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DIVISION OF MINES AND GEOLOGY
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Report of Investigations
No. 15

# PUMICE AND PUMICITE OCCURRENCES OF WASHINGTON

By

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## FOREWORD

The investigations and research projects that are carried on by the Division of Mines and Geology are determined by current or anticipated industrial demands for minerals and mineral products. When it became evident that scarcity of conventional building materials and interest in materials having good thermo-insulation characteristics would create a demand for pumice as a lightweight aggregate in portland cement, arrangements were made to investigate the pumice occurrences of the state, so that authoritative information on this resource would be available to the public. Pumicite, although of present small demand, was studied at the same time, because it was convenient to do so but particularly in view of the possibility that this material, related to pumice, could be heat-treated to provide another useful insulant.

It is believed that this report, giving the results of these investigations, is timely and will fill a marked need. It is obvious that all deposits of pumice and pumicite could not be examined in detail in the time allowed. However, all areas of occurrence were studied, and a sufficient number of individual deposits were examined in detail to provide practical information that may be applied in any mining or industrial development.

Mr. Ward Carithers, in charge of the project and the author of this report, resigned from the Division in May, 1946. As a result of the intense interest that developed in pumice after the field work was finished, some additions to the original investigation and to the report became desirable before the manuscript should be submitted to the printer. Consequently, Mr. Marshall T. Huntting, of the staff of the Division of Mines and Geology, spent ten days in a supplementary investigation in the Glacier Peak region, particular attention being paid to operating pits and properties. Additions made by Huntting to the report are pointed out in the second paragraph of the section headed "Field Work."

SHELDON L. GLOVER, Supervisor,
Division of Mines and Geology.

# INTRODUCTION

It has been known for many years that pumice and pumicite are among the mineral resources of Washington, and many brief references to their occurrence have been made in the literature.[1] However, no detailed economic information on these materials in Washington is known to have been published. Pumice is available at several places in the state, and in the past small amounts have been used locally for a concrete admixture and for insulation; for several years a logging company, lacking a better material, used pumice as a ballast along its railroad. In 1940 one operator in this state began mining pumice on a commercial scale for the manufacture of lightweight building blocks, and since that time there has been a growing interest in Washington pumice for its use in building construction and as an insulating material.

Pumicite deposits have at times been worked on a small scale in Washington, but it is doubtful that more than a few hundred tons of the material has been produced. Pumicite is generally a low-priced commodity, and present northwest markets for it are small. If, however, a local demand for this material should develop, there are ample deposits suitably situated with regard to transportation facilities.

## FIELD WORK

This report is the result of field work done chiefly in a period of three months, July through September, 1945. During this time all the previously known and reported pumice and pumicite occurrences were investigated, and before the work was completed many more occurrences were found. This work was not planned to indicate tonnages of the pumice and pumicite deposits, but rather to determine the areas in which they occur and to obtain information on their origin, mode of occurrence, extent, and properties, thus forming a basis for further prospecting and actual delimitation.

The intense interest currently shown in pumice made some additional field work desirable immediately before this report was submitted to the printer, so that the included information, particularly with respect to development of properties, would be as up to date as possible. These late data, obtained in July and August 1946, are identifiable in the text, on the map (pl. 4), and in the table on page 55 by location numbers 74 through 77 and by all other numbers referring to the Glacier Peak area that are followed by a letter (i.e., 26A).

### Prospecting Methods

The study of the pumice and pumicite deposits was carried on chiefly by observing road, trail, and railroad cuts in the areas of occurrence. In many places, however, these exposures were not available or were not deep enough to show total thickness of the material, and it was necessary to dig beneath the surface. To do

[1] See Glover, Sheldon L., Nonmetallic mineral resources of Washington: Washington Div. Geology Bull. 33, pp. 87-90, 1936.

this work, a 3-inch Iwan soil auger was employed with considerable success. This auger is a pod-shaped tool ordinarily employed for digging post holes. It is operated by merely twisting it downward into the ground until the pod, which is 6 inches long, is filled with earth, then, after removing and emptying the pod, the process is repeated. The auger is outfitted with a wooden handle and a 30-inch drill rod of ¾-inch pipe. Additional drill rods were made from standard ¾-inch galvanized-iron water pipe, cut and threaded in 2-, 3-, and 4-foot lengths. These were added to increase rod length as required.

In drilling the pumice, which occurs in loose, uncompact form, much like gravel, it was necessary to case each hole to prevent it from collapsing when the auger was removed for emptying. For this purpose, several 4-foot lengths of lightweight tubing were made from 20-gauge galvanized sheet iron. They were not unlike stove pipe. Each tube was tapered slightly, then beaded so that it would slip about 3 inches into the end of another. The diameter at the smaller end of each tube was 3½ inches, barely allowing the auger to pass through it. A drill hole was ordinarily started by digging a shallow pit with a shovel, setting a length of the casing, then twisting the auger down on the inside of it. As the hole progressed downward the casing was advanced by applying a little pressure on its upper end. After completing a hole the casing was removed by advancing the auger until the upper edge of the pod could be hooked on the lower edge of the tube, then, by simply lifting the drill rods, the casing was pulled out of the hole.

In drilling the pumicite, it was found that the walls of holes in this material held up without casing. Ordinarily, however, the upper 2 or 3 feet were cased to prevent overburden from sloughing in.

Approximately 50 holes, ranging in depth from 2 to as much as 20 feet, were drilled in pumice and pumicite. Ordinarily the holes less than 10 feet deep were drilled in a few minutes' time, and none required more than an hour to complete. One man could easily handle the drill for practically all the holes, but two men were desirable for those over 15 feet deep. No tripod was used to facilitate handling of the drill rods, but one probably would have been needed if any holes had been more than 20 feet deep.

The total cost of the drilling equipment was about $15. This included the auger, 20 feet of drill-rod pipe and couplings, 12 feet of casing, and two pipe wrenches for connecting and disconnecting the rods. The casing was made to order by a tinsmith at a cost of 67½ cents per foot. The other items are commonly stocked by most hardware stores.

Samples of pumice and pumicite were taken at many places. In usual sampling of the pumice, a 14-quart bucketful was taken and immediately weighed in order to determine the apparent density of the material as it might be mined. Later the samples were air-dried at room temperature, weighed again, and screened. Smaller samples of pumicite were taken for laboratory examination and screen analysis.

## ACKNOWLEDGMENTS

During the first two months of field work the writer was ably assisted by Stanley Elbersen. In the course of the work many people throughout the state gave cordial assistance and information. Special thanks are due Messrs. Joseph F. Scholze, Leavenworth; Daniel Soderlind, Kosmos; F. A. Rose, Yakima; J. W. Rider, Richland; Elmer Slater, Touchet; Fred Rawley, Brewster; and George and Charles Dike, Seattle. It is a pleasure to acknowledge the wholehearted and generous cooperation given by representatives of the U. S. Forest Service, Wenatchee and Columbia National Forests, and particular thanks are due Ranger Wallace Wheeler, Ardenvoir, and his staff; Ranger Harold Chriswell, Randle, and his staff; and Ranger Leslie Griffith, Spirit Lake, and his staff. To Mr. Sheldon L. Glover, Supervisor of the Division of Mines and Geology, the writer is indebted for aid in the preparation of the report.


# PUMICE

## GENERAL DESCRIPTION

Pumice is a fragmental highly cellular volcanic rock, commonly rhyolitic in composition, that is formed in the craters of erupting volcanoes when considerable water vapor and other gases are being released from viscous lava. These gases, expanding as they reach the surface of the molten rock, create a froth, which solidifies and breaks, and, during explosive eruption, is expelled from the crater as pumice. Under such circumstances the lava is quickly cooled and few crystals have opportunity to form. The cooled mass, therefore, is principally amorphous, a noncrystalline material or glass. Commonly, some crystals are present in pumice, but these result from previously crystallized material being present or being caught up in the rapidly solidifying lava. Finer, dust-like particles, or pumicite, are also ejected during these eruptions. The pumice may fall only a short distance from the crater, or be blown by the force of the explosion or by wind for many miles. Pumice deposits may occur as original beds, laid down from the air, or they may result from the reworking of such beds by water or wind.

As the material ejected from the volcanoes is of various sizes, irrespective of composition, certain textural terms are desirable in any adequate description of the resultant deposits. For the purpose of this report, grit-size material (intermediate in size between sand and gravel) is designated as pumice pellets; sand-size pumice is called pumice sand; and that finer than sand size is indicated as pumicite. Sand-size material composed of free mineral crystals ejected with the pumice is designated as crystal sand. Foreign sand, not predominantly volcanic in origin, is merely designated as sand, as in the customary usage of the term.

The pumice of Washington is from two volcanoes: Mount St. Helens, a peak in the southern part of the state; and Glacier Peak, a less well-known volcano just west of the crest of the Cascade Range, near the center of the state. No pumice deposit is known that may have originated in the other major Washington volcanoes: Mount Baker, Mount Rainier, and Mount Adams. Mount Tumac,

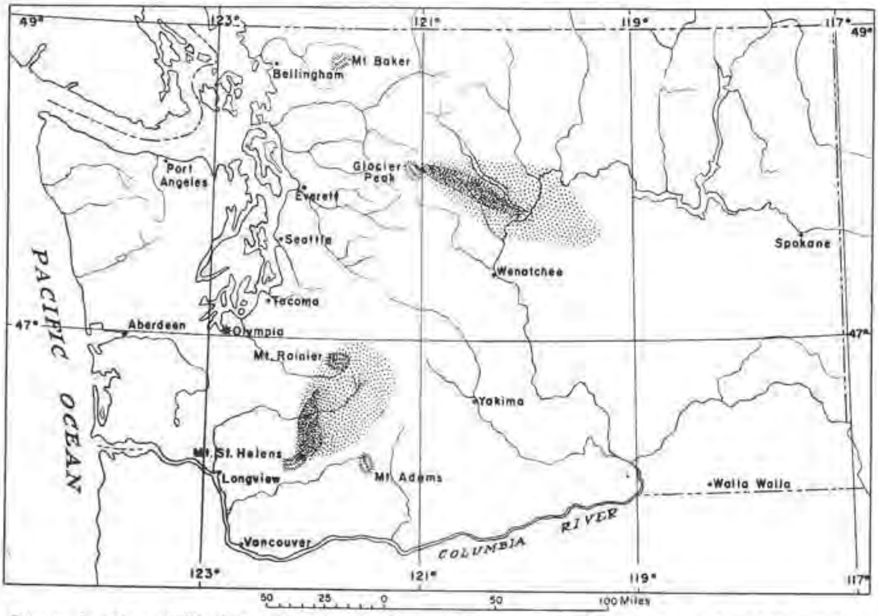



FIGURE 1—Map of Washington showing the distribution of pumice from Mount St. Helens and Glacier Peak. The relative thickness of deposits is roughly indicated by the density of the stippling.

a recent cinder or spatter cone on the crest of the Cascades, about 18 miles southeast of Mount Rainier, is composed of very scoriaceous pyroclastic material; no pumice was ejected. Many other comparatively recent volcanic eruptions have occurred in the state, chiefly in Skamania, Klickitat, and western Yakima Counties. They are characterized by large and small flows of andesitic lava which apparently issued from orifices without accompanying explosive violence that produces pumice.

## UTILIZATION

The chief use of pumice is as an abrasive, and until recent years about 80 percent of the pumice consumed in the United States was for this purpose. In the lump form, pumice is used to a small extent for hand rubbing of various surfaces such as lithographic stone, wood, bone, and metal that is to be electroplated or painted. A small quantity has also been used as a toilet article. The greater part of the lump material, however, is ground to powder, and its uses in this form are similar to those of pumicite. (See pp. 59-60.) Ground pumice is ordinarily produced from high-quality lump material under scientific control and is generally considered to be of a higher quality than natural pumicite. It thus commands a higher market price.

Washington pumice commonly has with it a small percentage of crystalline particles which occur as phenocrysts disseminated through the lumps, or as free crystals distributed among the finer, more granulated fragments of pumice. They are obviously a detriment to the use of the material as a high-quality abrasive.

Besides being an abrasive, pumice has other properties which are utilized in building construction and certain other industries. Owing to its cellular structure and to its consequent low apparent density, it is useful as an aggregate in lightweight concrete and as a thermal and acoustic insulation material. Pumice has also been used as an absorptive packing material and as a carrier for catalysts in some chemical industries. Washington pumice is highly adaptable to these uses, for the crystalline particles would not be injurious.

Pumice may be used in its natural state, without binder, as an insulating material. Thus, it can be effectively employed as an insulating bed under concrete or other floors. It can also be poured as a loose filler within walls and ceilings, providing the structure is strong enough to support the added weight. The thermal conductivity factor of loose pumice ranges from 0.5 to about 1.0, depending on its apparent density; comparatively, mineral wool ranges from 0.26 to 0.4, and wood shavings, from 0.4 to 0.5. In this way, pumice has been used as an insulant in several cold-storage warehouses constructed during the last few years in the Wenatchee and Okanogan areas of Washington. It is reported that the material gave excellent results.

In Europe, particularly in Italy and Germany, pumice has been much more intensely developed for building purposes than in America, but from 1938 to 1941 consumption of pumice by the building industries in this country increased remarkably. During the war years, 1941-45, restriction of private construction curtailed its use, but at present the use of pumice as a lightweight concrete aggregate, particularly in the fabrication of construction blocks and panels, is rapidly expanding. There are at least fifteen plants in Washington now manufacturing concrete masonry units in which pumice is used as an aggregate, and all but one of these began operation in 1945 or 1946.

Pumice, when employed as a lightweight aggregate in precast masonry units or in poured concrete, may completely replace sand and gravel, the aggregate more commonly used. This considerably reduces the weight of the material, and concrete that commonly weighs from 140 to 150 pounds per cubic foot when made in the conventional manner can be made to weigh as little as 50 pounds per cubic foot. This lightness of weight is obviously useful in certain types of construction, for the dead load that is commonly supported by steel framework in large buildings and bridges can be substantially reduced. Furthermore, precast building units of lightweight concrete are easily handled by workmen and are also less expensive to transport than ordinary concrete blocks. However, the strength of pumice concrete generally varies inversely with the lightness of weight. Blocks that have a low apparent density—say 60 or 70 pounds per cubic foot—have a crushing strength of from approximately 600 to 1,000 pounds per square inch. Blocks of greater density are proportionately stronger.

Besides being light in weight, certain other properties of concrete blocks made with pumice (or other lightweight aggregates) make them a desirable building material, particularly for residential construction. Among them are adequate heat- and sound-insulation, ability to hold nails or screws, resistance to fire, and ease of cutting or shaping. Also an attractive wall surface is provided which, if desired, may be stuccoed or plastered without further treatment. Some of these properties naturally vary, depending on the raw materials used, the methods and formulas employed in mixing, and other factors, all of which are controlled by the manufacturer. Despite the fact that pumice is the oldest known lightweight aggregate, its technology in the United States is in early stages of development, and as yet no standard practices in making concrete with pumice are employed. Most manufacturers have developed their own methods for handling pumice aggregate, and since its utilization, like that of many other nonmetallic minerals, is highly competitive, they keep their information confidential.

As the thermal-insulation effectiveness of pumice concrete, like that of other building materials, varies inversely with the density of the finished product, concrete made with pumice or other lightweight aggregate has a high insulating value. Pumice blocks of low density have a thermal conductivity (K) factor[1] ranging from about 1 to 2. Comparatively, ordinary concrete has a thermal conductivity factor of 6 to 9, and common brick, from 3 to 6. As substances of lower conductivity have greater insulating properties, the value of pumice concrete in the building trade is obvious.

Several varieties of block-making machines are in use in the state. Those available on the market range from single-block hand-tamp machines turning out 175 units a day to automatic machines with a capacity of 600 blocks per hour. In all but the simplest machines compaction of the aggregate is attained either by vibration or by hydraulic or air compression. Blocks in a wide range of sizes and shapes are being made; the two most commonly used sizes are 4 by 6 by 12 inches and 8 by 8 by 16 inches. One small plant makes solid and hollow blocks in 15 or more sizes and shapes.

The following excerpts from a report of field examinations and laboratory tests of lightweight volcanic aggregates in New Mexico[2] may be helpful to anyone starting a block plant using pumice as an aggregate:

> The general procedure for the manufacture [of building blocks] is as follows. The aggregate is first measured into the mixer, about two-thirds of the mixing water is added, and these materials are allowed to become thoroughly mixed. The necessary cement and the remainder of the water is added and the concrete is allowed to become completely mixed. The concrete is removed

[1] Thermal conductivity, commonly indicated by the factor "K", is the number of British thermal units transmitted per hour through 1 square foot of the material when the temperature gradient is one degree Fahrenheit per inch thickness.

[2] Clippinger, Donn M., Building blocks from natural lightweight materials of New Mexico: New Mexico Bureau of Mines and Natural Resources Bull. 24, 1946.

from the mixer and is introduced into a hopper above the mold, from which it is measured into the mold. There it is vibrated a few seconds to produce compaction. The wet blocks are ejected from the mold onto wooden or steel pallets and are placed on racks or stacked and allowed to stand for 24 to 36 hours. They may then be stripped from the pallets and stockpiled to cure until they have attained adequate strength to be shipped or used for building.

* * * The superiority of a trough-type mixer over the drum-type in the preparation of lightweight "dry-mix" concrete for masonry units is unquestionable. The difference between the density of the cement and that of the lightweight aggregate is so great that [in a drum-type mixer] the cement has a tendency to leave the mixture and to pack on the blades and sides of the revolving drum, robbing the batch of much of its cement. As the mix is drier than ordinary concrete, it does not have the scouring action that accompanies a wet mix of heavy sand and gravel and keeps the mixer clean. If the lightweight material is left in the mixer longer in an attempt to get a more thorough mixture, the cement forms in small balls which do not mix further. In the trough-type mixer the cement does not concentrate on the sides of the mixer; as it is agitated by the revolving blades, there is no chance for packing or for the formation of balls. A more thoroughly and satisfactorily mixed concrete is the result.

* * * In general a mixture of 1 part of portland cement to 6 parts of aggregate by volume gave a block of required strength. A great deal of the variation in the strength of the blocks is dependent upon the thoroughness of mixing, the sizing of the aggregate, and the amount of water used. * * * In mixing ordinary concrete, it has been proved that a "dry mix" produces a stronger concrete than a "wet mix." However, in casting vibrated blocks of lightweight concrete, a mix of ordinary concrete considered "dry" would be found to be a "wet" mix for block-making. For that reason it seems that a mixture as wet as possible that will produce a true block without slump would take advantage of the maximum strength of the cement added.

Compressive strengths of as much as 1,139 pounds per square inch were obtained there on test blocks without the addition of ordinary sand. That much greater strengths are obtainable without sacrificing the peculiar properties that make pumice desirable is indicated by reports of testing currently being conducted by the U. S. Navy. Unfortunately, information on the Navy technique is not yet available, but it would appear that for many construction purposes—particularly for prefabricated structures—pumice aggregates can be substituted for ordinary aggregates to the betterment of the resultant concrete in every particular.

The New Mexico tests indicate that lightweight aggregate should contain approximately 75 percent by weight of minus 4-mesh (0.185-inch) material for best results. In Washington there is a great deal of variation in aggregate sizes among the various pumice occurrences. For example, in the eastern Washington areas the aggregates range from 34 to 100 percent of minus 4-mesh material. However, most of the aggregates tested run from 70 to 80 percent of minus 4-mesh. This wide range of aggregate sizes makes it possible to supply practically all consumers with material to meet their requirements, although in some instances it may be necessary to mix pumice from two or more deposits in order to obtain an aggregate of required constituency. The graph on page 27 shows the ranges of aggregate sizes from the Mount St. Helens occurrences, and the graph on page 51 gives the same information for the Glacier Peak occurrences.

## MOUNT ST. HELENS OCCURRENCES

### Location

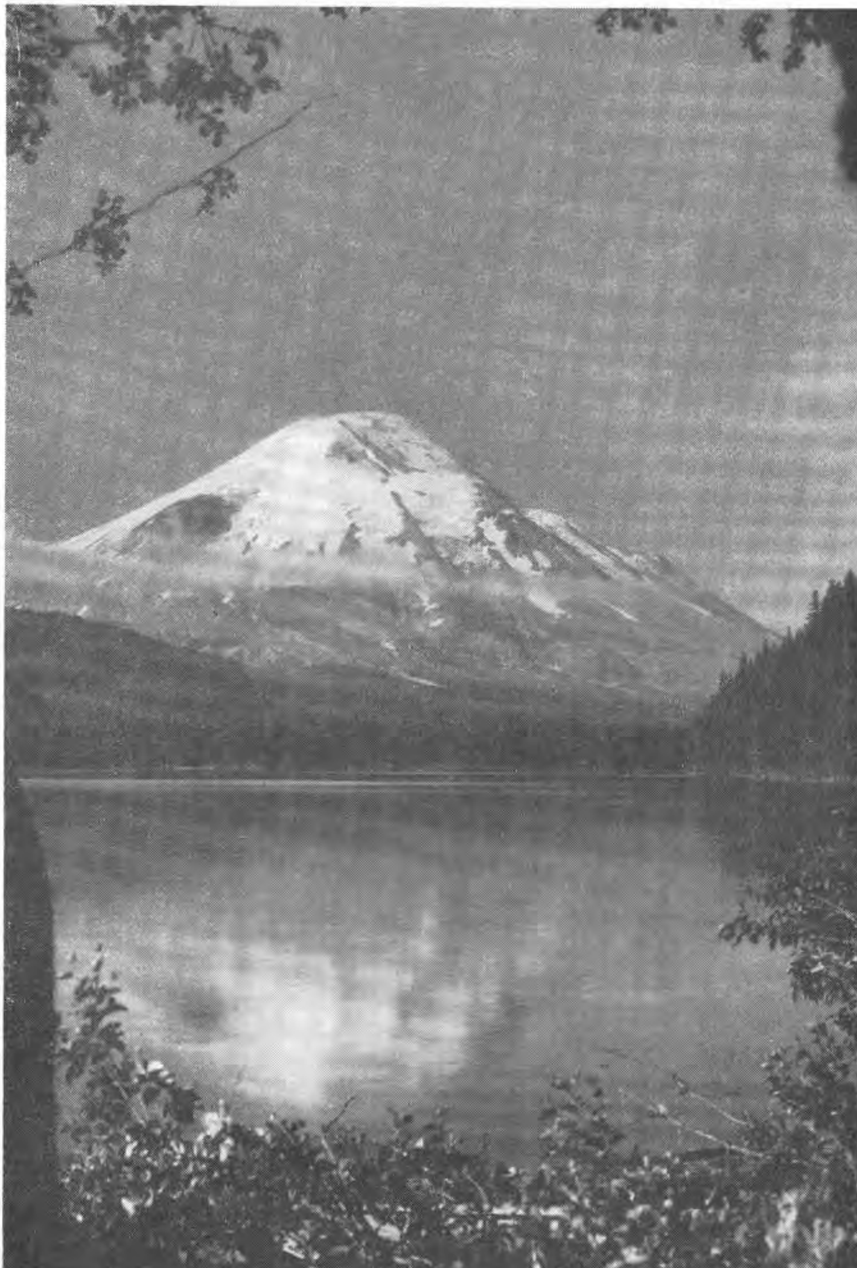
Mount St. Helens, in northern Skamania County, is a nearly symmetrical cone near the western edge of the Cascade Range, 35 miles east of Longview and 45 miles northeast of Vancouver, Washington. It is 9,671 feet in altitude and bears perennial snow and ice. An excellent highway leads 46 miles eastward from Castle Rock to Spirit Lake, at the base of the peak, and from there a secondary road reaches 3 miles up the north slope to the timber line at an altitude of 4,500 feet. Many trails lead around the mountain and into the surrounding well-forested territory. The region is well-known as one of the scenic recreational areas of the Pacific Northwest.

