

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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**LIGHTWEIGHT AGGREGATE INDUSTRY
IN OREGON**

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1951

State Governing Board

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FORWORD

The lightweight aggregate industry which has had such a phenomenal growth since World War II is based on the desirability and need of reducing the weight of structure without sacrificing strength. Although there is plenty of room for improvement in practice through better understanding of the problems involved and specifically through greater care in preparation of materials, the industry undoubtedly is here to stay and has made only a start in its development.

The Department has had a working interest in the development of lightweight aggregates. Its work has been along both geological and engineering lines in encouraging the industry's growth and it is hoped that some Departmental projects now under way will be of further assistance. The author of this paper, Mr. Ralph S. Mason, has done field and laboratory work on most of the materials now used as lightweight aggregates or as building stones. He has prepared jointly with Mr. Norman S. Wagner of the Department's staff several papers as progress reports on the industry. The Department has published a report on perlite in Oregon, and has file reports on deposits of other lightweight materials. This Short Paper summarizes Departmental reports and includes new material.

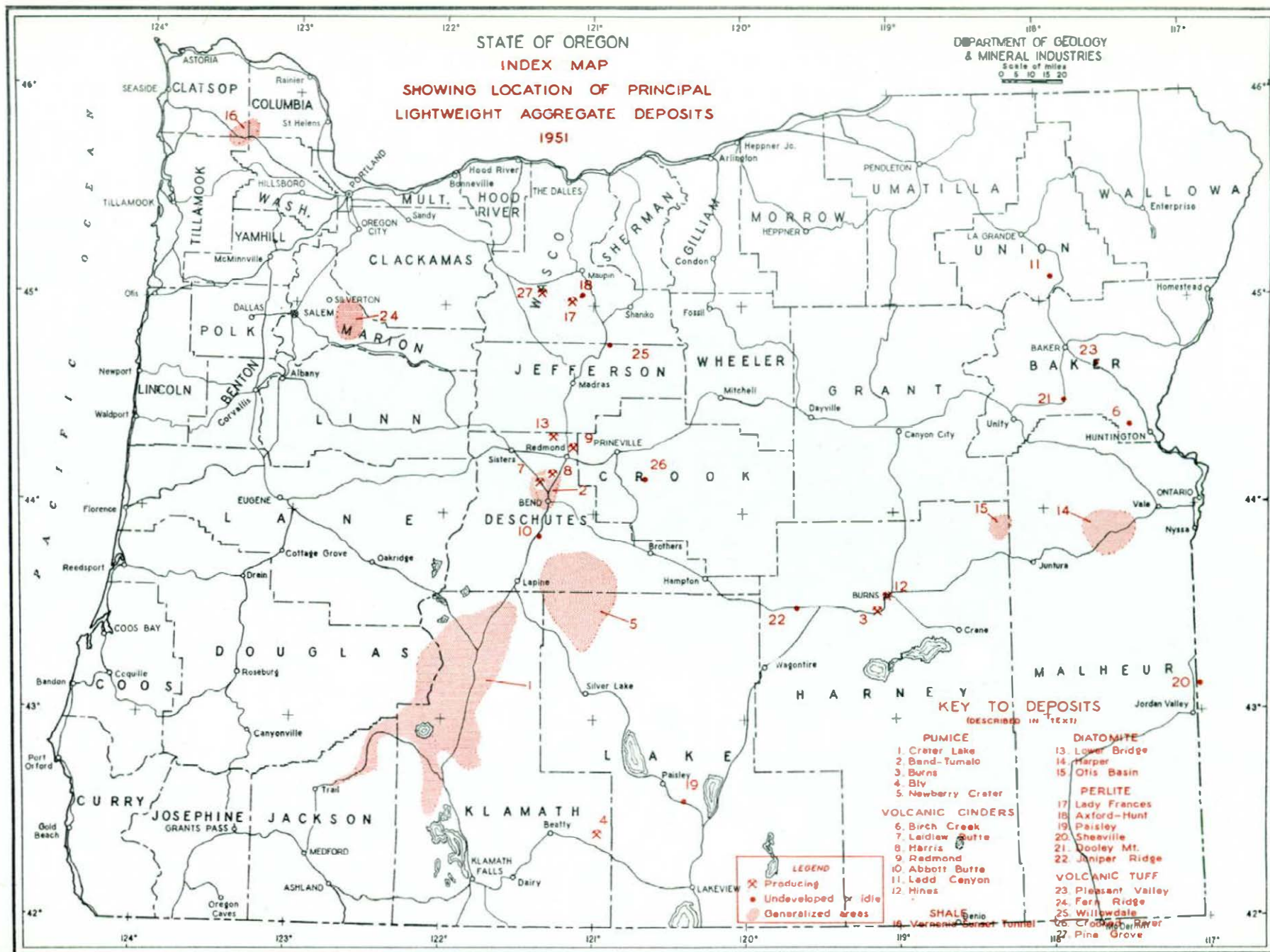
Experimental results on work done by Mr. Mason in investigating a new method of treating pumice are included in the Appendix. This project was undertaken to determine whether or not pumice could be glazed with volcanic ash to improve both absorption and strength characteristics. The treatment is simple and probably most pumice deposits would have an ash suitable for glazing located in their immediate vicinity. Further testing on a larger scale should be done before results may be evaluated. However, preliminary results of testing work appear to be encouraging.

F. W. Libbey
Director

August 16, 1951

CONTENTS

	<u>Page</u>
Foreword	
Index map	Opposite page 1
Introduction	1
Pumice	2
Definition	2
Location and extent	2
Composition	2
Deposits	3
Production	4
Uses	6
Trade specifications	6
Volcanic cinders	8
Location and extent	8
Composition	8
Deposits	8
Uses	9
Diatomite	9
Definition	9
Location and extent	9
Composition	9
Deposits	10
Uses	10
Expanded shale	11
Definition	11
Composition	11
Processing	11
Deposits	12
History and production	12
Uses	12
Perlite	13
Definition	13
Origin	13
Composition	13
Deposits	14
Uses	15
Volcanic tuff	15
Definition	15
Economics	15
Deposits	15
Conclusions	19
Appendix	19
Results of test work on coating lump pumice	19
An Act (Senate Bill 18)	21
Bibliography	22
Table 1. Physical properties of some Oregon volcanic tuffs	17



LIGHTWEIGHT AGGREGATE INDUSTRY IN OREGON

Introduction

Lightweight aggregates were probably first introduced by the Romans, who used pumice in the construction of some of their public buildings. Up until a few years ago pumice was used almost exclusively as an abrasive in this country. It was sometimes used as a building material where locally available, but little attention was paid to its special characteristics as a lightweight aggregate. Within the past five years, however, there has been a rapid increase in the use of both natural and artificially expanded lightweight aggregates and the trend is likely to continue. Public tastes vary periodically, and at the present time builders strongly favor using lightweight aggregate. This condition may change but the solid core of demand lies in the advantages to be gained by using these materials.

Present high costs of building construction have made it necessary for architects and builders to economize wherever possible. Lightweight aggregates render a manifold service by reducing dead weight of the exterior and interior walls which in turn saves on structural steel and foundation expense. The acoustical and thermal insulation qualities of lightweight aggregates also help to reduce costs by permitting thinner partitions. The increased ease of handling results in a further saving on building-construction costs.

