Arizona Geology

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THE STATE AGENCY FOR GEOLOGIC INFORMATION

Mission

To inform and advise the public about the geologic character of Arizona in order to increase understanding and encourage prudent development of the State's land, water, mineral, and energy resources.

Activities

Public Information

Inform the public by answering inquiries, preparing and selling maps and reports, maintaining a library, databases, and a website, giving talks, and leading fieldtrips.

Geologic Mapping

Map and describe the origin and character of rock units and their weathering products.

Hazards and Limitations

Investigate geologic hazards and limitations such as earthquakes, land subsidence, flooding, and rock solution that may affect the health and welfare of the public or impact land and resource management.

Energy and Mineral Resources

Describe the origin, distribution, and character of metallic, nonmetallic, and energy resources and identify areas that have potential for future discoveries.

Oil and Gas Conservation Commission

Assist in carrying out the rules, orders, and policies established by the Commission, which regulates the drilling for and production of oil, gas, helium, carbon dioxide, and geothermal resources.

Fire and Sediment Deposition

Philip A. Pearthree
Arizona Geological Survey

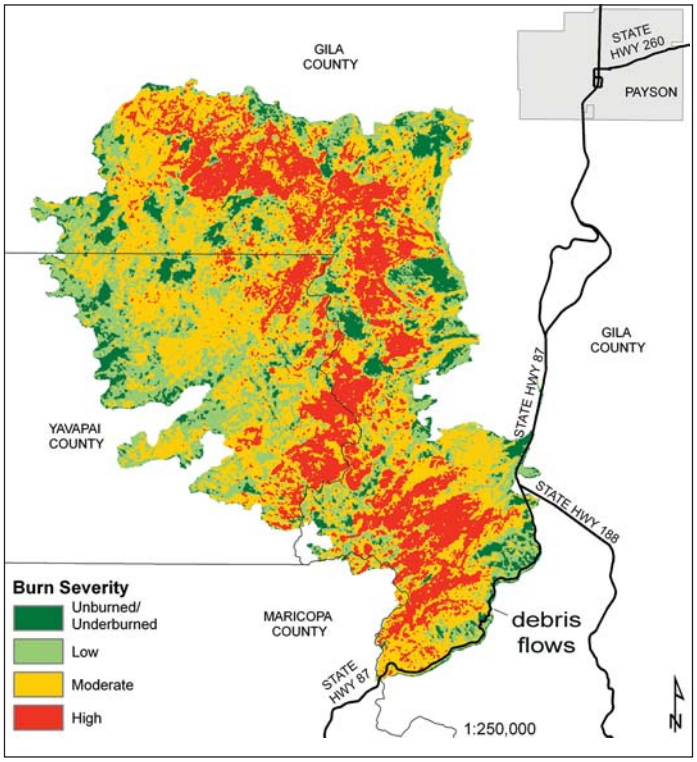


Figure 1. Location and intensity of the Willow Fire, which burned in June and early July, 2004. Map provided by the U.S. Forest Service

If you were in Arizona during late June and early July you may have seen smoke towering above the Willow Fire, which burned 120,000 acres (about 187 square miles) in the Tonto National Forest between Phoenix and Payson (Figure 1). Although there was concern for a time that the fire would burn into the Payson area, it did not reach Payson and ultimately caused little damage to structures. The southward spread of the fire was stopped along State Route 87 (a major 4-lane highway) about 20 miles southwest of Payson. Fires are obviously an important part of the Arizona landscape–many have occurred in the high country of Arizona in the past couple decades. In addition to damaging forests and human-built structures, fires increase the potential for flooding and related mass movements in mountain watersheds.

Before the Willow Fire was completely contained, U.S. Forest Service staff asked the Arizona Geological Survey to join their Burned Area Emergency Response team to assess potential for mass movements (landslides, debris flows, rockfalls) along SR 87. In response, Ann Youberg and I reviewed pre-fire aerial photographs, burn-intensity maps, and topographic maps and then conducted a one-day field survey of the burned area with Forest Service personnel July 16. We recognized evidence of past debris flows in two small, steep, moderately burned drainages and inferred that post-fire debris flows could pose a threat to the highway. One week after our field reconnaissance, debris flows did indeed occur in these drainages, temporarily closing the southbound lane of SR 87.

