FIELDNOTES
From The State Of Arizona
Bureau Of Geology And Mineral Technology

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BOWIE ZEOLITE
AN ARIZONA INDUSTRIAL MINERAL

by Mr. Ted H. Eyde

The following article was contributed by Ted Eyde, a Tucson consulting geologist, and edited for FIELDNOTES by H. Wesley Peirce of the Bureau staff. We thank Ted for the interest and effort represented.

INTRODUCTION

The value of industrial materials produced in Arizona each year exceeds 100 million dollars. Although this sum is dwarfed by the billion dollar metals industry, the utility of the nonmetallic materials exceeds their value – they greatly enhance our daily lives. There are about twenty-eight major groups of nonmetallic substances inventoried in Bureau bulletin no. 180, Mineral and Water Resources of Arizona. The last item on the list is ZEOLITES. Very likely, few Arizonans have ever heard of this word even though one of our deposits is the largest known of its type and the first to be commercialized in the United States. Lack of awareness of most everything related to our earth resources is the rule, not the exception, as was suggested in the last issue of FIELDNOTES ("Back to Basics"). Anyway, we hope that this brief introduction to zeolites will prove interesting to those not already familiar with the subject.

GENERAL STATEMENT

What is a zeolite? The question is easier to ask than to answer. Zeolites are a family of well-defined hydrous aluminum silicates of alkali and alkaline earth elements that closely resemble each other in composition and mode of occurrence. They contain

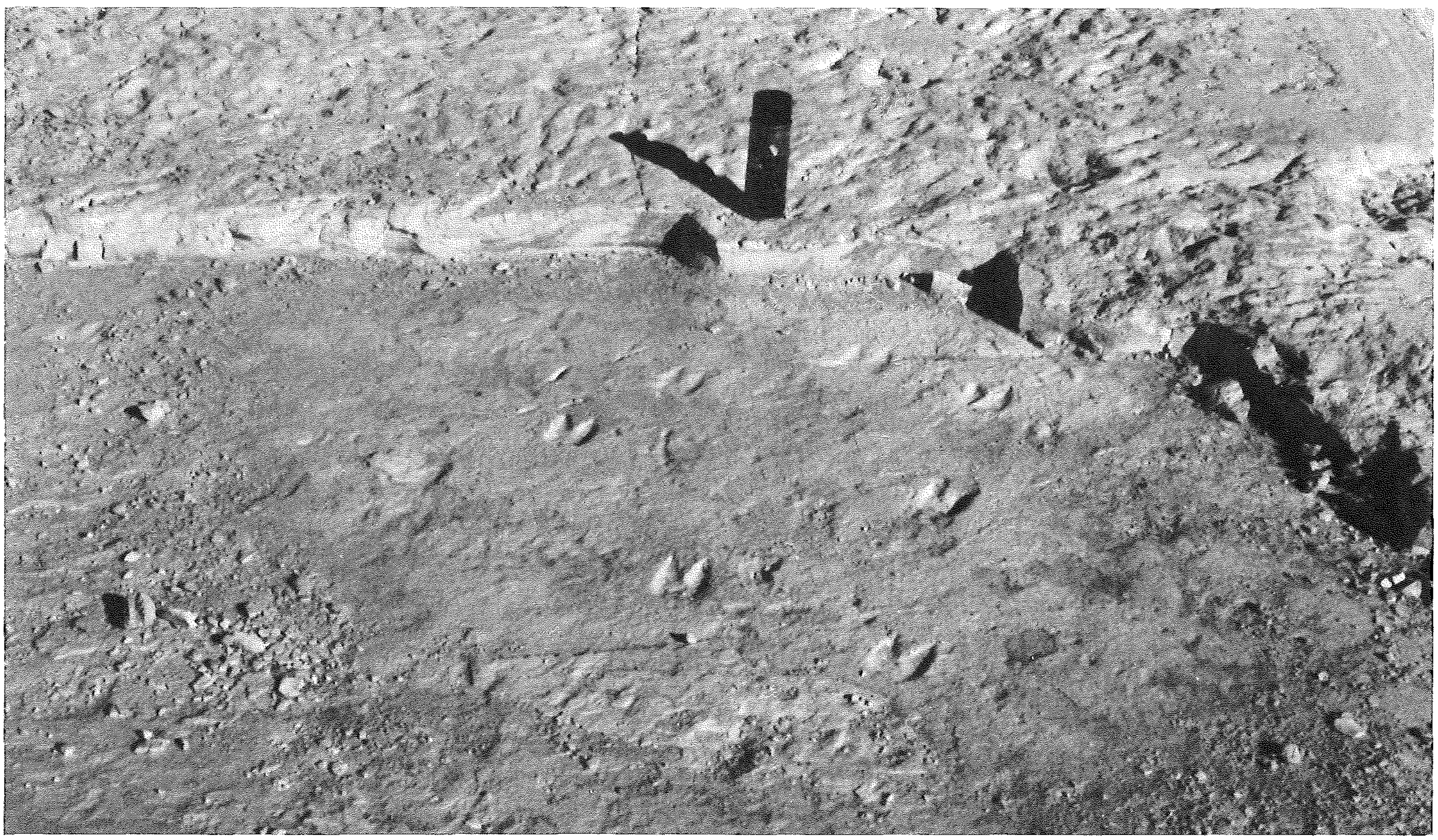


Fig. 1 – Camel-like tracks exposed on upper surface of gray ash unit beneath lighter colored "high-grade" zeolite bed about 6" thick – Bowie chabazite deposit, Arizona.

essential aluminum, silicon and water and in most cases calcium and/or sodium. Although there are many individual species it is not necessary to name them all here. Zeolites are especially interesting and useful because of the way they are put together in a three-dimensional network structure. On a molecular scale they are porous and full of holes, having an aperture size on the order of 10 Å in diameter.* They are literally molecular sieves that can be used for the selective separation of certain molecular mixtures based on the size and shape of molecules. Too, they are noted for their ability to selectively adsorb gases.