At the present time the bulk of lightweight aggregates produced in Oregon is obtained from deposits of pumice with a minor use of volcanic cinders. The trend, however, is toward the production of artificially expanded shale, and there is little doubt but that this will continue.

Very little research has been done on the production of artificial lightweight aggregates in the State, but it seems likely that study of this problem will become increasingly urgent as the specifications for building materials are steadily becoming more rigid.

Unlike many areas, Oregon currently has no furnace slag which may be processed into lightweight aggregate, but the State has a rich store of natural lightweight aggregate materials. Many of these need only to be examined and analyzed before their potentials are recognized. Others will require further study and research to discover their best possible use. The work being conducted by the Division of Industrial Research of the Washington State Institute of Technology at Pullman serves as a good indication of the scope and nature that research on lightweight aggregate must take.

Pumice

Definition

Pumice is a glassy volcanic rock, which has a very porous or sooriaceous structure due to the expansion of gases and vapor while in a viscous molten state. Rapid reduction in pressure upon ejection during an explosive volcanic eruption allows the dissolved gases in the escaping magma to expand quickly, thus producing a porous mass. Pumice is light, spongy, and frothlike in appearance; white, gray, or buff in color; hard and brittle. The cutting or abrasive quality is due to the thin partitions of glass composing the walls between vesicles. Numerous voids produce a material having a low bulk specific gravity and possessing considerable strength with moderate absorption.

Location and extent

Large deposits of pumice occur in Klamath, Jackson, and Deschutes counties in Central Oregon (see map opposite page 1). The deposit which originated from the caldera, now Crater Lake, covers approximately 3,500 square miles as a sheet which varies in thickness from a few inches to as much as 30 or 40 feet, depending on the contour of the land, amount of drifting caused by wind, and the distance from the source. Crater Lake pumice erupted from Mt. Mazama, the name given posthumously to a volcanic cone which collapsed during an eruption about 4,000 years ago.

The Crater Lake deposits are by far the largest and most extensive of all the Central Oregon pumice beds which include deposits located at Newberry Crater, Devils Hill, and the Bend-Tumalo area. Of these, only the Crater Lake and Bend-Tumalo areas have produced any large amounts of pumice aggregate. A small deposit near Burns and another near Bly are also being worked. A small amount of abrasive pumice is produced annually from the Newberry Crater deposit.

Composition

Chemical analyses of Central Oregon pumice samples vary somewhat, depending on size of the lumps, proportion of crystals to glass, amount of weathering, and other factors. The following table by Fahey (1937)* shows the analysis of a lump of dacite pumice from near Chemult which is typical of Crater Lake pumice.

SiO ₂	68.565
Al ₂ O ₃	14.22
Fe ₂ O ₃	1.42
FoO	1.49
MgO	0.83
CaO	2.35
Na ₂ O	5.18
K ₂ O	2.47
H ₂ O+	} 3.32
H ₂ O-	
TiO ₂	0.58
P ₂ O ₅	0.10
MnO	0.03
BaO	----
Total	100.555

*Bibliography at end of this report.

The pumice deposits of Central Oregon are composed for the most part of pale buff or brownish, nearly equidimensional subangular lumps having a spongy texture. In the larger lumps numerous vesicles occupy much of the volume, which results in a relatively low apparent specific gravity as compared to the smaller pieces which contain fewer voids and a greater proportion of heavier mineral crystals. The pumice lumps consist of a porous matrix of volcanic glass in which numerous mineral crystals consisting of plagioclase, hypersthene, augite, and hornblende are embedded.

Lumps of pumice range in size from masses measuring a foot or more in either dimension down to small pieces the size of rice grains. Material smaller than this, which is called pumicite, grades on down to dust. Since the bulk specific gravity of pumice is due to the presence of voids, the larger lumps tend to be lighter than smaller ones, and finely divided material differs little in weight from other mineral grains.

Deposits

Crater Lake area (1)*

The Crater Lake pumice beds lie exposed on gently rolling ground which supports a meager forest cover of lodgepole pines and underbrush. For the most part the removal of the brush and timber is all that is required to prepare the deposit for production. The town of Chemult is the center of pumice production in the Crater Lake area.

Most of the land near Chemult is public domain. Much of the more suitable pumice-covered land, from a standpoint of favorably situated areas lying along the railroad rights of way, has been taken up by various interests who have filed mining claims.

Generally speaking, the pumice ejected from the throat of now extinct Mt. Mazama shows a gradual downward gradation in size with distance from the source. There is also a vertical variation in particle size resulting from differences in the rate of eruption, changes in the winds during eruption, and sorting while falling to earth. The volume of Crater Lake pumice beds has been computed by Williams (1942) to be in the neighborhood of 3.5 cubic miles. This figure does not include other types of ejecta spewed forth from Mt. Mazama during the various stages of its growth and destruction.

The area is characterized by a semiarid climate with long dry summers and cold winters during which the major part of the annual precipitation falls as snow. Elevation of the area is approximately 5,000 feet above sea level. Two railroads traverse the length of the deposit; the main line of the Southern Pacific is joined by the Great Northern Railroad at Chemult. U.S. Highway 97 and State Highway 58 also pass through the area.

Bend-Tumalo area (2)

The Bend-Tumalo area lies 65 miles north of the Crater Lake pumice beds at an elevation of 3,500 feet and has a more moderate climate than that at Chemult.

Lump pumice found in the Bend-Tumalo area resembles that of the Crater Lake deposits to the south. There is a distinct difference in the nature of the two deposits, however. The Bend-Tumalo deposits are generally covered with an overburden of transported material as much as 20 feet thick. The pumice has been carried to its present location from a distant source by stream action. The Bend-Tumalo deposits are remarkably clean and well sorted, although there is some contamination with both the overlying material and an underlying stratum of pumice of poorer grade which is not used. Areal extent of the deposits is difficult to determine without the aid of drill holes or test pits, and past operations at the numerous pits reveal that the areas of pumice having sufficient thickness and a favorable stripping ratio are quite irregular in outline and frequently of limited extent. Apparently the lenses of pumice now being mined represent material that was once washed into stream channels or topographic lows and deposited there. Operators have had to abandon otherwise excellent deposits of pumice when overburden increased to more than an economic thickness. Stripping operations are carried on commonly only a short distance in advance of mining.

*Numbers are the same as key numbers on index map opposite page 1.

The land in the Bend-Tumalo area is a mixture of state, federal, county, city, and private ownership, and many of the tracts are quite small. Some of the operators do not own the land outright but are operating under a lease and royalty agreement. Shipping points for the area are either in or near Bend or at Deschutes, a siding on the Oregon Trunk Railway a few miles north of Bend. Material from the pits is generally trucked to these sidings for shipment. Processing plants are located either at the pit or at the siding.

Burns pumice (3)

A small deposit of lump pumice located near Burns in Harney County has been worked for several years. The pumice lumps are unweathered and harder than the pumice in either the Crater Lake or Bend-Tumalo areas.

Bly pumice (4)

Shipments of pumice plaster aggregate have been made since 1946 from a deposit located six miles northeast of Bly in Klamath County. Operation is discontinued during the winter months.

Newberry Crater area (5)

Although considerable tonnages of pumice occur in the general vicinity of Newberry Crater (see map opposite page 1), the more readily accessible areas were withdrawn from mineral entry in December 1945. A small quantity of abrasive pumice is shipped annually from a pit within the crater. This deposit was located prior to the withdrawal order and was not affected by it.

