DEPARTMENT OF MINERAL RESOURCES

STATE OF ARIZONA
Phoenix, Arizona

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P E R L I T E

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P E R L I T E

PRODUCTION AND USE

INTRODUCTION:

The volume of inquiries reaching this department has made necessary a report on the relatively new material, perlite.

This report is not intended as a technical treatise on the production or uses of perlite, but is rather a collection of facts and opinions, often without correlation, by which those interested might find answers, in part, to inquiries on the subject.

ACKNOWLEDGMENTS:

In the course of obtaining authentic material for the preparation of this report, every known producer of perlite or fabricator of perlite products, whether within the State or without, was invited to submit pertinent data.

Apologies are offered those who may have been overlooked in locating perlite producers and fabricators, and sincere gratitude is expressed to those listed below who contributed, or offered to contribute and assemble, information for this report and for the benefit of the industry in general:

Alexite Engineering Co., Colorado Springs, Colorado
Great Lakes Carbon Co., Los Angeles, California
Murdock & Bassler, Phoenix, Arizona
National Perlite Company, Campbell, California
Rheem Research Products Co., Los Angeles, California
United States Perlite Co., Los Angeles, California
Western Perlite Corporation, Phoenix, Arizona

Free use has been made of the reports of:

U. S. Bureau of Mines, I. C. 7364
"Perlite, Source of Synthetic Pumice", Oliver C. Rolston, August 1946.

Arizona Bureau of Mines, "Arizona Perlite", Eldred D. Wilson and George H. Roseveare, October 1945.

Arizona Bureau of Mines, Metallurgical Tests Ore No. 712, E. H. Crabtree, Jr.

Both of the above agencies have accomplished much and are now engaged in experimentation on the production and uses of perlite. Considerable neutral and authentic information may be expected from these sources in the future.

DEFINITION:

"Perlite is a silicious volcanic glass containing between two and five percent of water. When heated to proper temperature it 'pops' or suddenly expands into lightweight cellular glass fragments."(1)* It is closely related to obsidian and pitchstone and is found in proximity to a variety of glasses of volcanic origin.

Not being a common host rock for metallics, nor in itself having had particular merit in commercial fields, it has been only in the past few years that more than passing attention has been given perlite.

"Since perlite is a volcanic glass, a study of perlite involves consideration of its distinguishing features and origin as compared with other volcanic glasses", and is discussed by Eldred D. Wilson and George H. Roseveare as follows:

> "Species: The principal volcanic glasses are obsidian, perlite, pitchstone, vitrophyre, tachylite, pumice and vitric or glassy tuff. They were originally defined according to their most obvious or external physical properties, but positive distinction between obsidian, perlite, and pitchstone is based upon the amount of combined water present. Accordingly, the content of water that can be driven off above 110 degrees Centigrade (expressed in analyses as plus H_2O) is less than one percent in obsidian, about 2 to 5 percent in perlite, and 5 to 10 percent in pitchstone. Some published analyses of obsidian, perlite, and pitchstone are as follows:

		Perlite			
	Obsidian (a)	rhyolitic (b)	dacitic (c)	andesitic (d)	Pitchstone (e)
SiO_2	:73.84	:74.73	:69.56	:65.13	:70.19
Al_2O_3	:13.00	:10.82	:15.65	:15.73	:12.37
Fe_2O_3	: 1.82	: 2.46	: 1.24	: 2.24	: 1.45

*(1) Eldred D. Wilson, Arizona Bureau of Mines.

