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Arizona Geology

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ARIZONA GEOLOGICAL SURVEY

Information to
Arizonans since 1889

MISSION

To provide objective information to enhance public understanding of geologic processes, materials, and resources in Arizona and to assist citizens, businesses, governmental agencies, and legislators in making informed decisions relative to managing land, water, mineral, and energy resources.

GOALS

- Provide information about geologic processes, materials, and resources in a timely, courteous manner.
- Map and describe the bedrock and surficial geology of Arizona. Current emphasis is on the Phoenix-Tucson urban corridor, which contains 80 percent of the State's population.
- Investigate and document geologic processes and materials that might be hazardous to the public or limiting to land and resource management.
- Administer the rules, regulations, and policies established by the Arizona Oil and Gas Conservation Commission.

Arizona Coal

J.D. Nations, R.L. Swift
and H.H. Haven

Northern Arizona University

New Information. The writers are completing a study of the distribution and thickness of coal beds beneath Black Mesa, which covers 3,200 square miles within the Navajo and Hopi Reservations in northeastern Arizona (Figure 1). They produced a database of information from more than 230 subsurface and surface locations and constructed maps that show coal thickness trends. These maps can be used to locate areas that are favorable for exploration and development. The database and maps may also be used to evaluate the potential for coalbed methane. Results of the study will be released as Arizona Geological Survey and U.S. Geological Survey open-file reports, the availability of which will be announced in a future issue of *Arizona Geology*.

Production History. Black Mesa coal was mined for pottery firing as early as 900 A.D. More than 100,000 tons were mined between 1300 and 1600. Prior to the

introduction of natural gas, local reservation schools used coal for heating, probably fewer than 10,000 tons per year. Between 1960 and 1970, Arizona mines produced fewer than 1,000 tons of coal annually. Peabody Western Coal Company, which began mining on Black Mesa in 1970, produced 13,192,000 short tons, with an estimated value of \$300 million, in 1996. From 1970-1996 Peabody leases produced 265 million tons of coal.

Operating Mines. Two coal mines, the Black Mesa and the Kayenta, generate approximately \$40 million in royalties annually to the Navajo Nation and the Hopi Tribe. Nearly 700 tribal members work at the mines and support facilities. Coal for residential use is supplied to tribal governments for distribution to Navajo and Hopi people.

The Black Mesa Mine, which opened in 1970, produces nearly 5 million tons of steam coal annually.

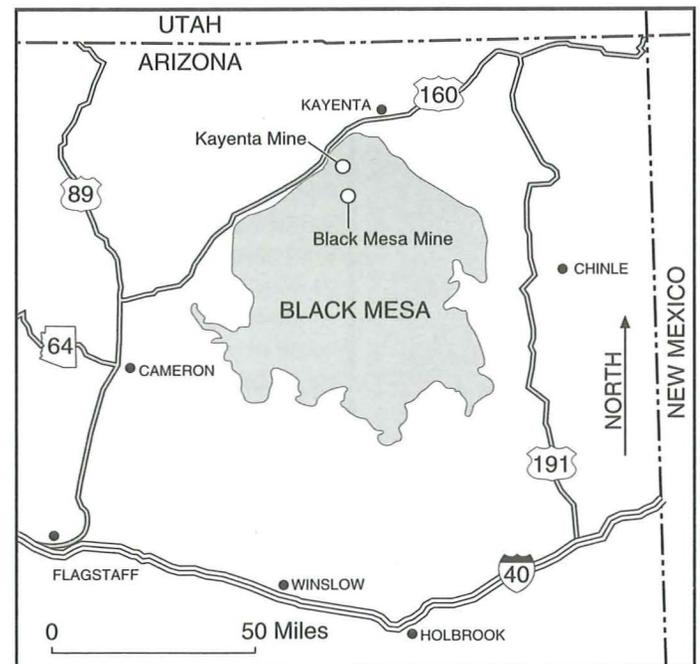


Figure 1. Black Mesa and Kayenta mines.