Many years ago an Arizonan walked into the Bureau's mineral identification laboratory wanting to know why certain rocks had "shot" at him. The episode occurred in front of a fireplace in a cabin in the White Mountains of east-central Arizona. There were some large pieces of black rock that were being heated by the fire. Soon, projectiles zinging across the room sent him and his wife for cover and, eventually, to the Bureau lab with a piece of the popping rock. It was a volcanic rock that contained a zeolite mineral. Zeolite minerals contained just beneath the rock's surface had their water converted to steam and when steam pressure overcame the confining force — POW!

The following is taken from Mumpton (1976, p. 50-51).

In less than 20 years time, the status of the zeolite group of minerals changed from that of museum curiosity to one of a full-fledged, industrial mineral commodity. This remarkable transformation is due in large part to the belated recognition in the late 1950's of the widespread occurrence of zeolite minerals as major constituents of Cenozoic sedimentary rocks of volcanic origin, and to the research efforts of several industrial organizations during this period on the development of commercial applications for synthetic molecular sieves. The discovery that zeolite minerals formed on a large scale by reactions of volcanic tuffs and tuffaceous sedimentary rocks in marine and lacustrine environments was in itself a milestone in the geological sciences; however, the realization that such materials were also capable of being utilized in numerous areas of industrial and agricultural technology provided the impetus for the exploration and development programs that have taken place on natural zeolites since that time in dozens of countries of the world.

Although the commercial use of natural zeolites is still in its infancy, more than 300,000 tons of zeolitic tuff is currently mined each year in the United States, Japan, Italy, Hungary, Yugoslavia, Bulgaria, Germany, Korea, and Mexico, and used for filler in the paper industry, in pozzolanic cements and concrete, as lightweight aggregate, in fertilizer and soil conditioners, as ion exchangers in wastewater treatment, as dietary supplements in animal husbandry, in the separation of oxygen and nitrogen from air, as reforming petroleum catalysts, and as acid-resistant adsorbents in gas drying and purification. In this era of environmental concern and of energy and resource conservation, the attractive physical and chemical properties of natural zeolites will be utilized worldwide even more in the years to come in the solutions to these problems.

Since 1961, Arizona natural zeolite has been mined from a locality in Graham County several miles north of Bowie. The major component of the deposit is the zeolite mineral chabazite, the largest deposit of it's kind known in the United States. Although not realized until recently, this deposit was first reported by Oscar Loew in 1875. It is believed that this reference is the earliest published record of a bedded zeolite deposit anywhere in the world (Sheppard, et al, 1976). Indeed, considering that the deposit was destined for rediscovery in 1959, it seems remarkable that Loew was able to diagnose the zeolitic nature of the deposit over 80 years earlier.

In 1957 the Linde Division of Union Carbide Corporation planned to expand it's synthetic zeolite manufacturing facilities. This is a rare case in which a synthetic mineral product was utilized industrially before the discovery and development of suitable natural material. In this same year, 1957, a large bedded deposit of the zeolite mineral erionite was discovered in Pine Valley near Carlan, Nevada. This development, along with recognition of the fact that molecular sieves made from natural zeolites could be competitive with synthetic products, set off a major exploration program by the Union Carbide Nuclear Company on behalf of the Linde Division.

In early 1958 a sample of zeolitic tuff (glass particles produced by explosive volanic activity) was submitted to the Linde Company. The sample was supposed to have been collected somewhere near the Cochise-Graham County line north of Bowie in the vicinity of San Simon Wash. The sample, which laboratory tests proved to be high purity chabazite, was traced back to a group of three prospectors who had staked placer claims on what they believed to be a unique deposit of light-weight ornamental stone. The actual "rediscovery" was made by a retired railroad engineer, Ernest Baugher, from Buffalo, New York. He interested two fellow railroad men, Frank Meadows and Paul Sanger, in providing for expenses and manpower for staking claims. Another part-time prospector, Frank Clark, a retired butcher, staked claims in the southeast portion of the deposit. The chabazite from this part of the deposit contains abundant iron oxides that make a beautiful mottled and banded texture. He made bookends, paper weights, and pencil holders that were sold to souvenir stores in Bowie. At the time that the sample was submitted to the Linde Division no one knew the true nature of the material. However, some of the outward manifestations seemed unusual thus generated interest in determining the mineralogy of this natural substance that occurred in relative abundance.

In 1959 a Union Carbide Nuclear Company geologist sampled the outcrops on the B.M.S. claims and submitted them to the company laboratory. X-ray diffraction techniques suggested a low zeolite (chabazite) content. Because questions then arose, the deposit was revisited and resampled with similar laboratory results. Actually, the original sample had been run by a technique referred to as oxygen adsorption, not x-ray diffraction as in the later tests. Had the initial sample not been done that way curiosity might not have been aroused.

*1 Å is an angstrom unit of size. One inch equals 254,000,000 Å.

Plate 1

A. Outcrop of zeolitized tuff along bank of San Simon Wash, Graham County.

B. Core drilling to determine nature, distribution and depth to buried zeolite.

C. Core of chabazite.

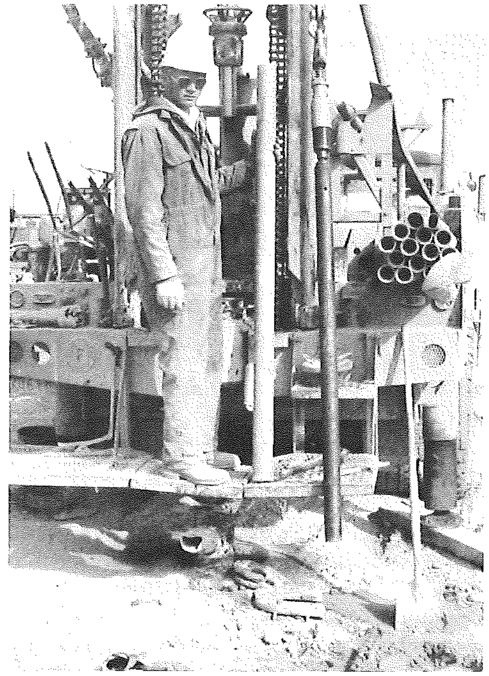
D. An organized core record.

