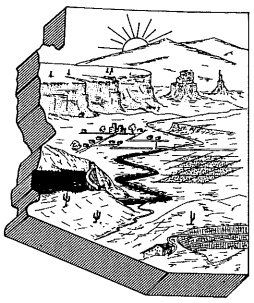


FIELDNOTES

From The State Of Arizona
Bureau Of Geology And Mineral Technology

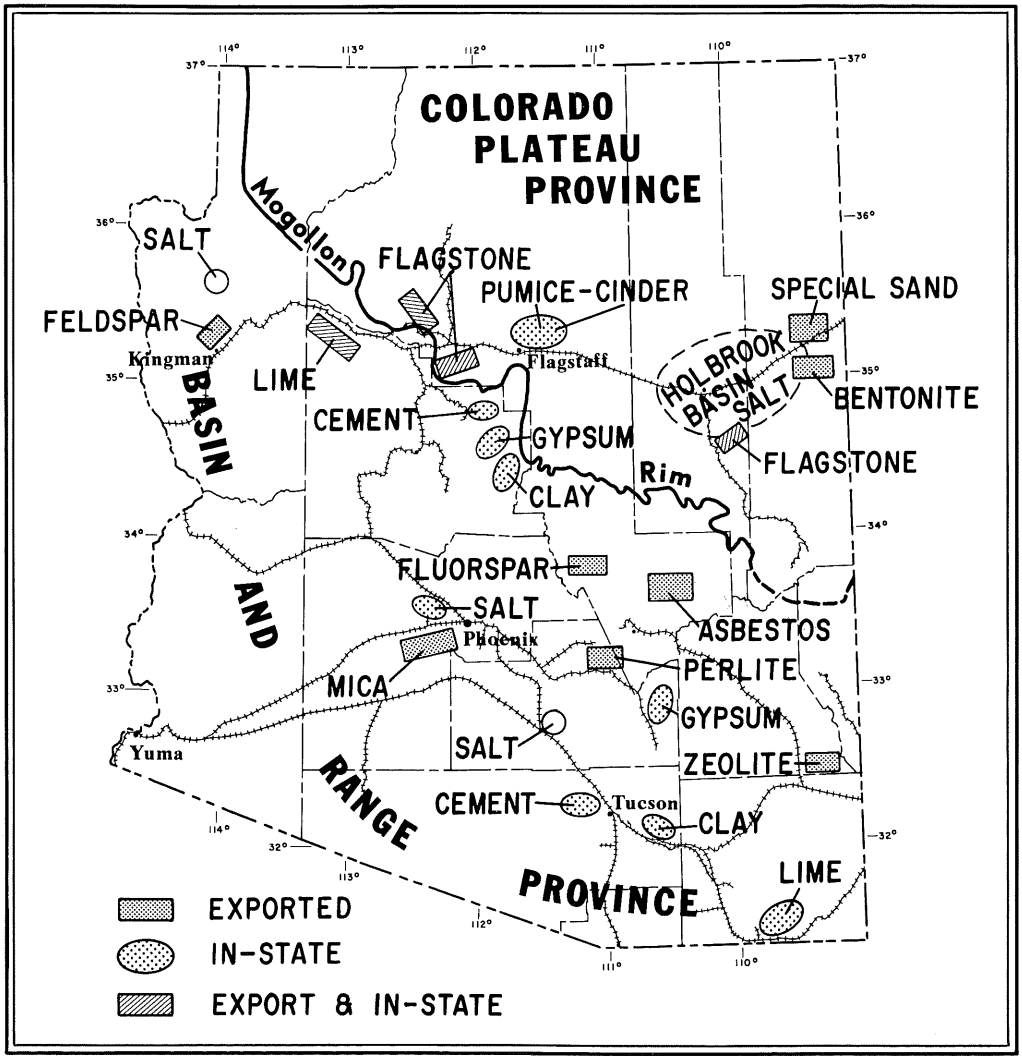
Volume 10, No. 2 | Earth Sciences and Mineral Resources in Arizona | June 1980