Arizona Coal *(continued from page 1)*

GOVERNOR
JANE DEE HULL

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December 1998

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Arizona Geology

is published quarterly by the Arizona Geological Survey to provide information about geologic materials and processes and their potential impacts on the development and use of Arizona's land, water, mineral, and energy resources. We encourage your comments and suggestions.

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Peter F. Corrao

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Arizona Geological Survey
416 West Congress St., Suite 100
Tucson, AZ 85701
(520)-770-3500

<http://www.azgs.state.az.us>

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The coal is crushed and transported 273 miles through an 18-inch-diameter slurry pipeline to Southern California Edison's Mohave Generating Station near Laughlin, Nevada (Figure 2).

The adjacent Kayenta Mine, which began operating in 1973, produces almost 8 million tons of steam coal annually. The coal is crushed at the mine and carried 17 miles by a conveyor belt to storage silos. From there it is transported 78 miles on the Black Mesa & Lake Powell Railroad, a dedicated, electrified coal-haul railway, to the Navajo Generating Plant near Page, Arizona.

Occurrence and Quality. Black Mesa is underlain by rocks of Late Cretaceous age, including the Yale Point, Wepo, Toreva, and Dakota formations and the Mancos Shale. Coal seams are present in the Dakota, Toreva, and Wepo.

The Wepo contains the highest rank and quality of coal on Black Mesa as well as the largest minable reserves. Although its coal seams average 4-8 feet in thickness, some are as many as 20 feet thick. Peabody reported eight coal zones, some of which contain multiple beds that range in cumulative thickness from 24-91 feet. The thickest bed indicated is 18.6 feet. The average net thickness of Wepo coal within the Peabody lease is 40 feet. The coal is subbituminous, with an average ash content of 7.3 percent, Btu per pound (dry) of 12,382, and

sulfur content of 0.58 percent.

The thickest and most extensive coal in the Toreva Formation is in the southeastern part of Black Mesa, where the average of 21 measurements is 12 feet. The rank and quality of this coal, known from only a few sample analyses, averages 13.8 percent ash, 12,338 Btu per pound (dry), and 1.09 percent sulfur.

Coal beds in the Dakota Formation average 2 feet in thickness, except in Coalmine Canyon and near Steamboat, where they are 7-9 feet thick. Rank and quality of coal in the Dakota, also known from only a few samples, averages 11.9 percent ash, 11,125 Btu per pound (dry), and 1.6 percent sulfur.

Reclamation. Reclamation is designed to preserve a traditional American Indian lifestyle by restoring mined land to hardy rangeland with up to 10 times more forage for grazing than native range. Mining and reclamation proceed at the same rate, about 500 acres

annually. Topsoil, removed before an area is mined, is returned after mining is completed and the surface has been contoured. The reclaimed land is also used for wildlife habitat and native plants. Peabody Western has received a number of awards for mining and reclamation, including an Excellence in Surface Mining Award from the U.S. Department of Interior's Office of Surface Mining in 1996.

Acknowledgments. Our Black Mesa studies have been supported by four grants from the National Science Foundation and one from the Mobil Corporation. Continuation of the project and preparation of this report were supported by Cooperative Agreement No. 1434-HQ-97-AG-01897 between Northern Arizona University, the Arizona Geological Survey, and the U.S. Geological Survey, with funding from the National Coal Resources Data System Program.



Figure 2. Mining coal on Black Mesa. Coal beds are visible in cut on left

Geologic Mapping Begins

The Arizona Geological Survey (AZGS) began its 1998-1999 field season in October. New mapping will be done under the STATEMAP program in which State geological surveys and the Federal government contribute matching funds as specified by the National Geologic Mapping Act of 1992. Mapping priorities were determined by the Arizona Geologic Mapping Advisory Committee, members of which represent the environmental and engineering geology community, mineral explorationists, Arizona universities, and Federal and State land- and resource-management agencies. The

24-member Advisory Committee has consistently recommended that the highest mapping priority be given to the Phoenix-Tucson corridor, which contains 10 percent of Arizona's land but 80 percent of its population.