Production

History

Although several sporadic attempts to ship pumice, mainly as an abrasive, had been made since as early as 1929, no real continuous operation occurred until 1945, when several producers started shipments of pumice for lightweight aggregate from both the Chemult and Bend-Tumalo areas. Prior to that time there had been a small production of pumice blocks from a plant near Chemult, and an operator shipped some lump pumice from a deposit at Beaver Marsh south of Chemult.

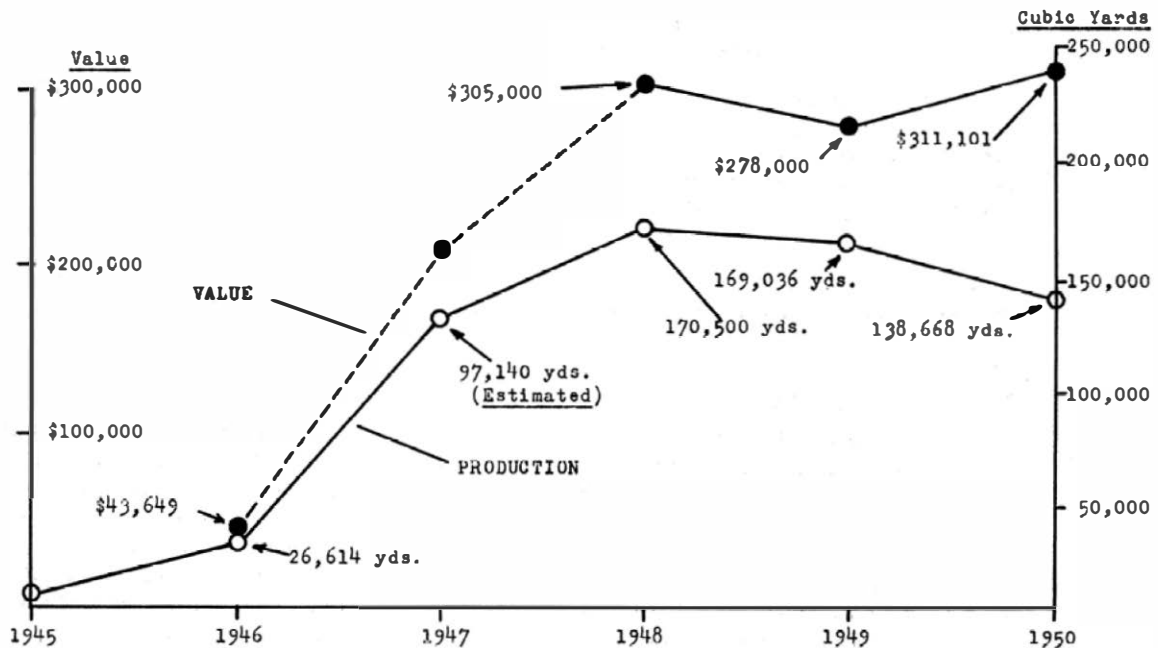
In 1930 the Pacific Portland Cement Company at Gold Hill leased a deposit 10 miles east of Trail in northwestern Jackson County and trucked lump pumice to the Company's plant where it was used as an additive in the production of a "Special" cement. Production from this pit for this purpose continued until 1945 when the company discontinued its use to concentrate on manufacturing standard cements.

Since 1945, production of pumice aggregate in the State has increased greatly as shown on the accompanying graph. Greatest production has been from the Bend-Tumalo area. At the present time four of the eight producers in the State are located there. The Chemult area is more ideally situated than that at Bend from the standpoint of reserves, ease of mining, and proximity to two railroads, but Chemult is in a very sparsely populated area and operation during winter months is difficult if not at times impossible.

Prices

Pumice aggregate prices during 1949 ranged from \$1.25 to \$1.62 per cubic yard f.o.b. cars at plant for blends and as much as \$1.80 per cubic yard for sized aggregate. These prices reflect a downward revision from about \$2.00 per cubic yard for material which was merely crushed and screened during 1948. The downward trend in price has been

due to increased competition coupled with a tapering-off in demand as numerous small block plants which sprang up at the height of the boom closed down as demand slacked off. Pumice is also experiencing competition from expanded shale which is now being produced by two plants in the Portland area. Freight increases during the past few years have raised the delivered cost of pumice considerably, but the increase has been absorbed partially by the producers.



Producers

Several pumice producers have not been able to trim their costs sufficiently to meet the reduction in aggregate prices and have gone out of business. The more firmly established operators have been able to pare their costs by enlarging their plant facilities, which has enabled them to reduce unit costs. Experience gained over the past few years has also helped them to operate their plants more efficiently. The outlook for the future seems to be one of a few, well-organized, efficiently run plants serving the industry, rather than a relatively large number of small operators working on a semipermanent basis with poor equipment. At the close of 1950 eight pumice producers were active in the State. Production statistics were obtained from the six operators listed below. Production by the two plants not reporting is believed to be small.

Chester T. Lackey, Deschutes Concrete Products Company, Redmond, Oregon.

William E. Miller, Central Oregon Pumice Company, 644 Franklin Street, Bend, Oregon.

Thomas Philipsen, Western Pumice Sand Company, 2321 Eberlien Street, Klamath Falls, Oregon.

Don Robbins, Harney Concrete Tile Company, Burns, Oregon.

Merle Sleeper, Pumice Engineering Company, Box 808, Bend, Oregon.

Lloyd A. Williamson, 114 Oregon Avenue, Bend, Oregon.

Uses

Originally the pumice industry produced almost exclusively an aggregate for precast concrete blocks. More recently, the producers have diversified their production somewhat in utilizing the inherent value of the lightweight material, and today they are supplying not only block aggregate but ready-mix aggregate, poultry litter, florists' bedding material, and plaster aggregate. The unit value of plaster aggregate is, of course, much higher than that of the other products and accounts largely for the nearly 12 percent increase in value of products sold despite the 16 percent reduction in yardage during 1950. Production of ready-mix aggregate increased to roughly 15 times the 1949 level and that of plaster aggregate to more than $2\frac{1}{2}$ times.

Pumice aggregate concretes are finding increasing use in the construction of sub-floors for buildings using radiant heating. The low thermal-transfer qualities of the pumice concrete prevent escape of heat downward while a thin layer of standard sand-cement-gravel concrete poured on top of the heating coils serves as a good conductor for the heat upwards into the room.

Pumice has been suggested* as the best cheap material that has been found so far to ward off harmful atomic radiations. If this proves to be an accurate statement, pumice producers should find a ready market for their product for some time to come.

Trade specifications

As the demand for lightweight concrete blocks increased, it was inevitable that many operators would enter the field with the production of inferior blocks. Consumer dissatisfaction, with, in some cases, outright failure of these substandard blocks, resulted in a demand for more rigid requirements. This demand came principally from builders and agencies underwriting loans on domestic construction. Block manufacturers have met this demand for standard-sized blocks by perfecting their mixes, tightening down on specifications for lightweight aggregates, and conducting periodic tests on their finished products. Specifications for lightweight aggregate blocks have been established by the American Society for Testing Materials and the National Board of Fire Underwriters. The Federal Housing Administration, which underwrites much domestic construction, insists that lightweight blocks meet the A.S.T.M. standards for crushing strength and the "U" factor for heat loss (see glossary). The A.S.T.M. specifications for hollow load-bearing concrete masonry units require a minimum crushing strength of 1,000 pounds per square inch of gross area and a minimum "U" coefficient of .25. The city of Portland code is the same for crushing strength, and in addition the absorption must not exceed 15 pounds of water per cubic foot of volume.

