

# 2013

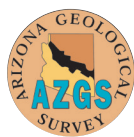
# ANNUAL REPORT

## ARIZONA GEOLOGICAL SURVEY



Balancing rocks, Tuba City, Arizona

National Archives /Terry Eiler



Open File Report OFR-14-01



Havasupai Falls, Havasupai Reservation

Janel Day

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## Arizona Geological Survey

**M. Lee Allison, State Geologist and Director**

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For information on the mission, objectives or geologic products of the Arizona Geological Survey visit [www.azgs.az.gov](http://www.azgs.az.gov).

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# DIRECTOR'S VISION



## Celebrating 125 Years of Geological Services

Lee Allison  
Director & State Geologist

The Arizona Geological Survey celebrated its 125th anniversary in 2013, tracing our origins back to the creation of the Office of Territorial Geologist in 1888, 25 years before Arizona became a state. Over this time we underwent a number of transformations, moving into the University of Arizona in 1893, where we served under a variety of names but for the longest period as the Arizona Bureau of Mines. For the last 25 years we have been an independent agency reporting directly to the Governor, one of only two state geological surveys in the nation in that position.

My colleague Priscilla Grew, when she was State Geologist of Minnesota, was asked by a state legislator when her organization would be finished carrying out its geologic survey of the state. She famously replied, "When you're finished legislating."

During 125 years, our mission has grown and evolved, in response to changing needs of our society and environment. When Arizona became a state in 1912, more than 40% of the residents were involved in mining, and we focused on basic geologic mapping and identification and assessment of mineral resources. We continue to carry out those tasks, and more work still needs to be done. Arizona is consistently the number 1 or 2 non-fuel mineral producing state in the country, yet only about one-quarter of the geology of the state is mapped at a scale of 1:24,000 or better. Of course, AZGS continues to play a prominent role with Arizona's natural resources and natural hazards. We are deeply involved in natural hazards assessment and mitigation, groundwater

geology, environmental geology, and the rapidly growing specialty area of geoinformatics, or geoscience cyberinfrastructure.

In this, our 125th anniversary year, we are celebrating the efforts of hundreds of geologists and geoscientists to understand Arizona's remarkable geology and apply that knowledge to making our lives safer and richer. All told, AZGS and its predecessor agencies have published more than 1,000 geologic products

(maps, reports, assessments, etc). As we continue to respond to new demands and take advantage of new technologies, we are taking the lead in creating new products and establishing new communication pathways to serve Arizona. All of our publications are now digital and put online as soon as they are released. A lot of our work is communicated to our constituents through electronic and social media, including blogs, Facebook, YouTube, Twitter and a new

online video magazine, "Arizona Mining Review."

Over the past year, AZGS has continued to grow due to our success in bringing in external funds to support and underwrite our work on state issues. This allowed us, as one example, to continue operations of the Arizona Broadband Seismic Network, the first statewide earthquake monitoring system, without any direct state or federal support.

AZGS has maintained services and expanded into new areas during the economic recession by creative, entrepreneurial, and aggressive pursuit of new funding opportunities. In FY13,



# DIRECTOR'S VISION

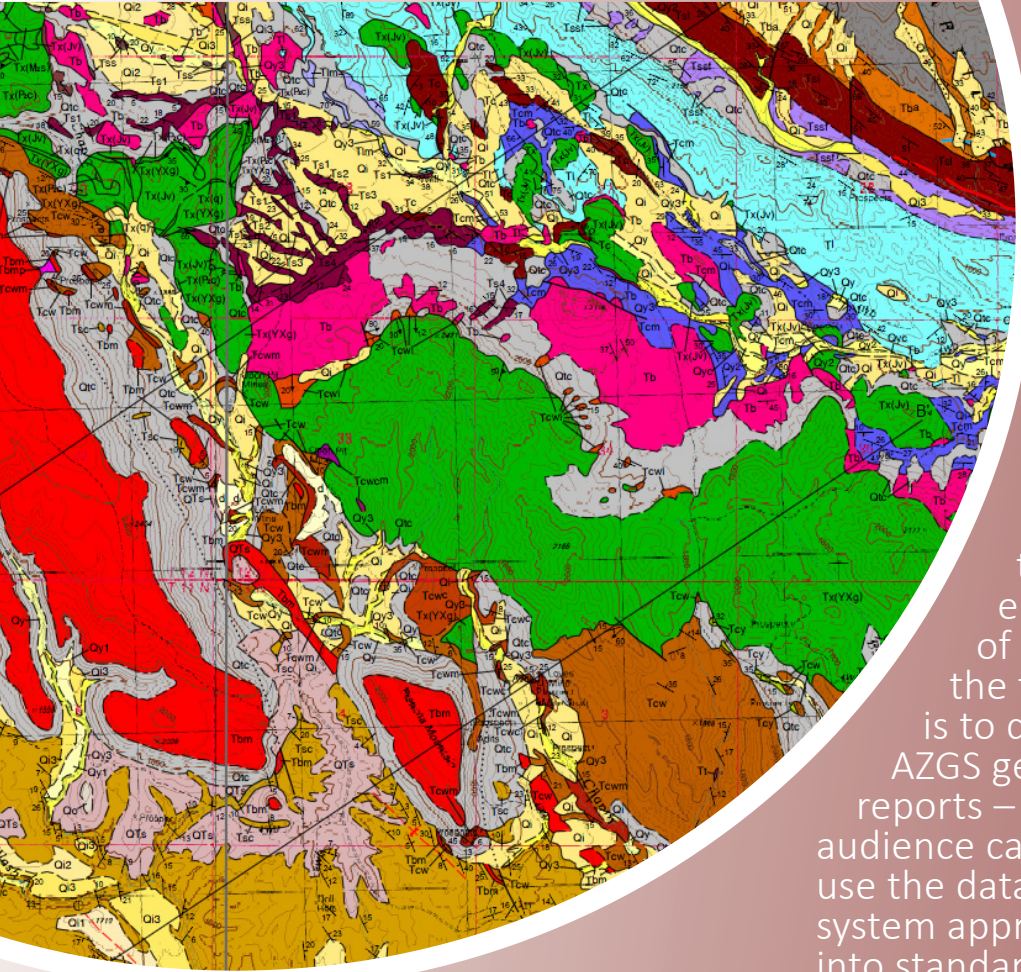
AZGS raised over 90% of its total budget from grants, contracts, and cooperative agreements, mostly from federal sources, and almost entirely through competitive solicitations. We started FY13 with about three-quarters of the annual budget revenues in place and raised sufficient funds during the year to meet all obligations.

We start FY14 with funding in place or committed to fully fund the Survey for the full year. We continue to be successful in moving from a primarily state-funded to a grant-funded mode of operation. One of our challenges is to maintain this level of fund-raising to help us meet Arizona's continually growing and evolving needs.

M. Lee Allison, Director & State Geologist

## Some notable accomplishments of 2013 :

- Nearly 1,000 AZGS publications placed in an online document repository for free downloading, encompassing almost all AZGS documents dating from 1915 to present ([repository.azgs.az.gov](http://repository.azgs.az.gov))
- Mapping of new earth fissures in Cochise County and updating existing maps throughout Arizona, all available online in an interactive map viewer (<http://services.azgs.az.gov/OnlineMaps/EarthFissureViewer/>)
- Issuance of 33 drilling permits for the Arizona Oil & Gas Conservation Commission, primarily for potash exploration core holes in the Holbrook basin (<http://services.azgs.az.gov/OnlineMaps/holbrookPotash/>)
- Successful deployment of the \$22 million National Geothermal Data System project, with 965 data sets representing over 5.6 million data points posted from over 60 data providers in all 50 states, and hundreds more datasets under review, a large number of standardized web services enabled, and over 100 geologic and gravity web map services online
- Completion of the initial inventory of over 800,000 documents, 10,000 maps, and 7,500 historical photos from the collections of the Arizona Dept. of Mines & Mineral Resources, acquired through its merger with AZGS
- Took a leadership role in organizing the national geoscience cyberinfrastructure under the National Science Foundation's EarthCube program



## GEOINFORMATICS

The Arizona Geological Survey's Geoinformatics team comprises six 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 control how they view or use the data. This interoperable data system approach, which packages data into standardized interchange formats 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.

“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.” —Steve Richard.

# GEOINFORMATICS

## Geoscience Information for the 21st Century



**Steve Richard**  
Chief, Geoinformatics

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. Now anyone can access these maps and other documents as Adobe Acrobat (.pdf) files from our online repository at <http://repository.azgs.az.gov>.

*The end result is easy access to and more control over high quality data that can facilitate decision making and help solve problems in the geosciences.*

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. The end result is easy access to and more control over high quality data that can facilitate decision making and help solve problems in the geosciences.

Geoinformatics expertise at the AZGS has been instrumental in obtaining several major contracts. The survey is managing 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 will provide access to an exhaustive 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. Several other projects are engaging AZGS geoinformatics specialists in developing technology for web access to geoscience information. 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.

# GEOINFORMATICS

## Online, Interoperable Data



**Ryan Clark**  
Lead Developer

I work on web development and online data distribution at the Arizona Geological Survey. AZGS does exciting work in these fields because of our national collaborations with other state and federal agencies to bring more and more geologic data online in an interoperable way.

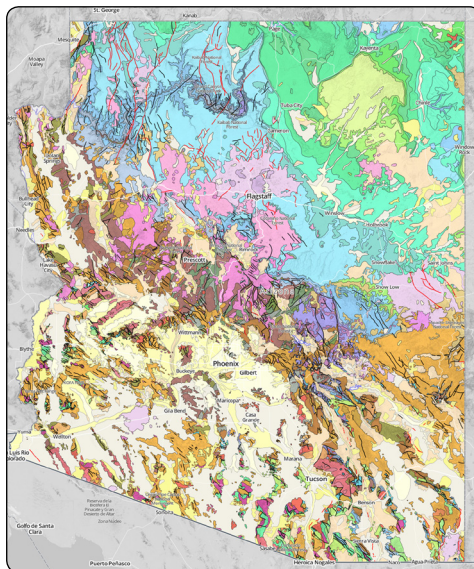
Most of my time is spent working on the National Geothermal Data System (NGDS), cataloging datasets and resources from across the country. To assist in that effort, I've developed a customized, online data repository that is currently being used across all 50 states. This repository (<http://repository.stategeothermaldata.org/>) gives people a place to host geothermal datasets and create standard metadata for those datasets.

The repository is just one branch in the tree that is the NGDS. To aggregate the data from all those branches and provide a way to search across all of them, we've been working closely with partners at Siemens Corporation to develop software on a platform called CKAN (<http://CKAN.org>). CKAN has already been embraced by numerous data-sharing entities, including the White House's <http://data.gov>. By developing on this platform, we're ensuring that the NGDS will integrate seamlessly with other systems.

I also keep my ear to the ground listening for new, often disruptive technologies that make data sharing easier, faster, and more efficient. A couple of months ago a web site called GitHub introduced the ability to look at a particular sort of geospatial data file called GeoJSON. GitHub is a popular web site for storing, sharing and collaboratively editing source code for

software, but now, instead of seeing the GeoJSON files as structured text, you see an interactive map that you can pan, zoom and click. This was followed by spreadsheet-like visualization of .CSV files. The open data community exploded with discussions everywhere about "Git for Data." By offering truly

transparent data on a platform that many developers are familiar with, GitHub is opening doors to new kinds of data collaboration. If software developers make cool things using AZGS data and enjoy the process, we become more popular and relevant to the modern technologic and geoscientific landscapes, while increasing the utility of our data. With that in mind, I've been experimenting with the GitHub platform as a way to distribute AZGS data (<https://github.com/azgs/geologic-map-of-arizona>).



Online version of the Geologic Map of Arizona  
(<http://data.azgs.az.gov/geologic-map-of-arizona/>)

In the meantime, I have done a lot of work on trying to find ways to make online geologic maps quick, responsive, and fun to use. With the advent and subsequent explosion of applications like Google Maps, the way that we think about maps is fundamentally changed, and traditional geologic maps have been left in the dust. Maps have become something that the general public can interact with smoothly and without a lot of prior knowledge about an area. I'm working to move geologic maps into that same space by experimenting with ways to make the map perform faster (<http://azgs.github.io/geologic-map-of-arizona/map.html>), making geologic map data fit into smaller packages (<http://bl.ocks.org/rclark/5779893>), and building tools to create geologic maps in a web browser (<http://rclark.github.io/make-polys/>).



# GEOINFORMATICS

## Geographic Information Systems (GIS)



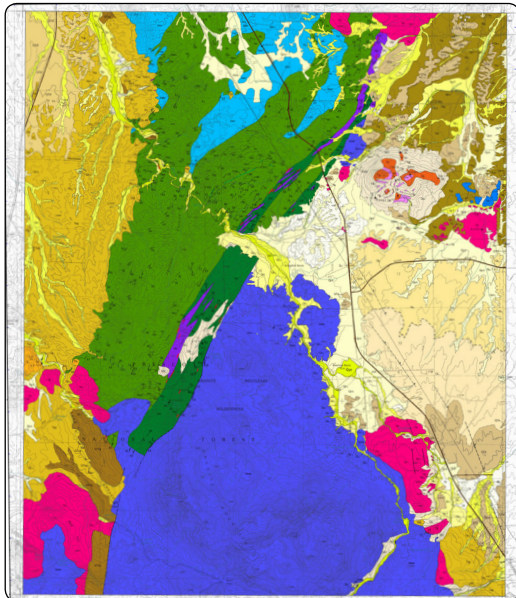
**Janel Day**  
GIS Manager

I approach my work creating maps like a director would approach a new production. I research my subject extensively and try different approaches. The producer is GIS, or geographic information systems. The audience is the map reader. The map is the show: stage, set, and cast.

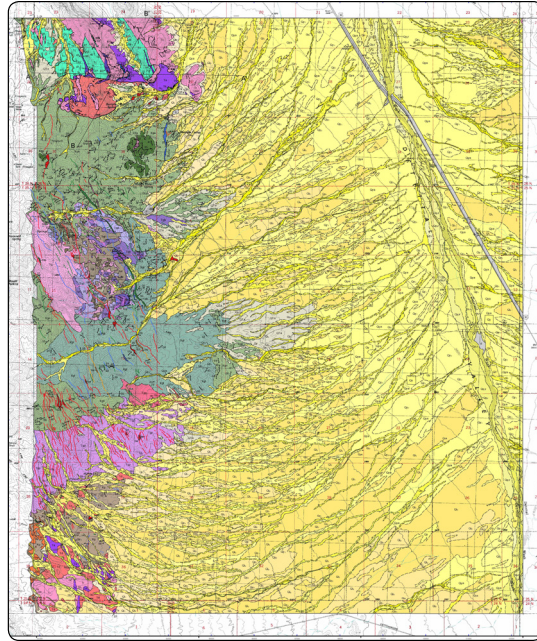
Whether it is designed for geology or recreation, the end goal of a map is the same, to communicate with the audience. My role is to weave a story by connecting the audience to the subject.

I research my subject using the internet, talk to experts, and consult with other sources that enrich my knowledge of my subject. I then go into the 'field' to get my own experience interacting with the subject. It's in the field where the map audience becomes important. I attempt to 'capture' the human experience of the subject.

I synthesize all of the information I've collected and think about map reader expectations. Expectations differ between paper maps and web-based maps, but the design concept is the same: develop a map



Digital Geologic Map series, published in FY2013: Jerome Canyon



Digital Geologic Map series, published in FY2013: Middle Water Spring

that is easy for the reader to understand. In the case of geology, for example, the map must include the appropriate 'supporting' information, like topography, for context.

GIS helps bring all of the information together, and facilitates map making, with programs to build and manage maps. At the Arizona Geological Survey, maps are an integral part of almost every program. AZGS has published hundreds of maps during its history. For FY2013, the Arizona Geological Survey published 6 maps for its Digital Geologic Map (DGM) Publication Series. An additional 12 maps were compiled and drafted during this same time period and will be released in FY2014 and FY2015.

### Interactive Map Services

AZGS provides a number of online and interactive map resources focusing on geology, mineral resources and natural hazards. All online maps can be linked to from the AZGS Online Map Services webpage, located at [http://azgs.az.gov/map\\_services.shtml](http://azgs.az.gov/map_services.shtml).