INDUSTRIAL MINERALS AND ROCKS OF ARIZONA

by H. Wesley Peirce

INTRODUCTION

Industrial minerals and rocks are the staff of life, the bread and butter of the mineral world. They are those naturally-occurring, inorganic, nonmetallic-appearing rocks and minerals that enter into commerce. They include the more mundane, everyday rocks and minerals of the earth – the sands, gravels, limestones, clays, salts, cinders, etc., that usually do not figure in "get rich quick" fantasies, as do the romanticized metals such as gold and silver. At today's prices, one ounce of gold is equal to about 200 tons of commercial sand and gravel. Which would you rather have? Chances are that gold is perceived as neater – it would better fit a strong box. However, someone has to do the "dirty" work if we are to have the conveniences (houses, roads, and so on) that are the hallmark of modern civilization. Most of us are users, not producers, and we know little about the blood, sweat, tears, knowledge, imagination, risk, patience and investment that lie behind the everyday things that we use, but take for granted. Over the long haul it would appear unwise to lose sight of the basic supports of modern life, which include the high volume, low value, essential industrial minerals.



Map of Arizona showing railroads, major geologic provinces, and selected industrial mineral commodities presently being produced.

In this issue

OVERVIEW

Five figures have been developed to help summarize highlights of the industrial minerals industry in Arizona. Three of these contain commodity-related names that can be consulted, should the reader be unfamiliar with the kinds of materials that characterize Arizona IM (industrial minerals) production.

As might be expected, Arizona's IM industry is strongly influenced by population and industrial growth and the condition of the economy. We are the sixth largest state in area and have been number one in population growth over the past decade. Figures 1 and 2 reflect the growth pattern in IM output in terms of tonnage. As can be seen in Figure 1, growth, as reflected in value, is misleading because of severe inflation. Between 1950 and 1960, IM tonnage output per resident had increased from about four to 16 tons per year. Except for periods of depression in the business cycle, this higher rate seems to generally prevail. As suggested in Figure 2, the largest growth item, in terms of tonnage, has been sand and gravel. Also, it is interesting to note the consistency in percentage contribution through time that each of the four groups represented tends to make each year, regardless of the amount of total production.

Although the land area of the State is about equally divided between the Plateau to the northeast and the Basin and Range country to the southwest (see map, p. 1), it is the latter province that has received the lion's share of the growth. In fact, over 92% of the populace lives in Basin and Range territory. Considering the large influence of construction on IM output, especially sand and gravel, it is not surprising to learn that 98% of the 1978 IM production came from this growth region. In terms of tonnage and value, commodities exported from Arizona (see map, p. 1), though geologically interesting and individually important, are quantitatively small.

Figure 3 attempts to rank Arizona's IM and products as to value per short ton. That which is most basic and used locally in largest quantities (sand and gravel, brick clay, cinders), has the least value per unit. That which is used in relatively small quantities (zeolite) and is exported has the highest value.

Figure 4 depicts the general production history of certain nonmetallic commodities and groups. According to the record, *clays* have been exploited continuously since before 1900. However, salt, all of which was imported prior to the 1970's, is the newest of the industrial minerals now being produced in Arizona.

Although the 1978 value of overall Arizona mineral production exceeded $1.6 billion, only 10% of this, or about $170 million, is attributed to the nonmetallic industrial minerals. Combined cement and lime approached $85 million, sand and gravel $65 million, stone $10 million, and all others about $10 million. Perhaps it should be recalled that monetary value is not always a measure of usefulness. Isn't it true that the best things in life are free? How about relatively cheap?

In the remaining paragraphs I should like to selectively discuss some aspects of the rocks and minerals that make an Arizona industrial minerals industry possible.