The pumice deposits of Mount St. Helens are in Skamania and Lewis Counties, and occur as erosional remnants of two beds, or sheets, of different ages that were deposited throughout a fan-shaped area extending from north to east from the volcano. These sheets extend as far as 50 miles from the peak, but not all of this wide area contains pumice to a depth that is economically important. The thickest parts of the beds are confined to a belt 1 to 6 miles wide that extends north to northeast from the volcano for a distance of about 30 miles. The direction of the major part of the showers was probably controlled by south and southwest winds which prevailed at the times of eruptions, as they do at present. This belt extends from the northeast slope of Mount St. Helens across the Spirit Lake area at the head of the North Fork of the Toutle River, across the upper valley of the Green River, and across the Cowlitz River Valley near the confluence of the Cowlitz and Cispus Rivers.

### Accessibility

Some parts of the pumice area are well served by transportation facilities; others are not. An excellent State highway leads up the Cowlitz Valley and extends westward to the Chehalis area, northward through Morton to the Puget Sound area, and eastward across the Cascade Range to the Yakima area. Many secondary roads branch from the highway, and one road leads south to the Columbia River. The Cowlitz area is also served by the standard-gauge railroad of the Kosmos Timber Company which connects with the Chicago, Milwaukee, St. Paul, and Pacific Railway at Morton.

The north side of Mount St. Helens, as previously mentioned, is also served by an excellent State highway. Also a railroad of the Weyerhaeuser Timber Company runs to within 15 miles west of the peak and connects with the main Puget Sound-Portland line near Longview. The area between Mount St. Helens and the Cowlitz Valley is served only by trails.



MOUNT ST. HELENS FROM SPIRIT LAKE.

## Physiography and General Conditions

With the exception of several square miles of flat and rolling topography in the Cowlitz Valley, the terrain on which the pumice was deposited is rough, mountainous, and highly dissected. Altitudes range from as low as 750 feet in the Cowlitz Valley to over 6,000 feet on some of the highest peaks and ridges, and the relief over a large part of the area is from 2,500 to as much as 3,500 feet. A striking feature of the region is the great number of streams that drain it. These are parts of the Toutle, Green, Lewis, and Cowlitz River systems which flow southwestward into the Columbia River.

The climate of the region is humid, and annual precipitation is from 50 inches at some places to more than 100 inches at others. At the higher elevations considerable snow falls during winter months, but along the Cowlitz Valley the temperature is fairly mild and snow is no problem. Much of the area is covered by an excellent stand of timber—fir, spruce, and hemlock—and a heavy growth of underbrush. Logging is a well-developed industry in the Cowlitz and lower Cispus Valleys, and farming is important in the Cowlitz Valley.

## Geology

Mount St. Helens lies on a platform of sandstones and mudstones which are lithologically similar to the Eocene sediments occurring in the area to the west. Probable correlatives of these rocks are exposed in a few places north and northeast of the volcano, but the most widespread bedrock exposures in the pumice area between Mount St. Helens and the Cowlitz Valley are andesite and basalt flows which are part of the Miocene volcanics shown on the geologic map of Washington.[1] These volcanics are, in places, interbedded with tuff, conglomerate, sandstone, and shale which occur in thicknesses as much as 250 feet or more. North of Spirit Lake the volcanics are intruded by masses of granitic rock, and several metal-mine prospects are located in this area.

These probably Tertiary rocks are overlain by the lavas and pyroclastic ejecta of Mount St. Helens which are well described in detail by Verhoogen.[2] They consist chiefly of tuff breccia, andesitic pumice, pumicite, and variants of olivine basalts and pyroxene andesites.

In regard to the age of the volcano, Verhoogen[3] considers that the Mount St. Helens volcanic activity started in Glacial or pre-Glacial time, and that "late in the Pleistocene, a volcano situated somewhere in the vicinity, perhaps on the present site of Mount St. Helens, erupted tuffs, vitrophyres, dacites, and hornblende andesites. This volcano was probably greatly worn down by glacial erosion. Fragments of the lavas were redeposited as gravels in

[1] Washington Div. Geology, Preliminary geologic map of Washington, to accompany Bull. 32, part 1, 1936.

[2] Verhoogen, Jean, Mount St. Helens, a recent Cascade volcano: California Univ., Dept. Geol. Sci. Bull, vol. 24, no. 9, pp. 266-294, 1937.

[3] Idem, p. 268.

the bed of the Toutle River, and also in the extensive mudflows, the remnants of which are now found below later flows of olivine basalts. It is questionable whether this early volcano ever reached any great height; the pattern of drainage of the region indicates that it did not. * * * The activity of the volcano seems to have continued without interruption until very recent times. Many flows cannot be more than a few hundred years old, as evidenced by the vegetation." Verhoogen's conclusions appear to be based chiefly on his observations of the lavas of Mount St. Helens; the pumice sheets, representing pyroclastic ejecta from the volcano, give some corroborating evidence regarding the early history of the peak.

The two sheets of pumice, though apparently identical in original composition, are quite distinctive, and there is evidence that a long period of time intervened between the showers. The older pumice is ordinarily light yellow or buff in color, owing to partial oxidation of contained iron. The younger pumice, on the other hand, is relatively unaltered and is generally light gray. Both sheets were doubtless laid down over the terrain as more-or-less continuous blankets, but since their deposition they have been reworked to some extent or eroded completely away. The older sheet is the more discontinuous, especially in the rough, mountainous region between Mount St. Helens and the Cowlitz Valley. In many places, particularly on the slopes of the volcano, it has been reworked by water and is now mixed with considerable sand, silt, and gravel and is overlain by the younger sheet. At other places the latter lies on terrain that has been completely stripped of the older pumice. The older pumice sheet lies on the floors and sides of glaciated valleys and is clearly post-Glacial in age. Volcanic activity may have occurred during Glacial time, as indicated by Verhoogen, in the Mount St. Helens area before this older pumice was ejected, but no evidence of it was found in the study of the pumice sheets. If there were any pumice deposits, they would have undergone considerable erosion, and may not now be recognized.

Wherever the two pumice sheets occur together, they are separated by a layer of silty and clayey material from 6 to 18 inches thick, that accumulated during the period of time that intervened between the two showers. In the separating bed is commonly a small amount of highly altered pumice. Some of the bed is doubtless composed of alteration products of the underlying pumice, but part may be wind-blown material. Nearly all the oldest trees of the region are rooted in or below this separating layer; the younger pumice was deposited around their trunks. In several places logs, not completely rotted away, are found lying under the younger pumice, and also many stumps of old trees, probably killed by the pumice shower, are rooted in the older pumice and protrude up through the younger pumice. This indicates a relatively recent age for the younger pumice—probably not more than a few hundred years. The study of wood cores from old trees in the Mount St. Helens area by Lawrence[1] showed a series of narrow rings

[1] Lawrence, Donald B., Continuing research on the flora of Mount St. Helens: Mazama, vol. 21, no. 12, pp. 49-54, 1939.

starting in the year 1802 or 1803 which might have been caused by a retardation of growth due to the younger pumice shower occurring at that time. Later work by Lawrence[1] on trees scorched by a recent lava flow on the northwest side of the peak indicates that the flow occurred in 1804 or 1805.

The period of time that elapsed between the two major showers of pumice is shown by erosional features of the volcano itself. Extending northward from the base of the cone there is a large fan-like alluvial deposit which, together with some lava flows, has partly filled the valley of the North Fork of the Toutle River, blocking its stream and forming Spirit Lake. The alluvium in this deposit is composed of pebbles and fragments of solid and scoriaceous lava, well-rounded pumice pellets, sand, and clay. This material was apparently deposited by melt waters flowing off and eroding the slopes of the volcano as it existed at that time. Exposures in road cuts, in a gravel pit, and in several tree casts show good assortment of this material and, in places, well-developed cross bedding. The deposit is overlain by the younger pumice sheet, and, near the northern end, is overgrown by a forest containing trees at least 500 years old. As the alluvium was deposited in the valley of the North Fork of the Toutle River it filled around and buried or partly buried many trees. Some of these trees have since rotted completely away, leaving casts, locally called "tree wells," that extend several feet down from the present ground surface. In the Forest Service gravel pit about 2 miles south of Spirit Lake there are several trees, some living, others dead, that have recently had their trunks covered to a depth of 10 feet or more by alluvium. Eventually trees such as these may also rot away and leave "tree wells."

The north side of Mount St. Helens is only one area that shows an erosional period following the first pumice eruption of the volcano. Similar evidence occurs on the east side where alluvial material has been deposited on and around a ridge, leaving the higher points protruding above the alluvium as island masses. Probably other sides show similar erosion and deposition, as is indicated by the topographic maps. Judging from the size and extent of the alluvial fans, it appears likely that a fairly large cone was built up during the eruption of the old pumice. In the period of erosion following, the volcano may have been mildly active and erupted lava flows without the explosive violence that causes pumice ejections. The present cone, however, is due to a major explosive eruption, possibly in 1802 or 1803, at which time the younger pumice was ejected. The peak's symmetry is broken at a few places by several prominent projections from the sides that may represent remnants of an older eroded cone. An Indian legend, that Mount St. Helens was changed by the Gods from an ugly witch woman to a beautiful young maiden because she befriended the Indians by giving them fire, appears to have been based on the recent geologic history of the volcano.

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[1] Lawrence, Donald B., The "floating island" lava flow of Mount St. Helens: Mazama, vol. 23, no. 12, pp. 56-60, 1941.

There are many references in the literature to reports by early settlers in the lower Columbia River area, that Mount St. Helens was in eruption as late as 1842 and 1854. At least one very recent eruption is indicated in the vicinity of the volcano where a sprinkling of pumicite and pumice granules can be found underlying the moss on fallen, somewhat rotted trees. These trees lie on top of the younger pumice sheet, thereby indicating that this minor eruption is later than the major one that produced the extensive younger pumice sheet.

The pumice deposits of possible commercial interest that occur in the region north of Mount St. Helens are erosional remnants of the formerly widespread older and younger pumice sheets. The older pumice, although mostly light yellow or buff in color, is less oxidized in some places and there, particularly in the lower part of the bed, is nearly gray in color. The pumice itself is composed chiefly of finely vesicular but rarely fibrous glass, and it invariably contains a small percentage of phenocrysts of plagioclase feldspar (andesine?), hypersthene, hornblende, and magnetite. To some extent, these crystals also occur separately from the pumice and are more-or-less evenly distributed through the bed. Their presence suggests that the magma from which the pumice was formed was partly crystallized before it was ejected from the volcano. They are an unusual feature.

The younger pumice is considerably fresher looking than the older material. Although a few of the most vesicular pieces found on the slope of the volcano are pink-colored, probably due to oxidation affecting the thinner and more fibrous walls of vesicles, most of the younger pumice is light-gray in color. Like the older pumice, the younger is a vesicular glass containing small amounts of phenocrysts of feldspar, hypersthene, hornblende, and magnetite. These crystals, also, are distributed like sand through the younger sheet.

In general, the size of the pumice pellets in the younger and older sheets diminishes with distance from the volcano. On the north slope of Mount St. Helens the average diameter is about half an inch, though some fragments measure nearly a foot across. In the Cowlitz Valley the fragments average about an eighth of an inch in diameter, and a very few fragments as much as one inch. Farther northeastward the pumice diminishes to sand size. In vertical sections of the air-laid beds no assortment is recognizable, and the beds are loose aggregates of variously sized pellets.

## Pumice Deposits

### RANDLE-KOSMOS AREA

The older pumice sheet occurs extensively over several square miles in the Cowlitz Valley, near the confluence of the Cowlitz and Cispus Rivers, in the vicinity of the towns of Randle and Kosmos. (See fig. 2.) It lies on the terrain chiefly as the original air-laid blanket with a thickness ranging from a few inches to as much as 6 feet. Possibly the thickest parts are due to drifting. In several places, however, deposits have been modified by water that has eroded the air-laid pumice from the valley sides and redeposited it at lower elevations. These reworked deposits, distributed chiefly along the northern and southern edges of the area, contain, besides pumice, varying amounts of foreign rock and silt. In producing pumice from a deposit of this kind, beneficiation to remove these impurities may be desirable.

The overburden in the area generally consists of about 12 to 18 inches of soil and highly altered pumice overgrown by trees and brush. A large part of the area has been logged off, but stumps, brush, and logs remain to be cleared away before mining operations may begin. The younger pumice sheet overlies the older in the Randle-Kosmos area, but is inconsequential in thickness. The only pumice deposit (no. 19, fig. 2) known to have been worked in this area, in 1945, is near the railroad of the Kosmos Timber Company, in the center of sec. 5, (11-6E).[1] This deposit, 13 feet thick, is a reworked one, probably formed along the edge of an abandoned channel of the Cispus River, which removed part of an air-laid bed upstream and redeposited it here in a pond or an eddy. The pumice is rounded, well-assorted, and is associated with thin beds of clay, silt, and a little gravel. The apparent density and mechanical analysis of a sample are in the table on page 28. A pit here (see pl. 2), locally known as the "Popcorn" pit, was opened several years ago by the Kosmos Timber Company, who used the material for ballast along their railroad. In 1945 the operation was taken over by the Western Sales and Manufacturing Company, Seattle, who produce



REWORKED PUMICE IN THE "POPCORN" PIT, NEAR KOSMOS.
The man stands on the base of the deposit.

[1] Abbreviated form for: section 5, Township 11 North, Range 6 East.

the pumice for the manufacture of lightweight concrete building blocks. The pit covers an area of about one acre, and after stripping about 18 to 24 inches of overburden the pumice is moved by a power shovel into railroad cars spotted on a spur track that leads into the pit. Several hundred tons have been mined.

Following are stratigraphic sections measured from the surface through the pumice sheets in the Randle-Kosmos area; the numbers given the locations correspond to those on figure 2. The apparent densities and mechanical analyses of samples taken are in the table on page 28.

*Sections through pumice in the Randle-Kosmos area*

| | *Inches* |
|---|---|
| Location 1. Road cut near the center of sec. 14, (12-5E) | |
| Silt mixed with altered pumice | 10 |
| Buff-colored pumice, older bed | 4 |
| Brown silty clay (base concealed) | 2+ |
| Location 2. Drill hole near the west quarter corner of sec. 8, (12-6E) | |
| Soil | 12 |
| Silt containing altered pumice | 36 |
| Buff-colored pumice, older bed (Sample 2) | 70 |
| Brown clay (base concealed) | 2+ |
| The water table, July 6, 1945, was 9 feet below the surface. | |
| Location 3. Road cut 600 feet south of location 2. | |
| Soil mixed with altered pumice | 14 |
| Buff-colored pumice, older bed | 26 |
| Brown silt (base concealed) | 12+ |
| Location 4. Road cuts in the NW¼NE¼ sec. 9, (12-6E) | |
| Soil | 2–6 |
| Buff-colored pumice, older bed | 35–36 |
| Brown silt (base concealed) | 3+ |
| Location 5. Road cut near the east center of the SW¼ sec. 11, (12-6E) | |
| Soil | 6–12 |
| Buff-colored pumice, older bed (Sample 5) | 32 |
| Brown silt (base concealed) | 3+ |
| Location 6. Road cut near the southeast corner of sec. 11, (12-6E) | |
| Soil | 6–12 |
| Buff-colored pumice, older bed | 30 |
| Gravel and clay (base concealed) | 120+ |
| Location 7. Ditch near the east quarter corner of sec. 12, (12-6E) | |
| Gravelly soil | 24–30 |
| Buff-colored, water-worn pumice (older bed) | 41 |
| Brown silt (base concealed) | 2+ |
| Location 8. Open-cut near the south quarter corner of sec. 24, (12-5E) | |
| Soil | 6–12 |
| Buff-colored pumice, older bed (Sample 8) | 72 |
| Brown silt (base concealed) | 12+ |
| Location 9. Road cuts near the center of sec. 19, (12-6E) | |
| Soil | 6–12 |
| Buff-colored pumice, older bed | 48 |
| Brown silt (base concealed) | 12+ |

| | Inches |
|---|---|
| Location 10. Open-cuts near the west quarter corner of sec. 20, (12-6E) | |
| Soil | 6-8 |
| Buff-colored pumice, older bed | 48 |
| Brown silt (base concealed) | 12+ |
| Location 11. Drill hole at the southwest corner of sec. 14, (12-6E) | |
| Soil and roots | 12 |
| Buff-colored pumice, older bed | 36 |
| Brown silt containing fragments of rock (base not found) | 18+ |
| Location 12. Pit at the southwest corner of sec. 23, (12-6E) | |
| Soil and silt | 12 |
| Buff-colored pumice, older bed (Sample 12) | 36-48 |
| Brown silt (base concealed) | 12+ |
| Location 13. Road cut near the southeast corner of sec. 23, (12-6E) | |
| Gray pumice, younger bed | 2 |
| Silty soil | 6 |
| Buff-colored pumice, older bed | 30 |
| Brown silt containing sand and pebbles (base concealed) | 48+ |
| Location 14. Road cuts near the southwest corner of sec. 29, (12-6E) | |
| Soil | 12 |
| Buff-colored pumice, older bed (drifted?) | 42-72 |
| Brown silt (base concealed) | 12+ |
| Location 15. Open-cuts near the south quarter corner of sec. 35, (12-5E) | |
| Soil | 6-12 |
| Buff-colored pumice, older bed (base concealed) | 48+ |
| Location 16. Pit near the south quarter corner of sec. 36, (12-5E) | |
| Soil | 12 |
| Buff-colored pumice, older bed (Sample 16) | 60 |
| Brown silt (base concealed) | 12+ |
| Location 17. Open-cut near the west quarter corner of sec. 6, (11-6E) | |
| Soil, silt, and altered pumice | 36 |
| Buff-colored pumice, older bed | 30 |
| Brown silt (base concealed) | 24+ |
| Location 18. Railway cut near the west quarter corner of sec. 5, (11-6E) | |
| Silty soil | 12 |
| Buff-colored pumice, older bed | 48 |
| Brown silt (base concealed) | 1+ |
| Location 19. Pit near the center of sec. 5, (11-6E) ("Popcorn" pit) | |
| Silty soil | 12-24 |
| Well-assorted pumice and thin beds of clay, sand, and gravel (Sample 19) | 156 |
| Brown silty clay containing a few leaf imprints (base concealed) | 12+ |
| Location 20. Railway cut 300 feet west of location 19. | |
| Silty soil | 12 |
| Buff-colored pumice, older bed (base concealed) | 36+ |
| Location 21. Railway cut near the center of the W½ sec. 4, (11-6E) | |
| Silt containing a little altered pumice | 8 |
| Buff-colored pumice, older bed | 48 |
| Brown silt (base concealed) | 3+ |
| Location 22. Open-cut in the E½SE¼ sec. 4, (11-6E) | |
| Sand-size gray pumice and pumicite, younger bed | 1 |
| Silt and altered pumice | 12 |
| Buff-colored pumice, older bed (Sample 22) | 51 |
| Brown silt (base concealed) | 1+ |

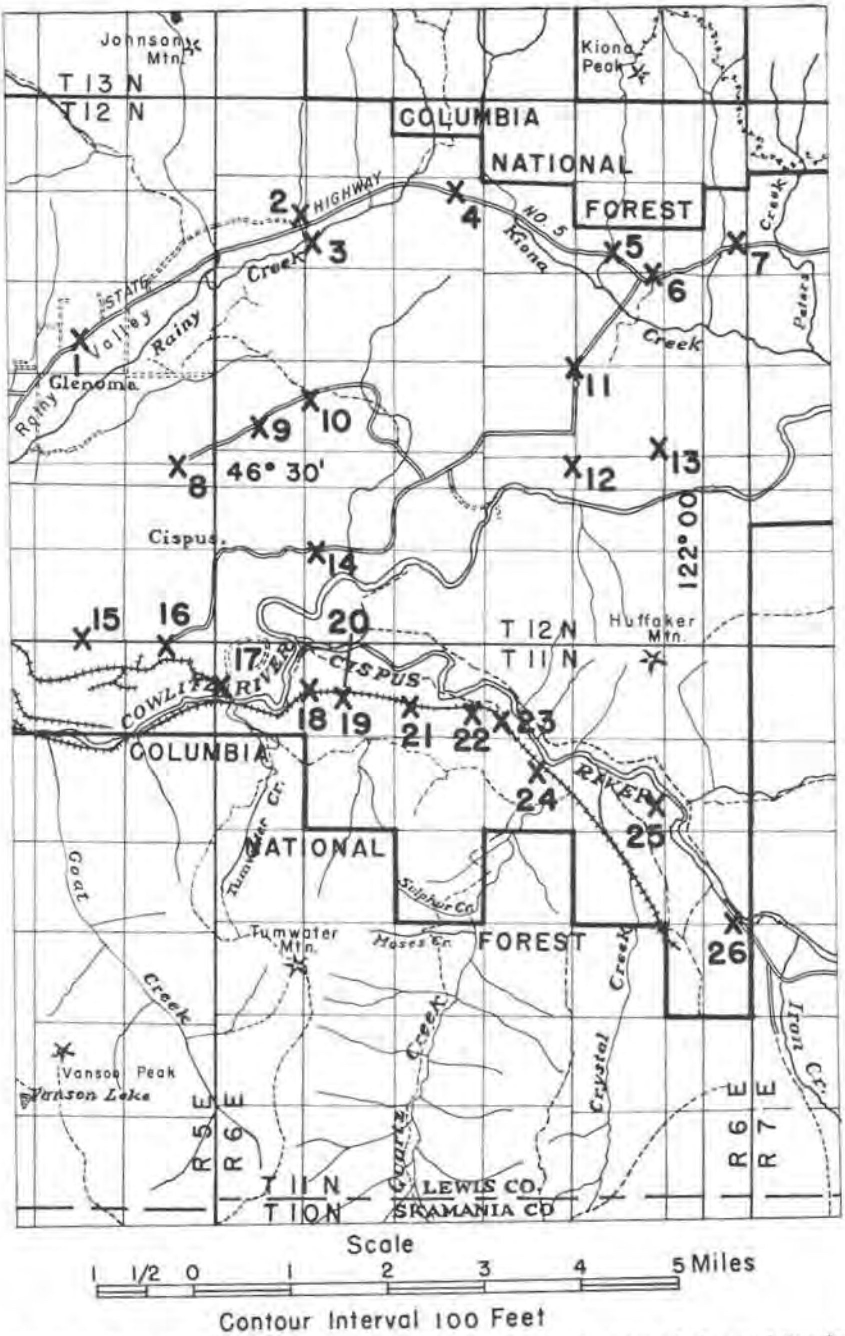


FIGURE 2—Area between Randle and Kosmos, showing the location of observed pumice occurrences. The numbers refer to the text. Base, Columbia National Forest map.

| | Inches |
|---|---|
| Location 23. Railway cuts for a quarter of a mile in the SW¼ sec. 3, (11-6E) | |
| Silty soil | 6-12 |
| Buff-colored pumice, older bed | 54-60 |
| Brown silt (base concealed) | 6+-72+ |
| Location 24. Railway cut in the NE¼ sec. 10, (11-6E) | |
| Silty soil | 24 |
| Buff-colored pumice, older bed | 54 |
| Brown silt (base concealed) | 12+ |
| Location 25. Railway cuts near the east quarter corner of sec. 11, (11-6E) | |
| Soil | 1-2 |
| Gray pumice, younger bed | 6-10 |
| Brown silt and a little altered pumice | 6-14 |
| Buff-colored pumice, older bed | 20-25 |
| Brown clay containing rock fragments (base concealed) | 12+ |
| Location 26. Road cut near the southeast corner of sec. 13, (11-6E) | |
| Soil | 2 |
| Gray pumice, younger bed | 22 |
| Brown silt containing a little altered pumice | 8 |
| Buff-colored pumice, older bed | 24 |
| Brown silty clay containing rock fragments | 0-24 |
| Bedrock | |

## MOUNT ST. HELENS AREA

The younger pumice is fairly continuous over the terrain for many miles to the northeast of Mount St. Helens, but it is generally too thin to be economically important excepting on the north slope of the volcano. Here pumice lies to a depth of from 10 to more than 15 feet on the tops of many ridges that extend northward from the snow fields of the peak. Although the continuity of the pumice sheet is broken between these ridges by gulches that contain turbulent snow-fed streams, a large tonnage of pumice is available in the area. Overburden consists only of 1 or 2 inches of soil and pumicite overgrown by grass, shrubs, and a few small trees.

