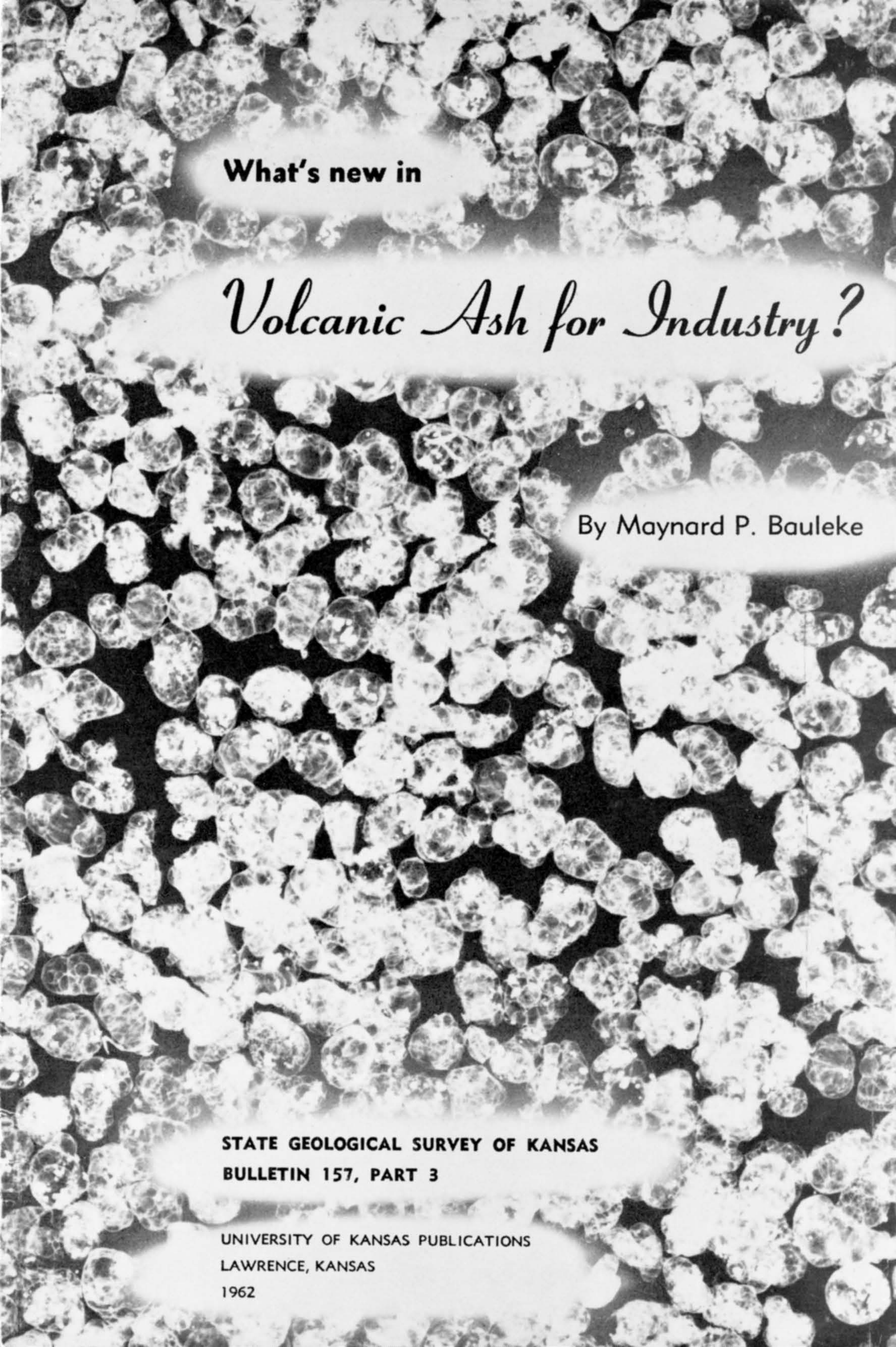
What's new in

Volcanic Ash for Industry?

By Maynard P. Bauleke



STATE GEOLOGICAL SURVEY OF KANSAS
BULLETIN 157, PART 3

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Cover

"Popped" volcanic ash . . . magnified about 30 times to show the multicellular structure that develops within the bloated shards. . . . The ash—Pearlette ash from the Ernest Hanzlicek pit, Lincoln County, Kansas—was bloated in the ceramic laboratory of the State Geological Survey. Photograph printed directly by transmitting light from photographic enlarger through ash bubbles.