E. Removal of overburden above 6" "high-grade" zeolite bed.

F. Final scraping to expose top surface of 6" "ore" horizon.

PLATE 1

A



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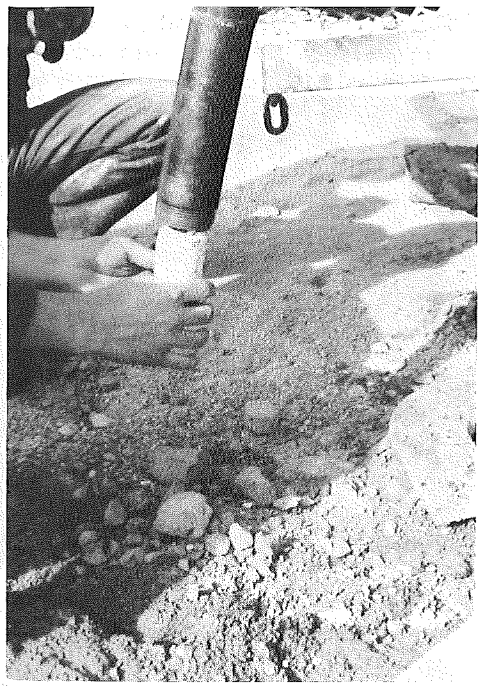

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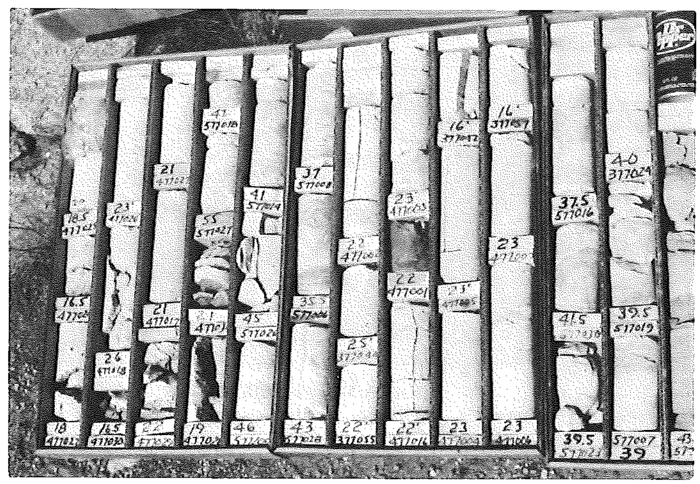

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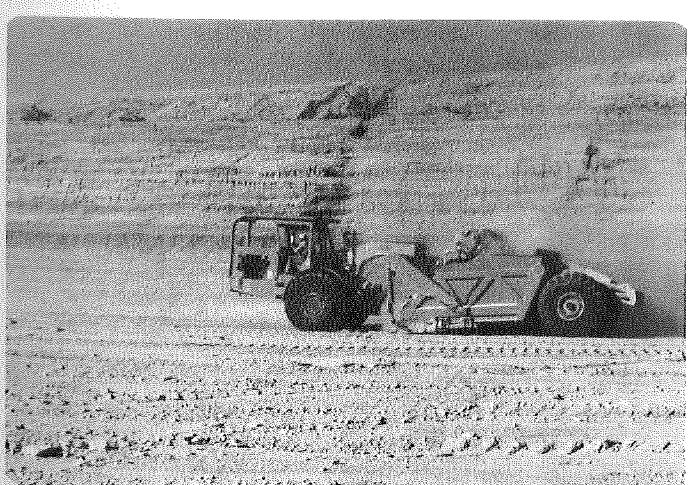

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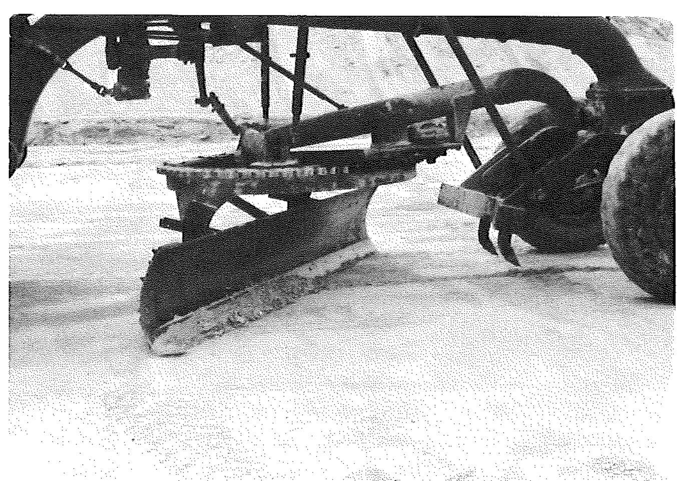

