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THE LIGHTWEIGHT AGGREGATE, PUMICE

by

N. S. Wagner[1]

Interest in Oregon pumice occurrences is nothing new. For years people have toyed with the idea of developing it for aggregate purposes, but past production never amounted to much - was very limited and sporadic.

The California Stucco Products Company was perhaps the first company to attempt to develop the field in anything resembling a large scale. This company opened a pit near Chemult, Oregon. The history of this operation began and ended in 1929. Many obstacles existed, not the least of which were transportation difficulties and consumer indifference.

Today the picture has changed. Both the prevalent building boom and the building materials shortage have contributed to the public demand. What is more important, during the nearly 20 years that have elapsed since the California Stucco Products Company endeavored to operate, the public has become "insulation" conscious. Thus, the consumer is as interested in insulative value as he is in lightness of weight, and since pumice possesses both of these properties, it is being actively produced as an aggregate today.

This current activity in connection with pumice mining in Oregon is the chief subject of this talk. To begin with, however, it might be well to tell you something about the rock itself - and the nature of its occurrence.

Origin

As is generally known, pumice is a volcanic rock. As such, pumice belongs to the variety of rocks that originates from a molten magma which has been erupted to the surface of the earth.

By no means does all such magma make pumice, nor does it even make a lightweight rock. In fact, most magmas are extruded as lavas which cool to form rocks that are dense and stony or glassy in texture and have corresponding specific gravities. Yet as a rock, pumice has such a highly developed cellular structure that it will float on water.

What then are the circumstances under which pumice acquires this cellular structure? As the reasons back of the formation of this cellular structure are tied in with the composition of pumice and also with the very nature of its occurrence, I am going to outline the mechanics of the origin in some detail.

In the first place, volcanic eruptions occur in two distinct ways. Sometimes molten magma will just well up and be discharged from the vent as a lava which will flow over the surrounding country and eventually solidify. Sometimes the molten magma within a volcano will be erupted so explosively that solidified fragments will be hurled high into the air.

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[1] Field Geologist, State Department of Geology and Mineral Industries, Baker, Oregon. From a talk given before the Associated Concrete Products Manufacturers, March 7, 1947, at Portland, Oregon.

Under such circumstances, the fragments will rain down to blanket the surrounding country with an unconsolidated assortment of volcanic materials. Explosive eruptions may assume such proportions that the finer ashes are blown to the level of the upper air currents which may carry them thousands of miles before they fall. Naturally enough, the larger and heavier pieces of ejecta fall near the vent, or directly upon the volcano itself. As a volcanic product, pumice is explosively ejected in fragmentary form, and falls both near the volcano or far away depending on the size of fragments.

Now geologic events and processes, no matter what sort of events or processes, or no matter how obscured and complicated they may seem to be before they are understood, are, in the last analysis, governed by the common ordinary variety of physical and chemical laws. Thus, it isn't just happenstance that there are two types of volcanic eruptions, and that pumice deposits are associated with the explosive type.

The picture is this: Molten magma isn't just melted rock. Molten magma is melted rock more or less highly charged with gasses. It differs from lava in much the same manner that soda water differs from ordinary water.

In the deep magma reservoirs within the earth, pressure is so tremendous that these gasses remain dissolved and dissociated within the magma. So long as the magma remains static, all is well. But when the magma is forced to the surface of the earth, this pressure is reduced and the gasses are liberated. It is the <u>manner</u> in which these gasses are liberated that is important. Whether they escape passively or violently has a profound bearing on the nature of the surface manifestations of volcanic activity. If the gasses can escape freely, then the surface manifestations of volcanic activity are characterized by lava flows. When gas escape is impeded conditions favor the explosive fragmental type of eruption.