New mapping will be done in areas north and west of Tucson (Figure 3), because most of the Phoenix and Casa Grande areas have already been mapped. Mapping of surficial geology in the Catalina Mountain foothills and adjacent to the Tucson Mountains will improve understanding of the nature and extent of unstable soils and areas at risk for flooding and debris flows. New bedrock and

surficial mapping in the Picacho Mountains, Sawtooth Mountains, and Samaniego Hills will improve understanding of the origin and distribution of potential mineral resources and outline areas with elevated risk for land subsidence and earth fissures.

Funding from the STATEMAP component of the National Geologic Mapping Act has been important to the AZGS. From 1992-1998 the AZGS produced and released 71 open-file reports that focused on geologic mapping. Forty-four of them were completed with partial STATEMAP funding.

Young Faults in Arizona

P. A. Pearthree, in cooperation with the U. S. Geological Survey (USGS), compiled a summary of information available on Quaternary faults (active in the last 2 million years) in Arizona. The compilation, released as Open-File Report 98-24, is part of a project to prepare a map and database of Quaternary faults throughout the world. The USGS generated the 1:750,000-scale fault map that's included in this report.

The data structure provides systematic information about each fault zone. Each fault has a unique name and number as part of the worldwide fault data set. Faults have been numbered on the accompanying map. Fault data sheets include data sources, location, geologic setting, geomorphic expression, age of youngest movement, slip rates, length, and orientation. About 100 Quaternary faults have been identified in Arizona.

Ordering information for this report is on page 5 of this issue.

