2014 ANNUAL REPORT

ARIZONA GEOLOGICAL SURVEY

Open-File Report OFR-14-07

Arizona Geological Survey
at a glance

M. Lee Allison Ph.D., P.G.
Director & State Geologist

ARS 27-103. Objectives of Arizona Geological Survey

1. Serve as a primary source of geologic information in this state to enhance public understanding of the state's geologic character, geologic hazards and limitations and mining and mineral resources.
2. Inform, advise and assist the public in matters concerning the geological processes, materials and landscapes and the development and use of the mineral resources of this state.
3. Encourage the wise use of the lands and mineral resources of this state toward its development.
4. Provide technical advice and assistance in geology to other state and local governmental agencies engaged in projects in which the geologic setting, character or mineral resources of the state are involved.
5. Provide technical advice and assistance in geology to industry toward the wise development and use of the mineral and land resources of this state.

AZGS is entrepreneurial and largely self-funded

State appropriations make up less than 9% of the agency's budget for the past several years;

State appropriations decreased 45% during the recession but the agency staff more than doubled and revenues increased eight-fold;

AZGS absorbed the merger of the Dept. of Mines & Mineral Resources without additional funds;

External grants help maintain state services no longer funded by the State.

AZGS protects lives and property from natural hazards

AZGS operates the state earthquake monitoring network with no state or federal funds;

The online interactive Hazards Viewer is used extensively by realtors, home buyers, developers, and local planners — http://data.azgs.az.gov/hazard-viewer/.

AZGS encourages economic development through the wise use of natural resources

AZGS is digitizing all the state's mining and mineral resource files, documents, and maps and posting them online for free downloading - http://minedata.azgs.az.gov/;

Arizona Mining Review is a monthly, online e-video magazine – https://www.youtube.com/user/azgsweb

The AZGS report on potash in the Holbrook basin spawned over $60 million in private sector exploration and plans for two billion+ dollar underground mines.

AZGS is a national and international leader in cyberinfrastructure

The AZGS-built National Geothermal Data System was launched by the US Secretary of Energy at the White House in May 2014 — www.geothermaldata.gov;

We are designing the data integration framework for the AZ Natural Resources Review Council Decision Support System (NRRC-DSS) to respond to federal land management actions.

AZGS spun off a new company in 2014 to commercialize our digital technology

USGIN Foundation Inc is negotiating contracts nationally and internationally — http://usgin.org .

AZGS is a leader in communications and outreach to Arizona citizens

The Arizona Experience website, launched as part of the Arizona Centennial, reaches ~20,000 viewers each month — http://arizonaexperience.org/;

AZGS uses Facebook, Twitter, YouTube, and blogs extensively.

AZGS Staff Collage

Top Left— L to R forefront, National Geothermal Data System crew: Esty Pape, Leah Musil, Lee Allison, Kim Patton, Pam Berry-Santos; Steve Richard, Christy Claudill, Laura Bookman, Adrian Sonnenschein, Mike Mahan.

Top Right—Phil Pearthree mapping Quaternary deposits.

Middle Left—**Top**, Jeri Young examining seismic signature of M 5.3 Duncan event. **Bottom**, Ann Youberg on a debris flow deposit.

Middle Right—Kate Kretschmann participating in the 2014 "Great Arizona Shake Out."

Bottom Left— L to R, Janel Day, Esty Pape, Steve Richard and Christy Claudill.

Bottom Right—L to R, Hall Stewart of Commonwealth Silver & Gold with Lee Allison on the set of the Arizona Mining Review.

TABLE OF CONTENTS

Director's Report 5

Mapping 7

Economic Geology 12

Environmental Geology 16

Geoinformatics 22

Special Projects 26

Geologic Extension Service 28

Administration 35

Professional Accomplishments 40

Publications 41

Presentations & Outreach Events 45

Arizona Geological Survey

M. Lee Allison, State Geologist and Director

Manuscript approved for publication in December 2014.
Printed by the Arizona Geological Survey. All rights reserved.

For an electronic copy of this publication: www.repository.azgs.az.gov. Printed copies are on sale at the Arizona Experience Store, 416 W. Congress, Tucson, AZ 85701 (520.770.3500)

For information on the mission, objectives or geologic products of the Arizona Geological Survey visit www.azgs.az.gov.

This publication was prepared by an agency of the State of Arizona. The State of Arizona, or any agency thereof, or any of their employees, makes no warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed in this report. Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the State of Arizona.

Citation: Conway, F.M. and Davis, R. (eds.), 2014, Annual Report of the Arizona Geological Survey: Fiscal Year 2014. Arizona Geological Survey Open-File Report OFR-14-07, 52 p.

Layout and Design by Stephanie Mar.

Director's Report

In Fiscal Year 2014, the Arizona Geological Survey (AZGS) maintained its core functions in addressing natural hazards and natural resources in Arizona, and not only cemented our role as a national leader in geoinformatics or geoscience cyberinfrastructure but expanded our impact globally as well.

AZGS geologists responded to natural hazards including debris flows and landslides following wild fires, the magnitude 5.3 Duncan Arizona earthquake, and a plethora of new or expanded earth fissures resulting from monsoon downpours. The deadly landslides in Washington and Colorado this past year prompted us to reallocate a modest amount of internal funds to start a statewide inventory of known landslides, something never before undertaken. A full inventory, characterization, and assessment will be a multi-year effort, assuming we can continue to support the work.

We made substantial progress in getting the hundreds of thousands of pages of reports and files gathered by the former Arizona Department of Mines & Mineral Resources digitized, georeferenced, and online at the interactive Arizona Geological Survey Mining data website.

Our Phoenix operations moved out of temporary space to co-locate with the Arizona Department of Water Resources, with much better public access and enhanced ability to collaborate between our agencies.

One of the highlights of the year was the formal launch of the National Geothermal Data System (NGDS) by U.S. Secretary of Energy Ernest Moniz at the White House Energy Datapalooza, in Washington, DC in May 2014. NGDS went operational as a federated data network with over 10 million data records covering 30 different types of data, from 60+ contributing data providers in all 50 states. AZGS has managed this Department of Energy project since 2010 on behalf of the Association of American State Geologists. NGDS is the largest application of the US Geoscience Information Network (USGIN).

We spun off USGIN Foundation, Inc. as a non-profit company to commercialize the services and turn NGDS into a sustainable operation. The USGIN data framework meets all the requirements of the White House Open Data Access Initiative, and has wide applicability to other resources beyond geothermal, including petroleum, minerals, and water, and natural hazards.

The Arizona Natural Resources Review Council adopted USGIN as the basis of a Natural Resources Decision Support System linking data, documents, and maps among the nine state environment, resource, and transportation agencies, to better enable the State of Arizona to respond effectively to the thousands of federal agency land use and land management proposals made every year.

Notable Accomplishments FY 2014

Arizona

- Initial launch of the Mining Data online repository to provide free access to hundreds of thousands of pages of historic mine files, maps, records, and photographs.
- Completed first statewide mapping of earth fissures.
- Engaged 116,000 Arizonans, including more than 80,000 K-12 students, in the Great Arizona Shakeout earthquake preparedness drill.
- Collaborating with Arizona state agencies to design and build the Natural Resources Review Council Decision Support System (NRRC-DSS) to coordinate land management decisions.
- Published six geologic quadrangle maps as part of the USGS STATEMAP program.
- Deployed a temporary seismic monitoring network to detect and locate aftershocks from the magnitude 5.3 Duncan earthquake.

National

- Public launch of the AZGS-led National Geothermal Data System at the White House Energy Datapalooza by U.S. Secretary of Energy Ernest Moniz.
- Leading the National Science Foundation-funded EarthCube test enterprise governance initiative to develop geoscience cyberinfrastructure management.

International

- Co-leading the 13-nation Belmont Forum e-infrastructure and data management effort to recommend global strategies and short- and long-term funding investments.

The AZGS took on a major project for the National Science Foundation (NSF) to design and test a community-led governing structure for geoscience cyberinfrastructure under the EarthCube program. It is a dramatic departure from how scientific organizations are set up, and is intended to build community consensus on a system architecture, a challenge the community has struggled with for 15 years.

Following on the heels of early EarthCube successes, NSF asked AZGS to lead the US Secretariat for the Belmont Forum e-Infrastructure and Data Management project in partnership with colleagues from the University of Reading in the United Kingdom. I serve as co-chair of the project's international Steering Committee with representatives from 13 nations' science funding agencies, the European Union, International Council for Science, and International Social Science Council. We have an 18-month process, with 120 experts in science, technology, legal and security issues from the participating countries, to produce a strategic plan for enabling global change research.

The AZGS' growing national and global presence is paying dividends on multiple levels. The digital technologies we are developing are being put to work on the State's Natural Resources Decision Support System, at our new portal for digital mines and mineral resources, and at the interactive, online Natural Hazards in Arizona viewer. This is critical since AZGS funding continues to be dominated by external grants. The State appropriation for AZGS is less than 10% of our total budget, as it has been for several years. The grants we bring in help support basic operations of the agency so that we continue to maintain all the services to Arizona that we provided prior to the recession and the substantial cuts that all agencies took.

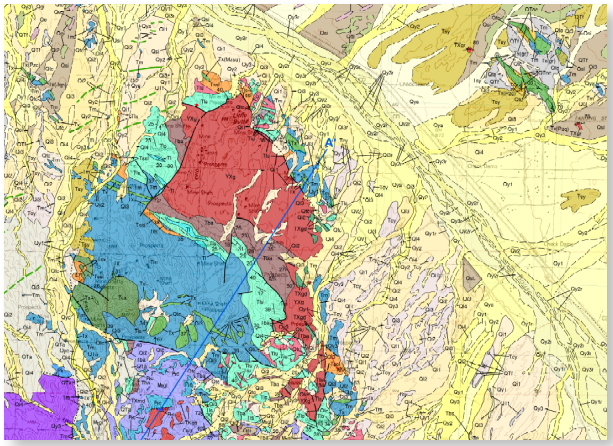
In summary, AZGS helped save lives and property from natural hazards, supported the wise development of our natural resources, is making Arizona a global leader in cyber technology, and has become an entrepreneurial center of economic development. This report provides more details on these activities and perspectives from the geologists and others on staff who are carrying out the work.

M. Lee Allison
State Geologist & Director

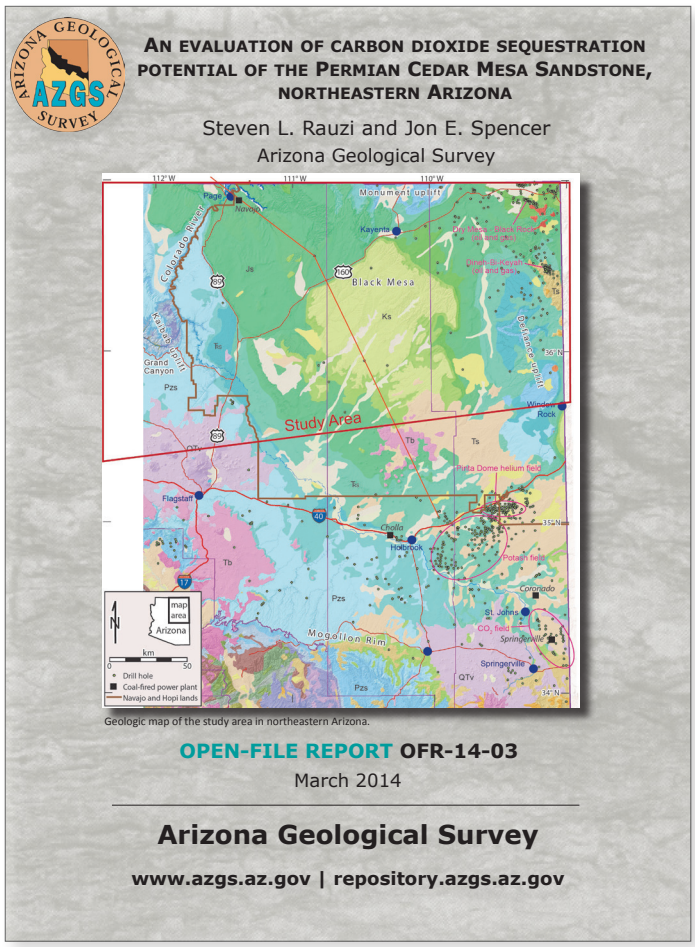
Mapping

"Geologic maps are the key to understanding Arizona's natural resources and natural hazards"

Jon Spencer mapping Aubrey Hills, western Arizona (12/2013)



Geologic map Bouse and Ibex Peak area (DGM-107)



AN EVALUATION OF CARBON DIOXIDE SEQUESTRATION POTENTIAL OF THE PERMIAN CEDAR MESA SANDSTONE, NORTHEASTERN ARIZONA

Steven L. Rauzi and Jon E. Spencer
Arizona Geological Survey

Geologic map of the study area in northeastern Arizona.

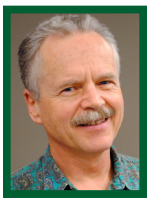
OPEN-FILE REPORT OFR-14-03
March 2014

Arizona Geological Survey

www.azgs.az.gov | repository.azgs.az.gov

Carbon sequestration report 2014.

Since 1915, the Arizona Geological Survey and its predecessor agencies have published more than 1,000 geologic reports and maps. Recently, interest in Quaternary surficial analysis and geologic hazard mapping has grown. While emphasis areas change, our commitment to publishing informative, unbiased, geologic maps and reports remains steadfast.



Geologic mapping in Arizona: the STATEMAP Program

by Jon Spencer, Ph.D. (Chief, Geology Section; Senior Geologist)

Geologic mapping is one of the most basic functions of state geological surveys. Geologic maps have diverse uses, and have an unusually long shelf life compared to other types of scientific publications. Some maps made over 100 years ago are still in use because no new mapping has been done. Their most important uses are for mineral- and energy-resource exploration and geologic-hazard identification. They are also used for scientific investigations to determine geologic history and to better understand geologic processes.

The Arizona Geological Survey (AZGS) has had a strong geologic mapping program for over 30 years. For the past 20 years geologic mapping has been supported with Federal funds provided through the STATEMAP program, which is a component of the National Geologic Mapping Act of 1992. STATEMAP is a matching fund program in which States must contribute matching funds equal to awarded Federal funds. The Survey received an award of $151,162 for FY2014, which was matched with $151,261 in State funds. Since the STATEMAP program began, the Survey has received $3.77 million in Federal funds.

Along with AZGS Research Geologist Phil Pearthree, I am responsible for submitting STATEMAP proposals, carrying out funded geologic mapping, and supervising mapping geologists. As part of the program, I spend many weeks mapping in Arizona each year. Arizona has such great geology, and the rocks are so well exposed, that I am reminded every field season of how fortunate I am to be able to do geologic mapping and related studies in Arizona. What a great State!

Each year the Arizona Geologic Mapping Advisory Committee (GMAC) recommends to the AZGS several map areas that are considered high priority for new geologic mapping. GMAC members represent government, industry, and academic interests in Arizona geology. During FY2014 the AZGS STATEMAP mapping program was targeted at three map areas recommended by the GMAC, as follows: (1) New geologic mapping along the Colorado River between Lake Havasu City and Parker improved understanding of copper and gold deposits in the western Buckskin Mountains and sand and gravel deposits derived from the ancestral Colorado River. (2) New mapping southwest of Quartzsite on the east side of the Colorado River improved understanding of the distribution of sand and gravel resources derived from the ancestral Colorado River and identified details of the stratigraphy of the Bouse Formation. (3) New geologic mapping of Kingman, and Sacramento Valley to the west of Kingman, identified potential geologic hazards associated with flooding and with volcanic materials that underlie much of Kingman.

A buried Laramide porphyry copper deposit near Copperopolis, Arizona

by Charles Ferguson, Ph.D. (Research Geologist)

This year's newly released STATEMAP map, Geologic map of the western half of the Columbia 7 ½' Quadrangle and the eastern half of the Copperopolis 7 ½' Quadrangle, Yavapai County, Arizona, involved mapping along the complex boundary between the Transition Zone and Basin and Range province just north of Phoenix. The map product can be downloaded from the AZGS Document Repository. The map area comprises mid-Tertiary volcanics that bury a Laramide porphyry copper deposit. The map and cross-section show that the structural transition is not the simple down-to-the-basin normal fault in which rocks in the footwall (northeastern) block are essentially untilted. Instead, our work shows that the southwestern edge of the Transition Zone gradually and significantly tilts to the southwest across an approximate 10km wide zone where the Tertiary strata flex upwards across a paired syncline into a flat-lying block that is abruptly truncated to the southwest by a major, moderately low-angle, and down-to-the-southwest normal fault zone. Our findings support recent industry reports indicating that nearby parts of the Transition Zone are in fact tilted strongly towards the basin (Eurasian rethinks Arizona's copper riches, 2013; Northern Miner, v. 99, no. 22).

When not mapping for the AZGS, I teach a short course I developed nearly 20 years ago called "Whole Lava Love" with the cooperation of Jon Spencer, and then State Geologist and Director Larry Fellows (Arizona Geology, v. 28, no. 1, 1998). Since its inception, the short course has been taken by several dozen undergraduates, graduates, professors, and industry professionals. Two original Whole Lava Love students are now professors at prestigious institutions; George Hilley at Stanford, and Adam Maloof at Princeton. Dr. Maloof discuss his research on NPR's "Science Friday" nationally syndicated show (http://sciencefriday.com/guests/adam-maloof.html#page/full-width-list/1). Another former student, Brian Gootee, is now a geologist with the AZGS, and one of his classmates, Susanne McDowell went on to earn a Ph.D. at Vanderbilt working with Calvin Miller on geochronology and petrogenesis of magmas related to the Peach Springs Tuff super eruption in the Kingman area. Her research is summarized beautifully in a paper published recently in *Contributions to Mineralogy and Petrology* (Contrib Mineral Petrol (2014) 167:1031).

West-dipping unconformity near the ghost town of Columbia in the Copperopolis area of the Transition Zone north of Phoenix.