It goes without saying that many factors may impede gas escape, but in this connection the composition of the melt itself remains as perhaps one of the most important. Melts of both basic and siliceous composition will make lava flows - but each in its own characteristic way, and because of its own individual characteristics. Melts of basic composition are notably fluid and because of their lower melting point they remain fluid longer than those of siliceous makeup. These factors combine to permit a relatively free and regulated liberation of gas. Because of relatively low melting points, basic melts will flow long distances over even gently sloping surfaces. Volcanic cones built of basic lavas may attain great heights, but they are typified by gently sloping flanks (2-8°), and by bases whose diameter may be many times greater than their height. The very eruptions of such volcanoes are as distinctive as is their shape - the eruptions consisting of great billowing clouds of smoke and relatively passive outpourings of molten rock.

Melts of siliceous composition,on the other hand, tend to be viscous and they solidify quickly. Thus they don't flow readily and, because they cool quickly, they commonly congeal on steep slopes after flowing only a short distance. Thus volcanic cones built of siliceous lavas are characterized by steep sides and bases which are of small areal extent in proportion to their height. This viscosity and tendency to solidify quickly impedes the liberation of contained gas with the result that eruptions associated with lavas of siliceous composition are punctuated by explosive bursts. In addition to the general outpourings of molten lavas, cappings of congealed lavas are also shattered and hurled into the air.

Pumice originates from the more siliceous lavas. To make a long story short, the formation of pumice represents one phase in the eruption of siliceous lavas, a phase in which the relief of gas pressure is so excessively rapid as to transform the lava into a froth, and in which eruption is accomplished in so explosive a manner that this froth is broken into fragments which are shot high into the air as already mentioned.

So much for the origin of pumice. The overall account of volcanic activity as just presented has been reduced to the barest essentials. The types of volcanic activity and volcanoes described represent the extremes in type, and they are here described as more or less ideal examples. One of the things which befuddle geologist in making field interpretations of geologic processes, whether the process be the mechanics of volcanism, or the mechanics of ore formation, or any other aspect of geologic happening, is that these processes rarely ever carry through to completion in a simple, uninterrupted manner in nature. Thus, actually, most volcanoes in the world today represent composites of the two types mentioned. The very character of a magma often changes during the life cycle of a given volcano or, perhaps, the magmas involved were fundamentally of an intermediate composition from the outset - neither truly siliceous nor truly basic.

Oregon deposits

In Oregon we have extensive pumice deposits. It was Mt. Mazama (which is the name given to the formerly active volcano situated where Crater Lake now is) and several lesser volcanoes in the general region, which erupted these deposits. For the most part, these volcanoes erupted basic lavas in a characteristically passive manner. It was only during the later part of the volcanism that lavas became more acid and eruptions became increasingly explosive in nature. Nevertheless, the pumice deposits cover an area embracing some 3500 square miles according to Moore[2] who studied them extensively in 1930. This area lies east of Crater Lake between Bend and Klamath Falls and embraces the southern portion of Deschutes County, the northern part of Klamath County, and the northwest corner of Lake County.

Several different overlapping pumice falls are recognized. An attempt to describe them individually would entail needless confusion. For our purposes here, it will be sufficient to say that the volume of frothy pumiceous and scoriaceous glass erupted from Mt. Mazama alone has been calculated by Williams[3] at 7.5 cubic miles.

By way of contrast, the figures on the smallest deposit described by Moore - that of the Newberry Crater - reads like this, "If the area covered by the pumice sheet is reckoned at 150 square miles, and the average thickness is taken as 2 feet, a total of 300,000,000 cubic yards is obtained."

Taking the "Younger Pumice of Crater Lake," as it is known, this fall forms a single sheet which covers about 3000 square miles. This fall has an average thickness of 6 feet near the center of the deposit and tapers to a foot at the margins. Moore's estimate, based on an average thickness of 3 feet, amounts to 45,000,000,000 cubic yards.

The significant thing with us here now is that, assuming pumice should prove to have lasting value as an aggregate, or as a resource, there is an almost unlimited quantity of it to be had. Of course, as a low unit value product, only such pumice as is advantageously situated with respect to transportation can ever be regarded as minable. But in this respect the Southern Pacific and the Great Northern Railways, as well as several first class highways, cut through some of the best of the deposits.