# GEOINFORMATICS



## Building the Arizona Natural Hazards Viewer for a Safer Arizona

Adrian Sonnenschein  
GIS Specialist

Natural hazards pose a serious threat to residents in the state of Arizona. Geologists at the Arizona Geological Survey (AZGS), and scientists from other organizations, have long compiled data regarding natural hazards in Arizona, but those data exist in esoteric formats on private servers. To promote public awareness and to mitigate the threat of natural hazards, the AZGS has developed an online viewer, Natural Hazards in Arizona (<http://data.azgs.az.gov/hazard-viewer>), using geographic information system (GIS) technology that serves hazards-related data in your browser window.

The natural hazard viewer will empower people to explore statewide and local hazards in a common map environment. Users will choose from five hazard map layers – earth fissures, earthquakes and faults, floods, and wildfires. Each hazard will be accompanied by descriptive text outlining the nature of the hazard and its historic impact on Arizona. The “Find Local Hazards” search tools will allow individuals to enter their home or business address to perform a proximity analysis of hazards within a 3-mile search radius. A pop-up window then identifies nearby natural hazards and provides information and online resources for mitigating risks. We will include a print utility for manufacturing a customized map to a PDF or a letter size sheet of paper.

Data of each hazard layer will be available for download through the viewer interface. Available data formats will range from Excel

spreadsheet, to GeoTIFF, to ESRI shapefile; the latter requires GIS software for scrutinizing. You will be able to choose to download the hazard data en masse or individually. For those interested in local data only, the bounding box search will allow for an areal selection of a subset of the data.

We are using open-source standards to construct the viewer, thus assuring sustainability and low-cost upkeep. Moreover, updating current data or adding new hazards data layers

as they become available will be accomplished with minimal effort. Source code for AZGS’ Natural Hazards in Arizona viewer will be published under a Creative Commons license and hosted on GitHub.com for the world to see. Anyone can then implement and/or expand the

system we engineered at the AZGS.

The most effective means of mitigating a natural disaster is prior awareness coupled with planning to protect you, your family and property. The Natural Hazards in Arizona viewer serves to promote awareness and understanding of natural disasters in a format that bridges a gap between the geo-scientific community and the public. A personal computer and internet access are the only tools needed to begin reducing the risk of natural disasters in your area.

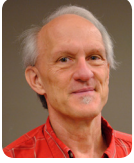
\*Editor’s note. The Natural Hazards in Arizona viewer launched on 24 September 2013.



Natural Hazards in Arizona viewer (<http://data.azgs.az.gov/hazard-viewer/>)

# GEOINFORMATICS

## US Geoscience Information Network



**Steve Richard & Ryan Clark**  
Chief, Geoinformatics & Lead Developer



Map-based information [geospatial data] is crucial to energy and mineral resource development, transportation, environmental monitoring, public safety, and emergency planning to name a few applications. However, much of this data is contained in documents, images, and datasets with no structure and few common points of reference, stored by individual agencies each with their own cataloging and data management systems. Dissimilar vocabularies and software inhibit concurrent searches across individual repositories. A data seeker must perform multiple queries and transform the data into common format before information can be extracted and used for analysis.

In response to increasing demand for geospatial geoscientific data, representatives of the Association of American State Geologists (AASG) and the U.S. Geological Survey (USGS) met in Denver in 2007 to discuss opportunities for making geoscience data more accessible by taking advantage of the emerging information sharing and communication capabilities emerging with the World Wide Web. The US Geoscience Information Network (USGIN) is an outgrowth of the recommendation from this group that the USGS and state geological surveys work together to create a distributed, national “Geological Information Network” (GIN) of digital Earth Science data using common standards and protocols. This network represents a rethinking of how geological surveys make geoscience information available to the public to adapt to the changing landscape of public data delivery. Instead of demanding adoption of one system of data management, the network provides a framework to allow a wide variety of

data management systems to interact with each other.

The Arizona Geological Survey has been actively engaged in testing and deploying a dynamic infrastructure for this network. It consists of the protocols, interchange formats, conventions, and workflows that package data so they become visible within the system. USGIN infrastructure includes 1) tools for registration of new resources, searching the metadata catalog, authentication, and resource validation; 2) registries for vocabularies, agents, specifications, schema, and information exchange protocols; and 3) documentation of methods and educational resources.



Both data consumers and data providers use this infrastructure for data delivery. Any provider can serve data by adhering to these protocols. This ability allows an agency to retain control over how data is served, viewed, and accessed. Elements of this framework are based in open-source software platforms whenever possible, ensuring free access and participation by all who want to use the system.

USGIN represents an exciting step forward in data management and information technology. The system can be extended to accommodate virtually any area of geospatially referenced technical information. The USGIN blueprint has been used in the development of the National Geothermal Data System, and is an important input in the development of the Arizona Natural Resource Council (NRRC) data system, the NSF Earth Cube, as well as for meeting the new Federal open data mandate.

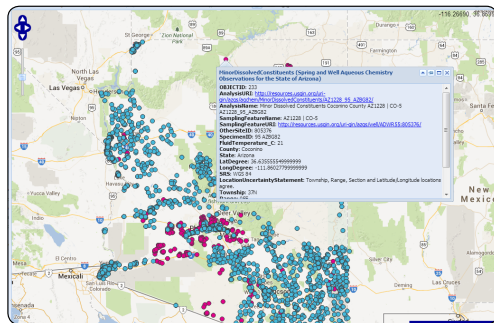
# GEOINFORMATICS



## Bridging the Gap Between Researchers and Resource Developers

Christy Caudill Daugherty  
Geoinformatics Content Specialist

Data are perhaps the most important and expensive products of exploration activities and geologic research. They are the evidence used to make evaluations regarding scientific theory and potentially lucrative resource development projects. The geosciences are amassing extensive data collections from disparate sources that encompass multiple disciplines and research areas. New approaches to managing and providing access to these collections are expanding the community of people who can use these data, increasing their value, and helping to solve geoscience problems. Careful data management yields numerous benefits, including saving time and increasing efficiency in the scientific process and in land-management decisions, preserving reliability and authenticity of the data, helping to prevent costly duplication of effort by enabling data sharing, and ensuring that data are compatible with industry practices.



Geothermal data for Arizona accessed through the National Geothermal Data System

The current AZGS project managing such a large data collection effort is the National Geothermal Data System (NGDS, funded by the US Department of Energy), which preserves legacy and current geologic data for the entire nation through a collaboration with 45 state geological surveys and institutions. As the prime contractor on the project, the AZGS geoinformatics team is tasked with ensuring that the data compiled through this initiative are managed using a vision much more expansive than the old mentality of a centralized database with a single point of access. We are instead creating a distributed

catalog, where data providers enter, process, and manage their own data, making it an open community endeavor. Already, the project catalog includes over 5 million data points and over 18,000 publications.

Key data are integrated into the NGDS system through conformance to an 'interchange format,' making them interoperable and available on multiple software platforms. This interoperability not only allows software developers to create applications for using the data based on the cyber infrastructure, but researchers to expose their data to a free and vast network of sub-surface data repositories. For data consumers, this means making the most efficient use of their time by presenting concise and relevant data in tables with predictable fields, measurement units, and definitions. The goal is to bridge the gaps between researchers, data repositories, and potential resource developers.

As a geoinformatic content specialist, I facilitate the data integration process through sophisticated data management, creating automation and developing new techniques to process data more efficiently and with greater efficacy. My position here at AZGS fits my personal and professional goals of getting science information to the people. Work on this geothermal data project has developed into an exciting mix of innovation, technology, and collaboration. Embracing the zeitgeist of 'free and open-source', our geoinformatics team has created multiple open-source automations (data processing code that exploits software like Excel and ArcMap), established our own internal workflow websites, and even developed open-source applications for the end user to discover the data (as shown in the graphic). These applications allow potential resource developers to access and easily 'mash-up' research data. The data management approaches and innovations developed for this project are translatable to other projects and disciplines, and are now being assessed for use in the recent Open Data Initiatives issued by the White House.

## National Geothermal Data System: An Exemplar of Open Data

Kim Patten  
Project Manager



The Arizona Geological Survey is currently managing the State Geological Survey Contributions to the National Geothermal Data System (NGDS) for the Association of American State Geologists (AASG). This project, funded by the U.S. Department of Energy's Geothermal Technology Office, digitizes, preserves, and digitally deploys geothermally relevant data with the goal of reducing risk in geothermal exploration nationwide; by providing greater quantities of data, exploration risk is minimized due to more informed decision making. For almost three years now I have had the pleasure of working with the State Geological Surveys from across the country to complete this work. I cannot express my gratitude enough to each of the Surveys for making my job such a rewarding experience.

This year, the project garnered a Top 12 Geothermal Finds of 2012 (ranking #7 on the list), and a feature in *Scientific American*. Data associated with more than 1 million wells across the nation has been collected and is digitally available, with this number expected to double in the next year. For the third year in a row, the project has received "good" or "outstanding" review comments during the annual Department of Energy's Geothermal Technologies Office peer review.

Data is now flowing in from all fifty states, including new data from eighteen states (field work), and new drill projects in Idaho, Nevada, Oregon, Utah, Washington, and Wisconsin. The Utah Geological Survey's new geothermal gradient wells in

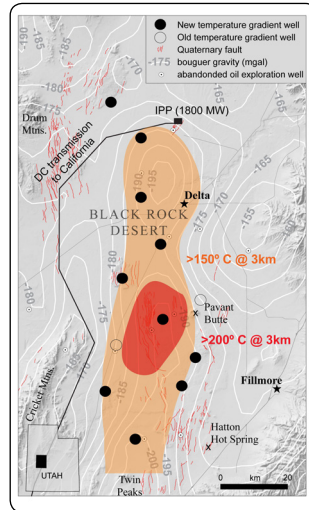
the Black Rock Desert helped confirm a potential sedimentary geothermal field, making this one of the year's Top 12 Geothermal Finds. In Hawaii, the data collection and digitization efforts have

led to new interest in geothermal development on the islands – a significant step towards reducing the islands' consumption of oil for energy production. Similar trends are appearing throughout the country, from increased questions on the applicability of ground source heat pumps, to direct use applications, to new hydrothermal and enhanced geothermal production.

In February of 2013, the White House Office of Science and Technology Policy released a memorandum to the heads of federal agencies calling for increased public access to data gathered in federally funded scientific studies.

Following this memo, in May of 2013 an Executive Order, "Making Open and Machine Readable the New Default for Government Information," and a subsequent Office of Management and Budget memo on implementing the Open Data Policy were released. The policies call for making federally funded data available on open source distributions, with metadata management, scalability, and interoperability. The NGDS, and its underlying platform, the U.S. Geoscience Information Network, embody this directive and has the potential to be a blueprint for large-scale sharing of geoscience data.

We look forward to promoting the NGDS as an exemplar of the policy in the next fiscal year.



Map indicating the new temperature gradient well's drilled by the Utah Geological Survey



The National Geothermal Data System is featured in *Scientific American*, May 2013.

### EarthCube: Transforming Geosciences Research for the 21st Century



**Genevieve Pearthree**  
Lead Project Coordinator

In 2008, MIT's Earth Systems Initiative team of 25 researchers generated 200 terabytes of data exploring marine microbial communities as part of the Darwin Project. They estimated that by 2013 their annual output could reach 20 petabytes (one petabyte can store the DNA information of the entire US population, cloning it twice). That's 2 x10<sup>15</sup> (one quadrillion) bytes from just one research group. The Earth science communities are



generating oceans of data requiring a new paradigm for efficaciously

staging, sharing and communicating information. The National Science Foundation's EarthCube – a community-driven model for managing, sharing, and exploring data- might just be the solution.

EarthCube is an exciting cyberinfrastructure initiative spearheaded by the National Science Foundation (NSF) to facilitate collaborative and interdisciplinary scientific research while addressing information management and geoscience challenges of the 21st century. NSF goals for EarthCube are to transform the conduct of geosciences research by developing community-guided cyberinfrastructure for knowledge management across disciplines. The result: a system that integrates geosciences data and information in an open, transparent and inclusive manner.

The Arizona Geological Survey (AZGS) has contributed to the development of EarthCube since the initiative was first launched in July 2011. The AZGS EarthCube Governance Team, consisting of AZGS Director Lee Allison, Kim Patten (Associate Director for Planning and Development) and I have

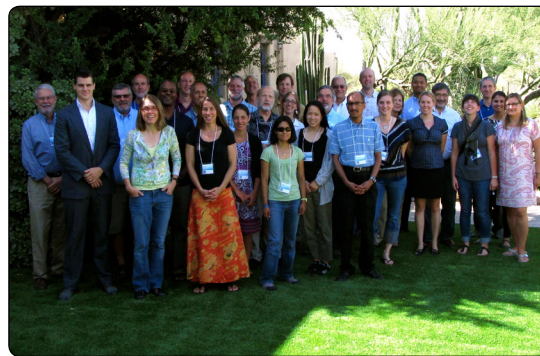
led EarthCube governance and community building activities since March 2012. Dr. Allison is the chair of the EarthCube Governance Working Group and is the lead author of two key governance documents representing milestones in developing a governance framework for EarthCube.

As part of the EarthCube Governance Working Group, my main job is to coordinate the diverse EarthCube stakeholder groups and facilitate stakeholder engagement. I help maintain the EarthCube website ([earthcube.org](http://earthcube.org)), host an EarthCube booth at geosciences conferences, and coordinate the two dozen NSF-funded EarthCube End-User workshops, which help determine what mainstream geoscientists need to better do their science. We also hosted a successful workshop of the End-User Workshops organizers to inform and guide next steps in EarthCube development.

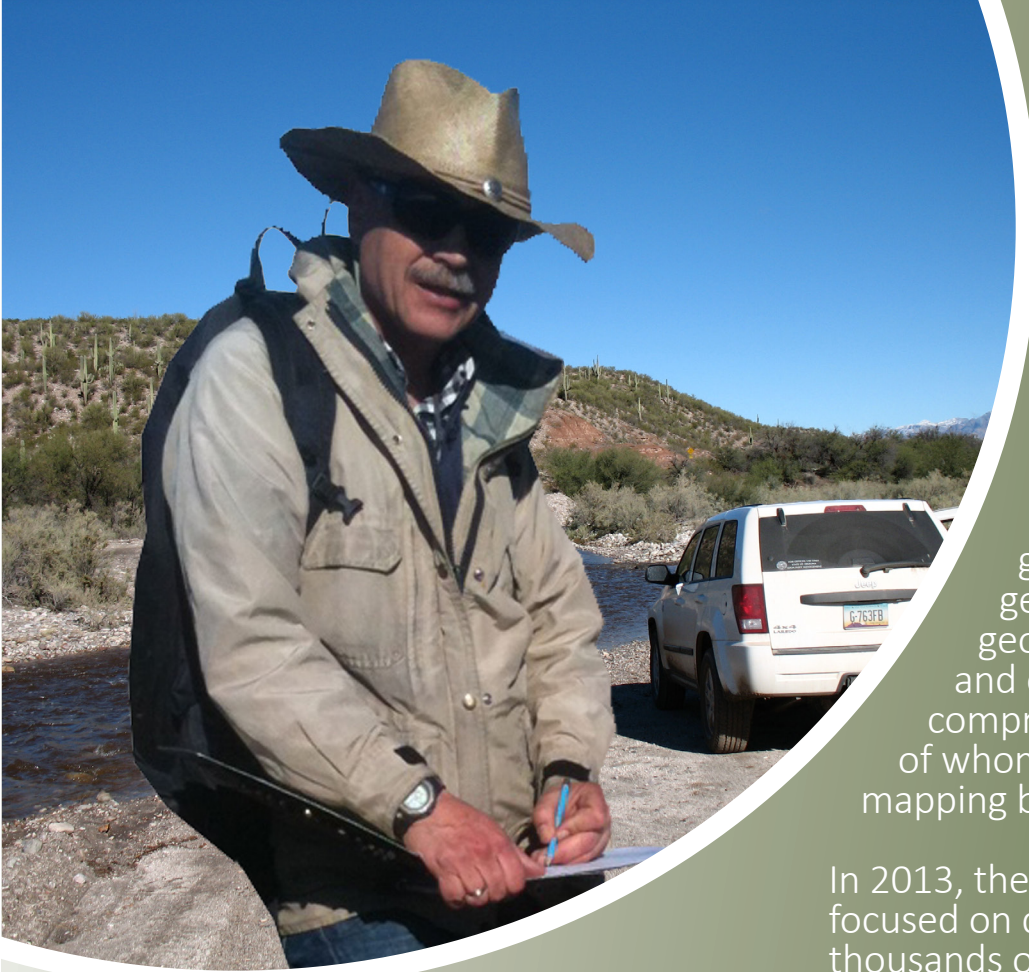
Moving forward, Dr. Allison is the principal investigator of a two-year, \$3 million NSF award to design, build, and test an EarthCube Enterprise Governance system to assure consistent and sustainable management, to implement cohesive policies, and to guide and steer community action.