Oregon pumice producers supplied the trade with a variety of blends, mixes, and sized aggregate during 1950. Some producers prepared a ready-mix consisting of 3/4-inch minus material while others shipped aggregate having a maximum size of 3/8-inch and still others sold a carefully sized aggregate which was blended in definite proportions to meet the specific needs of their customers. Although the principal market for pumice aggregate was in the concrete block field, a considerable portion was used in monolithic concrete construction.

The concrete block industry, like the pumice aggregate industry, has undergone a change from one of many small producers to one of a relatively few efficient plants using correct mixes and checking their product with periodic physical tests.

*Rock Products, p. 106, February 1950.

Washington State Institute of Technology, Division of Industrial Research, Pullman, is currently engaged in a research program on pumice concrete.* This program was initiated because of a request from concrete products manufacturers and is being carried on in co-operation with them. The Institute is attacking the most important problems in connection with the pumice block industry first, but nearly every phase of the problem has been tentatively outlined for future investigation.

The causes and control of shrinkage in walls constructed with pumice concrete blocks is receiving the Institute's attention at the present time. Although no final results are yet available (June 1951), preliminary work indicates that excessive shrinkage of the blocks after being laid up in a wall may be minimized by using a properly cured block containing (a) a minimum of moisture, and (b) the inclusion of steel reinforcing in the wall.

An investigation of the weathering abilities of various paints for use on exteriors of pumice concrete masonry is also being carried on. Paints are applied to walls of about 10 square feet area, and tested at an accelerated rate in a specially constructed weathering cabinet. All types of suitable coatings are being checked, particularly transparent types.

The problem of correct mix ratios for pumice concretes is also being investigated by the Institute and a large number of test cylinders are being prepared and strength tested. Tests on Oregon pumice are included in the present program since the bulk of pumice used by Washington block manufacturers originates in Oregon where large, easily accessible deposits of excellent material are available.

*Partially reported on in a paper "Dimensional change studies of unit masonry," by J. J. Wegner, Chemical Engineer, read at the AIME Northwest Industrial Minerals Conference, Portland, April 27, 1951.

Volcanic Cinders

Location and extent

Like pumice, volcanic cinders, or scoria, are ejected from volcanic cones. Many of these extinct cinder cones are scattered over the eastern portion of the State. In the Bend area they are numerous and contain a total of many thousands of yards of scoriaceous material. The location of some of the cinder deposits is such that they cannot at present be classed as commercial. On the other hand, the deposits at Laidlaw and Abbott buttes in the Bend area are ideally located near paved highways. Some deposits, such as the Birch Creek in Baker County, although readily accessible, are poorly located with respect to markets.

Composition

Oregon cinders have a greater bulk density than pumice and produce a block having a higher crushing strength than pumice block. Colors range from red to black with some deposits containing some beautiful iridescent masses. Size of the individual pieces ranges from 6 inches or more in diameter down to fines. Many of the deposits in the State contain evenly sized material three-quarters of an inch or less in diameter. Chemical composition of some volcanic cinders (Sample P-9205)* taken from Laidlaw Butte near Tumalo in Deschutes County is as follows:

SiO ₂	38.04 %
H ₂ O	0.14
Loss on ignition	1.50
CaO	7.35
MgO	3.77
Al ₂ O ₃	19.00
Fe ₂ O ₃	8.23
K ₂ O	8.50
Na ₂ O	12.76

Deposits

One of the largest deposits of cinders in the State is the Birch Creek cinder deposit (6), Tps. 13 and 14 S., R. 43 E., Baker County. It is located 13 miles northeast of Huntington on deeded land. The deposit contains thousands of yards of material weighing about 70 pounds per cubic foot and of a size ideally suited for block manufacture.

Laidlaw Butte (7), located in sec. 36, T. 16 S., R. 11 E., in Deschutes County near the town of Tumalo, contains a considerable tonnage of cinders.

A deposit of red cinders (8) occurs in sec. 22, T. 16 S., R. 12 E., in Deschutes County. It is owned by W. Harris of Deschutes, Oregon, and consists of material ranging in size from fines to 4-inch lumps. Another deposit (9) in the same general area, located in sec. 33, T. 14 S., R. 13 E., and owned by the city of Redmond, has also furnished cinders to local block plants.

Abbott Butte (10), sec. 35, T. 19 S., R. 11 E., in Deschutes County, is located about 12 miles south of Bend on The Dalles-California Highway. Cinders from this butte were used as road metal in the construction of Camp Abbott nearby during World War II. This deposit contains, in addition to the brick-red cinders, some that are iridescent. Abbott Butte is a rather small cone, but the volume of usable material is measured in thousands of yards.

The Ladd Canyon cinder deposit (11) is located in secs. 17 and 20, T. 5 S., R. 39 E., in south central Union County. Exact size of this deposit is not known, but several occurrences of cinders in this general vicinity have been found.

*Analysis by L. L. Hoagland, chemist, Oregon Department of Geology and Mineral Industries.

Hines cinders (12)

A cinder deposit covering 40 acres, located three quarters of a mile north of Hines in Harney County, has been used for road metal since 1929. The deposit is part of a lava and cinder belt extending northwards to the Grant County line. Pit material is highly compacted owing to the presence of clay. The cinders would apparently make a suitable lightweight aggregate but would require screening and washing to remove the clay.

Uses

Volcanic cinders have been used to a small extent in the production of concrete blocks and to a somewhat larger extent as a road metal.

Cinder blocks are heavier than those made with pumice, but their greater strength may offset this disadvantage.

Scoriaceous material when used for blocks must meet the same size specifications as pumice, since the two are used for similar purposes.

Diatomite

Definition

Diatomite or diatomaceous earth is the name applied to masses of tiny siliceous skeletons of a microscopic single-celled plant. These porous particles, called diatoms, were deposited on the floors of fresh water lakes and inland seas in vast quantities since Miocene time about 30 million years ago. Weight of overlying material has compacted the deposits of these minute diatoms into an earthy or chalklike mass of pure white or nearly white. Impurities such as clay, carbonaceous material, and volcanic ash are often found as interbeds in the deposits.

Location and extent

Diatomite is a rather common material in the central and eastern parts of the State, and large deposits of both impure and quite pure material are widely distributed; only those deposits having a high purity coupled with large size, ease of mining, and ready access to transportation are considered in this section.