Following are stratigraphic sections through the pumice measured in this area; the numbers given the locations correspond to those on figure 3. The apparent densities and mechanical analyses of samples taken are in the table on page 28.

*Sections through pumice in the Mount St. Helens area*

| | Inches |
|---|---|
| Location 27. Stream bank in the NW¼ sec. 1, (8-5E) | |
| Pumicite | 3 |
| Small-size gray pumice, younger bed (?) | 2 |
| Sand and gravel containing pumice (base concealed) | 48+ |
| Location 28. Road cut in the SE¼ sec. 27, (9-5E) | |
| Soil and pumicite | 1 |
| Gray pumice, younger bed (Sample 28A) | 48 |
| Rubble of pumice, clay, and gravel (Sample 28B) (base concealed) | 120+ |
| Location 29. Bank of a gulch in the N½ sec. 34, (9-5E) | |
| Soil and pumicite | 2 |
| Gray pumice, younger bed | 144 |
| Rubble of pumice, clay, and gravel, about | 300 |
| Lava flow | 60 |
| Lava flow (base concealed) | 72+ |

| | Inches |
|---|---|
| Location 30. Bank of a gulch in the NW¼ sec. 34, (9-5E) | |
| Soil and silt | 12 |
| Gray pumice, younger bed | 156-240 |
| Rubble of pumice, clay, and gravel, about | 360 |
| Lava (base concealed) | 36+ |
| Location 31. Road cut near the northeast corner of sec. 27, (9-5E) | |
| Soil | 3-4 |
| Gray pumice, younger bed | 60 |
| Rubble of pumice, clay, and gravel (base concealed) | 12+ |
| Location 32. Trail cut in the NW¼ sec. 13, (9-5E) | |
| Soil | 2 |
| Gray pumice, younger bed | 25 |
| Pumicite | 2 |
| Silt mixed with buff-colored pumice (base concealed) | 2+ |
| Location 33. Drill hole near the center of sec. 14, (9-5E) | |
| Soil | 2 |
| Gray pumice, younger bed | 10 |
| Well-assorted sand, clay, pumice, and gravel (base not found) | 68+ |

## SPIRIT LAKE-GREEN RIVER AREA

Northeast of Mount St. Helens, in the rough, mountainous region north of Spirit Lake and in the upper Green River Valley, pumice deposits are generally small in size. However, they may have some importance in the future when roads are extended into this area. Deposits of the older pumice occur in a few places as remnants of the former widespread blanket. They appear to be highly variable in depth, but some may be sufficiently deep and extensive to be minable. The younger pumice bed is rarely as thick as 2 feet, but in a few places the material of the original air-laid sheet has rolled to the bottom of steep slopes to form deposits as thick as 15 feet. A section of one of these is given at location 41 below.

Following are stratigraphic sections through the pumice measured in this area; the numbers given the locations correspond to those on figure 3. The apparent density and mechanical analysis of one sample taken in this area are in the table on page 28.

*Sections through pumice in the Spirit Lake-Green River area*

| | Inches |
|---|---|
| Location 34. Trail cut in the SW¼ sec. 3, (9-5E) | |
| Soil and pumicite | 3 |
| Buff-colored pumice, older bed | 24 |
| Brown silt (base concealed) | 1+ |
| Location 35. Pit in the E½ sec. 12, (9-5E) | |
| Soil | 3 |
| Gray pumice, younger bed | 24 |
| Sandy silt and sand (base concealed) | 24+ |
| Location 36. Pit in the SW¼ sec. 5, (9-6E) | |
| Soil | 1 |
| Gray pumice, younger bed | 12 |
| Silt | 6 |
| Buff-colored and gray pumice, older bed (base concealed) | 56+ |
| Location 37. Trail cuts near the north quarter corner of sec. 29, (10-6E) | |
| Soil | 2-3 |
| Gray pumice, younger bed | 6-12 |
| Brown silt (base concealed) | 24+ |

| | Inches |
|---|---|
| Location 38. Stream bank near the center of sec. 33, (10-6E) | |
| Soil | 2 |
| Gray pumice, younger bed | 16 |
| Pumice, sand, and gravel (base concealed) | 24+ |
| Location 39. Trail cuts in the NW¼ sec. 34, (10-6E) | |
| Gray pumice, younger bed, containing rotten stumps and logs | 12–36 |
| Silt | 0–4 |
| Buff-colored pumice, older bed (very erratic) | 0–12 |
| Brown silt (base concealed) | 6–12+ |
| Location 40. Pit in the SW¼SE¼ sec. 27, (10-6E) | |
| Soil | 1 |
| Gray pumice, younger bed | 8 |
| Brown silt | 5 |
| Buff-colored and gray pumice, older bed (Sample 40) | 44 |
| Brown silt (base concealed) | 1+ |
| Location 41. Stream cut at the base of a cliff near the south line of sec. 22, (10-6E) | |
| Gray pumice mixed with a little clay, sand, and rock fragments (reworked younger bed) (base concealed) | 120+ |
| Location 42. Pit in the N½ sec. 22, (10-6E) | |
| Soil | 6 |
| Gray pumice, younger bed (?) | 2 |
| Silt (base concealed) | 8+ |
| Location 43. Pit in the north center of sec. 16, (10-6E) | |
| Pumice and pumicite, younger bed | 1 |
| Silty soil | 5 |
| Buff-colored pumice, older bed (base concealed) | 24+ |
| Location 44. Portal of Golconda prospect tunnel near the west quarter corner of sec. 16, (10-6E) | |
| Soil | 3 |
| Gray pumice, younger bed | 8–14 |
| Silt | 14 |
| Buff-colored pumice, older bed | 45 |
| Sand and sand-size pumice | 3 |
| Brown clay containing rock fragments | 6–8 |
| Bedrock | |
| Location 45. Pit in the W½ sec. 8, (10-6E) | |
| Soil containing a little gray pumice, younger bed | 6 |
| Buff-colored pumice, older bed | 22 |
| Brown silt (base concealed) | 3+ |
| Location 46. Portal of Polar Star prospect tunnel in the N½ sec. 18, (10-6E) | |
| Soil | 2–3 |
| Buff-colored pumice, older bed | 10–14 |
| Rubble of rock fragments, clay, and sand (base concealed) | 72+ |
| Location 47. Pit in the N½ sec. 13, (10-5E) | |
| Soil | 6 |
| Yellow pumice, younger bed (?) | 7 |
| Sandy silt | 23 |
| Buff-colored, altered pumice, older bed (?) (base concealed) | 2+ |
| Location 48. Pit in the SW¼ sec. 12, (10-5E) | |
| Soil | 2 |
| Stream-worn pumice and silt | 23 |
| Pumice and sand (base concealed) | 3+ |
| Location 49. Pit in the NE¼ sec. 2, (10-5E) | |
| Silty soil | 6 |
| Silt containing altered pumice (base concealed) | 30+ |

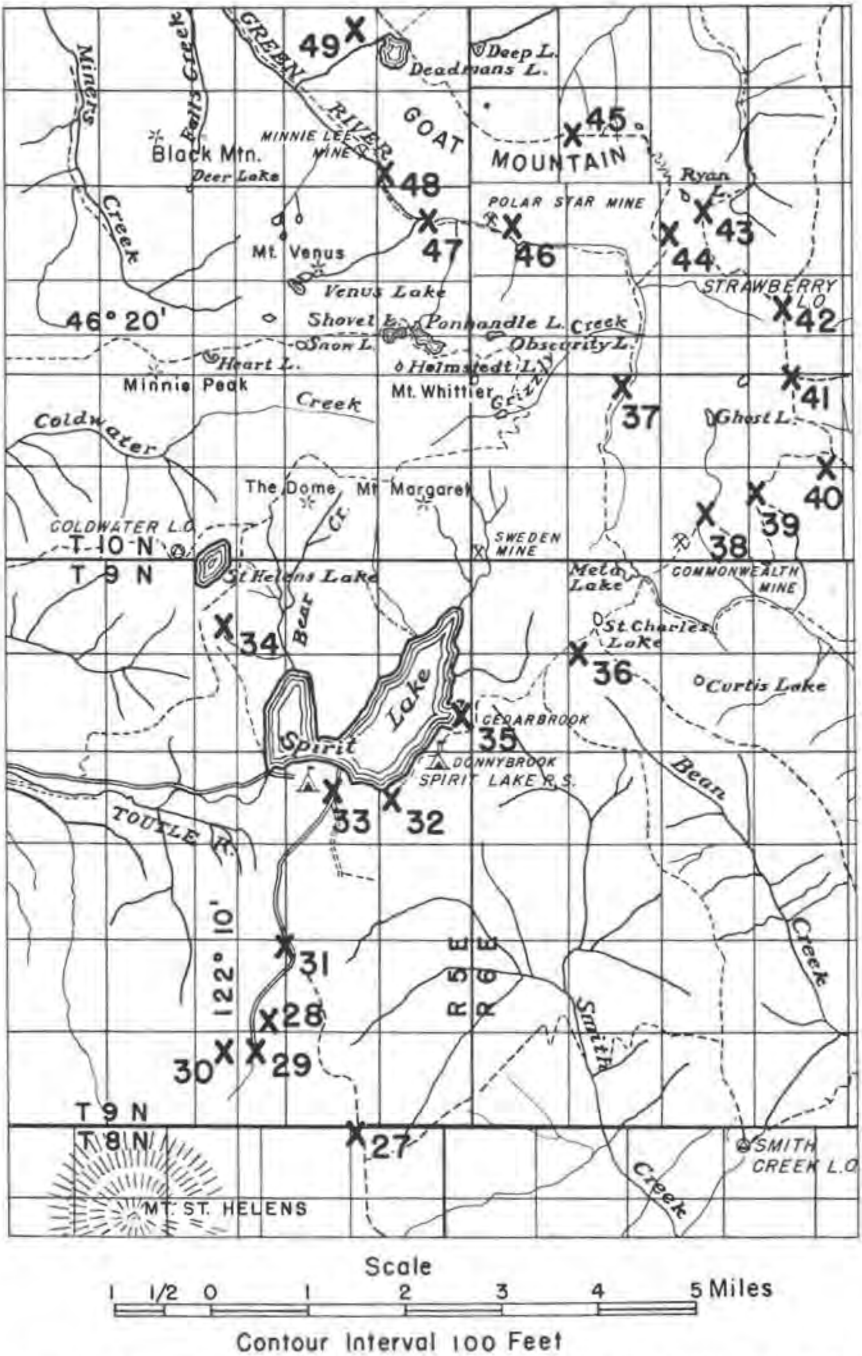


FIGURE 3—Area north of Mount St. Helens, showing the location of observed pumice occurrences. The numbers refer to the text. Base, Columbia National Forest map.

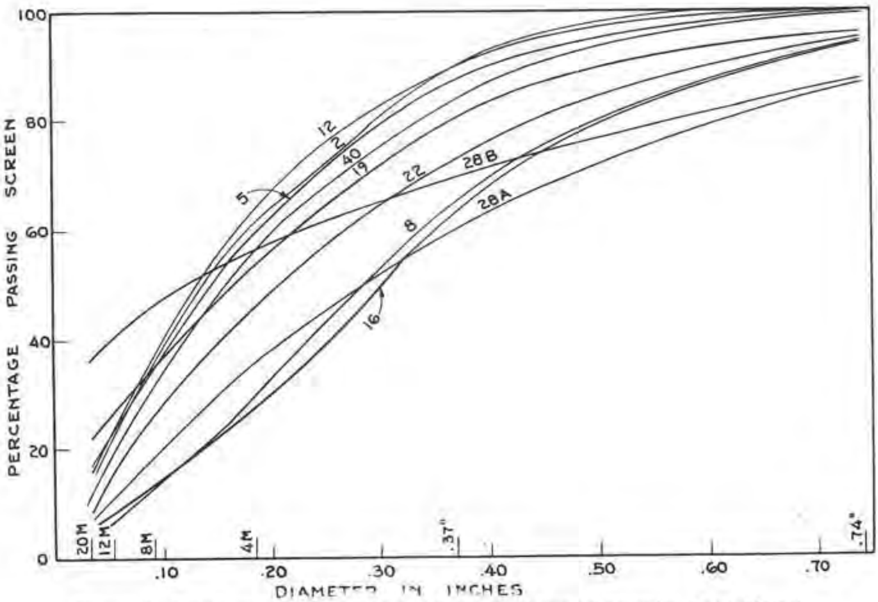


FIGURE 4—Graph showing results of screen analyses of samples from Mount St. Helens pumice occurrences.

*Apparent density and mechanical analyses of Mount St. Helens pumice*

| Sample-location number | LOCATION | Thickness of bed in inches | Weight per cu. ft. as sampled | Weight per cu. ft. air dried at 70° F. | Screen analyses by weight (Tyler standard screen scale) percent retained on sieves | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0.74 in. (18.85 mm) | 0.37 in. (9.4 mm) | 4 mesh (4.7 mm) | 8 mesh (2.36 mm) | 12 mesh (1.4 mm) | 20 mesh (0.83 mm) | Minus 20 mesh (minus 0.83 mm) |
| 2 | West quarter corner of sec. 8, (12-6E) | 70 | 57.3 | 34.7 | ............ | 9.5 | 30.0 | 26.0 | 12.0 | 8.4 | 14.1 |
| 5 | East center of the SW¼ sec. 11, (12-6E) | 32 | 49.6 | 34.4 | 1.0 | 11.7 | 26.9 | 24.7 | 12.8 | 10.9 | 12.0 |
| 8 | South quarter corner of sec. 24, (12-5E) | 72 | 52.4 | 32.2 | 6.3 | 28.3 | 35.7 | 17.3 | 6.0 | 3.3 | 3.1 |
| 12 | Southwest corner of sec. 23, (12-6E) | 42 | ............ | 41.1 | 1.4 | 9.0 | 25.8 | 27.3 | 15.1 | 10.7 | 10.7 |
| 16 | South quarter corner of sec. 36, (12-5E) | 60 | 49.8 | 32.3 | 6.8 | 29.7 | 35.6 | 15.0 | 5.4 | 2.3 | 5.2 |
| 19 | Center of sec. 5, (11-6E) ("Popcorn" pit) | 156 | 61.1 | 44.0 | 5.2 | 14.3 | 26.9 | 19.2 | 8.6 | 5.3 | 20.5 |
| 22 | E½SE¼ sec. 4, (11-6E) | 51 | 53.2 | 37.1 | 6.0 | 20.5 | 26.6 | 21.1 | 10.8 | 7.5 | 7.5 |
| 28A | SE¼ sec. 27, (9-5E) | 48 | 52.8 | 36.1 | 14.0 | 25.1 | 24.0 | 17.1 | 8.0 | 4.6 | 6.3 |
| 28B | SE¼ sec. 27, (9-5E) | 120+ | ............ | 72.7 | 13.5 | 17.1 | 13.4 | 9.3 | 5.5 | 5.3 | 35.9 |
| 40 | SW¼SE¼ sec. 27, (10-6E) | 44 | ............ | 34.7 | 1.7 | 15.0 | 27.5 | 23.9 | 11.8 | 11.3 | 8.8 |

## GLACIER PEAK OCCURRENCES

### Location

Glacier Peak is a volcanic cone in eastern Snohomish County, situated near the crest of the Cascade Range at latitude 48° 8′ north and longitude 121° 7′ west. It is 10,436 feet in altitude, but owing to the presence of many high peaks and ridges near by, it rises only 2,000 to 3,000 feet above the surrounding crests and from a distance does not present as spectacular a profile as do other major volcanoes of the state. At present, Glacier Peak is reached only by trails which extend from Forest Service roads west and east of the area; the nearest road is a recently constructed one leading up the Suiattle River from the west to within about 8 miles of the peak. Perennial snow and several glaciers occur on the sides of the volcano.

Most of the pumice of Glacier Peak was deposited over a fan-shaped area extending eastward and southeastward from the peak, across Chelan County. The major part of the pumice fell in a rough, mountainous region north and northwest of Wenatchee, between the volcano and the Columbia River, a strip some 40 to 50 miles in length. Some of the smallest material, however, was blown as far as 75 to 100 miles from the source and settled on the Columbia Plateau. Since its deposition, the pumice sheet has been affected by erosional processes, and the present deposits are remnants and concentrations of the former widespread blanket. These occur chiefly within a fan-shaped belt, 1 to 20 miles wide, that extends eastward from the upper part of the Chiwawa River Valley through the middle and lower parts of the Entiat River Valley, and crosses the Columbia River Valley in the vicinity of the towns of Chelan and Entiat. One

DIVISION OF MINES AND GEOLOGY

REPORT OF INVESTIGATIONS NO. 15, PLATE 3

GLACIER PEAK FROM THE NORTHEAST.

small deposit is known to occur east of the Columbia River near Adrian, in northern Grant County, another is north of Brewster in Okanogan County, and a third is near Bridgeport in Douglas County.

### Accessibility

The area in which the pumice deposits occur is served by several roads. The Chiwawa occurrences are reached by one that leads about 40 miles up the Chiwawa River Valley from Leavenworth, a town 25 miles west of Wenatchee on the Stevens Pass highway and on the main line of the Great Northern Railway. The Entiat occurrences are reached by a road that leads 38 miles up the Entiat Valley from Entiat, a town 20 miles north of Wenatchee on State Highway 10 and on the Okanogan branch-line of the Great Northern Railway. Several connecting County and Forest Service roads lead through the area between the lower Entiat and Lake Chelan Valleys.

### Physiography and General Conditions

The terrain between Glacier Peak and the Columbia River is exceedingly mountainous; altitudes range from about 700 feet along the Columbia to more than 5,000 feet on near-by peaks, and to more than 7,000 feet on summits farther west. Relief is from 3,000 to as much as 5,000 feet throughout a large part of the area. Eastward from the Columbia River, the area is an undulating plateau from 2,500 to as much as 4,000 feet in altitude.

With the exception of the Glacier Peak vicinity, where the streams flow westward to the Sauk River, the drainage of the pumice area is into the Columbia River. The valleys of the Chiwawa and Entiat Rivers and Lake Chelan all trend southeastward and form a prominent drainage pattern. These valleys were the main channels of mountain glaciers during Pleistocene time, and the typical features of ice erosion are well shown by the trough-like, steep-sided sections of the upper Chiwawa and Entiat Valleys and the entire Lake Chelan Valley.

Owing to its situation on the east slope of the Cascade Range, the region has rather diverse climatic conditions. In the area close to the Cascade divide, annual precipitation is 60 or more inches, and a large part of it falls during winter months as snow. The precipitation is less toward the east, and is only 10 to 15 inches at stations along the Columbia River.

Throughout the area, winters are cool; summers, warm. Pumice mining could be carried on during the entire year on deposits in the Columbia River area, but in the upper Chiwawa and Entiat Valleys operations would be seriously hampered, if not prevented, by snow during winter months.

Most of the region west of the Columbia River is well forested by pine, fir, tamarack, cedar, and spruce; and selective logging is done at a few places. The area is fairly free of underbrush, however, and is well suited to prospecting. The population is mainly along the Columbia River and in the lower parts of tributary valleys, where agriculture, chiefly fruit growing, is a well-developed industry.

## Geology

The oldest rocks in the region where pumice occurs are a widespread group of schists and gneisses that extend from the Columbia River westward through the Cascades. A part of these rocks, the Swakane gneiss in the vicinity of Entiat, are described and mapped by Waters, who states [1] that this gneiss "is the oldest cartographic unit [in the area] and is a complex of remarkably foliated, highly metamorphic rocks, in part of sedimentary and in part of igneous derivation." They are considered to be pre-Ordovician in age. The Swakane gneiss and other old gneisses and schists to the west are intruded by large masses of granitic rock, some of which are probably Mesozoic in age; others, probably Tertiary. In the Chiwawa Valley, north of Leavenworth, there are a few patches of sandstone, shale, and conglomerate which appear to belong to the Eocene (or late Cretaceous) Swauk formation that occurs extensively in the Mount Stuart quadrangle to the south.[2] East of the Columbia River, the pre-Tertiary rocks are covered by a thick series of basalt flows, chiefly Miocene in age, which are overlain by Pleistocene and Recent eolian and alluvial deposits.

Glacier Peak, composed chiefly of andesitic lavas, lapilli, and pumice, rests on a basement of deeply dissected gneiss and schist. The symmetry ordinarily displayed by recent volcanoes is not well shown by this cone, which is more-or-less elongated in a northwest-southeast direction. This is due mainly to the peak's topographic situation astride a ridge that extends northwestward from the crest of the Cascade Range between the upper parts of the Suiattle and Whitechuck Valleys. Erosion, consequently, has been more severe on the sides of the peak facing these deep valleys than on sides facing along the ridge.

Although Glacier Peak is the only volcano generally recognized in this area at present, there are probably other related cones in its vicinity. A small cinder cone is reported by Hougland [3] to occur about 5 miles southwest of Glacier Peak, and what is probably another small cinder cone is reported by Russell [4] to occur in Indian Pass, 7 miles to the south. The basins occupied by Ice Lakes near the head of the Entiat River had been reported as possible craters and sources of the pumice in the Entiat and Chiwawa Valleys, but an investigation specifically to check the report showed the lakes to be lying in cirque basins in no way connected with the origin of the pumice.

The present cone of Glacier Peak has been built up in relatively recent times; not as recently as the cone of Mount St. Helens, but certainly since Pleistocene time, for the eruptive rock, including the

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[1] Waters, A. C., A petrologic and structural study of the Swakane gneiss, Entiat Mountains, Washington: Jour. Geology, vol. 40, p. 605, 1932.

[2] Smith, G. O., U. S. Geol. Survey Geol. Atlas, Mount Stuart folio (no. 106), p. 5, 1904.

[3] Hougland, Everett, field notes (unpublished), 1934, in files of the Division of Mines and Geology, Olympia, Washington.

[4] Russell, I. C., A preliminary paper on the geology of the Cascade Mountains in northern Washington: U. S. Geol. Survey 20th Ann. Rept., pt. 2, p. 135, 1900.

pumice, is deposited on the sides and floors of glaciated valleys. Furthermore, the cone, though supporting several glaciers, is not deeply scoured by ice erosion, and streams flowing from the ice fields have cut youthful, V-shaped canyons in the flanks of the peak below the snow-line. The many sharp-pointed matterhorn peaks, cirque basins, and hanging valleys carved in non-volcanic rock in the Glacier Peak vicinity are in direct contrast with the less-glaciated cone. However, the volcano may have been active previous to the building of the present cone, for the eruption of the pumice, which probably accompanied the building of the cone, appears to have occurred rather late in the life of the volcano. In at least one place—in the canyon of Chocolate Creek, on the east side of the peak—a pumice bed, apparently in situ, overlies colluvial debris composed of volcanic rock of an earlier age. The pumice bed slopes about 15 degrees eastward and seems to conform with an old land surface. It is overlain by 20 to 50 feet of later colluvial deposits.

At another place, on the south side of Chelan Butte 6 miles south of Chelan, pumice similar in all respects to that from Glacier Peak is intercalated with terrace gravels along the Columbia River (see p. 51). These terraces are considered to be related to the Pleistocene continental glaciation of eastern Washington, and the relationship of the pumice to that episode is not understood.

So far as is known there are no reports by early settlers or explorers of Glacier Peak's being in eruption since their arrival in the Northwest, and although a recent eruption is indicated in the vicinity of the peak, where a one-fourth-inch to one-inch layer of pumicite and minute pumice pellets underlies the vegetation and surface drift, it probably occurred previous to early explorations of the Puget Sound area.

