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NO. 16

PERLITE DEPOSITS NEAR THE DESCHUTES RIVER

SOUTHERN WASCO COUNTY, OREGON

by

John Eliot Allen  
Geologist  
Department of Geology and Mineral Industries



1946

State Governing Board

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## FOREWORD

Expanded perlite is a new industrial product. Its light weight and its insulating and acoustical properties make it attractive for many industrial uses. Its potential market appears to be large.

Oregon has many occurrences of perlite but, as in all low-value industrial minerals, the deposits of commercial importance are the ones favorably located with regard to transportation. Not all perlites expand equally well, and not all parts of the same deposit are uniform in expansion characteristics. Therefore considerable study of a deposit is required before commercial production may be undertaken safely.

Because the development work at the Lady Frances Mine of Dant & Russell, Inc., provided much subsurface evidence on the occurrence of perlite not available at an undeveloped deposit, a detailed geological study of the area was made, and information on furnacing the perlite was obtained. Results are described in the accompanying report and the evidence presented will be of value in studies of undeveloped deposits in other areas.

F. W. Libbey  
Director

December 27, 1946

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## INTRODUCTION

### History

Perlite is "a glassy volcanic rock of rhyolitic composition with a marked perlitic structure" (Holmes, 1928), the latter consisting of a system of convolute and spheroidal cracks, developed in the glass during cooling. Chemically, it differs from normal volcanic glass or obsidian by containing 2 to 4 percent water. Since experiments in Japan many years ago (Kôzu, 1929) it has been known that certain types of volcanic glass would expand when heated abruptly. In 1928 students at the University of Nevada expanded perlite glass from a deposit in Bodie Canyon, between Aurora and Hawthorne, and in 1940 perlite was treated in a kiln at Las Vegas and used with gypsum to plaster a large building there.<sup>1</sup>

In 1941, L. L. Boyer conducted some experiments on crude perlite near Superior, Arizona, and later in the same year tests were made by the Arizona Bureau of Mines<sup>2</sup> which showed that when crude perlite is crushed to 4-mesh and heated to about 1700° F., a loss in weight of nearly 4 percent and an increase in volume of more than 600 percent takes place. The rock, due to its water content of from 2 to 4 percent, "pops" like popcorn to produce a light-colored frothy aggregate having physical characteristics which make it an excellent insulating, acoustical, and building-material aggregate.

Samples of perlite had been collected for the museum of the Oregon Department of Geology and Mineral Industries in 1940, and other samples were submitted to the department by Mr. J. W. Staats of Maupin in 1944. Early in 1945, Mr. E. D. Zoradi, of Dant and Russel Inc., came to the Portland office of the Department and was given the location of these and other samples of perlite from various localities in Oregon. As a result of his investigations, several plots of land were leased and claims located by Dant and Russell Inc., and prospecting work was begun in the fall of 1945 on the deposit located north of Frieda Station (see plates 1, 2, and 5).

### Geography

The Deschutes River Canyon has a depth of 3300 feet in the stretch just south of the area studied, where the river has cut down through a great fold in the Columbia River basalt of Miocene age into the underlying Eocene rocks. The walls of the canyon drop in a series of great steps, formed in turn by flows of basalt, rhyolite, and andesite, with interbedded softer materials. East of the canyon the slightly dissected Shaniko surface (Hodge, 1930) stretches for 25 miles eastward, and slopes northward to the Columbia River. West of the canyon and south of the mine, the mass of older rocks known as the Mutton Mountains rises to elevations of more than 4200 feet, standing a thousand feet higher than the Shaniko surface of Columbia River basalt.

The north side of the Mutton Mountains is drained by Eagle Creek, which empties into the Deschutes River half a mile south of the mine at Frieda. Although Eagle Creek has a drainage area of more than 30 square miles, it is an intermittent stream, and is dry for several months of the year. The flow of the Deschutes River above Crooked River "is more remarkably uniform than that of any other river in the United States comparable in size ... at the mouth of the stream the maximum discharge is only six times the minimum" (Honshaw, 1914). A gauging station at Mecca, 25 miles upstream from the area mapped, recorded, in the period 1911-1926, between 3 and 4 million acre-feet of runoff per year. Minimum monthly runoff has ranged from 195,000 acre-feet in September 1926 to 256,000 acre-feet in September 1917; and maximum monthly runoff ranged from 320,000 acre-feet in March 1926 to 475,000 acre-feet in May 1917 (Stearns, 1931). The annual precipitation is about 15 inches, although snowfall is greater in the higher part of the Mutton Mountains. The mean temperature range is from 45 to 52°. Climatically, the region is classified as dry steppe, with summer drought and cold winter.

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<sup>1</sup>personal communication, E.D. Zoradi.

<sup>2</sup>Bull. 152, p. 35, 1944.

The Frieda area is bare grassland, with an occasional oak and cottonwood in the canyons. Pine and fir trees grow on the crests of the ridges.

#### Acknowledgments

The writer was assisted in the topographic mapping of the Lady Frances mine area by Mr. R. G. Bassett, then engineer at the mine. He is much indebted to Mr. Elko Zoradi, Mr. Pierre Hines, and Mr. Fred Gustavson for suggestions and discussions of the problems involved, and to Mr. Paul B. Schmidt for many courtesies during the period spent at the mine, which totalled 12 days. The mine map base for plate 6 was constructed by Mr. Bassett.

### GEOLOGY

#### General stratigraphy

Perlite deposits in central Oregon generally occur within the Clarno formation, of Eocene (lower Tertiary) age. This series of andesitic, basaltic, and rhyolitic lavas with interbedded tuffs and ash is widespread in central Oregon (Hodge, 1931; Waters, 1942) (See plate 1 for general distribution), and similar rocks occur in several localities farther east in Oregon (Gilluly, 1937; Piper, 1939, p. 52; Bryan, 1929, p. 46). The Clarno is divided by a strong unconformity into a lower series, predominantly composed of andesitic tuffs, breccias, and flows; and an upper mainly rhyolitic series in which the perlites occur. In the Horse Heaven area, 35 miles southeast of the mine (Waters, 1945), the lower series is 5800 feet thick; in the Mutton Mountains only 500 feet of the andesite is exposed below the unconformity, whereas the overlying rhyolite is more than 2000 feet thick.

The base of the Clarno is exposed near the head of Hay Creek and Little Willow Creek east of Madras; near Mitchell; and near Muddy Creek Ranch, just west of the John Day River. The formation unconformably overlies slates, sandstones, and conglomerates of Mesozoic age. The rocks near Mitchell are of Cretaceous age; elsewhere they are probably older. The Clarno is stratigraphically overlain by tuffs of the John Day formation (Oligocene) although younger rocks lap upon it in a number of places.