In presenting the figures on the dimensions of the deposits you will recall that the thicknesses were given as averaging 2 and 3 feet. These figures may be misleading and may serve to give the wrong impression. When the pumice fell it filled valleys and canyons, and it has also been drifted by wind. Thus locally thicknesses of 30 and 40 feet are not uncommon and many greater ones have been measured.

When pumice falls like this, it also segregates. Big pieces fall close to the vents, and the smaller ones proportionately farther away. To try to give screen analyses would be as confusing as trying to discuss the volume in detail. Places showing great variations in fragment size can be found if one wanted to search for extremes. But for mining purposes in connection with aggregate production, miles and miles of pumice exist in which the fragment sizes range from an inch or so down to sands.

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[2] Moore, B.N., Nonmetallic mineral resources of eastern Oregon: U.S. Geol. Survey Bull. 875. 1937.

[3] Williams, Howel, The geology of Crater Lake National Park, Oregon: Carnegie Inst. Washington Pub. 540, 1942.

Composition

That pumice is siliceous in composition has already been pointed out. However, a complete chemical breakdown might be of especial interest. Silica, alumina, and soda in the order mentioned are the three most abundant constituents. In a typical pumice the silica amounts to about 69 percent; the alumina averages about 15 percent; and the sodium oxide about 5 percent. Potash, lime, and water are the next three most abundant constituents, running just a little over 2 percent each. Iron oxides are fairly constant at 2.75 percent. Titanium, manganese, magnesium, and phosphorus occur in amounts of less than 1 percent. All of the foregoing substances are combined as a glass.

Mining operations

Six Oregon pumice producers commenced operations in 1945. While three of them were in limited production early in the year, two did not get started until July, and the sixth not until the end of the year.

The production figures for 1946 sound insignificant in terms of the figures mentioned above or, for that matter, in terms of the production figures you are accustomed to dealing with. Just the same they are impressive. The 1946 production of pumice aggregate totaled 26,614 cubic yards with a value of $43,649.00 at the plant.

The impressive part about pumice production to me is not what it was last year, but what it is going to be this year. Last year operators were just getting themselves established. The indications are that 1947 production will be appreciably greater. For instance, in discussing this subject with me, one of the two largest producers in the Bend region tallied his shipment records for the first 15 days of February just past. His production for that month amounted to half of his entire last year's production.

The mining and processing of pumice, as it is now carried on, is the essence of simplicity. Around Bend, where 5 of the 6 producers are set up, mining is accomplished by dozers and scrapers. At one of the largest pits the only item of mining equipment is a Lull loader which digs and loads the pumice out directly. The small amount of overburden that is handled is removed by dozer on a contract basis. In this particular instance the operator is also marketing volcanic cinders, and his processing plant is situated on a railway siding located halfway between the two deposits. One other producer who mines aggregate for use in his own block plant, and not for retail, trucks pit-run material to his plant where it is processed. All other producers have screening and sizing plants at their pits and mine by dozing the pumice to elevator traps.

The largest single operation is at Chemult, and here a dozer and carryall has been used in the past, but a slackline with a 450-foot sweep has just been set up and will be used in the future. Incidentally, a 15-car siding has just been installed there.

Processing plants consist of shaker screens and rolls. Present practice consists of crushing and screening to one quarter- or three eighths-inch mesh, or whatever the customer wants. No further sizing is done, but some producers mix small amounts of pumice sand with their products if they judge the natural amount of fines to be insufficient. After this processing, the pumice is ready for delivery. Shipments are made both by motor truck and rail. In the Bend area trucking distances to the rail sidings vary from 1½ to 8 miles, with two of the biggest producers having 5- and 8-mile hauls. Truck distribution using semi-trailers has reportedly reached to such points as Vancouver, Washington, and Redding, California.

Only recently have rail rates been published but, since they have been established, rail deliveries have been made to points as far away as Bellingham, Washington, and King City, California. A considerable amount of the production is delivered by rail to San Francisco and Portland. The largest producer estimates that 30 percent of his deliveries are by truck and 70 percent by rail.