Limestones

Among the most versatile of the rocks of Arizona, and the world, are the limestones, especially the high-calcium varieties most suited to the manufacture of Portland Cement and lime. Arizona is reputed to have the largest lime-making plant west of the Mississippi River and also one of the largest cement plants (Rillito) in the West. Crushed limestone is utilized in many ways, including railroad ballast, filter stone, flux stone, rip-rap, road base, aggregate and sugar refining. The prime souce of Arizona's high quality limestone that enters into cement and lime manufacture is a marine sedimentary rock that was deposited in a shallow, warm sea about 300 million years ago. The rock is a carbonate sand consisting largely of fragments of fossils known as *crinoids*. Most of the lime that winds up in the concrete of our houses was originally extracted from sea water by these animals. This particular rock averages about 400 feet in thickness where present in the State. It is buried beneath the Plateau by younger rocks and is exposed only in the Grand Canyon and along the base of the Mogollon Rim in central Arizona, where it is exploited in the Verde Valley. Geologic mapping reveals that this rock is not present in Maricopa County, the home of Phoenix, because of subsequent removal by erosion. However, it reappears near Tucson where it is an important industrial commodity.

Sand and Gravel

Sand and rock fragments, mixed with cement and water, make concrete, perhaps the most basic of construction materials. It would be ideal to find a deposit that contains just the right proportions of sand and crushable, durable rock for concrete needs. However, it seldom happens. Usually, excess sand has to be moved in order to get enough rock to crush. Sand and gravel deposits occur along modern channelways and on adjacent floodplains and terraces. It is the quality of the gravel that

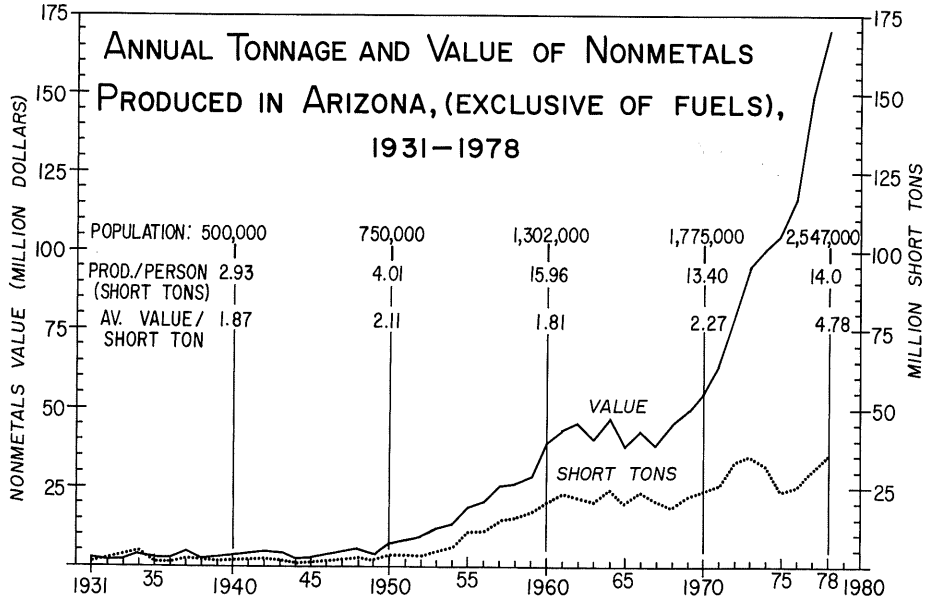


Figure 1, *IM.* Annual tonnage and value of industrial minerals produced in Arizona, 1931-1978 (see population statistics).