Perlite also occurs in eastern Oregon in rocks which are apparently later than Clarno age. In the Steens Mountains rhyolite flows and intrusives with perlite selvages may be Pliocene (Fuller, 1931); in the Harney Basin perlite occurs in rocks assigned to the Pliocene Danforth formation (Piper, 1939, p. 47); in Baker County in the vicinity of Pleasant Valley, perlite is associated with tuffs of probable Pliocene age.<sup>3</sup>

The Clarno rocks of the Mutton Mountains have been mapped in detail by Wilkinsen (1932), and more generalized maps of the area have been published by Hodge (1931, 1940, 1941). The generalized section, as abstracted from Wilkinsen's report is as follows:

<u>Thickness</u>	<u>Description</u>
50 ft. (?)	Upper andesite flows and plugs, generally massive, iron gray to black, fine textured, granular.
100 ft.	Alkali-rhyolite (pantellerite), vesicular, light to dark gray, mottled.
500 ft.	Rhyolite proper (subtype A), banded, gray, violet, and fawn colors, aphanitic groundmass, with orthoclase and some quartz phenocrysts. Includes interbedded tuff layers not over 100 feet thick.
700 ft.	Aphanitic rhyolite (lithoidite), massive, red colored, with perlite and obsidian beds, particularly at the top. Contains local interbedded pyroclastics, not over 50 feet thick.
150 ft.	Trachyte, platy, aphanitic, gray color with iron-stained bands, overlain by a thin bed of black glass. In some places the entire flow is glassy. (This is the main perlite zone.)

<sup>3</sup>Personal communication, W. D. Lowry.

<u>Thickness</u>	<u>Description</u>
0-500 ft.	Agglomerate, varying from fine grained to breccia in size; red, cream, and green colors. Contains interbedded tuff and ash.
100 ft.	Rhyolite porphyry (nevadite), as lenses and dikes, aphanitic with micro-crystals, gray to red in color.
———Strong disconformity———	
200 ft.	Andesite, dense aphanitic to glassy; dark gray, green to black in color.

A reconnaissance geologic map (plate 2) was made of the area near Frieda Station. This area of about 12 square miles is at the north side of Mutton Mountains on the Deschutes River about 9 miles south of the town of Maupin. A more detailed topographic and geologic map (plate 5), on a scale of 200 feet to 1 inch, was made of an area of about half a square mile around the Lady Frances Mine, located a thousand feet north of Frieda.

The 100-foot bed of rhyolite porphyry above the disconformity in Wilkinson's section does not appear near Frieda although it occurs farther to the north and east, on both sides of the river. The agglomerate bed stratigraphically above it is only a few feet thick at the Lady Frances Mine, but it thickens rapidly to the southwest, up Eagle Creek. Five sections were roughly measured both up and down river from the mine and near the mine; these are presented on plate 3. The perlite flow in which the mine is situated lies upon water-laid tuffs, upon agglomerates, and in places upon the underlying andesite. Farther east and north there are two zones of perlite, separated by a rhyolite flow. A rough idea of the relationships is suggested by the diagrammatic cross section on plate 7.

There are seven stratigraphic units distinguished on plate 5, a geologic map of the area adjacent to the mine, which may be summarized as follows:

<u>Thickness</u>	<u>Description</u>
0-50 ft.	Talus and soil cover.
0-100 ft. +	Recent alluvium, terrace, and landslide material.
****	Dike from 50 to 150 feet wide of gray, porous andesite cutting entire Clarno and Columbia River basalt section.
900-1000 ft.	Rhyolite, platy, banded, in places massive; gray to red color. Contains well-defined flow structures, and near the base is often cavernous, with lithophysae and nodules containing agate.
0-140 ft.	Perlite, blocky to splintery fracturing; light gray to nearly black in color; frequently contains well-developed flow planes of lighter and darker material.
0-75 ft.	Water-laid tuff and tuff breccias, varying from fine-grained, well-bedded yellow tuff to a perlite agglomerate, consisting of round "pillows" of perlite in a vitric tuff matrix which grades into massive perlite above. Considerable alteration of both matrix and perlite by silicification to form a greenish chalcedonic material.
———Unconformity———	
500 ft. +	Andesite breccias and flows, lapilli tuff, dark yellow to red, grading downward into andesite breccia and massive, blocky fracturing, usually vesicular and frequently amygdaloidal andesite.

Near the mine the various units are essentially flat lying, but the regional dip is to the north, and the perlite flow, which is at an elevation of 500 feet above the river at the mine, dips below river level less than 2 miles north.

### Andesites

The andesite flows occur in outcrops in the river bed just below the mine, and form prominent physiographic benches 400 feet above the river. They do not rise as high in the bed of Eagle Creek, but form low cliffs on either side of that stream for several thousand feet to the southeast. An interbed of green water-laid tuff and overlying tuff breccia appears east of the mine on both sides of the Deschutes River. On Eagle Creek the lavas are overlain by several hundred feet of dark red to yellow and green breccia containing andesitic scoria and lapilli of all sizes. These rocks weather to form abrupt cliffs, pinnacles, and spires. Steep dips in this material strongly suggest the former presence of an andesitic cinder cone about a mile from the mouth of Eagle Creek.

The lava varies from a black glassy augite andesite to a gray vesicular and frequently amygdaloidal lava. Both phases are porphyritic with from 5 to 20 percent andesine phenocrysts, sometimes in two generations. A few crystals of augite occur in the glassy phase. The hyalopilitic groundmass of the glassy phase is 20 to 35 percent brown glass, 20 to 30 percent trachytic oligoclase, 15 to 20 percent augite granules, and 5 to 20 percent magnetite, the remainder being alteration products such as chlorite and limonite. The vesicular phase has a groundmass containing 20 percent glass, as much as 15 percent magnetite, 3 percent augite granules, and 15 percent trachytic oligoclase-andesine. Amygdules, which make up 30 percent of the rock, contain, in order of formation, unidentified zeolites, interstitial chlorite, secondary magnetite, and chalcocony.

### Tuffs and perlite breccia

Above the andesite and andesite breccias are found isolated beds of fine-grained, well-bedded, water-laid vitric tuff, composed of minute shards of glass and perlite. At several localities up Eagle Creek the tuff is green and coarsely granular, being composed of partially altered fragments of andesite and glass. Above the tuff there is usually a layer of perlite breccia, from a few feet to more than 50 feet thick, which is overlain by massive perlite. At one locality a mile east of the mine great blocks of perlite breccia are imbedded in green tuff, which also contains angular and water-worn pebbles of andesite. The breccia is made up of rounded "pillows" of perlite in a matrix consisting of fresh to altered perlite tuff with angular fragments of andesite. Considerable secondary silicification of both perlite and tuff has taken place, with the formation of a pale green chalcodonic or plasmalike material. Some perlite fragments have rims of this siliceous material. Yellow unctuous clay occurs in the matrix. The rounded bodies of perlite frequently have smoothed and apparently striated surfaces.