Prices for pumice aggregate range from $1.25 to $1.85 per cubic yard loaded f.o.b. railroad cars or trucks.

The weight of pumice varies from pit to pit, but usually runs about 1100 pounds per cubic yard, pit run. What the weight of truly dry pumice is, I do not know. No shipper dries it although one operator is planning to do so. However, neither shipping in open cars during the winter nor mining during the stormy season has imposed any special difficulties so far. One operator whose shipments normally weigh out around 1050 pounds per cubic yard, found that the weight only jumped to about 1250 pounds during the winter.

Problems

One problem of serious nature is beginning to take shape. The aggregate as processed today tends to segregate during shipment. Also, when it is unloaded and stockpiled at the consumers' plants, there is a marked tendency for the fines to concentrate in the center of the piles, leaving the coarser sizes on the sides. Thus consumers who are operating small block plants, and who feed their mixer by shoveling off the stockpiles, find themselves making blocks of varying density from day to day depending on what portion of the stockpile they are drawing from.

I have heard many complaints about this from consumers. The solution, of course, is simple - and is one that perhaps should be practiced in the interest of putting out the best possible concrete products that can be made with pumice. That is, the making of clean, sized aggregate of both coarse and fine mesh.

One block manufacturer in eastern Oregon does size his aggregate, and he produces pumice for his own use. Of 12 block plants in eastern Oregon, which I have visited within the last 8 weeks, this is the only plant using a fixed charge of sized aggregate. The practice there is to size the pumice into minus 3/16-inch mesh, and into a plus 3/16-inch, minus 3/8-inch mesh, using them in a 60 to 40 ratio.

Otherwise, all that the other consumers have done about the situation to date is to complain and occasionally to switch producers in the hope of obtaining more satisfactory aggregate. One plant operator, however, has expressed his intentions of installing sizing equipment of his own if the producers themselves do not.

Other problems with respect to the use of pumice aggregate exist, but these are in the province of the consumer rather than the producer.

From my visits to block producers, I gather that on account of its high porosity, pumice does not cure the same as does common sand.

At least practices differ widely, and each block-plant operator has his own ideas on the subject. The problem would certainly seem to be one worth study to determine what the best practices might be.

Some question also exists concerning the best type of block machine for use with pumice, because of the capacity of pumice to float. This question was brought to light in an interesting way. One pumice operator has an overburden of a pink-colored assortment of ash and glass fragments. At one time one of his consumers who visited his pit decided that he would like to have a certain amount of this overburden ground fine and mixed with his aggregate. In its natural state the ash is very light in weight, but upon being ground quite fine, the producer reported that it became conspicuously heavy, its structure evidently being destroyed. It so happens that the consumer in question had used a vibrating-type block machine. His experience reportedly was that this special fraction tended to sink to the bottom of his blocks as was revealed by a dense, off-color streak.

If segregation does occur to this extent, it is worth knowing because, at present, many block manufacturers practice adding a fraction of common sand to their mix in the belief that it enhances their product. Since sand does not possess any conspicuous off-color, the question remains as to how much it tends to segregate with vibration. This might be another problem well worth at least a little investigation to determine how real it is, and what the best means for handling pumice mixes might be.

Conclusion

Such is the picture of the activity in connection with the production of pumice aggregate today. We have extensive deposits in Oregon, and several operators have taken advantage of the prevailing building boom and materials scarcity to try to develop the field. Experience indicates that it can be processed and shipped long distances at reasonably low cost. What the picture will be a few years from now - that is, whether or not a continuing demand for pumice aggregate will exist, will depend to a large measure on how successfully the pumice is used today.

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2,4-D

Not an isotope, not the number of a government order; it is the abbreviated name for 2,4-dichlorophenoxyacetic acid (you do not question the need of an abbreviation). And why is 2,4-D important? This is explained in the lead article of the February issue of The Scientific Monthly, the official publication of the American Association for the Advancement of Science. The article is entitled "2,4-D, a Potent Growth Regulator of Plants," and was written by Dr. H. B. Tukey of Michigan State College. Dr. Tukey states that 2,4-D has the earmarks of being to the plant world what the insecticide DDT has been to the insect world, and some of his further interesting comments are given in the following abstract:

In popular usage "2,4-D" has been used to mean any preparation that contains 2,4-dichlorophenoxyacetic acid or any of its salts, esters, amides or related compounds.

