1/4 of the SW 1/4 of Section 9, Township 21 North, Range 2 East (Figure 2), at an elevation of 2402 m (7880 ft).

The feature consists of unshaped stones stacked and placed together to form a U-shaped feature open to the northeast. It is approximately 3 X 3 meters in size (Figure 3). No prehistoric cultural materials were found in or around the feature. However, two small pieces of purple glass were found nearby (no makers mark evident). This, plus the shape and appearance of the feature, suggest that the site may date to the historic period. The function of the feature is unknown. It may have been a wind break for a fire, although, there is no apparent sign of burning within the feature. Subsurface investigation was not, however, performed by SWCA personnel, and the ground was deeply covered (5 to 10 cm) with pine duff, possibly obscuring signs of burning.

AR-03-07-01-1169

This site is a two room masonry structure located on a high hill top east of Bill Williams Mountain. It is located in the SW 1/4 of the NE 1/4 of the SW 1/4 of Section 9, Township 21 North, Range 2 East (Figure 2), at an elevation of 2484 m (8150 ft).

AR-03-07-01-1169 consists of a masonry structure of two contiguous rooms (Figure 4). The walls were constructed of dry- lain, unshaped andesite stones. In places, large boulders were incorporated into the wall construction. The long axis of the structure is oriented north-south. The northern room appears to be open to the east and the southern room to the south. There is an isolated wall running north-south, located just to the south of the structure. The structure is approximately 10 m long by 5 m wide, and the isolated wall is 4 m long. It was not evident, from the surface remains, whether or not the isolated wall was part of a larger structure.

No cultural materials, either prehistoric or historic, were found in or around the structure. This may in part be due to the thick covering of pine duff in the site area. Although, even in areas near the structure where the ground was partially exposed, no artifacts were observed. Without cultural materials, it is impossible to determine what cultural group occupied the site. However, the method of construction at the site suggests that it was built prehistorically.

A downhill ski slope is located on the north side of the hill on which the site is situated. The site does not appear to have been adversely affected by activities at the ski area, or by any other modern human activity. A partially burned pine tree, probably ignited by lightening, has fallen across the structure. This may have contributed to some wall collapse; however, the tree appears to have fallen in recent times, and the walls to have collapsed much earlier.

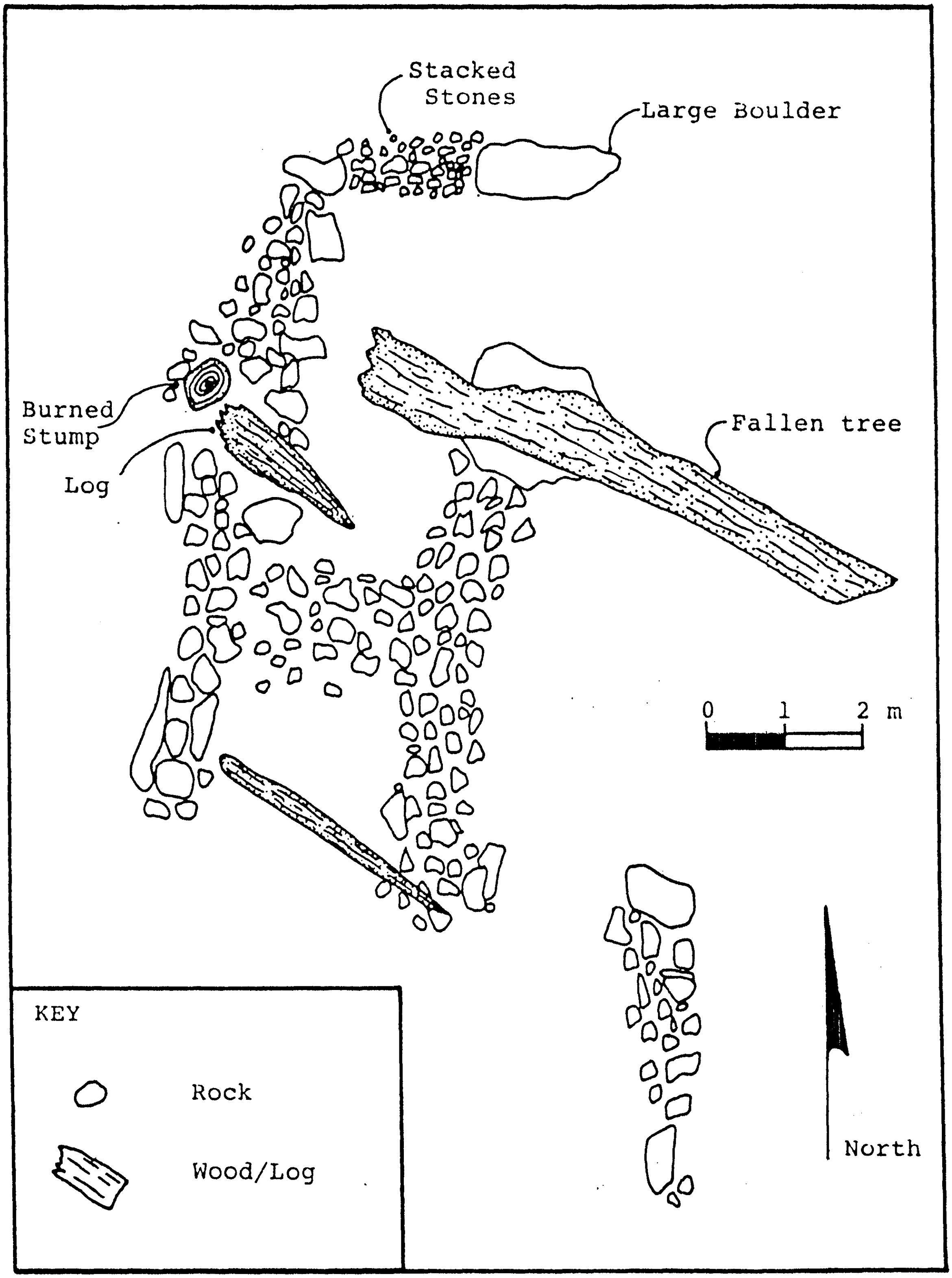


Figure 4. Site AR-03-07-01-1169 showing outline of stacked rock features.