Intense fires that burn vegetation and soil can lead to enhanced runoff, flooding, and debris flows. Vegetation and soil on mountain slopes capture or temporarily detain moisture and play a major role in moderating the amount of runoff that results from rainstorms. On steep, heavily vegetated slopes where fires burn intensely, post-fire increases in runoff may be dramatic. In addition, when fire destroys trees, grass, and other plants, soil is vulnerable to erosion. Because fires in Arizona typically occur in the early summer, fire-denuded watersheds are vulnerable to enhanced runoff and erosion during the following monsoon season.

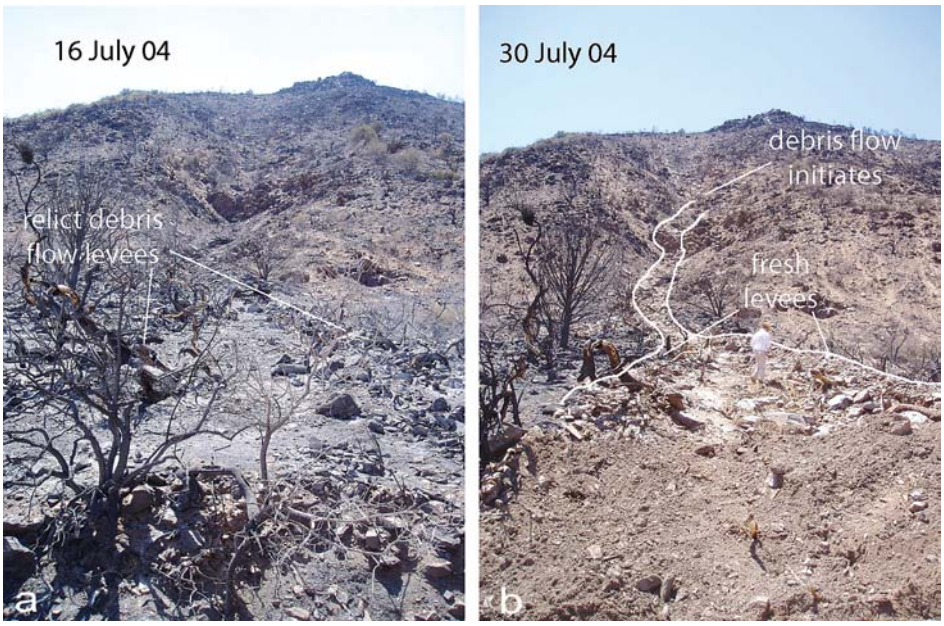


Figure 2. a) Photograph of a small wash near SR 87 taken just after the Willow Fire. **b)** Photograph of the same wash taken a few days after a heavy rain fell July 23, 2004.

Debris flows are mixtures of sediment-rich fluid and rock fragments that flow downhill as slurries. Because the fluid is substantially denser than clear water, debris flows are quite effective at picking up and transporting boulders. Debris flows are triggered by intense runoff in areas that have steep slopes and an ample source of fine soil and rock fragments. They may begin as small landslides or along steep washes when much fine sediment is picked up by floodwater. Fortunately, few people in Arizona have experienced debris flows because the flows typically occur in remote areas. Debris flows are, however, an important process of erosion and deposition in the mountains of Arizona. Although debris flows have commonly occurred after fires in Arizona and elsewhere in the western U.S., they can also occur in steep terrain without fire if precipitation is sufficiently intense. If you look at the mountain ranges surrounding your home, you may see nearly vertical white stripes extending part way down the mountainside. Many of these features are erosional scars left by debris flows.

During our field survey of fire-related hazards, we found evidence that debris flows had occurred in the past on two small drainages near SR 87 (Figure 2). The hillslopes and channels of these drainages are very steep, and the watersheds were devoid of living vegetation after the fire. As these channels exit the mountains, they spill out onto small, cone-shaped alluvial fans. Unfortunately, the southbound lane of SR 87 is cut into the toes of these fans. We observed parallel alignments of boulders and boulder piles on the fans that are typical of deposits left by debris flows.