The award, which began on September 15, 2013, will employ a two-stage process to implement an agile approach to engage diverse geo and cyber science communities to determine an appropriate governing system for EarthCube. The Governance award is also charged with coordinating NSF EarthCube

technical and community-building awards (AZGS Geoinformatics Chief Stephen Richard is part of two technical EarthCube award teams).



EarthCube End-User Principal Investigator Workshop attendees, August 15, 2013, Tucson, AZ. Photo by author.



Long the heart and soul of the Arizona Geological Survey, the geology section encompasses geologic mapping, economic geology, environmental geology, and energy resources. The team comprises ten individuals, most of whom spend considerable time mapping bedrock or surficial geology.

In 2013, the economic geology team focused on digitizing and broadcasting thousands of historic mining reports, maps and photographs. The geologic mapping team published six digital geologic maps and made headway on six more. As noted in Jon Spencer's article to follow, "...most important uses (for geologic maps) are for mineral- and energy-resource exploration and geologic-hazard identification."

## GEOLOGY

As it has for more than two decades, the AZGS provides administrative and staff support for the Arizona Oil and Gas Conservation Commission.

The environmental geology team bears sole responsibility for geologic hazard assessment, including mapping and monitoring earth fissures in south-central Arizona and maintaining the Arizona Broadband Seismic Network to monitor in-state earthquake activity. This year the team added basin analysis and 3-D groundwater flow models to their repertoire to support the Survey's growing role in Arizona hydrogeology research.

Read on!

# GEOLOGY



## Geologic Mapping In Arizona: The Statemap Program

Jon Spencer  
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. Probably their most important uses are for mineral- and energy-resource exploration and geologic-hazard identification. Some maps made over 100 years ago are still in use because nothing better has been done!

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 AZGS received an award of \$206,580 for FY2013, which was matched with \$206,697 in State funds. The AZGS has received \$3.45 million in Federal funds since the STATEMAP program began.

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



Abandoned mine in the northern Plomosa Mountains

academic interests in Arizona geology. During FY2013 the AZGS STATEMAP mapping program was targeted at three map areas recommended by the GMAC, as follows: (1) Arizona enacted a new law in 2011 that requires county planning and zoning commissions to consider maintenance of access to aggregate resources in their comprehensive development plans. Mapping during FY2013 improved the AZGS digital geologic-map database of the Phoenix metropolitan area so that aggregate sources are identified and can be outlined by planning and zoning commissions. (2) New geologic mapping in western La Paz County, near the towns of Parker and Bouse, improved understanding of the structural geology of iron, manganese, copper, and possibly gold deposits associated with the large Plomosa detachment fault. In addition, new maps delineate sand and gravel deposits delivered by the early Colorado River in the Cactus Plain area. (3) New geologic mapping in the southern Bradshaw Mountains, northwest of Lake Pleasant, identified the structural setting and extent of porphyry-copper mineralization around the Sheep Mountain deposit.



## The Peach Spring Tuff & Gold Mineralization in Western Arizona

Charles Ferguson  
Research Geologist



It is not uncommon for important discoveries to be made by scientists who are not looking for what they find. This is what happened in the spring of 2007; while conducting a routine highway survey for the Arizona Department of Transportation along the western foot of the Black Mountains near Oatman, Arizona, I discovered the eastern half of the source volcano of the elusive, 18.9 million year old Peach Springs Tuff. Ever since the Peach Springs Tuff had been identified as the deposit of a single massive volcano by Dick Young in the 1970s, geologists from industry, academia, and the USGS had been searching for its source volcano. After over 30 years, the general consensus was that the volcano must be buried in one of the many wide basins in the Mohave Desert somewhere near the California, Nevada, Arizona triple junction.

The Peach Springs Tuff is the deposit of what is commonly referred to as a supereruption. These are eruptions so large that everything within hundreds of square kilometers of the volcano are obliterated. The Peach Springs Tuff represents the deposit of over 800 cubic kilometers of dense rock equivalent volcanic ash, pumice, and huge blocks of rock cleared out of the throat of the volcano during its eruption (to compare this to something on a human scale, there are over 400 Hoover Dam's worth of concrete in a single cubic kilometer). The Peach Springs Tuff flowed all the way to Barstow, California, over 150 kilometers (100 miles) to the west, and to the east, it flowed as far as Peach Springs, Arizona. It didn't quite make it to Las Vegas, Nevada to the north, but it did flow as far south as Parker, Arizona. The tuff was so hot after it came to rest that it welded; in some places the welding was so intense that the ash and pumice turned into obsidian. In depressions, the deposit attained thicknesses of nearly 200 meters (over 600 feet). The volcano was so large it formed a crater, also known as a caldera, over 20 kilometers (12 miles) wide, and at least 2 kilometers deep (over 1 mile).



The basal 50 meters of the Peach Springs Tuff is exposed in road cuts along I-40 in Kingman, Arizona

As magnificent as the Peach Springs Tuff's eruption was in terms of natural phenomena and as important as finding the caldera serves as a testament to the hard work and thorough nature of the Arizona Geological Survey's scientific mission, the true significance of finding the source caldera is economic. The Peach Springs Tuff's volcano lies in close proximity to the Oatman district, Arizona's largest gold mining district. The Oatman district's gold mines were formed by hot springs like the ones currently active in and around the Yellowstone caldera of Wyoming. The Peach Springs Tuff's source caldera was the heat engine for the hot springs that formed this rich deposit. Continued investigation of the caldera has identified the western half of the volcano, which was ripped apart by tectonic forces of continental extension soon after the supereruption. The other half lies 40 kilometers (25 miles) to the southwest near Eagle Peak in the Sacramento Mountains, California. A pair of magnesite mines in the wall of the caldera near Eagle Peak match smaller magnesite deposits that occur in the wall of the caldera near Oatman. The magnesite was deposited in a highly saline lake that developed in a depression that predated the caldera.

# GEOLOGY



## Geologic Mapping In The Southern Bradshaw Mountains

**Brad Johnson**  
Research Geologist

In FY2013, I spent almost a hundred days doing geologic mapping bedrock geology about 40 miles northwest of Phoenix in the southern Bradshaw Mountains. As part of the STATEMAP mapping program, AZGS Research Geologist Charles Ferguson and I mapped an area the size of a 7 ½' quadrangle (halves of two adjoining quadrangles), centered on the Sheep Mountain porphyry copper deposit. This area is rugged and remote, and almost all bedrock. The geology is dominated by Cenozoic volcanic and sedimentary strata that overlie Precambrian igneous and metamorphic rocks. The porphyry copper deposit has potential to become a mine someday, but probably not at current copper prices. The deposit is mostly buried by younger volcanic and sedimentary rocks, and its extent is poorly known. Our new mapping will hopefully lead to a better understanding of how the deposit has been broken by faulting and tilted, and may contribute to identification of exploration drill targets and better delineation of the deposit.



Looking south from Silver Mountain, near the north-central edge of the map area. Outcrops in the foreground are Precambrian schist. The rugged terrain in the middle ground is Sheep Mountain, which is made up of faulted slices of Miocene volcanic and sedimentary rocks. Lake Pleasant is visible in the left background.



A rare exposure of the contact between weathered Precambrian granodiorite and overlying Miocene sedimentary breccia - crossing this photo from the hammer head to beyond the right edge, parallel to the hammer head. The breccia contains cobbles and boulders that were derived from erosion of the granodiorite, and is more than 1.5 billion years younger than the granodiorite.

### Geology of Energy Resources in Arizona

**Jon Spencer**  
Senior Geologist

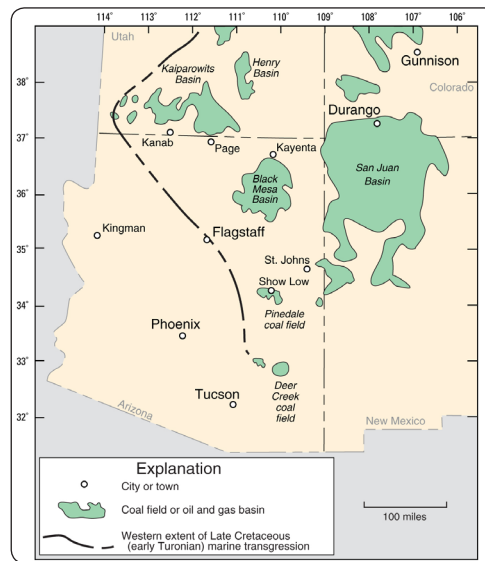


The dependence of modern society on energy resources is a topic of concern for many reasons. Geologists are involved both at the front end where they locate and delineate fossil fuels and uranium, and at the back end where they identify potential geologic disposal sites for spent nuclear fuel and for carbon dioxide produced by coal-, oil-, and gas-fired power plants. In addition, geologists are involved in identifying sources of rare metals important for an increasingly high-tech energy industry, including rare-earth elements for wind turbines and electric-vehicle motors, and other metals such as manganese for more efficient batteries.

New developments in horizontal drilling and hydraulic fracture technology are transforming some marginal shale oil and shale gas deposits into economic oil and gas targets. In the southwestern U.S., the Cretaceous Mancos Shale is part of the sedimentary-rock sequence in both the San Juan Basin of northwestern New Mexico and Black Mesa in northeastern Arizona. It has been the source of much oil and gas in the San Juan Basin, with renewed drilling and hydrofracturing now underway, but has received little attention in Arizona where it underlies the Navajo and Hopi Indian Reservations. In light of this discrepancy, AZGS Oil and Gas Program Administrator Steve Rauzi and I reexamined existing well data and rock-unit descriptions for the Mancos Shale in northern Arizona. We think that it is likely that the Mancos Shale in Arizona will eventually be the target of exploration efforts, especially if the price of oil and gas continue to increase.

The U.S. Department of Energy (DOE) established a national program to evaluate the feasibility of separating carbon dioxide (CO<sub>2</sub>) from industrial sources and pumping it underground for long-term storage or disposal. This program was established in response to concerns that CO<sub>2</sub> emissions, primarily from fossil-fuel combustion, are causing global warming. Carbon dioxide removal from industrial

sources and long-term storage in geologic reservoirs is known as “geologic sequestration.” The AZGS received DOE funding to evaluate the extent and suitability of subsurface geologic formations in Arizona for CO<sub>2</sub> sequestration. This was done under two programs (WESTCARB and RMCCS) that began before FY2013 and will end in FY2014. Results of these investigations indicate that the most suitable targets are on the Colorado Plateau, in upper Paleozoic sandstones beneath the Navajo and Hopi Indian Reservations.



Sedimentary basins in Arizona that are potential targets for oil and gas exploration in Mancos Shale and other Cretaceous sedimentary rocks (from Nations et al., 2000, USGS Professional Paper 1625-B).

During FY2013 I was involved in geologic mapping in western Arizona near the town of Bouse in La Paz County. This area is part of the western Arizona manganese province, which contains the largest manganese deposits known in the US. Current exploration interest in manganese is partly the result of speculation that manganese will be essential for future-generation electric-vehicle batteries. Western Arizona manganese deposits are roughly 10-15 million years old, which makes them very young by geologist’s standards! Most of these black manganese-oxide deposits were precipitated from hot water moving along fault zones. In some cases, hot springs carried manganese oxides out of the ground, across the land, and into lakes, where they made bedded manganese deposits.



## Arizona's Oil and Gas Program Including Potash and CO<sub>2</sub> Sequestration Activity in Fiscal Year 2013

Steven L. Rauzi

Oil and Gas Program Administrator

### Oil and Gas Activity

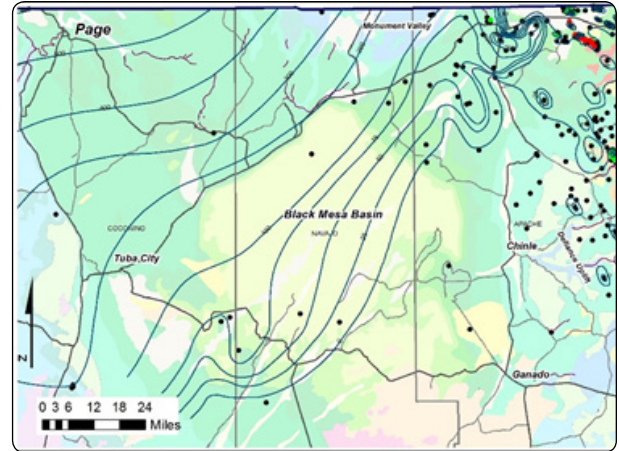
The Arizona Geological Survey (AZGS) provides administrative and staff support for the Arizona Oil and Gas Conservation Commission (AZOGCC). The AZOGCC consists of five members appointed by the Governor and one ex-officio member, the State Land Commissioner. Current Commission members include J. Dale 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. I serve as the administrator. The Oil and Gas Conservation Commission held four regular meetings in FY13. 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](http://www.azogcc.az.gov).

### Regulatory Highlights

Thirty drilling permits were issued and 33 wells were drilled in FY13. Of the wells drilled, 29 were for potash and 4 were for CO<sub>2</sub> 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 51,949 barrels from 21 producing wells in calendar year 2012, up from 36,925 barrels from 9 wells in 2011. Gas production totaled 116.6 million cubic feet from 4 producing gas wells, down from 168 million cubic feet from 5 wells in 2011. No CO<sub>2</sub> was produced in 2012. There were two active disposal wells and nine shut-in wells at yearend including 5 oil, 3 gas and 1 CO<sub>2</sub> well. There were 555,000 acres leased for oil and gas in Arizona as of June 30, 2013, up from the 504,000 acres at yearend 2012.

### CO<sub>2</sub> sequestration activity

The AZGS investigated the CO<sub>2</sub> sequestration potential in northern Arizona through the Rocky Mountain Carbon Capture and Sequestration (RMCCS) partnership. The entire project team



Thickness (isopach) map of Cedar Mesa sandstone in ft.

included the National Energy and Technology Laboratory (NETL) that received Department of Energy (DOE) funding provided by the 2009 American Recovery and Reinvestment Act (ARRA), the University of Utah, the AZGS, the Colorado Geological Survey, the New Mexico Bureau of Geology, the Utah Geological Survey, Schlumberger Carbon Services, Tri-State Generation and Transmission, and Shell Oil Company. The AZGS identified the Permian Cedar Mesa Sandstone as the most promising sequestration target in Arizona. The AZGS mapped the depth and thickness of the Permian Cedar and estimated that the Cedar Mesa has the potential to store (sequester) from 115 million metric tons up to 3.2 billion metric tons of CO<sub>2</sub> with a median capacity of 690 million metric tons. The Cedar Mesa attains its highest storage capacity beneath the Navajo Generating Station near Page, Arizona.

### Hidden Treasures, Fertile Ground

**Nyal Niemuth**

Research Geologist & Chief of Phoenix Branch



Staff of the Economic Geology Section of the Arizona Geological Survey respond to inquiries about mining, mineral resources, and other related requests while digitizing historic records and making that data available online. We curate and distribute information about prospects, discoveries, and mining from records that span more than 130 years.

Inquiries come 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.

Why is this significant? Arizona is one of the top two mineral-producing states in the U.S. In 2012, Arizona produced non-fuel minerals with a value of \$8 billion dollars, accounting for 10.5% of all U.S. mineral production.