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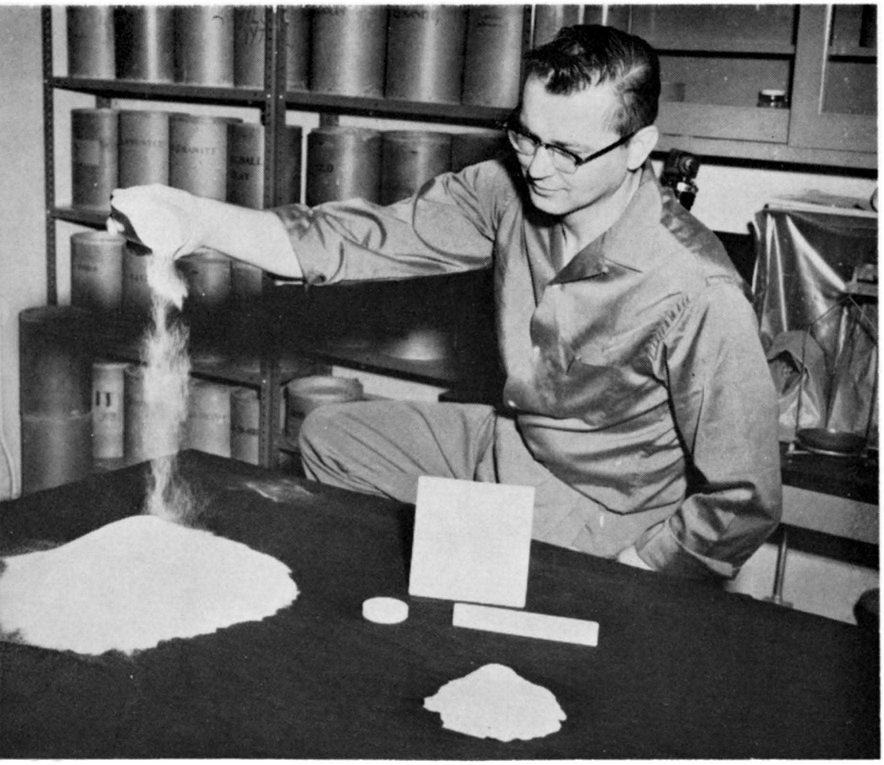
ABSTRACT

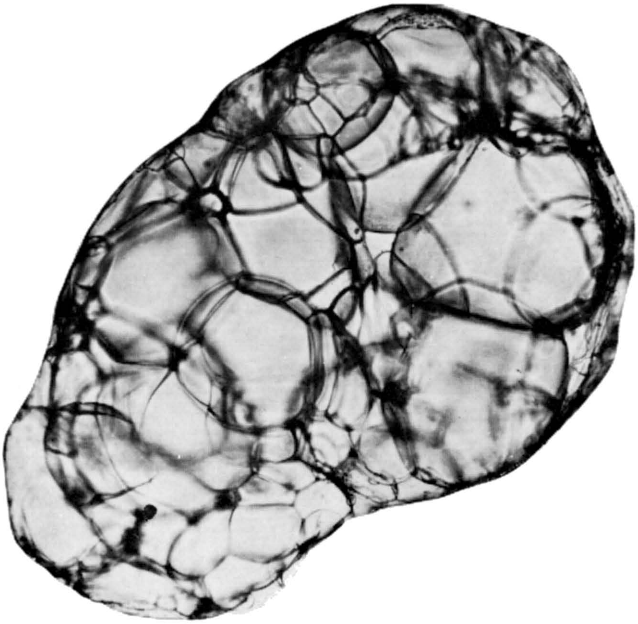
Kansas volcanic ash deposits and the uses for volcanic ash are briefly described. Bloated ash, a lightweight material, can be the basis for the development of new structural products and filtration media. Generalized instructions for bloating the ash are given.

ACKNOWLEDGMENT

Mrs. Roberta Gerhard, research assistant, helped plan and prepare this publication.



Maynard Bauleke, ceramist, demonstrates the lightness of bloated ash (+100-mesh fraction). . . . A one-pound sample of the bloated ash (large pile) is compared with a one-pound sample of raw ash (smaller pile). Both samples are Pearlette ash from Lincoln County. Blocks on table are experimental products made of bonded and compressed bloated ash. (See discussion on page 14.)



Single "popped" ash particle, ×150.

Introduction

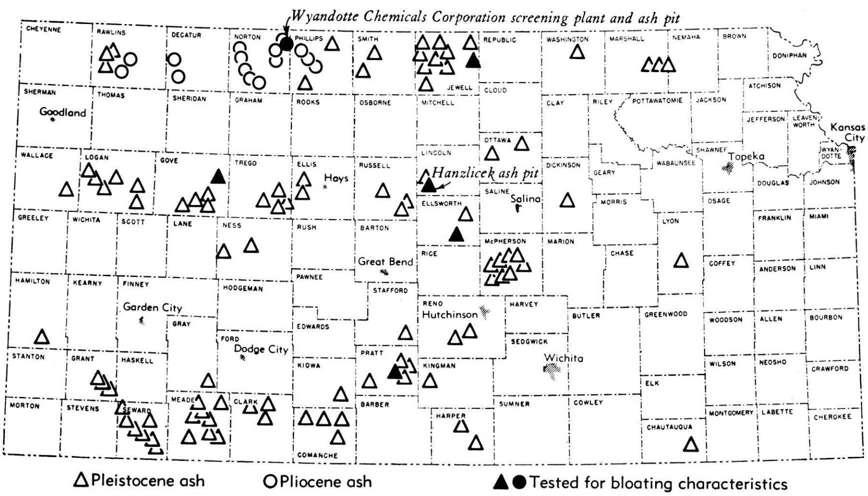
"Popped" volcanic ash is one of the latest developments in product research by the State Geological Survey of Kansas. In the laboratories of the Survey, Kansas ash has been bloated, or "popped"—and in this form has new industrial applications. Crushed, cracked, screened, and bonded, the "popped" ash has been tested for its suitability in various products. Bloated ash from Kansas has some interesting characteristics—and, we think, potential for development. Results achieved thus far are analyzed in this report. Experiments are continuing, and not all Kansas ash has yet been tested for its bloating characteristics.