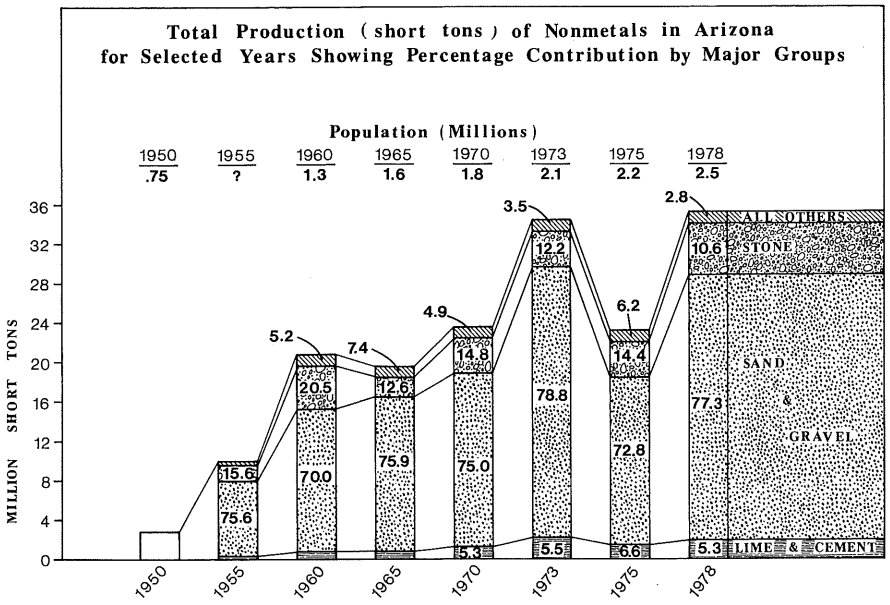


Figure 2*, *IM.* Total production (short tons) of industrial minerals in Arizona for selected years showing percentage contribution by major groups.

determines the suitability of a deposit. In turn, it is the ultimate source of the gravel that controls the utility of a deposit. It is a mistake to think that high quality gravel deposits occur just anywhere. They don't. In spite of the fact that there are good quality gravels associated with several of the Phoenix area channelways, none could satisfy the concrete aggregate specifications that attend the Palo Verde Nuclear Power Plant presently under construction near Phoenix. As a consequence, gravel is being hauled from as far away as the Colorado River region near Yuma.

During 1978, in Arizona, we had a record of 153 sand and gravel deposits that supplied 133 plants. In contrast, there are but two cement plants. It is cheaper to have a nearby source of aggregate and bring the cement to it. Sand and gravel operations tend to stay as close to consuming centers as possible because it costs a lot to move this bulk around. Hopefully, our planners will not lose sight of this basic fact.

Stone

This group is quite diverse and embraces all of the rock types that are either crushed or quarried as building stone. Stone includes marble crushed for poultry grit and swimming pool plaster, as well as the excellent flagstone of the Plateau country. This flagstone is noted for its durability and capability of splitting into slabs of even thickness. The formation is the Coconino Sandstone that originally was deposited as sand dunes about 250 million years ago. This stone is shipped to many parts of the U.S.

Cinders

Cinders are volcanic ejecta that commonly occur in the form of cinder cones. Sunset Crater near Flagstaff is such a feature. In northern Arizona, in parts of the Plateau region, cinder cones are numerous and frequently quarried for use as railroad ballast, highway aggregate, dirt road surfacing and for other purposes. The red hue in many of the paved highways is imparted by reddish cinders. Cinders are widely used in northern Arizona in lieu of scarce, good quality gravel. Both red and black cinders are trucked to the Phoenix area block plants that manufacture cinder block.

continued on p. 10

AVERAGE VALUES (Short Ton) of SELECTED ARIZONA NONMETAL COMMODITIES

AV. VALUE/S T ($)	COMMODITY GROUPS
2000-3000	*ZEOLITE (Chabazite)*
600-800	*ASBESTOS*
80-100	*FLUORSPAR (Acid grade)*
40-60	*CEMENT (Portland)*
30-50	*QUICKLIME*
25-35	*MICA*
20-30	*FLAGSTONE*
15-20	*SALT*
12-18	*FELDSPAR*
12-15	*CLAY (Montmorillonite), PERLITE, SPECIAL SAND, MARBLE (Crushed)*
4-6	*GYPSUM*
3-4	*STONE (Crushed)*
2-3	*SAND, GRAVEL, CLAY (Brick), CINDERS*

Figure 3, *IM.* Average values (short tons) of selected Arizona industrial mineral commodities.