Arizona is #1 in copper production! Total output in 2012 was 1.72 billion pounds worth over \$6.25 billion. This is two thirds of the nation's newly mined copper.

In addition to copper, Arizona also produces fuels and other minerals worth over \$2 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.

Using our library and archive of geologic and mineral reports, we assist customers in directing their activities to favorable geologic environments. We are an institutional memory for the State and industry

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.

*Arizona is one of the top two mineral-producing states in the U.S.*

A current example involves the search for the mineral potash. Increasing demand is being driven by a growing world population. Publication of information on the potash potential in Arizona by the Survey, combined with higher commodity prices, resulted in three exploration groups using our 1960s drill records and other data to pursue the development of the Holbrook evaporate basin. If they are successful, Arizona could well become a major source of potash for the world. The potash beds extend over approximately 200 square

miles and are about 1,000 feet deep. An estimated 210 million to 1.75 billion tons of recoverable potash could be worth, at a price of \$460/ton, \$100 to \$800 billion.

The strong minerals environment and the large, prosperous Arizona mining industry unfortunately also attract unscrupulous companies and individuals who attempt to exploit Arizona's reputation for successful, profitable ventures. They often make claims for valuable commodities that are unlikely to exist or tout resources not documented by realistic exploration data. We respond to inquiries from investors and also assist regulators who are seeking information and the knowledge of experts as part of their due diligence and investigations. Investors are protected from unwise investments and securities regulators are assisted with their cases.

### Delivering Archival Mining Assets Online



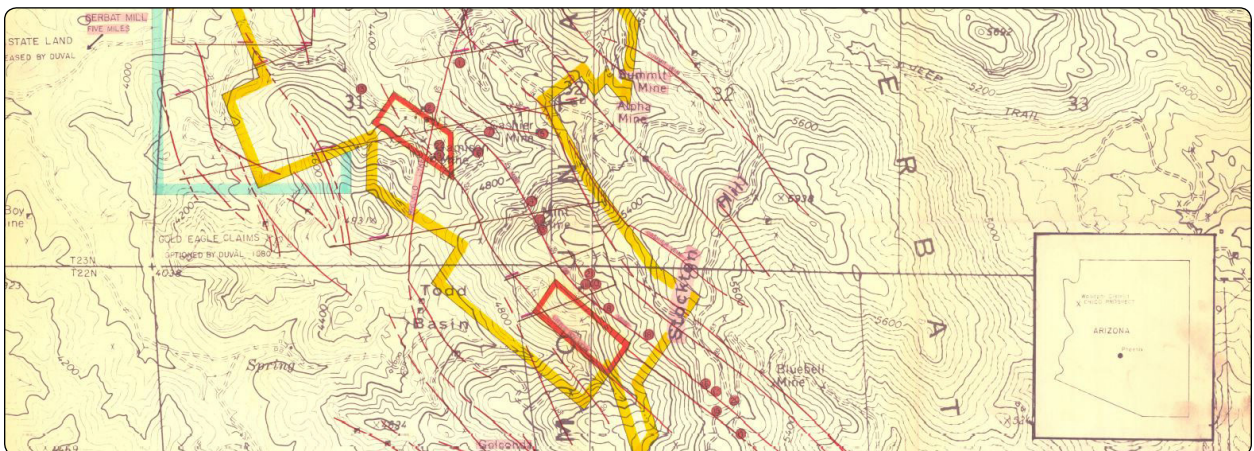
**Casey Brown**  
Metadata Librarian

Mining is a big business with a long history in Arizona. When exploration geologists want to know about the history of specific properties, the Arizona Geological Survey (AZGS) delivers. The 30 collections of mining records in AZGS archives, comprising an estimated 800,000 pages, were collected by the Arizona Department of Mines and Mineral Resources (ADMMR) over several decades. When the ADMMR closed in 2011, the AZGS was charged with cataloging and digitizing the mining records. These collections consist of property files containing everything from geological reports, engineering reports, geophysical surveys, drill logs, assays, maps, photographs and other related materials. Recently, when Copper Fox Metals inquired about the Van Dyke mine in Miami, Arizona, we were able to provide several photos of the mining operations from the 1980s, complementing existing reports and maps.

As the curator for ~800,000 pages of Arizona’s mining records, I make sure that these materials, a combination of published and unpublished documents, are accessible to the public in the short-term and are preserved for the long-term. The unpublished documents in these collections are likely to be the only locatable copies of maps and reports detailing exploration work performed

by mine owners or exploration consultants. It is exciting to be part of preserving a significant piece of Arizona’s mining history and the economic geology information amassed from thousands of mine reports. For exploration companies, doing archival research is much cheaper than hiring a drill to extract hundreds of feet of rock core for examination, and the information gleaned from an underground assay map could save tens of thousands of exploration dollars. Mining resources available at AZGS should be a first line of investigation for exploration companies operating in Arizona.

Our mine collections are almost universally organized by property files. A single file might contain one page or hundreds of pages of documents. We could lump and split files until the cows come home, but in the interest of time (and money) we catalog them the way the geologists created them, as a property file. This approach enhances discovery and lends itself nicely to online, interactive geographic (map) searches. In fiscal year 2013, we placed 4,068 property files, 678 maps and 3,328 images online at <http://search.usgin.org>. In the coming year, we expect to make 4,500 maps available online and continue to catalog the remaining 4,600 Arizona property files.



Historic mine map of Cerbat Mountain, Mohave County, Arizona

### Environmental Geology - Hits You Where You Live

Phil Pearthree

Chief, Environmental Geology



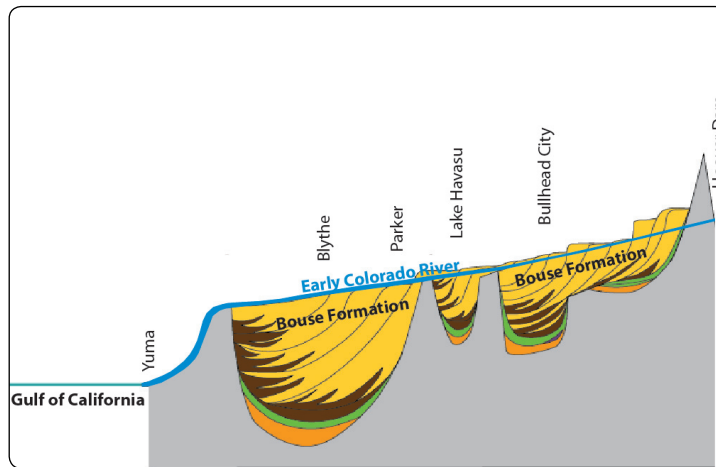
The Environmental Geology Section is primarily engaged in research and investigations into geologic hazards and geologic resources in Arizona; other staff members summarize some of these activities in this report. We are also partners with our bedrock mapping colleagues in the geologic mapping program. Sometimes as part of our geologic mapping investigations we have opportunities to address the larger geologic puzzles in Arizona, such as what geologic processes formed this amazing landscape that draws visitors from around the world.

A big part of this story is the development of the modern river systems. The Colorado River and tributaries have carved our most spectacular landscape, the Grand Canyon, and other impressive landscapes across the state. They also provide critical water resources for

urban areas and agriculture. Fifty million years ago (Ma) the landscape of Arizona was very different, when large river systems flowed from a highland/plateau in southwestern Arizona northeast onto what is now the Colorado Plateau. These river systems were completely disrupted by regional extension that broke apart and lowered the Basin and Range portion of Arizona. When Basin and Range extension began to wane 10-15 Ma, water from precipitation that fell on Arizona stayed in Arizona – river systems flowed into regional low spots (closed basins) and evaporated, leaving behind thick salt deposits.

Our modern river system has developed its current form in the past few million years, and much of the integration process has proceeded from the top, where most of the precipitation falls, down into our arid deserts. The Colorado River is the best-documented example of this process. Based on data derived in part from our geologic mapping program, Jon Spencer of the AZGS, Kyle House of the USGS, and I have confirmed that the Colorado River below the Grand Canyon is younger than 5.5 Ma, and didn't reach its full extent until after 4.8 Ma. Our studies indicate that the river developed by spilling into closed basins, filling them with

water and sediment and then spilling on to the next basin to the south, eventually linking with the Gulf of California. This all may have happened in a few hundred thousand years. Once the river was established to the Gulf, it eroded deeply into the deposits it



The Colorado River links up with the Gulf of California about 4.8 million years ago

had left in these lakes. This erosion was followed fairly quickly by deposition of thick sequences of primarily river sand and gravel, which we suspect was derived from erosion in the Grand Canyon and on the Colorado Plateau. At the peak of this aggradation around 4 Ma, the Colorado River was as much as 1000 feet higher than the modern river. By 3 Ma, the Colorado River had downcut several hundred feet below the maximum level of aggradation. Since that time the river has had its ups and downs, but nothing quite as spectacular as its 1st million years of existence. Thus, the river that is the lifeblood of the Southwest is a relatively new arrival to the region.



### Wildfires, Floods, Debris Flows, Oh My: A Progress Report

Ann Youberg

Research Geologist

Wildfires are increasing in size and severity across the western U.S., and Arizona is no exception. We have seen record-setting wildfires in the past few decades, with the five largest fires occurring since 2002. Forests that previously burned by frequent, low intensity surface fires (e.g., Ponderosa Pine forests), or in small, patchy mosaics (e.g., mixed conifer forests), now often burn by high-intensity crown fires across extensive areas, frequently resulting in very large contiguous patches of high and moderate soil burn severity. Concurrent with the recent increase in large wildfire activity has been an increase in the encroachment and development of the wildland-urban interface (WUI), placing people at a greater risk not only from wildfires, but also from the aftermath of fires.

Following wildfires, hydrologic changes in burned watersheds occur due to loss of vegetation, duff and litter, with concomitant changes to the soil that result in decreased interception and infiltration, significantly increasing runoff and erosion, often by orders of magnitude. The excess runoff and erosion leads to sediment-laden flood flows, which occur more frequently, and debris flows, which are less common but much more dangerous due to the speed and nature of the flows. To further complicate matters, fire season in Arizona ends with the onset of monsoonal rainfall, which often is what finally extinguishes our wildfires. Thus there is very little time to assess postwildfire damages to resources, evaluate potential hazards to values-at-risk, implement mitigation measures and execute emergency response plans.

Multivariate statistical models are available to quickly identify basins with the potential to produce postwildfire debris flows, but they have not been tested for use in Arizona. In addition, rainfall thresholds above which postwildfire debris flows are likely to be generated have not been developed for Arizona. To address these needs, I have been working in cooperation with geologists from the USGS Landslides Hazards Program to assess the performance of three postfire debris-flow models for use by Burned Area Emergency Response (BAER) teams in Arizona, and to develop rainfall intensity-duration (ID) thresholds for use by emergency responders and public-safety agencies. To accomplish these two goals, we developed a geodatabase with rainfall information, basin response (at least one debris flow or floods only), morphometric data, burn severity and soils data from 80 basins recently burned by the 2010 Schultz Fire, the 2011 Horseshoe 2, Wallow and Monument Fires, and the 2012 Gladiator Fire. We found that the models performed reasonably well under most conditions, with a few exceptions, and that they also functioned well in larger storms, up to 20-year return intervals, which are outside of the original dataset used to create the models. We also develop objectively defined rainfall ID threshold for Arizona to identify rainfall conditions above which postfire debris flows are likely to be generated. Results from this study will provide guidance to BAER teams for how best to apply these models in Arizona and rainfall ID thresholds for use by the emergency responders and public-safety agencies.



The San Francisco Peaks Schultz fire of June 2010. Photo courtesy of Sam Minkler.



### Arizona Earthquakes and Seismic Hazards



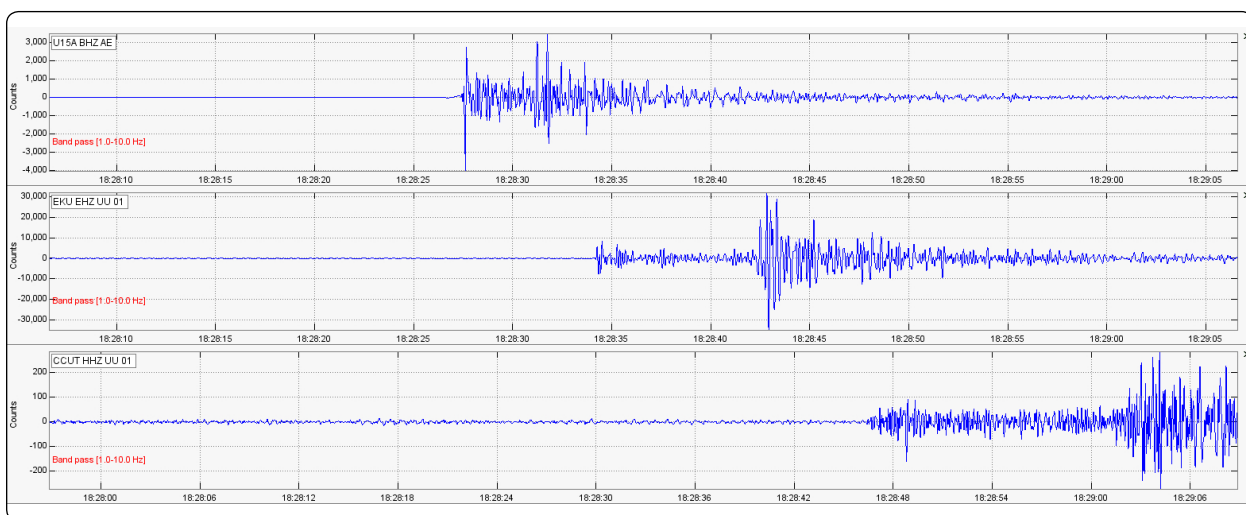
**Jeri J. Young**  
Research Geologist

Arizona indeed 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 nearly 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 go a long way in helping 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 determine 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.



Seismograms for small-magnitude earthquake



### Tracking Earth Fissures: An Anthropogenic Geologic Hazard

Joe Cook

Research Geologist

Earth fissures are tensional cracks, seams, or separations in the ground surface. They have been part of the landscape of some south-central Arizona basins since the late 1920s. They form as the result of uneven land subsidence patterns driven by groundwater withdrawal. The Arizona Geological Survey (AZGS) is tasked with mapping earth fissures throughout Arizona and providing earth fissure maps to the public. The financial impact of fissures on Arizona property values, damage to roads and highways, and the cost of mitigation and redesign of flood control structures over the past decade is on the order of millions of dollars.

Since 2007, Arizonans have been required to disclose the presence of earth fissures on their property when selling a home or land. With continued groundwater withdrawal and associated land subsidence, extension along known earth fissure traces as well as formation of new fissures occurs to this day.

Over the past several years, we have identified and mapped more than 153 miles of fissures in 24 earth fissure study areas. The resulting maps are the official source for disclosure of earth fissures and are freely available for viewing and download at AZGS' Earth Fissure Viewer (<http://azgs.az.gov/efv.shtml>).

AZGS earth fissure maps and GIS data are shared openly with the appropriate county engineers and planners, as well as the public to ensure awareness of the current extent of fissures. 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 the project manager of AZGS' earth fissure program, I frequently receive calls or e-mails from concerned homeowners, county authorities, real estate agents, and developers reporting new fissure growth. We examine and map newly formed

fissures promptly and update existing maps and the online fissure viewer accordingly.

AZGS actively collaborates with other agencies and groups to develop new strategies for studying and monitoring fissures. For example, the Arizona Department of Water Resources (ADWR) monitors land subsidence throughout Arizona.

Over the past year, we have worked closely with ADWR to explore the potential for combining land subsidence data with fissure maps to develop predictive criteria for identifying areas at high risk for earth fissure formation.



Reactivated earth fissure Pinal County 2013.