### Perlite

The perlite varies from light gray to nearly black in color, and has a blocky to splintery fracture. It overlies both perlite breccia and tuff, as well as andesite breccia, and underlies the rhyolite. A generalized cross section showing the relationships of the perlite with adjacent formations in the Frieda area is given in plate 7. In this area it crops out in three general localities (see plate 5) at and near the mine, 2000 feet south in the north wall of Eagle Creek, and over the ridge to the northwest on both sides of "Landslide Cove." These outcrop areas are believed to be connected beneath the soil cover, and perlite may be observed along the same zone for three miles to the southwest up Eagle Creek, and for two miles north along the west side of the river to a point half a mile south of Nona Station, where it dips below river level. Perlite also occurs across the river to the east and in Sheep Mountain to the south. To the east and north there are two beds of perlite separated by rhyolite.

At the mine portal the perlite is about 150 feet thick, but 400 feet south it is less than 30 feet thick, being replaced by bedded tuffs below and vitric tuffs above. North of the mine portal a plug of rhyolite 400 feet by 800 feet is surrounded on three sides by perlite, and contains vertical, contorted, and steeply dipping flow planes. The contact



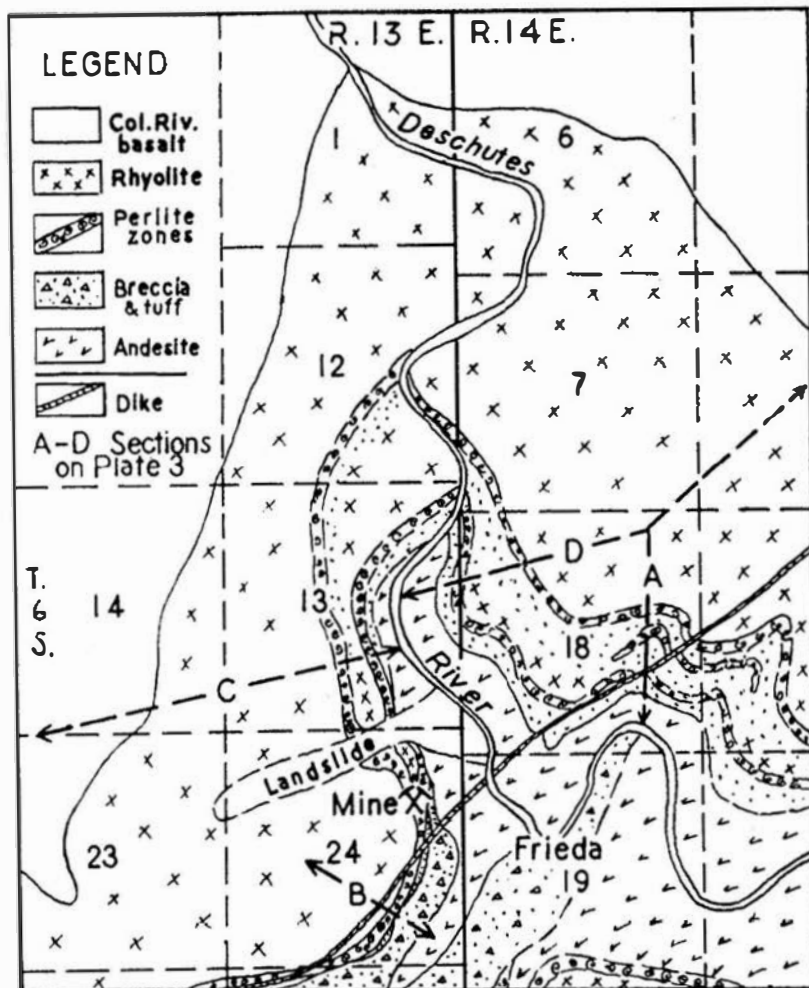
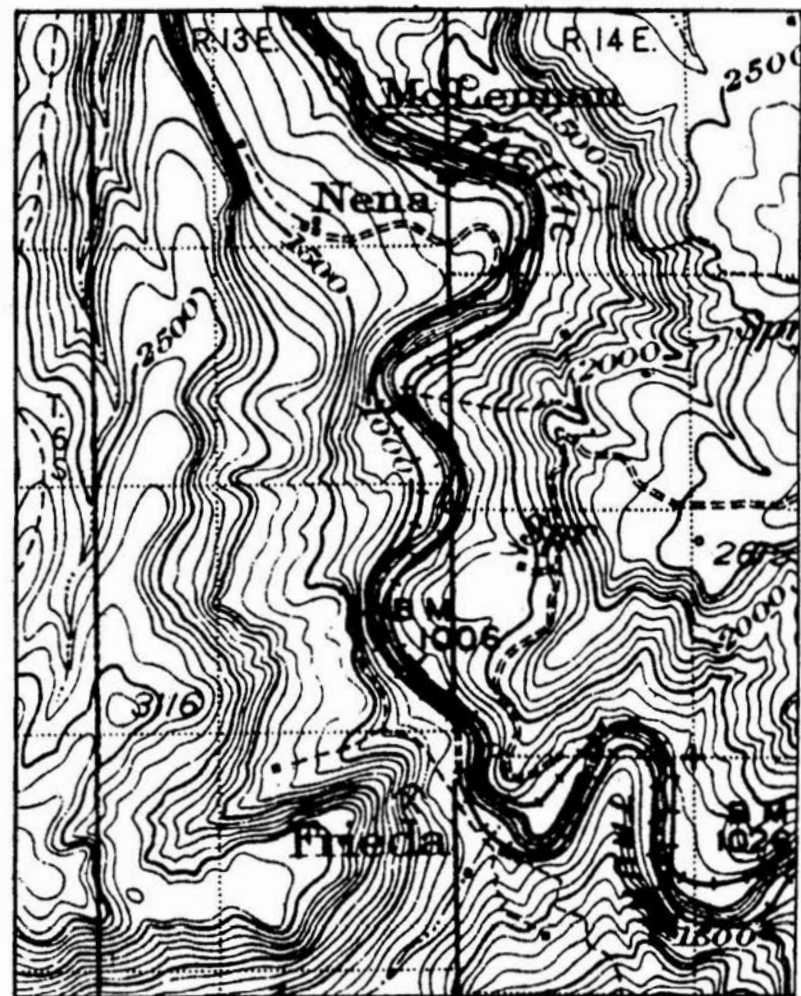


Plate 2 Geological map of Frieda district



Topographic map of Frieda district

between this plug and the adjacent perlite consists of interfingering lenses of perlite in rhyolite and rhyolite in perlite, the latter being parallel with flow planes in the perlite. The flow planes south and west of the plug, as exposed in the mine workings, dip gently away from the plug and then rise again, forming a synclinal structure (see plate 6) around the periphery of the plug. The base of the perlite where it overlies brecciated and tuffaceous rocks dips north toward the plug. North of the mine portal the tuff and breccia formation is very thin, and the perlite rests almost directly upon andesitic breccias and flows.

At the south outcrop area, perlite overlies perlite breccia which in turn overlies a thick section of andesite breccia and tuff. The perlite here is dark brown to black in color, breaks with a smooth blocky fracture, and consists of angular fragments of glass completely welded into a massive perlite, the only distinction between fragments and matrix being one of color. The angular and subangular fragments have a bluish gray color with reddish rims, whereas the interstitial glass is a dark brownish black.