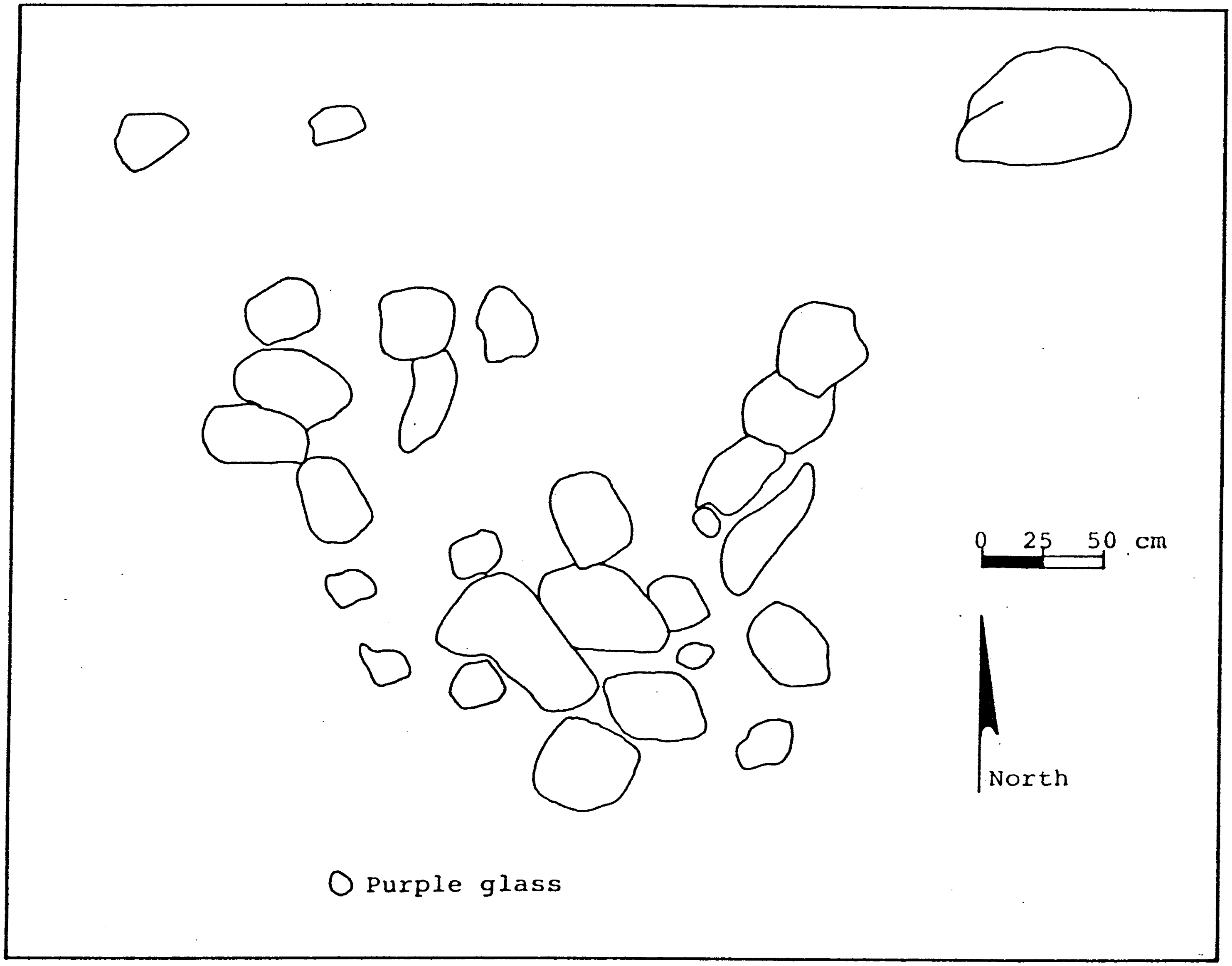


Figure 3. Site AR-03-07-01-1165, rock feature with associated purple glass.

Isolated Occurrence

One isolated occurrence was discovered during the survey. It consisted of two complete flakes of black obsidian. The flakes do not appear to be utilized. They are located in the NW 1/4 of the NW 1/4 of the NW 1/4 of Section 15, Township 21 North, Range 2 East.

Previously Recorded Sites

Eight previously recorded sites occur in the project area. Each of these sites was revisited by the SWCA crew, and site boundaries were reflagged with fluorescent pink flagging tape. The boundaries of the eight sites had previously been demarcated with horizontal bands of white paint placed near eye level on trees just outside of the extent of the site. At each site, a tree within the site boundary had been marked with a white "X", and a metal tag with the site number was placed at the base of the tree. This marking system was intact at all eight of the previously recorded sites.

AR-03-07-01-63

Site AR-03-07-63 is a small habitation site located on a ridge top on the east side of Bill Williams Mountain. It is in the NE 1/4 of the SW 1/4 of the NE 1/4 of Section 16, Township 21 North, Range 2 East (Figure 2), at an elevation of 2243 m (7360 ft). The powerline running east-west to the top of Bill Williams Mountain, and the area cleared for construction of the powerline, pass through the northern portion of the site.

The site was first recorded in May of 1977, and described as consisting of two circular masonry rooms and one square to rectangular room. On a subsequent visit to the site, by the original recorder, it was determined that the room thought to be rectangular is actually circular, and may be double-walled. The site area is approximately 1200 square meters. Examination by SWCA personnel suggests that an additional structural feature may be present several meters to the south of the recorded structures. The structures at Site AR-03-07-01-63 are non-contiguous and appear to have been constructed by stacking unshaped blocks of stone, without mortar, to form walls. The low amount of rubble present in the area of the structures suggests that, in fact, this construction method was used only to form the lower portion of the structure's walls. The remainder of the superstructure was probably constructed of some perishable substance such as wood or brush.

There has been extensive pothunting damage to at least two of the structures at the site. In addition to the looting damage, construction of the powerline has negatively impacted the site.