### Basin Analysis And Carbon Dioxide Sequestration: Investigating Arizona's Basins And Their Resource Potential

Brian F. Gootee  
Research Geologist

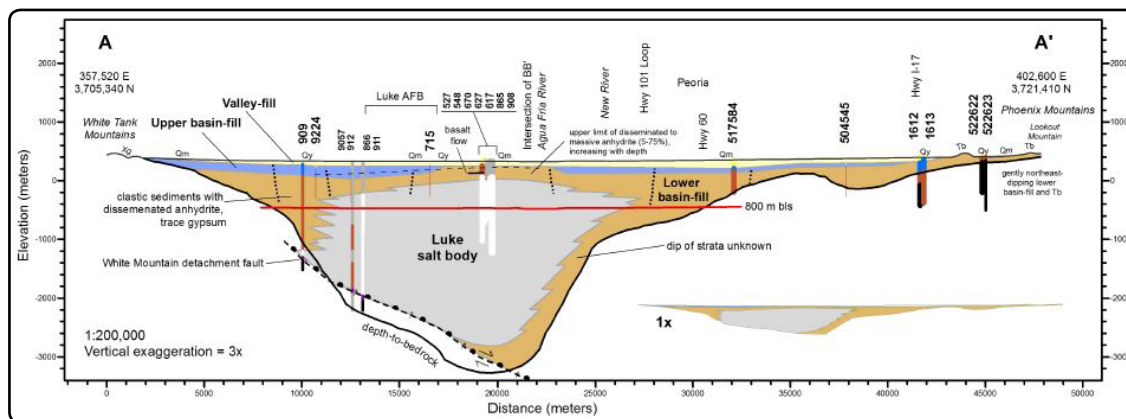


Basin analysis is the study of a basin's structure, stratigraphy, age, sedimentology and fluid chemistry. Arizona has nearly 90 distinct Cenozoic sedimentary basins within the Basin and Range province. Ten of Arizona's largest basins make up nearly 50% of all basin-fill sediment volume. These basins are generally perceived as having a thick sequence of gravel, sand and clay filled with abundant good-quality groundwater. However, basins are typically much more complex and poorly understood, limited to a relatively shallow level of water-well data. Below this "thin" horizon of wells lies a relatively unexplored vast "ocean" of basin-fill sediment and other rock strata.

Basins in Arizona not only provide us with natural resources such as groundwater, aggregates, and minerals, but also with opportunities to store fluids within cavities and pore spaces at great depths. As an example, liquefied petroleum gas is currently being stored in man-made salt caverns within the Luke salt body west of Phoenix. Storage of liquefied carbon dioxide (CO<sub>2</sub>) is another material that has been successfully stored, or sequestered, in similar types of deposits around the world, also known as Carbon Capture and Sequestration (CCS). Demand for CCS has increased due to concerns that elevated CO<sub>2</sub> emissions from anthropogenic sources have resulted in global warming. Recent

research by AZGS evaluated the potential for CO<sub>2</sub> storage potential in geologic formations that are below a level of 800 meters (2,600 feet) depth below land surface. Geologic evaluation is directed at porous and permeable geologic formations with impermeable sealing strata in basin-fill sediment saturated with saline groundwater >10,000 mg/L total dissolved solids. This research of Arizona basins enhances our understanding of basin-fill resources and their potential, which allows us to manage our resources more effectively.

My primary focus is on basin analysis, with occasional surficial geologic mapping and geologic hazards assessment. As part of analyzing a basin, published and unpublished materials are researched thoroughly. Gathering subsurface data from well records, geophysical logs, seismic reflection surveys, and gravity surveys are a large part of building a dataset to research a basin. I combine these data and use cutting-edge 3D software combined with GIS to visualize a basin's geometry and structure. Results from my work have been used to build numerical groundwater models for simulating groundwater flow over long time frames. All pertinent data for a specific basin (well lithology, depth-to-bedrock, cross-sections) are incorporated into a digital geodatabase, which can also be used for various other geologic and non-geologic studies.



Geologic cross-section of the Luke Basin, Maricopa County, Arizona



### Arizona's Water Future – The Role of Hydrogeology

**Mike Mahan**  
Geologist

Hydrogeology, as the word implies, represents the interaction of water and geology. The term refers to water and geologic interaction in the sub-surface environment or groundwater. Here in Arizona we have typically relied on groundwater to meet our agricultural, municipal, industrial, and domestic water supplies. The Central Arizona Project or CAP has supplemented these supplies but has not solved our water demands future. To better manage our groundwater resources, we need to determine the quantity and water-quality of our groundwater resources. Groundwater science studies typically involve conducting a basin characterization to answer the questions of how much groundwater there is, where it goes, and what is its quality. This includes determining the size of what is referred to as basin-fill aquifers. The distribution of basin parameters, such as depth to bedrock, scientific characterization of the basin-fill sediments, water-level monitoring, and chemical sampling, address these questions.

Additionally, we need to understand the distribution of geologic materials and the hydraulic properties associated with those materials that govern groundwater flow to production supply wells located within Arizona's basins. The hydraulic properties that govern groundwater flow in basin-fill aquifers includes both the groundwater flow and storage properties

of the basin-fill aquifer sedimentary materials. In order to determine these properties, we conduct aquifer-tests. We test one production well and at least one observation well. The test well is pumped at a specified rate and the drawdown (the lowering of the water-level in the test well and an observation well of a known distance from the test well) is recorded over time. Once the test well pumping is terminated, the drawdown recovery water-levels are also monitored and recorded.

The data collected from water-level monitoring is corrected for atmospheric barometric fluctuations. We use aquifer-interpretation software specifying the geological characteristics to provide information on the groundwater flow and storage properties for that location.



Groundwater discharge from the Butler Valley Aquifer test.

These data can then be used in 3-D groundwater flow models and to improve the model's predictive capabilities. This important groundwater resource management tool, supported by quality field data, and interpreted in a localized geologic setting, can evaluate a basin's groundwater resources and, more importantly, can give us guidance on how to manage water resources now and in the future. The value

of this process cannot be overstated in our water-scarce desert climate, and AZGS provides essential evaluations of basin-fill aquifers within the State of Arizona.



The Geologic Extension Service (GES) comprises graphic artists, editors, marketing and sales specialists, web designers, a technology transfer specialist, and a token geologist. GES plays a support role at the Survey, assisting other divisions in designing, publishing and promoting their products with the general goal of informing and engaging the public.

As the publication and outreach branch of the Survey, one of GES's chief responsibilities is to inform stakeholders of the geologic setting of Arizona and to provide ready access, via the online document repository ([repository.azgs.az.gov](http://repository.azgs.az.gov)), to the geologic reports and maps published by the Survey over the past century. The Survey's web design and tech transfer teams ensure design and delivery of AZGS products to a public that increasingly anticipates online service 24/7.

Part of the GES outreach effort is the operation of the Arizona Experience Store, a source for Arizona books, products, and information (416 W. Congress, Tucson; <http://store.azgs.az.gov/>). The Arizona Experience virtual museum ([arizonaexperience.org](http://arizonaexperience.org)) offers a vehicle to expand beyond the Earth sciences into the cultural and historic roots of Arizona.

The following section will provide a window into the GES and the people that make it work.

## GEOLOGIC EXTENSION SERVICE

# GEOLOGIC EXTENSION SERVICE



## Geologic Extension Service – Going Public with AZGS

**Michael Conway**  
Chief, Geologic Extension Service

Does Arizona have earthquakes? That's the most frequent question we get at the Arizona Geological Survey's Geologic Extension Service (GES), along with hundreds of other questions that range from the common (how to identify earth fissures, where to find placer gold, how to distinguish meteorites from terrestrial rocks, where should I sink my water well) to the rare (where's a good place in Arizona to look for Sasquatch?). We address the geologic questions, and if we don't have the answer- where to drill a well is not our forte- we'll point to a state or county agency that does. We know where to find gold, but Sasquatch licks us every time. And, yes, Arizona does have earthquakes.

As the Survey's outreach and extension arm, the role of the GES team is two-fold: 1) communicate to the public the role, mission and geologic products of the Survey; and 2) support the other AZGS teams – geoinformatics, geologic mapping and mineral resources, and environmental geology - as they carry out their tasks of building and delivering viable geologic and geoinformatics products to the broader community.

The GES team comprises graphic artists, writers, editors, web designers, and retail and marketing specialists. One day we are busy creating brochures and planning conference workshops, the next day we are capturing "Tell your Arizona Story" videos at the Tucson Festival of Books, or drafting and distributing a news release on the potential for carbon sequestration in one of the Cenozoic basins of south-central Arizona. Our work ranges from the local or statewide, highlighting geologic hazard awareness; to the national, promoting the National Geothermal Data System; from small, engaging 15 pre-schoolers with maps, rocks and minerals; to large, enrolling nearly 100,000 participants in a statewide earthquake preparedness drill to inform and educate Arizonans about how to behave during moderate to severe ground shaking.



The next generation of Arizona geologists waving topographic maps

And we take our message to the public via social media. Each day like clockwork we tweet to Twitter or post to Facebook. On a typical day, 800 to 1,000 people see our Facebook posts, which include everything from our GeoSNAPS photographs of geologic features in Arizona, to new map products, to regional or national releases on geologic hazards by federal science agencies.

We are also the publishing branch of AZGS. We work closely with AZGS geoscientists to build geoscience reports and maps and then to distribute them broadly. As part of our distribution model, we directly tap the science community, as well as state, county and municipal civil authorities to ascertain that they are aware of the products and to learn how our products can best serve them. We host the online AZGS Document Repository ([repository.azgs.az.gov](http://repository.azgs.az.gov)), which hosts approximately 90% of the Survey's publications, dating back to 1915, as free downloadable PDFs. The Survey rises or falls on the quality of our geoscience and geoinformatics products. It is the role of the GES to alert people to the nature, utility and availability of these products.

The Geologic Extension Service team provides agile and creative support to the mission of AZGS by collaborating with our colleagues and providing a broad array of information services to all.

# GEOLOGIC EXTENSION SERVICE

## AZGS and Project Websites

**Pam Barry-Santos**  
Web Developer



As an employee of a state science agency, you'd think that a job involving creating and maintaining the agency websites would center on raw data and charts, graphs and tables. Not here. When I started with the agency a few years ago, I was hired to help the agency maintain, update and then revamp the main site, the Oil and Gas Commission site and to work on a few project sites. Within months that list began to grow. At the Arizona Geological Survey, we have close to a dozen public-facing and project-supporting websites. And we're still adding to that list, with two new websites going live in the coming months.

Our agency does more than investigate fissures and map the state. We do that, and more, for the state. But we're also doing our part in the bigger picture of making data and knowledge accessible. Not just for the people who can come into our Tucson or Phoenix offices between 8 am – 5 pm on a weekday. To make sure everyone can access that information, it has to be available online. From conferences to grant-funded federal projects, our websites help people contribute and help them find information that wasn't readily available just a handful of years ago.

Our sites share with the public the progress and results of our state mandated work (publications, maps, fieldwork, permits, etc.), our community involvement (STEM outreach,

earthquake preparedness, fissure mapping, etc.) and the collaborative work we do with other government agencies and other states around the country. My job is to help make sure our agency's work doesn't just get printed out, filed away and buried in a filing cabinet... indefinitely.

My specific role as a web developer at the AZGS includes creating and maintaining the front-end websites. It means doing my best to make it possible for people to find what they are looking for, and to help make it easier for everyone to collaborate on these projects. And for each new project, we have different goals and different needs. We're always pushing to do more and take on new projects. It's the fun part of the job; I'm never doing the same thing, and tomorrow always brings the chance that we'll have a new website to create from scratch.

*My job is to help make sure our agency's work doesn't just get printed out, filed away and buried in a filing cabinet... indefinitely.*

# GEOLOGIC EXTENSION SERVICE

## A Virtual Arizona Experience



**Rowena Davis**

Arizona Experience Website Editor

A one-hundredth birthday calls for a big celebration, so the State of Arizona planned numerous projects to celebrate its Centennial on February 14, 2012. The Arizona Geological Survey was invited to be a major part of Arizona's centennial legacy by creating the Arizona Experience website ([www.arizonaexperience.org](http://www.arizonaexperience.org)), a dynamic online reference commemorating a century of statehood in a showcase of the state's people, places, history, and events.

Surrounded by experts in the geosciences, it was simple enough to accumulate materials on Arizona's geologic history and landscapes. However, to create a well-rounded, historically accurate site rich in the humanities and social sciences, our outreach team formed partnerships with over 300 Arizona agencies, museums, tourism bureaus, and non-profit organizations to collect images, video, and other multimedia material that brought Arizona's defining moments and figures to life.

My job is to put order to that wealth of information. I helped design the website structure and wrote, gathered, and edited content for twelve monthly themes central to Arizona, including mining, agriculture, landscapes, people, and water. Unveiled on the Centennial, the website was expanded throughout the centennial year. My goal is to create pages that tell an interesting story on their own, yet contribute understanding to the overall picture of the state as it exists today.



Historical mining image at the Arizona Experience ([arizonaexperience.org](http://arizonaexperience.org))

The website draws from AZGS's knowledge of cutting edge geospatial software to ensure a rich online presence with colorful interactive maps, slideshows, and multimedia displays presenting everything from Arizona habitats to historical mining towns to annual festivals held throughout the state. Our in-house video team created a virtual tour of Sunset Crater, a birdwalk along the San Pedro River, and dozens of videos. I used these elements to create educational pages that illustrate how Arizona's landscapes and natural resources shaped its settlement patterns, its economy, and even its cultural tapestry of Native American tribes, Spanish settlers, immigrant miners, ranchers, and numerous other groups.



We collaborate with other state agencies to create special features. For instance, we worked with the Arizona SciTech Festival to promote STEM (Science, Technology, Engineering, and Math) education in Arizona by showcasing the SciTech Fest blog and many of its activities. Our most notable collaboration is the Recreation and Cultural Sites Map, a partnership with the Arizona Office of Tourism and myriad partner agencies, including Arizona State Parks and the Arizona Commission on the Arts. This map displays a range of Arizona's tourism destinations, including public lands, scenic byways, and museums, and helps the user find specific activities to help plan the perfect Arizona experience.

Though the centennial year is over, the site continues to evolve, with several major projects planned for the coming months. Experience Arizona for yourself at [www.arizonaexperience.org](http://www.arizonaexperience.org).



# GEOLOGIC EXTENSION SERVICE

## Tech Transfer at AZGS

Jordan Matti

Tech Transfer Specialist



Two years ago, shortly after graduating from the University of Arizona with a master's degree in film studies, I was hired by the Arizona Geological Survey as a Tech Transfer Specialist to use my knowledge of film, web design, and technical writing to communicate with the public in simple, concise terms.

The Survey performs a number of public services: monitoring geologic hazards, mapping geophysical resources, and developing cyberinfrastructure for the geosciences. These subjects tend to be technical but relevant to public education and sometimes even public safety. I act as an intermediary between the Survey and the public, using mixed media to convey complex concepts in layman's terms.

For example, contrary to popular belief, seismic activity is relatively common in Arizona. To demonstrate this, I use a program called Worldwide Telescope to

generate graphical presentations of earthquakes in Arizona over a period of time. By entering earthquake location, date, and magnitude into Worldwide Telescope, I can generate a presentation in which each earthquake appears as a little flash of colored light, the size and color of which are magnitude-dependent. Likewise, much of my time at the Survey is spent

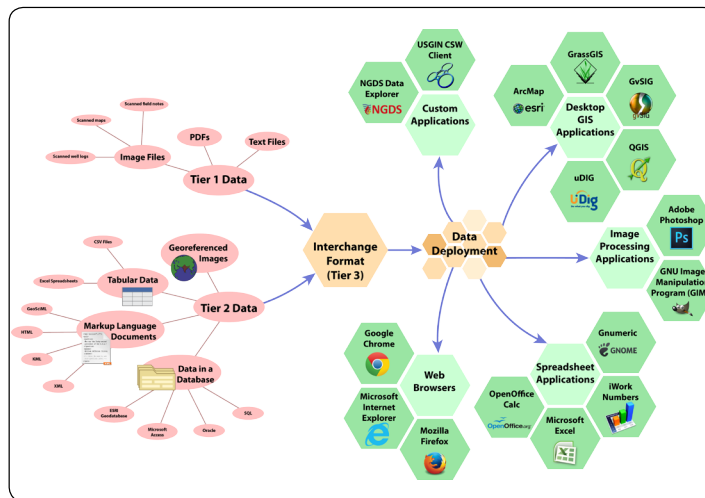
explaining and demonstrating the nature and purpose of the Survey's cyberinfrastructure development projects. Cyberinfrastructure can be defined as the theory, practice, and computing resources necessary to share large quantities of data, and the Arizona Geological Survey is a world leader in cyberinfrastructure development for geoscience data.