My course is now taught independently and consists of 1–2 sessions a year. Last winter, and for the next two winters, I will be teaching it formally as part of a three year REU (Research Experience for Undergraduates) grant awarded to Lily Claiborne (Vanderbilt), Nick Lang (Mercyhurst, Erie, PA), and Calvin Miller (Vanderbilt). Each year, the program awards 10 undergraduates from institutions all across the country support and guidance for the pursuit of research projects related to the Peach Spring Tuff's caldera-forming eruption. The eruption formed the Silver Creek caldera near Oatman, Arizona and was probably an important factor in generating the epithermal gold deposits of that area.

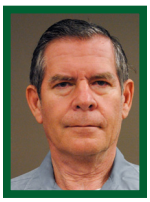
Geologic mapping along the lower Colorado River

by Brad Johnson, Ph.D. (Research Geologist)

I am often asked, since this is the twenty-first century, why can't we just use satellite imagery to do all our geologic mapping? My colleagues who map surficial geology are able to take advantage of satellite imagery and aerial photos to identify various deposits of gravel and other young sediments, which tend to have distinctive geomorphological expressions. But my work is focused

on bedrock geology. While some bedrock units, such as certain stratified volcanic and sedimentary rocks, have distinctive cliff-forming or slope-forming characteristics, and some have distinctive colors or textures, many rocks are indistinguishable or only vaguely distinguishable in satellite and aerial imagery. In Arizona, this is especially true of Proterozoic crystalline rocks; mapping these rocks requires traversing across them on the ground, and frequently using a rock hammer to break open rocks and a hand lens to identify minerals and rock textures. Even rocks that have distinctive geomorphological expressions must be examined in the field to see what they are. Not only that, but the nature of geological units varies from place to place, and only by direct observation can these variations be documented. The variations are often important in the interpretation of the conditions that led to the genesis of the rocks. In the bedrock mapping that we do here at the AZGS, satellite imagery is used to interpolate; to fill in the gaps between field traverses.

During the winter and spring of FY2014 I worked with Senior Geologist Jon Spencer in the Aubrey Hills, on the east side of Lake Havasu (Colorado River) in northwestern Arizona. The bedrock geology there consists of Proterozoic granite and gneiss at least 1.4 billion years old overlain by Miocene sandstone, conglomerate, and volcanic rocks. The rocks are distributed in two northwesterly elongate upper-crustal fault blocks that have been tilted southwestward up to 70 degrees as a result of crustal extension and movement of the upper crust. The fault blocks have moved relatively downward and away from present-day California, along the regional-scale Whipple-Rawhide-Buckskin detachment fault. The Proterozoic rocks show evidence of intense deformation that predated extension and tilting, probably by tens of millions of years based on regional considerations. Conglomerate and sandstone in the upper part of the Miocene section have been tilted less than sedimentary and volcanic rocks lower in the succession, indicating that tilting, faulting, deposition of these rocks occurred together.



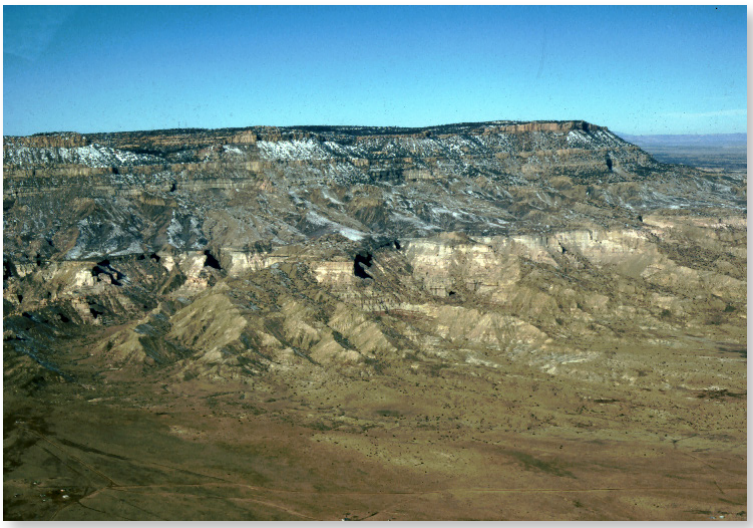
Oil and gas, potash and CO_2 sequestration activity in Fiscal Year 2014

by Steven L. Rauzi (Oil and Gas Administrator)

The Arizona Geological Survey (AZGS) provides administrative and staff support for the Arizona Oil and Gas Conservation Commission (AZOGCC). The AZOGCC consists of five members appointed by the Governor and one ex-officio member, the State Land Commissioner. Current Commission members include J. Dale Nations, Tucson, Chairman; Stephen R. Cooper, Casa Grande; Frank Thorwald, Show Low; Robert L. Wagner, Mesa; and Vanessa Hickman, ex-officio member and State Land Commissioner. Steven L. Rauzi is the administrator. The Oil and Gas Conservation Commission held two regular meetings in FY14. Links to rules and statutes and other information about oil and gas in Arizona may be found on the Commission's web page at www.azogcc.az.gov.

Regulatory Highlights. Forty four drilling permits were issued and 21 wells were drilled in FY14. Of the wells drilled, 19 were for potash and 2 were for CO_2 near St Johns in eastern Arizona. The AZOGCC permits the potash stratigraphic wells because the holes penetrate the Coconino Sandstone, a potential helium reservoir in the area of the Petrified Forest National Park. Oil production totaled 60,072 barrels from 25 producing wells in calendar year 2013, up from 51,949 barrels from 21 wells in 2012. Gas production totaled 72 million cubic feet from 5 producing gas wells in calendar 2013, down from 117 million cubic feet from 4 wells in 2012. No CO_2 was produced in 2013. There were two active disposal wells and four shut-in wells at yearend including 1 oil, 2 gas, and 1 CO_2 well. There were 891,000 acres leased for oil and gas in Arizona as of June 30, 2014, up from the 756,000 acres at year end 2013.

CO_2 Sequestration Activity. The AZGS joined the Rocky Mountain Carbon Capture and Sequestration partnership (RMCCS) to study CO_2 sequestration potential across the Colorado Plateau region. The AZGS determined that the Cedar Mesa Sandstone of Permian age has the capacity to store 0.70 billion metric tons of CO_2 in northern Arizona. The Cedar Mesa Sandstone underlies the Navajo Generating Station near Page, Arizona. The AZGS also digitized oil and gas well logs into computer usable LAS (Log ASCII Standard) format to aid subsurface investigations using well logs and developed a user-friendly web application to make the digitized well data available online. The online search and download map, the Arizona Oil and Gas Well Viewer, is hosted under the Online Data tab on the AZOGCC website. The AZGS released OFR-14-03, which describes the results of its investigation of the storage potential of the Cedar Mesa Sandstone in northeastern Arizona.



Black Mesa, Arizona. Mancos Shale, a potential source of shale gas, crops out at Black Mesa (Rauzi and Spencer, 2013)

Economic Geology

"Mining is an $8 billion industry in Arizona"
— Nyal Niemuth, Chief, Economic Geology

Morenci Mine, Arizona

For nearly half-a-century, Arizona has led the nation in raw copper production. In non-energy mineral production, Arizona is second only to Nevada. Other principal minerals mined in Arizona, in descending order of value, include: molybdenum concentrates, sand and gravel for construction, Portland cement, and silver.

Arizona's mineral resources

by Nyal Niemuth (Chief, Economic Geology)

Mining is alive and well in Arizona. In 2013, Arizona was one of the top two mineral-producing states in the U.S., producing non-fuel minerals with a value of $7.5 billion dollars, accounting for 10.2% of all U.S. mineral production. And we are still #1 in copper production! Total output in 2013 was 1.8 billion pounds worth over $6 billion. This includes two thirds of the nation's newly mined copper.

Arizona is the center of one of the world's three great clusters of porphyry copper deposits. Dozens of deposits are known, including many that remain unmined because they are sub economic at current commodity prices or not fully explored. Some unmined deposits are largely concealed and have not been the target of enough drilling to delineate the size and grade of the deposit. In addition to copper, Arizona also produces fuels and other minerals worth over $1.8 billion. The principal minerals, in descending order of value are molybdenum concentrates, sand and gravel for construction, Portland cement, and silver. Other minerals produced include coal, crushed stone, dimension stone, clay, lime, gemstones, gold, gypsum, perlite, pumice, salt, uranium, and zeolites.

Here in Phoenix, we address 100s of inquiries from the public, industry, and other government agencies. Requests for property data and commodity information from consultants, exploration groups, and mining companies are economically important. Their interest in Arizona leads to expenditures and investment through exploration, project development, and ultimately, to producing mines.

Our AZGS libraries in Tucson and Phoenix boast the largest public holdings and archive of primary geologic and mineral reports in Arizona. Internet access to this historic information improved greatly this year when a new portal http://minedata.azgs.az.gov was launched. We placed 4,068 mineral property files, 678 large format mine maps, and 3,328 photos online. In addition to key word searches, the site offers a geographic search tool, a photo browser, and multiple filters of search results. Our digitizing efforts will continue next year and more of our special collections will appear online.

Late in FY2014, the Phoenix Branch relocated to 3550 North Central Avenue. There, using our library and archive of geologic and mineral reports, we assist customers in directing their activities to favorable geologic environments. We provide Arizona and industry with an institutional memory through periods when commodities are price-depressed or are not required by current technology. This body of information benefits society by preserving limited economic resources. For example, our collection of mining data can save exploration companies millions of dollars in unnecessary drilling, assaying, and other work that has previously been done. In many cases this can also prevent unnecessary environmental disturbances.

Exposing 100 years of Arizona mine and mineral records at AZGS's mining data website

by Casey Brown (Librarian & Archivist)

The AZGS Mining Preservation project continues to digitize and catalog 1000s of mineral exploration files for free and public access at the new AZGS Mining Data website (http://minedata.azgs.az.gov/). In FY2014, the digitization team of Diane Bain, Becky Eden, myself, and volunteer Kevin Hart, made significant progress in the number of files cataloged and made web accessible. Diane's experience at the Arizona Department of Mines and Minerals (ADMMR) made her uniquely qualified to identify and describe images in the photograph collections. Becky's expertise with geography and GIS has been a perfect match for cataloging maps from various collections. Kevin has been a dedicated volunteer for years, digitizing thousands of images.

This year, we cataloged the remaining ~ 5,000 Arizona Department of Mines and Mineral Resources (ADMMR) maps and published the first three non-ADMMR collections: the Richard Mieritz's collection, James (Jim) Sell collection and the Reconstruction Finance Corporation's Arizona mining records, comprising over 1,100 files. We scanned and web-published 1,700 photographs from various collections. We cataloged another 2,500 reports that still require digitization.

The individual documents and their metadata can be found by name or geographic search through our new search portal, http://minedata.azgs.az.gov.

In March 2014, we built and deployed a new search engine to facilitate searches in a more intuitive and user-friendly fashion. The AZGS Mining Data portal facilitates the three most common inquiries received regarding the mining collections: a name search, a geographic search and photo browsing.

In the case of a known mine name, users enter the mine name into a search box and retrieve a list of mines matching that name. Primary mine names, assigned by AZGS, are unique to each county; there are several Bluebird Mines in Arizona. Alternate names can be searched using the geographic search page.

Or users may forego the mine name search, opting instead to filter results by selecting keywords (e.g., gold). This strategy allows people to limit search results using keyword filters. Adding successive filters continues to narrow results. A useful keyword filter would be to combine a county and commodity, e.g. 'Yavapai' and 'tungsten' to see mines in Yavapai County with tungsten. For geographic searches, a Google map displays clickable markers for mines. People may not know the mine by name, but they could point to an area on a map. By clicking a mine marker, the user is presented with all the documents from all the collections which match that mine. This feature has already proven its value by exposing files from collections other than the ADMMR mine files.

A searchable photo gallery allows the same name search functionality or keyword filtering while displaying results as thumbnails of photographs. Some people are only looking for photographs. This gallery makes images much easier to browse and find.

Preserving the past for the future

by Becky Eden (GIS Tech & Archivist)

You might picture an archival library as a dimly lit basement with rows and rows of filing cabinets. That's not what visitors see when they first step into the AZGS's Phoenix Archival Mining Library at 3550 N. Central Ave. Yes, there are rows of cabinets, each one full of mining property files and maps, but there are also shelves and shelves of Arizona mining and geology books, some of which date to the late 1800s. One of my primary tasks is to digitize and build metadata for a digital catalog to enhance discovery once the materials are deployed at the AZGS Mining Data website (http://minedata.azgs.az.gov/).

We also have shelves of publications available for sale to the public (over 140 items), including: AZGS Down-To-Earth series; mineral reports such as "Gold Panning in Arizona"; special papers such as "Laws and Regulations," and "Manual for the Determination of Status and Ownership"; bulletins such as "Gold Placers and Placering in Arizona"; circulars, e.g.,"A Survey of Uranium Favorability of Paleozoic Rocks in the Mogollon Rim and Region"; County Geologic Maps; the popular "Directory of Active Mines"; and the County Mine Map Series.

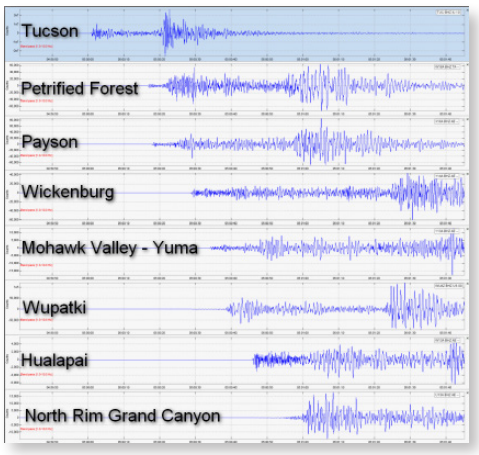
I operate the bookstore, keeping track of our finances and updating our inventory and making sure our shelves are full. Volunteers help keep our library organized, and I'm available to assist library patrons in their search for geoscience materials.

As a member of the Governor's Arizona Geographic Information Council, I know how important it is to preserve our digital geographic data for public use. I work with the AZGS GIS (geographic information system) team to preserve our STATEMAP data in a way that will make it accessible for the public. Part of my data management duties include recreating ArcMap documents from old ArcView files, creating metadata, and making sure these files are NCGMP09 compliant. This data will then be deployed at the online AZGS document repository (repository.azgs.az.gov).

Environmental Geology

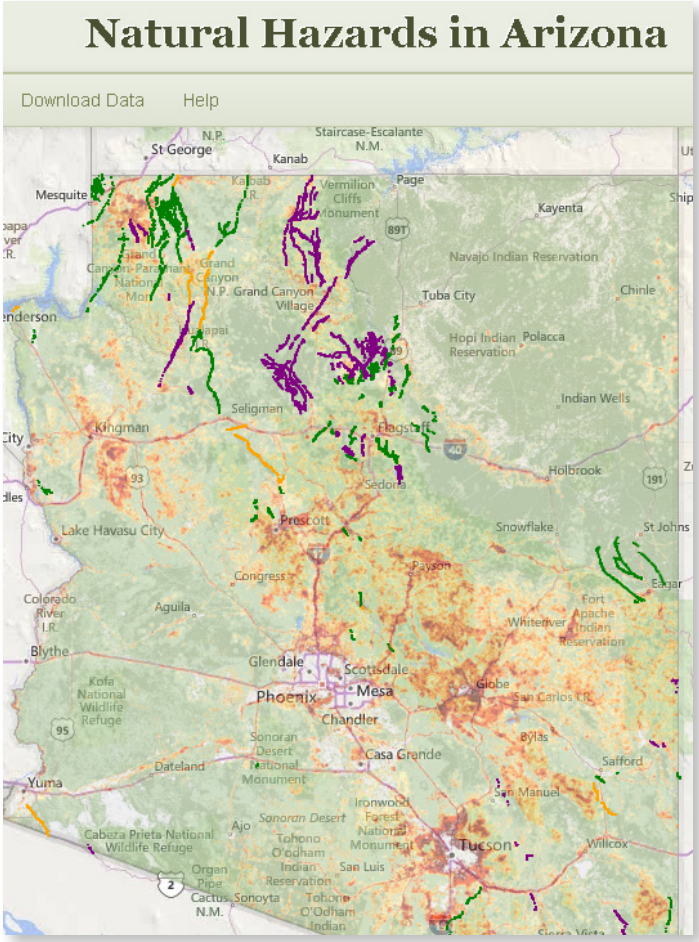
"Geologic hazards affect all Arizonans"

— Phil Pearthree, Chief, Environmental Geology



Seismograms from 28 June 2013, M5.3 earthquake near Duncan, Arizona

Reactivated earth fissure near Queen Creek, Arizona (4/2014)



Arizona Geological Survey - Natural Hazards in Arizona Viewer; Quaternary faults and fire risk index map. http://data.azgs.az.gov/hazard-viewer/

A key function of the Environmental Geology section is to investigate and monitor geologic hazards in Arizona. Earthquakes, debris flows, earth fissures, all fall in our purview. To monitor seismicity, we operate the Arizona Broadband Seismic Network.

Geologic mapping for a new seismic hazard assessment of Palo Verde Nuclear Generating Station

by Phil Pearthree, Ph.D., (Chief, Environmental Geology)

There was renewed concern about seismic hazards and nuclear generating stations in the U.S. in wake of the 2011 Fukushima tsunami disaster. The U.S. Nuclear Regulatory Commission required that seismic hazards for all U.S. nuclear stations be evaluated, and a project to re-assess seismic hazards for Palo Verde Nuclear Generating Station (PVNGS) west of Phoenix was initiated. When PVNGS was constructed in the late 1970s and early 1980s, the site was chosen in part because of a perceived low seismic hazard. Several decades of seismicity data have been recorded and several investigations of young faulting have been conducted in Arizona since the facility was constructed, so it was appropriate that the seismic hazards be reevaluated. The expert technical committee that was reviewing the seismic hazard evaluation recommended that the geology of the area immediately around PVNGS be mapped systematically in order to evaluate whether there was any evidence of young faulting near the facility.