Composition

Chemical analyses of diatomites from Terrebonne, Otis Basin, and Harper are given in the following table (Moore, 1937):

	<u>Terrebonne</u>	<u>Otis Basin</u>	<u>Harper</u>
SiO ₂	95.40 %	92.45 %	94.51 %
TiO ₂	---	.28	.15
Fe ₂ O ₃	1.40	1.60	1.15
Al ₂ O ₃ . . . . .	.91	4.00	2.87
CaO . . . . .	.65	.85	.53
MgO . . . . .	.45	.20	.19
Na ₂ O	---	.24	.31
K ₂ O	---	.18	.04
SO ₃	---	.07	.10
Cl	---	.07	None
CO ₂	---	.06	.15
<u>Total</u>	98.81 %	100.00 %	100.00 %

Deposits

By far the largest and at the present time the only consistent producer of diatomite in the State is the Dicalite Company at Lower Bridge (13) on the Deschutes River, about 6 miles west of Terrebonne, a town on the Oregon Trunk Railway in northern Deschutes County. This operation has been producing for more than 25 years and reserves are reported to be sufficient to supply the plant for a considerable time in the future. Probably next in importance as related to accessibility are the deposits located in the Harper district (14) in northern Malheur County, followed by the very extensive diatomite beds in Otis Basin (15) in northeastern Harney County. These deposits, as described by Moore (1937), are of good quality, a white to nearly white color, of large size, and some of them are conveniently located with respect to the Union Pacific Railway line extending from Ontario to Burns. There are also deposits in the region around Klamath Falls but these are generally small and contaminated with foreign material. Smaller deposits are also found at Indian Creek, Clover Creek, Richland, Durkee, Austin, and John Day Valley. Since diatomite in unprocessed form is a low-value commodity, only those deposits having exceptional purity, ease of mining, and favorable location may be considered as economic.

Uses

Diatomite finds its way into many industrial applications where it serves as an inert filler in numerous products. It also is used extensively as a filter aid and as a thermal insulant. These uses require beneficiation of the raw diatomite in order to enhance its value and to permit it to meet trade specifications. This need for beneficiation is not necessarily true of diatomite that is to be used as a lightweight aggregate for concretes. In this field, diatomite must compete with a wide variety of other products, most of which may be produced cheaply and are close to the point of use. Competition thus restricts the distance that diatomite used for this purpose may be economically hauled.

Diatomite is one of the longest established of the lightweight materials currently on the market. This gives diatomite producers who wish to compete in the lightweight-aggregate field a certain advantage over such newcomers as perlite producers because the producers of diatomite have been able, over a period of years, to standardize their product, make exhaustive tests, and overcome consumer resistance.

Oregon is the second largest producer of diatomite, exceeding Nevada and Washington but surpassed by California which produces the bulk of domestic diatomite. Production figures for Oregon are not published by the U.S. Bureau of Mines as production is by only one company.

Expanded Shale

Definition

Expanded shale is produced by rapidly heating crushed raw shale containing one or more of the following: carbonaceous or calcareous material, sulphur, or iron compounds. The process is dependent on the ability of the shale to form a viscous, airtight coating when heated in a rotary kiln. This film prevents the escape of gases generated by the carbonaceous or sulphur compounds contained in the shale when the heat penetrates to the interior of the lump.

Composition

Keasey shale, so called from the type locality near Keasey in Columbia County, is used by two operators as a raw material. It is a fossiliferous, tuffaceous siltstone which varies in character somewhat from place to place, but the following generalized analysis indicates the essential composition of the material:

Analysis of Keasey shale*

Moisture	27.0 %
Loss on ignition . . .	6.8
Silica	58.0
Aluminum oxide	16.5
Iron oxide	5.3
Magnesium oxide . . .	1.6
Calcium oxide	3.3
Sodium oxide	2.8
Sulphate	2.3

The expanded shale has a dark red color with a smooth, bloated surface which is usually pierced by a few holes and cracks.

Processing

In general furnace practice an expansion of about 100 percent is sought although variations in the raw material, temperature of the kiln, and duration of time that the material remains in the kiln, all affect the degree of expansion. Although practice varies, a firing period of about half an hour at a temperature of 2,000 degrees F. is usually required for proper bloating. A properly expanded shale has a cellular texture consisting of myriads of tiny air cells which are usually isolated from each other. It is the absence of connecting voids that gives expanded shale a strength advantage over raw pumice when used as a concrete aggregate.

Manufacturers of expanded shale follow either one of two systems in their production flow sheet. Some operators prefer to pre-crush the raw material to a size which will result in a finished product having the desired dimensions. Other operators crush the feed to a size which results in expanded material considerably larger than that required and which must then be re-crushed. The advantage of the first method is that the finished material presents less surface per unit of volume, thus reducing the absorption of water and cement and also lowering the bulk density. The second method of crushing has the

*Analysis by Charlton Laboratory, Portland, Oregon.

advantage of a greater possible kiln output because the kiln feed is more uniform and contains only material which will expand to a commercial size. This has the effect of increasing the kiln capacity, which is an important factor from a cost standpoint. The advantage of crushing the expanded material to the desired size lies in the relative ease of crushing as compared to the raw shale. Crushing the expanded material has an added advantage in that a certain amount of fines are produced which may be used to produce a properly blended aggregate.

Deposits

Deposits of shale suitable for conversion into lightweight aggregate occur in a large area surrounding Vernonia in Columbia County (16). In this general area, beds of Keasey shale of upper Eocene or lower Oligocene age crop out in numerous places. At the present time two quarries are being worked. One operator has a kiln located at the quarry while the other transports the raw material by railroad gondolas to a kiln in Portland.

History and production

Robert E. Brooke conceived the idea of establishing an expanded shale industry in northwestern Oregon in 1946, when he visited the Department with the request for some help in selecting a material suitable for the purpose. Numerous localities were visited and samples tested for their expansibility. It was discovered that Keasey shale from the large deposits located in the northern part of Washington County performed satisfactorily and was accessible to both railway and highway transportation. The Department also assisted Brooke in selecting a plant site, construction of which started in January 1947. First production occurred in June 1947 and continued until September when the operation was taken over by Northwest Aggregates, a wholly owned subsidiary of Empire Building Materials Company of Portland. Empire discontinued production temporarily and operations were not resumed until late in 1948, when the enlarged plant resumed production on a full-time basis.

A second producer entered the expanded shale picture in May 1950, when Smithwick Concrete Products Company opened up a quarry south of Vernonia and began producing "Haydite" from a large rotary kiln at its block plant in Portland. This company is licensed by the American Aggregate Company which controls the trade name "Haydite." Production from the Empire and Smithwick plants is in the neighborhood of 200 yards per day.

Uses

Expanded shale is finding increased use as an aggregate for concrete building blocks and also for monolithic concrete construction. Consumer dissatisfaction with pumice blocks has resulted in a shift to those using expanded shale as an aggregate. In general, expanded shale competes with pumice for most uses.

Perlite

Definition

The rapid growth of the perlite industry since 1945 has resulted in the industry's universal adoption of the term perlite, which originally was a petrographic term applied to a glassy volcanic rock with a peculiar pearl-like or spherulitic structure. Perlite as it is now used means not only a special type of rock but also the expanded material prepared from it as well as any volcanic material which can be "popped" when heated properly. Perlite is not a mineral but an extrusive igneous rock, classed as a rhyolite glass containing usually from 2 to 5 percent of combined water. Obsidian, which is a volcanic glass containing less than one percent of water, may be popped also. No obsidian is being processed in Oregon at the present time; however, production of lightweight obsidian aggregate has been reported in California (Clapp, 1947).

Origin

It has long been assumed by most geologists that perlite was formed when a rhyolite magma was chilled soon after extrusion, producing the glassy composition and characteristic shell-like fractures. This theory has been questioned by Wilfley and Taylor (1950), who believe that perlite is of secondary origin, possibly the result of hydrothermal alteration of a siliceous rock such as pumice.