As shown in thin section perlitic cracks are not abundant. The glass has an index of refraction of  $1.505 \pm .002$ , which indicates that it has a silica content of about 71 percent (George, 1924), whereas the gray perlite with the splintery fracture at the main deposit has a refractive index nearer 1.50, indicating a slightly higher silica content. Rod-shaped crystallites are not uncommon and tend to be oriented parallel to the flowage. Trichites also appear. Fine magnetite dust appears throughout, frequently arranged in lines.

### Rhyolite

Thick flows of rhyolite with a total thickness in excess of 1000 feet overlie the perlite. At the mine the contact is sharp, with the lower surface of the rhyolite being grooved, indicating flowage over already cooled and solidified perlite. At places a mile up Eagle Creek and two miles down the Deschutes River respectively, the contact is less definite, with blocks of perlite incorporated into a rhyolite breccia, and rhyolite fragments included sparsely in the perlite breccias. In these localities the lower 10 to 30 feet of the rhyolite is cavernous with rounded lithophysal nodules developed on the walls of the cavities, which in places make up as much as 30 percent of the rock volume. The rhyolite above the perlite exhibits well-defined flow structures with banding due to colors varying from lavender to yellow, brown to red.

In thin section the color bands are apparent under parallel light, but under crossed nicols they disappear, and the rock is seen to be an aggregate of radiating spherulites, composed of minute acicular crystals of quartz and orthoclase. The rock is made up of 15 percent well-developed spherulites, 35 percent irregular interstitial spherulitic material, 20 percent interstitial quartz, 20 percent magnetite, 10 percent secondary limonite, and a few biotite flakes. Complete petrographic descriptions of the various types of rhyolite in the area are given by Wilkinson (1932).

### Post-Clarno rocks

Stratigraphically above the rhyolite series in the Mutton Mountains is a relatively thin section of John Day tuffs, which are overlain by Columbia River basalt. The basalt caps the crests of the ridges and forms the upland surface east of the Deschutes River. The John Day tuffs do not occur within several miles of the mine.

### Andesite dike

A dike of gray, vesicular andesite cuts the entire Clarno section just south of the mine portal. The dike strikes N.  $50^{\circ}$  E. at the mine, and extends for at least 2 miles to the northeast and to the southwest. One half mile to the southwest the strike swings to the west. The dip varies from  $75^{\circ}$  northwest at the mine to nearly vertical farther west.