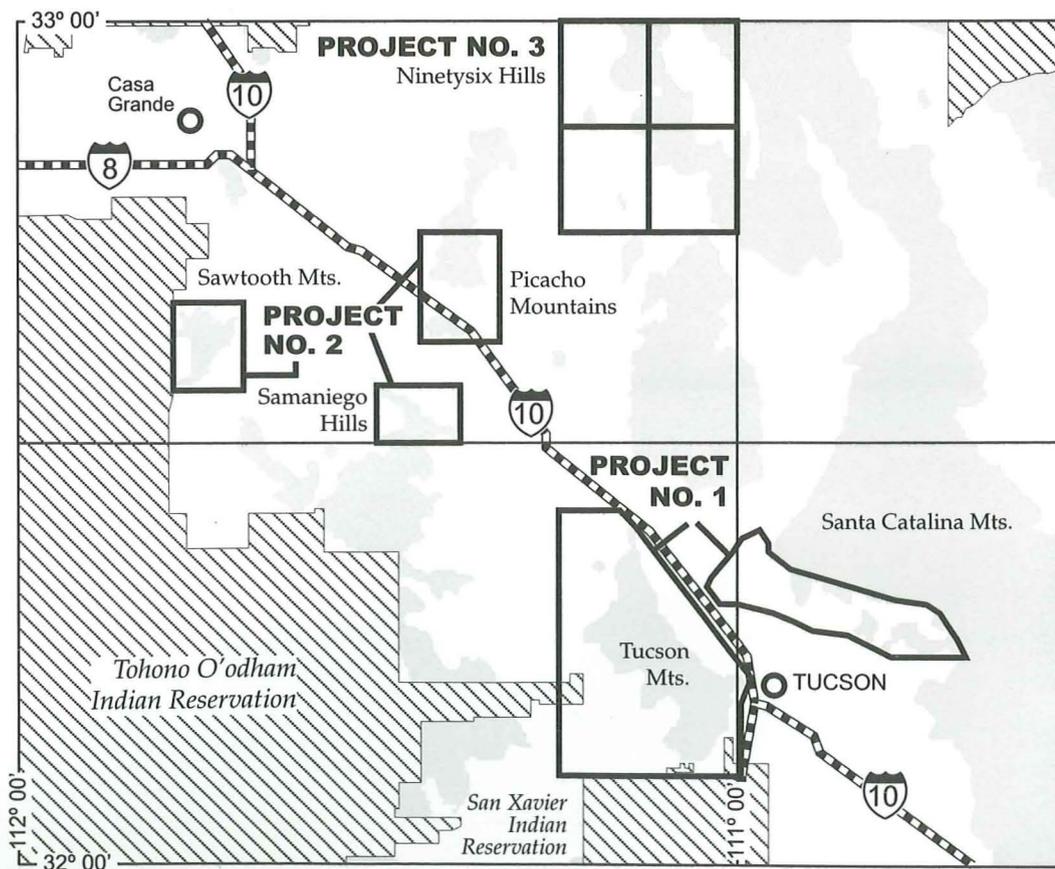


Figure 3. STATEMAP geologic mapping projects currently in progress.

Just Released

The Arizona Geological Survey released the following geologic maps and reports since the Fall issue of *Arizona Geology* was published:

Fieldguide to the geology of Chiricahua National Monument, southeastern Arizona: J. V. Bezy, 1998, Arizona Geological Survey Down-to-Earth 8 (Pub. number DTE 8), 32 p. \$6.95

Geologic map of the Humboldt Mountain 7.5' quadrangle, Maricopa County, Arizona: W. G. Gilbert, C. A. Ferguson, and R. S. Leighty, 1998, Arizona Geological Survey Open-File Report 98-11 (Pub. number OFR 98-11), 17 p., 3 sheets, scale 1:24,000. \$6.00

Geologic map of the New River Mesa 7.5' quadrangle, Maricopa County, Arizona: C. A. Ferguson, W. G. Gilbert, and R. S. Leighty, 1998, Arizona Geological Survey Open-File Report 98-12 (Pub. number OFR 98-12), 29 p., 3 sheets, scale 1:24,000. \$8.00

Compilation geologic map of the Ray-Superior area, central Arizona: S. M. Richard and J. E. Spencer, 1998, Arizona Geological Survey Open-File Report 98-13 (Pub. number OFR 98-13), 47 p., 3 sheets, scale 1:24,000. \$15.00

This map was compiled from previously published mapping, with new mapping added in several key areas. Many faults and contacts were reinterpreted on the basis of the new mapping.

Geologic map of the Maverick Mountain 7.5' quadrangle, Maricopa County, Arizona: S. J. Skotnicki and R. S. Leighty, 1998, Arizona Geological Survey Open-File Report 98-14 (Pub. number OFR 98-14), 18 p. scale 1:24,000. \$5.00

Geologic map of the Boulder Mountain 7.5' quadrangle, Maricopa and Gila Counties, Arizona: S. J. Skotnicki and R. S. Leighty, 1998, Arizona Geological Survey Open-File Report 98-15 (Pub. number OFR 98-15), 17 p., scale 1:24,000. \$5.00

Geologic map of the Tonto Basin 7.5' quadrangle, Gila and Maricopa Counties, Arizona: C. A. Ferguson, S. J. Skotnicki, and W. G. Gilbert, 1998, Arizona Geological Survey Open-File Report 98-16 (Pub. number OFR 98-16), 15 p., 2 sheets, scale 1:24,000. \$5.00

Geologic description, sampling, petroleum potential, and depositional environment of the Chuar Group, Grand Canyon, Arizona: B. H. Wiley, S. L. Rauzi, D. A. Cook, E. H. Clifton, Lung-Chuan Kuo, and J. A. Moser, 1998, Arizona Geological Survey Open-File Report 98-17 (Pub. number OFR 98-17), 92 p., 2 plates. \$15.00

Geologic map of the Hedgpeth Hills 7.5' Quadrangle, Maricopa County, Arizona:

R. S. Leighty and Gary Huckleberry, 1998, Arizona Geological Survey Open-File Report 98-18 (Pub. number OFR 98-18) 20 p., scale 1:24,000. \$7.00

Geologic map of the Biscuit Flat 7.5' quadrangle, Maricopa County, Arizona: R. S. Leighty and Gary Huckleberry, 1998, Arizona Geological Survey Open-File Report 98-19 (Pub. number OFR 98-19), 20 p., scale 1:24,000. \$7.00