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Photos by Ted H. Eyde

PLATE 2

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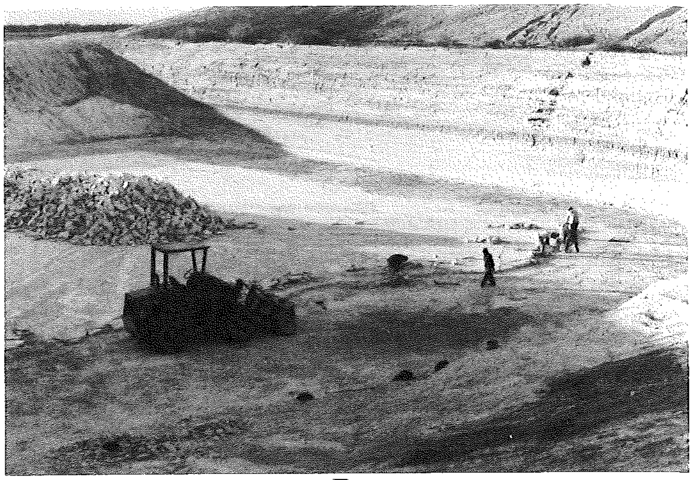

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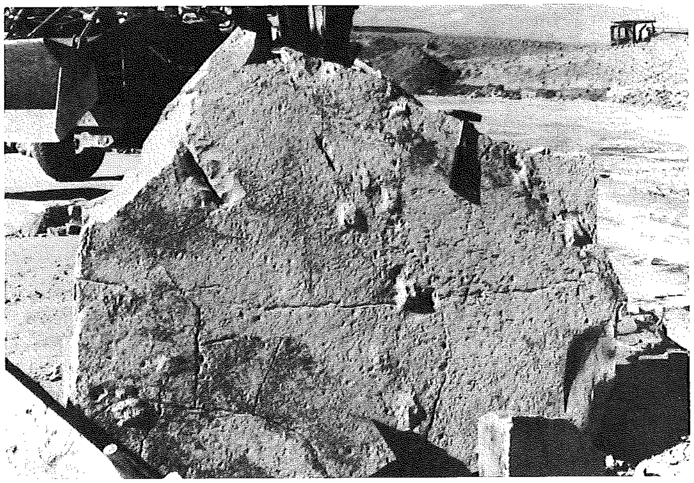

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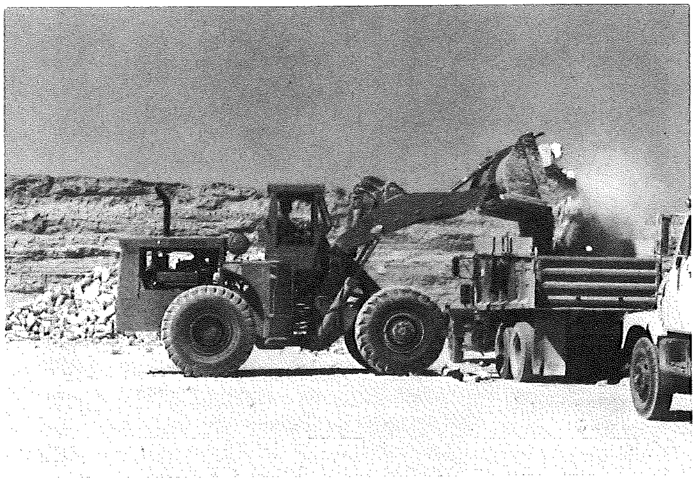

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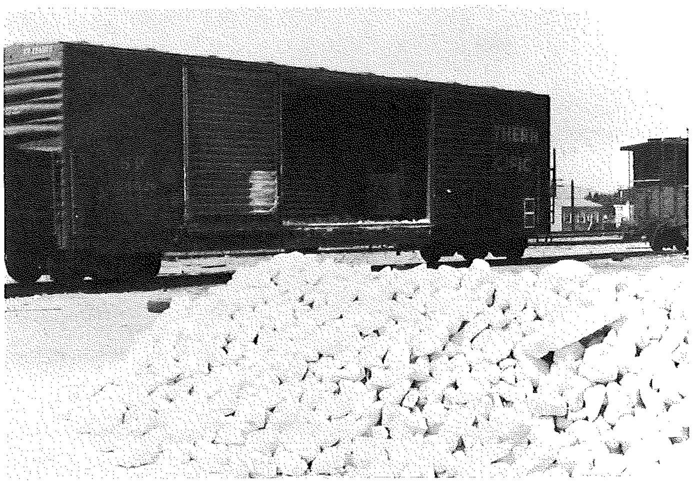

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Photos by Ted H. Eyde

Plate 2

A. Brushing top surface of zeolite (chabazite) bed so as to minimize contamination.

B. Zeolite pit showing 6" zeolite bed on pit floor, front end loader used in loosening blocks of zeolite, men cleaning impurity (ash) from base of zeolite blocks, and "ore" pile. Note thickness of overburden removed to expose 6" bed.

C. Hand removal of impurity clinging to base of zeolite blocks.

D. Casts of tracks on underside of block from zeolite bed. The primary tracks (see front page picture) are not zeolitized whereas the casts are. This emphasizes the amazing selectivity of the zeolitizing process.

E. Loading truck for the haul to railroad.

F. Ore pile awaiting shipment in box car. Variable moisture content causes weight fluctuations.

Anyway, there were contrasting analytical results and it was determined that more had to be learned about the deposit itself. Ted Eyde, a geologist assigned to the zeolite program, was sent to study the deposit in more detail. He collected samples from each of the lithologies in the zeolitic tuff zone. As a result he discovered that the basal unit, a bed about six inches thick, could be traced for nearly seven miles along both sides of San Simon Wash. This thin unit now is known as the high-grade bed (see plates). Overall, it appeared as though the tuffs, subsequently zeolitized, had accumulated in a shallow lake environment. Younger erosion has dissected and removed some of the originally more extensive deposit.