2,4-D is prepared by the chlorination of phenol (carbolic acid). The phenol compound is neutralized with sodium carbonate to form a sodium salt of 2,4-dichlorophenol which is then combined with chloracetic acid to give 2,4-dichlorophenoxyacetic acid. The process is cheap and lends itself to large commercial operations.

Physical properties add to the usefulness of this material. In refined form it is a white powder having no offensive odor or corrosive action on skin or container. It appears to be nontoxic to animals in the concentrations commonly used.

The acid itself is difficultly soluble in water. It is dissolved first in alcohol, then in water or some solvent such as polyethylene glycols. Sodium and ammonium salts are water-soluble and are generally equally as effective as the acid.

As a herbicide 2,4-D is used in a water-spray diluted to about 1 part per thousand. It may be applied in aerosol form just as DDT is used in aerosol bombs. For heavy concentrations in pastes and salves, lanolin may be used with other solvents in concentrations up to 1:100 or 1:200.

Many investigators have participated in studies of growth regulators, which are defined by Dr. Tukey as a group of chemicals which do not enter into the composition of the plant as do fertilizers but which used in minute amounts cause changes or effects in growth.

In the 1920's investigators established the fact that hormones entered into plant growth just as in animals. These plant hormones were isolated and a large amount of research was conducted on their growth-regulating properties. One of the growth regulators tested was known as 2,4-dichlorophenoxyacetic acid and entered into a patent assigned to E. I. Dupont de Nemours Company. At first the acid as applied showed powerful regulating activities but often so powerful that it was injurious. At this time it was discovered that growth regulators had practical uses such as rooting of cuttings and the prevention of pre-harvest drop of apples. From this followed work by investigators in the University of Chicago demonstrating the herbicidal properties of the chemical. In 1944 the Chemical Warfare Service became concerned and secret investigations were conducted at Camp Detrick, which included work in the U. S. Department of Agriculture and Ohio State University.

In the same year the paper by Hamner and Tukey was published which described successful field tests using the 2,4-D as a herbicide on bindweed.

During this time the American Chemical Paint Company conducted field trials independently and patented the material as a herbicide. This company as well as other companies went into production of the chemical in a large way and the price dropped from $125 a pound to $3.00. Inside of two years the value of production amounted to millions of dollars. Results of field work in 1945 and 1946, both in this country and in Europe, indicated successful use of 2,4-D as a herbicide. The reports showed that favorable results were obtained in inhibiting the growth of bindweed and sow thistle. The pollen of flowers shriveled, leading to the application of 2,4-D to destroy ragweed pollen in an attempt to reduce hay fever. Plants such as lamb's-quarters and pigweed were killed. The material has selectivity and it has been found that it would kill dandelion and narrow-leaf plantain without injuring the grass. With the exception of Bermuda grass, it was found that grasses and cereals were unaffected by concentrations that were toxic to broad-leaved plants as applied to grains. Wild radish, mustard, and the like were killed without injuring oats and wheat. A favorable result was obtained by dusting rice fields from an airplane.

It was found that 2,4-D was successful when applied to woody plants the same as to herbaceous plants and was most successful in periods of active plant growth, in sunlight, and at high temperatures. There were many examples of success in treating various trees and eliminating suckers.

By proper treatment weed seed may be destroyed in the soil. It is stated that amounts applied to the soil have ranged from 3 to 5 to 10 pounds per acre. Results appear to be better on sandy soils than on muck soils. Many details of treatment to eliminate weed seed are yet to be worked out.

2,4-D appears at present to be the most potent of the growth regulators. Much work is required to determine the many details of the usefulness of these materials.