Geologic map of the Union Hills 7.5' quadrangle, Maricopa County, Arizona: S. D. Holloway and R. S. Leighty, 1998, Arizona Geological Survey Open-File Report 98-20 (Pub. number OFR 98-20), 22 p., scale 1:24,000. \$7.00

Geologic map of the New River SE 7.5' quadrangle, Maricopa County, Arizona: R. S. Leighty and S. D. Holloway, 1998, Arizona Geological Survey Open-File Report 98-21 (Pub. number OFR 98-21), 25 p., scale 1:24,000. \$7.50

Geology and geologic hazards of the Casa Grande area, Pinal County, Arizona: J. E. Klawon, P. A. Pearthree, S. J. Skotnicki, and C. A. Ferguson, 1998, Arizona Geological Survey Open-File Report 98-23 (Pub. number OFR 98-23), 26 p., 6 sheets, scale 1:24,000. \$15.00

See "Just Released" continued on page 5

Ordering Information

You may purchase publications at the AZGS office or by mail. Address mail orders to AZGS Publications, 416 W. Congress St., Suite 100, Tucson, AZ 85701. Orders are shipped by UPS, which requires a street address for delivery. All mail orders must be prepaid by a check or money order payable in U.S. dollars to the Arizona Geological Survey or by Master Card or VISA. Do not send cash. Add 7% sales tax to the publication cost for orders purchased or mailed in Arizona. Order by publication number and add these shipping and handling charges to your total order:

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50.01- 100.00, add 10.75
101.01- 200.00, add 15.00
Over 200.00, call

Other countries, request price quotation.

Shipping and handling charges include insurance. For rolled maps, add \$1.00 for a mailing tube.

If you purchase Open-File Reports, Contributed Maps, or Contributed Reports at the AZGS office, allow up to two days for photocopying.

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From the Director

Governor Jane Dee Hull designated October 11-18 as Earth Science Week. In Tucson 20 earth science groups organized about 40 activities. The Arizona Geological Survey coordinated the scheduling and arranged for publicity. Other activities were offered in the Phoenix area. In Mesa, Hawthorne Elementary School filled the entire week with earth science activities.

The American Geological Institute (AGI) is to be commended for initiating Earth Science Week and providing information and assis-

tance to facilitate it. One part of the AGI's mission relative to publications and communications is to "inform the general public of the importance of the earth sciences in daily life and the role geoscientists play in meeting societal needs." Is there a more appropriate way to meet this objective than through Earth Science Week activities?

I polled the participants afterward to see whether there is interest in holding an Earth Science Week October 10-16, 1999, and, if so, what can be done to improve it. Almost all favored doing it again. They suggested that more

time be allowed for planning and that much more publicity will be needed. Activities should be scheduled throughout Arizona. Mark your calendars.

Special thanks are due to Governor Hull for giving official recognition to Earth Science Week and to those members of the agencies, departments, and professional societies who took their valuable time to make the first Earth Science Week a success.

Larry D. Fellows
*Director and
State Geologist*

Highway Geology Symposium

The 49th annual Highway Geology Symposium (HGS), held in Prescott in September, was a huge success. The total number of registrants was 202. The highest number of registrants in the previous 48 symposia was 140. Forty-two technical papers were presented. Some copies of the Proceedings and Field Trip Guide are still available for purchase. The cost for each is \$30.00 plus shipping and handling, which will vary with destination. Contact Russell Glass, treasurer of the HGS for specifics at (828) 298-3874.

Nick Priznar, Arizona Department of Transportation (ADOT), Materials Group, was the General Chairman of the 1998 HGS. The Arizona Geological Survey and the Department of Geology, Northern Arizona University, were cosponsors of the symposium with ADOT.

The 1999 Highway Geology Symposium will be held in Roanoke, Virginia. See page 6 for details.