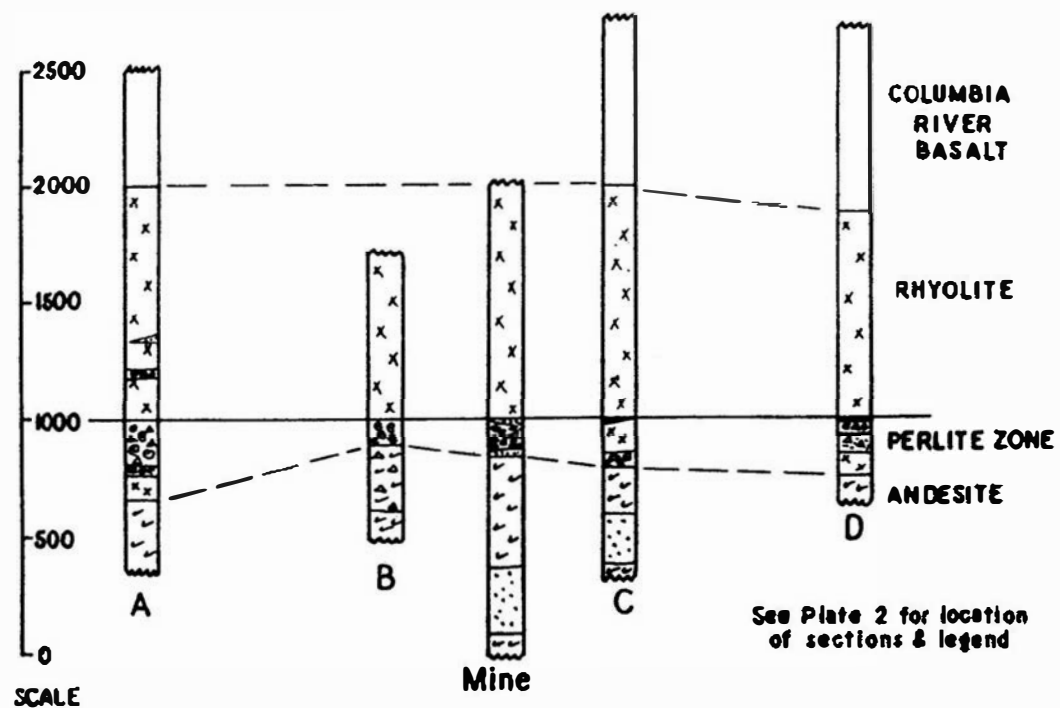


Plate 3 Generalized stratigraphic sections

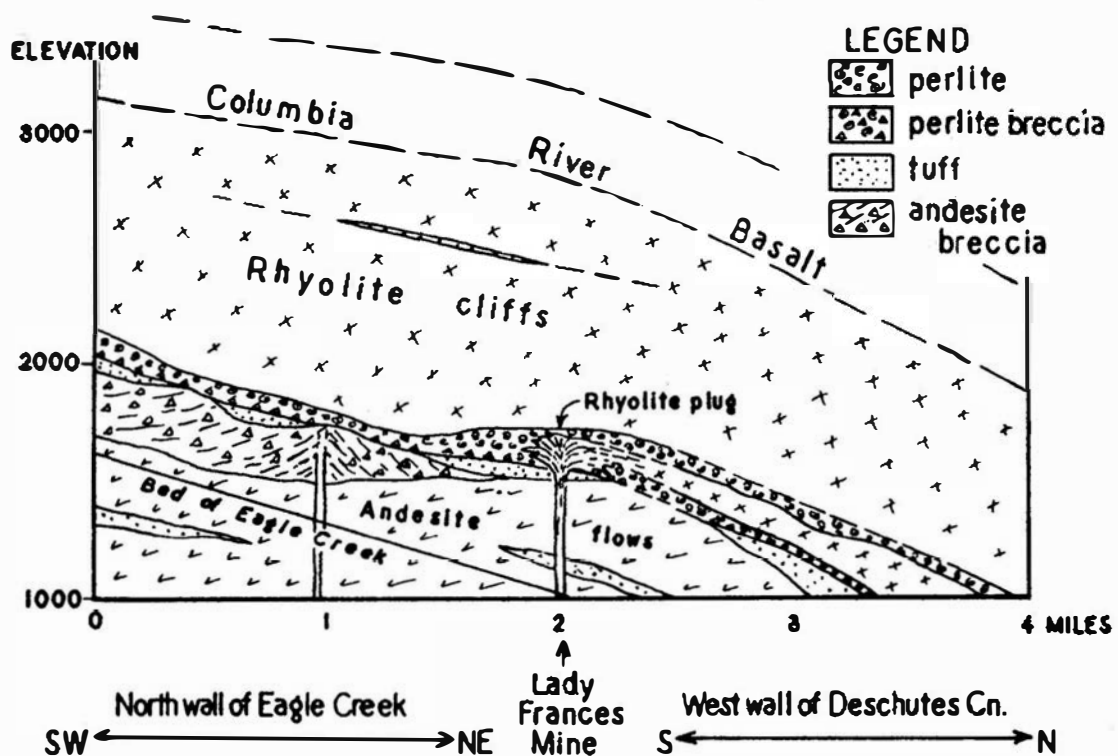


Plate 7 Diagrammatic cross section of Frieda district

As shown in thin section the rock is porphyritic and hyalopilitic, the only phenocrysts being 15 percent equant oligoclase (.05 to .3 mm) which has gradational outlines, being partially resorbed by the groundmass. Twinning is rare. The groundmass consists of 30 percent oligoclase-andesine laths up to .05 mm long; 20 percent anhedral oligoclase (?); 30 percent brown to colorless glass, in part devitrified, and 5 percent anhedral magnetite grains in all sizes up to .07 mm. Some of the magnetite is secondary, and some has been altered to goethite. A few small crystals may be apatite.

#### Origin of perlite

Most perlite contains from 2 to 4 percent contained water, and usually its chemical analysis shows that there is an excess of  $\text{Na}_2\text{O}$  over  $\text{K}_2\text{O}$ . Otherwise it is identical in composition to adjacent and related rhyolites, which usually contain less than 2 percent water and have an excess of  $\text{K}_2\text{O}$  (Fuller, 1935). Several characteristic analyses of perlites and rhyolites from the Steens Mountains of southeastern Oregon (Fuller, 1931) are given below:

#### Perlites and rhyolites of Steens Mountains

	Rhyolite	Perlite	Rhyolite	Spherulite	Rhyolite	Perlite	Rhyolite
	1	2	3	4	5	6	7
$\text{SiO}_2$	73.00	67.05	73.60	75.62	74.50	68.66	72.65
$\text{Al}_2\text{O}_3$	14.23	14.91	12.96	11.52	12.45	14.44	13.64
$\text{FeO}$	1.28	1.48	1.19	1.19	.83	1.28	.68
$\text{Fe}_2\text{O}_3$	.28	.92	.82	.82	.85	.80	.70
$\text{MgO}$	.24	.65	.20	.26	.28	.18	.60
$\text{CaO}$	1.25	2.44	.64	.62	1.82	1.96	.55
$\text{Na}_2\text{O}$	2.96	4.15	1.71	1.80	3.88	3.86	2.54
$\text{K}_2\text{O}$	4.86	3.04	7.27	6.50	4.27	3.28	5.70
$\text{H}_2\text{O}$ ( $\rightarrow$ 105° C.)	1.00	4.35	.80	.90	.66	4.80	1.50
$\text{H}_2\text{O}$ (at 105°C.)	.60	.50	.40	.33	.30	.40	1.50
$\text{CO}_2$	none	none	none	trace	none	none	none
$\text{TiO}_2$	.18	.34	.30	.34	trace	.25	.10
$\text{P}_2\text{O}_5$	trace	.12	trace	trace	.07	trace	trace
S	none	trace	none	trace	.04	none	none
$\text{MgO}_2$	none	trace	none	none	trace	none	trace
Totals	99.88	99.95	99.89	99.90	99.95	99.91	100.16

Analyses by W. H. and F. Herdsman.

The origin of the various types of volcanic glass, and of perlite in particular, is still a matter of considerable controversy. Conditions requisite for the formation of thick deposits of glass seem to be 1) an acid magma; 2) extremely rapid extrusion; and 3) extremely rapid solidification. Basic magmas are more fluid than intermediate or acid magmas, and upon extrusion tend to remain liquid long enough so that they can become crystalline except on their outer selvages. Acid magmas are viscous, and are generally erupted rapidly, often accompanied by explosions and the formation of breccia, tuff, and pumice. They may lose much of their combined water and cool rapidly, thus preventing crystallization. The difference in composition of the glassy margins and stony centers of acid rocks (more water and soda in the glass) has been attributed by several writers (Shand, 1943, pp. 37-38) to changes that have taken place since their formation, but this is not generally accepted by most geologists, who believe that the high water content, particularly, is an indication of retention of the water content of the magma.

Perlite deposits generally seem to overlie water-laid tuff beds of a similar composition, and are associated with explosive action. The only outstanding exception appears to be when perlite occurs as the chilled selvages of andesitic intrusions (Waters, 1942). E. D. Zoradi, who has visited numerous deposits in the southwest, reports (oral communication) that in every case where the base of a deposit is exposed, it lies upon tuff beds or upon agglomerates or breccias of explosive origin. This is true in the Frieda district, in the Steens Mountains (Fuller, 1931), in the Owyhee area (Bryan, 1928, p. 46), in the Superior (Pinal County) area, and in the Black Mountains of Mohave County, Arizona, (Wilson and Roseveare, 1945).

In the Frieda area the presence of perlite masses within the bedded tuff, the apparent "pillow structure" in the base of the perlite breccias, the repetition of water-laid tuffs below and above the perlite layers, and the degree of silicification and alteration of the breccias and portions of the perlites, suggest that the extrusions may have occurred beneath lakes of considerable depth; were, in fact, sub-lacustrine in nature. The extensive brecciation and silicification may have in part resulted from the interaction between the hot lava and the surrounding waters. The actual vent from which the perlite came seems to be represented by the rhyolite plug just north of the mine portal, and the excessive thickness of the perlite at this point is due to the proximity of the vent.

In the same area there are numerous thin rhyolite flows, with composition similar to perlite, which cooled slowly enough to crystallize. If lakes were present at the time of their extrusion, they might have been cooled rapidly enough to form perlites.

THE LADY FRANCES MINE (Perlite)  
Mutton Mountain District  
Wasco County

Owners:

Dant and Russell, Inc., Perlite Division, Portland, Oregon.  
James Abbott, Maupin, Oregon.

Operators:

Dant and Russell, Inc., Perlite Division.

Location and transportation:

The Lady Frances mine is on the west side of the Deschutes River, at a point 9 miles south of Maupin, the nearest town to the north on the Dalles-California Highway (U.S. 97) (see plate 1). Maupin is 100 miles by highway to Portland by way of the Wapinitia Pass (State Highway 50). A gravelled road follows up the east side of the river from Maupin, a distance of 14 miles, to a point opposite the mine, where the river is crossed by small boat. The Oregon Trunk Railroad on the west side of the river goes past the mine; the latter being 162 miles from the Portland terminal, via the junction with the main line at Wishram, and the Columbia River gorge.

The mine portal is at an elevation of approximately 1550 feet and about 500 feet above river level. It is 1400 feet west of the railroad and 1500 feet north of Frieda Station (see plates 4 and 5). A spur has been built opposite the mine. The portal lies 2100 feet S. 26° W. of the northeast corner of sec. 24, T. 6 S., R. 13 E.