X-ray diffraction tests again proved disappointing. This time, however, Dr. E.M. Flanigen and Dr. F.A. Mumpton, researchers working for Dr. D.W. Breck, a prominent inorganic chemist at the Linde Research Laboratory at Tonawanda, New York, puzzled by the contradictory analytical data, reran the original sample by x-ray diffraction, and yes, disappointing results! They then conducted oxygen adsorption analysis on the lower bed and made an amazing discovery. The material from the Bowie chabazite deposit, the lower bed in particular, adsorbed more oxygen than the company's natural chabazite standard from Reece River, Nevada, that was assumed to be 100% chabazite! Impossible you say? You are right. Actually, the lower high-grade bed is not pure chabazite. It's spectacular adsorption performance is believed to be directly related to the minute size (microcrystallinity) of the chabazite crystals. Following this discovery large bulk samples were sent to the Linde Company for additional laboratory testing.

The EZ (Eyde's Zeolites) claim group was staked on April 15, 1961. Exploration drilling was initiated and it was determined that the deposit was cut up by erosion into five separate bodies, and they were so numbered.

The first shipment of chabazite from the Bowie deposit was made in 1962. Several carloads amounting to about 165 tons was shipped. By 1977 four companies were involved and about 2,000 tons of product were shipped that year. Most of the production is used in natural gas purification facilities where hydrogen sulfide, carbon dioxide, and water are removed.

Union Carbide Corporation ships the mine run zeolite by rail to Riverside, Texas for grinding and on to their Chickasaw, Alabama plant for final processing. Norton Company ships by rail to East Greenville, Pennsylvania for grinding and on to Chattanooga, Tennessee for final processing. Both W. R. Grace Company and Letcher and Associates have their zeolite ground at Bowie. The former then ships in barrels by rail to its plant in Baltimore, Maryland while the latter ships in bulk by truck to its processing plant in Lancaster, California (Eyde, 1978).

Of major importance in the use of this natural chabazite from Bowie is its relative stability in low pH (acid) environments where it out performs the synthetic materials. "Beds" of this processed zeolite can be used repeatedly before replacement is necessary.

Geologically, it is not precise to say that these bedded zeolites are sedimentary deposits. In actuality they are alteration products derived from a volcanic product, ash, or tuff, that occurs in a layered or bedded form. It is the lateral continuity associated with the characteristic of being bedded that is important. How it got that way is a technical consideration subject to available evidence on a case by case basis.

Certain aspects of the zeolite mining process in the Bowie deposit are illustrated in Plates 1 and 2.

In the light of contemporary emphasis on land use, classification, and management, perhaps this Bowie zeolite deposit can be used to illustrate a principle or two:

1. Discovery has many interesting facets. Eighty years ago recognition of the Bowie zeolite occurrence was but a curiosity whereas rediscovery in 1959 lead to utilization after the true nature of the deposit was again determined.
2. The utility of earth substances varies through time in response to technological change and requirements. In the present case the utility spectrum ranged from none through ornamental stone to a natural gas purifying agent that is assisting in the alleviation of the energy shortage and in pollution control.
3. Discovery and development cannot take place if access to the land for mineral exploration and development purposes is foreclosed. In this case both State and Federal lands contain the zeolite reserves. However, those agencies with custodial responsibilities did not recognize that these lands contained potentially important zeolite deposits.
4. Very often sophisticated laboratory techniques are required in order to properly characterize an earth substance. An earth substance may be useful for itself in contrast to having a metal, like copper, extracted from it.
5. Discovery-recognition and demand for a substance might not coincide. The need for rediscovery can be trimmed by the routine collection, inventorying and organization of appropriate data, and its utilization.
6. A mineral substance might not have a formal value until it is discovered in sufficient quantity to encourage the development of uses. Many uses for zeolite minerals today, in particular those for pollution abatement importance, did not exist at the time the Bowie Arizona deposit was found.

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GEOTHERMAL PIPELINE

Geothermal Group Grows and Moves

by Mr. W. Richard Hahman Sr.

We've moved again! Currently, we are located at 2405 N. Forbes Blvd., Suite 106, Tucson, Arizona 85705. We now have comfortable quarters with adequate room to expand should it become necessary. We are sorry that the Bureau family cannot stay together at the University but adequate space cannot be found there.

Mr. Michael Ciarochi has joined our staff as a geological technician. Mr. Ciarochi's prior experience with exploration and mining companies will be of benefit to our geological mapping, sampling, and drilling programs.

The U.S. Department of the Interior, Bureau of Reclamation, Region 3, Boulder City, Nevada has joined the U.S. Department of Energy, Division of Geothermal Energy as a participant in the geothermal energy exploration, evaluation and development program in Arizona. This program is designed to determine the possibility of water supply augmentation and water quality enhancement through the development of high temperature geothermal resources on Federal lands in Arizona. Such lands include Hyder Valley, Kingman, Palo Verde, Safford, Verde Valley, Willcox, Yuma, and other lesser known regions. Another Bureau of Reclamation supported program in progress involves assessing the high temperature geothermal energy potential in the Springerville-St. Johns and Clifton-Morenci areas in an attempt to augment water supply and improve water quality. These Bureau of Reclamation programs have been dovetailed with the low to moderate temperature geothermal energy studies supported by the U.S. Department of Energy, Division of Geothermal Energy, to negate duplication of funding and effort.

The Hyder area, to include the Palomas and Sentinel plains, is characterized by numerous shallow hot wells and a former hot spring, Agua Caliente. The area is situated over a deep sediment filled basin, several major gravity and magnetic anomalies, and the trace of the northeast trending Gila lineament, a probable major structural boundary or fracture zone. The Sentinel basalt field, active during the past 3 million years, is close by. Geothermometry of hot wells suggests Na-K-Ca and SiO_2 reservoir temperature estimates of around 100°C. These estimates are, however, likely to be low if deeper hot waters are mixing with colder near-surface waters.

Not as much preliminary information is available for the Kingman region. Existing geochemical geothermometer data indicate potential minimum reservoir temperatures in excess of 100° – 150°C and groundwater that may contain total dissolved solids in excess of 3000 parts per million. However, there are not enough data available to speculate on the mixing of cool water with thermal brines.