AZGS personnel cooperated with geologists from Lettis Consultants International (LCI) to define and delineate surficial geologic map units around the PVNGS with primary purpose of evaluating whether there is any evidence of Quaternary faulting or other deformation. The project consisted of: (1) detailed geologic mapping in an 8-km radius area centered on the PVNGS; and (2) reconnaissance investigations and generalized mapping of a 40-km radius centered on PVNGS. The AZGS was the lead agency on the detailed geologic mapping effort, building on our existing 1:24,000-scale mapping in the vicinity. This mapping documented the surficial geology of the immediate vicinity of PVNGS and served to calibrate the reconnaissance mapping in the larger area around the facility. AZGS and LCI staff collaborated in mapping in the 40-km radius around the PVNGS. The intent of all this mapping was to identify alluvial surfaces and deposits of Pleistocene and Holocene age; these deposits and surfaces were scrutinized for evidence of deformation.

Geologic mapping around PVNGS revealed the existence of a diverse set of surficial deposits ranging in age from modern (wash beds) to early Pleistocene (probably ~2 million years old) remnant alluvial fans. Some of these deposits were emplaced by the Hassayampa River, but most were laid down by smaller tributaries with minor eolian deposits. The hills and mountains around PVNGS consist of 10 to 20 million-year-old volcanic rocks, which are moderately faulted and tilted. As part of the mapping process we closely evaluated the surficial deposits and did not find any evidence of young faulting.

Monitoring debris flows in burn basins—a first step in developing predictive models to enhance public safety

by Ann Youberg, Ph.D., (Research Geologist)

Wildfires are increasing in size and severity across the western U.S., burning millions of acres annually. In Arizona, the size of wildfires has increased dramatically since 2002. During the last decade, residential developments at the wildland-urban interface in Arizona have grown rapidly. Hydrologic changes in recently burned watersheds promotes the likelihood of post-fire flooding, erosion and debris flows for the years immediately following a wildfire. While floods are more common than debris flows, boulderly debris flows can be more destructive and dangerous to people and infrastructure in their path.

I am continuing my multi-year collaboration with the USGS Landslide Hazards group in Denver, Colorado, to help determine what burn conditions and rainfall intensities promote post-fire debris flows in Arizona.

Smoke-filled Oak Creek Canyon and environs during the Slide Fire, summer 2014. Photo provided courtesy of Ted Grussing.

During the burned area emergency response (BAER) assessment, a USGS post-fire debris-flow model (http://landslides.usgs.gov/hazards/postfire_debrisflow/) is used to evaluate the probability of debris flows occurring within the burned basins. After the BAER assessment, and once monsoon rains have begun, we monitor basin responses to rainfall (flood or debris flow) to evaluate the effectiveness of the model in predicting the impact of Arizona wildfires. We also collect precipitation data to determine rainfall-intensity thresholds that trigger post-fire debris flows. These data will provide the National Weather Service with important information as they assess storms approaching a burned area and consider issuing warnings.

In past years, we've collected data from the 2010 Schultz Fire, the 2011 Wallow fire, Horseshoe 2 and Monument Fires, and the 2012 Gladiator Fire. This past summer, we collected data from the Slide Fire in Oak Creek Canyon north of Sedona, using a new approach. The Slide Fire area includes four intensely studied basins. A rain gauge resides at the head of all four basins, atop the Mogollon Rim. At three of the basins, we installed hunting cameras where the channels exit the steep slopes and debouch on to alluvial fans. At 30 minute intervals, the cameras capture images of the channel; providing information on channel conditions, whether flooding occurs and whether debris flows are involved. At the fourth basin, we installed a rain-triggered video camera to record flow timing and type.

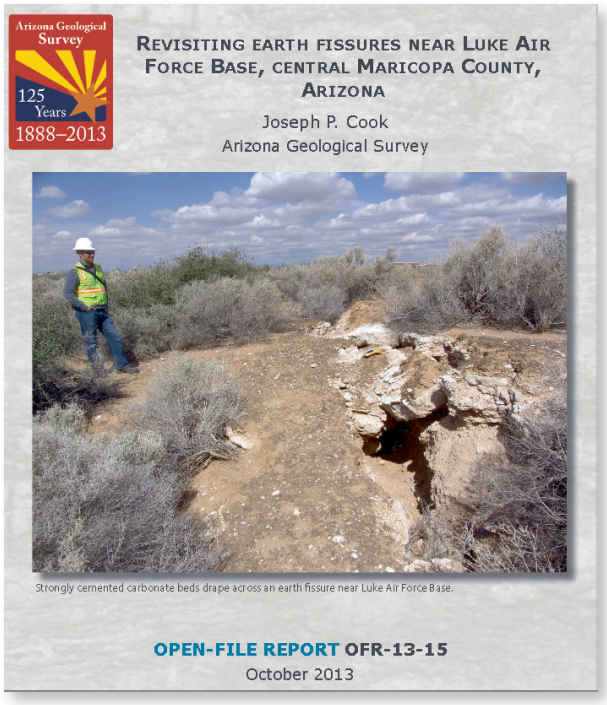
Information from this study will improve our understanding of post-fire debris flows in Arizona, which should lead to better predictive capabilities and protection of the public.

Surficial geologic maps—tools for assessing and mitigating geologic hazards in Arizona

by Joseph P. Cook (Research Geologist)

As an AZGS geologist, I investigate and document, whenever possible, the patterns and distribution of geologic hazards in Arizona, including: debris flows, landslides, flooding, and earth fissures. A growing population and expanding residential development into former agricultural lands and mountain front areas in Arizona, results in greater interaction between people and their property and geologic hazards.

In 2006, the AZGS was tasked with mapping earth fissures—an anthropogenic geologic hazard of south-central Arizona—and providing maps and information to the public. An online, interactive earth fissure viewer, with address search function is available here (http://azgs.az.gov/efv.shtml).



Prospective homebuyers, developers, real estate professionals, and city planners use AZGS fissure maps to make informed decisions about land use, infrastructure development, and new home construction. As part of my role as manager of AZGS earth fissure program, I work with county and city officials to provide assistance in characterizing fissure hazards to infrastructure and proposed developments. As a member of the Arizona Land Subsidence Group, which comprises scientists, engineers, and municipal workers, I frequently consult with the geotechnical community on the environmental and economic impact of earth fissures on Arizona.

AZGS recently released a Google Earth KMZ file displaying all mapped and inferred earth fissures throughout central and southeastern Arizona (http://tinyurl.com/AZGS-EF). In October 2013, we released a summary of the geologic setting and earth fissure history of the Luke study area (AZGS OFR 13-15). We continue to monitor new earth fissure development and reactivation in Cochise County, the greater Phoenix metropolitan area in Pinal and Maricopa County, and in the Harquehala Valley in far western Maricopa County.

My other chief task is to assist with surficial geologic mapping as part of the STATEMAP program. In 2013, I mapped the surficial geology of the Kingman and Kingman NW 7 ½' quadrangles of western Arizona. Young Quaternary surfaces in the Sacramento Valley west of Kingman display low relief and are composed of unconsolidated sediments. Some areas are slated for residential or agricultural development.

Mapping surficial geology now before development begins can inform decision made by the public, government agencies, and county and city planners about geologic hazards, soil characteristics, and flood or erosion risk.

Stalking Arizona earthquakes

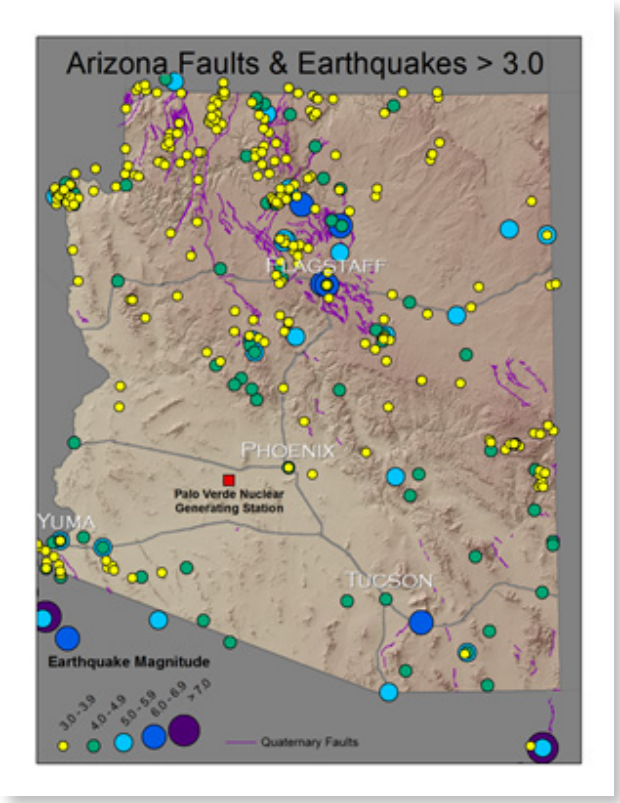
by Jeri J. Young, Ph.D. (Research Geologist)

Arizona experiences earthquakes, some of which can be damaging. The Arizona Geological Survey partnered with the three state universities (UA, NAU and ASU) and obtained a one-time FEMA Pre-disaster Mitigation grant for nearly a half of a million dollars in 2008 to create the state's first broadband seismic network that can detect most earthquakes for nearely all of the state.

The Arizona Broadband Seismic Network consists of 7 operational seismometers that record ground movement and help the AZGS detect quakes within the state, and help other entities, such as the United States Geological Survey (USGS) and Mexican Seismic Network locate quakes in other parts of the world.

Understanding Arizona's seismicity can help people prepare for potentially damaging earthquakes. Seismic records generated by the AZGS are used in ground-motion modeling by the USGS and are used to detemine what seismic building codes are appropriate for the state. In addition, information gathered by our network of seismometers is used to understand how the ground moves under critical structures such as Palo Verde Nuclear Generating Station. Often seismicity occurs in close proximity to known active earthquake faults; however, there are cases where seismicity occurs in areas without known faults. Repeated earthquakes in such areas provide clues to where previously unknown active faults could be.

As the seismic network manager, I keep the broadband seismometers working by monitoring their health and visiting them for repairs from time to time. In addition, I maintain near-realtime data flow from each station so that when an important earthquake occurs, the data can be used by AZGS and other entities. Lastly, when an Arizona earthquake occurs, I analyze multiple seismic records (seismograms) from our stations and those surrounding Arizona so that I can locate where the earthquake occurred, estimate its size (magnitude) and record it in the Arizona Geological Survey Earthquake Catalog. All of this information is eventually disseminated to the public via an active webpage and in articles for Arizona Geology.



A geologic framework for managing groundwater resources

by Brian F. Gootee (Research Geologist)

Managing groundwater resources of Arizona's water-rich sedimentary basins requires detailed knowledge of basin geology and hydrology. While numerical groundwater models provide hydrologists with a keen evaluation tool, the models are only as good as the data we input. Building data sets adequate to characterizing basin hydrology requires years, sometimes decades, of monitoring water levels and flow rates.

As a hydrogeologist, I've been gathering and analyzing such data for 15 years. For the past several years, I've worked hand-in-hand with staff at the Arizona State Land Department to evaluate basin hydrogeology in the Butler Valley basin of western Arizona. We developed a hydrogeologic conceptual and numerical groundwater model to demonstrate adequate water supply. Unfortunately, the results are constrained by the quality and volume of data, much of which dates to the 1970s.

To improve the model, we need to conduct continuous and intermittent water-level monitoring, seismic and gravity surveys, drilling, and aquifer testing. Butler Valley Basin is restricted at its downstream outlet by a shallow bedrock divide, referred to as the Narrows, separating it from its adjoining basin. Since the 1960's, efforts to define this important hydrogeology boundary using existing well data and coarse gravity and seismic surveys have failed. In 2014, we coupled new geologic mapping and new drilling to confirm a fairly shallow depth to bedrock in the Narrows, thereby defining the basin's boundary condition much more accurately.

Aquifer testing is an important part of characterizing the physical parameters of aquifer structure, stratigraphy, and groundwater flow. We have conducted aquifer tests in Butler Valley Basin in order to characterize these parameters and update the groundwater model. These measures of basin characterization can be expensive and are not without their own logistical and technical challenges.

New well drilling at the downstream outlet of Butler Valley Basin, May 2014.

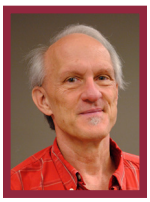
Performing an aquifer test from an old irrigation well in Butler Valley basin.

Geoinformatics

"Supporting development of a 21st century information economy in Arizona"

— Steve Richard (Chief, Geoinformatics Section)

Geoinformatics relies on information science infrastructure to address problems in the geosciences and geography. Geoinformatics is about how we discover, access, organize and distribute geoscience data.



Digitizing Arizona—think locally act globally

by Steve Richard (Chief, Geoinformatics Branch)

The Arizona Geological Survey's Geoinformatics team comprises 4 fulltime employees and a handful of rotating interns. One of the team's chief objectives is to deliver digital data—e.g., AZGS geologic maps, tables and reports—in such a way that the user audience can easily get the data, and can control how they view or use the data. This interoperable data system approach, which packages data into standardized interchange exchanges for use in many systems, has resulted in several major contracts of national and now international scope. One such effort yielded the National Geothermal Data System (NGDS), a customized, online data repository currently in use across the country by all State Geological Surveys and described by *Earth Magazine* as "one of the most successful programs to date" in the article "Digitizing Earth: Developing a Cyberinfrastructure for the Geosciences" by Sara E. Pratt. Geoinformatics special projects, such as USGIN, Earthcube, and the Belmont Forum are of national and international importance.

The Arizona Geological Survey plays a leading role in the development of information systems to improve accessibility of geoscience information. The use of the World Wide Web as a data delivery platform is transforming our approach to serving the citizens of Arizona. It has been almost 10 years since we transitioned our geologic map production to a completely digital process, releasing 'Digital Geologic Maps' online for easy download by a broader audience (http://repository.azgs. az.gov).

The next stage in this digital evolution is to present the data itself as a product. Maps, tables, and reports are all vehicles for data delivery. AZGS is developing interoperable systems that allow users to choose the type of data presented and how it is viewed. These systems work by packaging data into standardized 'interchange formats' that can be read, processed, and displayed by multiple sources.

By developing standardized approaches to delivering data to the user community, the Web will become like a giant database that can be searched to find the specific information necessary to solve geoscience problems, whether in engineering, environmental planning, or mineral resource development. To realize this vision, we are using standardized 'metadata'—computer analyzable description of datasets, and data components, as an important component of data packaging. This allows computer programs to provide search results that can be used by other programs to customize access to complex data, providing for easy access to and more control that can facilitate decision making in the geosciences.

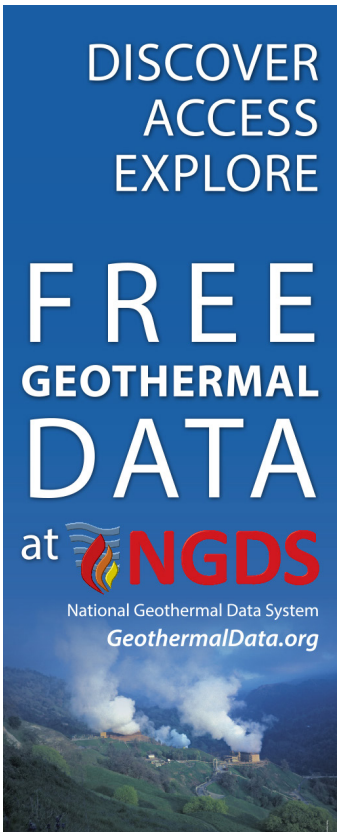
Geoinformatics expertise at the AZGS has been instrumental in obtaining several major contracts. The survey has spearheaded development of the National Geothermal Data System by a consortium of 45 State Geological Surveys with funding from the US Department of Energy. This system provides access to a comprehensive collection of information resources to support development of geothermal energy in the U.S. The survey is leading a project to develop the governance system for EarthCube, a National Science Foundation initiative to deploy cutting edge cyberinfrastructure to support geoscience research in the U.S. AZGS geoinformatics specialists are involved in four EarthCube-related technology projects, focusing on system architecture, catalog systems, and data services for Earth Science information of all kinds.

As team leader, I am actively involved with standards development for information exchange through the Open GeoSpatial Consortium and the International Organization for Standardization, in addition to developing architecture and practices for geoscience data distribution at the state and national level. These activities have put the AZGS on the map in the informatics community, supporting the development of a 21st century information economy in the State of Arizona.

National Geothermal Data System—Blazing fresh trails in data management

Christy Claudill (Geoinformatics Content Specialist)

Helmed by the AZGS, the National Geothermal Data System (NGDS), http://geothermaldata.org, has the potential to fundamentally change America's energy portfolio by providing free geothermally relevant data with the intent of reducing risk in geothermal exploration nationwide. Completion of the design and build component of the NGDS was celebrated with an official launch at the White House Datapalooza event on May 29 by National Secretary of Energy Earnest Moniz.



NGDS is an unprecedented national distributed data system. The system exposes voluminous data from state geological surveys working together under the auspices of the Association of American State Geologists (AASG). Funded by the U.S. Department of Energy Geothermal Technologies Office, the $22 million NGDS project coordinated the digitization and submission of geothermal-relevant information from over 65 collaborators and sub-awardees, bringing unprecedented amounts of new and legacy data online. Users can access over 9 million data records, over 3 million oil and gas well logs, 1 million water wells, and 47,000 geologic maps and reports in the NGDS central catalog, by far the largest collection of geothermal-related data searchable in one place.

Among the overwhelmingly positive impacts to state surveys from the data collection component, new drill projects were undertaken in Idaho, Nevada, Oregon, Utah, Washington, and Wisconsin. A potential sedimentary geothermal field was confirmed in the Black Rock Desert by Utah Geological Survey, and in Hawaii new interest in geothermal development is reducing the islands' consumption of oil for energy production. NGDS metadata can be harvested by other national and international online systems and already is compliant with and serving OneGeology map services. Beyond the research and fiscal impacts that such a system produces, it has the power to transform these State Surveys into technological powerhouses.