Volcanic ash is a little-used Kansas resource, but is available in 40 counties. Estimated reserves exceed 20,000,000 tons. Recognized by Kansas settlers at least as early as the 1880s, Kansas volcanic ash was not commercially produced until early in this century, when it was used as an ingredient in scouring soaps. By 1916 Kansas ranked first among the states in commercial volcanic ash production, and it remained in the lead through 1944. Peak annual production was 51,907 tons in 1923, and soon thereafter the State Geological Survey published its first comprehensive report on this resource (Landes, 1928). Since 1945 commercial production has steadily declined, and only two producers operated in Kansas in 1960.

The raw ash has been used for various purposes, most generally as an abrasive, but huge though unrecorded amounts have been used in Kansas blacktop roads. As the decline in production since 1945 reflects, ash as an abrasive has been replaced by other materials. Increased production of Kansas ash will depend upon development of products that utilize other properties of ash.

Kansas deposits tested for bloating characteristics of the ash

Ellsworth County	(Geological Survey Code # ELV-24) Pearlette ash; bloated. SE¼ NW¼ sec. 28, T. 16 S., R. 7 W.
Gove County	(GV-1) Pearlette ash; bloated. NE¼ SW¼ sec. 21, T. 13 S., R. 26 W.
Jewell County	(JV-6) Pearlette ash; bloated. NW¼ NE¼ sec. 16, T. 1 S., R. 6 W.
Lincoln County	(LV-2) Pearlette ash; bloated. SW¼ SE¼ sec. 27, T. 13 S., R. 10 W.
Norton County	(NNV-1) Calvert ash; did not bloat. NW¼ SW¼ sec. 25, T. 2 S., R. 22 W.
Pratt County	(PRV-4) Pearlette ash; bloated. NW¼ SE¼ sec. 34, T. 27 S., R. 12 W.



Kansas volcanic ash deposits and commercial producers.

Pearlette ash pit in Lincoln County. The raw ash currently is being produced by Ernest Hanzlicek for use in ceramics and sweeping compound. All bloated ash illustrated in this report was taken from the Hanzlicek pit (NW¼ SW¼ sec. 27, T. 13 S., R. 10 W.).

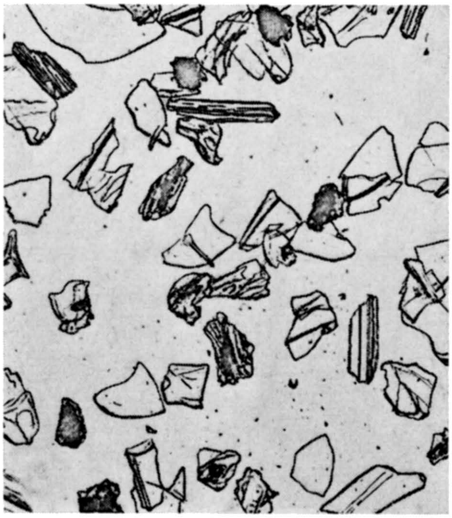
Just what is volcanic ash?

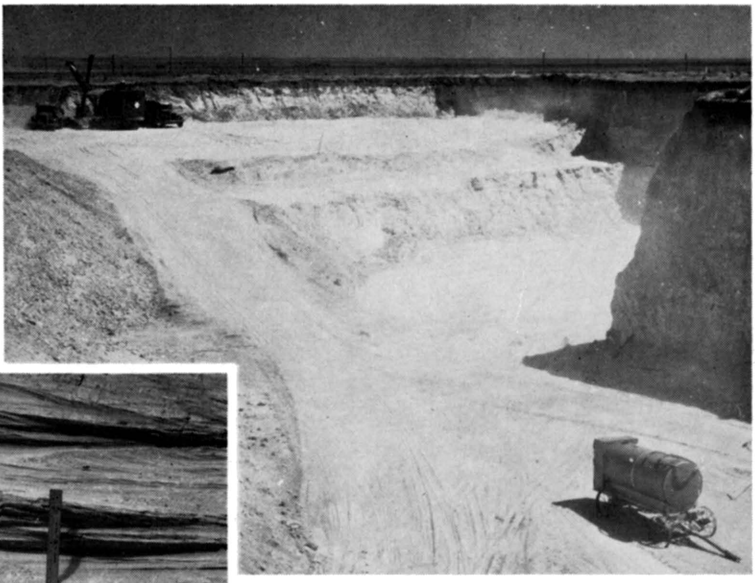
Kansas volcanic ash is a glass, not a crystalline material. It differs from other volcanic deposits such as pumice, obsidian, scoria, and perlite (consolidated materials) in that it consists of shards of finely divided material that is unconsolidated or only slightly consolidated. The shards are white to gray but whiten further in the bloating process. Unfortunately, volcanic ash is often called by other names. It is widely termed "pumicite" and locally in Kansas it is even referred to as "silica sand" or "silica", but technically these names are incorrect.