The pumice of Glacier Peak probably settled more-or-less evenly over the terrain to the east, but owing to the loose nature of the material and to the roughness of the region which it blanketed, much of this original sheet has been intensely reworked or eroded completely away. With few exceptions, the deposits that now occur are only on the lower, gently sloping parts of valley sides between tributaries, in some cirque basins, or on benches and ridge-tops that have escaped recent erosion. Many of the deposits, particularly those in the upper valleys of the Chiwawa and Entiat Rivers, show two distinct beds of pumice. The lower one is of angular, relatively unweathered fragments and represents part of the original air-laid sheet that has remained undisturbed since its deposition. The upper bed is of slightly rounded, somewhat weathered pumice together with a few pebbles of granite, gneiss, and schist—the country rocks of the region. This upper bed ordinarily shows some assortment, and it is believed to be of pumice that originally fell on the steep upper slopes of the valley sides, from where it rolled or was washed down and redistributed over the air-laid bed at lower elevations. Separating the two beds, there is nearly always a 1- to 6-inch bed composed of small-size pumice, pumicite, and sand layers. Some of this is fine-grained material from the upper bed that sifted through the coarser particles as it was being reworked.

In deposits in the Columbia River area this interlayer is not found, and the deposits here are believed to be entirely of pumice that has rolled down steep slopes and piled up at places where the gradient is less. This reworking of the Glacier Peak pumice has an economic bearing, for otherwise the original air-laid sheet would not be thick enough to be commercially important excepting at few places.

Two pumice deposits were seen that are wind-drifted. One is on Brewster Flat, about 5 miles north of Brewster, in Okanogan County; the other is on the north side of a shallow coulee near Adrian, in Grant County.

The deposits of Glacier Peak pumice consist of loose aggregates of various-size pellets that are light-gray or light-buff in color. The yellowish color, due to the oxidation of contained iron, is generally common only to the reworked bed of pumice in the upper Chiwawa and Entiat Valleys; the material in the lower bed and in the reworked deposits in the Columbia River area is predominantly light-gray in color. The pumice is strikingly similar to that of Mount St. Helens, and is composed of vesicular glass containing small phenocrysts of plagioclase (andesine?), hypersthene, hornblende, and magnetite. Individual, free crystals of these minerals are also distributed through the deposits, particularly in the interlayer between the two beds of some deposits. A little pumicite also occurs with the pumice. As in the Mount St. Helens deposits, the average size of the pellets diminishes with distance from the volcano. In the upper Chiwawa Valley, about 12 miles east of Glacier Peak, the pellets average about half an inch or more in diameter and many are as much as 3 or 4 inches. In the Entiat Valley the pellets average about a third of an inch; in the Columbia River area, less than a quarter of an inch; and farther east, on the Columbia Plateau, less than a tenth of an inch in diameter. Plate 4 shows the region east of Glacier Peak; places where vertical sections through pumice were observed are indicated, and the area in which the major part of the pumice appears to have fallen is delimited. Most of the commercial deposits now known in this area occur in the upper Chiwawa and Entiat Valleys; those farther east are widely scattered, and are generally small in size. However, unknown deposits undoubtedly occur at many places throughout this wide region where the physiographic conditions are favorable, and new discoveries will probably be made for many years in the future.

## Pumice Deposits

### GLACIER PEAK AREA

In the vicinity of Glacier Peak the pumice sheet is poorly represented as a clean bed. Here the unconsolidated volcanic material has been so intensely worked by water that most of the original deposit has been eroded away or buried by boulders, sand, and silt. One exposure of a pumice bed—that in the canyon of Chocolate

Creek, about 3½ miles east of the summit (location 1, pl. 4)—was found on the flanks of the mountain. Here two layers of pumice, each 7 feet thick, are separated by a 6-inch layer of fine pumicite and sand; they are exposed for a distance of about 100 feet along the canyon wall, and are overlain by 20 to 50 feet of boulders, gravel, and sand.

About 4 miles east of Glacier Peak (location 2, pl. 4), in about the NW¼ sec. 16, (30-15E), pumice can be seen from a distance lying on the crest of a narrow ridge at an elevation of about 7,500 feet. It appears to be about 15 feet thick but is relatively inaccessible.

In Buck Creek Pass, about 7 miles northeast of the summit, there are a few exposures of pumice along the banks of small streams. At one place (location 3, pl. 4) a section shows 66 inches of silt, sand, and a little pumice overlying at least 40 inches, base concealed, of coarse buff-colored pumice.

#### CHIWAWA VALLEY AREA

The upper Chiwawa Valley pumice deposits of commercial importance are scattered along the valley sides between the mouth of Chikamin Creek, in sec. 21, (28-17E), and the mouth of Buck Creek, in sec. 8, (30-16E). Below (southwest of) Chikamin Creek the pumice is inconsequential in thickness; and above Buck Creek the valley is narrow, steep-sided, and not generally favorable for the retention of the pumice deposited there. Some of the deposits along the Chiwawa Valley are small, underlying only a few hundred square feet; others appear to be several hundred acres in extent.

In the Chikamin vicinity, the deposits are from 2 to 3 feet thick, but they become increasingly thicker farther up the Chiwawa Valley and are from 3 to 4 feet thick in the Rock Creek vicinity, 6 to 8 feet near Maple Creek, and 10 to 12 feet near Phelps Creek. The deposits are covered by at least 1 foot but rarely more than 2 feet of silty soil overgrown by trees and a little brush.

Probably the largest pumice deposit in this area occurs near the confluence of Phelps Creek with the Chiwawa River. Here, on the northeast side of the Chiwawa Valley, on either side of Phelps Creek, are several hundred acres underlain by pumice to a depth of 10 or more feet. The deposit is exposed in several road cuts and in excavations around the mill buildings of the Royal Development Company, a copper-mining organization. The Scholze pit (location 9, pl. 4), the only operation in the Chiwawa Valley in 1945, is a few hundred yards southeast of the mill buildings, in the NW¼ sec. 27, (30-16E). This pit is quarry-like with a 175-foot face along the valley side, which here slopes 15 to 20 degrees toward the southwest and is covered by pumice to a depth of from 5 to more than 13 feet. After clearing away trees and brush and stripping about 18 inches of overburden, the pumice is shoveled by hand into trucks that are parked at the face. The pumice is mined during summer and fall months and hauled 40 miles to Leavenworth to be used as an aggregate in concrete blocks.

SCHOLZE PUMICE PIT IN THE CHIWAWA VALLEY.
The man stands at the base of the pumice deposit. The layer of sand which separates the lower, air-laid bed from the upper, reworked bed is well shown.

Following are stratigraphic sections from the surface through pumice occurrences measured at several places in the Chiwawa Valley; the numbers given the locations correspond to those on plate 4. The apparent densities and mechanical analyses of samples taken are in the table on page 55.

*Sections through pumice in the Chiwawa Valley*

Location 4. River bank in the SW¼ sec. 16, (30-16E)

| | Feet | Inches |
|---|---|---|
| Silt and a few boulders of gneiss | .... | 18–24 |
| Buff-colored pumice | .... | 48 |
| Sand | .... | 2 |
| Gray pumice | .... | 70 |
| Silt, sand, and gravel | 8–10 | .... |
| Bedrock of gneiss | 40+ | .... |
| Chiwawa River level | | |

Location 5. Road cut and drill hole 1,000 feet north of the Royal Development Company mill buildings, in the SW¼ sec. 22, (30-16E)

| | Inches |
|---|---|
| Silt and a little pumice | 24 |
| Buff-colored pumice | 48 |
| Sand | 3 |
| Gray pumice | 68 |
| Rock (concealed) | |

Location 6. Drill hole about 2,000 feet northeast of the mill buildings, near the center of sec. 22, (30-16E)

| | Inches |
|---|---|
| Silt and a little pumice | 24 |
| Buff-colored pumice | 55 |
| Sand | 2 |
| Gray pumice (base not found) | 42+ |

Location 7. Excavations north of the mill buildings, near the southwest corner of sec. 22, (30-16E)

| | Inches |
|---|---|
| Silt | 25 |
| Buff-colored pumice | 40 |
| Sand and pumicite | 2–12 |
| Gray pumice | 64 |
| Sand, silt, and fragments of gneiss and granite (base concealed) | 36+ |

Location 8. Road cuts just southwest of the mill buildings near the northeast corner of sec. 28, (30-16E)

| | Inches |
|---|---|
| Silt and a little pumice | 24 |
| Pumice and a little sand | 30 |
| Well-sorted layers of sand and rounded pumice pellets (base concealed) | 96+ |

Location 9. Scholze pit in the NW¼ sec. 27, (30-16E)

| | | Inches |
|---|---|---|
| Silt and a little altered pumice | | 18–24 |
| Light buff-colored pumice | | 56–60 |
| Sand and a little sand-size pumice | (Sample 9) | 3–7 |
| Gray pumice | | 60–68 |
| Silt and sand containing fragments and boulders of granite (base concealed) | | 24+ |

Location 10. Road cut and drill hole in the east center of sec. 34, (30-16E)

| | Inches |
|---|---|
| Silt | 27 |
| Buff-colored pumice | 43 |
| Sand | 2 |
| Gray pumice | 38 |
| Rock (concealed) | |

Location 11. Road cut and drill hole in the NW¼ sec. 2, (29-16E)

| | Inches |
|---|---|
| Silt and a little altered pumice | 18 |
| Pumice and some silt, probably not commercial | 39 |
| Buff-colored pumice | 23 |
| Sand | 1 |
| Gray pumice | 71 |
| Sand | 2 |
| Light-gray pumice | 61 |
| Silt and sand | 2 |
| Rock (concealed) | |

Location 12. Road cut and drill hole in the SW¼ sec. 2, (29-16E)

| | Inches |
|---|---|
| Silt containing a little altered pumice | 21 |
| Buff-colored pumice | 71 |
| Sand and sand-size pumice | 12 |
| Gray pumice | 17 |
| Rock (concealed) | |

Location 13. River bank near the northeast corner of sec. 1, (28-16E)

| | Feet | Inches |
|---|---|---|
| Well-sorted silt, sand, and gravel | 40± | .... |
| Well-sorted silt, sand, and stream-worn pumice | 4 | .... |
| Sand and a little sand-size pumice | .... | 10 |
| Slightly sorted pumice | 3 | 4 |
| Coarse sand and a little sand-size pumice | 1 | .... |
| Dark-brown silt | 2 | .... |
| Dark-gray glacial clay showing rusty streaks | 2+ | .... |
| Base concealed below river. | | |

Location 14. Road cuts near the center of sec. 6, (28-17E)

| | Inches |
|---|---|
| Silt and pumice | 12–18 |
| Buff-colored pumice | 12–18 |
| Silt and pebbles of gneiss and granite (base concealed) | 6+ |

| | *Inches* |
|---|---|
| Location 15. Drill hole in the SE¼ sec. 6, (28-17E) | |
| Silt and pumice | 24 |
| Buff-colored pumice | 25 |
| Sand and sand-size pumice | 10 |
| Silt and pebbles of gneiss (base concealed) | 2+ |
| Location 16. Road cut in the NW¼ sec. 8, (28-17E) | |
| Silt and a little altered pumice | 14 |
| Buff-colored pumice | 20 |
| Sand | 1 |
| Gray pumice | 5 |
| Fine gray sand | 7 |
| Silt and fragments of gneiss (base concealed) | 10+ |
| Location 17. Road cut and drill hole in the SW¼ sec. 8, (28-17E) | |
| Silt, sand, and a little altered pumice | 20 |
| Buff-colored pumice | 49 |
| Sand | 2 |
| Gray pumice | 9 |
| Sandy silt containing granite pebbles (base concealed) | 9+ |
| Location 18. Road cut and drill hole in the north center of sec. 17, (28-17E) | |
| Silt and a little altered pumice | 24 |
| Altered pumice and silt | 19 |
| Pumice and some sand | 40 |
| Silt and rock fragments (base concealed) | 3+ |
| Location 19. Road cut and drill hole near the southwest corner of sec. 16, (28-17E) | |
| Silt and altered pumice | 43 |
| Buff-colored pumice | 44 |
| Fine sand and a few pebbles (base concealed) | 18+ |
| Location 20. Road cut and drill hole in the NW¼ sec. 21, (28-17E) | |
| Silt and altered pumice | 24 |
| Altered pumice | 10 |
| Buff-colored pumice (Sample 20) | 30 |
| Sand (Sample 20) | 1 |
| Pumice (Sample 20) | 6 |
| Sand | 2 |
| Silt containing rock fragments (base concealed) | 3+ |
| Location 21. Road cut and drill hole in the east center of sec. 27, (28-17E) | |
| Silt and altered pumice | 30 |
| Buff-colored pumice | 20 |
| Coarse sand | 4 |
| Silt and gravel (base concealed) | 12+ |
| Location 22. Road cut near the east quarter corner of sec. 34, (28-17E) | |
| Silt and a little altered pumice | 20 |
| Buff-colored pumice | 18 |
| Sand | 3 |
| Silt and gravel (base concealed) | 4+ |
| Location 23. Road cut in the north center of sec. 11, (27-17E) | |
| Silt, sand, and a little altered pumice | 16 |
| Buff-colored pumice | 14 |
| Coarse sand and a little pumice | 4 |
| Fine sand (base concealed) | 5+ |
| Location 24. Road cut near the northeast corner of sec. 13, (27-17E) | |
| Silt, sand, and a little altered pumice | 30 |
| Buff-colored pumice | 8 |
| Coarse sand and a little pumice | 3 |
| Fine sand (base concealed) | 6+ |

### ENTIAT VALLEY AREA

The pumice deposits in the upper Entiat Valley are exposed at many places along the Entiat Valley road, which leads as far as Cottonwood Camp, 38 miles from Entiat, and along the Lake Creek road, which leads from the Entiat Valley over the Chelan Mountains to Lake Chelan at the mouth of Twentyfive Mile Creek. Most of the deposits are scattered along the lower valley sides, chiefly from the mouth of Fox Creek, in sec. 19, (28-19E), northwestward for about 15 miles to the vicinity of Anthem Creek, in the southeastern part of T. 30 N., R. 17 E. and about 4 miles above the end of the road at Cottonwood Forest Camp. Below Fox Creek the deposits are relatively small and widely scattered. Above Anthem Creek, at the head of the Entiat River, the pumice sheet is relatively thin, and the possibility for commercial deposits is unfavorable.

Along the 15-mile section of the valley the pumice is confined to areas where recent erosion has not swept it away—usually between the river and the toe of the steep valley sides where tributary streams and gullies are absent. They are mostly lenticular deposits having widths from about 200 to more than 500 feet and lengths from several hundred to several thousand feet. Thicknesses vary from 3 to 4 feet in the Fox Creek vicinity to as much as 11 feet in the Cottonwood area. Overburden commonly consists of 12 to 24 inches —rarely as much as 30 inches—of silty soil overgrown by trees and brush. At a few places granite boulders that tumbled from steep cliffs above are scattered over the surface.

The pumice along the Lake Creek road occurs widely over 15- to 25-degree sloping sides of a cirque basin near the head of this stream. It is generally 3 to 4 feet thick and is overlain by 12 to 24 inches of silty soil. Probably other similar cirque basins in the upper Entiat region also contain pumice deposits.

In 1945 one pit in the upper Entiat Valley had been worked on a commercial scale (location 29, pl. 4). Its location is approximately the NW¼ sec. 16, (29-18E), 2.2 miles southeast of Cottonwood Camp. The pit, about 75 feet square, is opened on a 15-degree sloping hillside. After the removal of trees, brush, and 6 to 24 inches of overburden, the pumice, 5 to 7 feet deep, was scooped up by a dragline scraper and dumped through an elevated ramp into a truck. Some pumice, however, was mined by hand. This pit was opened by the U. S. Forest Service, who charged 10¢ per yard royalty and issued a special use permit to the operators. Approximately 600 cubic yards of pumice was mined here in 1944 by the Oroville Independent Growers, Inc., and used as insulation in cold-storage warehouses. Considerable pumice appears to occur in the vicinity of this pit.

Greatly increased interest in pumice for use in lightweight concrete blocks and for loose-fill insulation was responsible for the opening in a year's time of at least twelve additional pits in the Entiat Valley. Of these, several had been worked out and abandoned by August 1946, and at least three were ready for production but had not yet made any shipments. Five pits were making more-or-less regular shipments to block plants and other users as far distant as Seattle.

In the vicinity of Cottonwood Camp at the end of the Entiat River road are three pits owned by George W. Heller of Chelan. One of these (location 26A, pl. 4), not now being operated, is at the edge of the road at the south end of the bridge crossing the river in the SE¼ sec. 7, (29-18E). The pit lies in a narrow ridge at road level and is approximately 50 feet long and 30 feet wide. The following section is exposed in the center of the west face of the pit:

*Section through pumice in Heller's south pit at Cottonwood Camp*

| | *Inches* |
|---|---|
| Silty soil and pumice | 12 |
| Buff-colored pumice | 52 |
| Crystal and pumice sand | 6 |
| Gray pumice | 52 |
| Granite cobbles and fragments (base concealed) | 6+ |

Five hundred feet north, on the opposite side of the river (location 26B, pl. 4), are two recently opened pits. Each is 150 feet square. The upper pit has been stripped of from 18 to 36 inches of mixed silt and pumice overburden, and with the erection of a loading ramp will be ready for production. The lower pit lies on a 25-degree southwesterly slope about 200 feet north of the road. Overburden at the upper edge of this pit is 3 feet thick. The apparent density and mechanical analysis of a sample taken of the pumice in the pit are shown on page 55. A section measured in a road cut just below the pit (location 26, pl. 4) is shown on page 44.

Mr. Roberts of Yakima, operating the pits for Mr. Heller, uses a bulldozer to strip overburden and to load pumice onto trucks at a loading ramp. He experimented with using a revolving cylindrical screen and also with rolls to eliminate the larger pieces of pumice, some of which reach 1½ inches. The equipment did not operate satisfactorily, so stationary screens were installed and all plus ½-inch material is dumped as waste. No accurate record of shipments is available, but several thousand cubic yards of pumice appear to have been excavated and shipped. At the time of examination shipments were being made by truck to Chelan, Yakima, and other points in central Washington.

A pit (location 31A, pl. 4), 300 feet south of the Entiat River road in the SW¼ sec. 22, (29-18E), is being opened by Elmer Cox for the Big Six Pumice Mining Corporation. The pit, 100 feet square, has been stripped of an average of 2 feet of overburden with a bulldozer which also will be used to load trucks at a loading ramp. The area in the vicinity of the pit is heavily timbered, thus adding to the cost of stripping. The pumice here is similar in character to that at Cottonwood Camp. A section measured near the pit (location 31, pl. 4) is shown on page 44. At the time of examination, July 1946, the pit was ready for production but no shipments had yet been made.

North of the road 100 feet, opposite the Big Six workings, is a pit 75 feet wide and 150 feet long owned by Kenneth Butler. It is in the NW¼ sec. 22, (29-18E), 3½ miles southeast of Cottonwood Camp (location 31B, pl. 4). A bulldozer has been used to remove trees, brush, and from 3 to 4 feet of mixed soil and pumice overburden. The same machine will be used to load pumice at the ramp at the lower side of the pit. The pumice in this pit is similar to that in the near-by Big Six pit and to that at Cottonwood Camp. A section measured in a road cut a short distance to the northwest (location 31, pl. 4) is shown on page 44. Although the pit was ready for production, no shipments had been made at the time of examination.

A pit owned by Jack J. Smart is 100 feet south of the Entiat River road (location 39A, pl. 4), in the SE¼ sec. 2, (28-18E), about 29 miles from Entiat. An area 100 feet square has been stripped with a bulldozer of trees, brush, and 2 to 4 feet of mixed soil and pumice overburden. A loading ramp is at the south edge of the pit, but apparently no shipments had been made by July 1946. The pit lies on a flat between the Entiat River and the steep valley side to the northeast. At least part of the deposit appears to be colluvial in origin. The following is a section exposed in an access-road cut at the south edge of the pit:

*Section through pumice at Jack J. Smart pit*

| | *Inches* |
|---|---|
| Silt and pumice | 12 |
| Buff-colored pumice | 12 |
| Crystal and pumice sand | 6 |
| Buff-colored pumice | 18 |
| Granite stream gravel and sand (base concealed) | 16+ |

At the northwest corner of the pit, under a 48-inch overburden of silt, sand, and pumice, is 60 inches of buff-colored pumice which lies directly on river gravel and sand. At no place is gray pumice exposed in this pit; here there is only the buff-colored pumice that in most other locations in the Entiat Valley overlies a thin layer of pumice sand which in turn overlies a layer of gray pumice, in most instances approximately equal in thickness to the buff pumice layer. The apparent density and mechanical analysis of a sample taken from the 60-inch layer at the northwest corner of the pit are shown on page 55.

An inactive pit (location 40A, pl. 4) owned by George W. Heller of Chelan is 100 feet north of the Entiat River road and 150 feet west of the Lake Creek crossing, in the SE¼ sec. 12, (28-18E). The following section was measured at the west side of the loading ramp:

*Section through pumice at Heller's Lake Creek pit*

| | *Inches* |
|---|---|
| Silt and pumice | 26 |
| Buff-colored pumice | 30 |
| Crystal and pumice sand | 18 |
| Buff-colored pumice | 16 |
| Granite boulders and sand (base concealed) | 12+ |

At the upper edge of the pit the overburden thins to 12 inches, but the pumice bed thins also to about 24 inches. The area excavated is 275 feet long and extends 100 feet up a 20-degree slope. An estimated total of several thousand cubic yards of pumice has been shipped. The pit was inactive at the time of examination, but the loading ramp and a large 1-inch screen remained in good condition, and probably some additional shipments could be made.

An abundance of large granite boulders pushed to one side near the loading ramp indicates that the pumice bed may have had some boulders scattered through it.

In the NW¼ sec. 19, (28-19E) is a pit (location 46A, pl. 4) operated by William Nichol of Entiat. It covers an area 240 feet long and 120 feet wide on the 30-degree southwestward-sloping valley side. A bulldozer is used to strip overburden and to push pumice onto trucks at a loading ramp. Pumice from this pit is being trucked to Wenatchee and other places in central Washington. The following section was measured at the west side of the pit:

*Section through pumice at Nichol pit*

| | *Inches* |
|---|---|
| Silt and pumice | 16 |
| Buff-colored pumice | 22 |
| Crystal and pumice sand | 5 |
| Buff-colored pumice | 10 |
| Granite boulders and sand (base concealed) | 6+ |

The apparent density and a mechanical analysis of a sample taken from a road cut near the pit (location 45, pl. 4) are shown on page 55.

Curtis Patty and partners have opened a pit (location 46B, pl. 4) in the NW¼ sec. 19, (28-19E), 50 feet east of the Nichol pit. It lies 200 feet north of the Entiat River road on a 30-degree slope which rises to the northeast. The pit is triangular in shape. The upper edge is 300 feet long and forms the base of the triangle; the loading ramp, 200 feet down slope, is the apex. A bulldozer (see pl. 6) is used to push pumice onto trucks, which haul to central Washington towns and to a bunker on the Great Northern Railway near Winesap, where several carloads a week are loaded and shipped to western Washington. The following section was measured in the upper (north) face of the pit:

*Section through pumice at Patty pit*

| | *Inches* |
|---|---|
| Silt and pumice | 30 |
| Buff-colored pumice | 30 |
| Crystal and pumice sand | 12 |
| Buff-colored pumice | 14 |
| Granite boulders and sand (base concealed) | 6+ |

Some granite boulders as much as 4 feet in diameter project through the pumice bed, thus somewhat hindering the work in the pit. The apparent density and mechanical analysis of a sample taken in a road cut near the pit (location 45, pl. 4) are shown on page 55. Two other pits on the Patty claim have been worked out and abandoned. The total production appears to have been several thousand cubic yards.