	Obsidian (a)	rhyolitic (b)	dacitic (c)	andesitic (d)	Pitchstone (e)
FeO	: 0.79	: 0.58	: 0.91	: 1.86	: 0.81
NiO	:	:	:	: Tr.	:
MgO	: 0.49	: 0.20	: 0.82	: 1.42	: 0.91
CaO	: 1.52	: 0.80	: 2.52	: 3.62	: 1.43
Na_2O	: 3.82	: 2.68	: 4.09	: 2.93	: 3.03
K_2O	: 3.92	: 4.40	: 2.19	: 3.96	: 3.57
H_2O+	: 0.53	: 2.94	: 2.92	:)	:)6.48
				)2.43	)
H_2O-	:	: 0.27	:	:)	:)
TiO_2	: 0.14	: 0.12	:	: 0.58	: 0.07
P_2O_5	: 0.01	: 0.12	: 0.13	: 0.23	: 0.03
MnO	: 0.07	: 0.03	:	: Tr.	: 0.02
FeS_2	: 0.02	:	:	:	:

"(a) - Average of 41 analyses cited by Johannsen (2)
(b) - Rhyolitic perlite, New Zealand, city by H. S. Washington (3)
(c) - Dacitic perlite, Columbia, cited by H. S. Washington (3)
(d) - Andesitic perlite, Eureka, cited by Hague (4)
Description indicates it to be a vitrophyre, which probably accounts for the low water content.
(e) - Average of 18 analyses cited by Johannsen (2)

"Obsidian: Composition may be representative of any igneous rock type but commonly is siliceous. Combined water content is generally less than one percent. Color black, less commonly reddish or brown and banded. Luster bright glassy. Hardness 5.5 to 7, generally 6 to 7. Gravity 2.25 to 2.7, depending on composition, but commonly 2.3 to 2.4. Fracture conchoidal to flaky with sharp edges. Thin edges transparent or translucent. Microscopically isotropic and colorless but containing numerous small inclusions. Index of refraction (5) ranges from 1.48 to 1.51 and averages 1.492. May contain spherulites (round aggregates of radiating crystals, chiefly quartz and feldspar) and lithophysae or 'stone bubbles' (hollow, concentric spherulites).

"Perlite: Composition most commonly rhyolitic, may range to andesitic. Characterized by about 2 to 5 percent, generally 3 or 4 percent, of combined water. Color generally gray to grayish black, less commonly some shade of red, brown, green or blue. Luster pearly. Hardness 5.5 to 7. Gravity 2.23 to 2.40. Brittle. Thin edges transparent. Microscopically isotropic and colorless but may show numerous small inclusions. Index of refraction (5) ranges from 1.483 to 1.506 and averages 1.497.

"Perlite tends to be intensely fractured by shrinkage cracks formed during solidification of the glass. Typically, these partings are curved or spheroidal, forming rudely concentric shelly or onionlike textures which suggested the early name 'pearlstone' or 'pearlite' for the rock. (2,4) In some areas, however, the fractures are less curved, as evidenced by a predominance of columnar, splintery, bladed, or granular textures.

"Shelly perlitic masses may contain subangular to spherical cores of glass (marekanite) from a fraction of an inch to more than an inch in diameter.

"Spherulites, lithophysae, and cellular cavities lined with tridymite are common in perlite deposits.

"Pitchstone: Quantitatively similar in composition to obsidian but contains 5 to 10 percent of water. Color black, brown, green or red. Luster pitchy rather than glassy. Hardness 5.5 to slightly above 7. Similar to obsidian in gravity and fracture. Thin edges translucent to transparent. Microscopically isotropic. Inclusions even more common than in obsidian. Index of refraction (5) ranges from 1.492 to 1.506 and averages 1.500.

"Vitrophyre: Glassy volcanic rock containing abundant phenocrysts, generally of feldspar or quartz and less commonly of ferro-magnesian minerals. The glass may be obsidian or pitchstone and more rarely perlite.

"Tachylite: Basaltic volcanic glass. Found rarely and in relatively small amounts.

"Pumice: Volcanic glass froth, most commonly of acid composition. Fibrous and highly cellular; will float on water.

"Vitric or glassy tuff: Volcanic tuff composed essentially of glass fragments rather than of crystalline or stony material.

"Occurrence and Origin of Volcanic Glass: The character of natural glass, whether obsidian, perlite, pitchstone, vitrophyre, pumice, or tuff, depends upon the composition of its present magma, type of eruption, and conditions of solidification. These factors are expressed to a variable degree in the geologic field relations of the deposits.