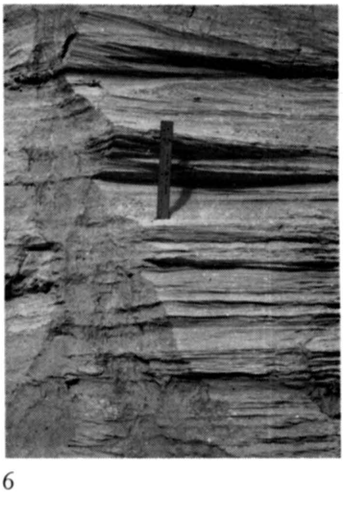
Are the ash deposits workable?

Most ash deposits are lens shaped, thick in the center and thinner toward the edges. The Kansas deposits range from a few square yards to about a square mile in area and some are as much as 30 feet thick. Most of the known deposits are easy to reach. The overburden is not excessive; in many localities the ash lies directly below the top soil. The deposits are unconsolidated; therefore the ash can be mined easily by any earth-moving equipment. Some deposits are now under lease; some are not. Many were leased when volcanic ash was used in household cleansers.

Raw ash is broken pieces or shards of small bubbles. Shards of Pearlette ash from the NE¼ NW¼ sec. 14, T. 3 S., R. 35 W., Rawlins County, magnification ×50.







Pearlette volcanic ash pit in Meade County, formerly operated by Cudahy Packing Company. Seventeen feet of clean ash is exposed in the face of the pit. Detail of bedding in Pearlette ash in pit face, in sec. 2, T. 31 S., R. 28 W.

How did the ash come to Kansas?

Kansas ash came from volcanoes located somewhere west or southwest of the state. Explosively thrown into the air, the ash was carried over Kansas by winds; after the ash particles settled to the ground, surface water collected them into local deposits.

How old are the ash deposits?

There seem to have been two distinct periods of volcanic eruptions. The first occurred in the Pliocene Epoch of geologic time (beginning about 11 million years ago), the second in the succeeding Pleistocene Epoch (beginning about 1 million years ago). Geologists recognize one large ash fall of Pleistocene age, the Pearlette ash, and at least seven of Pliocene age. In some counties it is possible to find deposits of more than one ash, but in the field it may be difficult for the untrained observer to differentiate them.

Do the ashes of different ages have different properties?

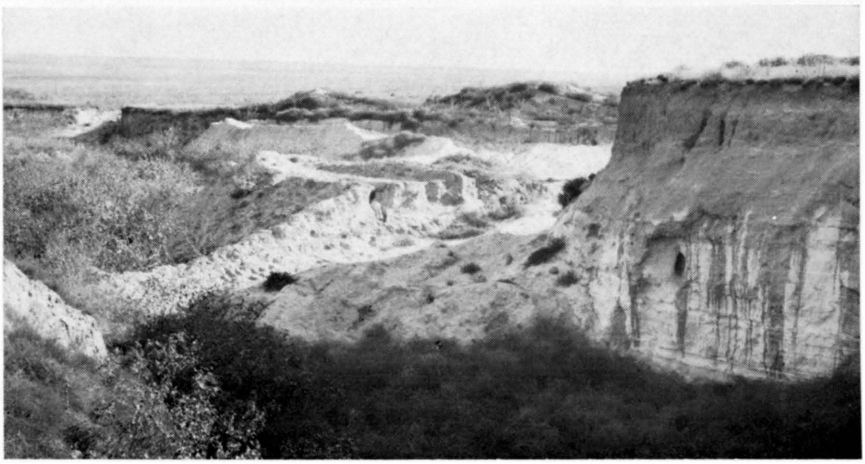
Chemical analyses and particle sizes of the ashes are similar, but flakes of ash from different ash falls may differ in thickness and shape. Flakes of Calvert ash, one of the Pliocene ashes, are thinner and flatter than Pearlette flakes. In the Geological Survey laboratory tests, Pearlette ash from Gove, Lincoln, Pratt, Ellsworth, and Jewell Counties readily bloated; Calvert ash (Carey and others, 1952, p. 38) from Norton County did not. Many other deposits of Pearlette, Calvert, and other ashes still remain to be tested for bloating characteristics of the ash.

What is the chemical analysis of the ash?

Generally, chemical analyses of the various ashes are very similar, especially if such mineral impurities as quartz (SiO_2) and calcite ($CaCO_3$) are removed. In some deposits the calcite has acted as a cement to bond the ash together into small hard lumps.

Chemical analysis of 54 Kansas volcanic ash samples

Oxide	Average (percent)	Range (percent)
SiO_2	72.3	60-74
Al_2O_3	11.8	9-13
Fe_2O_3	1.7	1-3
TiO_2	0.5	0.2-2
CaO	1.0	0.1-10
MgO	0.3	0.1-1.5
K_2O-Na_2O	8.0	6-10
Loss on ignition	4.3	3-11



Pearlette volcanic ash pits. Ash from Gove County pit (NE¼ SW¼ sec. 21, T. 13 S., R. 26 W.), above, was sampled for bloating tests. Grant County pit (NW¼ sec. 24, T. 30 S., R. 35 W.), below.

Does weathering action alter the ash?

There is some indication that under favorable environmental conditions, ash is chemically and mineralogically broken down into a montmorillonite-type clay mineral. Some Calvert ash has changed to montmorillonite, but this is the only known example of such alteration of Pleistocene or Pliocene ash in Kansas. The rate of alteration is much too slow to be a factor affecting use of volcanic ash deposits.

Alteration has, however, changed still older Kansas ash, of Cretaceous age (75 to 135 million years old), to a predominantly montmorillonite clay called bentonite.