Large-scale data-sharing operations allow us to perform analyses that help us find new geophysical resources, including new sources of energy for the next century. That said, cyberinfrastructure development is a complicated

and technical process; to explain it, I have written tutorials and technical documentation, shot and edited movies, generated PowerPoint presentations, and developed web pages.

As part of my job, I am called upon to assimilate, synthesize and distill information

from a wide variety of disciplines; to learn new and useful skills; and to master existing skills, like cinematography, writing, and film editing.



Graphic illustrating how USGIN works

# GEOLOGIC EXTENSION SERVICE



## Bringing it Together – A Story of Collaboration

**Randi S. Bellasai**

Sales and Marketing Manager

As Sales and Marketing Manager, I provide a bridge between the great work being done by the Arizona Geological Survey and all of our partners, including the public. I developed countless partnerships with Arizona organizations, including Local First Arizona, Arizona Farm Bureau, Arizona Lottery, and Visit Tucson.



Each week I tackled the question, “What can we do to put ourselves out there?” To address the question, I circulated public service

announcements, conducted media interviews, and provided numerous presentations to agencies and organizations. I engaged the public in a wide variety of venues. I chatted with people who wandered into the office, coming in with no idea what the Survey does and leaving with a greater appreciation for Arizona.

Public appearances allow AZGS to engage directly with the public. In addition to hosting an exhibit at the Tucson Gem and Mineral Show, I coordinated guest bloggers to participate in our “Gem of a Show Blog.” This blog was housed on the Arizona Experience website and was featured on Visit Tucson’s website. At the Tucson Festival of Books we had not only a booth for the store but a second booth set up as a film studio to capture “Your Arizona Experience,” as told by individuals attending the Festival. Enjoy these personal oral history videos on the Arizona Experience website.

A major component of outreach involved educators; I love interacting with teachers. We provided teachers topographic maps along

with other classroom resources as part of our “Topos for Teachers” program. We participated in education events, including Pima County FAIR for Educators and UA Teacher Day sponsored by Tucson Values Teachers.

We launched our newly remodeled bookstore in coordination with the expansion of the Arizona Experience website this past year. Within the store, we brought together free materials from over 70 agencies (city, county, state, and federal) for our public recreation and outdoors center. We hosted promotions with the Arizona Lottery; our store was the only location in all of southern Arizona chosen for the “Meet and Greet” with Robin Sewell, host of Arizona Highways Television.

We can’t talk about outreach efforts without mentioning our newest way to interact with people: social media. Whether you follow us Facebook, Twitter, YouTube, Foursquare, or Pinterest, there is always something new to discover. I love working with people, and this job lets me do just that.



The Arizona Experience Store at Tucson Gem and Mineral Show 2013

# GEOLOGIC EXTENSION SERVICE



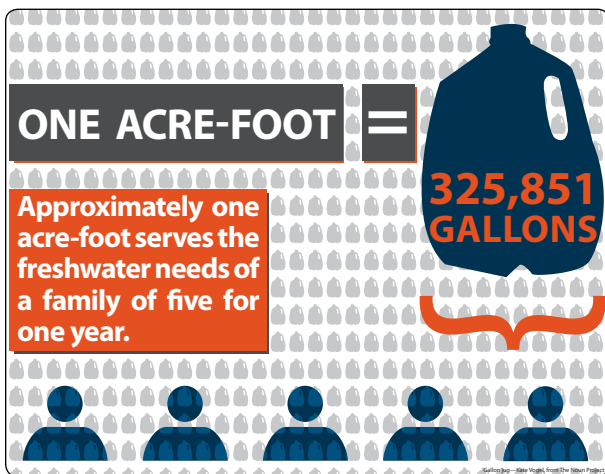
## Graphics that Rock

Stephanie Mar & Arnie Bermudez  
Graphic Designers



I was originally hired at the Arizona Geological Survey to work on the Arizona Experience website, an interactive website which celebrated Arizona's 2012 Centennial. I helped with the design and architecture of the site. Every month I designed and loaded pages and articles on the site, supplemented images and formatted graphics. I also aided our web developer with back-end development of the site which is built in Drupal, an open source content management platform. Another part of my duties was to design promotional materials for the site, both printed and digital. Though the Arizona's centennial year has ended, I continue to input and design articles and perform general site maintenance.

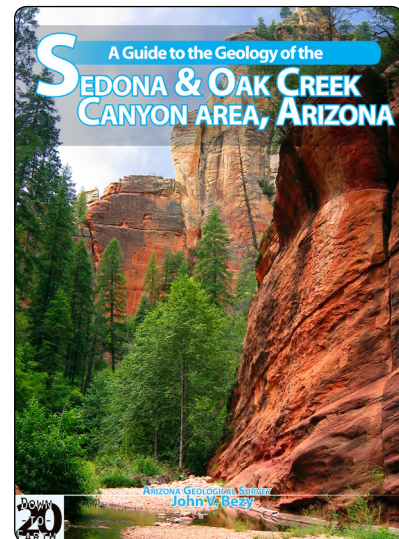
As work on the website slows down, I am increasingly spending time designing materials for other AZGS projects, such as banners for the EarthCube project and National Geothermal Data System website. One of the best things about working here is the collaboration with co-workers. They do stellar work, and I enjoy helping present that work to the public with images and design ideas.



Telling the story of water consumption with an Infographic

I have been working at the Survey as a graphic artist for a little over two years. Thanks to the diversity of assignments, software utilities, and human interactions, I have learned more here than at any other time in my professional career. I employ computer programs for design coupled with traditional methods of production such as pen and ink illustrations. On a typical day I could be designing a book, laying out a brochure, or creating an internet splash page.

A favorite project was designing the Down to Earth Series Sedona and Oak Creek Canyon Area Guidebook, a guide to the geology behind Sedona's famous red rock formations. I also enjoyed developing the EarthCube logo. Both were collaborative projects requiring the



Arnie Bermudez's cover of "A Guide to the Geology of the Sedona & Oak Creek Canyon Area, Arizona"

input of other members of the Survey's team and the greater geoscience community.

In 2013, my responsibilities expanded to include video editing and recording work. These assignments involved working closely with a team of designers and web content producers. Back at the office, I helped shape that footage into film clips and educational videos that appear throughout the Arizona Experience and the Survey's websites.

# GEOLOGIC EXTENSION SERVICE



## The Arizona Experience Store – A One-Stop Shop for all things Arizona!

**Michelle Harriman**  
Retail Manager

Have you ever wanted to know about the natural history or geology of Arizona? If so, make the newly remodeled Arizona Experience Store your first stop. Once the publication sales office for the Arizona Geological Survey, the Arizona Experience Store has grown to encompass all things Arizona – books, maps, minerals and gift items. For the geoscience community, we remain the chief provider of geotechnical publications of the Survey, the Arizona Geological Society and the U.S.



Geological Society. Our inventory includes more than 2,000 topographic, travel and geologic maps for Arizona. So whether you are hiking in the Santa Rita Mountains

or exploring for minerals in the Galiuros, we have the right map for you.

As a partner with the Arizona Experience website, created to celebrate Arizona's Centennial, the Arizona Experience Store offers a way to explore Arizona's lands, people, and culture via products and publications from state and federal agencies. Visitors can peruse our Recreation & Outdoors center, hosting one of the State's best selections of free public information from city, county, state, and federal agencies such as Tucson Parks and Recreation, Arizona State Parks, U.S. National Parks, Bureau of Land Management, U.S. National Forests. Arizona Game and Fish licenses are available along with rule and regulation publications. While shopping, check out the touch screen kiosk for locating online resources for local, state and federal agencies, or view one of our flyover tours including the Grand Canyon and Verde Valley shared from the Arizona Experience website.

We are southern Arizona's one-stop shop for Arizona Highways publications and gifts. Visitors

can purchase gift items from local photographers and artisans, including handcrafted copper and silver jewelry, mesquite root lamps, birdhouses, and glassware etched with petroglyphs, or choose from our broad selection of Arizona themed souvenirs. Guests young and old will enjoy learning about Arizona's flora and fauna from our selection of plant and animal books. History buffs can peruse the University of Arizona Press section for a multitude of publications explaining Arizona and Native Arizonan history. Our younger clientele can explore a multitude of science themed items such as crystal growing kits, dinosaur excavation projects, rock and mineral identification sets, and books about Arizona's animals and geology. The addition of the Online Store and the AZGS Amazon Store allow visitors to shop from wherever their travels may take them.

Arizona Experience store now offers a wide selection of minerals from historic Arizona mines. Specimens including native copper, wulfenite, malachite and azurite, to name a few, are offered by local collectors on consignment. Whether a visitor to Arizona or a native wanting to learn more about your home state, a visit to the Arizona Experience Store should be at the top of your list. See you soon!



The newly remodeled and rebranded Arizona Experience Bookstore

# GEOLOGIC EXTENSION SERVICE

## Interns Bring New Faces and Fresh Skills

**Rowena Davis**

Arizona Experience Website Editor



Arizona Geological Survey staff have completed many impressive projects over the past year. But they didn't do it alone. AZGS interns provide an enormous contribution of labor and ingenuity, helping projects run smoothly and contributing their unique skill set while acquiring work experience.

Because the Survey is an affiliate of the University of Arizona, most interns are graduate students studying geology or GIS (geographic information systems). However, the Survey also benefits from interns in media arts and other fields.

The largest group of the FY2013 interns is dedicated to digitizing oil and gas well logs as part of the Rocky Mountain Carbon Capture & Sequestration project. Led by the Energy and Geoscience Institute at the University of Utah, RMCCS studies formations on the Colorado Plateau to assess their carbon sequestration capacity. A total of seven interns have contributed their skills to the project since funding to AZGS started in December 2011.



Interns Ken Richards and Alicia Gershweir digitize oil and gas well logs as part of the RMCCS project.

Ken Richards, a UA graduate student in GIS, divides his time between the RMCCS and entering data for the National Geothermal Data System (NGDS) geoinformatics project. Ken took the lead in creating a well log map viewer for RMCCS that links the location of oil and gas wells with digital information already available from NGDS. This handy tool can be accessed at [welldata.azogcc.az.gov](http://welldata.azogcc.az.gov). He says he appreciates his time at the Survey because it is giving him programming experience and the opportunity to build hands-on applications. Michele Tartaglia and Laura Bookman, both GIS interns hired in May for the NGDS project, are accumulating valuable real-life experience working with Open Geospatial Consortium standards, very much in demand in the global geospatial community.

Internships also provide opportunities for permanent employment. Four former interns are now full time staff members. This practice cuts down on finding and training new employees and allows the new hires to continue to hone their skills. Adrian Sonnenschein, Jordan Matti, Jessica Alisdairi, and Genevieve Pearthree have become a valuable part of the AZGS team. Jordan, a tech transfer specialist at the Survey since 2011, now works with his own media arts intern to create videos, tutorials, and the in-house broadcast, the "Arizona Mining Review."

With a background in both GIS and software development, Jessica, hired in February 2013, has streamlined the data validation process on the NGDS project – and saved thousands of hours of work – by creating an original program called the NGDS Data Explorer to find errors in data entry. Adrian, a GIS intern who joined the team as a GIS specialist in February 2013, enjoys the collaborative atmosphere and the AGZS embrace of new digital platforms. "GIS options are coming out at a very fast rate, and it's exciting to not be locked into one library. Use of a diverse set of technology keeps work interesting," he noted.



The Administration section performs the behind-the-scenes support for the organization. The chief administrative officer focuses on policy and oversees the support provided by the HR director, the budget and accounting officer, and two financial specialists.

The HR director makes sure all personnel actions are completed and that staff and contracts are paid on time. The budget and accounting officer projects and monitors revenues and expenses to keep the Survey thriving. The financial specialists keep our books in order.

Administration's goal is to support the staff seamlessly and invisibly. The Survey's scientists perform extraordinary work, and this team strives to help them maintain their momentum.

# ADMINISTRATION

# ADMINISTRATION

## Keepin' It Real

**Debra Winstead**  
Chief Administrative Officer



The Arizona Geological Survey took in a little over \$10 million in FY2013, over \$9 million of which came from grants and contracts. Who keeps track of all that money? The administrative team does. In addition to keeping the books, the admin team performs human resources and budgeting functions, oversees facilities and fleet, monitors grants and contracts, arranges travel, organizes meetings, and generally provides the oil to keep the AZGS machine running smoothly.

In FY2013, the State of Arizona implemented new laws, policies, and regulations that affected all AZGS employees. The admin team stepped up to answer questions, customize requirements, and educate staff.

This year we implemented a budget-by-hours plan to help keep staff work time on projects in line with grant and contract budgets. The plan illustrates not only annual budgets per project but also annual work budgets per employee.

The main office for the Survey is, by state law, in Tucson. This year marked our 125th year of operations, making us older than the State of Arizona itself. Most state agencies are located in Phoenix, but Tucson was the capital when the Arizona Territorial Legislature appointed its first geologist and is the home of the University of Arizona, whose Bureau of Mines was a predecessor of the current AZGS.

The Survey became a state agency in 1888 through legislation that required proximity to the University of Arizona. Most Survey staff is housed in the downtown Tucson office when they aren't in the field. However, we maintain a presence in Phoenix, where the Economic Geology section, our seismologist, and a hydrogeologist are located.

Though the admin team is housed in Tucson, we coordinate activities for the Phoenix office as well.

For instance, the admin team cares for our seven-vehicle fleet which includes one sedan, four jeeps (one in Phoenix), and two trucks. Maintaining even relative cleanliness during field season is a challenge.

Keeping track of the Director's whereabouts is a task in itself, but the admin team is also

responsible for arranging travel for the entire staff. So far, we haven't lost anyone. AZGS hosts several meetings each year, sometimes as part of a professional group, sometimes as required by a grant or contract, sometimes in a commercial venue, sometimes in our office. The admin team makes sure these meetings are big successes.

There is always plenty to keep us busy. Our mission is to provide support for all the functions of the Survey and to keep smiling as we do it.

*This year marked our 125th year of operations, making us older than the State of Arizona itself.*

# ADMINISTRATION

## We Have Resources



**Paula LaRue**

Business Manager and Human Resources Director

One of Arizona's biggest resources is its human workforce. The Human Resources (HR) team manages resources for the Arizona Geological Survey's workers to help them examine the state's geologic resources safely and effectively. The HR division conforms to the laws and policies of state employment while keeping the Survey's humans happy.

Each staff member must be classified correctly in the state's HR system so that payroll, benefits, leave, and retirement are properly accounted for. Employees are paid every two weeks, and the HR division works hard to make payroll a seamless transaction. Most Survey staffers work on grants, often on specific tasks for each

grant, and those hours are tracked and billed in coordination with the payroll system. Arizona offers many benefits to its employees, including a choice of several health insurance plans, dental plans, a vision plan, life insurance, disability insurance, various types of leave accrual, and a defined benefit retirement plan. HR works with each employee to develop an overall benefits portfolio to meet the individual's needs. The state provides all its employees access to Your Employee Services (Y.E.S.), an online resource for employment details, employee time entry, payroll details, leave balances, benefit choices, training, and personal information. The HR division provides one-on-one training in the use of Y.E.S. and encourages employees to take

advantage of the wide variety of online training for professional development.

This year, Personnel Reform was implemented, making Arizona an "at will" employer, one that can dismiss an employee for any reason (as long as the dismissal does not violate discrimination prohibitions) just as an employee can resign

for any reason. New rules were established covering everything from recruitment to retirement. One of the major initiatives of Personnel Reform was a new performance management system, requiring considerable training and new time commitments for the Survey's division managers. Business



The administrative team: Debra, Fritz, Paula, Cynthia, and Adri.

management personnel ensure that the Survey's financial resources are used in compliance with state policy. Most of the Survey's funding is from grants, adding to the complexity of financial management systems. The State accounting system does not allow for the degree of detail needed for recording all grant transactions, so a parallel accounting system is also used in house. The Survey has two financial specialists who code every transaction for inclusion in both accounting systems. They also provide essential back-up for payroll, fleet management, and store management.