On the evening of July 23, an intense thunderstorm occurred in this part of the burned area. All of the larger drainages that cross under SR 87 experienced substantial floods, but none overtopped the highway. Debris flows occurred in many small, steep drainages, including the two that we had identified as representing a potential hazard. These debris flows developed in steep channel reaches, picked up many boulders as they headed down the channels, and spilled out onto and across the alluvial fans. One of the flows covered the southbound lane of SR 87 (Figure 3). Most of the boulders carried by the debris flows were deposited on the fans, adding to the levees and boulder piles that existed prior to the recent events. The Arizona Department of Transportation quickly cleaned up the debris.

Figure 3. The debris flow that moved along this small channel reached the ditch of SR 87 and lapsed onto the edge of the highway. The debris flow in the next drainage to the north crossed the highway.

The important question for the near future is whether more debris flows will impact SR 87 in this area. The potential for enhanced runoff will exist in the burned watersheds for several years, at least. Because so much sediment was removed from the channels that produced debris flows, decades or centuries will probably pass before sufficient sediment accumulates to sustain another debris flow in these watersheds.

Desiccation Cracks - Update

Raymond C. Harris
Arizona Geological Survey

Figure 1. Initial crack that formed along Nickels Road north of Willcox. View is to the north with Mount Graham in the background. Normally dry wash is on the right side of the road. Photograph was taken July 20, 2004.

Figure 2. The desiccation crack shown in Figure 1 was enlarged when runoff from the wash flowed into it. Photograph taken from the same spot as in Figure 1, only a few days later.

Figure 3. Fieldtrip participants are examining a large desiccation crack (foreground) that developed along the West side of Willcox Playa. This crack has been present for many years.

Figure 4. A large desiccation crack has developed along a private road south of Dragoon Road west of U.S. Highway 191. This crack has been present for several years.

Giant desiccation cracks, which resemble huge mud cracks, were featured in the summer issue of *Arizona Geology*, which was mailed in early May. Since that article was written, new cracks developed in Cochise County in July along Nickels (Figure 1) and Circle-I Roads north of Willcox and across State Line Road southeast of Portal. All of these new cracks are adjacent to areas in which other desiccation cracks were already present. The Cochise County Highway Department filled the cracks in the latter two roads quickly, before they could get larger.

In early stages the Nickels Road crack was not sufficiently developed to determine whether it was an "earth fissure" caused by groundwater pumping or a "giant desiccation crack" caused by the ongoing drought. Following a heavy rain a few days after the initial AZGS visit, the crack opened further and began to form junctions (Figure 2). The presence of these intersections, proximity of the new cracks to a cluster of older desiccation cracks mapped in the late 1970s, and the relatively shallow maximum depth led to the conclusion that the new crack was due to desiccation rather than groundwater pumping. Most of the Nickels Road cracks were on private land and the land owners eventually repaired them.

The AZGS led a trip for federal, state, county, and local officials in early August to view desiccation cracks in the Willcox region. In addition to viewing the Nickles and Circle-I Road cracks, trip participants observed cracks of similar origin on Willcox Playa (Figure 3), along Dragoon Road near the intersection with U.S. Highway 191 south of the Playa (Figure 4), and on the west side of the Sulfur Hills south of Kansas Settlement.

Desiccation cracks such as these are widely distributed throughout southern Arizona, and probably elsewhere in the Southwest. The AZGS maintains a database of the locations and character of these cracks in Arizona, as well as earth fissures that have resulted from groundwater pumping. Please contact Ray Harris at AZGS if you think you've seen them in other areas.

The development of additional desiccation cracks in Cochise County was not a surprise. That county has the highest concentration of cracks recognized in the State and has been suffering from a severe drought for many years.

BOOK WINS AWARD

The 2004 winner of the John C. Frye Memorial Award for Environmental Geology has been selected. We're proud to tell you that it's *A Home Buyer's Guide to Geologic Hazards in Arizona*, which was published by the Arizona Geological Survey in 2003 as Down-to-Earth 13. Raymond C. Harris and Philip A. Pearthree are the authors.

The Frye Award is given annually by the Association of American State Geologists and Geological Society of America (GSA) to recognize the outstanding paper in environmental geology published by a State geological survey or the GSA. The publication must have been released during the preceding three years.

Dr. John C. Frye was Director of the Kansas Geological Survey for nine years and the Illinois Geological Survey for twenty years before he became Executive Director of the GSA in 1974. He retired from the GSA only a few months before he died in 1982.