What is the particle size of the ash?

In most deposits about 75 percent of the ash will pass through a 200-mesh screen (0.003-inch opening).

Screen analysis of 96 Kansas volcanic ash samples

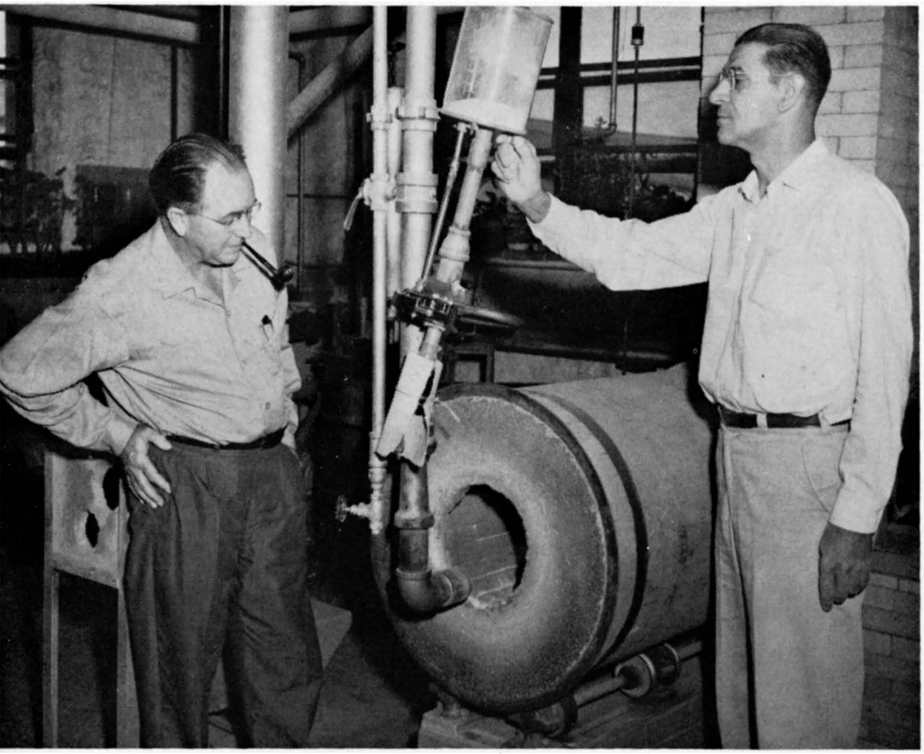
Screen size[a]	Average (percent)	Range (percent)
On 20 mesh	1.6	0.0-23
Through 20 on 60	2.1	0.1-17
Through 60 on 100	3.8	0.7-14
Through 100 on 200	17.6	2-50
Through 200 mesh	74.6	35-90

[a] Screen size openings are: 20 mesh, 0.033; 60 mesh, 0.010; 100 mesh, 0.006; 200 mesh, 0.003 inch.

What is the shape of the ash particle?

Most of the particles are small, irregular pieces of glass (photo, page 6). Mixed in with the shards are some glass bubbles and stringers typical of glass that has been thrust into a high-velocity gas stream and suddenly cooled. The particles are angular and jagged, giving the material better abrasive cutting properties than ordinary glass. (The abrasive rating of ash is harder than feldspar and softer than quartz.) The glass fragments are somewhat porous.

Volcanic ash pit north of Wilmore, Comanche County. About 13 feet of Pearlette volcanic ash is exposed in this inactive pit (SE¼ NE¼ sec. 12, T. 31 S., R. 18 W.). The Kansas Highway Commission has estimated that the deposit contains 3,000 cubic yards of recoverable ash.



Norman Plummer and William Hladik, ceramists, examine bloating equipment in a laboratory of the State Geological Survey. Raw ash, stored in the container, is fed into the air column (large pipe leading into the burner). Gas is supplied through the small pipe on the left. The bloated ash is collected in the rotary kiln chamber.

How is the ash bloated?

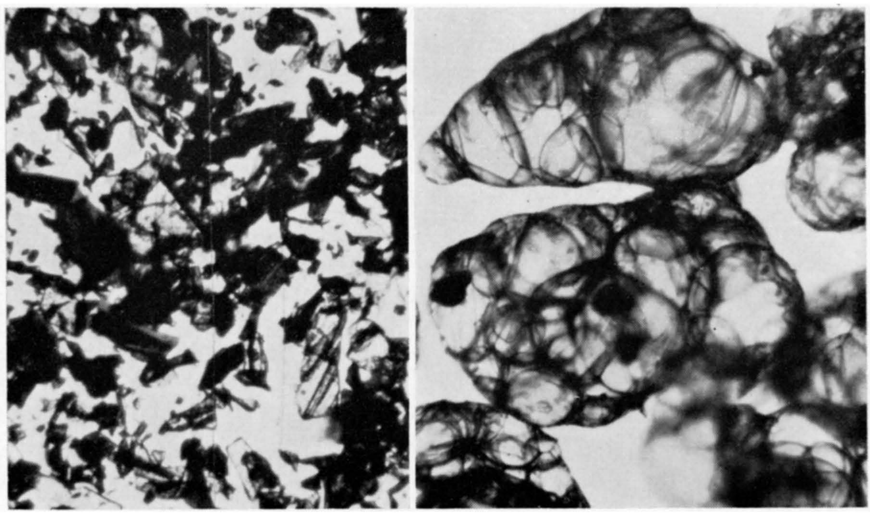
In the ceramic laboratory of the Geological Survey, Pearlette ash has been successfully bloated by injecting the ash into the air intake of a gas burner, thus mixing volcanic ash with the air used in burning the gas. As the small particles of glass soften, occluded gases expand them into spheres, which are solidified by sudden cooling as soon as they leave the flames. The combustion gases and the ash are exhausted into a collection chamber, where the bloated ash settles out.