Composition

Chemical properties

Since perlite is not a mineral but a rock, its chemical composition and physical properties may vary somewhat from deposit to deposit and from place to place within a deposit. The following analyses show the chemical similarity of rhyolite and perlite at the Lady Frances mine in Wasco County (Allen, 1946). Analyses of two perlites from Steens Mountain (Fuller, 1931) are also shown.

	<u>Rhyolite*</u>	<u>Perlite*</u>	<u>Perlites of**</u> <u>Steens Mountain</u>	
SiO ₂	75.88%	73.79%	67.05%	68.66%
Al ₂ O ₃	12.63	12.40	14.91	14.44
Fe ₂ O ₃	1.05	.52	0.92	0.80
FeO . . . . .	.27	.62	1.48	1.28
MgO . . . . .	.14	.11	0.65	0.18
CaO . . . . .	.60	.80	.44	1.96
Na ₂ O	2.80	3.16	4.15	3.86
K ₂ O	5.32	4.84	3.04	3.28
H ₂ O+ . . . . .	.54	3.24	4.35	4.80
H ₂ O- . . . . .	.43	.25	0.50 ^{1/}	0.4 ^{1/}
TiO ₂ . . . . .	.09	.09	0.34	0.25
P ₂ O ₅ . . . . .	.03	.01	0.12	traces
MnO . . . . .	.01	.02	---	---
Total	99.79%	99.85%	99.95%	99.91%

^{1/} 105° C.

*Analyses by James Kerr, University of Minnesota.

**Analyses by W. H. and F. Herdeman.

Although much research remains to be done to learn the cause of the expansion of perlite, it is generally agreed that the percentage of combined water contained in the raw material largely controls the degree and nature of the expansion during heating.

Physical properties

The Lady Frances mine in Wasco County produces from a relatively dead type of perlite a product which has a bulk specific gravity of about 12 pounds per cubic foot. The deposit near Sheaville in eastern Malheur County near the Idaho line has produced material experimentally weighing approximately 8 pounds per cubic foot, while the Paisley deposit in Lake County can be processed to produce perlite weighing from 5 to 13 pounds per cubic foot.

Popped perlite is characteristically light colored, ranging from a nearly pure white to various shades of off-white and cream. The size of the expanded perlite grains may be varied within limits by changing either the furnacing operation or the grain size of the raw material. Some perlites expand slowly and gently, producing a large proportion of spherical or globular pieces, while others tend to produce a preponderance of crushed concentric films. A few perlites, known in the trade as "puffing" perlites, have the ability to expand in a manner similar to popcorn, thus producing irregular masses measuring as much as a centimeter or more in greatest dimension.

Crushing strengths of perlites vary roughly with the bulk specific gravity. In other words, the extremely lightweight perlites have lower crushing strengths than those of greater weight. Expanded perlites having the same bulk density may have different crushing strengths depending on the type of raw material from which they were produced.

Deposits

The first deposit of perlite to be exploited in the State is at the Lady Frances mine (17) located on the Deschutes River about 14 miles south of Maupin in Wasco County. This deposit is being operated by the Dantore Division of Dant & Russell, Inc., which started operations in 1945. The property was first explored by driving a series of underground drifts and crosscuts in order to determine the tonnage and to take numerous samples for detailed expansion tests prior to the erection of the plant. Following the erection of a pilot popping plant at St. Helens, where production problems were studied, a large furnace and an acoustical tile plant were installed at the mine during 1949.

At the present time (June 1951) the Lady Frances mine is the only active producer of perlite in the State. The popping plant has a capacity of 10 carloads per week which supplies not only the acoustical tile plant having a capacity of 2 carloads per week but furnishes material which is marketed as a plaster aggregate and nursery bedding material. Since the Lady Frances mine was the first perlite deposit to be opened up in the State, the Department, which assisted in the original search for a suitable deposit, made a detailed geologic investigation (Allen, 1946).

Another deposit of perlite occurs a short distance northeast of the Lady Frances mine and on the east side of the Deschutes River. This deposit, known as the Axford-Hunt (18), has not been developed although the tonnage of perlite seems to be substantial.

A large deposit of perlite occurs in Lake County about 10 miles south of Paisley (19) on the highway to Lakeview. A low-lying hill having considerable areal extent was examined by the Department in 1949, and a large tonnage of suitable material was found to exist. This property is owned by Charles H. Combs and associates of Lakeview.

A deposit of perlite occurs near Sheaville (20) in eastern Malheur County. The deposit is owned by Northwest Perlite Corporation of Portland. Although the company has done considerable exploration and initial test work on the deposit, it has not announced definite plans for the construction of a mill and furnace. Other deposits occur at Dooley Mountain (21) in southern Baker County and at Juniper Ridge (22) southwest of Burns in Harney County.

Uses

Although perlite is a relative newcomer to the lightweight aggregate field, it has already found wide acceptance as an acoustical plaster aggregate. It is also used as a nursery bedding material; as an aggregate for monolithic concrete construction for walls, floors, and roofs; in precast concrete blocks for partitions; and to make an incombustible acoustical wallboard. One of the newest and fastest growing uses of perlite is reported by Argall (1950) to be as a mud additive for oil wells to prevent loss of circulation. It is also used in texture paints, stucco, insecticide carriers, and as a soil modifier for agriculture.* The use of perlite as a substitute for feldspar in ceramic glazes has been reported (Jacobs, 1950).

The Perlite Institute, an industry-sponsored organization, is actively engaged in seeking new markets for perlite and has helped to secure acceptance of perlite as a standard building material by underwriting companies, labor unions, and architects. The Institute is also striving for standardization of products within the perlite industry.

Volcanic Tuff

Definition

Volcanic tuff is a natural lightweight rock of volcanic origin composed largely of cemented particles of ash and pumice with minor amounts of obsidian, basalt, and other volcanic rocks. Oregon tuffs display a wide variety of colors and textures which vary from fine-grained to extremely coarse. Tuffs containing pumice lumps half an inch or more in diameter are characteristic of the Fern Ridge deposits, while the deposit near Willowdale closely resembles a true rhyolite.

Economics

Although many other excellent building stones are available in the State, such as basalt, andesite, rhyolite, sandstone, marble, granite, and slate, principal interest is at present concentrated on volcanic tuff. Deposits of tuff are generously scattered over the State. The material is easily quarried and shaped, is relatively light in weight, weathers well, and many of the deposits have a pleasing color and texture. Tuffs have the advantage of hardening with age upon exposure, and, though possessing a relatively high porosity, little difficulty from water seepage and frost damage has been reported. The high cost of labor is another factor favoring the use of volcanic tuffs, which require relatively simple equipment for quarrying and shaping. Some tuff blocks have even been cut with a carpenter's handsaw.

The currently high rail-freight rates should tend to place local stone in a better competitive position from a cost standpoint, but producers will have to overcome consumer resistance against buying a local product when they can get another material whose main appeal is the great distance that it had to be shipped.

The competitive position of Oregon building stones is improved further by an act passed by the State Legislature in 1943. This act, the full text of which appears in the appendix, grants a 5 percent differential in cost when Oregon stone is used in public buildings erected within the State.