Based on architectural remains, the original site recorders placed the age of the site at 1050 years B.P. (B.P. 1950), and assigned it to the Cohonina culture. Artifacts found on the surface include flaked and ground stone items, and five ceramic sherds. Ceramic types represented by the five sherds are Deadman's Gray, dating to pre A.D. 700 to 1150 (Colton 1958); Tusayan Corrugated, dating to A.D. 950 to 1275 (Colton 1952); and an unidentified piece of Tusayan White Ware. Several manos were noted as occurring 200 meters southeast and downslope from the site.

AR-03-07-01-64

Site AR-03-07-01-64 is a small sherd and lithic scatter located on a small hill situated on a ridge east of Bill Williams Mountain. It overlooks a deep arroyo to the north. The site is in the NE 1/4 of the NW 1/4 of the NE 1/4 of Section 16, Township 21 North, Range 2 East (Figure 2), at an elevation of 2237 m (7340 ft).

This site was first recorded in May, 1977. A small amount of rubble occurs in the site area, but does not form any recognizable features. The site covers an area approximately 660 square meters. Cultural materials observed on the surface of the site include flaked stone, and the sherds of the following ceramic types: Deadman's Gray (pre A.D. 700 to 1150); Lino Gray, dating to A.D. 500 to 700 (Colton 1958); and a Tizon Brown Ware, Sandy Brown, dating to the same general period as another Tizon Brown, Cerbat Brown (A.D. 700 to 1890) (Dobyns and Euler 1958). One clay cloud blower fragment was also found.

The site is possibly of the Cohonina culture. Based on ceramic evidence, its age was estimated at 1050 years B.P.

AR-03-07-01-149

This site is a sherd and lithic scatter, located on a long ridge on the east side of Bill Williams Mountain. It is located in the SW 1/4 of the SW 1/4 of the NE 1/4 of Section 16, Township 21 North, Range 2 East (Figure 2), at an elevation of 2228 m (7310 ft).

Site AR-03-07-01-149 was first recorded in June of 1978. At that time it was noted that the site had been heavily impacted by blading, and that large stones had been pushed to one side of the site by the blading activity. The site covers an area of approximately 700 square meters.

Based on ceramic and projectile point types observed on the surface, the site was dated to 1000 years B.P. Two obsidian projectile points, one triangular and the other side notched, were found. Ceramic types occurring at the site were Lino Gray (A.D. 500 to 750), Tusayan Corrugated (A.D. 950 to 1275), and Deadman's Gray (pre A.D. 700 to 1150). The site was assigned to the Cohonina culture.

AR-03-07-01-160

This site is described as a small stone structure badly disturbed by a modern engineer's road (Road 1110). The site is located approximately one-tenth of a mile due west of the northeast corner of the property boundary of Benham Ranch. It is in the NW 1/4 of the NE 1/4 of the SE 1/4 of Section 16, Township 21 North, Range 2 East (Figure 2), at an elevation of 2225 m (7300 ft).

The site is a small habitation consisting of a rock structure, the southern portion of which has been destroyed by construction of Road 1110. The site size is estimated at 1900 square meters. Based on ceramic data, it is assigned to the Cohonina culture, and dated to 1000 years B.P.

Cultural materials were limited to a few items of flaked lithic and ceramic. Lithic materials consisted of chert and obsidian. The ceramics included sherds of Deadman's Gray (pre A.D. 700 to 1150), and some unidentified Tusayan White Ware sherds.

AR-03-07-01-899

This site is a sherd and lithic scatter with possible structural features, located on a low ridge to the west and south of Bill Williams Mountain. The site is located in the SE 1/4 of the SE 1/4 of the SE 1/4 of Section 16, Township 21 North, Range 2 East (Figure 2), at an elevation of 2213 m (7260 ft).

Site AR-03-07-01-899 consists of a scatter of artifacts, one possible stone structure and two amorphous rubble piles. It is 3200 square meters in size. The site has been somewhat damaged by logging activities in the area. Based on ceramic analysis, the site has been assigned to the Cohonina culture, with a range of occupation from 1250 to 850 years B.P.

Cultural materials observed at the site include flaked lithics and ceramics. Flaked lithics were limited to 10 flakes of white mottled chert and fine-grained basalt. Ceramics consisted of Deadman's Gray (pre A.D. 700 to 1150), Kirkland Gray, unidentified Tusayan White Ware, and unidentified Tsegi Orange Ware.

AR-03-07-01-900

This site is a light artifact scatter with a possible stone structure, southwest of Benham Ranch and just north of 111C. It is located in the NE 1/4 of the SW 1/4 of the SE 1/4 of Section 16, Township 21 North, Range 2 East (Figure 2), at an elevation of 2231 m (7320 ft).

Site AR-03-07-01-900 consists of a light scatter of sherds and lithics, with one possible stone structure at the west end of the site, and an amorphous rubble pile at the east end. It was first recorded in August, 1984. The site covers an area of approximately 2100 square meters. There has been some mild damage to the site by modern logging activity.

This site has also been assigned to the Cohonina culture. Based on ceramics, the range of occupation is from 1050 to 850 years B.P. Ceramics at the site include Deadman's Gray (pre A.D. 700 to 1150); Tusayan Black-on-red, dating to A.D. 1050 to 1130 (Colton 1952); and one sherd of what is possibly Kana-a Black-on-white, dating to A.D. 700 to 900 (Colton 1952). Lithics include flakes of obsidian, white chert, orange chert, quartz, jasper with black banding, chalcedony, and basalt. One piece of sandstone with grinding on both sides was also found, but could not be assigned to a tool type.

AR-03-07-01-901

This site is a very small rock shelter on the side of a ridge on the east side of Bill Williams Mountain. It is located in the NE 1/4 of the SE 1/4 of the SW 1/4 of Section 16, Township 21 North, Range 2 East (Figure 2), at an elevation of 2274 m (7460 ft).

The site is a small rock shelter situated under a low overhang of a large boulder, and associated artifact scatter. Architecture at the site consists of one single-coursed rock wall (four stones in length). The wall was placed on a large bedrock boulder, located up against and under the overhang. The site covers an area of approximately 520 square meters. It does not appear to have undergone any damage from modern human activity.

Ceramic data provided an estimate of the range of occupation at 1250 to 850 years B.P. The rock shelter was probably utilized by the main prehistoric culture group in the area, the Cohonina. Observed ceramics were mainly sherds of Deadman's Gray and one Kirkland Gray. Lithics included flakes of black obsidian, and white and yellow chert. One two-handed vesicular basalt mano was also found.