A pit (location 47A, pl. 4) on a claim in the NE¼ sec. 33 and NW¼ sec. 34, (28-19E), is owned and operated by Asher and Fouts, of Entiat. The pit is 200 feet north of the Entiat River road on a 30-degree northeastward-rising slope and lies in a stripped area 500 feet long and 300 feet wide. The average depth of pumice in the pit is 4 or 5 feet, but as much as 11 feet has been reported from test pits near by. The following section was measured in the upper edge of the pit:

*Section through pumice in Asher and Fouts pit*

| | | Inches |
|---|---|---|
| Silt and pumice | | 26 |
| Gray pumice | (Sample 47A) | 45 |
| Crystal and pumice sand | (Sample 47A) | 2 |
| Buff-colored pumice | (Sample 47A) | 10 |
| Granite boulders and sand (base concealed) | | 6+ |

A noteworthy feature of this deposit is the relationship of gray and buff pumice, in that the gray overlies the buff here while in all other pits in the Entiat Valley it underlies the buff pumice or is entirely absent. In most Entiat Valley deposits the buff pumice bed is nearly equal in thickness to the gray bed, but here the gray bed is much the thicker. The apparent densities of the pumice

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PATTY PUMICE PIT IN THE ENTIAT VALLEY.

from this pit, as shown in the table on page 55, are very low, indicating excellent insulation quality. Being farther from the point of origin, the pumice pellets here are smaller than those farther up the river. Most of the pellets are between ⅛ inch and ¼ inch in diameter. The operators use two bulldozers to strip and to load trucks at a loading ramp. By July 1946, trucks had hauled 800 cubic yards of pumice for loose-fill insulation and 3,000 yards to concrete block plants in Methow, Wenatchee, and other central Washington towns.

Pumice is exposed intermittently along the Lake Creek road from where it leaves the Entiat River road to the four-mile post, near which is a pit on a claim located by Clifford Griffith (location

53A, pl. 4). Here, in the NE¼ sec. 31, (29-19E), a loading ramp has been built and an area 60 feet square stripped of vegetation and an overburden consisting of 1 to 2 feet of mixed soil and pumice. The pit was ready to produce in July 1946 but had not yet made any shipments. A test pit 50 feet northeast of the pit shows the following section:

*Section through pumice at Griffith pit*

| | *Inches* |
|---|---|
| Silt and pumice | 18 |
| Buff-colored pumice | 26 |
| Crystal and pumice sand | 6 |
| Buff and gray pumice | 26 |
| Granite fragments and sand (base concealed) | 6+ |

Pumice shows in cuts along the Lake Creek road up to the pit of L. A. Bortz of Entiat. This pit, 4½ miles from the Entiat River (location 54A, pl. 4), is in the NE¼ sec. 31, (29-19E), at an elevation of about 5,400 feet. An area 50 feet wide and extending up a 25-degree slope has been stripped of very sparse vegetation and a few inches to 2 feet of overburden. Pumice is loaded onto trucks by means of a ramp and a Bagley-type scraper operated with gasoline engine and hoist. A 1-inch screen is used to eliminate any large-size foreign material. At the time of the examination, 600 cubic yards of pumice was being trucked to Methow for loose-fill insulation, and 60,000 concrete blocks had been made at Twisp with pumice from this pit. The pumice pellets here average ¼ inch to ½ inch in diameter; considerable pumice sand is intermixed. The apparent density and mechanical analysis of a sample taken from the east side of the pit are shown on page 55. The following section was measured in the east side of the pit:

*Section through pumice in Bortz pit*

| | | *Inches* |
|---|---|---|
| Silt and pumice | | 24 |
| Buff-colored pumice | (Sample 54A) | 33 |
| Crystal and pumice sand | (Sample 54A) | 4 |
| Buff and gray pumice | (Sample 54A) | 24 |
| Granite boulders and sand (base concealed) | | 6+ |

Following are stratigraphic sections through pumice occurrences measured in the upper Entiat Valley and in the Lake Creek Basin; the numbers given the locations correspond to those in plate 4. Apparent densities and mechanical analyses of samples taken are in the table on page 55.

*Sections through pumice in the upper Entiat Valley*

Location 25. Road cut near Cottonwood Camp in the SE¼ sec. 7, (29-18E)

| | *Inches* |
|---|---|
| Silty soil | 13 |
| Buff-colored pumice | 25 |
| Sand | 3 |
| Gray pumice | 35 |
| Silt, sand, and rock fragments (base concealed) | 100+ |

Location 26. Road cut 500 feet southeast of location 25

| | Inches |
|---|---|
| Silty soil | 12–30 |
| Buff-colored pumice | 38 |
| Sand and some pumice and pumicite | 8 |
| Gray pumice | 56 |
| Silty sand and fragments of granite (base concealed) | 6+ |

Location 27. Road cut near the southwest corner of sec. 8, (29-18E)

| | Inches |
|---|---|
| Silty soil and some altered pumice | 24 |
| Buff-colored pumice | 36 |
| Sand | 2 |
| Gray pumice (base concealed) | 30+ |

Location 28. Road cut near the north quarter corner of sec. 17, (29-18E)

| | Inches |
|---|---|
| Silty soil and some altered pumice | 12 |
| Buff-colored pumice | 48 |
| Sand | 8 |
| Gray pumice (base concealed) | 30+ |

Location 29. Pumice pit in the NW¼ sec. 16, (29-18E)

| | | Inches |
|---|---|---|
| Silty soil | | 6–22 |
| Buff-colored pumice | (Sample 29) | 40 |
| Sand | (Sample 29) | 2–8 |
| Gray pumice | (Sample 29) | 40 |
| Brown silt | | 2 |
| Silty sand and fragments and boulders of granite (base concealed) | | 12+ |

Location 30. Road cut near the south quarter corner of sec. 16, (29-18E)

| | Inches |
|---|---|
| Silty soil | 24 |
| Buff-colored pumice | 40 |
| Sand | 3 |
| Gray pumice | 40 |
| Silty sand and rock fragments (base concealed) | 2+ |

Location 31. Road cut in the NE¼ sec. 21, (29-18E)

| | Inches |
|---|---|
| Silty soil | 24 |
| Buff-colored pumice | 42 |
| Sand | 6 |
| Gray pumice (base concealed) | 24+ |

Location 32. Road cut in the NE¼ sec. 27, (29-18E)

| | Inches |
|---|---|
| Silty soil | 18–24 |
| Buff-colored pumice | 48 |
| Sand | 2 |
| Gray pumice (base concealed) | 24+ |

Location 33. Road cut in the SE¼ sec. 26, (29-18E)

| | Inches |
|---|---|
| Silty soil overlain by a few granite boulders | 12 |
| Buff-colored and gray pumice | 60 |
| Gravel (base concealed) | 12+ |

Location 34. Road cut and drill hole near the south quarter corner of sec. 26, (29-18E)

| | Inches |
|---|---|
| Silty soil and gravel | 18–24 |
| Buff-colored pumice | 40 |
| Sand | 2 |
| Gray pumice | 24 |
| Gravel (base concealed) | 3+ |

Location 35. Drill hole in the NE¼ sec. 35, (29-18E)

| | Inches |
|---|---|
| Silty soil | 12 |
| Buff-colored pumice | 36 |
| Sand and silt | 12 |
| Gray pumice (base not found) | 18+ |

| | Inches |
|---|---|
| Location 36. Drill hole about 300 feet northeast of location 35 | |
| Silty soil containing altered pumice | 40 |
| Buff-colored pumice | 45 |
| Sand and silt | 6 |
| Gray pumice | 26 |
| Silty sand and rock fragments (base not found) | 3+ |
| Location 37. Drill hole about 100 feet northeast of location 36 | |
| Silty soil containing altered pumice | 30 |
| Buff-colored pumice | 34 |
| Sand and silt | 7 |
| Gray pumice | 21 |
| Silt and rock fragments (base not found) | 3+ |
| Location 38. Road cut near the west quarter corner of sec. 36, (29-18E) | |
| Silty soil | 12 |
| Buff-colored and gray pumice | 48 |
| Gravel and boulders (base concealed) | 48+ |
| Location 39. Drill hole in the NE¼ sec. 2, (28-18E) | |
| Silty soil containing some altered pumice | 24 |
| Buff-colored pumice | 43 |
| Sand | 6 |
| Gray pumice | 34 |
| Gravel (base concealed) | 4+ |
| Location 40. Road cut near the west quarter corner of sec. 12, (28-18E) | |
| Silty soil, granite boulders, and altered pumice | 36 |
| Buff-colored pumice | 30 |
| Sand | 6 |
| Gray pumice (base concealed) | 12+ |
| Location 41. Road cut and drill hole near the center of sec. 13, (28-18E) | |
| Silty soil and altered pumice | 10 |
| Buff-colored pumice | 28 |
| Sand | 4 |
| Gray pumice | 9 |
| Gravel (base concealed) | 6+ |
| Location 42. Road cut about 1,000 feet southeast of location 41 | |
| Silty soil and altered pumice | 30 |
| Buff-colored pumice | 15 |
| Sand | 3 |
| Gray pumice | 9 |
| Gravel (base concealed) | 6+ |
| Location 43. Small pit about 1,000 feet southeast of location 42 | |
| Silty soil containing granite boulders and altered pumice | 10–20 |
| Buff-colored pumice | 45 |
| Sand | 2 |
| Gray pumice | 8 |
| Sandy silt and granite fragments (base concealed) | 6+ |
| Location 44. Road cut 650 feet west of the southeast corner of sec. 13, (28-18E) | |
| Silty soil containing granite boulders and altered pumice | 24–30 |
| Buff-colored pumice (base concealed) | 30+ |
| Location 45. Road cut 100 feet southeast of location 44 | |
| Silty soil, granite boulders, and altered pumice | 30 |
| Buff-colored pumice (Sample 45) | 69 |
| Sand (Sample 45) | 6 |
| Gray pumice (Sample 45) | 10 |
| Gravel and sandy silt (base concealed) | 6+ |

| | *Inches* |
|---|---|
| Location 46. Road cut and drill hole in the north center of sec. 19, (28-19E) | |
| Silty soil, sand, and altered pumice | 28 |
| Buff-colored pumice | 46 |
| Sand | 12 |
| Gray pumice | 9 |
| Sand and gravel (base concealed) | 6+ |
| Location 47. Road cuts for 200 feet in the SE¼ sec. 28, (28-19E) | |
| Silty soil, pumicite and altered pumice | 30–36 |
| Buff-colored small-size pumice | 20–24 |
| Sandy silt | 24 |
| Gravel (base concealed) | 12+ |
| Location 48. Road cut in the north center of sec. 12, (28-18E) | |
| Silt, sand, and altered pumice | 24 |
| Buff-colored pumice | 30 |
| Silt and some pumice | 6 |
| Sand and granite fragments (base concealed) | 6+ |
| Location 49. Road cut near the south quarter corner of sec. 1, (28-18E) | |
| Silty soil | 15 |
| Buff-colored pumice | 40 |
| Sand | 7 |
| Gray pumice | 14 |
| Sand and granite fragments (base concealed) | 6+ |
| Location 50. Road cut in the east center of sec. 1, (28-18E) | |
| Silty soil and altered pumice | 28 |
| Buff-colored pumice | 16 |
| Sand | 5 |
| Gray pumice | 20 |
| Sand and granite fragments | 6+ |
| Location 51. Road cut 330 feet south of the northeast corner of sec. 1, (28-18E) | |
| Silty soil | 3–12 |
| Buff-colored pumice | 22 |
| Sand | 5 |
| Gray pumice | 8 |
| Silty sand and granite fragments | 6+ |
| Location 52. Road cut and drill hole about 1,000 feet west of the northeast corner of sec. 1, (28-18E) | |
| Silty soil | 14 |
| Buff-colored pumice | 24 |
| Sand | 4 |
| Gray pumice | 22 |
| Sandy silt (base concealed) | 4+ |
| Location 53. Road cut and pit near the center of sec. 31, (29-19E) | |
| Silty soil and altered pumice | 35 |
| Buff-colored pumice | 42 |
| Sand | 7 |
| Gray pumice | 14 |
| Sand and rock fragments | 4+ |
| Location 54. Road cut and pit in the NE¼ sec. 31, (29-19E) | |
| Silty soil | 18 |
| Buff-colored pumice | 33 |
| Sand | 3 |
| Gray pumice | 23 |
| Bedrock (?) of granite | |

| | Inches |
|---|---|
| Location 55. Road cut and pit in the SE¼ sec. 30, (29-19E) | |
| Silty soil and altered pumice | 22 |
| Buff-colored pumice | 28 |
| Sand | 3 |
| Gray pumice | 19 |
| Silt and granite fragments (base concealed) | 6+ |
| Location 56. Road cut near the west quarter corner of sec. 29, (29-19E) | |
| Silty soil and altered pumice | 17 |
| Buff-colored pumice | 28 |
| Sand | 6 |
| Gray pumice | 18 |
| Silt and granite fragments | 4+ |
| Location 57. Road cut in the NE¼ sec. 30, (29-19E) | |
| Silty soil and altered pumice | 10 |
| Buff-colored pumice | 15 |
| Sand | 1 |
| Gray pumice | 16 |
| Silt, sand, and fragments of granite (base concealed) | 100+ |
| Location 58. Road cut near the center of sec. 21, (29-19E) | |
| Silt and altered pumice | 26 |
| Buff-colored pumice | 24 |
| Silt and granite fragments (base concealed) | 30+ |
| Location 59. Road cut and pit near the center of sec. 27, (29-19E) | |
| Silt and altered pumice | 30 |
| Buff-colored pumice | 18 |
| Sand | 4 |
| Buff- to gray-colored pumice | 26 |
| Silt and granite fragments (base concealed) | 2+ |

### COLUMBIA RIVER VALLEY AND OUTLYING AREAS

Several occurrences of pumice are in the mountainous areas bordering the Entiat and Lake Chelan Valleys, along the Columbia River Valley in the Entiat-Chelan vicinity, and still farther removed from Glacier Peak. Most of those known are too small for commercial operation, but may be mined by local residents who wish a few yards of the material for their own use. A few of the known deposits, however, contain several hundred, possibly several thousand, cubic yards of granular pumice, and owing to their ease of access compared to the larger deposits in the upper Entiat and Chiwawa Valleys, they are decidedly commercial. At least four of these deposits have been mined for commercial purposes, and many others have supplied local residents with a few cubic yards of pumice.

These deposits were formed from a relatively thin but widespread blanket of pumice that, after settling from the air, rolled or was washed down steep slopes and piled up at places where the gradient was low enough to retain the material. The deposits are lenticular in shape and several are as much as 100 feet wide and several hundred feet long. Thicknesses vary from a few inches to more than 10 feet. Overburden is rather heavy, and consists of from 2 to as much as 5 or more feet of silt. Owing to the heavy overburden, the underlying pumice is not exposed except in deep road cuts, and probably some deposits will lie undiscovered for many years.

Three small pits operated by Cleo Hicks of Bridgeport are located near the south and west shores of a small lake that is 9 miles by road southwest of Bridgeport and at an elevation of about 3,000 feet on the Columbia Plateau. Vegetation is scant or absent, and the soil overburden is thin, averaging less than 2 feet. The pumice is white, clean, and uniformly fine. Nearly all the pumice pellets are less than ⅛ inch in diameter, but only a few are less than 1/16 inch. No free crystals are mixed through the bed, but a thin layer of sand composed largely of such material underlies the pumice. The following section was measured in the east side of a small pit west of the lake:

*Section through pumice in Hicks pit*

| | Inches |
|---|---|
| Silt and pumice | 18 |
| White pumice (Sample 77) | 24 |
| Pumicite | 4 |
| Crystal sand | 6 |
| Silt (base concealed) | 6+ |

Only the white pumice that overlies the thin pumicite bed is used, the pumicite forming the floor of the pits. The white pumice bed ranges from a few inches to a maximum of 4 feet in thickness, and varies considerably within short distances. A tractor and Fresno scraper are used to strip the overburden, but trucks are loaded by hand. Apparently only a few hundred cubic yards of pumice have been produced, and probably no large tonnage remains. The remarkable features of the pumice in these pits are its purity, uniformity of grain size, and extremely low apparent density. Mechanical analysis and apparent density of a sample from the west pit are in the table on page 55.

On the Twentyfive Mile Creek-Lake Creek road, 9 to 10 miles from Lake Chelan, pumice is exposed intermittently in road cuts along the south slope of Grouse Mountain. The bed is less than 30 inches thick except at one place (location 60, pl. 4) in the north center of sec. 27, (29-20E), where an open cut shows the following stratigraphic section:

*Section through pumice on Grouse Mountain*

| | | Inches |
|---|---|---|
| Silty soil, sand, and altered pumice | | 16 |
| Pumice containing some sand | (Sample 60) | 60 |
| Sand and pumicite | (Sample 60) | 3 |
| Pumice | (Sample 60) | 20 |
| Rock fragments (concealed) | | |

The apparent density and mechanical analysis of a sample taken here are in the table on page 55. Bedrock of granite appears in road cuts within 100 feet east and west of the exposure, and the quantity of pumice in the deposit appears to be only a few hundred cubic yards.

Several exposures of pumice occur in cuts along the road following the west shore of Lake Chelan between First Creek and Twentyfive Mile Creek. Some of these deposits are from 25 to as much as 56 inches thick but appear to be limited to such small areas that they each would contain only a few cubic yards of pumice.

On the Davis place, about a quarter of a mile south of the mouth of Twentyfive Mile Creek, in the north center of sec. 30, (29-21E), pumice occurs in a basin area of about 7 acres (location 61, pl. 4). A hole drilled near the center of this depression, probably the site of a former pond, penetrated 44 inches of silt and pumicite, then 46 inches of well-rounded granular pumice mixed with silt. The base of the pumice layer was not found. The fine material could be separated easily from the pumice by screening.

A pumice deposit (location 62, pl. 4) occurs about 4 miles north of Manson, on the Joe Creek road, in the SE¼ sec. 11, (28-21E), where road cuts and a small pit along the base of a 20- to 30-degree sloping hill, show pumice for a length of about 300 feet. The road cut and a drill hole showed the following section:

*Section through pumice on the Joe Creek road*

| | *Inches* |
|---|---|
| Silt and gravel containing about 20 percent pumice.......... | 30 |
| Pumice and sand (Sample 62)............................ | 64 |
| Gravel (concealed) ........................................ | |

The apparent density and mechanical analysis of a sample taken here are in the table on page 55. On the hillside, 30 feet to the southeast, a drill hole showed 57 inches of silt and gravel overlying 41 inches of sandy pumice; and about 400 feet to the southeast, on a bench about 150 feet elevation above the road, a pit and drill hole showed 42 inches of silt and gravel overlying 40 inches of pumice. Probably pumice underlies several thousand square feet in this area, but a few scattered outcrops of gneiss indicate that its continuity is broken.

In the SW¼ sec. 35, (29-21E) a small pocket of pumice is exposed by a road cut along the cliffs of the east shore of Lake Chelan, at an altitude of about 2,000 feet (location 63, pl. 4). Here 43 inches of small-size pumice is overlain by 40 inches of silt and rock fragments. A cliff rises several hundred feet above the cut, and the pumice apparently rolled off it to form this small deposit. A pit dug into the slope about 75 feet below the road shows 43 inches of pumice and considerable silt overlain by 30 inches of talus and silt. The deposit appears to be too small for commercial operation. About a quarter of a mile to the north, on a bench near Antilon Creek, an old house has walls insulated with pumice. A pit and drill hole near by showed 48 inches of silt overlying 12 inches of silt and pumice (location 64, pl. 4).

Pumice is exposed at several places in road cuts near the head of the South Fork of Gold Creek, a tributary to the Methow River. A few truckloads have been shipped by George Firman of Okanogan from a road cut on a claim (location 74, pl. 4) in the SE¼ sec. 5, (30-21E). The cut is at an elevation of 4,900 feet, 13 miles from the Methow River. Pumice is exposed for a distance of 400 feet along the road. A maximum of 30 inches of pumice and sand was measured, but the average thickness is only 12 inches. The overburden averages 18 inches in thickness. In the pumice layer the grain size grades gradually from a maximum diameter of ½ inch at the top to pumice sand composed entirely of small individual mineral crystals. The lower half of the pumice layer is largely crystal sand.

Other small pumice exposures occur along the South Fork of Gold Creek road up almost to the summit, where Don Peterson of Tonasket and his partners have an operating pit (location 75, pl. 4) in the center of sec. 17, (30-21E). The pit is beside the road at an elevation of 5,800 feet, 16 miles from the Methow River and 200 yards from the summit of the ridge dividing Okanogan and Chelan Counties. The operators used a bulldozer to strip from 6 to 30 inches of overburden and to load pumice over a ramp onto trucks. The pit lies on a 20-degree easterly slope. At the center of the upper face the following section was exposed:

*Section through pumice in Peterson pit*

| | | Inches |
|---|---|---|
| Silt and pumice | | 18 |
| Pumice and sand | (Sample 75) | 12 |
| Pumice, pea-size | (Sample 75) | 3 |
| Pumice sand | (Sample 75) | 1 |
| Pumice and pumice sand | (Sample 75) | 36 |
| Pumice, pea-size | (Sample 75) | 6 |
| Pumice and pumice sand | (Sample 75) | 26 |
| Granite rubble (base concealed) | | 6+ |

The mechanical analysis and apparent density of a sample taken in the pit are shown in the table on page 55. The largest pumice pellets are ¾ inch in diameter, but most are pea-size and smaller, and the sand content is high. A prominent feature of the deposit is the distinct banding, with alternating layers of coarse and fine pumice and sand. About 15 truckloads were hauled from the pit in its first 6 days of operation. Most of this was sent to Tonasket to be used for loose-fill insulation in a fruit warehouse.

Pumice is exposed in road cuts continuously for 150 feet to the south of the pit and for 450 feet to the north. One hundred feet north of the pit the pumice is only 28 inches thick and is overlain by 30 inches of soil, but 150 feet farther north the overburden thins to 14 inches and pumice thickens to 65 inches. Gopher holes and surface exposures show pumice to extend at least 300 feet down slope below the road and also for about the same distance above the road.

Along the road from the head of the South Fork of Gold Creek to Copper Mountain and for 7 miles to the south are intermittent exposures of pumice in road cuts. The overburden ranges from 6 to 30 inches. Pumice in the cuts is as much as 18 inches thick, and at one locality a test pit showed more than 5 feet of fine, very sandy pumice. This was at the junction with the Copper Mountain lookout road (location 76, pl. 4), at an elevation of about 5,750 feet, in the center of sec. 16, (29-22E). The mechanical analysis and apparent density of the material from this test pit are shown in the table on page 55. The pumice here is too sandy to have much value as an insulant and is too heavy to have much advantage over ordinary river sand in concrete work.

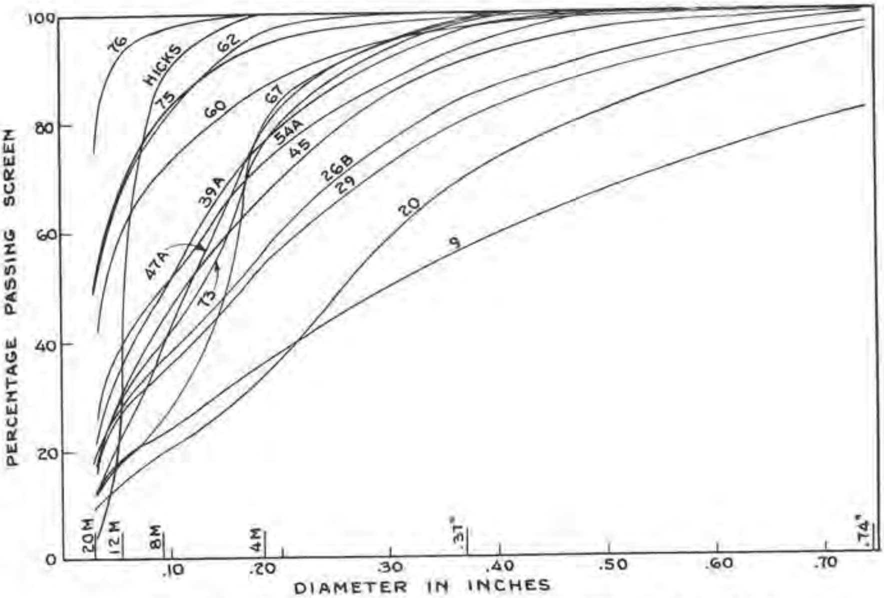


FIGURE 5—Graph showing results of screen analyses of samples from Glacier Peak pumice occurrences.