In short, the HR and business management teams help make sure ALL Arizona's resources are utilized to their full potential.



# ADMINISTRATION

## Finances



**Fritz Schellenberg**  
Budget and Accounting Officer

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, the revenues from the indirect costs and publication sales are non-lapsing, that is, balances at the end of the state fiscal year are automatically carried over to the next fiscal year.

**State General Fund Appropriation**  
**Total General Fund Appropriations for FY13: \$872,500.**

**Contracts and Grants**  
There were relatively few new grants and contracts awarded to AZGS in F13, but work continues on multi-year awards.

**Total Grants and Contracts for FY13: \$8,054,700.**

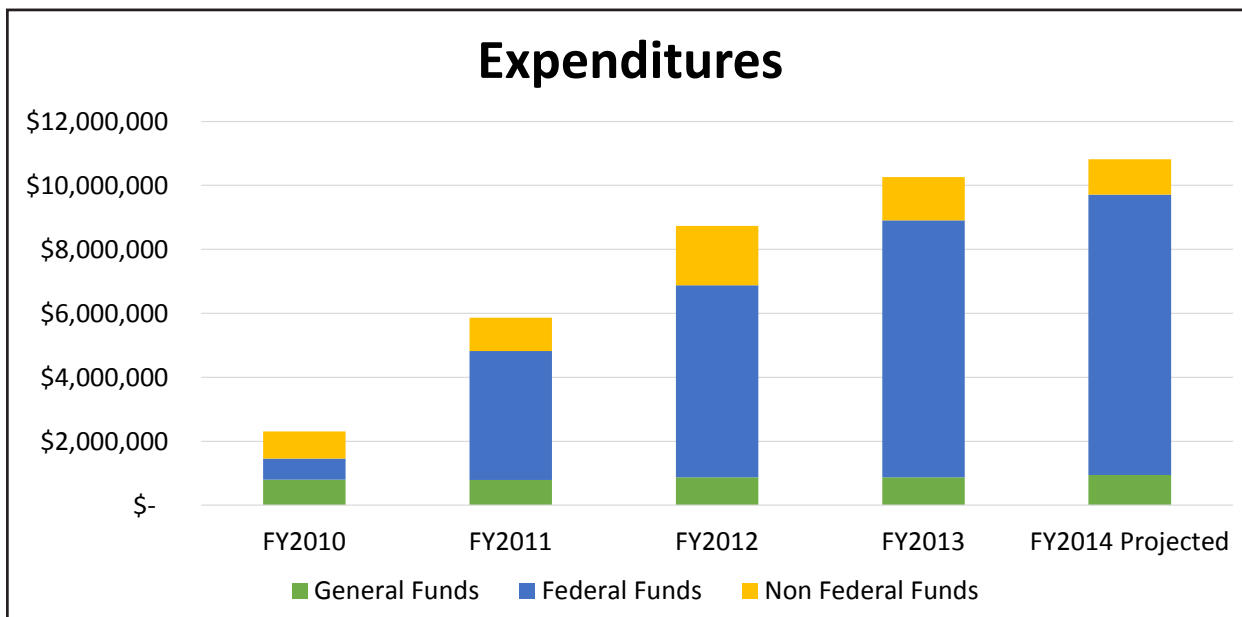
### Map and Bookstore Sales

The Arizona Experience Store in Tucson sells all agency publications and maps and serves as the official USGS Earth Science Information Center for Arizona, which includes carrying all of the nearly 2,000 USGS topographic map titles for Arizona. The store also carries topographic maps produced by the US Forest Service and US Bureau of Land Management.

**Total Publication Sales FY13 \$72,829.**

AZGS acts under contract as the primary sales outlet for the Arizona Geological Society, a non-profit professional group, headquartered in Tucson.

Revenues	Fiscal Year 12	Fiscal Year 13
General Funds	\$886,900	\$872,500
Non-Federal Funds	\$1,535,656	\$1,302,134
Federal Funds	\$5,951,760	\$8,054,700
Sales & Publications	\$88,740	\$72,829



# ADMINISTRATION

## Grant List

AZGS has a long history of seeking and obtaining external funding for its programs and services. Diverse funding sources include federal, state, local, and other agencies and organizations. The following list includes grant funds available during FY-2013.

<b>Federal</b>	<b>Grant Funds</b>	<b>Ending Date</b>
Dept. of Energy - National Geothermal Data System (NGDS)	\$21,858,200	4/30/14
Boise State University - NGDS	\$737,600	4/30/14
National Science Foundation - Interop Geosciences Information Network	\$625,000	8/31/12
Rocky Mountain Carbon Capture and Sequestration	\$266,000	9/30/13
National Science Foundation - EarthCube Framework	\$252,500	10/31/13
California Energy Commission - Westcarb	\$232,400	12/1/13
U.S. Geological Survey Statemap '12	\$221,900	9/20/12
U.S. Geological Survey Statemap '13	\$206,600	9/14/13
National Science Foundation - EarthCube Governance	\$100,000	3/31/13
Federal Emergency Management Agency - AZ Shakes 2	\$49,600	8/05/12
Federal Emergency Management Agency - AZ Shakes 3	\$47,300	9/15/13
Federal Emergency Management Agency - AZ Shakes 4	\$48,200	3/25/14
U.S. Geological Survey Data Preservation '12	\$41,500	8/14/12
U.S. Geological Survey Data Preservation '13	\$41,000	8/31/13
Columbia University - Digital Environment for Sample Curation	\$18,000	8/31/14
<b>State, Local and Other</b>		
The Arizona Experience Virtual Museum	\$800,000	2/14/14
Central Arizona Project - Earth Fissure Evaluation	\$81,800	6/30/13
Arizona State Land Dept. - Butler Valley Hydrology	\$84,500	6/30/13
Arizona Broadband Seismic Network	\$55,000	on-going
Stantec Consulting Services - Gillespie Area Drainage Master Study	\$32,800	12/31/12
Havasupai Tribe - Havasu II Geologic Hazard Evaluation	\$7,000	8/31/12

### Budget and Finances

Finances at AZGS remained stable throughout Fiscal Year 2013. With federal budget sequestration, our grant awards for continuing projects were reduced. We carved a niche in our administration section dedicated to seeking out grants to advance the Survey's objectives.

### Physical Assets

The Arizona Experience Store became the first state agency to offer Arizona Lottery products.

# ADMINISTRATION

## Awards and Recognitions

The Geological Society of America's prestigious Kirk Bryan Award for Research Excellence was awarded to Dr. Phil Pearthree, Chief of AZGS's Environmental Geology section, and his colleagues, Michael Perkins, adjunct assistant professor of geology and geophysics at the University of Utah, and Kyle House, United States Geological Survey.

Dr. Pearthree and his co-authors were honored at the GSA Annual Meeting and Exposition award ceremony in Denver, Colorado, on October 28, 2013. Phil Pearthree has been employed by the Arizona Geological Survey since 1988, and now serves as chief of the Environmental Geology section overseeing research on Quaternary geology, geologic hazards, and hydrology.

Their paper, "*Stratigraphic evidence for the role of lake spillover in the inception of the lower Colorado River in southern Nevada and western Arizona,*" is the latest contribution to the question of why and how the Colorado River took the form that it did. The paper was published in Geological Society of America Special Paper 439, 335–353 pp (2008).



On 11 July 2013, the AZGS received the Arizona Preservation Award at the Governor's Tourism Award Gala for their work on the Arizona Experience website ([arizonaexperience.org](http://arizonaexperience.org)). The award is presented to the individual, organization, or community that has made the most significant contribution toward the preservation of some aspect of the natural, cultural, or aesthetic legacy of Arizona.



# ADMINISTRATION

## Arizona Geological Survey Staff FY-2013

Director & State Geologist, M. Lee Allison

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# ADMINISTRATION

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## Interns

Bookman, Laura	Student Intern	*
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Canto, Belen	Student Intern	*
Gershweir, Alicia	Student Intern	*
Richards, Ken	Student Intern	*
Lee, Jefferson	Student Intern	*
Rudd, Jessica	Student Intern	*
Spencer, Leah	Student Intern	*
Tartaglia, Michele	Student Intern	*

Nations, Jack D., Chairman, Arizona Oil & Gas Conservation Commission

\* These individuals no longer employed at the Survey.



## POTENTIAL TARGETS FOR SHALE-OIL AND SHALE-GAS EXPLORATION IN ARIZONA

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



Each year the Arizona Geological Survey publishes a number of geologic reports and maps in the appropriate publication serial, e.g., Open-File Reports (OFR), Digital Geologic Maps (DGM). Additionally, the Survey supports the Contributed Map and Contributed Report series as a venue for geologists from outside the Survey to publish their findings. Physical copies of all AZGS products are available at our Arizona Experience Store (for pricing call or e-mail: 520.770.3500 | [store@azgs.az.gov](mailto:store@azgs.az.gov)), or you can visit our online document repository (<https://repository.azgs.az.gov>) to view or download free high resolution PDF products.

## PUBLICATIONS

The following page include all AZGS published materials for FY2013.

# PUBLICATIONS

## Publications of The Arizona Geological Survey FY2013

### CONTRIBUTED MAP SERIES (CM)

- Martz, J.W., W.G. Parker, L. Skinner, J.J. Raucii, P. Umhoefer and R.C. Blakey, 2012, Geologic map of Petrified Forest National Park, Arizona: Arizona Geological Survey Contributed Map CM12-A, 1 map sheet, map scale 1:50,000, 18 p.
- Murphy, R.T., J.E. Faulds and F.L. Hillemeier, 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.
- Péwé, T.L., R. Kenny and T.J. Bales, 2012, Reconnaissance environmental geology of the Tonto Foothills, Scottsdale, Maricopa County, Arizona: Arizona Geological Survey Contributed Map , 4 map sheets, map scale 1:24,000.

### CONTRIBUTED REPORT SERIES (CR)

- Beck, S., Linkimer, L., Zandt G. and Holland, H., 2013, Focal Mechanisms and Preliminary Attenuation Measurements in Arizona. Arizona Geological Survey Contributed Report CR-13-C , 21 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.
- Fuller, J.E., 2012, Evaluation of avulsion potential on active alluvial fans in central and western Arizona: Arizona Geological Survey Contributed Report CR-12-D, 83 p.
- Hoxie, D.T., 2012, Exhuming the Remains of the Inactive Mountain-Front Pirate Fault, Santa Catalina Mountains, Southeastern Arizona. Arizona Geological Survey Contributed Report CR-12-F, 18 p.
- Huebschman, R.P., 2013, Stratigraphy of lower permian skarn protoliths, Southeastern Arizona: Arizona Geological Survey Contributed Report CR-13-B, 27 p.

### DIGITAL GEOLOGIC MAP SERIES (DGM)

- Ferguson, C.A., B.F. Gootee, P.A. Pearthree, and J.P. Cook, 2012, Geologic map of the Paulden 7 ½' Quadrangle, Yavapai County, Arizona: Arizona Geological Survey Digital Geologic Map DGM91, version 1.0, map scale 1:24,000.
- Ferguson, C.A., J.P. Cook and P.A. Pearthree, 2012, Geologic map of the White Hills West 7 ½' Quadrangle, Mohave County, Arizona: Arizona Geological Survey Digital Geologic Map DGM-97, version 2.0, map scale 1:24,000.

Gootee, B.F., C.A. Ferguson, J.E. Spencer, and J.P. Cook, 2012, Geologic Map of the Spring Water Canyon 7.5' quadrangle, Pima County, Arizona. Arizona Geological Survey Digital Geologic Map DGM-80, map scale 1:24,000.

Johnson, B. J, P.A. Pearthree and C.A. Ferguson, 2012, Geologic map of the Middle Water Spring 7 1/2' Quadrangle, Mohave County, Arizona: Arizona Geological Survey Digital Geologic Map DGM-96, version 1.0, 1 map sheet, map scale 1:24,000.

Pearthree, P.A. and C.A. Ferguson, 2012, Geologic map of the Wineglass Ranch 7 ½' Quadrangle, Yavapai County, Arizona: Arizona Geological Survey Digital Geologic Map DGM-87, version 1.0, map scale 1:24,000.

Pearthree, P.A., 2012, Geologic map of the Yuma southeast 7 ½' Quadrangle, Yuma County, Arizona: Arizona Geological Survey Digital Geologic Map DGM-87, version 1.0, map scale 1:24,000.

Spencer, J.E. and J.J. Young, 2012, Geologic map of the Jerome Canyon 7 ½' Quadrangle, Yavapai County, Arizona: Arizona Geological Survey Digital Geologic Map DGM-94, version 1.0, map scale 1:24,000.

Spencer, J.E., A. Youberg, T.C. Shipman, 2012, Geologic Map of the Spring Water Canyon 7.5' quadrangle, Pima County, Arizona. Arizona Geological Survey Digital Geologic Map DGM-79, 1 plate, map scale 1:24,000.

Youberg, A., J.E. Spencer, and J.P. Cook, 2012, Geologic map of the Prescott Valley North 7 ½' Quadrangle, Yavapai County, Arizona: Arizona Geological Survey Digital Geologic Map DGM-92, version 1.0, map scale 1:24,000.

Young, J.J. and J.P. Cook, 2012, Geologic map of the Chino Valley South 7 ½' Quadrangle, Yavapai County, Arizona: Arizona Geological Survey Digital Geologic Map DGM-93, map scale 1:24,000.

Young, J.J., J.P. Cook, and P.A. Pearthree, 2012, Surficial Geologic Map of the Western Piedmont of the Maricopa Mountains and the Southern Piedmont of the Buckeye Hills, Maricopa County, Arizona. Arizona Geological Survey Digital Geologic Map DGM-75, map scale 1:24,000.

### DIGITAL MAP SERIES (DM)

Arizona Geological Survey, 2012, Earth fissure map of the Bowie San Simon study area: Cochise County, Arizona: Arizona Geological Survey Digital Map – Earth Fissure DM-EF-23, 1 map sheet, map scale 1:24,000.