"The most favorable environment for natural glass is a thick volcanic series, prevailingly of acid to intermediate composition, that contains abundant breccia and tuff indicative of catastrophic eruption. With geologic antiquity, glass tends to devitrify or become crystalline. Thus there are few, if any, known natural glasses older than Mesozoic.

"Glass tends to form from a magma of acid or intermediate, rather than basic composition. Basaltic magma is more fluid than granitic magma. Hence basaltic eruptives crystallize readily and do not form glass except when quickly chilled.

"As summarized by G. W. Morey (7), a granite magma remains fluid only because certain constituents, particularly water, serve to lower the viscosity. This water, far above its critical temperature, exerts great pressure on the overlying crust. Sudden failure of the crust results in violent eruption of breccia, tuff, and magma which, losing some of its combined water and cooling rapidly, has too great a viscosity for crystallization. During quieter eruptions, the magma maintains its fluidity sufficiently long to crystallize.

"Obsidian, perlite, pitchstone, and vitrophyre form masses ranging up to more than 100 feet thick and several square miles in area. Pumice occurs as flows and ejectments. Tuff occurs as beds, with or without notable stratification.

"All natural glasses are generally regarded as extrusive; Grout states (8) that they occur chiefly as flows and thin selvages of dikes. However, an extrusive character for perlite and pitchstone seems questionable. It is very difficult to explain how glass such as perlite, containing sufficient water or gas to make it expand or explode when heated, could solidify under atmospheric pressure without expanding into pumice or exploding into tuff. Even if the water or gas is assumed to be present as components that unite upon heating, what would keep them from escaping? As suggested by B. S. Butler, the water might be retained if the molten glass were intruded as near-surface sills, sheets, or dikes, which would permit rapid cooling under pressure. Perlite in some localities is demonstrably of intrusive character, but conclusive field evidence has not been obtained in enough districts or places to warrant a generalization. Further laboratory and field research is needed to throw light on this problem."

HISTORY:

The history of the perlite industry in its present stage apparently originated with the discovery and development of the process of "popping" the raw material by L. Lee Boyer, a metallurgist, in his laboratories in Superior, Arizona.

The peculiar property of perlite in exploding when heated to a critical temperature was first reported by S. Kozu of the Tohoku Imperial University in Japan in 1929 or 1930. Kozu, in reporting expansion properties of various volcanic glasses, merely stated that perlite exploded at a certain point; he did not study the resultant product or pursue the subject further, nor would his laboratory technique be applicable to commercial production without considerable modification.

It remained for Mr. Boyer to rediscover the explosive action of perlite, to investigate the resultant product, and to evolve means of quantity production.

Mr. Boyer was attempting to discover an insulating enamel and was using his volcanic glasses in his experiments. Perlite did not fuse, but exploded in a manner similar to popcorn. Upon studying the "popped" material Boyer found that it had undergone considerable physical change and had assumed properties to be hereafter described. He then built a small pilot plant in Superior to develop a continuous popping process, and upon successfully operating this plant, he built a larger semi-commercial plant in Phoenix, Arizona, doing business as Perlite Industries.

Since 1941 numerous other enterprising individuals and companies have realized the potential applications of perlite and have engaged with varying degrees of success in producing a marketable product.

In all, some 27 different perlite plants in various sections of the southwest are reported to have been built. Most of these were apparently ill-conceived, poorly financed, and/or improperly located. Furthermore, many of the operators apparently were attempting to "pop" perlite in manners based upon theory and without the background of even laboratory experience. The mortality rate of plants has therefore been high, even though a ready market for production has existed.