The Palo Verde area in this study encompasses the Hassayampa and Rainbow valleys. Some of the highest heat flow measurements in Arizona have come from here. The geothermometry from hot water wells in Rainbow Valley suggests Na-K-Ca temperatures of 120°C and SiO_2 temperatures of 180°C as minimum reservoir temperatures. Again, we are not able at this time to comment on various mixing possibilities.

The Safford area includes the Gila River Valley at Safford and the San Simon Valley. The region of interest is situated over a deep alluvial-filled graben which trends northwest. Several hot springs discharge near Fort Thomas and there are many hot saline artesian wells less than 1500 feet deep. Geochemical analyses of the hot water from these wells suggest minimum estimated reservoir temperatures of 60°C and 120°C using Na-K-Ca and SiO_2, respectively. A deep convective system with temperatures greater than 150°C may exist and could provide the mechanism which heats the shallow artesian aquifers.

A geothermal resource in the Verde Valley is indicated at the northern part by Verde Hot Springs near Childs that has a surface temperature ranging from 38 to 41°C, and, in the southern part by Chalk Hot Springs, just north of Horseshoe Dam, that has surface temperatures of 36°C. The indicated minimum reservoir geochemical temperatures for Verde Hot Springs are 118°C (SiO_2) and 146°C (Na-K-Ca). It has been reported to our group that additional hot springs and seeps exist both along the river and in the flanking countryside.

High temperature gradient wells occur north of the town of Willcox and could indicate a high temperature geothermal resource. The area lies astride a possible northeast trending lineament that apparently controls the occurrence of some geothermal systems in both Arizona and New Mexico. The Sulphur Springs Valley contains a large quantity of saline ground water in storage that might be suitable for both domestic and agricultural use after desalination.

An oil test well drilled in the Yuma area to a depth of 3217 meters encountered temperatures up to 138°C. This is not an exceptionally high temperature for this depth but does indicate some potential that should be evaluated. Should a geothermal resource be developed in this region it might be possible to augment existing water supplies through the desalination of saline brines.

Added note: for the record I should like to comment that bill H.R. 12536 (Wild and Scenic Rivers) of the 95th Congress would remove several high priority geothermal resource areas from evaluation and development. These include portions of the valleys of: (1) the San Francisco River, (2) the Gila River, & (3) the Verde River. This is another example of the clash between single vs. multiple uses of land. Geothermal potential remains obscure and generally remote from the minds of most citizens and Congressmen. Hopefully, these lands will not be removed from geothermal study prior to adequate evaluation of their potential.

"Land of Cochise" Field Conference-A BIG SUCCESS

On November 8 through 11, 1978, the New Mexico Geological Society held its 29th annual field conference. In cooperation with The Arizona Geological Society, a 106 car caravan containing some 240 participants snaked its way through southeast Arizona. The trip, initiated at Lordsburg, New Mexico, traveled to Douglas, Arizona the first night and Tucson, Arizona the second night. It has been ten years since any field trip of comparable magnitude has been held in the area. As evidenced from the numerous articles in the guidebook and the comprehensive roadlogs written chiefly by Stanley B. Keith and Jan C. Wilt of The Bureau of Geology and Mineral Technology, much new data and many new interpretations have arisen in the last ten years about southeast Arizona.

The field trip was particularly timely in view of the provocative Anshutz oil play which holds that oil reservoirs may be buried at several kilometers depth underneath large sheet-like thrust plates. Indeed, the registration for the conference filled in the fastest time ever. Much of this registration was occupied by oil geologists from various companies who were quietly in attendance throughout the trip.

Appropriately enough, the unofficial theme of the field trip was Mesozoic and Cenozoic tectonic development within southeast Arizona. The participants were exposed to numerous contrasting points of view which to anyone not familiar with the region must have seemed a bewildering array of complexity. Views about how the late Cretaceous-early Tertiary Laramide orogeny was effected may have seemed particularly baffling. Various geometric hypotheses offered included the low angle overthrust view urged by Floyd Moulton of Anshutz Corporation and Harald Drewes of the U.S. Geological Survey; basement cored uplifts submitted by George Davis of the University of Arizona; and a complex sequence of reverse faulting, basement uplift, and strike slip faulting suggested by Stanley Keith of our Geological Survey Branch. All of these views, despite disagreement about geometric style, agreed that Laramide orogeny in southeast Arizona manifested the influence of a profund NE-SW compression.

Bill Bilodeau of Stanford University discussed the complex Mesozoic structural framework which predated the Laramide orogeny.

If all this weren't enough, on the 3rd day, what was left of the group was exposed to the enigmatic metamorphic terrane in the Rincon Mountains. Here George Davis treated the group to his amazing taffy-pull and mega-boudin concept which suggests that the perplexing mylonite metamorphic fabrics were created by over 100% of Tertiary age regional ENE-WSW extension of Arizona's crust. To contrast, Harald Drewes suggested an older history for the mylonite fabric and implicated Laramide overthrusting in its genesis.

In addition to the 3 days of the official field trip, Sam Thompson of the New Mexico Bureau of Mines ably organized a pre-field trip stratigraphic trip to the central Peloncillo Mountains, Hidalgo County, New Mexico, lead by Gus Armstrong and Harald Drewes of the U.S. Geological Survey. A post-field trip stratigraphic tour of the Whetstone Mountains in Cochise County was lead by Joseph Schreiber of the University of Arizona, Dietmar Schumacher of Phillips Petroleum, and Gus Armstrong and Phil Hayes of the U.S. Geological Survey. Rarely have so many experts on southeast Arizona Paleozoic stratigraphy been together at such classic outcrops.