Deposits

Pleasant Valley tuffs (23)

Tuff quarries have been operated from time to time over the past 50 or 60 years at Pleasant Valley in Baker County. Numerous private and public buildings in Baker have

* Mineral Information Service, California Division of Mines, April 1, 1951.

been constructed from this stone quarried at two pits. The deposits are located in sec. 24, T. 10 S., R. 41 E. Both U.S. Highway 30 and the Union Pacific Railroad pass close by the pits. Blocks of tuff measuring a yard or more in each direction can be obtained readily. In general, the stone is light gray and fine grained with a few scattered fragments of pumice and dark glass. Physical properties of this and other tuffs found in the State are tabulated on page 17. The apparent tonnage of stone available in the area around Pleasant Valley is large. Thickness of the bed exceeds 100 feet in places with overburden from one to 15 feet in thickness. Quarry operations can be maintained throughout the entire year. The climate is characterized by dry summers and open winters with occasional subzero temperatures.

Fern Ridge tuffs (24)

Volcanic tuffs, named from the type locality on Fern Ridge near Stayton, are exposed over a considerable area east of Salem in Marion County. The tuffs closely resemble those at Pleasant Valley, although the Fern Ridge tuffs tend to have larger inclusions of light-colored pumice and dark lumps of glass and basalt. Several quarries have been worked from time to time and numerous buildings in the Willamette Valley have been constructed with the stone which has proved to be an excellent building material in spite of its relatively great porosity.

The tuff deposits are for the most part easily accessible over existing roads. The area is characterized by gently rolling uplands and steep-sided canyons. Overburden is almost entirely lacking in places while at others there is a covering of soil with dense brush and second-growth timber. Large blocks may be obtained readily in many places. One of the principal quarries was opened more than fifty years ago by the members of the Benedictine Abbey at Mt. Angel. The quarry, located in sec. 30, T. 7 S., R. 2 E., supplied stone for numerous Marion County buildings. The Abbey still owns the ground which is currently idle but under lease. At the tuff Stone Company's quarry, located 5 miles east of Sublimity in sec. 29, T. 8 S., R. 1 E., long slabs are cut out of the quarry face with circular saws mounted on traveling carriages. This novel method permits blocks of considerable length to be cut. Blocks from this operation are being marketed in a variety of shapes and sizes.

Willowdale deposit (25)

Three miles south of Willowdale post office on U.S. Highway 97 in northern Jefferson County a bed of reddish-brown rhyolite tuff is exposed over a considerable area. Legal description of the deposit is sec. 9, T. 9 S., R. 15 E. The stone is uniformly fine grained with occasional banding of contrasting colors, caused apparently by staining. Colors range from purplish red through red brown to light red and dark pink. Physical properties are given on page 17. Chemical composition is given in the following table:

Willowdale Tuff*

SiO ₂ (Silica)	71.58%
Al ₂ O ₃ (Alumina)	11.09
Fe ₂ O ₃ (Iron oxide)	1.57
CaO (Lime)	1.28
MgO (Magnesia)	0.88
TiO ₂ (Titania)	0.38
K ₂ O (Potash)	4.10
Na ₂ O (Soda)	3.98
Ignition loss	2.14

*Analysis by L. L. Hoagland, chemist, Oregon Department of Geology and Mineral Industries.

Table 1

Physical Properties of some Oregon Volcanic Tuffs

<u>Deposit</u>	<u>Crushing strength (lbs/sq.in.)</u>	<u>Apparent porosity^{1/}</u>	<u>Water of absorption^{2/}</u>	<u>Specific gravity</u>	<u>Color</u>	<u>Texture</u>	<u>Remarks</u>
Pleasant Valley tuff (Baker County)	2,916	33.9 %	22.3 %	1.53	Dark gray	Coarse grained	Considerable production in past.
Tuff Stone Company (Marion County)	1200-1900	38.4	33.20	1.14	Dark gray	Coarse grained	Producing sawed blocks with trav- eling quarry saw.
Mt. Angel tuff (Marion County)	---	36.0	26.6	1.35	Dark Gray	Coarse grained	Considerable production in past.
Willowdale tuff (Jefferson County)	3200-5000	22.9-31.6	12.1-21.9	1.66-1.89	Pink red brown	Medium fine grained	Deposit undeveloped.
Crooked River tuff (Crook County)	13,859	17.1	9.4	1.82	Cream white	Fine grained	Deposit undeveloped.
Pine Grove tuff (Wasco County)	---	34.9	22.90	1.53	Cream with pink and red bands	Medium fine grained	Small pro- duction at present.

^{1/} Apparent porosity is obtained by dividing the weight of absorbed water (in grams) by the volume (in cubic centimeters) of the stone.

^{2/} Water of absorption is obtained by dividing the weight of water absorbed by the weight of the dry stone.

The stone crops out close to the highway; the nearest railroad siding is at Gateway about 8 miles west on the Oregon Trunk Railway. Little or no overburden covers the deposit, one side of which forms a low cliff rising approximately 50 feet above the level of the valley floor.

In the past, production was limited to the sale of rough stone on a tonnage basis. The quarry site has been leased recently and an operator is planning on setting up stone-sawing equipment (1951). The attractive appearance of the stone, combined with its relatively low porosity and high crushing strength would indicate that it might have considerable appeal as a building stone.

Crooked River locality (26)

A deposit of rhyolite tuff of unusual attractiveness occurs in western Crook County in sec. 21, T. 16 S., R. 17 E. The locality is reached by taking the graveled Combs Flat road southeast from Prineville for a distance 17 miles to the junction at Crooked River, thence downstream for approximately 5 miles to the Bailey School at the mouth of Owl Creek. The rhyolite tuff beds lie a short distance to the northeast of the Carey Ranch which is about 1 mile up Owl Creek from the school house. The rock crops out along a fairly steep hillside for a distance of half a mile or more in a series of beds which dip steeply into the hill.

The tuff is dense and has a uniform texture. The matrix is a pale-pinkish color in which numerous creamy-white patches occur. In addition, there are some tiny black rock fragments which add interest to the appearance of the stone. It possesses a low apparent porosity and a remarkably high crushing strength. The specific gravity is much less than most common building stone; it can be sawed readily and little if any raveling or pitting has been observed. Architects who have seen the stone have been optimistic over its possibilities, since it would provide them with a new material which would be easy to prepare and would be an Oregon stone.

Table 1 on page 17 summarizes the physical properties of the Crooked River stone and compares them with other Oregon stones. The chemical composition of the stone is given in the following table:

Crooked River Tuff*	
SiO ₂ (Silica)	67.15%
Fe ₂ O ₃ (Iron oxide)	1.36
Al ₂ O ₃ (Alumina)	13.30
CuO (Lime)	3.88
MgO (Magnesia)	0.62
K ₂ O (Potash)	1.63
Na ₂ O (Soda)	3.03
Ignition loss	9.67

Blocks several feet square may be obtained from the deposit which has not as yet been developed. The stone can be sawed readily and it splits quite easily along one plane.

Pine Grove deposit (27)

Platy volcanic tuff occurs in Wasco County about 5 miles south of Pine Grove in the NW¹/₄ sec. 11, T. 6 S., R. 11 E. Colors range from greenish through gray to buff. Some portions of the tuff have bands of dark red or brown which give the stone an interesting pattern. A small amount of stone has been quarried. Physical properties of the tuff are given in the table on page 17.

*Analysis by L. L. Hoagland, chemist, Oregon Department of Geology and Mineral Industries.