"Just Released"

(continued from page 4)

Quaternary fault data and map for Arizona:

P. A. Pearthree, 1998, Arizona Geological Survey Open-File Report 98-24 (Pub. number OFR 98-24), 122 p., 1 HD DOS disk, scale 1:750,000. \$20.00

Geologic map of the Mesa 30' x 60' quadrangle,

Arizona: J. E. Spencer, S. M. Richard, and P. A. Pearthree, compilers; S. M. Kneale, digitizer, 1998, Arizona Geological Survey Digital Information Series 11 (Pub. number DI 11), version 1.0, 16 p., 3 DOS HD disks. \$30.00

Geologic map of portions of the Theodore Roosevelt Lake 30' x 60' quadrangle, Arizona:

J. E. Spencer, P. A. Pearthree, and S. M. Richard, compilers; S. M. Kneale, digitizer, 1998, Arizona Geological Survey Digital Information Series 12 (Pub. number DI 12), version 1.0, 12 p., 2 DOS HD disks. \$30.00

Geologic map of portions of the Globe 30' x 60' quadrangle, Arizona:

S. M. Richard, compiler, and S. M. Kneale, digitizer, 1998, Arizona Geological Survey Digital Information Series 13 (Pub. number DI 13), version 1.0, 13 p., 2 HD DOS disks. \$30.00

Geologic map of the Fountain Hills—Mount McDowell area, Maricopa County, Arizona:

S. J. Skotnicki, compiler, and S. M. Kneale, digitizer, 1998, Arizona Geological Survey Digital Information Series 14 (Pub. number DI 14), version 1.0, 14 p., 1 HD DOS disk. \$15.00

Heavy metals in surface soils and streambed sediments in the Wallapai mining district, northwestern Arizona, a historic mining district in a semiarid region:

Ulrike Rösner, 1998, Arizona Geological Survey Contributed Report 98-A (Pub. number CR 98-A), 43 p. \$8.00

1999 MEETINGS

Tucson Gem and Mineral Show (TGMS). The TGMS will hold its 45th Annual Show in the Tucson Convention Center February 11-14, 1999. Minerals of Mexico will be featured. For more information contact the TGMS office at (520) 322-5773.

The Arizona Geological Survey will have a booth at the show. Please stop by to say hello and look at our newest publications. Better

yet, stop in at our office, which is just a short walk from the Convention Center, meet our staff, and inspect all of the maps and reports on Arizona geology.

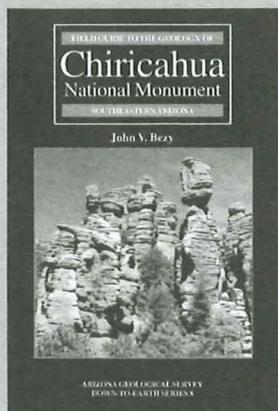
American Institute of Professional Geologists (AIPG), Arizona Section.

The AIPG will meet at the Arizona Geological Survey February 13 (Saturday) at 9:30 a.m. Tom Fails, National President of the

AIPG, will be the featured speaker. After the meeting the group will walk to the Tucson Convention Center, just a couple blocks away, for a guided tour of the Tucson Gem and Mineral Show.

AIPG members from other states who are in Tucson to attend the Gem and Mineral Show are encouraged to attend the meeting and go on the tour.

Highway Geology Symposium (HGS). The 50th annual HGS will be May 20-23 at the Hotel Roanoke in Roanoke, Virginia. A call for papers has been made with January 15, 1999 as the deadline for receipt of abstracts. Contact Skip Watts at Radford University, Institute for Engineering Geosciences, Radford, VA 24141 for more details. Telephone: (540) 831-5652; e-mail: cwatts@runet.edu



Chiricahua Mountains

The Field Guide to the Geology of the Chiricahua Mountains, written by John V. Bezy, National Park Service, tells non-geologists how the features in Chiricahua National Monument were formed. The book, small enough to fit

easily in a backpack, includes photographs and descriptions of 18 geologic features that can be seen from the Sugarloaf Mountain and Echo Canyon trails within the Chiricahua National Monument. The 32-page book, published as

Down-to-Earth 8, may be purchased from the Arizona Geological Survey for \$6.95 plus shipping and handling charges. Refer to page 4 of this issue to determine how shipping and handling charges are calculated.



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