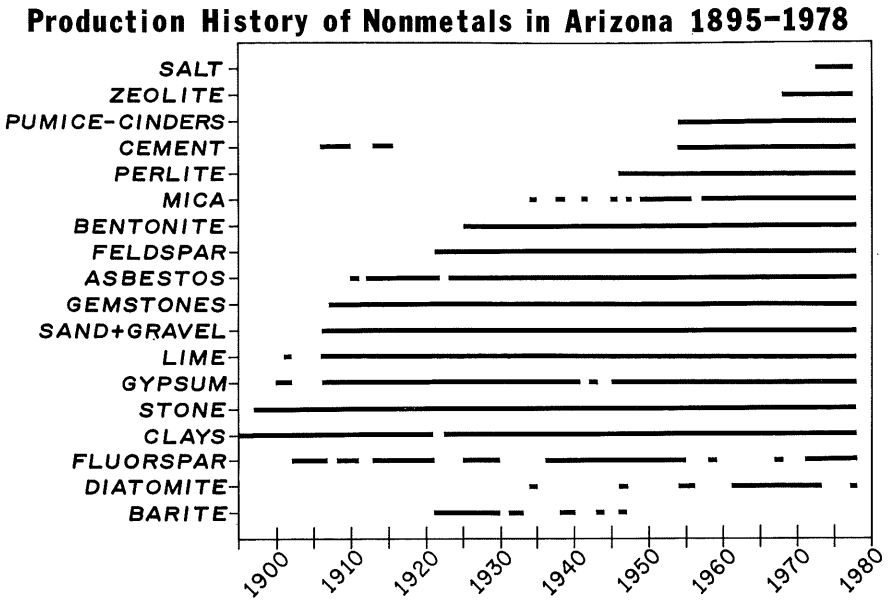


Figure 4, *IM.* History of industrial minerals produced in Arizona, 1895-1978.

*Figures 2-4: Basic data compiled by Solomon Toweh, University of Arizona Graduate Student.

Industrial Minerals continued

Gemstones

Although it is difficult to assign a credible monetary value, it is thought that Arizona is the U.S. leader in the sale of gemstones: Estimates range to about $5 million, the largest part of which would be assigned to turquoise removed under contract from a few of the State's large copper mines. Certainly, the beautiful 200 million year old petrified wood of northern Arizona is a significant part of the commerce in gemstones.

Special Clay

Special clay is to be distinquished from the more common clays utilized in the making of red brick. A unique clay has been mined on the Plateau in southern Apache County since the 1920's. It is of sufficient value to warrant the removal of 80 feet or more of overburden. Technically, the clay is a low-swelling montmorillonite that has been used in making beauty preparations, refining and decolorizing mineral and edible oils, the making of catalysts for refining petroleum, and in desiccants. The material has been shipped all over the world. Its origin is attributed to the alteration of vitric ash beds included within the five million year old Bidahochi Formation. There is much interest in finding additional resources of this type in Arizona, but thus far the results have not been encouraging. Deposits that are totally buried may exist but, if so, would be difficult to find.

Salt

Arizona's newest IM industry is the production of common salt, or halite, near Phoenix. In 1968, a salt exploration hole drilled west of Phoenix encountered salt 880 feet beneath a cotton field. This formation is massive rock salt estimated to be about 10,000 feet thick and to occupy about 15 cubic miles of the subsurface. Water is pumped into the salt and the resulting brine is evaporated in surface ponds by the Arizona sun. Uses include water softening, hide curing and cattle feed.

Adjacent to the salt works is a subsurface storage project that utilizes space created by controlled solutioning of salt. Both propane and butane are stored and removed by an automated system that services a nearby railroad spur. Excess butane from California petroleum refineries is stored here in summer and returned and added to winter gasoline supplies in order to enhance cold weather starting. It is cheaper to store propane and butane in Arizona salt than in California where there are no recognized massive salt deposits. There is another salt storage project on the Plateau in the Holbrook Basin salt deposit (see map, p. 1). Another is planned for the Red Lake deposit of northwestern Arizona where Southwest Gas plans to store natural gas to supply peak demand in California.