AR-03-07-01-902

This site is a single room rock outline and associated light artifact scatter. It is located on a small knob on the eastern slope of Bill Williams Mountain. It is in the NW 1/4 of the SE 1/4 of the SW 1/4 of Section 16, Township 21 North, Range 2 East (Figure 2), at an elevation of 2320 m (7610 ft).

Site AR-03-07-01-902 consists of one stone structure measuring approximately 4 X 4 meters, and an artifact scatter covering an area of 1800 square meters. It appears to not have suffered any appreciable damage from modern human activity. Based on analysis of ceramics, the range of site occupation was estimated at 1350 to 850 years B.P. Ceramics at the site included Deadman's Gray, unidentified Alameda Brown Ware sherds, and unidentified Tusayan White Ware sherds. Lithic artifacts consisted of flakes of orange chert and black obsidian. No formalized flaked lithic tools or groundstone were found.

DISCUSSION AND RECOMMENDATIONS

Survey of the proposed pumice mine project area for Del Tierra Engineering by SWCA personnel indicates, not surprisingly, that steep slopes were not used by prehistoric peoples for habitation or extensive activities. Unfortunately, the two newly discovered sites could not be precisely assigned to a culture group. It is believed, however, that AR-03-07-01-1165 is of recent date, and that AR-03-07-01-1169 appears similar to those described for the Cohonina culture. But, without associated ceramics, it is not possible to give the site a Cohonina designation. The location of AR-03-07-01-1169, high on a hilltop, seems unique when compared to the location of other sites in the project area, which are on the tops of low ridges. What difference in function this might indicate is not known at this time.

Because of their potential for adding to our understanding of the prehistory and history of the area south of Williams, Arizona, both sites AR-03-07-01-1165 and AR-03-07-01-1169 are felt to be potentially eligible for nomination to the National Register of Historic Places. However, additional study, possibly including subsurface testing, is needed to determine that eligibility. It is recommended that both sites be avoided by this proposed project and all future undertakings in the project area. If avoidance can not be achieved, it is recommended that an appropriate mitigative plan be designed to address the research potential of these two sites.

It is felt that the recording procedures have exhausted the research potential of the one newly recorded isolated occurrence, and that it is not eligible for the National Register of Historic Places.

The previously recorded sites add to our knowledge of Cohonina settlement patterns and lifeways. The small stone structures evident on a number of the sites, correspond to McGregor's (1951) description of Cohonina structures. This, as Cartledge (1979) points out, however, may be the result of our uneven knowledge of the Cohonina; the scales being tipped in favor of more information for sites at high elevation, such as those in the present project area.

Each of the eight previously recorded sites is potentially eligible for inclusion on the National Register of Historic Places. Final determination of that eligibility can only be made through further investigations. For the present time, it is recommended that the eight sites be avoided by this and all future undertakings. If avoidance is not possible, an appropriate mitigation program should be designed and implemented to reduce impacts to these resources. All sites have been adequately marked for identification in the field, but prior to any ground disturbance in the project area, all site locations should be shown to Del Tierra personnel or their representatives to prevent unnecessary or inadvertent disturbance to any of the sites.

REFERENCES CITED

Cartledge, Thomas R.

1978 Cultural Resource Clearance Investigation: A Cultural Resource Survey of the Proposed Andrews Timber Sale, Williams Ranger District, Kaibab National Forest, Arizona. USDA Forest Service.

1979 Cohonina Adaptation to the Coconino Plateau: A Re-evaluation. The Kiva 44(4):297-317.

1984 Cougar Timber Sale, Cultural Resource Survey, Williams Ranger District, Kaibab National Forest, Arizona

Colton, Harold S.

1938 Names of Four Culture Roots in the Southwest. Science 87(2268):551-552.

1952 Pottery Types of the Arizona Strip and Adjacent Areas in Utah and Nevada. Museum of Northern Arizona, Ceramic Series No. 1, Flagstaff.

1958 Pottery types of the Southwest. Museum of Northern Arizona, Ceramic Series No. 3D, Flagstaff.

Dobyns, Henry F. and Robert C. Euler

1958 Tizon Brown Ware: A Descriptive Revision. In Pottery types of the Southwest, edited by Harold S. Colton. Museum of Northern Arizona, Ceramic Series No. 3D, Flagstaff.

Greenwald, David H.

1985 An Archaeological Survey of a Drill Pad and Access Road Near Hualapai Hilltop, Coconino County, Arizona. Ms, Department of Anthropology, Museum of Northern Arizona, Flagstaff.

Greenwald, Dawn M.

1986 An Archaeological Survey of a Drill Site and Access Road on Arizona State Lands, Coconino County, Arizona. Ms, Department of Anthropology, Museum of Northern Arizona, Flagstaff.

Hargrave, Lyndon L.

1937 A New Sub-Culture in Arizona. Southwestern Lore, 3(2).

Jennings, Calvin H.

1971 Early Prehistory of the Coconino Plateau, Northwestern Arizona. Ph.D. dissertation, Department of Anthropology, University of Colorado, Boulder.

McGregor, John C.

1950 Excavations of Cohonina Sites, 1949. Plateau 22(4):68-74.

1951 The Cohonina Culture of Northwestern Arizona. The University of Illinois Press, Urbana.

1967 The Cohonina Culture of Mount Floyd, Arizona. Studies in Anthropology 5. University of Kentucky Press.

Stebbins, Sara T.
1984 Archaeological Survey of One Project Site (35 acres) in the Mineral Exploration Area, Coconino Plateau, Coconino County, Arizona. Ms, Department of Anthropology, Museum of Northern Arizona, Flagstaff.

1985 An Archaeological Survey of Brimmer and Supai Mineral Exploration Locales, and Associated Access Roads, Totalling 15 Acres, Arizona State Federal Lands, Coconino County, Arizona. Ms, Department of Anthropology, Museum of Northern Arizona, Flagstaff.

Wigglesworth, Karen S.
1988a Archaeological Survey of the Sage Project Area on the Boquillas Ranch, Coconino County, Arizona. Ms., SWCA, Inc., Environmental Consultants, Flagstaff.