PROPERTIES AND USES:

Processed perlite, as disclosed by laboratory tests and actual installations, to be later discussed, possesses the following properties:

1) Extremely low in heat transfer or conductivity.
2) Extremely low in electrical conductivity.
3) Insoluble in water and most acids.
4) Inorganic.
5) Free of oxidizing elements.
6) Low bulk density (2.0 to 13 lbs. per cu. ft.)
7) Buoyant - even after saturation.
8) Mildly abrasive.
9) Absolutely fireproof.
10) Easily handled in all of its commercial applications.

The above characteristics combine to make an ideal insulating material usable in a greater variety of ways than any other known product.

Most insulating materials on the market depend upon one of three characteristics: (1) the resistance of the material itself to heat transfer, or (2) the physical properties of the material which allow it to support air voids between the material particles, or (3) reflection. In the last two cases, the material itself may be a conductor of heat. Asbestos is a good example of the first, rock wool the second and aluminum foil the third.

Perlite has many of the advantages of all three, although the latter is of little consequence in conjunction with the first two:

1) Expanded perlite material itself, without considering its internal voids, is resistant to heat conduction.

2) The perlite particles are irregular in shape and support air voids between each other in bulk or loose use.

3) Perlite is white in color, thereby reflecting heat.

4) An additional property in some perlites is the existence of permanently sealed semi-vacuum voids within each particle of material.

Vermiculite, a mineral insulation of the micaceous class, more nearly resembles perlite in its application than other prominent products. It has the following objectionable features, however, which are not shared by perlite:

1) Vermiculite can be recompressed to near its original pre-exfoliation state. Perlite will support its voids and cannot be compressed without crushing.

2) Vermiculite is "greasy" and cannot be used as an aggregate without the use of a wetting agent. Perlite needs no preparation for such use.

3) Vermiculite concrete must be supported by a secondary material of strength. Perlite aggregate concrete has sufficient strength alone to qualify under most building codes.

Numerous tests are of record demonstrating the properties and applicability of perlite.

Laboratory tests have been conducted at Massachusetts Institute of Technology, the University of Arizona, the Arizona Highway Department, by Mr. Boyer in his laboratories in Superior and Phoenix, and by many organizations interested in the development of the material.

The test at M.I.T. indicated that perlite had a Kf of 0.446 to 0.563 and is superior in insulation to rock wool and equivalent to 85% magnesia, which is used as an insulation for steam pipes. The expanded perlite used in the test had a bulk density of 13.1 pounds per cubic foot, which is slightly higher than ground cork.

The Great Lakes Carbon Company has found their bulk material varies from a Kf of .26 to .34, depending upon the weight and size distribution of particles.

The report and test by E. H. Crabtree, Jr., metallurgist of the Arizona Bureau of Mines, indicates that perlite having a density of 12.6 pounds per cubic foot is competitive to asbestos, vermiculite, rock wool and cork. Comparative tests were not made with the cheaper organic commercial insulating materials. A lower bulk density, as obtainable, greatly enhances the Kf factor of perlite.

In the laboratories of the University of Arizona, the material produced from pilot plant operations were found to weigh 5.63 pounds per cubic foot. This decrease in density increases insulating value and would materially improve the position of perlite in the comparative tables prepared by the agency. These comparative tables indicated, according to Mr. Crabtree, that "perlite conducted heat more slowly than rock wool in the temperature range between 10 degrees and 55 degrees Centigrade. Between 30 degrees and 50 degrees, it apparently was better than ground asbestos; above 50 degrees, the asbestos appeared to be the better. From 32 degrees to 58 degrees, perlite was better tham vermiculite. From 30 degrees to 43 degrees, it was better than ground cork; above this range up to 53 degrees, the cork had greater resistance. The perlite was greatly superior to air in its resistance to heat conduction."

"From these results it would appear that the loosely compacted expanded perlite has a thermal conductivity factor of from 0.25 to 0.30 which compares very favorably with other insulating products now being produced."

The Arizona Highway Department tested concrete blocks in which perlite was used as the aggregate. Their results denote that the structural strength of perlite is sufficient for building blocks, etc., with a modulus of rupture varying from 285 to 356 and a crushing strength of 887 to 1109 pounds per square inch.