Conclusions

In Oregon there appears to be an excellent opportunity for the production of a new type of lightweight aggregate. A mixture consisting of crushed, nonexpanding clay or shale and some combustible material such as sawdust or coal forms a feed which when ignited in a specially designed traveling-grate kiln produces a lightweight aggregate clinker suitable for use in standard applications. Since Oregon has limitless occurrences of clays and shales often located adjacent to quantities of sawdust and low-grade coal deposits, this manufacturing process would seem to offer considerable inducement to operators possessing sufficient capital to build the necessary plant.

The future of the lightweight aggregate industry in Oregon seems destined to be one of continual growth. A steady influx of residents and industry should create a large demand for building materials for years to come. It will be up to the lightweight aggregate producers to secure their just share of this business. Reserves of pumice, perlite, diatomite, expandable shale, and volcanic cinders are large, of good grade, and generally quite well located with respect to markets or transportation.

The industry has little competition from out-of-state producers because few of the out-of-state deposits are located close enough to markets in Oregon to stand the cost of transporting the low-value material. The main problem facing lightweight aggregate producers will apparently be consumer acceptance. Any new commodity must overcome a certain amount of sales resistance from consumers accustomed to familiar products. Once this reluctance to change has been overcome there remains the continuing problem of producing a superior product having a minimum variation in composition and specifications. Non-metallic producers, unlike metal miners, have to keep "selling" their customers.

Competition in the lightweight aggregate business is between individual producers of the same product and also between producers of different types of material which may be suitable for the same job or same customer. An exception to this condition exists among the "Haydite" producers who are licensed by areas. In Oregon, however, this advantage is offset by the production and sale of an expanded shale almost identical to "Haydite" from similar raw material.

Appendix

Results of Test Work on Coating Lump Pumice

Purpose

The test work described below was undertaken with the hope that some simple and inexpensive method might be discovered to coat pumice lumps and thus to improve the material as an aggregate in concrete mixes. Pumice has high moisture absorption characteristics and there would be a very definite advantage in lessening the porosity of the pumice surface. High absorption is undesirable because: (1) an excess of water and cement must be added to the mix, (2) precast blocks show an unduly great amount of shrinkage, and (3) the time required to cure pumice blocks appears to be greater than that for standard sand-cement-gravel units. If these disadvantages can be either overcome or diminished appreciably at moderate cost, the producers of pumice could supply the trade with a superior product.

Scope

The Department is not equipped to do elaborate physical testing, and only simple preliminary research into the problem could be attempted. Two series of tests were carried out. In the first series nine coating materials were tested on pumice lumps from one deposit. In the second series the two coatings which gave the best results in the first test were used to coat pumice lumps from five different deposits in central Oregon.

Description of tests

In the first series $\frac{1}{4}$ -inch lumps of Chemult pumice were immersed in slurries of the following materials: (1) pumicite, (2) expanded perlite, (3) ground limonite, (4) silt from Columbia Brick Works at Gresham, (5) volcanic ash from Gilliam County, (6) the same ash ground to -200 mesh, (7) obsidian, (8) a 50-percent solution of sodium silicate, and (9) ground pumice lumps. All of these materials, with the exception of the coarse volcanic ash from Gilliam County and the sodium silicate, were ground to approximately 200 mesh. The lumps were immersed in each of the slurries for about 30 seconds and then allowed to dry before being placed in an electric furnace, heated to 1950° F. Two test runs were made; in the first the lumps were calcined for 15 seconds and in the second they were calcined for 1 minute. Immediately after calcining, the lumps were removed from the furnace and allowed to air cool.

The lumps were next placed in water and the time required for them to lose their buoyancy was noted. Due to the small amount of material used in the preliminary testing, the data were regarded as indicative rather than conclusive. Several anomalies, or at least wide variations, were observed, probably caused by differences in textures of the lumps. Of the nine coating materials tested, two proved far superior to the remaining seven. The samples coated with coarse ash from Gilliam County and the ground pumice from the Chemult area floated nearly twice as long as the next best coating material.

In the second series of tests, larger quantities of pumice from the five cooperating producers' deposits were coated with the ash and ground pumice and calcined for 10 minutes at 1950° F. A longer calcination period was used to permit a more complete fusion of the coatings if possible, since examination of the coatings of the lumps in the first test under the binocular microscope revealed that fusion was incomplete in nearly every case. The coated lumps were saturated as in the first test, after being weighed dry. A comparison of the absorption of the two series of coated lumps with similar uncoated lumps is given in the following table:

<u>Samples</u>	<u>Percent Absorption</u>			<u>Percent Improvement</u>	
	<u>Uncoated</u>	<u>Coated with</u>		<u>Chemult pumice</u>	<u>Gilliam ash</u>
		<u>Chemult pumice</u>	<u>Gilliam ash</u>		
1	114.0	70.0	43.0	44.0	71.0
2	90.3	79.0	47.3	11.3	43.0
3	99.0	79.1	61.2	19.9	37.8
4	100.0	85.0	56.3	15.0	43.7
5	59.6	52.9	54.5	6.7	5.1

Note: Test work was undertaken in order to point to the value of coatings, not to indicate relative quality of pumice used; therefore source of pumice samples is not given.

From the above table it is evident that considerable improvement in reducing the absorption of pumice was obtained by coating and calcining the lumps. The volcanic ash from Gilliam County consists of thin glassy shards. Apparently the tiny curved plates seal the pores more effectively than finely ground materials. In the first series of tests Gilliam County ash ground to -200 mesh proved to be less than one half as effective as the natural unground material.

Conclusions

From the preliminary test work it is apparent that the porosity of pumice lumps of the size used in block manufacture can be coated effectively with either ground pumice or volcanic ash from a deposit in Gilliam County. While the latter material is considerably better, the economics involved in transportation might be such that the use of ground pumice would be more feasible.

No data are available concerning costs of treating lump pumice in the manner described. Testing on a pilot-plant scale would need to be done to determine the economics of operation. It is believed that even more effective coatings can be developed as only a few of the large number of possible variations in types of coating materials, fineness of grind, methods of coating, and calcining have been tried.

AN ACT
(Senate Bill 18)

To encourage the production of industrial and building material mined and produced in the State of Oregon.

BE IT ENACTED BY THE PEOPLE OF THE STATE OF OREGON:

Section 1. Any board, commission, officer, employee or other person or persons acting for the state, or any county, municipality or taxing district whose duty it is or may be to purchase or contract for the use of any nonmetallic mineral construction material or materials, except cement, sand, gravel, crushed rock and plaster, to be used in the construction of public buildings or other structures on behalf of the state, county, municipality or taxing district, shall select, purchase or contract for the use of such materials as are produced or manufactured in the state of Oregon when the prices quoted for the same are not more than 5 percent in excess of the lowest bids or prices quoted for the same materials produced or manufactured elsewhere, quality and service considered.

Section 2. In all cases wherein such building or construction materials are or can be produced in Oregon, the architect or other person preparing the specifications shall require that all bidders shall submit alternate bids covering the use of such Oregon materials and the use of materials from outside the state.

Section 3. With respect to such common building materials as cement, sand, crushed rock, gravel, plaster, etc., for such buildings and structures, the contractor shall be required to use Oregon produced or manufactured materials in all cases where the bid prices of such materials are no greater than those of similar materials produced or manufactured outside of Oregon.

Section 4. This act shall not apply in any case wherein the provisions hereof interfere or conflict with federal statutes or regulations.

Approved by the governor February 6, 1943.

Filed in the office of the secretary of state February 8, 1943.

Oregon Laws, 1943, Chapter 24, page 30.

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