1988b Archaeological Survey of Two Drill Pad Locations on the Boquillas Ranch, Coconino County, Arizona. Ms., SWCA, Inc., Environmental Consultants, Flagstaff.

d:89289-ar.1a

MATERIAL SAFETY DATA SHEET &

LABORATORY ANALYSES

Volcanic Pumice Material

Three Sites in Arizona

SHB Job No. E89-104

SERGENT, HAUSKINS & BECKWITH

CONSULTING GEOTECHNICAL ENGINEERS

SERGENT, HAUSKINS & BECKWITH CONSULTING GEOTECHNICAL ENGINEERS
SOIL & FOUNDATION ENGINEERING • ENGINEERING GEOLOGY • HYDROGEOLOGY
MATERIALS ENGINEERING • MATERIALS TESTING • ENVIRONMENTAL SERVICES

July 12, 1989

Chem-Stone, Inc.
2215 West Mountain View Road
Phoenix, Arizona 85021

SHB Job No. E89-104

Attention: Mr. David L. Bellaire

Re: Material Safety Data Sheet &
Laboratory Analyses
Volcanic Pumice Material
Three Sites in Arizona

Gentlemen:

Presented herein is our report of the analyses of the pumice rock material submitted to us by Chem-Stone, Inc. (Chem-Stone). Also included is a completed Material Safety Data Sheet to be used for compliance, in part, with OSHA regulations. This report includes discussions concerning the scope of work performed, the analytical methods used, the results of laboratory tests performed by Sergent, Hauskins & Beckwith Geotechnical Engineers, Inc. (SHB), and the results of analyses performed by outside laboratories and subconsultants. A summary discussion is presented concerning the primary components of the material which could be identified as hazardous substances, the potential health effects of these substances, and recommended mitigative measures.

Should any questions arise concerning this report, please contact the undersigned.

Respectfully submitted,

Sergent, Hauskins & Beckwith Engineers

REGISTERED GEOLOGIST CERTIFICATE NO. 22745 ANDREW HARVEY III Date Signed 7/12/89 ARIZONA, U.S.A.

By ______________________
Andrew Harvey, III, P.G.

Copies: Addressee

klw/89J-4/7-10-89

TABLE OF CONTENTS Page

REPORT

REGISTERED GEOLOGIST
CERTIFICATE NO
22745
ANDREW F.
HARVEY III
Date Signed 7/13/89
ARIZONA, U.S.A.

SHB Job No. E89-104

1. INTRODUCTION

1.1 Purpose of Study

This report presents the findings of an investigation of rock samples submitted to SHB by Chem-Stone. The purpose of the investigation was to provide data on some of the chemical and physical properties of the material. These data provided information needed to compile a Material Safety Data Sheet in compliance, in part, with the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), Hazard Communication Standard.

The purpose of the engineering analysis was to define certain physical properties which may uniquely characterize the rock deposit. These properties may influence the selection of appropriate end-uses of the material.

1.2 Project Description

Details of the project and anticipated material uses were provided by Mr. David L. Bellaire of Chem-Stone. The project sites consist of three undisclosed locations of natural volcanic pumice. The rock products at these sites are expected to be utilized for garment finish processing. The material will be excavated, processed, and shipped off-site.

airborne components of the rock materials. Sources of this information included: 1) NIOSH Pocket Guide to Chemical Hazards (NIOSH, 1985), 2) Dangerous Properties of Industrial Materials (Sax, 1984), 3) Handbook of Toxic and Hazardous Chemicals and Carcinogenics (Sitting, 1985), and 4) Occupational Health Guideline for Crystalline Silica (OSHA, 1978). Information on the permissible exposure levels and reporting requirements for hazardous air contaminants were obtained from OSHA documents (OSHA 1989a; OSHA 1989b).

1.3.2 Documentation of Potential Health Hazards

In order to assure that the issues of potential health hazards, material handling precautions, and dust control measures were adequately addressed, the firm of Sunshine Environmental Services, Inc., of Phoenix, Arizona was consulted. This firm specializes in hazardous substance identification and documentation. The information supplied by Sunshine Environmental Services was used in the preparation of portions of the Material Safety Data Sheets. This information is discussed in Section 5 of this report.

1.3.3 Laboratory Testing

About 75 pounds of rock samples from each site were sent by Chem-Stone to SHB. These samples were crushed to about 2-inch size and split for submission to the analytical and engineering laboratories. It is understood that the samples received are representative of the entire rock deposit at each site. The tests performed on the samples are described below:

- Chemical analyses for selected elements were conducted on the three samples by Evergreen Analytical, Inc., of Wheat Ridge, Colorado. Laboratory analyses were performed for major elements suspected to be present in the rock material. Analyses for the suite of elements included in the Environmental Protection Agency (EPA) Priority Pollutants List were conducted to establish the levels of potential pollutants. The analyses for EPA Priority Pollutants included Sb, As, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Tl, and Zn. Additional analyses were performed for the elements Si, Bo, Al, Mg, Mn, Fe, Ca, K, V, and Na. The percentage of crystalline quartz (SiO_2) in the samples was estimated for reference to the OSHA standards for respirable quartz mineral dust.

- Aggregate tests on the submitted samples were performed in the SHB Laboratory Engineering Department. These tests consisted of Los Angeles abrasion (200 and 1000 revolutions), specific gravity, absorption, and unit weight.

2. SAMPLE DESCRIPTION

The rock samples submitted by Chem-Stone were examined and their general lithologic and geotechnical characteristics were noted. The material received by SHB consisted of both broken and unbroken, subangular to angular rock clasts ranging in size from about 2 to 6 inches. No field examination was made of the in-place rock. The descriptions presented below are strictly applicable only to the material received by SHB, but are assumed to be generally representative of the entire rock deposit at the sites.

2.1 <u>Site A</u>

The rock is a volcanic pumice of rhyolitic composition, with a slightly frothy texture characterized by considerable very small voids. The glassy components of the pumice are slightly compressed and moderately welded. Major crystalline components consist of quartz, hornblende, and biotite. The color is very light gray to light gray on fresh surfaces, and yellowish-brown on weathered surfaces. The rock samples were unweathered to slightly weathered and moderately soft to moderately hard.