Zeolite

Not only is the production of natural zeolite relatively new in Arizona (Fig. 4), it is the first operation of its kind in the U.S. *Zeolite* is a large family of similar mineral species that vary slightly, but importantly, in their specific physical-chemical attributes. Technological need, combined with the belated recognition that *large* deposits of high-grade zeolite occur naturally, sparked exploration throughout the U.S. The use of natural zeolites promises to rise dramatically during the coming decade. Emphasis is placed on *natural* because in the past these minerals have been produced synthetically. Fundamentally, zeolites are used in making molecular sieves capable of selectively removing certain molecular mixtures based on the size and shape of molecules. As an example, one use for Arizona chabazite is the separation of hydrogen sulfide from natural gas. Like the *special clay*, zeolite minerals tend to represent an alteration product derived from vitric ash deposits. Many of the zeolite minerals are known to occur in Arizona's Basin and Range Province.

THE FUTURE

Arizona, like a magnet, attracts people. Population growth seems inevitable, as does the industrial growth that must occur if people are to find employment. Whether or not there will be significant expansion in basic IM industries depends upon growth rate. Arizona has the potential for development of additional IM deposits through either new discoveries or changes in circumstances that affect development of deposits already known to exist.

Because of geologic variety and complexity, Arizona's major mineral production and remaining development potential is vested in the southwestern half of the State – the Basin and Range geologic province. Actually, many geologic mysteries remain; and, inherent in these are mineral resource discovery opportunities, opportunities that must be identified if the State and nation are to continue to have the basic ingredients that have come to be the foundations of modern civilization.

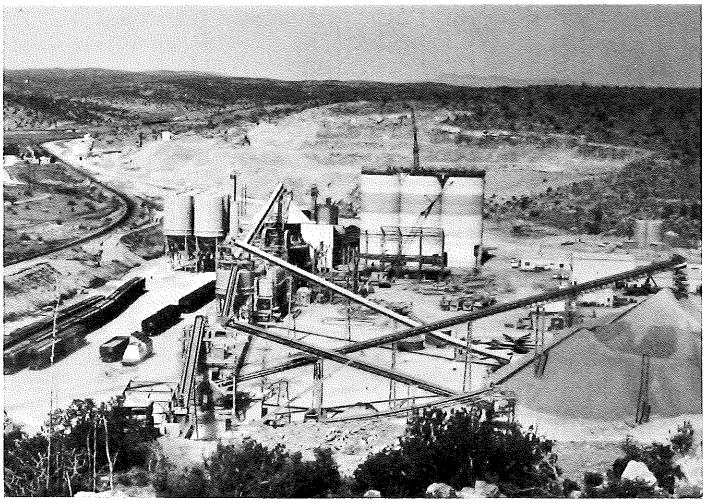
SOME ARIZONA INDUSTRIAL MINERAL OPERATIONS

Harvesting salt from an evaporation pond

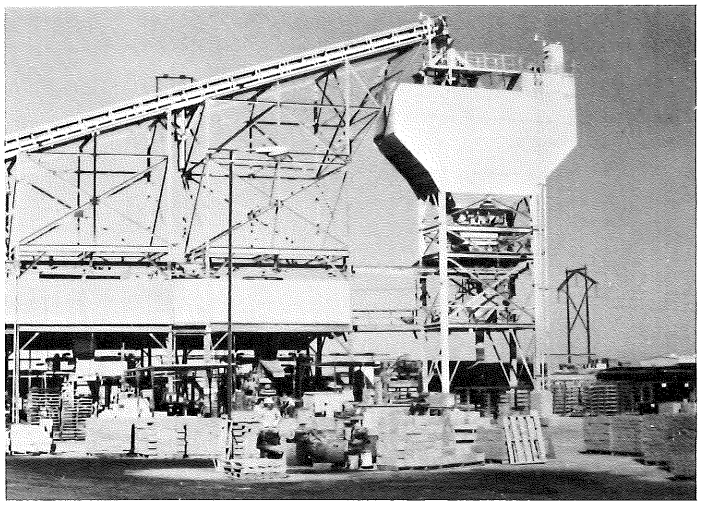
Salt washing and stacking

Propane-butane loading/unloading system. Products stored in a solution cavity washed out of salt

Stone yard. Flagstone is quarried from the Coconino Sandstone of northern Arizona



Lime plant of the Flintkote Company, U.S. Lime Division. Fuel on railroad cars is coal shipped from New Mexico



Block-making plant, Phoenix area

Photos: H.W. Peirce