The award will be presented at the annual meeting of the GSA in Denver in November 2004. More information about the award will be provided in the Winter issue of *Arizona Geology.*

ANNUAL REPORT

The annual report of the Arizona Geological Survey (AZGS) for Fiscal Year 2004, which ended June 30, 2004, has been completed and may be viewed and downloaded from the AZGS website (www.azgs.az.gov). Paper copies of the report are not distributed.

The AZGS has three major goals: 1) to serve as the primary source of information about the geology of Arizona, 2) to sell publications and maintain high customer satisfaction, and 3) to effectively assist the Arizona Oil and Gas Conservation Commission. To fulfill these goals in 2004, AZGS staff answered thousands of requests for information and sold more than 9,000 reports and maps. Publication sales increased almost nine percent from 2003. AZGS geologists completed 24 maps and reports, worked on 11 cooperative projects with other agencies or groups, gave 12 talks, and led 18 field trips to explain the geology of Arizona.

The report includes information about the types of information and service provided, staff employed, and funds expended. In addition, it contains brief summaries of the major projects undertaken and a list of all the reports and maps that were completed. State agencies are required by statute to prepare an annual report.

OIL PRICES BOOST DRILLING

Oil, natural gas, and helium prices have increased substantially during the last several years. As a result, the total number of acres of land leased for oil and gas in Arizona (federal and State Trust land) increased from 325,000 in 2001 to 488,000 during the past summer. During that time the amount of federal land leased for oil and gas in Arizona remained steady at 100-110,000 acres per year. (The U.S. Bureau of Land Management, which administers leasing of federal land, has held only two lease sales since July 1999.) Oil and gas leases on State Trust Land, administered by the State Land Department, have increased 27 percent from about 225,000 acres in 2001 to 380,000 acres now. Those who lease State Trust Land for oil and gas pay $1.00 per acre per year. Revenue from leases is deposited in the State General Fund.

So far this year the Arizona Oil and Gas Conservation Commission has issued five permits to drill on State Trust Land. We estimate that an equal number of permits will be issued before yearend. Two wells have been drilled. Ridgeway Arizona Oil Corporation drilled near St. Johns in May and is currently evaluating the carbon dioxide potential of that test hole. Ridgeway, which drilled the discovery carbon dioxide well in 1994, has drilled 15 wells in addition to the one being tested. Three were completed as gas wells and are shut in, four are temporarily abandoned, and eight were plugged and abandoned.

In early September Holbrook Energy drilled in the old Pinta Dome helium field northeast of Holbrook to evaluate potential for additional helium. Testing is now in progress. Gas, primarily nitrogen, produced from the Pinta Dome field contained 8-10 percent helium, some of the highest concentrations in the world. Helium content in gas is generally considered to be of commercial interest when the concentration is more than 0.3 percent. The field produced from 1961 until it was abandoned in 1976.

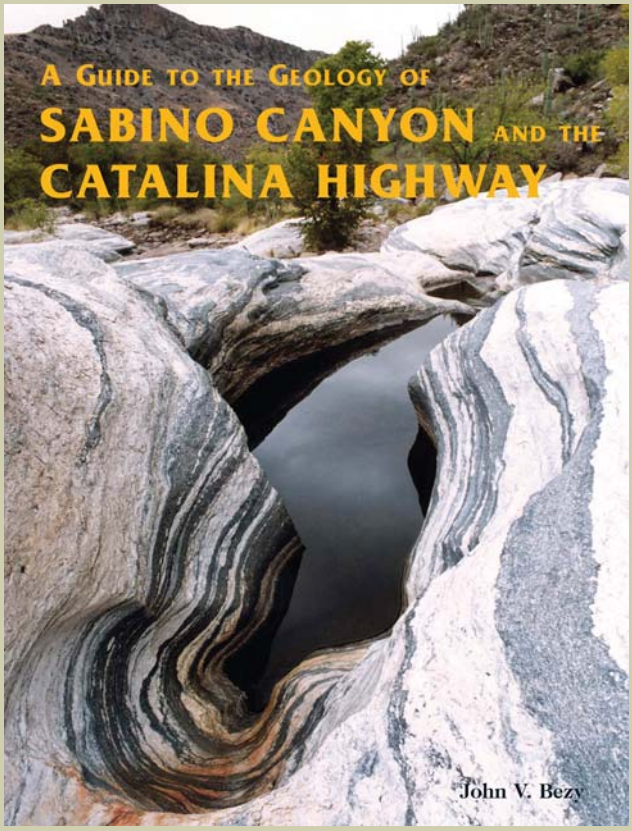
Sabino Canyon Book

The Arizona Geological Survey recently released *A Guide to the Geology of Sabino Canyon and the Catalina Highway* as Down-to-Earth 17. John V. Bezy wrote the book. Sabino Canyon is one of the most popular tourist destinations in the Tucson area. Local hikers also use it extensively. The road up the Canyon is closed to vehicular traffic except for service vehicles and the tourist shuttle.