AZGS also manages the system architecture, custom software builds, and user search interface.

The infrastructure, metadata management techniques and standards, and data access protocols developed by AZGS (through USGIN, usgin.org) are deployed by Surveys across the country and are garnering interest on an international level. The architecture is simple yet innovative, and allows AZGS to be an international pioneer and recognized leader in data preservation and standards.

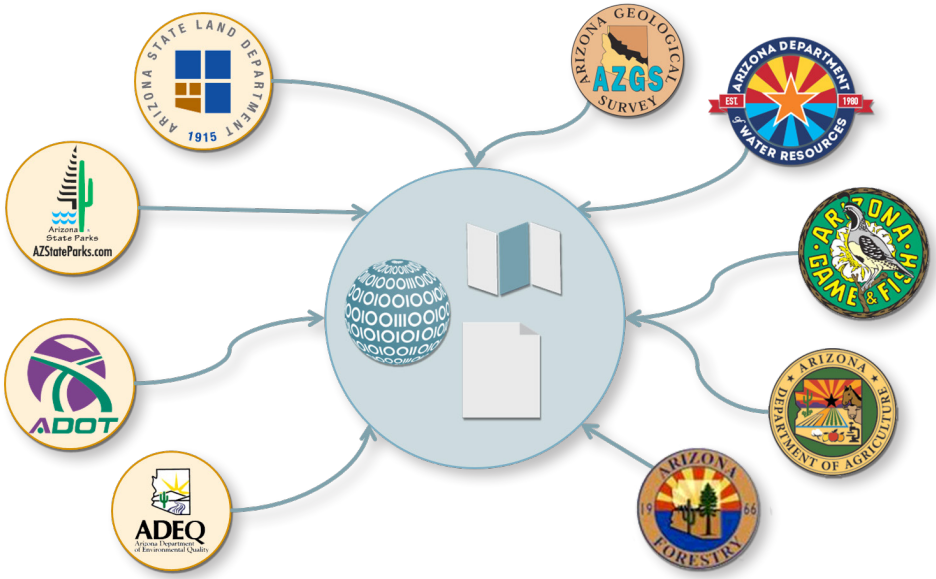
Under NGDS, AZGS build training manuals, conducted workshops on establishing web data and map servers and to encode interoperable data, created free online tools and open-source free software for data and metadata management, and developed and promulgated common technical standards, guidelines, and requirements. The global geosciences community recognizes AZGS as a national and international leader in data/metadata management implementations and open-source software utilization.

Resource management with the Natural Resources Review Council Decision Support System (NRRC-DSS)

by Jessica Good (GIS & Programming Technician)

As a software developer with the Arizona Geological Survey, I work to create and maintain tools to help increase the productivity of our staff geologists. One such tool is the NCGMP09 ArcGIS Toolbar, which I have been updating to account for changes in the way the data for our STATEMAP program products are stored and to which I have been adding new features as suggested by the geologists.

In January 2013, Governor Jan Brewer released Executive Order 2013-02, "Establishing the Arizona Natural Resources Review Council" (NRRC) to "develop land and natural resource management strategies for Arizona and coordinate with state natural resource agencies and their existing management plans." One of my roles here at AZGS is to work with the NRRC GIS Subcommittee to build and deploy a *Decision Support System* (NRRC DSS) website to coordinate sharing of resources among Arizona state agencies—see figure—to engage and impact federal land and resource management plans.



The NRRC DSS could become a model for other states in their efforts to coordinate with federal agencies in developing sustainable resource management plans that benefit their citizens.

Belmont Forum Data Management Project: establishing sustainable e-infrastructures for global change research

by Genevieve Pearthree (Project Manager)

The Belmont Forum, established in 2009, is comprised of the world's major funding agencies of global environmental change research and international science councils, and serves as a roundtable for these agencies to collectively address issues related to global environmental change. It is guided by the Belmont Challenge, which aims "To deliver knowledge needed for action to avoid and adapt to detrimental environmental change including extreme hazardous events."

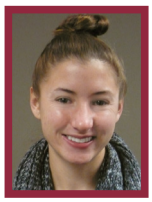
From our Paris workshop. Starting top left: Toshio Koike (Japan), Lee Allison (USA), Marko Komac (OneGeology), Mustapha Mokrane (World Data System), Andrew Treloar (Australia), Pierre Philippe Mathieu (European Space Agency), Barbara Percy (UK), Dale Peters (South Africa), Kathie Bowden (UK), Johannes Karte (Germany), Christoph Waldmann (Germany), Michelle Manning (UK), and Genevieve Pearthree (USA)

The Belmont Forum coordinates funding for Collaborative Research Actions (CRAs), which are high-priority research and community-building activities to improve the way funding agencies collaborate with each other and develop opportunities for research. In 2013, the Belmont Forum initiated the multi-phased E-Infrastructures and Data Management CRA, which brings together 120 natural scientists, computer and information scientists, legal scholars, social scientists, and other experts representing more than 10 countries to establish recommendations on how the Belmont Forum can implement a more coordinated, holistic, and sustainable approach to the funding and support of global environmental change research.

Arizona Geological Survey Director Lee Allison (US) is working with University of Reading Professor Robert Gurney (UK) to helm Phase I (October 2013 – April 2015) of the E-Infrastructures and Data Management CRA under a joint United States/United Kingdom Secretariat. During Phase I, an international steering committee of experts are leading working groups of expert researchers to focus on issues of collecting, standardizing, and opening data with the goal of delineating a sustainable data infrastructure that will support collaboration between the world's climate scientists.

I manage the US Secretariat Team, which includes AZGS project coordinators Randi Bellassai, Rachael Black, Kendra Decker, Anna Katz and Kate Kretschmann. Our team is responsible for producing a Community Strategy and Implementation Plan to identify short- and long-term funding investments and strategic science policies that the Belmont Forum can implement. Phase II will begin in late 2015/early 2016 and will deliver on the recommendations generated during Phase I. Phase II may include one or more CRAs to implement the strategies and vision generated from Phase I.

Recommendations from this project could influence how the Belmont Forum operates by promoting more coordinated and sustainable policies, procedures, and funding mechanisms to support global e-infrastructure for environmental change research. The project could also help the Belmont Forum members cooperate to leverage their domestic programs in order to have an even greater impact nationally and globally.



EarthCube: growth and governance in geosciences research

by Rachael Black, Kate Kretschmann, and Anna Katz (Project Coordinators)

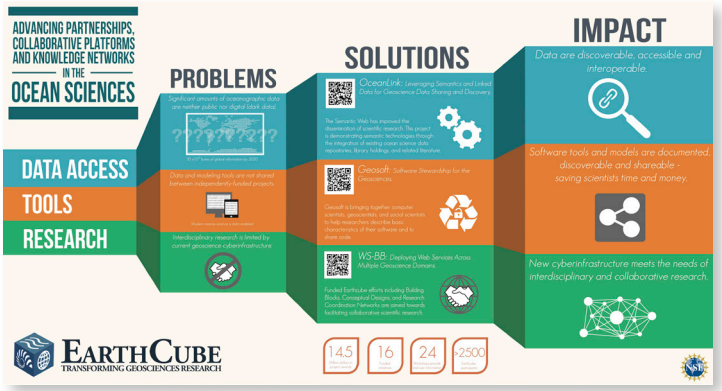
In September 2013, we started work at the Survey to support the NSF EarthCube initiative, a community-driven effort to create cyberinfrastructure for managing, sharing, and exploring geoscience data, software, and models. At the time, EarthCube was an emerging concept for coordinating projects within NSF's *Cyberinfrastructure in the 21st Century* vision: highly conceptual, deliberately open-ended, and about to launch a major new phase of development. Through a great deal of hands-on community building, we have had the pleasure of helping EarthCube take shape over this last year, and look forward to ushering it into another new phase in 2015.

As the scope and vision of EarthCube continues to be refined, we're realizing that EarthCube isn't just developing cyberinfrastructure for the geosciences--it's creating and testing a community process that will be replicable for other scientific domains. If successful, EarthCube could accelerate understanding of the Earth system, improve the productivity of the geosciences, and pave the way for cyberinfrastructure developments for science communities across the globe.

The Survey has contributed to the development of EarthCube since its inception in 2011, and Dr. Lee Allison is currently Principal Investigator of the Test Enterprise Governance project, a $3.6 million NSF award to design and test an EarthCube governance structure. As the "Arizona Team," we act as the communications center and face of the initiative, coordinating the interactions of over 2,500 participants from diverse science and technology fields, with funded project teams distributed across the country.

Over the past year, we've been heavily invested in this intense development process. We've organized and run five national workshops around the country, expanded EarthCube web properties and outreach, managed exhibit booths, town halls, and presentations at national scientific conferences, and collaborated with dozens of other projects, programs, and institutions.

The peak of the year's activities was the EarthCube All-Hands Meeting, held in Washington, DC last June. Nearly 150 members of the geo- and cyber-science communities—from 90 diverse academic institutions, government agencies, and consortia—shared their progress with EarthCube thus far and planned activities for the coming year. The event was an unequivocal success, and we left with a critical deliverable in hand—a demonstration governance structure to begin testing in October. The next few months will bring more progress,



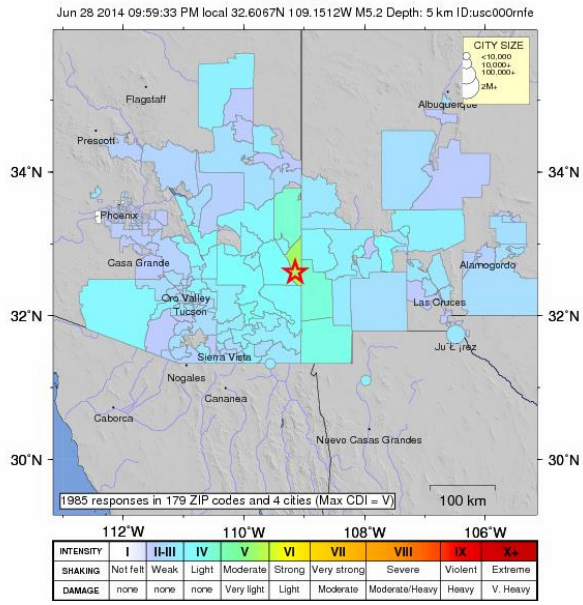
as we welcome an EarthCube Program office manager to coordinate support for the demonstration governance structure. We'll also be supporting the population of governing bodies and testing and adjusting the structure for long-term operations.

With the advancement of NGDS, USGIN, EarthCube, and the global Belmont Forum initiative, our Survey is now standing at the epicenter of cyberinfrastructure development for the geosciences. The Arizona Team is looking forward to another year of contributing to these remarkable efforts.

Geologic Extension Service

"Communicating the Survey's mission, programs and products to our stakeholders—the Arizona public, civil authorities, educators, industry and business"

— Lee Allison, State Geologist



AZGS Facebook post showing intensity map of 28 June 2014, M 5.3 earthquake, reached more than 100,000 people.

Serving the Arizona public requires transparency, forthrightness and strong customer service values. The Geologic Extension Service team, comprising a geoscientist, web architect, editor, graphic artist, tech transfer specialist, and bookstore manager, strive to internalize these values in an effort to continuously improve the products and services of the AZGS.

Spinning up the AZGS outreach strategy

by Michael Conway, Ph.D. (Chief, Geologic Extension Service)

A decade ago, the Arizona Geology quarterly magazine was our primary venue for delivering topical geologic news and reports to the public. Now, we rely more on social media, which is fast joining print, TV and radio outlets as a major source of consumable news and information for those under the age of 60. Over the past several years, the AZGS Geologic Extension Service (GES) has embraced social media outlets, Facebook, Twitter and YouTube as vehicles for rapid and timely delivery of geologic news and information to our stakeholders. On 28 June 2014, our Facebook post on the magnitude 5.3 earthquake near Duncan, Arizona, reached over 100,000 people; hundreds of whom shared the information with their personal networks. Integrating social media into a agency-wide communication strategy requires patience and determination. Regular daily posts, including weekends, are essential to growing and sustaining an audience. Finding fresh material means pursuing developing stories from our own staff, other Arizona natural resource agencies, the U.S. Geological Survey, the National Weather Service, American Geophysical Union, the American Geological Institutes, and the Geological Society of America, among others. From the July 2013 to the end of June 2014, the AZGS-GES Facebook audience more than doubled to 2,330 (6/30/14), while Twitter followers increased by about 35% (6/30/2014).

Conventional information outlets, including both formal and informal presentations, remain a mainstay of ours, including: AZGS technical serials (e.g., OFR, DGM, and CR), the Arizona Geology e-Magazine (http://azgeology.azgs.az.gov), Arizona Mining Review e-Video Magazine, news media releases, and print, TV and radio interviews. AZ Shakes, our earthquake preparedness program, successfully enrolled more than 116,000 Arizonans in the Great Arizona ShakeOut—*Drop, Cover and Hold On* drill on October 16, 2013.

As the communications branch of the AZGS, we support the communication and outreach objectives of AZGS's Geoinformatics, Geology, Economic Geology, and Environmental Geology sections. This involves balancing multiple, synchronous projects, each with its own goals, needs and timelines. Our services range broadly from designing exhibit space, to reviewing and editing documents, to illustrating the intricacies of distributed data networks—no mean task.

Facebook post with video short of AZGS' Joe Cook describing fresh earth fissure activity near Chandler Heights.

In FY2014, GES staff worked with AZGS geologists and staff to publish contributed maps and reports (5), digital maps and digital geologic maps (8), open-file reports (10) and a variety of miscellaneous briefs and reports (7).

Reaching Arizona and beyond—AZGS on the WWW

by Pam Barry-Santos (Web Architect)

The Arizona Geological Survey (AZGS) offers a lot more than maps. Not to say there aren't maps—we produce a lot of them. The agency is also tasked with sharing any geoscience information involving the state with people geographically close and distant. This directive ranges from sharing information that was generated last week to work done generations ago.

The Geologic Extension Service, the division within AZGS for which I work, is tasked with ensuring that our work is available to all members of the public. While we have a publicly accessible library with a wealth of historical documents and a variety of newer materials, in recent decades the focus of the survey has been to share as much with the public as possible, through our websites.

We host a variety of websites that range from interactive maps, historical data, and informational sites to document repositories and collaborative platforms where scientific professionals discuss what's next in the world of interoperable data platforms. We have one general interest site that focuses on all things Arizona (http://arizonaexperience.org) and another site that shares oil and gas permitting information (http://www.azogcc.az.gov).

Our main site (http://www.azgs.az.gov) keeps the public informed with the latest news from the agency (including latest publications, public presentations, notifications about earthquakes, etc.) and updates on work being done within the agency. Additionally, with federal grant funding, we're able to showcase work that is done in our agency on a national level, which allows us to continue to promote the agency, and the state, as a leader in the geosciences.

My role within the agency is to help find ways to get this information from the hands of the science staff to the public, through our sites, and to ensure the functionality and stability of those sites. Whether it's updating a site with the latest announcement or building a new site from scratch for a project focusing on collaborative data-sharing networks, my work is never the same. Each project brings its own triumphs and small frustrations, but it's never the same day at the AZGS. And there's always more to learn and share.

Select AZGS Website Environments

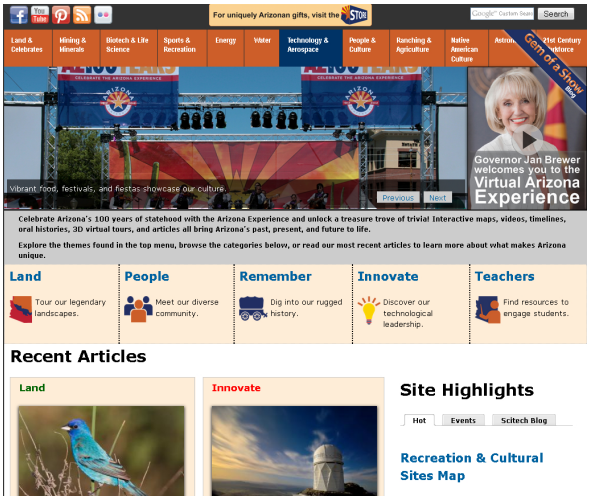
Arizona Geological Survey	azgs.az.gov
Arizona Experience Store	store.azgs.az.gov
Arizna Oil & Gas Conservation Commission	azogcc.az.gov
Arizona Experience	arizonaexperience.org
AZGS Online Repository	repository.azgs.az.gov
AZGS Mining Data	minedata.azgs.az.gov
Belmont Forum	bfe-inf.org
National Geothermal Data System	geothermaldata.org
USGIN	usgin.org
EarthCube	earthcube.org

Arizona Experience interactive multimedia website grows with specialty agriculture feature

by Rowena Davis (Arizona Experience Content Editor)

Two years after the Arizona Geological Survey arranged, built, and premiered the Arizona Experience website, it is proving to be a useful resource and a valuable platform for educators, businesses, and tourism opportunities. Created as a legacy project for the Arizona Centennial, the website that I was hired to administer features material from nearly 300 content providers and collaborative projects with businesses, agencies, and non-profits around the state.

In FY 2014, we are expanding those partnerships with a grant from the Arizona Department of Agriculture. Over a period of two years, the Arizona Experience will build interactive maps of Arizona's U-Pick farm agri-tourism opportunities and film festivals associated with various specialty crops. (Specialty crops are fruits and vegetables, tree nuts, dried fruits, and horticulture and nursery crops, including floriculture.) This project showcases some of the surprising agriculture developments taking place in Arizona (such as the introduction of lavender along the Mogollon Rim) and will help raise public interest in farms, locally grown produce, and the value of experiencing food sources firsthand.



Arizona Experience web portal serving Arizona educators, business and tourism industries.