Bloating temperatures are difficult to measure; optical pyrometer measurement of the yellow flame was between 1600 and 1700°F. Mixing the ash with the fuel-air mixture has the advantage of exposing the raw ash particles to the maximum flame temperature.

To obtain a material having low bulk density it seems desirable to feed the ash at a high rate, because production of an abundance of glass spheres causes the spheres to stick together to form an agglomerate.

The accompanying flow diagram illustrates the general procedure for bloating ash.

Raw Ash
|
Crush
|
Screen
|
Bloat
|
Collect
|
Screen
|
Crush
|
Sack



Raw ash shards (left) average 66 pounds per cubic foot bulk density. **Bloated ash,** 35-48 mesh fraction (right), shows cellular development, averages 2-3 pounds per cubic foot bulk density. Both photographs ×80.

How much does the bulk density change during bloating?

The bulk density of the raw ash averages 66 pounds per cubic foot; that of run-of-the-mill bloated ash has been between 12 and 25 pounds per cubic foot. In our bloating equipment not all of the ash was bloated to the same degree. As the particle size of the bloated material decreases, the bulk density increases. By selective screening, bloated ash having bulk density as low as 2½ pounds per cubic foot has been obtained.

Is the bloated ash easy to crush?

The walls of the glass spheres are extremely thin. The bloated ash can be crushed very easily by rolls, by air impact, or by whirling blades such as those in a Waring blender.

Uses of bloated ash

Filtration media

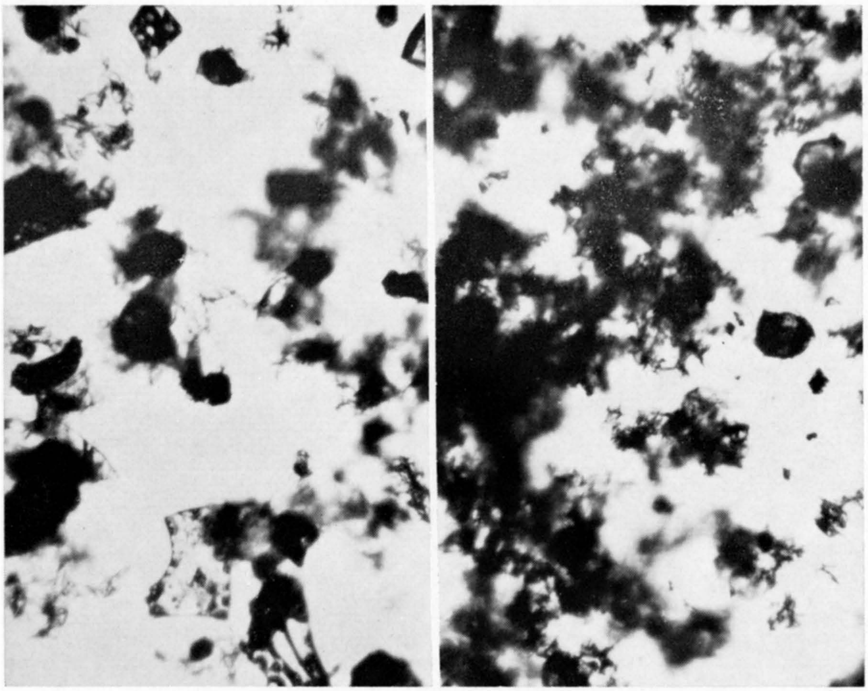
As a filter material the bloated ash can be used either crushed or uncrushed. The filtration rate through uncrushed ash is greater, because the spherical particles are separated by larger pore spaces for fluid to pass through than are the interlocking irregular fragments of crushed bubbles. Excellent filter media can be made by gently crushing the bloated spheres so that they crack open but do not shatter into numerous thin pieces.

Low-density filter material can be developed by two methods:

1. Selective screening of the bloated ash to separate a low-bulk-density material (about 4 pounds per cubic foot). Gentle crushing of the low-bulk-density fraction then raises its density to 7 to 8 pounds per cubic foot but has the advantage of mixing small and large particles, which form a tight-screen filter matt.

2. Fine crushing of the bloated ash (less than 10 microns) and air classifying of the material into a narrow range of particle sizes. The resultant small ash particles of uniform size pack with a maximum of tiny pore spaces, forming a good filter matt.

Filter material is used in food and petroleum processing and in treatment of water for domestic and industrial use and in swimming pools. If developed, filtration uses could consume large tonnages of ash.



Crushed ash bubbles compare favorably with commercial filter material. Left, Kansas bloated ash that has been crushed but not size classified . . . usable as filter material. (Bloated ash of 4.5 pounds per cubic foot bulk density was crushed in a Waring blender for 1 ½ minutes to form crushed material of 8.5 pounds per cubic foot bulk density.) Right, fragments and clusters of commercial, size-classified filter material made from bloated perlite. Note the similarity of the small ash fragments and fragments of commercial filter material. Both photographs $\times 80$.