About three-quarters of a mile north of Staymen, a station on the Great Northern Railway 6 miles south of Chelan, a bed of pumice (location 65, pl. 4) crops out in a gully near the center of sec. 3, (26-22E). It occurs in a terrace 700 feet above the Columbia River level. The wall of the gully exposes about 50 feet of well-sorted sand and gravel of which about 25 percent is pumice pellets. This overlies 6 feet of well-sorted water-worn pellets of pea-size pumice interstratified with ⅛- to ½-inch beds of sand. The base of this pumice bed is concealed. The same member is exposed in the gully about 300 feet to the south. Probably a large quantity of pumice occurs in this deposit, but a washing process would be necessary to separate it from the sand and gravel.

In the SE¼ sec. 32, (27-22E), about 4 miles from Staymen, pumice is exposed by gopher holes for a length of at least 500 feet along the road that leads from Staymen to Knapp Coulee (location 66, pl. 4). Here the road follows along the base of a steep slope, a favorable place for a pumice deposit to occur. Two holes that were drilled 200 feet apart showed 36 inches of silty soil overlying at least 36 inches of pea-size pumice. The bottom of the pumice was not found, owing to difficulty in drilling the fine dry pumice. Further exploration of the deposit appears warranted.

Several pumice deposits occur along the road that leads from Winesap up Oklahoma Gulch, a narrow tributary of the Columbia River Valley. One of these (location 67, pl. 4), in the NE¼ sec. 8, (26-21E), was mined in 1945 by H. E. Clearwater, the owner, and B. E. Knowles & Son, of Wenatchee, for cold-storage warehouse insulation. The deposit, lenticular in shape, lies near the base of the northeast valley side. It is 200 to 300 feet long, about 75 feet wide, and varies in thickness from 1 or 2 feet near its upper edge to more than 10 feet in its center and lower edge. Overburden consists of 2 to 5 feet of silty soil. The pumice pellets average from about ⅛ to ¼ inch in size and are intermixed with a small percentage of sand (chiefly crystals) and silt. The apparent density and mechanical analysis of a sample taken here are shown in the table on page 55. A road cut and drill hole 200 feet north of the pit showed 72 inches of pumice overlain by 60 inches of silt and gneiss fragments.

About 2,500 cubic yards of pumice is said to have been mined from the Clearwater deposit, but considerable pumice still remains. This pit was purchased in 1945 by George Goman of Winesap, and in the early summer of 1946 Floyd Barry of Spokane was using pumice from it to build prefabricated slabs, beams, and other shapes for all-concrete houses. The first experimental house was ready for erection near Dishman in August.

A small amount of pumice has also been mined on the Goman place (location 68, pl. 4), in the SW¼ sec. 5, (26-21E), about half a mile up Oklahoma Gulch from the Clearwater pit. The deposit, lying along the base of the valley side for several hundred feet, is 4 to 6 feet thick along its lower edge, and thins to a few inches within 100 feet up the hill.

At the Dick nickel prospect (location 69, pl. 4), in the north center of sec. 9, (26-21E), about 20 open-cuts and pits have been made in connection with mineral exploration. Several of these excavations show small, discontinuous deposits of pumice, but no commercial possibilities have been indicated.

Pumice also occurs near the lower part of Oklahoma Gulch (location 70, pl. 4) where a pit in the SW¼ sec. 9, (26-21E), on the lower slopes of the southwest side of the valley, shows 32 inches of pea-size pumice and sand overlain by 39 inches of silt and rock fragments.

A pumice deposit (location 71, pl. 4) that has been recently mined to a small extent occurs in the NW¼SE¼ sec. 3, (26-20E) near the Mud Creek road, about 4 miles northeast of Ardenvoir. The deposit lies near the base of a northward-sloping hill, about 40 feet above the level of the road. It is 42 to 48 inches thick along its lower edge but thins to 6 inches within 20 feet up the slope of the hill. Overburden consists of 30 to 36 inches of silty soil. The topography indicates that the length of the deposit may be 400 to 700 feet.

A cut along the Entiat River road about 2½ miles north of Ardenvoir (location 72, pl. 4) shows 48 inches of pea-size pumice and sand overlain by 72 inches of silt and rock fragments. The deposit is about 50 feet in length and lenses out within 60 feet up the slope of the hill. A small amount of pumice has been mined from here by local residents.

A deposit of pumice (location 73, pl. 4), occurs in the NW¼ sec. 29, (27-19E), at an altitude of about 4,300 feet. It may be reached from Ardenvoir by ascending the Tyee Ridge road for a distance of 7 miles, thence by a series of logging roads for an additional 9 miles. Several hundred cubic yards of pumice were mined here in 1944 by C. A. Harris of Ardenvoir. The deposit, lenticular in shape, lies at the base of a 20-degree, westward-sloping hill, and is exposed for a length of 115 feet by a road cut. Near the center of the deposit, where the maximum thickness of pumice is shown, the following section was measured:

*Section through Harris pumice deposit*

| | | Inches |
|---|---|---|
| Silt, sand, and some pumice | | 49 |
| Slightly yellowish pumice and thin layers of sand | (Sample 73) | 43 |
| Sand and a little pumice | (Sample 73) | 4 |
| Light-gray pumice | (Sample 73) | 25 |
| Sand | | 12 |
| Rock fragments | | |

The apparent density and mechanical analysis of a sample taken here are shown on page 55. Eastward, up the slope of the hill, the deposit thins to 43 inches within 15 feet, and lenses out within 50 feet. Northward and southward from the deposit, road cuts expose pumice intermittently for several hundred feet along the base of the slope, but not more than 24 inches of pumice is shown in any one place.

Many other scattered exposures of pumice occur along the Tyee Ridge road and branching logging roads through this area, but, other than the Harris deposit, none appears to have economic possibilities. They do, however, indicate that the material is widespread, and other commercial deposits may occur where physiographic conditions are favorable.

Pumice, chiefly sand-size and mixed with considerable sand and silt, occurs near the east quarter corner of sec. 20, (31-25E), Okanogan County, on the Okanogan Highway about 6½ miles north of Brewster. Here the highway has been graded through two low ridges, about a quarter of a mile apart, that trend in an east-west direction. The northern one, about 800 feet long, rises to a height of about 15 feet above the surrounding relatively flat terrain; pumice and sand have accumulated, apparently by drifting, on the north side of this ridge. The deposit, lenticular in shape, is about 100 feet wide, and near the center, where its maximum thickness occurs, the road cut and a pit show 75 inches of alternating pumice and sand layers overlain by 42 inches of silty soil. The mechanical analysis of a sample taken here follows:

*Mechanical analysis of Brewster Flat pumice*

| | Plus 20 mesh | Minus 20, plus 35 mesh | Minus 35, plus 45 mesh | Minus 45, plus 60 mesh | Minus 60 mesh | Total |
|---|---|---|---|---|---|---|
| Percent by weight | 24.1 | 31.4 | 21.8 | 7.0 | 15.7 | 100.0 |
| Percent by volume | 43.9 | 30.7 | 12.4 | 3.9 | 9.1 | 100.0 |

The apparent density of this sample, air dried, is 50 pounds per cubic foot. Inspection of the material under the microscope shows that nearly all of the portion larger than 0.7 millimeters, about 60 percent by volume and 40 percent by weight, consists of pumice; most of that smaller than 0.7 millimeters consists of individual crystals of plagioclase, hypersthene, hornblende, and magnetite, together with some dust.

The southern ridge, about 200 feet long, rises to a height of about 10 feet, and shows on its north side a lenticular deposit of pumice similar to that just described. This deposit is 40 feet wide, 24 inches thick through its middle, and is overlain by 42 to 48 inches of silty soil mixed with a little sand-size pumice.

Another deposit of sand-size pumice, apparently wind-drifted, occurs near Adrian, a station on the Great Northern and Northern Pacific railroads 6 miles east of Soap Lake, in central Grant County. Here pumice occurs for a distance of at least half a mile, and probably for more than a mile along the base of a 40- to 50-foot gravel bluff on the north side of a shallow coulee. The deposit appears to be lenticular, 20 to 30 feet wide and from 1 to more than 3½ feet thick. Overburden consists of 12 to 36 inches of silt, sand, and gravel. About a quarter of a mile north of the Great Northern depot at Adrian, an open-cut from which some pumice was mined at one time exposes 36 inches of gravel overlying at least 40 inches of pumice. The mechanical analysis of a sample taken here follows:

*Mechanical analysis of Adrian pumice*

| | Plus 20 mesh | Minus 20, plus 35 mesh | Minus 35, plus 45 mesh | Minus 45, plus 60 mesh | Minus 60 mesh | Total |
|---|---|---|---|---|---|---|
| Percent by weight | 8.0 | 36.4 | 15.4 | 24.8 | 15.4 | 100.0 |
| Percent by volume | 11.9 | 50.7 | 16.3 | 12.9 | 8.2 | 100.0 |

The apparent density of the air-dried sample is 37.7 pounds per cubic foot. Nearly all of the material larger than 0.5 millimeters in diameter, 62.6 percent by volume and 44.4 percent by weight, consists of pumice. Most of that less than 0.5 millimeters is composed of dust and free crystals of plagioclase, hypersthene, hornblende, and magnetite.

A quarter of a mile southwest of the open-cut, several shallow pits show the pumice to be from 1 to more than 24 inches thick overlain by 1 to 2 feet of silt, sand, and gravel. An abandoned irrigation ditch excavated along the gravel bluff cut into pumice at several places for a distance of about half a mile.

*Apparent density and mechanical analyses of Glacier Peak pumice*

| Sample-location number | LOCATION | Thickness of bed in inches | Weight per cu. ft. as sampled | Weight per cu. ft. air dried at 70° F. | Screen analyses by weight (Tyler standard screen scale) percent retained on sieves | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0.74 in. (18.85 mm) | 0.37 in. (9.4 mm) | 4 mesh (4.7 mm) | 8 mesh (2.36 mm) | 12 mesh (1.4 mm) | 20 mesh (0.83 mm) | Minus 20 mesh (minus 0.83 mm) |
| 9 | NW¼ sec. 27, (30-16E) (Scholze pit) | 127 | 48.2 | 30.6 | 18.8 | 23.7 | 22.1 | 12.2 | 4.9 | 6.4 | 11.9 |
| 20 | NW¼ sec. 21, (28-17E) | 36 | 42.5 | 24.2 | 4.0 | 25.9 | 36.2 | 14.1 | 5.4 | 4.7 | 9.7 |
| 26B | SE¼ sec. 7, (29-18E) (Heller pit) | 95 | 47.1 | 30.0 | 0.7 | 14.9 | 28.7 | 20.8 | 7.3 | 12.9 | 14.7 |
| 29 | NW¼ sec. 16, (29-18E) (Forest Service pit) | 88 | 47.7 | 31.9 | 2.9 | 17.0 | 25.9 | 18.1 | 6.9 | 11.5 | 17.7 |
| 39A | SE¼ sec. 2, (28-18E) (Smart pit) | 60 | 49.2 | 30.0 | ........... | 3.8 | 19.3 | 28.2 | 13.3 | 14.6 | 20.8 |
| 45 | Southeast corner of sec. 13, (28-18E) | 85 | 48.4 | 30.8 | 0.3 | 8.6 | 23.4 | 24.0 | 10.4 | 14.4 | 18.9 |
| 47A | NW¼ sec. 34, (28-19E) (Asher-Fouts pit) | 57 | 44.9 | 27.8 | ........... | 1.8 | 18.3 | 41.7 | 17.5 | 7.1 | 13.6 |
| 54A | NE¼ sec. 31, (29-19E) (Bortz pit) | 61 | 51.4 | 31.0 | 0.5 | 6.0 | 20.2 | 23.7 | 9.7 | 14.7 | 25.2 |
| 60 | North center of sec. 27, (29-20E) | 83 | 48.7 | 33.7 | ........... | 2.7 | 11.0 | 15.2 | 10.8 | 19.1 | 41.2 |
| 62 | SE¼ sec. 11, (28-21E) | 64 | 50.3 | 43.8 | ........... | 0.5 | 3.0 | 16.9 | 14.7 | 13.9 | 51.0 |
| 67 | NE¼ sec. 8, (26-21E) (Clearwater pit) | 72+ | ........... | 29.8 | ........... | 0.5 | 19.5 | 55.9 | 5.3 | 6.9 | 11.9 |
| 73 | NW¼ sec. 29, (27-19E) (Harris pit) | 72 | 43.3 | 29.9 | ........... | 2.1 | 23.4 | 35.2 | 10.3 | 12.8 | 16.2 |
| 75 | Center of sec. 17, (30-21E) (Peterson pit) | 84 | 53.5 | 36.4 | ........... | 1.5 | 4.4 | 12.9 | 12.1 | 19.5 | 49.6 |
| 76 | Center of sec. 16, (29-22E) | 60+ | 64.2 | 55.6 | ........... | ........... | ........... | 2.3 | 4.7 | 20.1 | 72.9 |
| 77 | 3 miles SW. of Bridgeport (Hicks pit) | 24 | 44.9 | 21.4 | ........... | ........... | ........... | 11.7 | 64.5 | 20.3 | 3.5 |

# PUMICITE

## GENERAL DESCRIPTION

Pumicite, also known by a variety of other names (volcanic ash, volcanic dust) is composed of very finely divided, usually angular fragments of glassy material which, like pumice, is ejected from violently erupting volcanoes. These dust-like particles may settle in water or on land to form, at times, thick beds. On land it is commonly reworked by wind, much like drifting snow or sand, into natural depressions or onto leeward sides of hills where it may be subsequently buried under other material. Much of it, however, is swept into streams and is carried away.

Most of the known pumicite deposits of Washington occur in the eastern part of the state (see fig. 6), chiefly in the south-central and southeastern counties. However, several deposits are in Chelan County, one is in Spokane County, and two occurrences are known in western Washington, one in Skagit and one in Lewis County. Several of the deposits are of consolidated pumicite, cemented sufficiently to prevent lumps from being easily broken between the fingers, yet incohesive enough to allow powder to be readily rubbed off. These are mostly beds interstratified with other sedimentary rocks and flows of basalt. In places they are prominent stratigraphic units in the eastern Washington continental formations of Miocene age. The volcanoes that were the sources of these consolidated beds are not known, but presumably the material is related to vulcanism in the Cascade range during Tertiary time.

Unconsolidated pumicite, on the other hand, makes up the greatest number of known occurrences, though it is not necessarily representative of the largest tonnage. It is a loose, powdery material that commonly occurs close to the surface, covered only by a few feet of silty soil. In some parts of the state many of these deposits are distributed within relatively small areas. Although a few of them may have resulted from the erosion and redeposition of the consolidated pumicite beds, most of them are believed to be of pumicite that originated in volcanoes erupting in Washington and Oregon during late Pleistocene or early Recent time, and that was distributed in Washington by the action of wind.

The pumicite of Washington is light buff, light gray, or bluish gray in color. Some specimens from consolidated deposits show a peculiar silvery sheen, owing probably to the reflection of light from a great many fine platy particles of glass arranged parallel to one another. In the hands, pumicite feels harsh, particularly if the grains are coarse, and its apparent specific gravity is rather low. Often pumicite is mistaken for diatomite, which also occurs in the same general region and in some places has stratigraphic features in common with the consolidated pumicite beds. But diatomite is usually lighter in color than pumicite and is often snow white when dry; it also has a lower apparent density, and between the fingers feels less harsh.

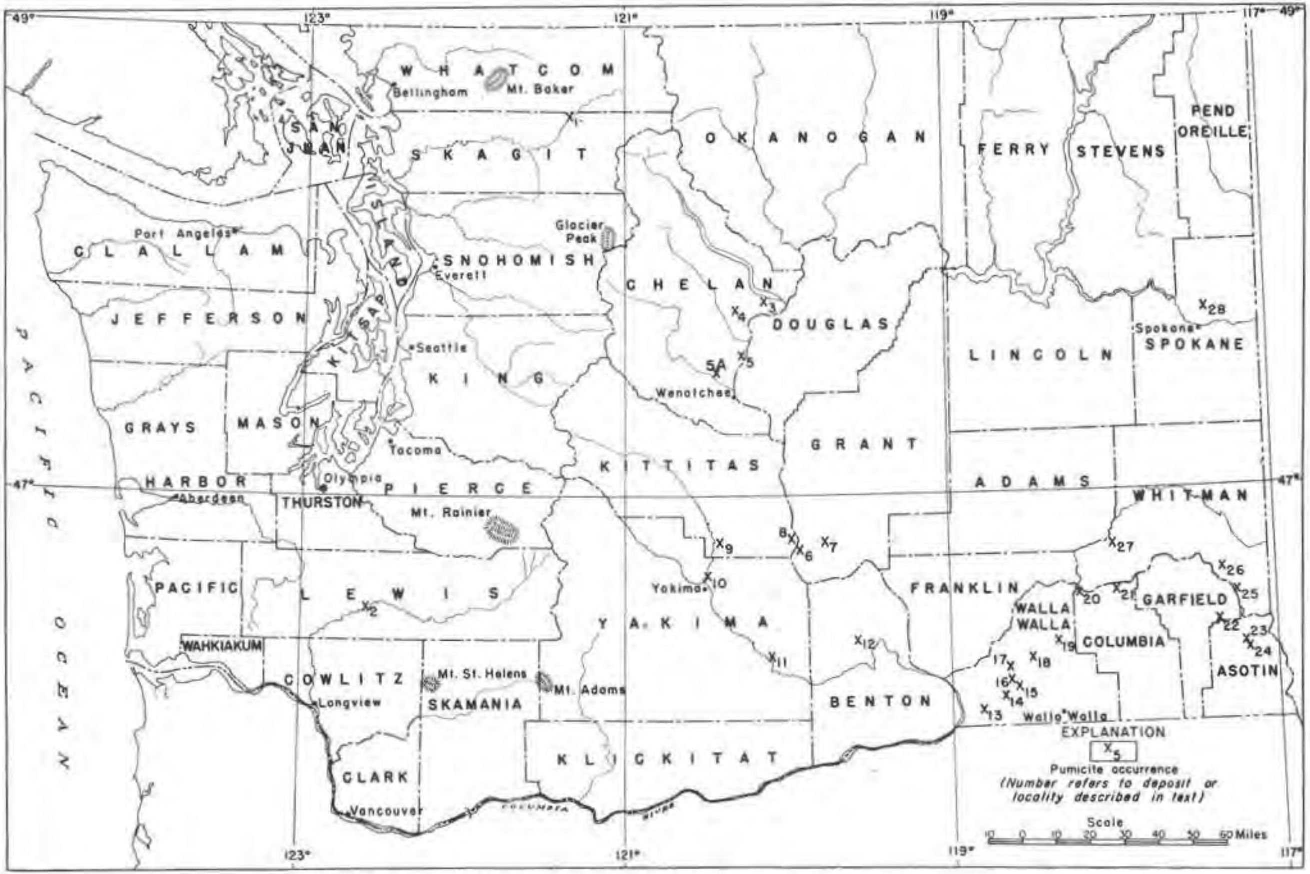


FIGURE 6—Map of Washington showing distribution of pumicite occurrences.

Under the microscope, pumicite shows as finely divided, markedly angular particles of glass. Some are rather flat, others are spine-shaped, and still others are elongated particles with striations parallel to their long axis. These striations, commonly called "flutes" or "fluted structure," are probably due to tiny gas tubes formed like those in pumice when the material was molten. Some of these tubes are entirely within an individual particle of pumicite; others are exposed along broken sides.

Microscopically, the pumicite in the consolidated deposits, with one exception, shows a marked difference from that in the unconsolidated deposits. The consolidated material is chiefly irregularly shaped angular fragments of clear glass that are somewhat platy. Elongated and striated particles are rare. Owing to a slight devitrification of the glass, the edges of the particles are usually anisotropic rather than isotropic. The unconsolidated deposits, on the other hand, contain a considerable amount, usually 40 to 50 percent, of elongated, striated particles together with the angular particles. This pumicite is completely isotropic.

Calcium carbonate, an impurity common to some pumicite beds, was found in only one Washington deposit. It occurs as a cementing material of concretionary masses within a thin layer of the Beverly deposit. (See p. 65.)

With the pumicite, in both the consolidated and the unconsolidated deposits, are more or less impurities consisting of silt-size particles of feldspar, quartz, amphibole, pyroxene, and other minerals. Clay is generally also present in small amounts. Most deposits contain less than 10 or 15 percent of these impurities, but a few have as much as 30 or 40 percent. Some of the impurities were probably included with the pumicite by wind—picked up from the surrounding area—but some are composed of minute crystals, probably formed within the source volcano by partial crystallization of the original magma before eruption.

Pumicite similar to that in Washington is produced from acidic magmas. It generally has the composition of rocks of the rhyolite and granite types, which are composed of complex silicates of aluminum, sodium, potassium, calcium, magnesium, and iron. No chemical analyses of Washington pumicite are available, but if some were made, they would probably compare closely with the following one given by Hatmaker[1] for a typical pumicite or pumice:

*Approximate analysis of a typical pumicite or pumice*

| | *Percent* |
|---|---|
| Silica ($SiO_2$) | 72.0 |
| Alumina ($Al_2O_3$) | 14.0 |
| Potash and soda ($K_2O$ and $Na_2O$) | 7.0 |
| Lime and magnesia ($CaO$ and $MgO$) | 2.5 |
| Iron oxide ($Fe_2O_3$ and $FeO$) | 1.0 |
| Loss upon ignition | 3.5 |
| Total | 100.0 |

[1] Hatmaker, Paul, Pumice and pumicite: U. S. Bur. Mines Inf. Circ. 6560, p. 4, 1932.

The size of individual pumicite fragments varies considerably among the Washington deposits. This textural feature is important in the evaluation of the material, for, other things being equal, the finest-grained pumicite—usually that which will pass a 200- or a 300-mesh sieve—will command the highest price. Samples from many of the deposits were taken, air-dried at room temperature, and screened through a series of sieves having meshes of 20, 65, 100, and 200, Tyler Standard Screen Scale. The sizes of opening of these sieves are: 0.833, 0.208, 0.147, and 0.74 millimeters, respectively. Each sample was subjected to 5 minutes of screening on a Ro-Top Testing Sieve Shaker, a mechanical shaking device, and the fractions retained on each sieve were then weighed and their percentages computed. These textural analyses are with the descriptions of the individual deposits given in another section of the report.

Before screening, the unconsolidated pumicite needed no preparation, but the samples of consolidated material, in order to free as many individual particles as possible, were passed through a crusher. This method did not satisfactorily break down all the pumicite to grain size; the undisintegrated material, in lumps larger than 65 mesh, was rejected from these analyses. These lumps would have broken down had they been passed through rolls, or some other type of machine ordinarily employed for the refining of pumicite, and practically all would then have passed the 65-mesh sieve.

## UTILIZATION

Pumicite has been employed for various purposes for a great many years, and some properties of this material were recognized and made use of by the Romans some 18 centuries ago.[1] The many and varied modern uses of pumicite as concisely given by Hatmaker[2] follow:

> Pumicite is used extensively as an abrasive in cleansing and scouring compounds, in mechanics' soap and preparations of similar character. Waste vegetable oils such as cottonseed oil may be saponified and used as the soap content.
>
> As a substitute for ground pumice, some pumicites are used in electroplating with gold, silver, and nickel, and in the manufacture of pearl buttons. Other uses as an abrasive are in tooth pastes and powders, metal polishes, and rubber erasers. It can also be molded into tablet form for household and toilet use.
>
> Pumicite is used to a considerable extent as an admixture to concrete in dams and other types of massive construction, in grain elevators, and also for general concrete work. It is claimed that 4 to 5 pounds per sack of cement added to the mix results in greater uniformity of the concrete, increases the workability of the mix, and hinders segregation of the other aggregates. The use of pumicite as a cement admixture in the construction of grain elevators is said to facilitate slipping the forms upward as the concrete work progresses.
>
> In the construction of the Los Angeles Aqueduct pumicite was

[1] Barbour, E. H., Nebraska pumicite: Nebraska Geol. Survey, vol. 4, pt. 27, pp. 357-401, 1913. See also: Landes, K. K., Volcanic ash resources of Kansas: Kansas Geol. Survey Bull. 14, p. 51, 1928.