All in all, however, the large audience kept its patience and humor through all these discussions and asked plenty of penetrating questions. Judging from many discussions held over outcrops at the various stops, an atmosphere of enlightenment and good fun prevailed. Hopefully, the participants left southeast Arizona with the impression of how far we have come in the last ten years and how much further we have to go towards understanding the many complexities of southeast Arizona geology.

PUBLICATION ANNOUNCEMENT

Enviromental Geology Series

Joe LaVoie, the Bureau's publications production ramrod, reports that the first two maps of a series are in press and can be expected in December, 1978. A new environmental geology study, "Environmental Geology of the McDowell Mountains Area, Maricopa County, Arizona," is being published by the Bureau. The study was conducted by personnel at Arizona State University under the supervision of Dr. Troy L. Péwé in cooperation with the City of Scottsdale. Publication is being assisted by the City and the Arizona State University Graduate College. The folio series consists of ten geologic and derivative maps. This series is being prepared as nine separate envelopes, the first containing two maps – (1) geology, and (2) land forms. The subsequent eight envelopes contain: (3) land slopes, (4) caliche, (5) ground water, (6) geologic hazards, (7) material resources, (8) excavation conditions, (9) waste disposal, and (10) construction conditions.

The map series scale is 1:24,000 and the area covered includes parts of the following 7½ minute quadrangles: Curry's Corner, McDowell Peak, Sawik Mountain, and Paradise Valley. All maps will be in color, accompanied by explanation and text, as well as photos, charts, line drawings, and other pertinent data on the reverse side.

Maps will be sold individually for $1.25 with the exception of envelope #1 which contains two maps. Envelope #1, therefore, will be sold for $2.50 and will not be split. When the entire set is available (scheduled for Summer, 1979), it will be sold for $10.00.

The Bureau is currently accepting orders for Envelope #1 which contains the Geology and Landforms maps. Again, over-the-counter price is $2.50; for mail orders please add 25¢ (postage and handling). Payment by check or money order must accompany all orders. Payment in U.S. currency is required on all foreign orders and additional charges will be made to cover foreign postage (approximately 20% of order for surface mail).

Orders should be sent to:

Bureau of Geology and Mineral Technology
Attn: Publications
845 N. Park Ave.
Tucson, Arizona 85719

Safety Corner
WARNING
Beware of Cyanide

by Mr. David D. Rabb, Mining Engineer
Mineral Technology Branch

With the rising price of gold and silver realtive to the dollar, many small mines and old dumps in Arizona are attracting renewed interest. The use of either sodium or potassium cyanide solutions to extract gold and/or silver from ores is a time-proven method and can be an efficient process for some ores (not all, but some).

In any case it is *most important* that the user of this method realize the dangers involved. Read about and study the subject. Know the procedures involved and carefully follow safety rules. Take all precautions. Store and safeguard raw cyanide. Get official permits before starting any leaching. Sometimes it is advisable to talk to experienced operators and authorities and consider their advice. And finally, properly dispose of all leached tailings and barren solutions. It is this last item that I would like to discuss further.

Anyone who uses cyanide should know that it is very poisonous. Cyanide is lethal if 0.1 grams are ingested, inhaled, or absorbed through the skin. Exposure to concentrations as low as 100 ppm for 30 minutes can cause death. Tailings pulps carrying only traces of cyanide, and even so-called "barren" solutions in many cases, constitute a real hazard to both humans and animals. Under some conditions, as little as 0.1 ppm has proven fatal to fish.

For years various investigators have sought a satisfactory method of treating cyanide wastes. Methods tested include:

1. Acidification with dilution and removal of resulting HCN gas by blowing large quantities of air.
2. Reaction with "lime sulphur" or with sodium sulphide.
3. Treatment with ferrous sulphate.
4. Oxidation with potassium permanganate.
5. Aeration to cause atmospheric decomposition of the cyanide.

All of the above methods have been used commercially for the reduction of cyanide content of solutions; however, they all tend to leave substantial cyanide residues. This residual can be serious unless extremely large dilutions are available. Another objection is that, by the first four methods, the pollution load is increased by the addition of objectionable chemicals.

The one treatment now generally accepted is chlorination of solutions at a pH above 8.5 (the only economical and, if done properly, satisfactory method for treatment). The source of chlorine can be commercial bleach solutions, any alkaline hypochlorite, or gaseous chlorine applied in the manner of a common water treatment plant. The reaction, $NaCN$ + $NaOH$ 3 Cl_2, going to inactive sodium cyanate and table salt, is practically instantaneous and is completed in seconds. No cyanide radical can exist in the presence of free available chlorine at a pH of 8.5 or higher.

In the early Western mining days, "metallurgical cattle raising" was a common social problem which netted certain irresponsible characters a considerable profit at a mining company's expense because a cow died from drinking water near a cyanide plant. Courts usually awarded the damages claimed and the men who operated the cyanide plant were blamed, regardless of the facts.

All cyanide tails, before being abandoned, should be flushed with fresh water and then treated with chlorine water (such as we maintain in much-used swimming pools) until there is free chlorine in the OFF solution. The standard orthotoludine test is simple, easy to perform, definitive, and understandable by the layperson.

The situation today is much more serious than most people realize. It would be extremely unfortunate should inexperienced persons, young or old, ever gain access to a can of raw unused cyanide at a carelessly-abandoned operation or allowed to swim in an unguarded pond of cyanide tailings water which had not been rendered harmless and free from all cyanide. No dollars of insurance could ever pay for this kind of negligence. It's up to the minerals industry to educate and police its associates so as to minimize the potential for needless accidents. Prepare for the curious.

The Bureau of Geology and Mineral Technology at the University of Arizona and the Department of Mineral Resources in Phoenix are capable of advising on matters such as those raised here. The Bureau's phone is 602/626-1943 (ask for Dave Rabb); the Department's phone is 602/271-3791 (ask for John Jett).