Development and equipment:

When the property was first visited in November 1945, development consisted of an adit 100 feet long with a 40-foot inclined raise; 4 open cuts in perlite, and 5 other location cuts. The crew was living in box cars converted to mess and bunkhouses. The mine was reached by a narrow switchback trail up the steep hillside.

In September 1946, development work consisted of 1150 feet of drifts and crosscuts in perlite and about 300 feet of raises (see plate 6). A road to the portal more than a mile long had been built; buildings consisted of an office, bunkhouse, messhouse, and change-house, and foundations for a small pilot mill had been laid. Also two diesel-electric power plants to furnish power for lights and for the mill, and a pump and pipeline from the river have been installed. A 2-ton army truck furnishes transportation to and from camp to mine, and a railroad siding has been put in at the campsite below the mine.

Metallurgy:

A 30-ton pilot mill was being constructed at the mine to crush, wash, and size the perlite for shipment to the expanding plant at St. Helens, Oregon. The mill will consist of a 6 by 8-inch Dodge crusher, a 2 by 4-foot Marcy rod mill, 2 Hummer screens, a Western hydroseparator with Adams density control, settling and dewatering tanks, and sacking apparatus. The perlite, after being crushed to 1 inch, will be ground to pass 20-mesh, and the oversize from the screens will be returned to the mill. It is important both to the production of a clean product and to the success of later treatment that all fines smaller than 200-mesh be removed by the hydroseparator.

At the St. Helens pilot plant, the perlite is expanded in a 4 by 8-foot specially designed rotary kiln\*, fired by 4 gas burners to temperatures ranging from 1500 to 2500°F. The sized perlite is raised by a small 20-foot bucket elevator to a 3 by 4-foot storage cone, and is fed into the kiln, which rotates at 8 rpm, above and about 1 foot ahead of

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\*Patent applied for.



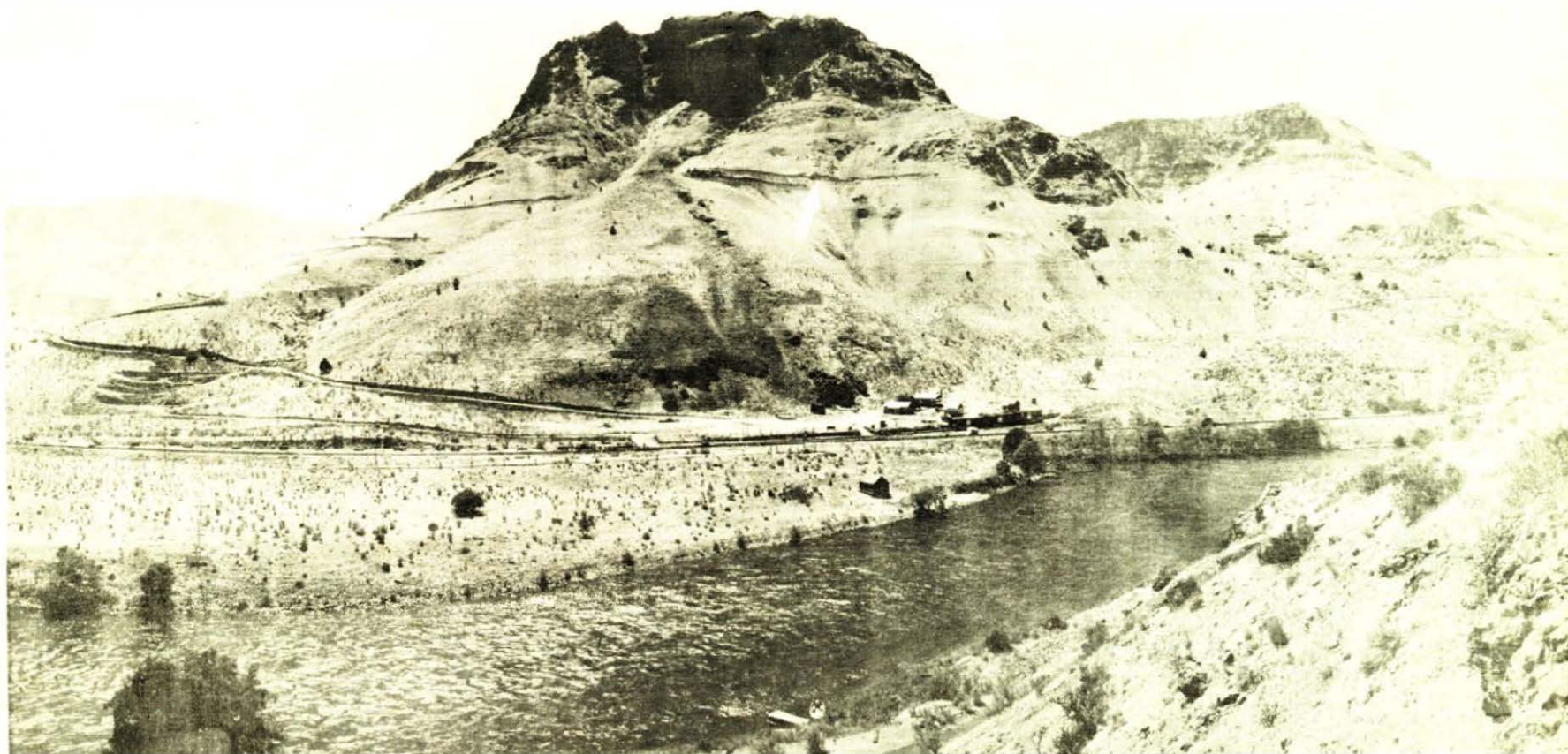
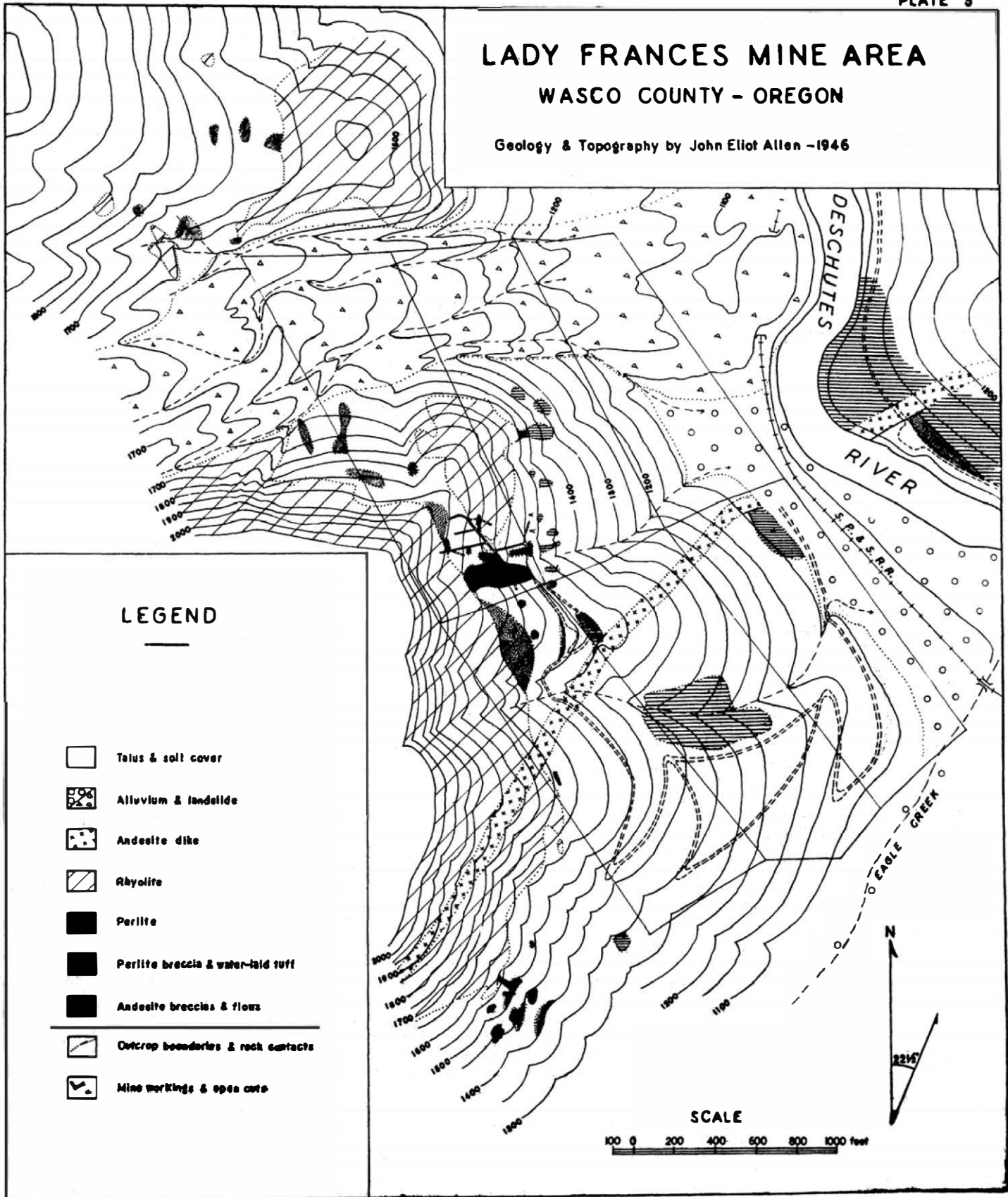