Subsequent tests of 10" x 16" x 14' beams, with three 5/8" reinforcing bars, conducted under the supervision of a local architectural firm, indicated a sag of 1/16" on a 12' span under a 7-1/2 ton load distributed along the span.

A test, the results of which were submitted verbally to and reported by Mr. Boyer, was conducted by the Central Arizona Light and Power in which it was determined that 1/2" of perlite was insulation against 33,000 volts of electrical current. Air Research of Phoenix conducted many experiments with perlite and found it adaptable to many delicate applications in the field of electronics.

Many practical tests have been made by Mr. Boyer. Among them is one in which the insulating value of loose perlite is simply and effectively demonstrated. A miniature test house with gable roof was built, the room being 1 cubic foot in size. A thermometer was placed in the attic, one in the room and one outside the house. Loose perlite, 5/8" in thickness, was placed on the ceiling. A 100 watt light bulb was placed in the attic. Temperature changes were as follows:

	Start	Finish	Change
Atmosphere	70°F.	70.5°F.	0.5°F.
Room	70°F.	71.0°F.	1.0°F.
Attic	70°F.	120.0°F.	50.0°F.

The time of the test was four hours. In this period a 50° attic temperature rise affected the room temperature only 1°. A part of this rise in room temperature resulted from the atmospheric change penetrating the uninsulated room walls.

In actual application many uses for perlite have been found and the product has been much in demand.

1) As an aggregate in concrete, perlite has advantages attributable to both its low bulk density and its insulating properties. Installations have been made, in both home and business construction, of perlite concrete building blocks of all sizes, solid and hollow, laid in the manner of standard blocks. Such blocks weigh only one-third the amount of a standard concrete block and can be cast with a rough surface for plastering, or sufficiently smooth to make a presentable appearance for industrial buildings.

Murdock & Bassler find that their finished concrete block, in which perlite is used as an aggregate, has 400 pounds strength, a "K factor" far more suitable for climatic conditions than is obtained in the use of conventional building materials.

The Alexite Engineering Company, fabricating the PerAlex Dunbrick at strength above 1200 pounds has a Kf of 0.7 to 1.0.

2) Concrete slabs of perlite has been used in several instances, and present interesting possibilities in pre-fabricated construction. The slabs can be readily waterproofed, and can be rough cast for ready adherence of plaster.

The slabs are pre-cast and secured by various means in a prepared structural steel framework. In this manner the wall slabs are not bearing walls and can consequently be of a leaner mix and a thinner section than ordinarily required.

A deep-freeze plant, only recently completed in Phoenix, is so constructed. Scrap pipe and structural steel was welded to form studdings, joists and rafters, and pre-cast 4 ft. x 10 ft. x 3 in. panels, reinforced with light steel mesh, were secured between members.

The Allison Steel Manufacturing Company, Arizona's largest steel fabricators, regularly advertises a pre-cast concrete building with pre-cast perlite roof panels. Several such buildings are in use, and in the course of construction, as warehouses and for other industrial purposes.

3) A firm of local architects constructed and tested an 8" x 16" perlite concrete beam and found it adaptable to a variety of uses at a considerable saving in reinforcing steel and handling. One remarkable feature of this beam was its elasticity and the resumption of a measure of its unburdened position when released from pressure, and the absence of fracturing in "sag".

Only the inability to obtain sufficient quantities of perlite has retarded a more widespread use in office buildings, theaters, etc. Beams and walls in most cases could be poured in place as in the conventional concrete structure; and would materially reduce the weight of structural steel in the masonry type of building.

In a radio station in Phoenix, perlite was used in a 4" concrete interior wall to muffle ballroom noise and other interference. The light weight of a solid wall of even this thickness made additional support below unnecessary.

4) As a substitute for sand in plaster there are many actual installations under a variety of conditions.

A casting plant office constructed of corrugated iron was unbearably hot in the summer time. By applying a common binder and 1-1/2" of perlite plaster on top of the corrugated roof a temperature reduction of 20° was claimed.