Substitute in plaster mixes

Because of its light weight and thermal and acoustical insulating properties, bloated ash is potentially a substitute for perlite in trowel and wall-finish plasters. At present, direct substitution seems impractical, because the glass wall of an ash particle bloated to the same size as a perlite particle is extremely thin and fragile. It may be possible to agglomerate smaller but stronger ash spheres into clusters, which would have the particle-size distribution specified for perlite.

Also, there is a possibility of substituting some of the denser bloated ash for sand in ordinary plaster mixes, especially in the manufacture of plaster wallboard.

Thermal insulation

Loose bloated ash may be used for thermal insulation in wall cavities and for other pourable insulation applications, such as fill in cement blocks. The material should also be useful as insulation in cryogenic (low temperature) storage equipment. The thermal insulation properties of ash are excellent, but temperature above 1000°F. should be avoided to prevent sintering of the spheres and a corresponding volume shrinkage.

Fireproof acoustical tile

Addition of a noncombustible silicate binder* to the bloated ash produces a lightweight and fireproof acoustical tile for suspended ceilings. The essential steps in producing the tile are:

Mix bloated ash and binder

↓

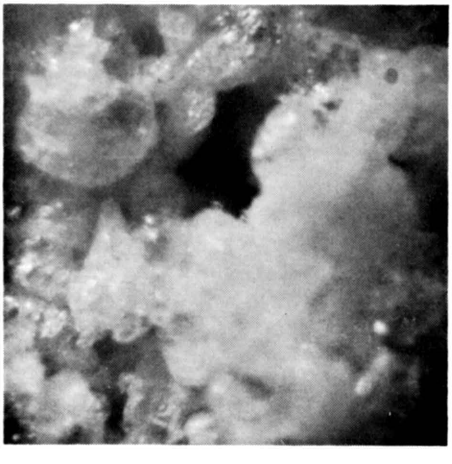
Press

↓

Cure in oven at 200°F.

All silicate-bonded tile produced in the Geological Survey ceramic laboratory showed brittle fracture. Transverse breaking strength (flexure) was 150 pounds per square inch, sufficient for non-load-bearing applications. A small percentage of organic fiber incorporated in the batch improves the strength, yet fire-resistant properties are retained.

If the binder content and pressing pressure are low, ash particles may be rubbed loose from the surface. A fire-resistant paint may be applied to the surface to control dusting.



Fractured surface of bonded* bloated ash shows the compacted spheres that provide good thermal insulation properties; ×80.

**Sauereisen Binder No. 1500, manufactured by Sauereisen Cement Co., Pittsburgh, Pennsylvania.*

Some uses of volcanic ash

Raw ash	Raw or bloated ash	Bloated ash
Ceramic compositions	Oil and grease absorbents	Filtration media
Glass manufacture	Inert fillers, extenders, and carriers	Low-temperature insulation
Mild abrasives		Lightweight fireproof acoustical tile
Road-construction material		Plaster wallboard
Concrete aggregate		
Plant fertilizer		

Uses of raw ash

Concrete aggregate

The use of ash in concrete in the Midwest has been insignificant, but in the West ash has been added to concrete used in dams and buildings. Ash could also be used in place of fine sand in concrete blocks.

The ash has natural cementing properties and as a fine aggregate would fill small pore spaces to produce a denser concrete. Concrete containing volcanic ash continues to increase in strength as it ages. If volcanic ash could gain acceptance as an aggregate material added to concrete mixes, large tonnages would be utilized.

Road construction material

Volcanic ash has been applied as a top dressing on Kansas blacktop highways to improve the reflectivity of the road surface. Large quantities of ash, not recorded in commercial production statistics, have been used in road construction, but usage has been limited to areas close to ash deposits.

Abrasive material

Twenty years ago ash was widely used as the abrasive material in household cleansers. According to a recent survey of five leading cleanser producers, finely ground silica sand is the abrasive now most

The only ash-screening plant in Kansas, northeast of Norton, Norton County . . . Wyandotte Chemicals Corporation, manufacturers of specialty cleaning chemicals, operates the plant and a nearby pit of Calvert ash.

widely used. Volcanic ash is no longer used—mostly because the finely ground ash does not have sufficient abrasiveness to remove stains with the speed that the housewife desires. There is no indication that large amounts of ash will again be used in cleansers. Usage as an abrasive will probably be confined to specialty cleansers and abrasives.

Ceramic compositions

Volcanic ash may be used as a flux material in ceramic bodies and glass in much the same way as feldspar and nepheline syenite. Unfortunately, Kansas volcanic ash contains about 2 percent iron oxide, which causes discoloration in an otherwise white body. If a pure white color is not required, ash has the following ceramic applications:

1. A flux to reduce the vitrification temperature of ceramic compositions used in whitewares and structural clay products.

2. A material for low-cost glazes used on structural clay products, wall tile, sanitary ware, and ceramic artware.

3. A source of potassium oxide in the manufacture of iron-containing glasses.

4. When mixed with limestone, volcanic ash could form the basis for a cheap glass into which radioactive waste could be incorporated as an insoluble solid before being dumped into the earth for storage.