One exciting element is an interactive map of wine trails in Arizona's three wine growing regions: Sonoita, Willcox, and the Verde Valley. At higher elevations, Arizona's mineralized soils prove ideal for viticulture, producing the tart, flavorful grapes used in wine. For the past thirty years, winemakers have been exploring which types of varietals grow best for producing innovative and distinctive wines that are increasingly recognized by wine connoisseurs. Wine is potentially a highly lucrative tourism draw, and Arizona's wine industry has been expanding under careful incubation by a host of state agencies. An interactive map that shows the location, services, and hours of operation of local wineries and tasting rooms is an important agri-tourism tool for visitors in planning a smooth and relaxing wine tasting experience.

While these maps are an obvious asset to tourism, information on Arizona's specialty crops can aid educators as well. Like most features on the Arizona Experience, these maps represent the cutting edge of digital mapmaking technology and can be used in the classrooms to promote geographic literacy and improve computer skills. As the website approaches its third year, we continue to emphasize our relationship with STEM educators and our role as a digital education platform while seeking funding opportunities from a variety of sources to keep the great accomplishments of the past years moving forward.

Building and deploying exhibits and displays—from San Francisco to Washington D.C.

by Randi Bellasai (Assistant Project Manager)

As the Arizona Geological Survey has extended its scope and purpose, my position has similarly expanded during my time here. During FY14, I slowly transitioned out of promotional duties for the Arizona Experience Store and began helping the agency raise its profile overall. For the he first half of the year, I represented AZGS in public appearances that allowed us to engage directly with the public and presented to groups such as the Southern Arizona Attractions Alliance. Additionally, I helped host exhibits at the Festival and Events Association of Tucson and Southern Arizona, Tucson Meet Yourself, Fall Fest in Phoenix, Tucson Gem and Mineral Show, and Tucson Festival of Books. My contributions in the store led to delegates from the US showcasing the Arizona Experience during their trip to Korea.

As my position evolved, I became responsible for supporting some of the Survey's largest and most notable projects, including AASG State Geothermal Project funded by the US Department of Energy, US Geoscience Information Network (USGIN), and EarthCube. I contributed to the modification of several websites, development of promotional materials, construction of a comprehensive communication and marketing strategy, and coordinated logistics for numerous events and seven workshops. As an outgrowth of this facilitator role, I began to help coordinate and submit grant applications to potentially fund a variety of AZGS staff projects.

In June, 2015, AZGS will be hosting the 107th Annual Meeting for the Association of American State Geologists. I have taken the lead on all of the logistic planning for this event and look forward to showcasing Flagstaff off to our national colleagues. I have enjoyed expanding my knowledge and helping the agency extend its work into additional areas. Arizona is an amazing place and AZGS is an incredible place to work!

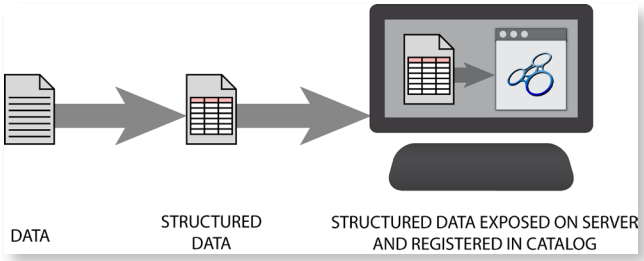
Earth Cube team member Anna Katz presents materials I helped create, arrange, and transport at the 2013 Geological Society of America meeting in Denver.

Arizona Experience Store booth at 2014 Tucson Festival of Books.

Tech Transfer—A cornerstone of AZGS' communication

by Jordan Matti (Tech Transfer Specialist)

The goal of tech transfer is to facilitate public access and understanding of the activities here at the Arizona Geological Survey; ranging from economic and environmental geology, general information about Arizona, and geocyberinfrastructure and international data sharing platforms. Over the last year, my responsibilities as tech transfer specialist have included on-site videography for a grant from the Arizona Department of Agriculture; filming and editing the Arizona Mining Review, the Arizona Geological Survey's monthly webcast; generating media for the USGIN and NGDS projects; and social media for both USGIN and NGDS.



In early 2014, the Arizona Geological Survey received a grant from the Arizona Department of Agriculture to create promotional videos focused on specialty crops of Arizona, including lettuce, lavender, and dates. I was tapped to act as a videographer at specialty crop festivals around the state, including Yuma, Sonoita, Concho, and Willcox. The interviews and footage will be used to promote crops, businesses, and tourism. It's been a wonderful opportunity to see different parts of Arizona and acquire field experience as a videographer.

Closer to home, I act as videographer and broadcast engineer for the Arizona Mining Review, a monthly webcast in which State Geologist Dr. Lee Allison conducts interviews related to the mining industry, both in Arizona and abroad. I am often faced with technical challenges as we strive to master the medium and expand our capabilities with each episode. Fortunately, the webcast has been positively received by the mining community.

Filming at Yuma's Lettuce Festival, February 2014.

With the official rollout of the National Geothermal Data System in May of 2014, our attention has turned to the backbone of NGDS: USGIN, a federated information framework designed to help users create distributed data-sharing networks. Ninety percent of the world's data was generated over the last two years, and centralized networks are not a practical method of facilitating access to such large quantities of data. Instead, USGIN proposes a decentralized network that grows with each participant.

As part of my duties, I explain and promote USGIN via diagrams, short videos, and social media, a process that has been both challenging and rewarding.

Arizona Experience Store—all things Arizona

by Nancy Greene (Store Manager)

The Arizona Experience Store is the public face of the AZGS at street level. We are the first point of contact for visitors and callers; we welcome them while embracing the highest standards of customer service.

Over the past several years, the Arizona Experience Store has grown to encompass all things Arizona including topographic, hiking and US Forest Services maps, books, minerals and gift items. Our inventory includes more than 2,500 topographic, travel and geologic maps for Arizona. We are a one-stop shop for Arizona Highways publications as well as most of the Department of Fish and Game publications. To assist customers, we host a touch-screen kiosk for locating online resources at local, state and federal agencies. And we now host a children's section, with books on Southwest fauna and flora, science toys, and mineral kits for the novice mineral collector. We continue to grow our *Recreational & Public Lands Information* section, which now comprises dozens of free brochures, flyers and maps.

For the geoscience community, we provide geotechnical publications, including AZGS technical reports and maps, Arizona Geological Society digests, and select U.S. Geological Survey publications.

In the first half of 2014, I've worked diligently to expand our merchandise and freshen our appearance. We are doubling down on social media—Facebook and Twitter—to promote the store and reach new customers. I have added children's books and toys, established a section of Southwest cookbooks and adult fiction by Arizona authors. I've focused a great deal of effort in bringing in new consignments by artists and authors including jewelry, glass art, garden ornaments, cutting boards and books. We have added Arizona Native American herbal remedies and more food items including Tucson-made teas and spices.

The glass display cabinets and point-of-sale station have been redesigned to showcase our new product lines. When customers enter they now see a beautiful display of Arizona minerals, Mata Ortiz jewelry and Native American baskets. Store fixtures are re-situated to achieve better flow and visibility, and the stock room and office have been cleaned out and reorganized for efficiency. We purchased a new sidewalk rolling sign for the south entry to attract the attention of Congress St. traffic. With help from our graphics team, we designed and deployed new signage—inside and out—to better serve our customers.

The Arizona Experience Store is a great place to stop and pick up something uniquely *Arizona* for just about everyone!

Administration

"Dotting the i's, crossing the t's, paying the bills, allocating funds, keeping the field vehicles running—no easy task—and getting the paychecks out on time."

— Fritz Schellenburg, Budget Officer

Funding for the Survey stems from a broad spectrum of state, federal and private sector entities, each with its own financial policies and reporting procedures. The result: a challenging and rewarding administrative experience.

Additionally, we handle human resources and work with ADOA to assure the smooth transfer of funds, while implementing state-wide policy.

Following the money!

by Fritz Schellenberg

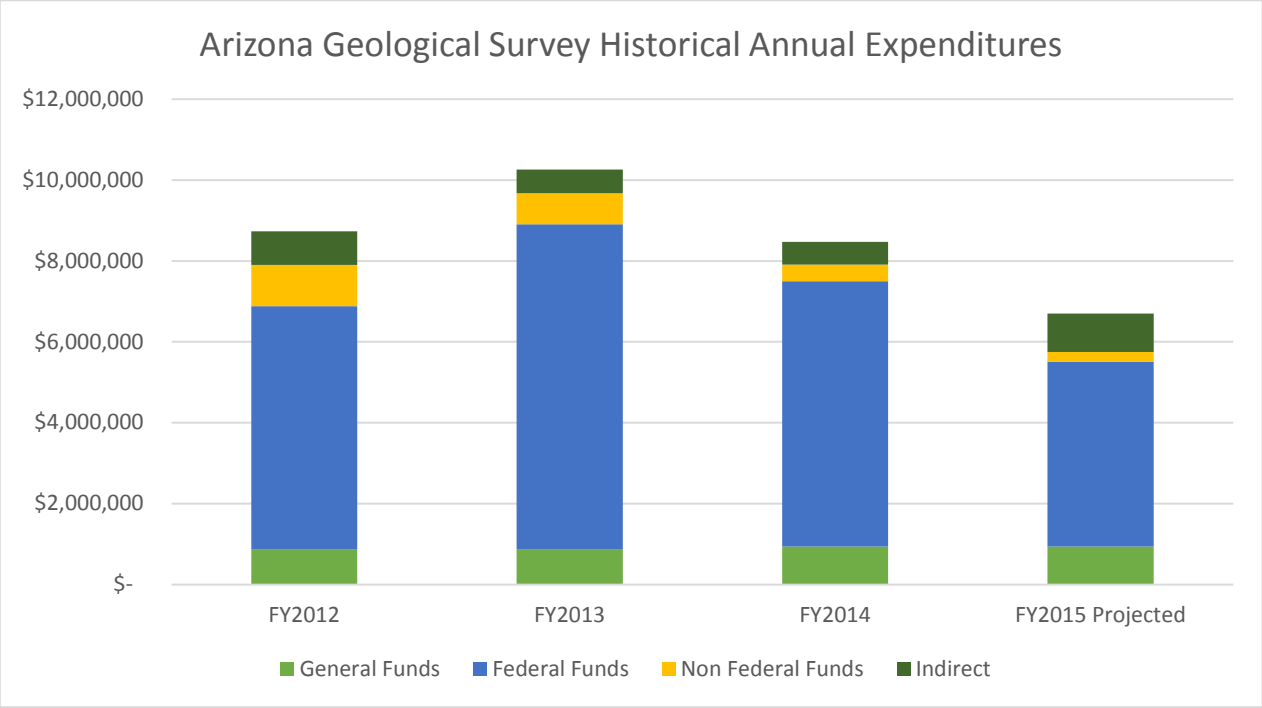
AZGS revenues come from appropriations of State General Funds by the Arizona Legislature, sales of publications, and grants and contracts. The Survey charges an indirect cost on external grants and contracts to cover administrative and support costs of those projects. By statute, appropriations are nonlapsing and cannot be carried forward year-to-year, conversely indirect costs and publication sales are lapsing and can be carried forward.

Total General Fund Appropriations FY14: $941,400

Contracts and Grants FY14
The AZGS was awarded several new grants and contracts in FY14. Additionally, work continues on multi-year awards.

Total Grants and Contracts FY14: $6,027,900.
See the following page for a full listing of grants and contracts, award values, and end dates.

Revenue	FY2012	FY2013	FY2014	FY2015 Projected
State General Funds	$876,200	$871,200	$941,400	$941,700
Federal Funds	$5,951,700	$8,054,700	$6,471,900	$4,547,200
Federal Funds (Indirect)	$562,100	$626,200	$648,900	$874,000
Grants & Contracts	$1,062,200	$749,200	$556,000	$165,200
Total	$8,542,200	$10,301,300	$8,618,200	$6,528,100



Grant list FY2014

Compiled by Fritz Schellenberg

Federal	U.S. Dollars	End Date
U.S. Dept. of Energy—National Geothermal Data System (NGDS)	$21,858,200	12/31/2014
National Science Fdtn. via Univ. Arizona—Earthcube Test Governance	$2,900,000	8/31/2015
U.S. Dept. of Energy Via Boise State Univeristy (NGDS)	$738,200	4/30/2014
National Science Fdtn.—E-Infrastructure via Belmont Forum	$652,500	3/31/2016
U.S. Dept. of Energy—Sandia National Laboratory (NGDS)	$400,000	4/30/2015
U.S. Dept. of Energy via Univ. of Utah (RMCCS)	$266,000	9/30/2013
National Science Fdtn.—Earthcube Governance	$252,500	10/31/2013
U.S. Dept. of Energy via California Energy Commission—WESTCARB	$232,400	7/15/2013
U.S. Geological Survey—Statemap '13	$206,600	9/14/2013
U.S. Geological Survey—Statemap '14	$151,200	9/14/2014
U.S. Dept of Energy, Univ. of California, San Diego—Earthcube CINERGI	$117,600	12/31/2015
National Science Fdtn.—Earthcube Domain Workshop (Data Facilities)	$93,100	12/31/2014
National Science Fdtn. University of California @ San Diego—Big CZ Software	$62,300	11/30/2015
National Science Fdtn. Univ. of California, San Diego—Earthcube Concept Design	$57,300	12/31/2015
Federal Emergency Management—AZ Shakes 4	$48,200	3/25/2014
Federal Emergency Management—AZ Shakes 3	$47,300	9/15/2013
U.S. Geological Survey—Data Preservation '13	$41,000	8/31/2013
U.S. Geological Survey—Post Fire Debris Flow	$40,000	6/14/2016
National Science Fdtn.—University of Alabama—EarthCube End-User PI Workshop	$27,400	11/15/2013
U.S. Geological Survey—Data Preservation '14	$27,300	8/31/2014
National Science Fdtn. Columbia Univ.—Digital Environment for Sample Curation	$18,000	11/30/2014
Federal Emergency Mgmt. Admin.— Arizona Div. Emergency Mgmt. Hazard Viewer	$100,000	9/30/2013
U.S. Energy Association—Kenya Data Management Assessment	$4,000	1/20/2014

State, Local, Other		
Arizona State Land Dept.—McMullan Valley Hydrology	$227,000	10/31/2014
Arizona Department of Agriculture—Virtual Arizona Experience	$109,200	9/30/2015
Arizona State Land Dept. Butler Valley Hydrology	$82,200	8/31/2014
Arizona Department of Water Resources—San Pedro Watershed	$35,000	6/30/2014
Arizona Public Service (APS)—Palo Verde Generating Nuclear Station seismic hazards assessment	$28,200	12/13/2014
Arizona Dept. of Emergency Management—Yarnell Hill Post-Fire Debris flow modeling	$8,200	12/31/2013
McDowell Sonoran Conservancy—Special Geologic Research Studies	$3,500	on-going

Arizona Geological Survey Staff FY2014

Director & State Geologist, M. Lee Allison, Ph.D.

Administrative Staff

Castro, Cindy	Fiscal Services Specialist	*
Larue, Paula	Human Resources / Business Manager	*
Madero, Adrieanna	Administrative Services Officer	adrieanna.madero@azgs.az.gov
Patten, Kimberly	Associate Director of Planning and Development	*
Schellenberg, Albert, F.	Budget and Accounting Officer	fritz.schellenberg.azgs.az.gov

Geoinformatics

Claudill, Christy	Geoinformatics Content Specialist	christy.caudill@azgs.az.gov
Clark, Ryan	GIS Web Developer	*
Day, Janel	Geoscience Information Manager	*
Musil, Leahanna	Information Technology Specialist	*
Palmer, Ronald	IT Support Specialist	ron.palmer@azgs.az.gov
Pape, Esty	Geologist	esty.pape@azgs.az.gov
Richard, Stephen	Chief, Geoinformatics	steve.richard@azgs.az.gov
Sonnenschein, Adrian	GIS Specialist	*

Special Projects Team

Black, Rachael	Project Coordinator	rachael.black@azgs.az.gov
Katz, Anna	Project Coordinator	anna.katz@azgs.az.gov
Kretschmann, Kate	Project Coordinator	kate.kretschmann@azgs.az.gov
Pearthree, Genevieve	Project Manager	genevieve.pearthree@azgs.az.gov

* No longer affiliated with the Arizona Geological Survey.

Arizona Geological Survey Staff FY2014

Director & State Geologist, M. Lee Allison, Ph.D.