A minus 14 mesh material is favored by plasterers in that it can be easily worked and finished. Tint may be added in the mixer for permanent interior or exterior color.

Perlite plaster has the following advantages over standard sand plaster.

a) Perlite does not crack. Temperature changes and curing do not affect it.

b) Nails can be driven into perlite plaster with only local fractures. It can be sawed like wood.

c) Perlite plaster weighs about one-third as much as standard sand plaster.

d) Perlite plaster insulates.

e) Perlite plaster has unusual acoustical properties heretofore achieved only by special installation for that express purpose.

5) Bulk insulation has been gaining favor rapidly during the past few years as a means of improving older dwellings and frame buildings.

Usually bulk insulating material is spread on ceilings between joints and is blown into wall spaces between studdings. The most common blown type of insulation is rock or mineral wool. The character of wool, it is claimed, permits wadding in some places and a sparcity of fiber in others, resulting in an uneven distribution. Perlite is granular rather than "stringy" and will pour or blow into areas difficult to reach, and will distribute with uniform compactness in vertical walls.

In industrial application, where vibration might compact material through position changes of the particles, an insulating blanket can be solidified by a light spraying of sodium silicate or a slow drying adhesive. Railroad refrigerator cars could thus be insulated without appreciable weight and with a resultant reduction in the number of icings necessary from origin of perishable freight to market.

6) A large field of application is yet to be opened in the use of perlite as a filtering media.

Dry climate air conditioners are of the evaporative type and, in general, use excelsior as a filter and water distributor. The excelsior is organic and deteriorates rapidly; it cannot be uniformly distributed and is therefore not uniformly resistant to the air being pulled through, and it is odoriferous when remoistened after each drying. Perlite, in 1/4" plus sizes, would make an ideal substitute for the excelsior in overcoming the above objectionable features. In areas of high mineral content in water, which causes "scaling" concurrent with evaporation, the perlite can be washed periodically with dilute acid. Such cleaning will restore the original properties of the filter.

Perlite also offers many possibilities as a filtering media to remove sludges from acid circuits. In one instance, it was removed after such use and re-used as a high grade fertilizer.

7) As a chicken litter perlite has been successfully used. Being inorganic, perlite is not subject to decay and limits bacteria action. It is far superior to peat moss and like materials for this reason, as well as its effect in limiting odor, and in insulating coop floors in colder climates.

After use as a chicken litter the residue make an excellent fertilizer.

The contained chemicals are gradually released, preventing "burning", and the structure of particles is ideal for soils having a tendency to pack.

8) A Phoenix foundry in making aluminum castings for aircraft found that perlite was superior to sand for molds, both in cost and in percentage of acceptable castings. Perlite molds had a longer life, and the porosity allowed the escape of gases and/or air which cause pits and defects. With sand, a binder which would burn out had to be used for gas escape, and the re-use of such molds was limited.

The resistance to temperature of the binding media alone limits the use in the foundry field; in relatively low melting temperature, such as in the case of aluminum, perlite, with the binders now known, will have an ever increasing utility.

9) A host of other applications of perlite present themselves.

The U. S. Bureau of Mines suggests perlite fines as a paint base. Being inert and not subject to oxidation, it would last indefinitely.

It can be used as a refractory brick in many industries, lasting longer and being cheaper to reline than ordinary fire brick.

A partial list of actual and/or potential applications is tabulated as follows:

A. Light aggregate for concrete.
   1. Building blocks.
   2. Pre-fabricated slabs.
   3. Concrete poured in place.

B. Plaster, insulating and acoustical.

C. Bulk insulation.
   1. Poured or blown.
   2. With binder for rigidity.

D. Filtering media.
   1. Evaporative air conditioning.
   2. Industrial sludges.

E. Chicken litter.

F. Foundry or molding sand substitute.

G. Paint base.

H. Refractory brick.

There is no known limit of utility of the product and no commercial material of competitive nature is reported to have such versatile application.