* * *

DEMAND FOR GEOLOGIC MAPS
New Program Needed?

The Bureau produced it's popular county geologic map series consisting of 11 sheets between the years of 1957-1960. The one and final printing consisted of 10,000 copies each of the 11 maps, for a total of 110,000 items. To date approximately 75,000 of these maps have been sold. The Pima-Santa Cruz combined map has been the most popular (8,791 copies sold), with Maricopa second (8,322 copies sold). The least popular has been the Navajo-Apache combination (5,514). The scale of the county series is 1:375,000.

We feel that this map series has served Arizona very well but that it is time to plan for new, more detailed state-wide geologic coverage (probably at a scale of 1:250,000). An aggressive map production program will require funding above the current level, at least temporarily. No doubt, any tangible funding increase to support this effort will require considerable outside sympathy.

Should you have ideas on such a program, consider sharing your thoughts with appropriate State officials, congressmen, and the Bureau.

* * *

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Permission for copying must be requested through the Dean of the Graduate College of the respective university, as coded below:

UA: University of Arizona, Tucson, AZ 85721
ASU: Arizona State University, Tempe, AZ 85281
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Bureau Initiates Historical Seismicity Reveiw

The Geological Survey Branch is conducting a thorough study of historical earthquakes felt in Arizona. Ms. Susan M. DuBois has been hired primarily for this purpose, having recently completed a similar research project for the Kansas Geological Survey. Drs. H. Wesley Peirce (Principal Geologist in the Geological Survey Branch) and Marc L. Sbar (Seismologist, Department of Geosciences at the University of Arizona) will also assist in the investigation. This project represents Phase I of an overall assessment of seismic risk in Arizona. Phase II, Late-Cenozoic faulting, will begin later. Although assistance funds for Phase I have been requested from the U.S. Nuclear Regulatory Commission, the basic program will proceed regardless of the outcome of our proposal.

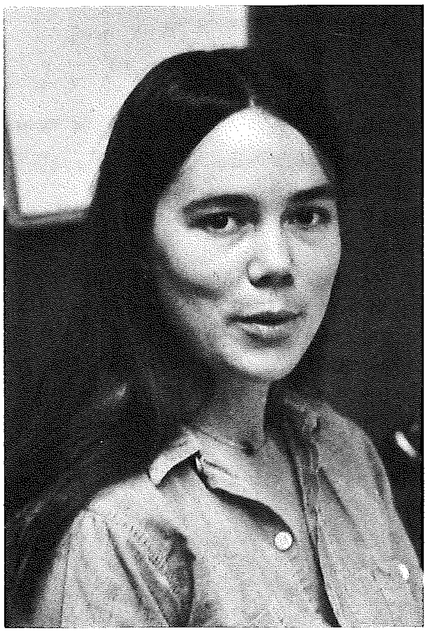
The anticipated rapid development of Arizona and resultant increased demand for seismic risk data have indicated the need for a major re-assessment of earthquake hazards in the state. Power plants, dams, hospitals, and other critical structures which are built to meet the demands of an expanding population are required to be designed to withstand effects of local and regional earthquakes. It is desirable to minimize the risk of damage to all man-made structures and more importantly, the risk to health and safety of people. Thus, it is essential to employ all obtainable information concerning past seismicity.

The period of historical record in Arizona is very short: roughly 125 years. Reports of large events which took place near Ft. Yuma in 1852 and 1853 were recorded by military personnel. Many accounts of damage from the 1887 Sonoran earthquake exist. However, it is likely that several smaller earthquakes were not noticed or not reported prior to the 1920's because of sparse settlements, few newspapers, lack of seismic-recording technology, and general lack of understanding of earthquake phenomena.

It is our intention to carry out an agressive, full-time data gathering and interpretive program for nine months. Sources referenced in previously-published earthquake catalogs will be checked. Military post and Spanish Mission records will be screened for earthquake reports as will be microfilmed newspaper collections at the University of Arizona library. Already we have found previously-unpublished accounts from pioneer journals, Mormon diaries, and newspaper articles at the Arizona Historical Society in Tucson. Preliminary information suggests that the number of historical seismic events felt in Arizona approximates 300. However, much effort is required to evaluate the accuracy and significance of these phenomena. We will attempt to distinguish events originating in Arizona from those felt in the state as a result of outside epicentral activity. At the end of the study we expect to have a centralized, heavily documented data file on Arizona Historical Seismicity. The basic results will be published and the centralized file made available to the public in general.

Introducing Susan...

The Geological Survey Branch has hired Ms. Susan M. DuBois as Assistant Geologist on a temporary, full-time basis. Susan obtained a B.A. degree in Geology in 1975 from Carleton College and an M.S. degree in Geology from the University of Kansas in 1978. Her husband, Jim, has entered the Doctorate program in the Geosciences Dept., University of Arizona. An aspect of Susan's interest is reflected in the adjacent article that announces our Arizona historical seismicity study. We invite your interest in this effort and encourage everyone to share with Susan any special knowledge or information about Arizona earthquakes.



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"The Depositional History, Conodont Biostratigraphy, and Time Stratigraphy of the Redwall and Escabrosa Formations and Equivalents for a Paleotectonic Evaluation of Arizona."

Douglas W. Shakel.
"Geochronology of Some Crystalline Rocks in the Santa Catalina Mountains and Elsewhere in Arizona."

Deborah S. Sklarew.
"Analysis of Kerogen in Precambrian and Younger Stromatolites."

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SP 4-77: Mining and Mineral Operations in the Rocky Mountain States. A Visitors Guide, by Bureau of Mines State Liaison Officers. 1977. 87 p., 40 figs. This publication is a guide to mining and mineral operations in the Rocky Mountain States (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming). $2.40.

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FIELDNOTES
Vol. 8, No. 4 **Dec. 1978**
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