2.2 <u>Site B</u>

The rock is a volcanic pumice of rhyolitic composition, with a slightly frothy texture characterized by considerable very small void spaces. The glassy components of the pumice are slightly compressed and slightly to moderately welded. Major crystalline components consist of quartz, hornblende, and biotite. The color is very light gray on fresh surfaces, and yellowish-brown on weathered surfaces. The rock samples are unweathered to slightly weathered and moderately soft to moderately hard. In general, the samples appear slightly denser than the rock from Site A.

2.3 Site C

The rock is a volcanic pumice of rhyolitic composition, with a slightly frothy texture characterized by considerable very small voids. The glassy components of the pumice are slightly compressed and slightly welded. The degrees of welding and compression appear to be less than in the rock samples from Site A and Site B. Major crystalline components consist of quartz, hornblende, and biotite. The color is very light gray on fresh surfaces, and pinkish to yellowish gray on weathered surfaces. The rock samples are unweathered to slightly weathered and moderately soft. In general, the samples appear less dense than the rocks from Site A and Site B.

3. RESULTS OF ANALYTICAL LABORATORY ANALYSIS

The chemical analyses performed show similar concentrations of detected elements among the three samples. Elements which are present in high concentrations in all three samples are arsenic (390 to 500 mg/kg), silicon (25 to 31 percent), aluminum (5.4 to 5.8 percent), magnesium (5000 to 6300 mg/kg), and manganese (600 to 630 mg/kg). The sample from Site C contained higher concentrations of arsenic, magnesium, manganese, calcium, and vanadium than samples from Sites A and B. The results of these analyses are presented in Appendix A.

The percentage of total silicon includes elemental amounts from all minerals in the rock, including quartz and volcanic glass. The analytically determined amounts of total silicon in the samples from Sites A, B, and C are 31 percent, 30 percent, and 25 percent, respectively. Although the analytical laboratory tests report only the amount of total silicon (Si) in the samples, the total amount of silicon dioxide (SiO_2) would be a higher percentage of the total rock. Analysis of similar pumice rocks from a locality south of Williams, Arizona (T21N, R2E) showed a silicon dioxide (SiO_2) content of 66.1 percent (Funnell and Wolfe, 1964).

Several of the metals detected in the samples are on the EPA's EP Toxicity List (40 CFR Part 261.30). EP Toxicity testing determines the concentrations of specific contaminants in a liquid extract that has been leached from the solid material during specific laboratory test procedures. This testing was not performed as a part of this investigation.

The solid material exhibits the characteristic of EP toxicity if the extract contains contaminants at concentrations equal to or greater than the values determined by the EPA. Elements on the EP Toxicity List which were detected in the pumice samples included arsenic and chromium. An analysis of the EP Toxicity leachate concentrations would be required to definitely determine whether these metals exceeded the established contaminant limits. The general rule for determining whether the concentration of an element on the EP Toxicity List is at a hazardous level in a solid state is to use an attenuation factor of 100 times the maximum concentration for an aqueous leachate. For arsenic, the hazardous level in a solid state would be 5,000 mg/kg (EP Toxicity maximum concentration of 5.0 mg/l times 100). For chromium, the hazardous level in a solid state would be 5,000 mg/kg (EP Toxicity maximum concentration of 5.0 mg/l times 100). The maximum arsenic concentration detected in the samples of pumice submitted by Chem-Stone was 500 mg/kg. The maximum chromium concentration in the pumice samples was 9 mg/kg. The detected concentrations of arsenic and chromium are not at levels normally considered to present a hazardous condition in a solid state.

4. RESULTS OF THE ENGINEERING LABORATORY TESTS

Laboratory testing of the samples conducted by SHB yielded data on the abrasion characteristics, water absorption capacity, specific gravity, and unit weight. The result of these tests are presented in Appendix B.

The Los Angeles abrasion tests were conducted on rock samples which had been crushed to a 2-inch nominal size. The results of the abrasion tests show similar losses of rock material for each of the sample sites. At 200 revolutions, the loss of material, by weight, for sample Sites A, B, and C was 15.7 percent, 14.5 percent, and 16 percent, respectively. At 1000 revolutions the weight loss of material increased to 51.7 percent for Site A, 49.5 percent for Site B, and 51.2 percent for Site C.

Laboratory tests for the Site A material gave an apparent specific gravity of 1.393 and a unit weight of 77.2 pounds per cubic foot (lb/ft^3). The material from Site B had an apparent specific gravity of 1.26 and a unit weight of 68.7 lb/ft^3. Rock material from Site C had an apparent specific gravity of 1.319 and a unit weight of 60.8 lb/ft^3.

The absorption tests performed on the material consisted of total immersion of the samples under water for 24 hours. The absorption values obtained represent the maximum amount of water taken up by the samples under these conditions. The amount of absorption is reported as a percentage of the sample unit weight. The determined absorption was 27.02 percent for Site A material, 26.14 percent for Site B material, and 34.02 percent for Site C materials.

5. DISCUSSION OF POTENTIAL HAZARDS & MITIGATION

The Material Safety Data Sheet (MSDS) presented in this report (Appendix C) lists information concerning the physical and chemical properties of the tested materials. The purpose of the MSDS is to document the potentially hazardous conditions related to the storage and handling of the material. Data presented on the MSDS concerning potential health hazards, precautions, and control measures indicates the proper safety precautions which should be employed when working with the referenced material. The filing of the MSDS in the proper manner by the material processing or storage facility is intended to satisfy OSHA's Hazard Communication Standard (29 CFR 1910.1200).

Laboratory analyses, literature research, and examination of the material submitted by Chem-Stone indicates that the samples consist of volcanic pumice with a high content of crystalline silica, in the form of volcanic glass and quartz. Other naturally-occurring minerals are present in the pumice. These other minerals are considered to be relatively inert and nonhazardous. Respirable silica dust, expected to be produced during material excavation and processing, appears to be the only potentially hazardous component of the material.

The natural pumice, in sizes larger than airborne dust, is not known to have any adverse health effects. The dust generated when the pumice material is excavated, crushed, pulverized, or abraded may be inhaled by workers in the area. This respirable silica dust has the potential for adverse health effects.