The United States Bureau of Mines, in their Information Circular 7364 of August 1946, effectively sums up the comparative application of perlite and other competitive products as follows:

> "Perlite is merely a new product entering an established field now occupied by a number of mineral products like exfoliated vermiculite, pumice, bloated-clay granules, diatomite, mineral wool and others. Perlite has the virtue of considerably more strength than most of these competitors and can be made in a variety of densities. It is fireproof and mildewproof (cork is not), does not attract water as vermiculite does, nor disintegrate in moist conditions as mineral wool does, and can be made impermeable to water (vermiculite soaks up water and softens). There will undoubtedly be certain uses where each of the competitors finds a special field, but perlite promises greater versatility than any of them. Diatomite and vermiculite brick in furnace walls are more fragile, and salvage during rebuilding will be lower than is the case with perlite brick and slabs. Perlite is fairly resistant to many chemicals, and even with equal resistance a granule with glassy exterior presents less available surface for attack. Pumice of proper characteristics is too often found in remote locations, and the known deposits of perlite and pumice show that perlite is much more available to transportation in the western states. Pumice can be improved by heat treatment similar to that which perlite requires.
>
> "Most of the open-hearth furnaces of the Nation are now provided with vermiculite insulation, either in the form of brick or of mortar. Some perlites have softening temperatures as high as those of vermiculite and therefore have the opportunity to compete.
>
> "Loose-fill vermiculite in walls of structures that are quiescent can remain indefinitely, but on railroad cars and other structures slabs of vermiculite are preferable. A loose fill of the stronger perlite is not so likely to shake down if it is closely sized. Vermiculite attracts moisture and loses some of its insulating value, whereas perlite does not. In general, it would appear that in this perlite has something more to offer. Mineral wool has to be protected against moist air attack by oiling the fibers; perlite does not."

In evaluating the uses of perlite under any given set of conditions, it must be remembered that there is wide fluctuation in the characteristics of the "popped" material. This variable is a result of both the type of raw material used, and the method of processing. The user must therefore ascertain that the particular material he intends to use has those characteristics he desires.

DEPOSITS:

Perlite deposits are not uncommon in the western states, although they vary widely in reaction to processing. Many deposits contain impurities disseminated throughout the mass, or have banded impurities and/or overburden tending toward extraction difficulties. Some deposits of better grades of material are geographically situated to the detriment of their commercial values.

The largest production of raw perlite has been derived from the Superior, Arizona area, and within that region is contained the holdings of most of the producers previously described. It is estimated that there are some 150 located mining claims in the Superior district having varying quantities of exposed perlite and aggregating tens of millions of tons of clean material extractable by pit mining methods.

Other major deposits of merit exist in Mohave County and western Maricopa County in Arizona, as well as in Nevada, New Mexico, Colorado, California and possibly other western states.

It appears unlikely that any single group or small number of groups will ever "corner the market" as far as raw material supply is concerned.

PROCESSING:

While an abundance of raw perlite is available there is a general lack of technique in processing.

Perlite "pops" at various temperatures depending upon the type of raw material and size of furnace feed and other considerations. Usually the temperature range is from 1650 to 2250 degrees Fahrenheit. The furnace product characteristics will likewise vary between deposits and treatment practices.

Perlite from the Superior district pops at a relatively low temperature and yields an expansion in volume of 8 - 12 to 1. Medium gray Aguila, Arizona perlite pops at a higher temperature and expands about 5 - 8 to 1, while light gray crude expands in a greater ratio. The Superior district processed material is lighter in weight, while the Aguila material has greater strength. Each, therefore, has certain predominant traits, but either or both can be readily marketed for the uses listed. Specimens of some Nevada perlites have been examined which expanded 30 to 1, but at that ratio were devoid of any strength and could be pulverized between the fingers. An expansion range of 6 - 12 to 1 appears to be the most desirable for the greatest volume of applications.