Quoting from the Number 55 issue of Cenco News Chats, the house organ of the Central Scientific Company, Chicago,

> "A solution of 2,4-D containing as little as 1 - 1/3 ounces of the chemical in 10 gallons of water (1/10 of 1 percent by weight) when used as a spray is deadly to many species of broad-leaved plants. Some species on which it has been effective are:

Dandelion	Daisy	Three-seeded mercury
Narrow-leaf plantain	Heal-all	Burdock
Lawn pennywort	Chickweed	Wild mustard
Japanese honeysuckle	Winter cress	Frenchweed
False strawberry	Pokeweed	Wild lettuce
Annual morning-glory	Curled dock	Annual sow thistle
Broad-leaf plantain	Ragweed	Pigweed
	Poison ivy	

> "The same is true of many other woody plants and of perennial farm weeds, including bindweed, Canada thistle, white top, Russian knapweed, leafy spurge, Klamath weed, perennial sow thistle, Texas blue weed, gaura, and others. Many experiments are in progress on various weeds and the results have been promising.

> "2,4-D has not been found effective on crabgrass, quakegrass, Johnson grass, nutgrass, or other weedy grasses and sedges. It does affect bent grass and anyone with a bent grass lawn should be cautious about this new treatment. A favorable feature of the 2,4-D spray is that it does not hurt Kentucky bluegrass, annual bluegrass, redtop, fescue, and buffalo grass. It will kill or seriously retard the growth of White Dutch clover."

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PERLITE MINE IN COMMERCIAL PRODUCTION

Dant and Russell, Inc., perlite division, is now processing perlite mined from the Lady Frances mine on the Deschutes River, southern Wasco County, Oregon. The material is crushed and sized at the mine and then shipped to the furnace plant at St. Helens on the Columbia River, north of Portland. Two commercial products are being marketed - a superior plaster sand which weighs about 12 pounds per cubic foot, and an accoustical plaster made up essentially of perlite plus a binder. Both products possess many advantages in building construction, and will come to be recognized as representing a forward step in building technique.

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NEW CHIEF, CALIFORNIA DIVISION OF MINES

Dr. Olaf P. Jenkins, Chief Geologist of the California Division of Mines since 1929, has been appointed Chief, Division of Mines, succeeding W. W. Bradley who for many years was State Mineralogist and has now retired.

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PUBLIC LAND POLICY OF NORTHWEST MINING ASSOCIATION
52nd Annual Meeting - 1946

We disapprove of public land policies by which Federal administrative agencies have used arbitrary and dictatorial methods to acquire more and more land to the detriment of state and county tax rolls. In some instances such methods have been employed to withdraw lands from application of the U.S. mining laws as was done in setting up a program of sustained yield of timber on 2½ million acres of the old Oregon and California Railroad revested lands in western Oregon.

We therefore urge the following:

1. That Congress continue its review of Western land policies, particularly withdrawal policies.
2. That no land withdrawals be made without public hearings in the states affected.
3. That the Mineral Leasing Act of February 25, 1920, be not extended to include other minerals.
4. That there should be no basic change in our mining laws which provide for discovery, location, and patent.
5. That lands acquired by the Federal government and not needed for clearly defined governmental purposes be disposed of, and that the lands retained be administered with respect to their mineral content under the public land laws applicable to both metalliferous and nonmetalliferous minerals.
6. That full support be given to Oregon's Senator Cordon in his efforts to return lands designated as O. and C. Railroad revested lands to their rightful status as potential producers of mineral wealth.

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WASHINGTON FUEL REPORT ISSUED

A comprehensive report entitled "Washington Fuel Requirements and Supplies" has just been issued by the State of Washington, Dept. of Conservation and Development. This report is the result of a study by the Battelle Memorial Institute. A limited number of copies are available at the Dept. of Conservation and Development, Olympia, Washington., at a price of $10.00. In Oregon, the report is on open file at the following places: Oreg. Dept. of Geology & Mineral Industries, Portland Chamber of Commerce, Bonneville Power Admin. offices, and the U.S. Bureau of Mines, Albany.

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