[2] Op. cit., pp. 8-9.

blended in equal parts by volume with hydraulic cement to make what was called "tufa cement." The details of this utilization are fully described in the Transactions of the American Society of Civil Engineers, vol. 76, 1913, page 520, and the results are summarized in the "Final Report, Construction of the Los Angeles Aqueduct," published by that city. Pumicite was also used in the Niobrara Dam at Valentine, Nebr. Besides having been employed in a number of other structures in the Western States, a considerable tonnage is reported under contract for the Los Angeles flood control district.

Pumicite has been used to some extent as an insulating material for packing steam and water pipes, for lagging boilers, and for lining cold-storage rooms. It has also been used in filter cells, in paints as a filler, and in sweeping compounds. Much of the pumicite produced is consumed by soap manufacturers who have their own specifications for the material, depending upon the product.

## DISTRIBUTION OF DEPOSITS

### Western Washington

#### SKAGIT COUNTY

The only occurrence of pumicite in northwestern Washington is near the Skagit River, in sec. 11, (36-11E). (See location 1, fig. 6.) This is 9 miles north of Marblemount, on the Newhalem automobile road and the Seattle City Light Department railroad. Here three deposits of pumicite occur along the road within an area of about 40 acres. This was apparently at one time a small lake basin. It was formed possibly as a result of local ponding of the Skagit River, which, elsewhere in the vicinity, is in a constricted channel. These deposits are remnants of what was at one time a continuous bed of pumicite that covered this basin, but Damnation Creek, a small stream that has confluence with the Skagit near by, has cut most of the bed away and has piled a blanket of gravel over that which remains.

The most southerly deposit of the three covers a triangular area between the road and near-by cliffs. It is exposed for 160 feet along the road. It is 18 feet thick above the road at the center, tapers to nothing at each end, and has a maximum lateral width of about 100 feet. Overburden consists of 6 feet of assorted stream gravels and talus along the road, but this increases in thickness toward the cliffs to the west.

The second deposit of pumicite occurs 600 feet north of the first, and is exposed along one side of the road for 180 feet. It is 25 feet thick above the road at its center, and tapers to nothing at each side. Its base is concealed below the road, and a hole drilled at its center penetrated 15 feet of pumicite without reaching the base of the deposit, indicating that it is at least 40 feet thick. The exposure appears to be the end of a northwest-trending ridge that extends back from the road for at least 200 feet. At the road overburden is 10 feet thick, but it becomes increasingly thicker toward the northwest, and is 20 feet thick at a place 150 feet from the road.

The third deposit of pumicite is 180 feet north of the second, where the road cuts along the eastern edge of a knoll about 150 feet in diameter and 20 feet high. This knoll appears to be entirely composed of pumicite except for a 3- to 10-foot capping of gravel. The base of this deposit, also, is concealed below the level of the road.

All three of the deposits are of fine-grained light-gray pumicite which shows a barely perceptible stratification. This is due to knife-blade partings of fine-grained sand. Under the microscope, the material shows as very fine, even-grained pumicite with about 5 percent or less of impurities, chiefly quartz grains. A textural analysis of a sample from the second, 25-foot, deposit follows:

*Mechanical analysis of Skagit River pumicite*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 0.2 | 0.3 | 0.3 | 7.6 | 91.6 | 100.0 |

Practically all of the material retained on the 100-mesh and coarser sieves, less than 1 percent, is fine sand.

The deposits appear to be of particularly high quality pumicite, and owing to their situation beside a railroad there is an opportunity for development. The deposits, however, are probably not large. Some 15,000 to 18,000 tons are estimated to be available above the level of the road and not covered by more than 15 feet of overburden. A few carloads have been mined, but no information is available on the disposition of the material.

### LEWIS COUNTY

A consolidated bed of pumicite (location 2, fig. 6) in central Lewis County is described by Glover[1], who recognized it as a slightly altered pumicite but, because of the features of its occurrence, termed it a shale. His description follows:

> An outcrop of striking appearance occurs a mile south of Highway No. 5 on Mill Creek, at approximately the center of the SE¼ sec. 13, (12-1E). The creek has cut its valley through a thick deposit of reddish-colored Pleistocene gravel to a light-gray horizontally stratified silty shale. Later erosion has produced a shallow gorge in the lower more resistant material and in one place has exposed the bed in a 12-foot vertical wall for 250 feet. The physiography indicates that the shale underlies the terrace-like flats along both sides of the creek. These extend upstream for a half mile, have a width of 100 to 150 feet between the gorge and the gravel bluffs, and are surfaced with as much as 6 feet of reworked Pleistocene gravel. The shale is remarkably uniform in texture. The upper part is rather thin-bedded and stained, the lower part is massive, but all is cut by a vertical and horizontal system of joints. Aside from yellow staining on joints the material weathers nearly white. The fresh shale is light bluish gray and dries to a light gray. It is very compact and brittle, breaks with a conchoidal fracture, and is so fine-grained that grit can hardly be detected between the teeth. The peculiar nature of this shale is apparently due to its being composed of extremely fine volcanic dust that has undergone some decomposition in place. The small amount of actual clay substance accounts for the weak plasticity and the small (14 percent) dry and fired linear shrinkage. At cone 06 a sample of this material became steel-hard, moderately porous, and buff-red in color.

[1] Glover, Sheldon L., Clays and shales of Washington: Washington Div. Geology Bull. 24, p. 178, 1941.

## Central Washington

### CHELAN COUNTY

Pumicite is abundant in Chelan County, having been distributed over the region with the pumice of Glacier Peak. (See pp. 29-33.) Very little of it, however, has accumulated in deposits of sizeable quantity, and furthermore, it has been generally mixed with considerable amounts of impurities. It is doubtful that any deposits occur that are large and pure enough to be economically important.

One deposit (location 3, fig. 6) is exposed along the Wenatchee-Chelan highway, in the SW¼ sec. 17, (27-22E), 3 miles southwest of Lakeside at an altitude of about 1,400 feet. Three road cuts expose 8 to 10 feet of pumicite interstratified with thin beds of clay and sand. The deposit was formed under water, probably in Lake Chelan, when at one time its surface stood at a higher elevation.

A deposit of light-brown pumicite (location 4, fig. 6) is on the Mud Creek road, near the southeast corner of sec. 4, (26-20E), about 3 miles north of Ardenvoir. A road cut exposes it for 75 feet, and to a depth of 8 feet. The overburden consists of 1 to 3 feet of silty soil. The deposit is an alluvial fan extending from a gully northward into the narrow Mud Creek Valley. It was probably formed by the reworking of pumicite that deposited from the air onto the hillside drained by this gully. Under the microscope the material was found to be only about 50 percent pumicite, the rest being clay, silt, sand, and a few pebbles. Following is a textural analysis:

*Mechanical analysis of Mud Creek pumicite*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 1.3 | 1.8 | 3.5 | 16.2 | 77.2 | 100.0 |

Most of the material coarser than 65 mesh is sand and pebbles.

Pumicite (location 5, fig. 6) is exposed intermittently for half a mile in highway and railroad cuts in the NW¼ sec. 29, (25-21E), about 2 miles south of Entiat. It is light-brown in color, and lies as a bed 1 to 3 feet thick on a narrow bench between the Columbia River on the east and steep cliffs on the west. It is overlain by 3 to more than 10 feet of silt and talus. The pumicite is impure, having about 30 percent of silt, sand, and rock fragments intermixed, and the available tonnage is small. Following is a textural analysis of a sample:

*Mechanical analysis of Entiat pumicite*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 5.4 | 3.2 | 4.8 | 14.9 | 71.7 | 100.0 |

The material coarser than 20 mesh is entirely rock fragments.

Other small deposits of pumicite are known in the county, and some of those most easily accessible may warrant development when a market demand arises. Small deposits on both sides of the Wenatchee Valley in the vicinity of Monitor and Cashmere (location 5A, fig. 6) are exemplified by those in McDougal Canyon, on the north side of the valley in sec. 2, (23-19E). The McDougal Canyon deposits are favorably located, being only 3 miles by road from the Great Northern Railway at Cashmere. They occur in the steep-sided canyon as erosional remnants of what was probably at one time an extensive bed. Stratification is only faintly developed, but the deposits appear to be flat-lying or gently dipping to the west. They rest on a thin layer of sand derived from underlying Swauk sedimentary rocks. This base is not well-exposed but seems to be roughly parallel to the present topography. The lowest exposure, at an altitude of about 1,000 feet, is in the N½SE¼ sec. 2, (23-19E), on land owned by George Oken of Cashmere. A bed of clean, light buff colored pumicite averages about 6 feet thick for an exposed length of 100 feet in the canyon side. The third dimension of the bed probably does not exceed 25 feet.

Three-tenths of a mile farther up the canyon, in the SE¼NE¼ sec. 2, at an altitude of approximately 1,200 feet, R. A. Boyles of Monitor and F. R. Chidester of Cashmere have three claims covering beds of pumicite that are exposed in several places about 25 feet above the canyon floor. About 100 cubic yards of pumicite from the northernmost exposed bed were sold in 1946 for use in pumice-block manufacture in Wenatchee. The face of the pit shows the pumicite to be 13 feet thick, but a drill hole 18 feet back from the face disclosed a depth of only 9 feet, and it is probable that the bed pinches to nothing within the next 25 feet. This bed is exposed for an average thickness of 9 feet for 350 feet along the canyon side. Overburden of sand and soil is from 1 to 3 feet thick. The pumicite is unconsolidated, light buff colored, and free from visible impurities. Under the microscope, the material shows about 80 percent sharp, angular, and platy fragments of pumicite glass, with a remainder of silt-size quartz, feldspar, magnetite, and ferromagnesian minerals. Following is a textural analysis of a sample taken from a 9-foot auger hole near the pit:

*Mechanical analysis of Cashmere pumicite*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 1.7 | 3.1 | 2.8 | 14.3 | 77.1 | 100.0 |

Another pumicite bed with about the same dimensions as the one at the pit shows in the canyon 500 feet south of the pit.

### GRANT COUNTY

A bed of consolidated pumicite (location 6, fig. 6) occurs about 4 miles southeast of Beverly, in southwestern Grant County. Here the Columbia River has cut across the Saddle Mountains, an east-west-trending faulted anticlinal fold, and exposed many hundred feet of basalt flows and some intercalated sedimentary rocks. The pumicite occurs as a 25- to 40-foot bed with other sedimentary rocks, in the upper part of the basalt series, and is well exposed in bluffs in the W½ sec. 23, (15-23E). It is visible from a road about a mile distant that leads southward from Beverly along the east bank of the Columbia River. In this locality the bed strikes nearly east and dips 10 to 12 degrees south, down the lower slope of the mountain. Toward the north, on steeper slopes, the bed has apparently been removed by erosion; so the outcrop of the north side of the bed trends eastward and roughly follows the contours of the hillside. According to Mr. Tom Eakin,[1] who has studied the geology of this area in connection with U. S. Geological Survey ground-water investigations, this pumicite bed can be traced eastward for several miles by intermittent outcrops. Beyond the east line of Range 23, however, the bed is probably too thin to be economically important.

*Section in W½ sec. 23, (15-23E)*

| Top of section | *Feet* |
|---|---|
| Soil and gravel | 2–10 |
| Basalt | 70 |
| Buff-colored silt containing thin tuffaceous beds | 10 |
| Loosely consolidated conglomerate | 20 |
| Gray fine-grained consolidated pumicite | 28 |
| Gray coarse-grained consolidated pumicite containing calcium carbonate concretions | 2 |
| Loose clayey sandstone | 15 |
| Coarse pumicite and silt | 5 |
| Light-buff silty clay | 14 |
| Loosely consolidated sandy conglomerate, about | 100 |
| Basalt flows to valley floor, about | 200 |
| Approximate total | 470 |

The gray fine-grained bed of pumicite, here 28 feet thick, is 35 feet thick at a place 800 feet to the northeast. A sample of this material studied under the microscope was found to consist of about 95 percent slightly devitrified, platy fragments of pumicite. A few particles are fluted. The remainder of the material is silt, chiefly quartz particles, and a little clay. A textural analysis of the sample follows:

*Mechanical analysis of Beverly pumicite*

| Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|
| 8.2 | 25.5 | 66.3 | 100.0 |

[1] Oral communication.

The 2-foot bed of coarse-grained pumicite that underlies the 28- to 35-foot bed presents an interesting feature: It contains, chiefly in its upper 6 inches, a great many concretion-like masses. Most of these are small spheres 2 to 6 millimeters in diameter, so thickly disseminated that in places they give a pisolitic structure to the material. They consist of a thin shell which is composed of fine-grained pumicite, a little clay, and a few diatom tests, surrounding coarse, loosely compacted pumicite. They can be easily crushed between the fingers, and, when cracked open by a slight blow, the coarse pumicite on the inside of the shell can be easily removed. Larger ball-like masses also occur in this bed ranging from 10 to as much as 100 millimeters in diameter. These larger ones are well cemented by calcium carbonate, and in cross sections show a marked concentric structure.

The Beverly deposit of pumicite appears to offer a good opportunity for development. It could be reached by about a mile of easily constructed road, and is within 5 miles of the Chicago, Milwaukee, St. Paul, and Pacific Railway at Beverly. Although the bed is overlain stratigraphically by about 100 feet of overburden, erosion has stripped some of this away and left approximately 30,000 to 40,000 tons of material that can be quarried before underground mining methods would have to be employed.

About 6 miles northeast of the Beverly deposit is another outcrop of pumicite (location 7, fig. 6). This occurs on the steep north face of the Saddle Mountains and is probably a continuation of the Beverly deposit, but owing to erosion is not now connected with it. From a distance, the bed appears to be about 10 to 20 feet thick. It has stratigraphic relationships similar to the Beverly deposit, and continues along the cliff for nearly 2 miles in an easterly direction from the center of sec. 4, (15-24E) into sec. 2, (15-24E). According to Mr. Eakin,[①] this pumicite underlies a considerable area on the top of the Saddle Mountains in this vicinity.

### KITTITAS COUNTY

Another bed of consolidated pumicite (location 8, fig. 6) crops out in steep cliffs of Sentinel Bluffs, on the north side of the Saddle Mountains through sec. 4, (15-23E) and sec. 32, (16-23E). This is on the west side of the Columbia River opposite Beverly, and the bed may be a correlative of the beds in Grant County to the east. It is inaccessibly situated and so was not investigated in detail, but as seen from a distance the bed appears to be thin and unimportant economically.

A consolidated pumicite deposit (location 9, fig. 6) occurs in the NW¼ sec. 22, (15-19E), about half a mile southeast of Roza, a station 15 miles north of Yakima on the Northern Pacific Railway and near the Yakima-Ellensburg highway. Here a bed of light-gray pumicite at least 3 feet thick, and probably considerably thicker, is exposed by an open-cut at the edge of a shallow gully. The pumicite is slightly varved, and probably dips eastward about 8 to 10

① Oral communication.

degrees. The overburden consists of 2 feet of silty soil at the exposure. A continuation of this bed is exposed by another open-cut about 1,000 feet to the east. Under the microscope a sample from the first cut shows about 98 percent sharp, angular, platy fragments of glass and a remaining 2 percent of silt-size particles of quartz and feldspar. It is rather coarse in grain, as indicated by the following mechanical analysis:

*Mechanical analysis of Roza pumicite*

| Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|
| 12.4 | 30.3 | 57.3 | 100.0 |

Two or three tons of this pumicite were mined at one time by F. A. Rose of Yakima for use in mechanics' soap.

### YAKIMA COUNTY

There are a number of small deposits of unconsolidated pumicite scattered through the northern part of Yakima County and also in southern Kittitas County. Each generally contains considerable silt and sand, and none that was investigated appears to be commercial. Some may be the result of reworking of consolidated deposits, but probably most are small pockets of pumicite that was blown into this area from Mount St. Helens, a volcano about 100 miles southwest. A typical deposit (location 10, fig. 6) is in the NW¼ sec. 6, (13-19E), near the Yakima-Ellensburg highway. Here a bed having a maximum thickness of 2 feet is exposed in a road cut for about 100 feet. The overburden is 2 to 5 feet of silt and talus. The microscope shows it to consist of about 85 percent glass fragments, the rest being minute crystals and fragments of feldspar, pyroxene, and amphibole. A textural analysis of a sample follows:

*Mechanical analysis of Yakima pumicite*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| Tr. | 4.9 | 7.5 | 18.2 | 69.4 | 100.0 |

A series of sedimentary rocks which includes at least three pumicite members is exposed on the southwest side of Snipes Mountain, a long, narrow ridge that rises above the floor of the Yakima Valley between Sunnyside and Granger. (See location 11, fig. 6.) The series occurs between basalt flows, and has been folded with the basalt into a northwest-trending anticline. Erosion has cut into this fold at several places, and near the center of sec. 32, (10-22E), just southwest of the highest point on Snipes Mountain, a stratigraphic section through a part of the north limb of the anticline is exposed.

*Section on Snipes Mountain*

| Top of section | *Feet* |
|---|---|
| Gravel | 2-40 |
| Basalt | 8 |
| Green-gray sandy silt | 5 |
| Gray pumicite (Sample A) | 8 |
| Concealed | 30 |
| Gray sandy silt | 7 |
| Gray pumicite | 1½ |
| Sandy silt, about | 100 |
| Gray pumicite (Sample B) | 11 |
| Silt and pumicite layers | 8 |
| Basalt (base concealed) | 10+ |

These beds strike N. 40° W. and dip 55°-60° NE. The upper pumicite bed (Sample A) is composed almost entirely of slightly devitrified, angular fragments of glass. It is unusually coarse in texture, as shown by the screen analysis:

*Mechanical analysis of Snipes Mountain pumicite, Sample A*

| Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|
| 29.4 | 45.4 | 25.2 | 100.0 |

The lower, 11-foot, bed of pumicite (Sample B) consists of about 97 percent volcanic glass, similar to that of the upper bed except that it is considerably finer in grain size, as indicated by the following analysis:

*Mechanical analysis of Snipes Mountain pumicite, Sample B*

| Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|
| 2.5 | 34.6 | 62.9 | 100.0 |

This 11-foot bed can be traced by outcrops for at least 600 feet toward the northwest, and for about half a mile toward the southeast. Approximately a quarter of a mile to the southeast, in the east center of sec. 32, (10-22E), it is well-exposed in both limbs of the Snipes Mountain anticline. On the southwest limb a considerable amount of the overlying rocks has been stripped away by erosion, and throughout an acre or so the pumicite lies just below the surface on a 20- to 30-degree dip-slope. On the northeast limb, the bed dips about 40 degrees under 100 to 200 feet of silt, gravel, and basalt. A quarry was operated on this outcrop many years ago, but for what purpose the pumicite was used is not known.

Two other deposits of consolidated pumicite are reported to occur in Yakima County. One, not examined, is said[1] to crop out in sec. 25, (12-20E), in the Rattlesnake Hills, about 7 miles southeast of Moxee City. It is a 15-foot bed associated with other sediments and is relatively impure.

[1] Private report: Tabulated summary of special geologic reconnaissance reports, Washington and northern Idaho, Northern Pacific Railway Co., Land Dept., Geol. Division, 1941.

The other deposit, reported by Mr. John Anderson[1] of Yakima, is said to underlie several acres at the Pease ranch, in sec. 28, (14-20E), about 10 miles northeast of Yakima. In 1945 this area was within the U. S. Army, Fourth Corps artillery firing range; so it was not investigated.

### BENTON COUNTY

One pumicite deposit (location 12, fig. 6) is known in Benton County. It is near the middle of the north line of the NW¼ sec. 4, (10-26E), on the northeast slope of the Rattlesnake Hills. In 1945 this was within the restricted area of the Hanford Engineer Works. The deposit crops out and is exposed by two open-cuts for a length of 90 feet along the north side of a gully that trends eastward from the Rattlesnake Hills. Its exposed thickness is 15 feet, and it underlies about 10 feet of tuffaceous material and 1 to 10 feet of silt. The bed does not show on the opposite side of the gully or elsewhere in the vicinity. This deposit is not interbasalt; instead it appears to be lying horizontal and unconformable on basalt flows which crop out within 100 feet southwest of the open-cuts, and which dip 50° to 55° northeastward. No other exposure of the bed was found in the vicinity. This deposit is presumably a remnant of a relatively recent, post-basalt series, a correlative of the Ringold formation.

The pumicite is nearly pure white in color except for a few places where stained by iron oxide and for minute black grains that are evenly disseminated through it. Although the material is slightly compacted, it is different from that of the other consolidated deposits. Lumps are easily crushed between the fingers, and are composed of about 95 percent angular fragments and elongated, striated grains in about even proportion, none of which shows devitrification. The other 5 percent is chiefly feldspar and quartz together with a little amphibole and magnetite. A textural analysis follows:

*Mechanical analysis of Benton County pumicite*

| Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|
| 12.7 | 28.8 | 58.5 | 100.0 |

A small quantity of this pumicite was mined at one time by J. W. Rider of Richland, who sold it to a soap manufacturing concern for use in scouring powder.

About a quarter of a mile north of the open-cuts is another deposit of pumicite which apparently is about 50 feet long, 20 feet wide, and 4 or 5 feet thick. It is unconsolidated, mixed with considerable sand and silt, and may be a deposit reworked from an unexposed bed somewhere on the hillside to the south.

[1] Oral communication.

## SOUTHEASTERN WASHINGTON

A large section of southeastern Washington, including parts of Walla Walla, Columbia, Garfield, Asotin, Whitman, and Spokane Counties, is characterized by a rolling topography which presents a monotonous repetition of hills whose summits are nearly concordant in altitude. This region is designated the Palouse Hills,[1] and the soil throughout is nearly all a silty clay, probably eolian in origin, that has been known as the Palouse formation. It generally covers a basalt bedrock, and to a considerable depth except in the valleys of the largest streams. Lying on the Palouse formation and forming near-surface exposures are occasional deposits of unconsolidated pumicite. These are isolated and widely scattered in general, but in some areas are particularly abundant.

Several authors have pointed out that, owing to southwesterly prevailing winds, most of the material ejected from Crater Lake and other now extinct or dormant central Oregon volcanoes was deposited northeast of its source. Moore[2] states that Crater Lake may have furnished the volcanic dust that settled in Baker and Wallowa Counties, Oregon, which are just south of the Palouse Hills region. A similar origin is indicated for the pumicite of Walla Walla County and other parts of the Palouse Hills. The occurrences are chiefly on the north or northeast sides of hills, where best protected from further wind action and from running water, and are in sharp contact with the underlying brown silty clay of the Palouse formation. They are generally overlain, with a gradational contact, by 1 to 4 or more feet of pumiceous silt. Figure 7 shows an idealized section through a typical pumicite deposit of eolian origin in southeastern Washington.

Some of the pumicite in this general area, however, has been deposited by water—apparently by being washed away and redistributed after, or possibly even during, its deposition from the air. These deposits are usually mixed with considerable foreign material which detracts from their quality.

No attempt has been made to find and describe all of the pumicite deposits in southeastern Washington. In one section, northwest of Walla Walla, nearly every hill has at least some pumicite on its north or northeast side, and to find and map each deposit through the entire area would be an almost unending task. Those that are described, then, may be considered more-or-less typical of many that might be expected to occur in the region.

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[1] Freeman, O. W., and others, Physiographic divisions of the Columbia Intermontane Province: Assoc. Am. Geographers Annals, vol. 35, no. 2, p. 64, 1945.

[2] Moore, B. N., Deposits of possible *nuée ardente* origin in the Crater Lake region, Oregon: Jour. Geology, vol. 42, no. 4, p. 375, 1934.