There are two methods currently employed in popping perlite: the "flash" and the "continuous" pop. Several types of furnaces have been conceived to accomplish both with varying degrees of success. The flash pop has some merit in fuel efficiency and ratio of equipment cost to capacity.

General furnace types which have been tried are:

1. Rotary horizontal - short.
2. Rotary horizontal - long.
3. Stationary vertical.
4. Stationary angular.

The short rotary horizontal furnace relies upon the flash pop and immediate exclusion from the furnace of the expanded product. The raw material passes directly through the apex of the firing flame and is expanded instantaneously. The furnace is only long enough to give momentary retention of product to fully complete expansion. This process is the first employed and has many adherents, among them the Western Perlite Corporation whose plant is nearing completion in Phoenix.

The long rotary horizontal, or kiln type, furnace such as is operated by the Alexite Company relies upon a controlled heat over the entire length of the furnace and a long period of exposure to complete expansion. It is the type advocated by A. C. Bowen, of Phoenix, long interested in the perlite industry, and is currently being used by Chemi-Cote Perlite Company of Phoenix. Bowen was the originator of some successful electrical heat control attachments effecting improved results in the long rotary furnace, by overcoming the fusion of perlite to furnace linings.

The stationary vertical furnace has been tried by several groups without reports of notable success. Variations of burners to create swirls, multiple apexes and other conditions have been futile to obtain other than small quantities of extremely light and fragile particles.

Insufficient is known of the stationary angular furnace by which to judge its merits. The originator is secretive as to specific details and makes only general claims. While there may be merit in the furnace, no actual installation is known.

The Rheem Corporation combines a rotary pre-heater, a rotary horizontal and a stationary vertical, all in closed circuit. They have experienced some difficulties with this method and are reportedly abandoning operations.

Undoubtedly there will be developments and improvements in furnace design resulting from future experiences, but for the present it is considered wise to abide by the record of successful plants.

Experiments are under way to "pop" perlite electrically and with numerous common fuels. Unfortunately laboratory success is not always a reliable criteria of actual plant operations. Processing of perlite at best remains a "tricky" procedure and caution is urged before investment in plant facilities for this purpose.

COSTS:

Costs of crude and processed bulk perlite vary widely and no general average can be given.

In Phoenix processed bulk perlite, when available, sells for \$5.00 - \$6.00 per cubic yard. Blocks with a dimension of 5" x 8" x 24" sell for \$300.00 per M, f.o.b. plant.

In Los Angeles processed bulk perlite sells at 25¢ per cubic foot on an average, with sized products yielding as much as 50¢ per cubic foot for specialized applications. Selected screen sizes may be expected to warrant a premium price in any given locality.

Freight, hauling, and handling of processed perlite for shipment to other than local points places the cost at point of consumption in far greater disadvantage than would the shipment of crude material in a like tonnage.

In general, it may be considered that processing near the point of consumption has economic advantages to the point of the success or failure of a production venture.

CONCLUSION:

There appears to be ample evidence that perlite will have useful and economical application in the fields heretofore discussed. Sufficient actual installations have been made to demonstrate its utility, as well as to warn potential users of its limitations.

Perlite is not a "cure-all" in the insulating, acoustical or light aggregate adaptions. Processing and usage of the material is, as yet, in its infancy, and considerable information must yet be obtained and correlated before bounding the extremes of its utility.

The processing of perlite has not reached maximum efficiency in many respects. Primarily, the characteristics of processed material are not standardized and products vary widely in bulk density, screen size ratios, strength, absorption, Kf, and like important factors. The term "perlite" covers all material derived from the volcanic glass of that geological classification, yet the features of given batches of processed perlite may be found to be at wide variance in important respects.

Care in the selection of the particular material having the characteristics desired, and the exercise of further care in limiting application to fit those characteristics, will result in successful uses of perlite yielding satisfaction beyond that obtainable from many competitive products.

It may be concluded that properly processed perlite has great merit within its field and should find increasing favor with architects and builders in both dwelling and commercial construction.