Rock exposed in the canyon is mostly gneiss, which, in this area, formed seven miles or more below the land surface. Sabino Creek follows a major fracture (fault) or a series of closely spaced faults that shattered the rock. Water in the creek preferentially eroded the fractured rock. The fault, iron-stained fault surfaces, some of which were polished by movement on the fault (slickensides), and rock that was pulverized by the fault (breccia) are clearly exposed at several localities.

The gneiss is also exposed along the Catalina Highway, which ends at Summerhaven near the top of Mt. Lemmon. The Santa Catalina Mountains formed within the last 20-30 million years as the result of crustal stretching followed by uplift and erosion.

This 45-page book is in full color in an 8.5x11 format. Ordering information is provided in the "Just Released" section below. The book may also be purchased at the Sabino Canyon Visitor Center and the Palisades Visitor Center on the Catalina Highway.



Just Released

A guide to the geology of Sabino Canyon and the Catalina Highway: J.V. Bezy, 2004, Arizona Geological Survey Down-to-Earth 17, 45 p. $7.95 plus shipping and handling

Geomorphology and hydrology of an alluvial fan flood on Tiger Wash, Maricopa and La Paz Counties, west-central Arizona: P.A. Pearthree, J.E. Klawon, and T.W. Lehman, 2004, Arizona Geological Survey Open-File Report 04-02, 41 p., 2 plates, scale 1:24,000, 1 CD-ROM (maps are on CD-ROM). $15.00 plus shipping and handling

Geologic map of the Phoenix Mountains, central Arizona: J.K. Johnson, S.J. Reynolds, and D.A. Jones, 2003, Arizona Geological Survey Contributed Map 04-A (CM 04-A), v. 1.0 (formerly Digital Geologic Map 28), 1 CD-ROM that includes 15p. of text and a 1:24,000-scale map. $15.00 plus shipping and handling (A paper copy of the text and map is available for $15.00 plus shipping and handling.)

Geologic map of the Grasshopper Junction SE 7.5' Quadrangle, Mohave County, Arizona: R.J. Varga, 2001, Arizona Geological Survey Contributed Map 04-B (CM 04-B), v. 1.0 (formerly Digital Geologic Map 07). 1 CD-ROM includes a 1:24,000-scale map. $15.00 plus shipping and handling (A paper copy of the text and map is available for $15.00 plus shipping and handling.)

Geologic map of the northern Hualapai Mountains, Mohave County, Arizona: B.R. Siwiec, 2004, Arizona Geological Survey Contributed Map 04-C (CM 04-C), 1 CD-ROM that includes a 1:24,000-scale map. $10.00 plus shipping and handling (A paper copy of the map is available for $7.00 plus shipping and handling.)

Geologic maps and cross sections of selected areas in the Rawhide and Buckskin Mountain, La Paz and Mohave counties Arizona: R.J. Scott, 2004, Arizona Geological Survey Contributed Map 04-D (CM 04-D), 1 CD-ROM that includes 11 p. of text and 7 sheets, scales 1:5,160, 1:5,200, 1:10,000. $15.00 plus shipping and handling (A paper copy of the text and sheets is available for $58.00 plus shipping and handling.)

Please refer to ordering instructions on back page.

Publication 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 7.6% 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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Other countries, request price quotation

Shipping and handling charges include insurance.
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NEW PUBLICATION LIST

This new 48-page catalog lists more than 800 reports and maps that are available for purchase, including items published by the Arizona Geological Survey (AZGS), Arizona Geological Society, and selected maps and reports published by the U.S. Geological Survey. Many items in the catalog are on open-file status and are reproduced only when ordered. AZGS staff ship most mail orders one day or less after the order is received.

Because postage and UPS rates have increased, shipping and handling costs have had to be adjusted accordingly.

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