Plate 4 View of Lady Frances perlite mine south of Maupin, Wasco County looking west across Deschutes River.

# LADY FRANCES MINE AREA WASCO COUNTY - OREGON

Geology & Topography by John Elliot Allen - 1946



## LEGEND

-  Talus & soil cover
-  Alluvium & landslide
-  Andesite dike
-  Rhyolite
-  Perlite
-  Perlite breccia & water-laid tuff
-  Andesite breccias & flows
-  Outcrop boundaries & rock contacts
-  Mine workings & open cuts

## SCALE

100 0 200 400 600 800 1000 feet



the burners. The system operates at a vacuum of from .4 to .8 inches of water, this being maintained by an automatically regulated steam jet directed upwards in the exhaust stack. The expanded perlite is drawn from the furnace into a downdraft box where the coarse material is removed; thence into a cyclone six feet in diameter, where the fines are collected, thence into a 10-foot cyclone which catches any remaining dust.

#### Laboratory testing:

In order to determine whether any correlation exists between percentage of combined water and the density of perlite after its expansion, the Perlite Division of Dant and Russell, Inc., made a series of drying and ignition tests under the supervision of John R. Anderson and R. Richardson.

Weighed samples of the raw perlite were heated at 220° F. for three hours and the decrease in weight taken as the percent of saturated water. Identical samples were heated at 1200° F. for three hours and the entire loss in weight assumed to be due to evaporation of the total water present. The difference in these two percentages is the amount of water existing in combination in raw perlite. Identical samples of the raw perlite were expanded in an assay muffle at 2000° F. and the densities measured.

In plate 8-A the density in pounds per cubic foot of the expanded perlite is plotted against the percentage of combined water. Several samples of perlite from the surface of a Nevada deposit were included for comparison. These samples show substantially higher percentages of water and lower densities than the perlite found below the surface of the Oregon deposit. Surface samples from the Oregon deposit contain approximately the same amount of water and have slightly higher densities than the Nevada perlite.

From the figure it can be seen that although the majority of the samples contain about 3.25 percent water with densities varying from 10 to 32 pounds per cubic foot in the expanded product, those samples which contain about 4 percent water vary from 10 to only 16 pounds per cubic foot in the expanded product.

In order to determine the crushing characteristics of the perlite found in various portions of the deposit, and to determine percentage of fines that could be expected from the grinding operation, the Perlite Division of Dant and Russell, Inc., made an extensive series of crushing and screening tests conducted by John R. Anderson.

Samples taken at 5-foot intervals in the mine were crushed to minus  $\frac{1}{4}$ -inch. The amount of the sample was decreased by quartering and splitting until about two kilograms remained. Six hundred grams of the soresned sample were recorded in 5 columns as +10 mesh, -10 to +20 mesh, -20 to +150 mesh, -150 to +200 mesh, and -200 mesh, "Before Grinding." This sample was then placed in a laboratory rod mill with 450 cc of water and was ground for three minutes. The sample was then dried and screened again. This analysis was reported under the heading, "After Grinding."

The histograms on plate 8-B are of four groups of samples from different parts of the mine, and represent a graphic mean of percentage weights plotted against screen sizes. It will be seen that the large sizes were reduced in the rod mill without creation of excessive fines.

#### Economics:

The expanded aggregate, which weighs less than 12 pounds to the cubic foot, can be used as a light-weight aggregate for plaster, concrete, and a multitude of other uses where light weight and insulating and acoustic properties are of value (Ralston, 1946).

**TUFF**

## RHYOLITE

NE 1/4 Sec. 24, T.6 S., R.13 E.