Inert fillers, extenders, and carriers

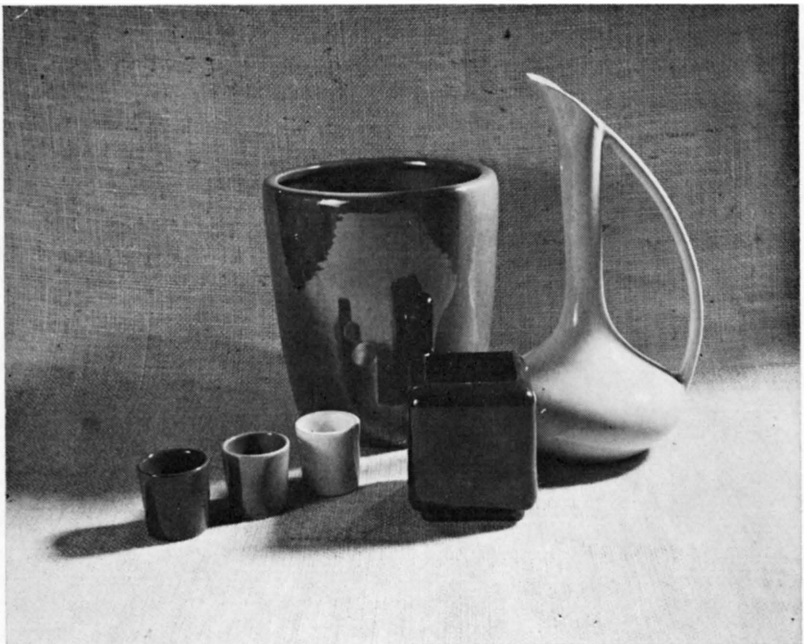
Ash is usable as a filler, extender, or carrier in plastics, rubber, insecticides, and fertilizers.

Fertilizer and soil opener for potted plants

Ash is a source of potassium for plants and serves the same purpose as granite dust.

Grease and oil absorbent

In areas near ash deposits, garage operators use the porous ash to absorb oil spilled on floors. The noncombustible nature of the ash greatly reduces the hazard of spontaneous combustion in oily waste piles.



Pottery, manufactured in Kansas, contains Kansas Pearlette ash from Lincoln County in the ceramic bodies and glaze.

Summary

Kansas volcanic ash has commercial possibilities, especially in bloated form—although bloated ash is still in the experimental stage of product development. Its light weight and its cementing properties and acoustical and thermal insulating properties favor the use of ash in structural products. It is also an effective medium in filtration. Our reserves total about 20 million tons of minable ash. Kansas ash is an available, usable resource that seems to have new potential.

At the time of this report, ash from 6 of the more than 100 deposits in Kansas had been tested by the Geological Survey for bloating characteristics. Ash from the five Pearlette deposits tested was found to be bloatable; the other ash sampled was unbloatable.

All data of the State Geological Survey on the physical and chemical properties of Kansas volcanic ash, as well as information gained through product tests, are available to the public. Small samples (either bloated or raw ash) for laboratory testing will be supplied to companies interested in evaluating volcanic ash for product development. For additional information visit the Geological Survey in Lindley Hall at The University of Kansas, or write to the Division of Ceramics, State Geological Survey.

Publications on the geology and occurrence of Kansas volcanic ash, and on applications that are pertinent to Kansas ash, are listed in the Selected References.

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PART 1. METHODS OF CHEMICAL ANALYSIS FOR CARBONATE AND SILICATE ROCKS, by Walter E. Hill, Jr., Wanda N. Waugh, O. Karmie Galle, and Russell T. Runnels, p. 1-30, fig. 1, July 15, 1961.

PART 2. PLASTIC FLOWAGE OF SALT IN MINES AT HUTCHINSON AND LYONS, KANSAS, by James D. Snyder and Louis F. Dellwig, p. 31-46, fig. 1-7, pl. 1-2, September 15, 1961.

PART 3. THE MINERAL INDUSTRY IN KANSAS IN 1960, by Walter H. Schoewe, p. 47-90, fig. 1-3, December 30, 1961.

PART 4. RELATIVE AGES OF VISIBLY CRYSTALLINE CALCITE IN LATE PALEOZOIC LIMESTONES, by John W. Harbaugh, p. 91-126, fig. 1-10, pl. 1-10, December 31, 1961.

PART 5. FACTORS INFLUENCING THE PRECIPITATION OF DOLOMITIC CARBONATES, by Frederic R. Siegel, p. 127-158, fig. 1-9, December 31, 1961.

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PART 1. THE DECEMBER 25, 1961, EARTHQUAKES IN NORTHWESTERN MISSOURI AND NORTHEASTERN KANSAS, by Louis F. Dellwig and Lee C. Gerhard, pl. 1-12, fig. 1-3, March 31, 1962.

PART 2. PROGRESS REPORT OF THE KANSAS BASEMENT ROCKS COMMITTEE AND ADDITIONAL PRECAMBRIAN WELLS, by Virgil B. Cole and Daniel F. Merriam, p. 1-11, fig. 1-3, April 15, 1962.

PART 3. WHAT'S NEW IN VOLCANIC ASH FOR INDUSTRY?, by Maynard P. Bauleke, p. 1-19, 14 illus., May 15, 1962.