Studies have shown repeated or prolonged exposure to high levels of dust containing crystalline silica may

APPENDIX C

cause development of silicosis, a sometimes fatal pulmonary fibrosis characterized by the presence of nodules in the lungs (OSHA, 1978). The symptoms of silicosis tend to be progressive with the long-term continued exposure to the dust containing free silica. The typical symptoms include cough, shortness of breath, wheezing, and repeated, nonspecific chest illnesses. The symptoms appear to increase with advanced age and smoking habits. Studies on long-term workers in the granite processing and sandblasting industries suggest that silicosis can lead to tuberculosis. The levels of exposure to silica dust in these workers is many times the typical levels expected to occur with pumice dust. Studies have also indicated that exposure to silica dust may cause cancer in humans, and demonstratively causes cancer in test animals. Crystalline silica also has been observed to cause the development of fibrous nodules in the cornea of the eye, with resulting loss of visual acuity.

OSHA has recognized that exposure to dust containing silica presents a potential health hazard and, along with other government agencies, has set recommended exposure limits on the amount of respirable dust levels in the air. The dust levels are considered safe for workers exposed to levels at or below the recommended limits for an 8-hour work day (8-hour time weighted average (TWA)). Sampling for dust levels should be conducted within the worker's breathing zone. Samples are collected by a total dust method, which analyzes the amount of dust of all particle sizes, or a method which collects dust particles only of a size range small enough to enter the lungs.

The OSHA permissible exposure limit (PEL) established by the federal government is the upper level of exposure to a contaminant allowed for industry workers. The OSHA PEL for materials which contain quartz is a value based on the percentage of crystalline silica in airborne samples. The OSHA limits are determined both for total dust (crystalline silica plus other components) and respirable dust (the amount of dust of all components which passes a filter to eliminate the larger particles which would not lodge in the lungs). The OSHA PEL standard for total dust is calculated by the formula: 30 milligrams silica per cubic meter of air divided by the percentage SiO_2 + 2, averaged over an 8-hour work shift. The OSHA PEL standard for respirable silica dust is calculated by the formula: 10 milligrams silica per cubic meter of air divided by the percentage SiO_2 + 5, averaged over an 8-hour work shift.

The pumice samples submitted by Chem-Stone have an analytically determined silicon range between 25 and 31 percent. Using these concentrations as the percent of crystalline silica in the samples, the OSHA PEL levels are determined according to the formulas discussed above. The PELs for respirable dust range from 0.30 to

0.37 milligrams silica per cubic meter of air for an 8-hour work shift. The calculated PELs for total dust range from 0.83 to 1.00 milligrams silica per cubic meter of air for an 8-hour work shift.

The National Institute of Occupational Safety and Health (NIOSH) has recommended an exposure limit of 50 micrograms (0.050 milligrams) respirable free silica per cubic meter of air averaged over a work shift of up to 10 hours per day, 40 hours per week (NIOSH, 1985). The American Conference of Governmental Industrial Hygienists (ACGIH) has recommended a threshold limit value of 0.1 milligrams respirable quartz dust per cubic meter of air for an 8-hour TWA (NIOSH, 1985).

Limiting the concentrations of respirable dust in the working zones to the permissible exposure levels is best obtained through good industrial hygiene practices. Proper ventilation of the working zones can reduce the amounts of airborne dust. The use of wet processes with pumice material can also reduce dust levels. Where dust control measures are not feasible, personal respirators may be used to protect personnel from excessive levels of dust exposure. Respirators selected for protection from airborne silica particles should be those which have been approved by the Mine Safety and Health Administration or by NIOSH (NIOSH, 1985).

If pumice dust levels are kept at concentrations below the permissible exposure level established for respirable crystalline silica, no adverse health effects are expected to occur from the silica component of the material. The recommended safety precaution, such as ventilation and respirator use, can greatly reduce the exposure to potentially hazardous components of pumice dust.

REFERENCES

Funnell, J.E. and Wolfe, E.J., 1964, Compendium on Nonmetallic Minerals of Arizona, Prepared for Arizona Public Service Company by Southwest Research Institute, San Antonio, Texas.

Occupational Safety and Health Administration (OSHA), 1978, Occupational Health Guideline for Crystalline Silica, U.S. Department of Labor.

Occupation Safety and Health Administration (OSHA), 1988, Appendix A to Section 1900.1200 Health Hazard Definitions (Mandatory), Federal Register, Title 29 CFR Part 1910. 1200, U.S. Department of Labor.

Occupational Safety and Health Administration (OSHA), 1989a, Air Contaminants - Permissible Exposure Limits, Federal Register, Title 29 CFR Part 1910.1000, U.S. Department of Labor.

Occupational Safety and Health Administration (OSHA), 1989b, Air Contaminants; Guide and Bibliography to Final Rule, Federal Register, Title 29 CFR Part 1910, U.S. Department of Labor.

Sax, N.I., 1984, Dangerous Properties of Industrial Materials, Sixth Edition, Van Nostrand Reinhold Company, New York.

Sitting, M., 1985, Handbook of Toxic and Hazardous Chemicals and Carcinogens, Second Edition, Noyes Publications, Park Ridge, New Jersey.

Evergreen Analytical, Inc.

4036 Youngfield
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854

INORGANIC ANALYSIS DATA SHEET

Client Sergent, Hauskins & Beckwith Client Project # ---

Lab Project # 5812 Date of Analysis June 23, 1989

Units: mg/kg (1) Basis: As Received

Client Sample #	Site A	Site B	Site C	
Evergreen Sample #	X10613	X10614	X10615	
Antimony (F)	<1	<1	<1	
Arsenic (F)	390	420	500	
Beryllium	2.0	2.4	2.4	
Cadmium	<0.5	<0.5	<0.5	
Chromium	9	7	8	
Copper	11	14	12	
Lead	<20	<20	<20	
Mercury	<0.02	<0.02	<0.02	
Nickel	<4	<4	<4	
Selenium (F) (2)	<50	<50	<50	
Silver	<1	<1	<1	
Thallium (F)	<1	<1	<1	
Zinc	23	26	20	
Silicon	31 %	30 %	25 %	
Aluminum	5.6 %	5.8 %	5.4 %	
Magnesium	5000	5200	6300	

(1) Values are milligram/Kilogram except where noted.
(2) Interference in the Selenium determination (most likely Iron) forced dilution and the higher than usual detection limits.