Geologic Extension Service

Barry-Santos, Pam	Web Developer	pam.barrysantos@azgs.az.gov
Bellassai, Randi	Sales and Marketing Manager	randi.bellassai@azgs.az.gov
Conway, Michael	Chief, Geologic Extension Service	michael.conway@azgs.az.gov
Davis, Rowena	Web Content Manager	rowena.davis@azgs.az.gov
Greene, Nancy	Bookstore Manager	nancy.greene@azgs.az.gov
Harriman, Michelle	Bookstore Manager	*
Mar, Stephanie	Graphic Designer	stephanie.mar@azgs.az.gov
Matti, Jordan	Tech Transfer Specialist	jordan.matti@azgs.az.gov

Environmental Geology

Cook, Joseph P.	Research Geologist	joe.cook@azgs.az.gov
Gootee, Brian F	Research Geologist	brian.gootee@azgs.az.gov
Mahan, Michael	Geologist	*
Pearthree, Philip A.	Chief, Environmental Geology	phil.pearthree@azgs.az.gov
Youberg, Ann	Research Geologist	ann.youberg@azgs.az.gov
Young, Jeri J.	Research Geologist	jeri.young@azgs.az.gov

Geology Mapping

Ferguson, Charles A.	Research Geologist	charles.ferguson@azgs.az.gov
Johnson, Brad	Research Geologist	brad.johnson@azgs.az.gov
Rauzi, Steven L	Oil and Gas Administrator	steve.rauzi@azgs.az.gov
Spencer, J.E.	Chief, Geologic Mapping; Senior Geologist	jon.spencer@azgs.az.gov

Phoenix Branch

Bain, Diane	Records Archivist	diane.bain@azgs.az.gov
Brown, Casey	Metadata Librarian	casey.brown@azgs.az.gov
Eden, Becky	Records Archivist	becky.eden@azgs.az.gov
Niemuth, Nyal	Phoenix Branch Manager	nyal.niemuth@azgs.az.gov

Professional Accomplishments

M. Lee Allison, Ph.D., AZGS Director

- Earth and Space Science Informatics (ESSI) Section, Executive Committee, American Geophysical Union, member, November 2008- present
- Association of American State Geologists, Chair/co-chair, Data Discovery & Access Committee, 2008-present
- Coalition on the Public Understanding of Science (COPUS, www.copusproject.org), co-founder 2006, member Organizing Committee, 2006; co-convener of organizing workshops, member Core (Steering) Committee, 2007-present
- American Association of Petroleum Geologists, Astrogeology Committee, October 2006-present
- US Geoscience Information Network (USGIN) Steering Committee (AASG-USGS), co-chair, February 2007- present
- Adjunct Professor, University of Arizona Dept. of Geosciences, March 2008 – present
- Representative for Informatics, American Geophysical Union, EOS Editorial Advisory Board, March 2008-present
- Advisory Committee, Advanced Cyberinfrastructure, U.S. National Science Foundation, 2013-2014
- Natural Resources Review Council, gubernatorial appointment by Executive Order, March 2013 – present; GIS Subcommittee, Chair
- Geological Society of America, Geoinformatics Division, Vice-chair, October 2013 – October 2015
- North American Member, OneGeology Board of Directors, October, 2013 – present
- Co-chair, Belmont Forum e-Infrastructure Steering Committee and Secretariat, September, 2013 – April, 2015

Nyal Niemuth, Ph.D., Chief, Economic Geology

- Arizona Geological Society, member
- Arizona Board of Technical Registration, Enforcement Advisory Committee - Geologists
- Mining Foundation of the Southwest, Board of Governors
- Society for Mining, Metallurgy, and Exploration (SME), professional member
- SME Maricopa Section, Vice Chairman

Phil Pearthree, Ph.D., Chief, Environmental Geology

- Geological Society of America, Fellow
- Western States Seismic Policy Council, member
- Pima County Regional Flood Control District Advisory Committee, member
- Peer review of several scientific articles, Geological Society of America, Earth and Planetary Science Letters
- Field trip organizer, Assn. of Environmental and Engineering Geologists Annual Meeting in Scottsdale

Jon Spencer, Ph.D., Senior Geologist, Chief, Geologic Mapping

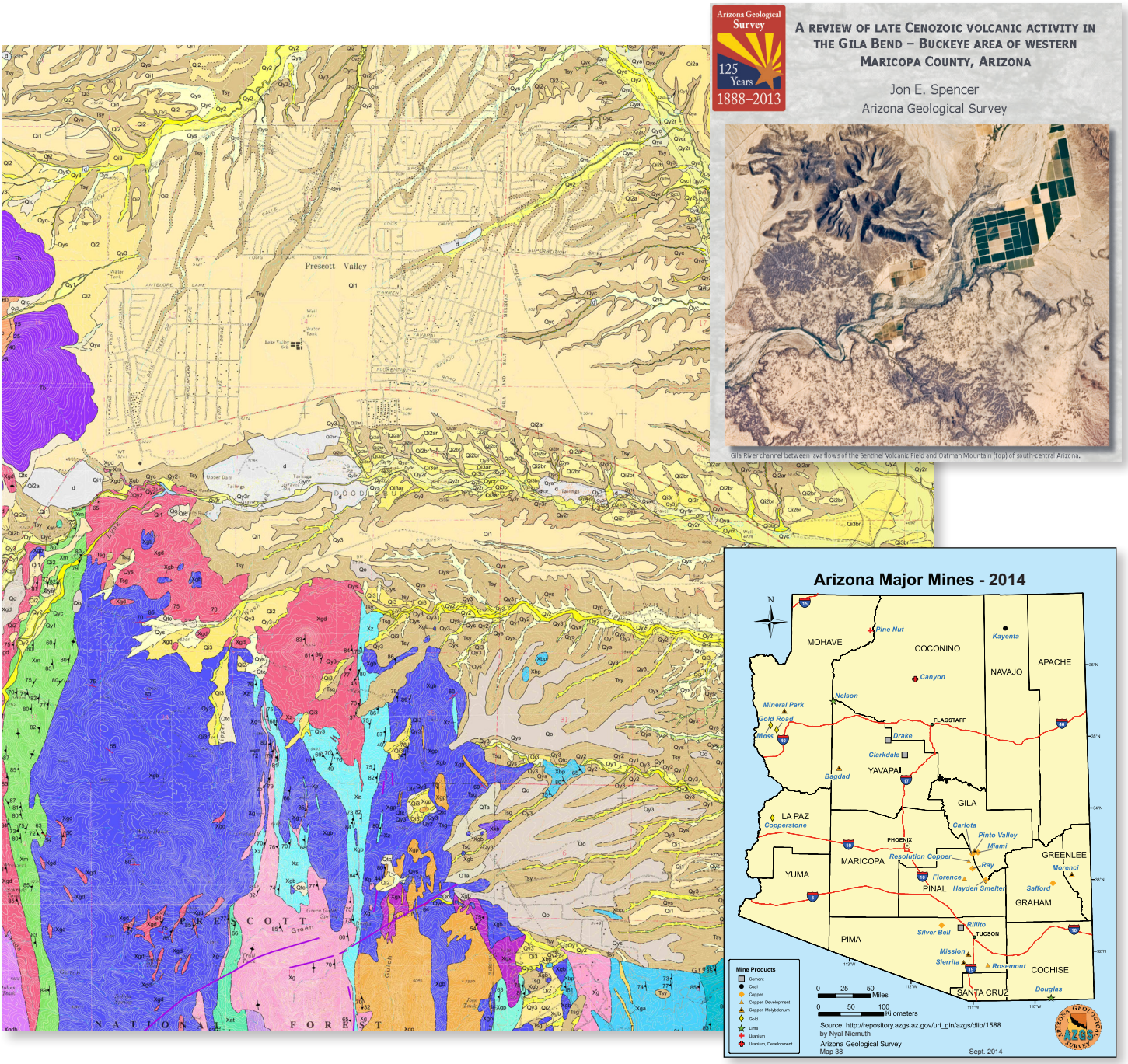
- Geological Society of America, Chair, CRevolution session, Oct. 2013
- Geological Society of America, Chair, Arizona Geology 125th Anniversary, Oct. 2013
- Arizona Geological Society Doug Shakel Student Poster Event, Judge, April 2014
- University of Arizona, Ph.D. Committee member, Sept. 2013
- University of Arizona, M.S. Committee member
- Peer review of several scientific articles, Geological Society of America, Journal of African Earth Sciences
- Field trip organizer, American Institute of Professional Geologists, Santa Catalina Mtns, April 2014

Michael Conway, Ph.D., Chief, Geologic Extension Service

- Treasurer, Arizona Geological Society
- Member, Western States Seismic Policy Council
- Arizona Represetntative to the National Earthquake Managers Council

Publications

The geologic reports and maps of staff geologists comprise the heartblood and legacy of the Survey



Contributed Reports

Briggs, D.F. 2014, History of Helvetia-Rosemont Mining District, Pima County, Arizona. Arizona Geological Survey Contributed Report, CR-14-D, 11 p.

Briggs, D.F., 2014, History of the San Manuel-Kalamazoo Mine, Pinal County, Arizona. Arizona Geological Survey Contributed Report, CR-14-A, 9 p.

Chenoweth, W.L., 2013, Exploration and Production History of the Uranium-Vanadium Mines on Cove Mesa, Apache County, Arizona. Arizona Geological Survey Contributed Report, CR-13-A, 27 p.

Chenoweth, W.L., 2014, The Geology and Production History of the Black Rock Point Nos. 1 and 3 Uranium-Vanadium Mines, Apache County, Arizona. Arizona Geological Survey Contributed Report, CR-14-B, 12 p.

Contributed Maps

Murphy, R.T. and Faulds, J.E., 2013, Preliminary Geologic Map of the North Half of the Union Pass Quadrangle, Mohave County, Arizona. Arizona Geological Survey Contributed Map, CM-13-A, 1 map sheet, map scale 1:24,000.

Digital Geologic Maps

Cook, J.P. and Youberg, A., 2013, Geologic Map of Safford 7 1/2' Quadrangle, Graham County, Arizona. Arizona Geologic Survey Digital Geologic Map, DGM-104 v.1.0, one map plate, map scale 1:24,000.

Spencer, J.E., Richard, S.M., Johnson, B.J., Love, D.S., Pearthree, P.A. and Reynolds, S., 2013, Geologic map of the Artillery and Rawhide Wash 7.5' minute Quadrangles, Mohave and La Paz Counties, Arizona. Arizona Geological Survey Digital Geologic Map, DGM-100, 1:24,000 map scale, 2 map sheets.

Ferguson, C.A. and Pearthree, P.A., 2013, Geologic Map of the Sullivan Buttes 7 1/2" Quadrangle, Yavapai County, Arizona. Arizona Geological Survey Digital Map, DGM-102 v. 1, 1:24,000 map scale, 1 map sheet.

Johnson, B.J., Cook, J.P. and Pearthree, P.A., 2013, Geologic Map of the Prescott Valley South 7 ½' Quadrangle, Yavapai County, Arizona. Arizona Geological Survey Digital Geological Map, DGM-103, 1:24,000 map scale, 1 map sheet.

Cook, J.P., 2013, Geologic Map of the Artesia 7 ½' Quadrangle and the Northeastern Corner of the Mount Graham 7 ½' Quadrangle, Graham County, Arizona. Arizona Geological Survey Digital Geologic Map, DGM-106, 1 map sheet, 1:24,000 map scale.

Youberg, A., 2013, Geologic Map of the Thatcher 7 1/2' Quadrangle, Graham County, Arizona. Arizona Geological Survey Digital Geologic Map, DGM-105 v. 1.0, one map sheet, map scale 1:24,000.

Digital Information

Arizona Geological Survey, 2014, Locations of Mapped Earth Fissure Traces in Arizona, v. 03.31.14. Arizona Geological Survey Digital Information (DI-39 v. 03.31.14), ArcGIS Layer Package.

Digital Maps

Arizona Geological Survey, 2014, Earth Fissure Map of the North Sulphur Springs Valley Study Area, Cochise County, Arizona. Arizona Geological Survey Digital Map Series - Earth Fissure Map 26 (DM-EF-26), map scale 1:24,000.

Miscellaneous publications or online releases

DuBois, S.M. and Smith, A.W., 1980, The 1887 Earthquake in San Bernardino Valley, Sonora: Historic accounts and intensity patterns in Arizona. Arizona Bureau of Geology and Mineral Technology, Special Paper #3, 108 p.

Gootee, B.F., 2014, The Redwall Limestone - The fascinating history and character of Grand Canyon's thickest limestone. A Powerpoint presentation, Grand Canyon Guide Training Seminar 8 February 2014, 27 slides.

Tenney, J.B. c. 1927, History of Mining in Arizona, v.1 & v. 2. Arizona Bureau of Mines, 600 p.

Open-File Reports

Allison, M.L. and Richard, S.M., 2013, State Geological Survey Contributions to the National Geothermal Data System: Accomplishments for Federal Fiscal Year 2012, October 1, 2011 to September 30, 2012. Arizona Geological Survey Open File Report, OFR-13-11, 38 p.

Clark, R.C., Day, J. and Richard, S.M., 2014, The AZGS geologic map toolbar for creating geologic map data using the NCGMP09 database and ESRI ArcMap. Arizona Geological Survey Open File Report, OFR-13-13, 18 p.

Cook, J.P., 2013, Revisiting earth fissures near Luke Air Force Base, central Maricopa County, Arizona. Arizona Geological Survey Open File Report, OFR-13-15, 10 p.

Spencer, J.E., 2013, A review of late Cenozoic volcanic activity in the Gila Bend – Buckeye area of western Maricopa County, Arizona. Arizona Geological Survey Open-File Report, OFR-13-07, 32 p.

Rauzi, S.L. and Spencer, J.E., 2013, Potential targets for shale-oil and shale-gas exploration in Arizona. Arizona Geological Survey Open File Report, OFR-13-09 v. 1, 9 p.

Gootee, B.F., 2013, An Evaluation of Carbon Dioxide Sequestration Potential in the Luke Basin, South-Central

Arizona. Arizona Geological Survey Open File Report, OFR-13-05, 10 p., 2 map plates and 2 appendices.
Gootee, B.F., 2013, An Evaluation of Carbon Dioxide Sequestration Potential in the Higley Basin, South-Central Arizona. Arizona Geological Survey Open File Report, OFR-13-10, 14 p., 6 map plates and 2 appendices.
Palmer, R., 2014, Setting up Hyper-V 2012 Replication on Workgroup Servers: A Guide. Arizona Geological Survey Open File Report, OFR-14-04, 27 p.
Rauzi, S.L. and Spencer, J.E., 2013, A Brief Overview of the Cretaceous Mancos Shale in Northeastern Arizona and its Hydrocarbon Potential. Arizona Geological Survey Open-File Report, OFR-13-08, 8 p.
Rauzi, S. L. and Spencer J.E., 2014, An evaluation of carbon dioxide sequestration potential of the Permian Cedar Mesa Sandstone, northeastern Arizona. Arizona Geological Survey Open File Report, OFR-14-03, 22 p.

Special Paper #9

Proceedings of the 48th Annual Forum on the Geology of Industrial Minerals, Phoenix, Arizona, April 30 - May 4, 2012

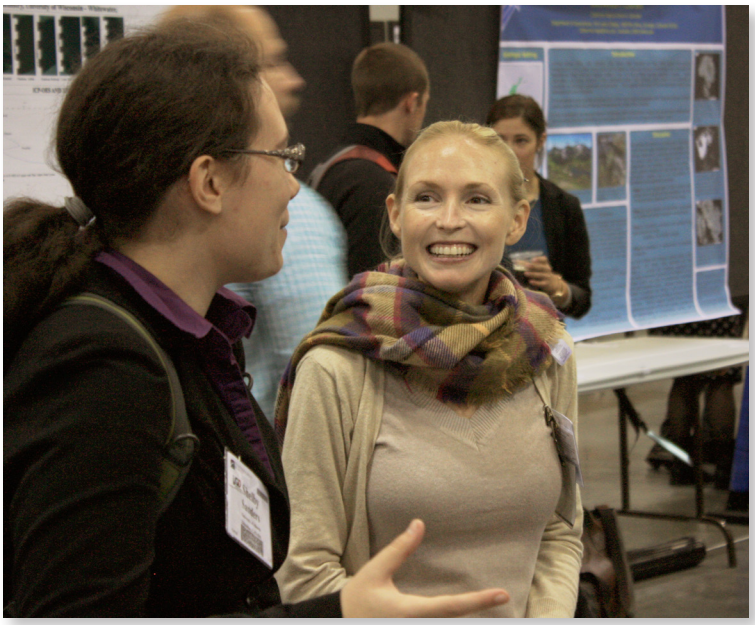
Crouse, D.L, and Embree, P., 2014, Pinite in Nevada, and why it might be of interest, in, Conway, F.M., ed., Proceedings of the 48th Annual Forum on the Geology of Industrial Minerals, Phoenix, Arizona, April 30 - May 4, 2012. Arizona Geological Survey Special Paper #9, Chapter 5, p. 1-8.
Davis, J.G., 2014, St. Peter Sandstone Mineral Resource Evaluation, Missouri, USA, in, Conway, F.M., ed., Proceedings of the 48th Annual Forum on the Geology of Industrial Minerals, Phoenix, Arizona, April 30 - May 4, 2012. Arizona Geological Survey Special Paper #9, Chapter 6, p. 1-7.
Murray, K., Dixon, J., Meier, L., Dennis, M. and Schieffer, J., 2014, Industrial Minerals on Arizona State Trust Land, in, Conway, F.M., ed., Proceedings of the 48th Annual Forum on the Geology of Industrial Minerals, Phoenix, Arizona, April 30 - May 4, 2012. Arizona Geological Survey Special Paper #9, Chapter 7, p. 1-9.
Cocker, M.D., 2014, Lateritic, supergene rare earth element (REE) deposits, in, Conway, F.M., ed., Proceedings of the 48th Annual Forum on the Geology of Industrial Minerals, Phoenix, Arizona, April 30 - May 4, 2012. Arizona Geological Survey Special Paper #9, Chapter 4, p. 1-18.
McLemore, V.T., Rare Earth Elements Deposits in New Mexico, 2014, in Conway, F.M., ed., Proceedings of the 48th Annual Forum on the Geology of Industrial Minerals, Phoenix, Arizona, April 30 - May 4, 2012. Arizona Geological Survey Special Paper #9, Chapter 3, p. 1-16.
Kyle, J.R. and McBride, E.F., 2014, Geology of the Voca Frac Sand District, western Llano Uplift, Texas, in, Conway, F.M., ed., Proceedings of the 48th Annual Forum on the Geology of Industrial Minerals, Phoenix, Arizona, April 30 - May 4, 2012. Arizona Geological Survey Special Paper #9, Chapter 2, p. 1-13.