**TUFF &  
BASALT**

## BASALT

## Portal

**TUFF**

**SCALE**

SURFACE CONTACT  
UNDERGROUND CONTACT  
FLOW LINES  
FAULTS

P E R L I T E

Geology by  
John Eliot Allen

# APPENDIX

The results of three chemical analyses arrived too late to be included in the text. The three samples consisted of banded rhyolite immediately overlying the main perlite mass at the mine; dark-colored perlite in the main north drift near the rhyolite intrusive plug; and light-colored perlite from the bench near the portal. These analyses and the mineral composition norms calculated from them are given below:

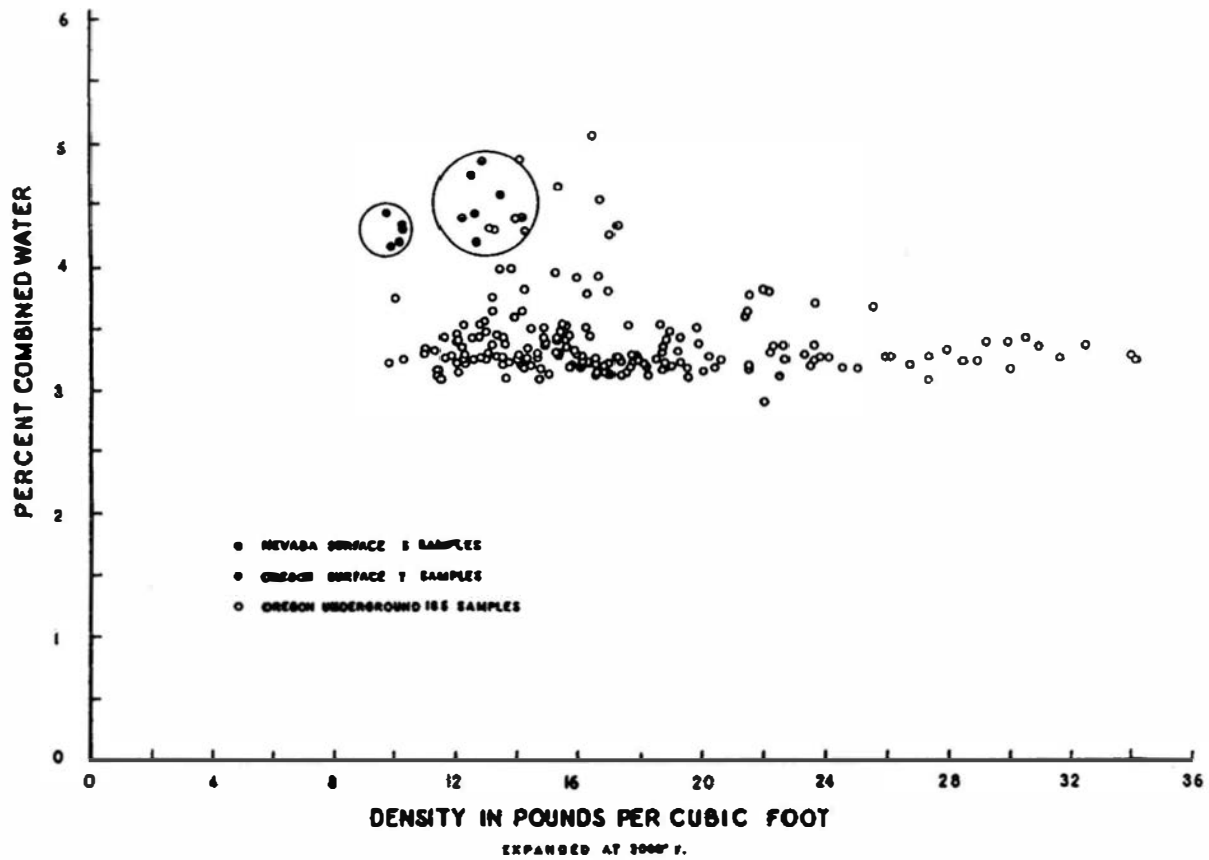
	I	II	III
	MM11	North drift	No. 2 bench
	R 1082	R 1084	R 1083
	<u>Rhyolite</u>	<u>Perlite</u>	<u>Perlite</u>
SiO <sub>2</sub> . . . . .	75.88	73.79	73.28
Al <sub>2</sub> O <sub>3</sub> . . . . .	12.63	12.40	12.55
Fe <sub>2</sub> O <sub>3</sub> . . . . .	1.05	.52	.58
FeO . . . . .	.27	.62	.63
MgO . . . . .	.14	.11	.08
CaO . . . . .	.60	.80	.80
Na <sub>2</sub> O . . . . .	2.80	3.16	2.97
K <sub>2</sub> O . . . . .	5.32	4.84	5.00
H <sub>2</sub> O+ . . . . .	.54	3.24	3.60
H <sub>2</sub> O- . . . . .	.43	.25	.19
TiO <sub>2</sub> . . . . .	.09	.09	.09
P <sub>2</sub> O <sub>5</sub> . . . . .	.03	.01	.01
MnO . . . . .	.01	.02	.02
Total	99.79	99.85	99.80

Analyses by James Kerr, University of Minnesota, October 23, 1946.

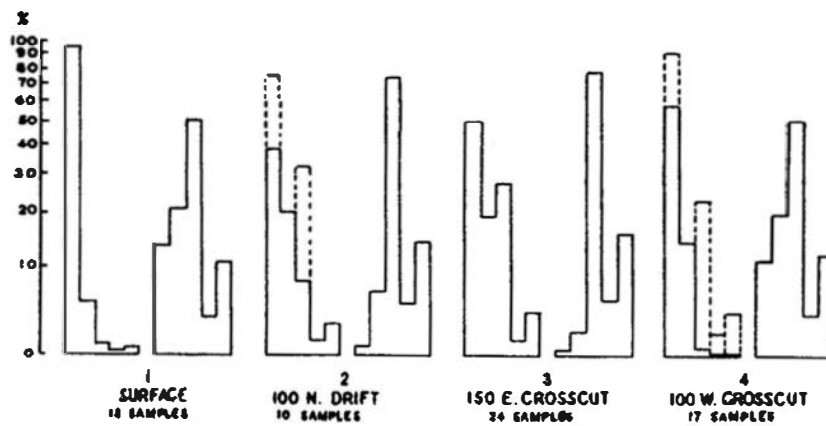
Norms calculated from analyses:

	I	II	III
Quartz . . . . .	37.80	34.86	34.86
Orthoclase . . . .	31.14	28.36	29.47
Albite . . . . .	23.58	26.72	25.15
Anorthite . . . .	3.06	3.89	3.89
Corundum . . . . .	1.22	.61	.82
Hypersthene . . .	.43	.96	.73
Magnetite . . . .	.70	.70	.93
Hematite . . . . .	.64		
Water . . . . .	.97	3.49	3.79
Total	99.54	99.59	99.64

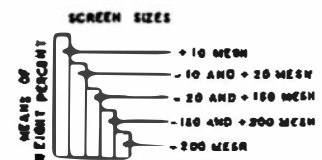
With the exception of their water content, the rhyolite and the adjacent perlites correspond very closely in chemical composition, corroborating their suggested common origin. The two glasses are remarkably similar, the only difference of possible significance being the slight excess of water in the bench sample. The analysis of the rhyolite indicates that the thin-section study (see p. 6) was in error concerning the excessive percentages of iron oxide minerals attributed to it; these minerals have a marked masking effect when in finely divided form. The silica content of the perlite, estimated from the index of refraction of the glass as a little more than 71 percent, is shown to be a little over 73 percent. Unlike so many other analyses of natural glasses and corresponding rocks, the soda-potash ratio (see p. 8) is not reversed in these samples.



A



# EXPLANATION



LEFT FIGURE BEFORE GRINDING  
RIGHT FIGURE AFTER GRINDING

SEVERAL OF THE UNDERGROUND SAMPLES  
IN 2 AND 4 FALL INTO TWO DIFFERENT  
SIZE GROUPS

B

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