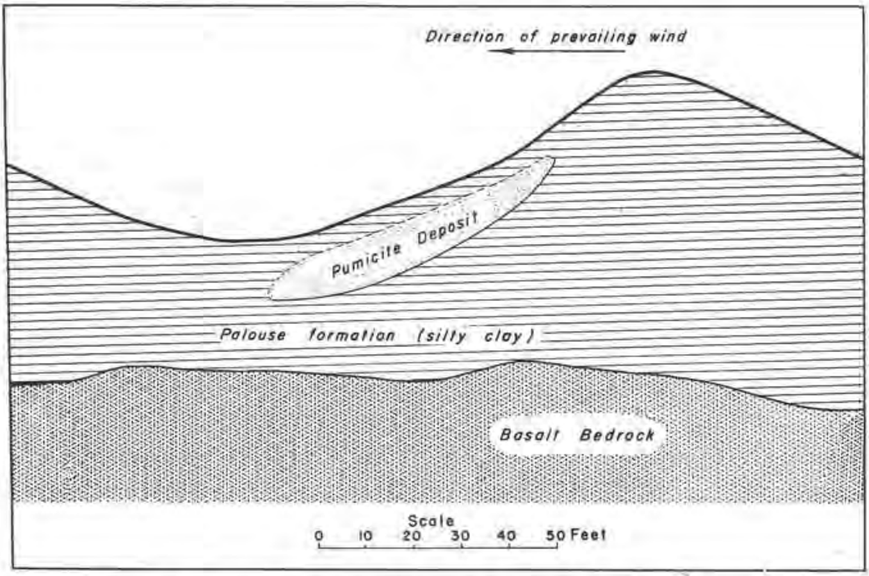



FIGURE 7—Idealized section through a wind-drifted pumicite deposit in southeastern Washington.

### WALLA WALLA COUNTY

Near the southwest corner of sec. 21, (7-32E), just south of the Wallula-Walla Walla highway about 5 miles east of Wallula, a pumicite deposit (location 13, fig. 6) occurs on a northward-sloping hillside. It is exposed in intermittent patches over an area about 100 feet square to a depth of at least 4 feet. An effort was made at one time to develop this deposit, and possibly these exposures are a result of exploratory work that may have been done. The overburden consists of 2 to 8 feet of intermixed silt and pumicite.

The material is composed of 90 to 95 percent pumicite, chiefly striated particles, together with silt and minute crystals of feldspar, pyroxene, and amphibole. The texture is somewhat coarse, as indicated by the following screen analysis:

*Mechanical analysis of pumicite east of Wallula*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 0.1 | 10.9 | 9.1 | 26.5 | 53.4 | 100.0 |

Practically all the material retained on the 20 and 65 mesh sieves is frothy particles of pumice.

North of the town of Touchet a shallow gully that trends southward for about 6 miles is known as Ash Hollow (location 14, fig. 6). Several pumicite deposits were found throughout this area. Some are exposed by road or stream cuts; others were discovered by drilling blindly on the north or northeast slopes of hillsides. In addition to those noted below, many other deposits doubtless exist. Near the north center of sec. 21, (7-33E) an area about 400 feet long and 75 feet wide is underlain by pumicite. A drill hole near the center showed the following section:

| | *Inches* |
|---|---|
| Silt and a little pumicite | 18 |
| Gray, silty pumicite grading into clean pumicite | 24 |
| Light-gray pumicite | 28 |
| Brown silty clay (base concealed) | 8+ |

Near the north quarter corner of sec. 21, (7-33E) an area at least 500 feet long and 100 feet wide contains pumicite underlying 2 or 3 feet of overburden. A stream bank and drill hole showed the following section:

| | *Inches* |
|---|---|
| Silt and a little pumicite | 24 |
| Light-gray pumicite | 46 |
| Brown silty clay (base concealed) | 9+ |

A deposit of pumicite occurs near the west quarter corner of sec. 16, (7-33E). It is possibly 200 to 300 feet long and 75 feet wide, and the bank of a gully that cuts through it shows 48 inches of light-gray pumicite underlying 12 inches of silt.

In the SE¼ sec. 5, (7-33E) an area 500 to 600 feet long by at least 100 feet wide appears to be a favorable place for a pumicite deposit, so a hole was drilled near the center of this area. It showed the following section:

| | *Inches* |
|---|---|
| Silt containing considerable pumicite | 18 |
| Light-gray pumicite | 92 |
| Brown, silty clay (base concealed) | 8+ |

Pumicite occurs on the Strohmaier place (location 15, fig. 6) in the SW¼ sec. 24, (8-33E), 8 miles north of Touchet. It is in a pod-shaped deposit about 700 feet long, 100 feet wide, and 6 to 7 feet thick at the center. About 300 feet from its west end, cultivation has loosened the overburden so that part of it has been stripped off by wind. This exposure and a drill hole here showed 72 inches of pumicite underlying 3 to 6 feet of silt and pumicite. Another hole drilled 150 feet to the east, near the center of the deposit, showed the following section:

| | *Inches* |
|---|---|
| Brown silty soil containing a little pumicite | 90 |
| Light-gray pumicite (sampled) | 77 |
| Brown silty clay (base not found) | 13+ |

A third hole, drilled 50 feet to the north, within 15 feet of the floor of a gully, showed 95 inches of silty soil grading downward into pumicite and overlying 55 inches of clean pumicite; and a fourth hole, drilled 400 feet to the east, showed 78 inches of pumiceous silt overlying at least 30 inches of clean pumicite, base not found. A fifth hole, drilled 200 feet east of the fourth, showed 100 inches of pumiceous silt but no pumicite; and a sixth hole, drilled on the north side of the gully, opposite the center of the deposit, showed 96 inches of compact brown silty clay and no pumicite.

Under the microscope, the sample taken from the second hole was found to consist of about 90 percent pumicite and 10 percent silt and small crystals of feldspar, pyroxene, and amphibole. A textural analysis follows:

*Mechanical analysis of Strohmaier pumicite*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 0.0 | 0.7 | 0.9 | 8.7 | 89.7 | 100.0 |

About 800 feet southeast of this deposit, near the south quarter corner of sec. 24, (8-33E), a random hole was drilled on the northeast slope of another hill. It showed 40 inches of silt and pumicite overlying 56 inches of light-gray fine-grained pumicite. An area of several hundred square feet here appears to be underlain by this deposit.

Another deposit of pumicite (location 16, fig. 6) is exposed in the SW¼ sec. 23, (8-33E) by a cut on the Dodds road near its junction with the Touchet River road, 9 miles north of Touchet. The cut, on the northern and northeastern side of a hill, exposes the deposit for 550 feet. Near its center the cut and a drill hole showed 18 to 24 inches of silty pumicite overlying 176 inches of clean pumicite. A sample of this material contained about 90 percent clear fragments and striated particles of glass together with about 10 percent feldspar, pyroxene, and amphibole fragments and crystals. A textural analysis follows:

*Mechanical analysis of Dodds road pumicite*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 0.0 | 0.7 | 1.6 | 17.0 | 80.7 | 100.0 |

Seventy-five feet southwest of the road cut, another hole was drilled to a depth of 10 feet without finding pumicite, indicating that the width of the deposit is less than this distance.

A cut along the Touchet-Eureka road exposes a pumicite deposit (location 17, fig. 6) in the SE¼ sec. 35, (9-33E). Here the cut and a drill hole show 140 inches of pumicite overlain by 36 inches of pumiceous silt.

Another deposit (location 18, fig. 6) is exposed for 300 feet along the Eureka-Prescott road, near the north quarter corner of sec. 5, (9-34E). It is about 50 feet wide as indicated by surface exposures, 36 to 40 inches thick, and is overlain by 12 to 24 inches of silt.

In a gully, followed by the Prescott-Pleasantville road, a deposit of pumicite (location 19, fig. 6) is exposed along a stream bank for a length of about 800 feet and to a depth of 4 feet. It is probably less than 25 feet wide, and overburden is 12 to 24 inches thick.

### COLUMBIA COUNTY

Two deposits of pumicite are known in Columbia County, but owing to the similarity of the topography in the northern part of this county to that in Walla Walla County, it is believed that others also occur.

One (location 20, fig. 6) is near the south quarter corner of sec. 30, (13-37E), about a mile from Lyons Ferry on the road that leads to Pleasantville and Prescott. Here light-gray pumicite has accumulated on the northern sides of two small ridges which are about 100 feet apart and project into a shallow gully that is tributary to the Snake River, half a mile north. Each deposit is about 200 feet long and 30 to 50 feet wide, as indicated by intermittent surface exposures. They range in thickness from a foot or so near their edges to more than 10 feet through their centers. The pumicite is composed of fine, fairly even-textured glass fragments that are chiefly elongated, striated particles. Some 5 percent of feldspar, amphibole, and pyroxene impurities are present. A screen analysis follows:

*Mechanical analysis of Lyons Ferry pumicite*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 0.0 | 0.9 | 1.0 | 16.3 | 81.8 | 100.0 |

The other pumicite deposit in Columbia County (location 21, fig. 6) is reported[1] to occur in sec. 13, (13-39E), near the Snake River, about 10 miles west of Central Ferry. It is said to be 2 to 9 feet thick and interbedded with fine sand.

### GARFIELD COUNTY

A few small pockets of pumicite occur intermittently for several miles in a gully along the Walla Walla-Lewiston highway near the Garfield-Asotin County line. These deposits, probably alluvial, contain considerable impurities, and none appears to have commercial quality or quantity. A typical one of these (location 22, fig. 6) is in the center of sec. 18, (11-44E). It is about 50 feet long, 20 feet wide, and has a maximum thickness of 8 feet. The microscope shows it to be slightly altered pumicite together with 30 to 40 percent of clay, silt, sand, and pebbles. A screen analysis follows:

*Mechanical analysis of pumicite in sec. 18, (11-44E)*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 1.7 | 3.4 | 4.8 | 18.2 | 71.9 | 100.0 |

[1] Private report: Tabulated summary of special geologic reconnaissance reports, Washington and northern Idaho, Northern Pacific Railway Co., Land Dept., Geol. Division, 1941.

### ASOTIN COUNTY

Two pumicite deposits are known in Asotin County; both are near the confluence of Asotin Creek and Dry Gulch, about 12 miles west of Asotin. One (location 23, fig. 6) is in the SE¼ sec. 34, (10-44E), 250 feet in elevation above the floor of Dry Gulch, at an altitude of about 1,900 feet. Here, on the north side of the gulch, a quarry 30 feet wide and 20 feet deep at the face has been opened on a well-consolidated bed of gray pumicite. The bed is well stratified and thinly laminated, indicating that it was deposited in water. Overlying the pumicite is an erosional surface on which patches of well-sorted stream gravels are unevenly distributed, and over this is a few inches of hillside debris. About 200 feet to the east of the quarry, and 20 feet higher in elevation, is an open-cut that shows 10½ feet of similar pumicite. Here, owing to slumping of the deposit, the bedding is tilted about 10 degrees toward the north, and at one place a fissure 1 to 2 feet wide in fine-grained, thinly laminated pumicite is filled with coarse, unlaminated pumicite.

Another open-cut, 8 feet wide and 18 feet long, has been made 100 feet west of the quarry and at the same elevation. It shows a vertical thickness of 15 feet of bedded pumicite. Near the lower end of the cut about 2 feet of cross-bedded sand and gravel, chiefly quartzitic in composition, lies in a narrow, channel-like depression in the pumicite.

The two open-cuts, west and east of the quarry, are near the ends of the pumicite deposit, and beyond them basalt flows crop out in gullies. Nothing in the exposed bedrock indicates that the deposit is interbasalt. Instead, it probably is an erosional remnant of a terrace deposit that was incised and largely removed by erosion. Lupher[1] has described an episode of Pleistocene glacier-related aggradation in the Lewiston Basin region, 12 miles to the northeast, when stream gravels accumulated in the Snake River Canyon and several tributary canyons, including the one occupied by Asotin Creek. Some streams were ponded by this fill, and possibly the pumicite occurrence is related to these events.

A sample of the pumicite taken from the quarry face and studied under the microscope was found to consist almost entirely of slightly devitrified, angular fragments of glass. Striated shards are rare. It is quite similar to the consolidated pumicite in Yakima, Kittitas, and Grant Counties. About 5 percent of the sample is silt, chiefly quartz and feldspar. The texture of the material is rather coarse, as indicated by the following screen analysis:

*Mechanical analysis of Asotin consolidated pumicite*

| Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|
| 11.2 | 36.2 | 52.6 | 100.0 |

[1] Lupher, R. L., Clarkston stage of the northwest Pleistocene: Jour. Geology, vol. 53, no. 5, pp. 337-348, 1945.

So far as is known, none of this pumicite has been mined commercially for abrasive use. The quarry was opened at least 48 years ago, as indicated by old markings on its walls that show dates as old as 1898, and, according to a local resident, the material mined was used as a building stone in the Lewiston-Asotin area.

The other known occurrence of pumicite in Asotin County (location 24, fig. 6) is an unconsolidated deposit in the NW¼NW¼ sec. 3, (9-44E). It lies in a narrow gully on the east side of the Asotin Creek Canyon at an altitude of about 1,850 feet, and is exposed for a length of 100 feet and to a maximum thickness of 10 feet along the bank of an intermittent stream. Its width is less than 30 feet. Under the microscope, a sample from this deposit showed about 70 percent pumicite, of which angular fragments and striated particles are in nearly equal proportion; the other 30 percent is silt, chiefly quartz particles. No gravel nor sand, ordinarily found with deposits that have been reworked by streams, was found with this pumicite; so the deposit is probably eolian in origin. A textural analysis follows:

*Mechanical analysis of Asotin unconsolidated pumicite*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 0.5 | 1.0 | 2.7 | 32.3 | 63.5 | 100.0 |

WHITMAN COUNTY

A road that leads along the north bank of the Snake River between Wawawai, Whitman County, and Lewiston, Idaho, exposes several small noncommercial deposits of pumicite (location 25, fig. 6). They occur as alluvial fans at the mouths of some narrow gulches that dissect the walls of the Snake River Canyon.

The largest of these deposits may have an extent of an acre or two. The material occurs from a few inches to 4 or 5 feet thick, but is mixed with considerable silt, sand, and gravel. The overburden consists commonly of 1 to as much as 4 feet of silt and gravel. These deposits probably originated from wind-blown pumicite which, after settling on the walls of the Snake River Canyon, was carried down the gullies by intermittent streams and deposited along the floor of the canyon.

Another pumicite deposit (location 26, fig. 6) lies on the north bank of an intermittent stream in Wawawai Canyon, a tributary of the Snake River Canyon, 12 miles southwest of Pullman. It is at an altitude of about 1,400 feet, in the NE¼ sec. 18, (13-44E). The deposit is 150 feet long, 10 to 25 feet wide, and, near its center, shows the following stratigraphic section:

*Section through pumicite in Wawawai Canyon*

| | *Inches* |
|---|---|
| Silt, sand, and basalt fragments | 42 |
| Buff-colored pumicite containing thin lenses of gravel (Sample A) | 84 |
| Light-gray pumicite together with a little sand and basalt pebbles (Sample B) | 90 |
| Silt and gravel (base concealed) | 36+ |

Both the buff-colored and the gray pumicite beds thin out at each end of the deposit. Under the microscope the buff-colored pumicite showed from 25 to 30 percent impurities, chiefly silt, sand, and gravel. A textural analysis of this bed follows:

*Mechanical analysis of Wawawai pumicite (Sample A)*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 2.4 | 2.0 | 3.3 | 33.9 | 58.4 | 100.0 |

The underlying, light-gray pumicite consists almost entirely of elongated, striated particles; silt, sand, and gravel make up less than 10 percent of the bed. This material is finer in texture than that composing the buff-colored bed, as indicated by the following screen analysis:

*Mechanical analysis of Wawawai pumicite (Sample B)*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 0.7 | 2.1 | 3.9 | 23.7 | 69.6 | 100.0 |

The presence of the gravel lenses in these pumicite beds indicates that the deposit is alluvial in origin. Possibly the material accumulated in rather still water, a result of local or regional ponding, or it may be the result of deposition caused by a lessening of gradient in this particular tributary of the Snake River.

About 5 miles west of Lacrosse, in the east center of sec. 19, (15-39E), pumicite (location 27, fig. 6) is exposed along the bank of Willow Creek for about 100 feet. It is near the Washtucna-Lacrosse highway and adjacent to the Oregon-Washington Railroad & Navigation Co. railroad. The exposure has a maximum thickness of 8½ feet near its west end, where it is cut off by Willow Creek, and diminishes toward the east. It lies on the south slope of the shallow Willow Creek Valley, and so has a width of probably less than 30 feet.

At the thickest place in the exposure the following section is shown:

*Section through pumicite deposit near Lacrosse*

| | *Inches* |
|---|---|
| Soil | 3-5 |
| Gray pumicite containing a few pieces of compact silt and basalt pebbles (Sample A) | 96 |
| Light-brown pumicite and sand | 3-5 |
| Light-gray pumicite (Sample B) | 6 |
| Gravel, silt, and clay (base concealed) | 36+ |

The 96-inch bed consists of 90 to 95 percent pumicite composed of glassy fragments and elongated fluted particles in about equal proportion. The rest is chiefly feldspar and pyroxene particles. The material is fairly fine in grain, as indicated by the following textural analysis:

*Mechanical analysis of Lacrosse pumicite (Sample A)*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| Tr. | 0.6 | 1.1 | 6.4 | 91.9 | 100.0 |

The 3- to 5-inch light-brown bed consists of discolored pumicite together with about 15 percent impurities. The underlying 6-inch bed is chiefly clear, glassy particles together with a very small percentage of impurities. A textural analysis of this bed follows:

*Mechanical analysis of Lacrosse pumicite (Sample B)*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 0.3 | 1.2 | 2.4 | 13.8 | 82.3 | 100.0 |

Another similar deposit exists about 2,000 feet to the east. Here 24 inches of silt overlies the same sequence of pumicite beds. The upper pumicite layer is 36 inches thick, the light-brown layer is 3 inches, and the lower, light-gray layer is 6 inches.

### SPOKANE COUNTY

One pumicite occurrence is known in Spokane County and, though it is not properly in southeastern Washington, it is placed in this group because of possible similarities to the deposits of that area. The deposit (location 28, fig. 6) is on the Stanger place, half a mile north of Mead, in the SW¼ sec. 2, (26-43E). Here a pit 150 feet long and 25 feet wide has been dug in the south side of an east-west-trending ridge that rises 15 to 20 feet above the surrounding area. The pit and a hole drilled near its center show 10 feet of light-gray pumicite underlying 5 feet of sand and overlying brown sandy silt. The pumicite consists of 75 to 80 percent glassy fragments and elongated fluted particles in nearly equal proportion; the other 20 to 25 percent is fine sand and silt composed of frosted quartz grains together with some feldspar, biotite, amphibole, magnetite, and other minerals. The material is rather coarse in grain as indicated by the following textural analysis:

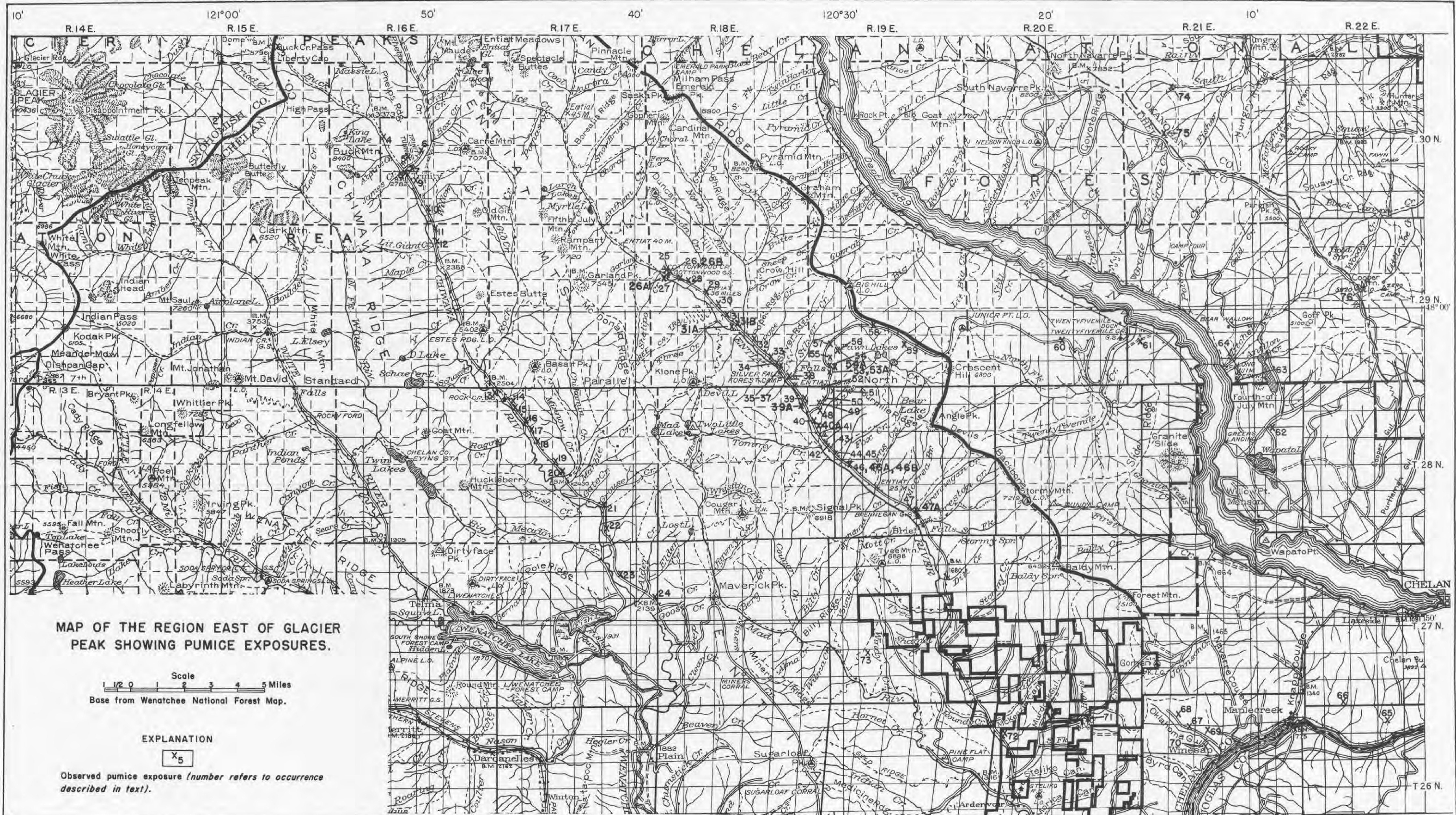
*Mechanical analysis of Mead pumicite*

| Plus 20 mesh | Minus 20, plus 65 mesh | Minus 65, plus 100 mesh | Minus 100, plus 200 mesh | Minus 200 mesh | Total |
|---|---|---|---|---|---|
| 1.7 | 14.8 | 6.1 | 33.1 | 44.3 | 100.0 |

Nearly all the material retained on the 100-mesh and coarser sieves consists of fine sand grains.

A railroad cut 300 feet east of the pit shows the same bed of pumicite, here less than 5 feet thick. It crops out on the south side of the ridge, but dips 10 degrees northward, so has increasingly heavy overburden in that direction. The same bed of pumicite is also shown in a highway cut a third of a mile west of the pit. Here it is 10 inches thick, dips at a slight angle toward the north, and is overlain by 10 or more feet of sand. The origin of this pumicite is not known, but the frosted sand grains that occur with it suggest that it is eolian.

The pit on the Stanger place was opened several years ago by Building Supplies, Inc., who have operated a brick plant near by. The pumicite was used for dusting brick molds.




## MAP OF THE REGION EAST OF GLACIER PEAK SHOWING PUMICE EXPOSURES.

Scale

1 1/2 0 1 2 3 4 5 Miles

Base from Wenatchee National Forest Map.

EXPLANATION

X5

Observed pumice exposure *(number refers to occurrence described in text).*