External Publications

Allison, M. Lee, Chickering, C., Patten, K., Anderson, A., & Richard, S.M. 2013. Sustaining the National Geothermal Data System: Considerations for a System-Wide Approach and Node Maintenance, Geothermal Resources Council Transactions, Geothermal Resources Council Annual Meeting, Las Vegas, NV, October 2, 2013.
Allison, M.L. and K.A. Lehnert, 2013, Digital geosciences: a framework for data-intensive, multi-disciplinary research and education, Geological Society of America's 125th Anniversary Annual Meeting & Exposition, Denver, Colorado, October 28, 2013.
Allison, M.L., G. Pearthree, and K. Patten, 2013, An agile approach to development of cyberinfrastructure governance, Geological Society of America's 125th Anniversary Annual Meeting & Exposition, Denver, Colorado, October 28, 2013.
Anderson, Arlene, Blackwell, D., Chickering, C., Boyd, T., Horne, R., MacKenzie, M., Moore, J., Nickull, D., Richard, S.M., & Shevenell, L. 2013. National Geothermal Data System (NGDS) Geothermal Data: Community Requirements and Information Engineering, Geothermal Resources Council Transactions, Geothermal Resources Council Annual Meeting, Las Vegas, NV, October 2, 2013.
Arizona Geological Survey, 2013, Arizona geology: a session on all aspects of arizona geology convened to commemorate the 125th anniversary of the Arizona Geological Survey (Posters) Geological Society of America's 125th Anniversary Annual Meeting & Exposition, Denver, Colorado, October 28, 2013.
Boyd, Suzanne, Zheng, S., Patten, K., & Blackman, H. 2013. NGDS User Centered Design: Meeting the Needs of the Community, Geothermal Resources Council Transactions, Geothermal Resources Council Annual Meeting, Las Vegas, NV, October 2, 2013.
Claiborne, L. L., McDowell, S. M., Miller, C. F., Lang, N. P., and Ferguson, C. A., Cribb, J. W., and Covey, A., 2014, prelude to a supervolcano: REU investigations in the Miocene volcanic field of the southern Black Mountains: Geological Society of America abstracts with programs, v. 46, no. 6, p. 825.
Clark, Ryan C. and Stephen M. Richard, "US Geoscience Information Network: Data Integration Framework." Geological Society of America Abstracts with Programs, v. 43, n. 5, p.631.
Conway, F.M., M.L. Allison, J. Matti and R. Palmer, 2013, Using an online TV station and video abstracts for community engagement, Geological Society of America's 125th

Anniversary Annual Meeting & Exposition,
Ferguson, C.A., and K.A. Howard, 2013, Early Miocene Silver Creek caldera as a strain marker in the Colorado River Extensional Corridor, USA, Geological Society of America's 125th Anniversary Annual Meeting & Exposition, Denver, Colorado, October 28, 2013.
Gootee, B., J.J. Young, P.A. Pearthree, and C.A. Ferguson, 2013,Detailed mapping of the southern terminus of the Big and Little Chino Fault Zones, north-central Arizona, Geological Society of America's 125th Anniversary Annual Meeting & Exposition, Denver, Colorado, October 28, 2013.
Gurney, R. and M.L. Allison, 2013, Towards a global e-infrastructure and data management plan, Geological Society of America's 125th Anniversary Annual Meeting & Exposition, Denver, Colorado, October 28, 2013.
House, K., P.A. Pearthree and M.E. Kirk, 2013, The evolution of thought on the evolution of LOCO [the lower Colorado River]: All agree that water was involved, Geological Society of America's 125th Anniversary Annual Meeting & Exposition, Denver, Colorado, October 28, 2013.
McDowell, S.M., Miller, C.F., Mundil R., Ferguson, C.A., Wooden, J.L., 2014, Zircon evidence for a ~200 k.y. supereruption-related thermal flare up in the Miocene Black Mountains, western Arizona, USA. Contrib. Mineral. & Petrol., v. 168, p. 1031.
Patten, Kimberly, Allison, M.L., Richard, S.M., Blackman, H., & Anderson, A.. 2013. National Geothermal Data System: An Exemplar of Open Access to Data, Geological Society of America Abstracts with Programs, Vol. 45, No. 7, p. 648, 2013.
Pearthree, P. and P.K. House, 2013, Insights into the origin and development of the Lower Colorado River from the latest Miocene-early Pliocene deposits and paleogeomorphology of Cottonwood and Mohave Valleys, Geological Society of America's 125th Anniversary Annual Meeting & Exposition, Denver, Colorado, October 28, 2013.
Pratt, R. D., Claiborne, L. L., Miller, C. F., and Ferguson, C. A., 2014, Investigation of a pre-supereruption ignimbrite, petrology of the Miocene Cook Canyon Tuff, Black Mountains, Arizona: Geological Society of America abstracts with programs, v. 46, no. 6, p. 511.
Spencer, J.E., 2013, Quaternary low-angle normal faulting, Geological Society of America's 125th Anniversary Annual Meeting & Exposition, Denver, Colorado, October 28, 2013.
Spencer, J.E., P.J. Patchett, J.A. Roskowski, and D.L. Dettman, 2013, Isotopic evidence for a Lacustrine origin for the Pliocene Bouse Formation in the Lower Colorado River Valley, Geological Society of America's 125th Anniversary Annual Meeting & Exposition, Denver, Colorado, October 28, 2013.
Spencer, J. E. and D. Love, 2013, Folding in the Upper Plate of the Buckskin-Rawhide Detachment Fault, southwestern Artillery Mountains, western Arizona (poster), Geological Society of America's 125th Anniversary Annual Meeting & Exposition,
Wenrich, K.J. and J.E. Spencer, 2013, Uranium and rare earth element (REE) resources in northern Arizona breccia-pipe ore bodies, Geological Society of America's 125th Anniversary Annual Meeting & Exposition, Denver, Colorado, October 28, 2013.

Presentations & Outreach Events



Professional conferences, exhibits and public presentations are unequaled opportunities for AZGS staff to share with the broader community our products, programs and aspirations. Each year we engage in dozens of outreach opportunities to keep our stakeholders abreast of our accomplishments and challenges.

Professional Presentations
AZGS Staff & Associates

Allison, M.L., and E. Zanzerkia, "Seeking consensus for cyberinfrastructure governance in the USA," European Geophysical Union General Assembly, Vienna, Austria, April 30, 2014.

Allison, M.L., S. Richard, H. Blackman, A. Anderson and K. Patten, "National Geothermal Data System (USA): an Exemplar of Open Access to Data," European Geophysical Union General Assembly, Vienna, Austria, April 29, 2014.

Allison, M.L., 2014, Arizona Mining Update, Mining Appreciation Celebration, Tucson, AZ, February 14, 2014.

Allison, M.L. and J. Day, 2013, A Coordinated and Centralized GIS Database Model for Arizona, AGIC 2013 Education & Training Symposium, Prescott, Arizona, September 25, 2013.

Allison, M.L. and K.A. Lehnert, Advocates, GSA Geoinformatics Division, 2013, Digital geosciences: a framework for data-intensive, multi-disciplinary research and education, GSA 2013 Conference, Denver, Colorado, October 29, 2013.

Allison, M.L., G. Pearthree, and K. Patten, 2013, An agile approach to development of cyberinfrastructure governance, technical session Digital Geosciences: A Framework for Data-Intensive, Multi-Disciplinary Research and Education, GSA 2013 Conference, Denver, Colorado, October 29, 2013.

Allison, M.L., I. Zaslavsky, E. Law, E. Robinson, 2013, Collaborative frameworks and experiences in earth and space science (poster), American Geophysical Union Fall Meeting, San Francisco, CA, December 10, 2013.

Allison, M.L., D. Arctur, K. Lehnert, E. Robinson, 2013, Emerging concepts for cyberinfrastructure in the geosciences I and II, American Geophysical Union Fall Meeting, San Francisco, CA, December 12, 2013.

Allison, M.L., S.M. Richard, H. Blackman, A. Anderson, 2013, National Geothermal Data System: an exemplar of open access to data (poster), American Geophysical Union Fall Meeting, San Francisco, CA, December 12, 2013.

Black, R., 2014, EarthCube test enterprise governance: collaborative approaches to building community-led cyberinfrastructure for the geosciences, Research Data Access Preservation Summit, Lightning Talks session, San Diego, CA, March 26, 2014.

Brown, C., Niemuth, N., 2014, Digitizing, Cataloging and Exposing Arizona Historical Mine Records on the Web, Arizona Historic Preservation Conference, Rio Rico, AZ, June 11–13, 2014.

Conway, F.M., M.L. Allison, J. Matti, and R. Palmer, 2013, Using an online TV station and video abstracts for community engagement, in the technical session 125 Years of Geoscientific Leadership, at the GSA 2013 Conference, Denver, Colorado, October 29, 2013.

Conway, F.M., Update to WSSPC on earthquake activity in Arizona, 2013 – 2014, Denver, CO, May 22, 2014.

Diggs, S. and M.L. Allison, "EarthCube: Advancing Partnerships, Collaborative Platforms and Knowledge Networks in the Ocean Sciences," European Geophysical Union General Assembly, Vienna, Austria, April 29, 2014.

Ferguson, C. A., and R. Waldrip, 2013, Detrital zircon analysis identifies recycled eureka clasts in the powder rim gravel (late Miocene) of southern Wyoming, GSA 2013 Conference, Denver, Colorado, October 29, 2013.

Ferguson, C. A., and K.A. Howard, 2013, Early Miocene Silver Creek caldera as a strain marker in the Colorado River Extensional Corridor, USA, in the technical session Arizona Geology: A Session on All Aspects of Arizona Geology Convened to Commemorate the 125th Anniversary of the Arizona Geological Survey (Posters), at the GSA 2013 Conference, Denver, Colorado, October 29, 2013.

Gootee, B.F., J.J. Young, P.A. Pearthree, and C.A. Ferguson, 2013, Detailed mapping of the southern terminus of the Big and Little Chino Fault Zones, north-central Arizona, GSA 2013 Conference, Denver, Colorado, October 29, 2013.

Gootee, B.F., "The Redwall Limestone, Inside and Out: The fascinating history and character of the Canyon's greatest hiking impediment." 2014 Guide Training Seminar Agenda, at the Community Building, Grand Canyon National Park, February 8, 2014.

Gurney, R., M.L. Allison, R. Cesar, R. Cossu, B. Gemeinholzer, F. Genova, T. Koike, M. Latif, M. Mokrane, D. Peters, A. Treloar, J. Vilotte, C. Waldmann, "Towards global environment information and data management," European Geophysical Union General Assembly, Vienna, Austria, April 30, 2014.

Gurney, R. and M.L. Allison, 2013, "Towards a Global e-infrastructure and Data Management Plan", GSA 2013 Conference, Denver, Colorado, October 29, 2013.

House, K., P.A. Pearthree, and M.E. Kirk, 2013, The evolution of thought on the evolution of LOCO [the lower Colorado River]: All agree that water was involved, GSA 2013 Conference, Denver, Colorado, October 28, 2013.

Lehnert, K., M.L. Allison, D. Arctur, J. Klump, C. Lenhardt, "Geosamples.org: Shared Cyberinfrastructure for Geosciene Samples," European Geophysical Union General Assembly, Vienna, Austria, April 29, 2014.

Patten, K., M.L. Allison, S.M. Richard, H. Blackman, and A. Anderson, 2013, National Geothermal Data System: an exemplar of open access to data, GSA 2013 Conference, Denver, Colorado, October 29, 2013.

Pearthree, G.M., M L. Allison, K. Patten, 2013, Development of EarthCube Governance: An Agile Approach, American Geophysical Union Fall Meeting, San Francisco, CA, December 12, 2013.

Pearthree, P. and P.K. House, 2013, Insights into the origin and development of the Lower Colorado River from the latest Miocene-early Pliocene deposits and paleogeomorphology of Cottonwood and Mohave Valleys, GSA 2013 Conference, Denver, Colorado, October 28, 2013.

Spencer, J.E., 2013, Quaternary low-angle normal faulting, GSA 2013 Conference, Denver, Colorado, October 27, 2013.

Richard, S.M., Geoscience Terminology Work Group (GTWG), 2013, Geoscience terminology for data interchange: the CGI Geoscience Terminology Work Group, (Invited), American Geophysical Union Fall Meeting, San Francisco, CA, December 13, 2013.

Spencer, J.E., 2013, Low-angle normal faulting and the state of stress in extensional wedges, University of Michigan Department of Earth and Environmental Sciences, Ann Arbor, Michigan, October 11, 2013.

Spencer, J.E., 2013, The Pliocene Bouse Formation and initiation of the modern Colorado River, University of Michigan Department of Earth and Environmental Sciences, Ann Arbor, Michigan, October 11, 2013.

Spencer, J.E., chair, CRevolution 2: Cenozoic landscape evolution of the Colorado Plateau–Rocky Mountain Region and the carving of Grand Canyon I (Sponsored by Arizona Geological Survey, U.S. Geological Survey, GSA Structural Geology and Tectonics Division, GSA Geophysics Division, GSA Quaternary Geology and Geomorphology Division, and Grand Canyon National Park), GSA 2013 Conference, Denver, Colorado, October 28, 2013.

Spencer, J.E., P.J. Patchett, J.A. Roskowski, and D.L. Dettman, 2013, Isotopic evidence for a lacustrine origin for the Pliocene Bouse Formation in the Lower Colorado River Valley, GSA 2013 Conference, Denver, Colorado, October 28, 2013.

Spencer, J.E., chair, Arizona geology: A session on all aspects of Arizona geology convened to commemorate the 125th anniversary of the Arizona Geological Survey (posters), sponsored by GSA Environmental and Engineering Geology Division, at the GSA 2013 Conference, Denver, Colorado, October 29, 2013.

Spencer, J. E. and D. Love, 2013, Folding in the upper plate of the Buckskin-Rawhide Detachment Fault, southwestern Artillery Mountains, western Arizona, at the technical session Arizona Geology: A Session on All Aspects of Arizona Geology Convened to Commemorate the 125th Anniversary of the Arizona Geological Survey (posters), at the GSA 2013 Conference, Denver, Colorado, October 29, 2013.

Wenrich, K. J. and J.E. Spencer, 2013, Uranium and rare earth element (REE) resources in northern Arizona breccia-pipe ore bodies, technical session Arizona Geology: A Session on All Aspects of Arizona Geology Convened to Commemorate the 125th Anniversary of the Arizona Geological Survey, GSA 2013 Conference, Denver, Colorado, October 29, 2013.

Young, J., 2013, The Arizona Earthquake Catalog, Seismic Source Characterization Workshop for Palo Verde Nuclear Generating Station, Litchfield Park, Arizona, September 25, 2013.

Conference Booths

National Geothermal Data System Exhibit booth, AAPG Annual Convention, Houston, Texas, April 6–8, 2014.

National Geothermal Data System exhibit booth, Stanford Geothermal Workshop, Stanford, California, February 24–26, 2014.

Earthcube Exhibit, American Meteorological Society Annual Meeting, Atlanta, GA, February 3–7, 2014.

Geologic Maps of Arizona exhibit, Geological Society of America Wall of Maps, GSA 2013 Conference, Denver, Colorado, October 27–29, 2013.

National Geothermal Data System exhibit booth, in conjunction with the Association of American State Geologists, GSA 2013 Conference, Denver, Colorado, October 27–29, 2013.

EarthCube exhibit booth, in conjunction with the Geological Society of America Geoinformatics, GSA 2013 Conference, Denver, Colorado, October 27–29, 2013.

EarthCube exhibit booth, American Geophysical Union Fall Meeting, (attendance 22,000), San Francisco, California, December 9–13, 2013.

National Geothermal Data System exhibit booth, American Geophysical Union Fall Meeting, (attendance 22,000), San Francisco, California, December 9–13, 2013.

Workshops

AZGS staff, GeoSciML Meeting," Tucson, AZ, June 29–July3, 2014.
AZGS staff, "EarthCube All Hands Meeting," Washington, DC, June 24–26, 2014.
AZGS Staff, "Belmont Forum e-Infrastructure & Data Management Town Hall Meeting'" Vienna, Austria, April 29, 2014.
AZGS staff, "EarthCube Assembly Advisory Council Synthesis Workshop," Tucson, AZ, April 16–18, 2014.
AZGS staff, "EarthCube End User Workshop," Washington, DC, March 18–20, 2014.
AZGS staff, "EarthCube Portfolio Workshop," Boulder, CO, February 12–14, 2014.
Allison, M.L., & AZGS Staff, co-chair, "Belmont Forum e-Infrastructure & Data Management Steering Committee Meeting", Vienna, Austria, April 26–27, 2014.
Allison, M.L., & AZGS Staff, co-chair, "Belmont Forum e-Infrastructure & Data Management Secretariat Meeting", Vienna, Austria, April 25, 2014.
Allison, M.L., K.J. Patten, G.M. Pearthree, R.C. Black, and A.M. Katz, facilitated an EarthCube Test Enterprise Governance Project Team Meeting, Arlington, Virginia, January 15–17, 2014.
Allison, M.L., K.J. Patten, G.M. Pearthree, R.C. Black, A.M. Katz, and K. Kretschmann facilitated an EarthCube Test Enterprise Governance Project Team Meeting, co-located at the GSA 2013 Conference, Denver, Colorado, October 25, 2013.
EarthCube Town Hall Meeting, American Geophysical Union Fall Meeting, 9–11 am, Westin San Francisco Market Street Banquet Room, San Francisco, California, December 11, 2013.
Belmont Forum e-Infrastructure Town Hall Meeting, American Geophysical Union Fall Meeting, 3–5 pm, Westin San Francisco Market Street Banquet Room, San Francisco, California, December 11, 2013.

Outreach

Public Presentations

Allison, M.L., 2013, The Havasu Canyon Floods, Central Arizona Geology Club, Prescott, Arizona, November 12, 2013.
AZGS, Children's Museum Tucson, Science Sunday with Arizona rocks and minerals, Tucson, Arizona, July 28, 2013.
Conway, F.M., 2013, Earth fissures of Cochise County, Southwest Wings Birding and Nature Festival, Cochise College, Sierra Vista, Arizona, August 3, 2013.
Conway, M., 2013, Earth fissure in Maricopa and Pinal Counties, Phoenix Realtors, Phoenix, AZ, 30 October 2013.
Conway, F.M., 2013, Geology of the Tucson Basin and Environs, Colossal Cave Mountain Park, Vail, Arizona, November 3, 2013.
Conway, M., 2014, Geology of Arizona & the Arizona Experience—a vehicle for educators and students: Pima Public Library, Safford, AZ. Tuesday, Jan. 28, 2014.
Conway, M., 2014, Volcanism in Southwestern U.S., Sahuaro High School, Tucson, Arizona, 11–2pm, March 7 2014.

Public Exhibits

The Arizona Experience staffed a booth at the Tucson Festival of Book at the University of Arizona, Tucson, AZ, March15-16, 2014.
The Arizona Experience staffed a booth at the Tucson Gem and Mineral Show, Tucson, AZ February 13-16, 2014.
The Arizona Experience staffed a booth the 9th annual Certified Local Fall Festival, Phoenix, Arizona, November 9, 2013.
The Arizona Experience Store staffed a booth at the Tucson Meet Yourself festival, Tucson, Arizona, October 11–13, 2013.