Evergreen Analytical, Inc.

4036 Youngfield
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854

INORGANIC ANALYSIS DATA SHEET

Client Sergent, Hauskins & Beckwith Client Project # ---

Lab Project # 5812 con't Date of Analysis June 23, 1989

Units: mg/kg (1) Basis: As Received

Client Sample #	Site A	Site B	Site C		
Evergreen Sample #	X10613	X10614	X10615		
Manganese	630	600	625		
Iron	2.6 %	2.6 %	2.2 %		
Calcium	1.0 %	1.3 %	1.6 %		
Sodium	1.4 %	1.3 %	1.3 %		
Potassium	2.4 %	2.4 %	2.1 %		
Vanadium (F)	14	16	24		
Boron (2)	0.01 %	0.01 %	0.01 %		

(F) Furnace atomic absorption determination.
(1) Values are milligram/Kilogram except where noted.
(2) Analysis performed by Hazen Research, Inc., Golden, CO.

Approved ______ Quality Assurance Officer ______

SERGENT, HAUSKINS, & BECKWITH

CONSULTING GEOTECHNICAL ENGINEERS

PROJECT: PUMICE RESOURCE ANALYSIS

JOB NO: E89-104

W.O: 1

DATE: 6/16/89

===

LAB NO.	1	2	3
SAMPLE ID	SITE "A"	SITE "B"	SITE "C"
L.A. ABRASION			
200 REVS	15.7%	14.5%	16%
1000 REVS	51.7%	49.5%	51.2%
SPECIFIC GRAVITY			
BULK (SSD)	1.286	1.198	1.22
BULK (DRY)	1.012	.948	.910
APPARENT	1.393	1.26	1.319
ABSORPTION %	27.02	26.41	34.02
UNIT WT. DRY RODDED	77.2	68.7	60.8

APPENDIX C

Material Safety Data Sheet
May be used to comply with
OSHA's Hazard Communication Standard,
29 CFR 1910.1200. Standard must be
consulted for specific requirements.

U.S. Department of Labor
Occupational Safety and Health Administration
(Non-Mandatory Form)
Form Approved
OMB No. 1218-0072

IDENTITY *(As Used on Label and List)*	*Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.*
PUMICE	

Section I

Manufacturer's Name: CHEM-STONE, INC.	Emergency Telephone Number: 1-800-223-3155
Address *(Number, Street, City, State, and ZIP Code)*: 2215 West Mountain View	Telephone Number for Information: (602)997-2013
Phoenix, Arizona 85021	Date Prepared
	Signature of Preparer *(optional)*

Section II — Hazardous Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% *(optional)*
QUARTZ (CRYSTALLINE SILICA) SiO2				
CAS Number: 14808-60-7				
NIOSH: 0.050 mg/M^3 (respirable free silica - 10-hr TWA)				
ACGIH: 0.1 mg/M^3 (respirable quartz)				
IDLH level not applicable.				

Section III — Physical/Chemical Characteristics

Boiling Point: 2230 °C		Specific Gravity (H_2O = 1): 1.2	
Vapor Pressure (mm Hg.): 0 mm at 20 °C		Melting Point: 1710 °C	
Vapor Density (AIR = 1): NOT APPLICABLE		Evaporation Rate (Butyl Acetate = 1): NOT APPLICABLE	

Solubility in Water
insoluable

Appearance and Odor
Off-white powder or fragments; no odor

Section IV — Fire and Explosion Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL
No combustible	NOT APPLICABLE	N/A	N/A

Extinguishing Media
Will not burn.

Special Fire Fighting Procedures
None

Unusual Fire and Explosion Hazards
None

(Reproduce locally)

Section V — Reactivity Data

Stability			Conditions to Avoid
	Unstable		
	Stable	X	Material is stable

Incompatibility (*Materials to Avoid*)
Powerful oxidizers: F_2, ClF_3, MnF_3, OF_2 - May cause fires

Hazardous Decomposition or Byproducts
None known

Hazardous Polymerization			Conditions to Avoid
	May Occur		
	Will Not Occur	X	Polymerization will not occur

Section VI — Health Hazard Data

Route(s) of Entry: Inhalation? Skin? Ingestion?

Health Hazards (*Acute and Chronic*)
Acute - minor irritation to eyes and nose.
Chronic - Repeated exposure to dust containing free silica may cause lung damage (silicosis) characterized by scarring and fibrosis of the lungs

Carcinogenicity: NTP? IARC Monographs? OSHA Regulated?
IARC: Limited evidence that silica can cause cancer in humans. Experimental evidence indicates silica may cause cancer in test animals.

Signs and Symptoms of Exposure
Cough, wheezing, shortness of breath, repeated nonspecific chest illnesses, impairment of respiratory function, eye irritations.

Medical Conditions Generally Aggravated by Exposure
Pulmonary infections. Predisposes to active tuberculosis.

Emergency and First Aid Procedures
Eyes - immediately wash with large amounts of water.
Inhalation - If large amounts are inhaled, immediately move person to fresh air.

Section VII — Precautions for Safe Handling and Use

Steps to Be Taken in Case Material Is Released or Spilled
Ventilate area of spill or release. Collect spilled material by sweeping or vacuuming. Reclaim or dispose in a secured sanitary landfill.

Waste Disposal Method
No specific method is required. Free silica can be disposed of in a secure sanitary landfill in accordance with local regulations.

Precautions to Be Taken in Handling and Storing
Avoid concentrations of dust. Provide adequate ventilation.

Other Precautions
Attacked by hydrogen fluoride (or hydrofluoric acid)

Section VIII — Control Measures

Respiratory Protection (*Specify Type*)
Dust mask for levels below the exposure limit. Approved respirator for higher levels.

Ventilation		
	Local Exhaust: Recommended	Special: Not applicable.
	Mechanical (*General*): Recommended	Other: Not applicable.

Protective Gloves	Eye Protection
None required.	Safety goggles recommended.

Other Protective Clothing or Equipment
Protective coveralls where exposure level is over the recommended limit.

Work/Hygienic Practices
Vacuum work clothes before removal. Avoid dust inhalation.

C-2

* USGPO: 1986-491-529/45775