News Media (Print/Radio)

6/30/14 "Social media rumbles after quake" *Arizona Daily Star*
6/29/14 "Eastern Arizona rocked by magnitude 5.2 earthquake", *Ledger: Building Community Connections in STV & QC*, http://sevledger.com/pages
6/9/14 "Earth fissure viewer for Arizona on Google Earth, WryHeat column. https://wryheat.wordpress.com/author/wryheat2/page/7/
6/3/14 "National Geothermal Data System—Free Online Access to America's Digital Geothermal Resources" USA Oil and Gas Monitor, http://usaoilandgasmonitor.com
6/10/14 "Access and use of Data Lead to Innovative Ways to Reduce Energy Consumption, Officials Say" NEWS Eos, Vol.95, No.23, 10 June 2014
6/2/14 "FACT SHEET: Harnessing the Power of Data for a Clean, Secure, and Reliable Energy Future" the WHITE HOUSE, http://www.whitehouse.gov/thepress-office/2014/05/28
5/30/14 "The 2014 Energy Datapalooza focused of the Green Button standard, an EPA proposal to limit carbon emissions, the National Geothermal Data System, privacy concerns about data disclosures, and more" Open energy makes significant progress with Green Button standard, http://www.techrepublic.com
5/29/14 "Energistics Publishes the Energy Industry Profile

(EIP) Standard" The Energy Standards Resource Centre
5/29/14 "Energy Department Launches the National Geothermal Data System to Accelerate Geothermal Energy Development" Energy.gov
5/28/14 "Energy Department Announces National Geothermal data systems to accelerate geothermal energy development" Office of Energy Efficiency & Renewable Energy, http://energy.gov
5/6/14 "Museum that celebrated state's mining, geologic past mourned" *Tucson Sentinel*
5/5/14 "Years later, not much to show for state Mining and Mineral Museum's closure", *Cronkite News*, http://cronkitenewsonline.com
5/2/14 "Arizona Geological Survey Mining Collections", Wry Heat Blog
3/27/14 "Lack of rain lessens Arizona's potential for landslides" KTAR, http://ktar.com
3/24/14 "Though far short of Texas, Arizona does have oil" *Arizona Daily Star*
2/20/14 "Exploratory wells to be drilled in valley" *The Bisbee Observer*
2/14/14 Jon Spencer, telephone interview with Kyle Dickman, *Outdoor Magazine*, regarding geology of the Prescott area and Mogollon Rim.
2/3/14 "AZ lawmaker wants to reopen Mining and Mineral Museum" Arizona Daily Star
1/27/14 "An experimental virtual tour through the Grand Canyon" The Voice of Tucson /Tucson Citizen.com, http://tucsoncitizen.com
6/30/14 "Tucson's biggest quake 1000 times stronger than Saturday's" http://www.kvoa.com/news/tucson-s-biggest-quake
06/30/14: Eastern Arizona rocked by magnitude 5.2 earthquake (*White Mountain Independent*)

Great Arizona ShakeOut Media Print/Radio/TV/Web-based

Involving Michael Conway, Jeri Young or Phil Pearthree

10/17/13: Valley students take part in earthquake safety drill (*My Fox Phoenix*)
10/17/13: ShakeOut in Ahwatukee: Schools across Ariz. participate in natural disaster drills (*Ahwatukee Foothills News*)
10/17/13: Valley students take part in earthquake safety drill (*My Fox Phoenix*)
10/16/13: Great Arizona ShakeOut on Oct 17 at 10:17 a.m. (*Arizona Range News*)
10/15/13: 'Great Arizona Shakeout' earthquake preparedness drill scheduled for Thursday participate in (*Pendleton Times-Post*)
10/15/13: Earthquake drill: Arizona to participate in quake drill Thursday (*ABC15.com*)
10/15/13: Arizona to participate in quake drill Thursday (*Your West Valley News*)
10/15/13: Over 80,000 School Children Expected To Participate In Ariz. Quake Drill (*CBS Las Vegas*)
10/15/13: Arizona to participate in quake drill Thursday (*Azdailysun.com*)
10/15/13: Groups across Arizona to participate in earthquake-preparedness exercise (*AZCentral.com*)
10/15/13: Groups across Arizona to participate in earthquake-preparedness exercise (*AZCentral.com*)
10/15/13: Over 80,000 School Children Expected To Participate In Ariz. Quake Drill (*CBS* Las Vegas)
10/15/13: Arizona to participate in quake drill Thursday (CBS 5 AZ KPHO)
10/15/13: Earthquake drill: Arizona to participate in quake drill Thursday (*ABC15.com*)
10/15/13: Arizona to participate in quake drill Thursday (*Tucson News Now*)
10/14/13: Great Arizona ShakeOut—Oct 17 @ 10:17 a.m. (Arizona Range News)
10/14/13: 'Great Arizona Shakeout' earthquake preparedness drill, The Arizona Republic
10/14/13: Ready for the ShakeOut? (*ASU News*)
10/14/13: Great Arizona Shake Out this Thursday (*MyRadioPlace.com*)
10/14/13: Great Arizona ShakeOut—Oct 17 @ 10:17 a.m. (*Arizona Range News*)
10/14/13: Arizona, are you ready for the ShakeOut? (*ASU News*)
10/09/13: NAU joins statewide drill to test emergency notification system (*NAU News*)
09/23/13: Emergency Kit Cook-Off: A Recipe for Preparedness (*Emergency Management*)
09/17/13: Earthquake drills—why not take part in the Great ShakeOut? (*Industrial Fire Journal—Fire & Rescue*)
09/17/13: Great Arizona ShakeOut to raise earthquake awareness (*White Mountain Independent*)

News Media (TV)

Lee Alison interviewed on KOLD News (Tucson channel 13)/KMSB Fox (Tucson channel 11) regarding the 5.2 magnitude earthquake near Duncan Arizona, for broadcast, June 29, 2014.
Lee Alison interviewed on KGUN9 (Tucson channel 9) regarding the 5.2 magnitude earthquake near Duncan Arizona, for broadcast, June 29, 2014.
Lee Alison interviewed on Fox10 (Phoenix channel 10) regarding the 5.2 magnitude earthquake near Duncan Arizona, for broadcast, June 29, 2014.
Lee Alison interviewed on KVOA News (Tucson channel 4) regarding the 5.2 magnitude earthquake near Duncan

Arizona, for broadcast, June 29, 2014.

Jon Spencer was interviewed on KUAT's Arizona Illustrated Nature, "Volcanic Features of Arizona" for broadcast, February 3, 2014.

Jon Spencer was interviewed on KUAT's Arizona Illustrated Science, "Arizona Landscape- geologically young have formed in past 30–40 Ma years" for broadcast, February 4, 2014.

Phil Pearthree and Jon Spencer were interviewed on KUAT's Arizona Illustrated Science, "The Origin of the Colorado River" for broadcast, February 10, 2014.

Michael Conway & Joseph P. Cook were interviewed on KUAT's Arizona Illustrated Science, "Natural Hazards in Arizona" for broadcast/cable channels, September 24, 2013.

Michael Conway was interviewed on KAET's News Broadcast, ShakeOut in Arizona, Oct. 16, 2013.

Field Trips

Nyal Niemuth led a field trip for the Association of Lighting and Mercury Recyclers, Historic mine sites and cinnabar mineralization of the Phoenix Mountains, Phoenix, Arizona, December 3, 2013.

Jon Spencer led two-day field trip to areas of alteration and mineralization in the northern Plomosa and western Buckskin Mountains for a University of Arizona group and a BLM geologist, Jan. 11–12, 2014.

Jon Spencer led one-day field trip to northern Plomosa Mountains for a USGS group for discussion on compiling and publishing a geologic map of the eastern half of the Blythe 30' x 60' Quadrangle, Feb. 22, 2014.

Jon Spencer led one-day field trip along the Catalina Highway north of Tucson for AIPG Arizona Section Spring 2014 Field Trip. 'Core complex geology along the Catalina Highway', April 12, 2014.

Informal Communication Outlets

The Arizona Geological Survey exploits a number of informal outlets—social media,videos and websites—for communicating with our stakeholders. In FY 2014, we continued to produce the Arizona Mining Review (AMR), an e-video magazine with regular news and updates on the state of mining in Arizona.

Social Media

Social Media & Websites

AZGS maintains an assemblage of websites and social media outlets for informing stakeholders of our research and outreach efforts.

Arizona Experience
ArizonaExperience.org
facebook.com/AZExperience
youtube.com/user/ArizonaExperience

Arizona Geological Survey
AZGS.AZ.gov
AZGeology.azgs.az.gov
facebook.com/AZ.Geological.Survey
repository.AZGS.AZ.gov
store.AZGS.AZ.gov
twitter.com/AZGeology
youtube.com/user/azgsweb

Arizona Mineral Education
AZMineralEducation.org

Belmont Forum e-Infrastructure & Data Management Cooperative Research Agreement
BFE-Inf.org

EarthCube
EarthCube.org
workspace.EarthCube.org
facebook.com/NSFearthcube
twitter.com/EarthCube
youtube.com/EarthCubeNSF
earthcube.webex.com
github.com/EarthCube

National Geothermal Data System
GeothermalData.org
StateGeothermalData.org
Data.GeothermalDataSystem.org
facebook.com/NationalGeothermalDataSystem
twitter.com/geothermaldata

U.S. Geosciences Information Network
USGIN.org
tech.USGIN.org
repository.USGIN.org
github.com/usgin

Social Media—An outreach vehicle to our Arizona Stakeholders

First launched in 2007, the Arizona Geology Blog by AZGS Director Lee Allison is fast approaching 4,000 posts. Featured topics range broadly, from showcasing the latest earth fissure map of Cochise County, to the 'ups and downs' of Arizona's copper mining industry, to the newest science discoveries from ASU, NAU and the UA. Each year, Dr. Allison's blog entries garner 100,000s of views, providing an opportunity to profile Arizona's geologic setting to people across the U.S. and the world.

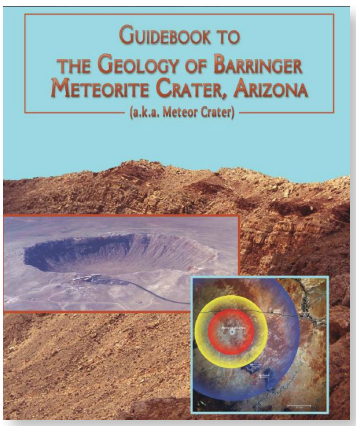
The Arizona Mining Review (AMR) e-Video Magazine is released on the final Wednesday of each month. AZGS Director Lee Allison interviews experts from mining, academia and federal and state agencies regarding economic mineralogy, new mining techniques, new geologic interpretations of mining districts, environmental concerns, the status of individual mines, abandoned mines, mineral education, and more.

Arizona Mining Review

On the set with Jordan Matti, Arizona Mining Review (AMR) videographer, and Dr. Lee Allison, the host of AMR.

AMR shows are available online at the AZGS Youtube channel (youtube.com/user/azgsweb).

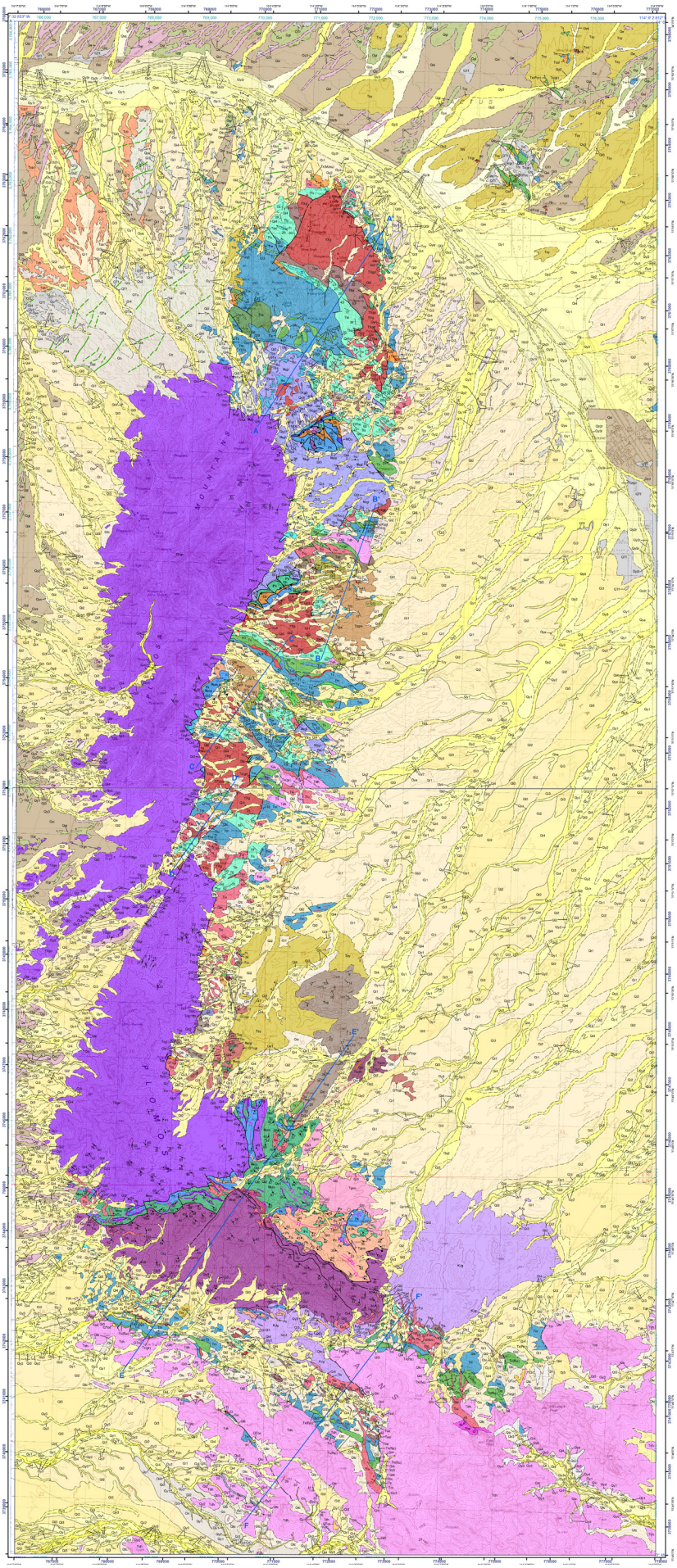
And join the more than 3,300 people, news media outlets, institutions and state and federal agencies that follow us on Facebook. Each day we post the latest information on Arizona geology, geologic hazards, mining and environment. Most days, more than 1,000 people view our posts. During the Duncan earthquake swarm of June-July 2014, more than 125,000 people viewed our regular updates noting the where, when and magnitude of aftershocks that shook eastern Arizona.



Showcasing the Guidebook to the Geology of Barringer Meteorite Crater at AZGS Facebook page.

In the past 3 years, we have posted more than 8,700 tweets and picked up 2,700 followers. Roughly two-thirds of our twitter posts are original, the remainder are reposts of information circulated by the U.S. Geological Survey, other state surveys or Arizona state agencies, Geology.com, and dozens of other Earth science aficionados.

Examples of AZGS tweets.



About the Cover: Geologic map of the Bouse and Ibex Peak 7 ½ minute quadrangles, La Paz County, Arizona (DGM-107), 2014, by Jon Spencer, Ann Youberg, Diane S. Love, Phil Pearthree, Ted Steinke, and Steve Reynolds. Available online at http://repository.azgs.az.gov/uri_gin/azgs/dlio/1586.

Digital Geologic Maps

In 2000, the Arizona Geological Survey initiated the Digital Geological Map (DGM) Series. The series comprises colorful, digital maps printed on demand using a large format printer at the Arizona Geological Survey. Digitized PDF copies are available as free downloads at the AZGS Online Document Repository [http://repository.azgs.az.gov].

Unlike traditionally prepared maps, which are built on paper or Mylar, digital geologic maps exist in a digital GIS (geographic information system) framework, assuring ease of revision as new geologic information becomes available.

Structure symbols

- bedding, inclined
- bedding, inclined, approximate
- bedding, horizontal
- apparent dip of bedding
- bedding, inclined, transposed
- tectonic foliation, parallel to bedding
- tectonic foliation
- gneissic layering
- joint
- mylonitic foliation
- mylonitic foliation and lineation
- mylonitic foliation and lineation with normal sense-of-shear
- mylonite foliation, recrystallized
- mylonitic lineation without foliation
- eutaxitic foliation
- flow banding
- dip of fault

Contacts, faults, and geomorphic features

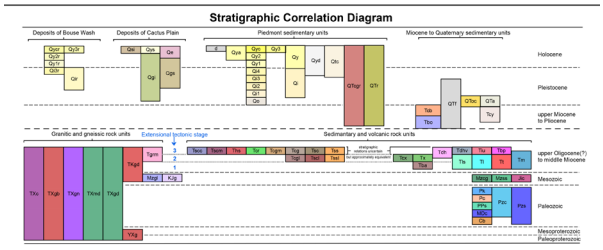
- contact, accurate
- contact, approximate
- contact, inferred
- fault, accurate
- fault, approximate
- fault, concealed
- detachment fault, accurate
- detachment fault, concealed
- low-angle fault, accurate
- low-angle fault, approximate
- thrust fault, accurate
- thrust fault, concealed
- shear zone
- linear geomorphic feature of uncertain origin
- linear geomorphic feature of uncertain origin, approximately located

Veins and marker beds

- marker bed
- tuff
- barite vein
- manganese-oxide vein
- conglomerate in Mesozoic metasedimentary rocks
- calcite vein

Folds

- overturned anticline, accurate
- overturned syncline, accurate



Annual Report 2014; 416 W. Congress St., Suite 100 • Tucson,Arizona 85701-1381 • azgs.az.gov