# PUBLICATIONS

## Publications of The Arizona Geological Survey FY2013 (Continued)

- Arizona Geological Survey, 2012, Earth fissure map of the Croton Springs Study Area: Cochise County, Arizona: Arizona Geological Survey Digital Map – Earth Fissure DM-EF-25, version 1.0, map scale 1:12,000.
- Arizona Geological Survey, 2012, Earth fissure map of the Elfrida Study Area: Cochise County, Arizona: Arizona Geological Survey Digital Map- Earth Fissure DM-EF-24, version 1.0, map scale 1:12,000.
- Arizona Geological Survey, 2012, Earth fissure map of the Picacho & Friendly Corners Study Area: Pinal County, Arizona: Arizona Geological Survey Digital Map- Earth Fissure DM-EF-03, 3 map sheets, map scale 1:24,000.
- Arizona Geological Survey, 2012, Earth fissure map of the Three Sisters Buttes Study Area: Cochise County, Arizona: Arizona Geological Survey Digital Map- Earth Fissure DM-EF-22, version 2.0, 1 map sheet, map scale 1:24,000.
- DOWN TO EARTH SERIES (DTE)**
- Arizona Geological Survey, 2012, Arizona is earthquake country: Down-to-Earth #21, DTE-21, 44 p. Bezy, J.V., 2002, A guide to the geology of Catalina State Park and the Western Santa Catalina Mountains: Arizona Geological Survey Down-to-Earth Series DTE-12, re-released as e-book September 24, 2012, 57 p.
- MAP SERIES (M)**
- Niemuth, N., 2012, Arizona major mines map – 2012, M-37: Arizona Geological Survey (8.5"x11").
- Open-File Report (OFR)
- Brown, C., 2012, Walter E. Heinrichs Jr. mining collection: Arizona Geological Survey Open-File Report OFR-12-13, 45 p.
- Brown, C. and M.L. Allison, 2012, Arizona Geological Survey mining records digitization project: Arizona Geological Survey Open-File Report OFR-12-08, 17 p.
- Brown, C., 2012, ADMMR mining collection inventory: Arizona Geological Survey Open-File Report OFR-12-37, 151 p.
- Brown, C., 2012, ADMMR photo archive: Arizona Geological Survey Open-File Report OFR-12-25, 243 p.
- Brown, C., 2012, Anderson mine collection inventory: Arizona Geological Survey Open-File Report OFR-12-34, 12 p.
- Brown, C., 2012, Arimetco Inc. mining collection inventory: Arizona Geological Survey Open-File Report OFR-12-35, 9 p.
- Brown, C., 2012, Arthur L. Flagg mining photo collection: Arizona Geological Survey Open-File Report OFR-12-11, 14 p.
- Brown, C., 2012, Cambior Exploration USA Inc. mining collection: Arizona Geological Survey Open-File Report OFR-12-19, 16 p.
- Brown, C., 2012, Doug K. Martin mining collection: Arizona Geological Survey Open-File Report OFR-12-15, 11 p.
- Brown, C., 2012, Edwin Noel Pennebaker mining collection: Arizona Geological Survey Open-File Report OFR-12-14, 7 p.
- Brown, C., 2012, Fred Hohne mining collection: Arizona Geological Survey Open-File Report OFR-12-27, 9 p.
- Brown, C., 2012, Frederick Warren Osborn AZ photo collection: Arizona Geological Survey Open-File Report OFR-12-30, 5 p.
- Brown, C., 2012, George M. Colvocoresses mining collection: Arizona Geological Survey Open-File Report OFR-12-17, 18 p.
- Brown, C., 2012, Grover Heinrichs mining collection: Arizona Geological Survey Open-File Report OFR-12-24, 59 p.
- Brown, C., 2012, Guy Atlee mining photo collection: Arizona Geological Survey Open-File Report OFR-12-28, 4 p.
- Brown, C., 2012, James Doyle Sell mining collection: Arizona Geological Survey Open-File Report OFR-12-31, 80 p.
- Brown, C., 2012, John E. Kinnison mining collection: Arizona Geological Survey Open-File Report OFR-12-32, 20 p.
- Brown, C., 2012, Kelsey Boltz mining collection inventory: Arizona Geological Survey Open-File Report OFR-12-38, 22 p.
- Brown, C., 2012, Larry Kersey mining collection inventory: Arizona Geological Survey Open-File Report OFR-12-36, 8 p.
- Brown, C., 2012, Mason Coggin mining photo collection: Arizona Geological Survey Open-File Report OFR-12-29, 9 p.
- Brown, C., 2012, Reconstruction Finance Corporation Arizona records: Arizona Geological Survey Open-File Report OFR-12-18, 10 p.
- Brown, C., 2012, Richard Hahman mining collection: Arizona Geological Survey Open-File Report OFR-12-21, 3 p.



# PUBLICATIONS

## Publications of The Arizona Geological Survey FY2013 (Continued)

- Brown, C., 2012, Richard Mieritz mining collection: Arizona Geological Survey Open-File Report OFR-12-16, 8 p.
- Brown, C., 2012, Richinbar mine photo collection: Arizona Geological Survey Open-File Report OFR-12-12, 7 p.
- Brown, C., 2012, Roland Mulchay mining collection: Arizona Geological Survey Open-File Report OFR-12-20, 14 p.
- Brown, C., 2012, Sylvia Fink mining collection: Arizona Geological Survey Open-File Report OFR-12-33, 4 p.
- Brown, C., 2012, W.H. Crutchfield, Jr. mining collection: Arizona Geological Survey Open-File Report OFR-12-23, 3 p.
- Brown, C., 2012, West Oatman Project mining collection: Arizona Geological Survey Open-File Report OFR-12-22, 5 p.
- EarthCube Governance Working Group, 2012, EarthCube governance framework: A proposal to the community- documentation, research, and recommendations: Arizona Geological Survey Open-File Report OFR-12-39, 199 p.
- EarthCube Governance Working Group, 2012, EarthCube governance roadmap documentation, research, and recommendations: Arizona Geological Survey Open-File Report OFR-12-09, 239 p.
- Gootee, B.F., 2012, Geologic evaluation of the Tucson Basin for carbon dioxide sequestration potential: Arizona Geological Survey Open File Report OFR-12-40, version 1.0, 11 p., 3 plates.
- Gootee, B.F., 2013, An evaluation of carbon dioxide sequestration potential in Mohawk Basin, Gila River Trough, southwestern Arizona: Arizona Geological Survey Open File Report OFR-13-02, 8 p.
- Gootee, B.F., 2013, Geologic evaluation of Yuma Basin for carbon dioxide sequestration potential: Arizona Geological Survey Open File Report OFR-13-04, 17 p., 3 map plates.
- Gootee, B.F., M.K. Mahan and D.S. Love, 2012, A summary of salinities in Arizona's deep groundwater: Arizona Geological Survey Open File Report OFR-12-26, 23 p.
- Patten, K., 2013, National Geothermal Data System: Transforming the discovery, access, and analytics of data for geothermal exploration: Arizona Geological Survey Open File Report OFR-13-06, 37 p.
- Pearthree, P.A., J.J. Young and J.P. Cook, 2012, Surficial geology and flood hazards on the western piedmont of the Maricopa Mountains and the southern piedmont of the Buckeye Hills, Maricopa County, Arizona: Arizona Geological Survey Open-File Report OFR-12-07, 23 p.
- Rauzi, S.L. and J.E. Spencer, 2012, An evaluation of CO<sub>2</sub> sequestration potential of Paleozoic sandstone units, Northeastern Arizona: Arizona Geological Survey Open File Report OFR-12-10, 24 p.
- Rauzi, S.L. and J.E. Spencer, 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.
- Spencer, J.E., 2013, The Sonoran Desert Heritage Proposal: An evaluation of the mineral resource potential of lands proposed for withdrawal from mineral entry: Arizona Geological Survey Open File Report OFR-13-03, 30 p.
- Spencer, J.E., C.A. Ferguson and S.M. Richard, 2012, Geologic field guides to the southeastern Picacho Mountains and Picacho Peak, Pinal County, Arizona: Arizona Geological Survey Open-File Report OFR-12-04, 13 p.

### EXTERNAL PUBLICATIONS INCLUDING AZGS STAFF

- Allison, M.L. and G. Pearthree, 2012, Gathering community input on governance for cyberinfrastructure in the geosciences (poster), Geological Society of America Abstracts with Programs, Vol. 44, No. 7, p. 405.
- Allison, M.L., R. Davis, M. Conway, and R. Bellasai, 2012, The Virtual Arizona Experience: the land (poster), Geological Society of America Abstracts with Programs. Vol. 44, No. 7, p.405.
- Allison, M.L., S. Richard, R. Clark, D. Love, K. Patten, C. Coleman, C. Caudill, G. Chen, J. Day, J. Matti, E. Pape, and L. Musil, 2012, National Geothermal Data System: state geological survey contributions to date, Geological Society of America Abstracts with Programs, Vol. 44, No. 7, p. 353.
- Allison, M.L., S.M. Richard, R.C. Clark, K. Patten, D.S. Love, C. Coleman, G. Chen, J. Matti, J. Day, E. Pape, L. Musil, C. Caudill, 2012, A geothermal data system for exploration and development, Geothermal Resources Council Transactions, Geothermal Resources Council Annual Meeting, Vol. 36, 99 – 605 pp.
- Allison, M.L., J. Spencer, M. Conway, and N. Niemuth, 2012, Mineral and energy resources of Arizona 2012, A briefing paper for the Arizona Joint Legislative Budget Committee, August 31, 2012, 10 p.

# PUBLICATIONS

## Publications of The Arizona Geological Survey FY2013 (Continued)

- Anderson, Arlene, Blackwell, David, Chickering Cathy, Boyd, Toni, Horne, Roland, MacKenzie, Matthew, Moore, Joe, Nickull, Duane, Richard, Stephen, Shevenell, Lisa, "National Geothermal Data System (NGDS) Geothermal Data Domain: Assessment of Geothermal Community Data Needs," Proceedings of the 38th Stanford Geothermal Workshop on Reservoir Engineering, Stanford, California, February 11, 2013.
- Blackman, Harold, Boyd, Suzanne, Patten, Kim, and Zheng, Sam, "NGDS User Centered Design – Meeting the Needs of the Geothermal Community," Proceedings of the 38th Stanford Geothermal Workshop on Reservoir Engineering, Stanford, California, February 11, 2013.
- Bowring, J., M.L. Allison, G. Crane, C. DeLuca, C. Hood, C. MacDermaid, J. Pearlman, G. Pearthree, M. Ramamurthy, E. Robinson, and I. Zaslavsky, 2013, EarthCube's Governance Working Group Steering Committee presents roadmap at the June 2012 EarthCube Charrette, Eos, newsletter of the American Geophysical Union 406 p.
- Clark, Ryan, Kuhmuench, Christoph, Richard, Stephen, "NGDS Node Deployment Adoption of CKAN for Domestic and International Data Deployment," Proceedings of the 38th Stanford Geothermal Workshop on Reservoir Engineering, Stanford, California, February 11, 2013.
- EarthCube Governance Steering Committee and Collaborators, A Governance Roadmap and Framework for EarthCube, Geophysical Research Abstracts, Vol. 15, EGU2013-12322, 2013 EGU General Assembly 2013.
- Richard, S.M., 2012, Geo SciML portrayal – a path to interoperable web map services (poster), Geological Society of America Abstracts with Programs, Vol. 44, No. 7, p. 255.
- Richard, S.M., 2012, A geologic unit scheme for regional geologic map integration (poster), Geological Society of America Abstracts with Programs, Vol. 44, No. 7, p. 255.



Photo by Terri Garside

A chief function of the Arizona Geological Survey is to inform stakeholders of work products via press releases, presentations, public and conference exhibits, workshops, and field trips. We take this task seriously and, in FY2013, AZGS staff participated in dozens of events informing our stakeholders – geoscientists, policy makers, federal, state and local government, and the Arizona public – of our efforts.

The following pages include many AZGS outreach events for FY2013.

## PRESENTATIONS & OUTREACH

# PRESENTATIONS & OUTREACH

## Professional Presentations

### PRESENTATIONS

- Allison, M.L., S.M. Richard, R. Clark, K. Patten, C. Coleman, C. Caudill, G. Chen, 2012, Implementing USGIN, a Distributed Data Network for Geoscience Information, ESIP Federation Summer Meeting, Pyle Center, University of Wisconsin-Madison, July 17, 2012.
- Allison, M.L., 2012, EarthCube governance roadmap and workshops, ESIP Federation Summer Meeting, Pyle Center, University of Wisconsin-Madison, July 19, 2012.
- Allison, M.L., 2012, EarthCube: How do we organize, manage, and govern?, seminar, ESIP Federation Summer Meeting, Madison, Wisconsin, July 19, 2012.
- Allison, M.L., 2012, Building cyberinfrastructure in the geosciences – the USGIN experience, Geoscience Australia, Canberra, Australia, July 30, 2012.
- Allison, M.L. and S.M. Richard, 2012, U.S. Geothermal Data System, 34th International Geological Congress, Brisbane, Australia, August 6, 2012.
- Allison, M.L., K.T. Gallagher, S.M. Richard, and V. Hutchison, 2012, Strategic roadmap for the U.S. Geoscience Information Network, 34th International Geological Congress, Brisbane, Australia, August 6, 2012.
- Allison, M.L. and S. Rauzi, 2012, Challenges to developing potash in the Holbrook basin, Arizona, USA, 34th International Geological Congress, Brisbane, Australia, August 7, 2012.
- Allison, M.L., R. Atkinson, D. Arctur, S. Cox, I. Jackson, S. Nativi, and L. Wyborn, 2012, International convergence on geoscience cyberinfrastructure, 34th International Geological Congress, Brisbane, Australia, August 9, 2012.
- Allison, M.L., 2012, Arizona's other mineral potential, Arizona Mining Association Annual Meeting and Strategic Planning Retreat, Sedona, Arizona, August 28, 2012.
- Allison, M.L., 2012, Arizona contributions to the National Geothermal Data System, Arizona Governor's Office of Energy Policy's Geothermal Workshop, September 6, 2012.
- Allison, M.L., 2012, panel discussion on Big Data, American Geosciences Institute Leadership Forum, Washington, DC, September 10, 2012.
- Allison, M.L., 2012, Sustainability of USGIN and NGDS, AASG Liaison Meeting, Washington, DC, September 10, 2012.
- Allison, M.L., 2012, keynote address, Arizona's Geologic Hazards, Arizona Hydrologic Society 25th Annual Water Symposium, Phoenix, Arizona, September 19, 2012.
- Allison, M Lee, Richard, Stephen M., Clark, Ryan C., Patten, Kim J., Love, Diane S., Coleman, Celia, Chen, Genhan, Matti, Jordan, Day, Janel, Pape, Esty, Musil, Leah, and Caudill, Christy, "A Geothermal Data System for Exploration and Development," Geothermal Resources Council Annual Meeting, Reno, Nevada, October 1, 2012.
- Allison, M.L. and G. Pearthree, 2012, Gathering community input on governance for EarthCube (poster), EarthCube End-user Domain Workshop for EarthScope, Arizona State University, Tempe, Arizona, October 29, 2012.
- Allison, M.L. and G. Pearthree, 2012, Gathering community input on governance for cyberinfrastructure in the geosciences (poster), Geological Society of America Annual Meeting, Geological Society of America Abstracts with Programs, Vol. 44, No. 7, p. 405, Charlotte, North Carolina, November 6, 2012.
- Allison, M.L., 2012, USGIN strategic vision for AASG, Association of American State Geologists Mid-Year Meeting, Charlotte, North Carolina, November 6, 2012.
- Allison, M.L., R. Davis, M. Conway, and R. Bellasai, 2012, The Virtual Arizona Experience: the land (poster), Geological Society of America conference, Geological Society of America Abstracts with Programs. Vol. 44, No. 7, p.405, Charlotte, North Carolina, November 6, 2012.
- Allison, M.L., S. Richard, R. Clark, D. Love, K. Patten, C. Coleman, C. Caudill, G. Chen, J. Day, J. Matti, E.Pape, and L. Musil, 2012, National Geothermal Data System: state geological survey contributions to date, Geological Society of America conference, Geological Society of America Abstracts with Programs, Vol. 44, No. 7, p. 353, Charlotte, North Carolina, November 6, 2012.
- Allison, M. Lee, 2012, The National Geothermal Data System and the Energy-Water Nexus, Energy/Water Datasets and Models Workshop, U.S. DOE, Virtual, November 28, 2012.
- Allison, M.L., R. Davis, F.M. Conway, and R. Bellasai, 2012, The Virtual Arizona Experience (poster), American Geophysical Union Fall Meeting, San Francisco, California, December 3, 2012.

# PRESENTATIONS & OUTREACH

## Professional Presentations (Continued)

- Allison, M.L., co-convenor, on behalf of EarthCube Governance Steering Committee, 2012, A governance roadmap for cyberinfrastructure in the geosciences (posters), Technical Session, American Geophysical Union Fall Meeting, San Francisco, California, December 4, 2012.
- Allison, M.L., co-convenor, Towards a global cyberinfrastructure for the geosciences, Union Session, American Geophysical Union Fall Meeting, San Francisco, California, December 5, 2012.
- Allison, M.L. and G. Pearthree, 2013, EarthCube governance framework- A proposal to the community, (webcast), Breakout Session, ESIP Federation Annual Meeting, Washington DC, January 8, 2013. <http://commons.esipfed.org/node/674>
- Allison, M.L., moderator, EarthCube Townhall, Breakout Session, ESIP Federation Annual Meeting, Washington DC, January 9, 2013.
- Allison, M.L., 2013, Arizona's potash potential, Little Colorado River RC&D Winter Watershed Conference, Show Low, Arizona, February 1, 2013.
- Allison, M.L. and G. Pearthree, 2013, EarthCube Governance Framework- A proposal to the community, (webcast), EarthCube Cyberinfrastructure for Paleogeoscience Workshop, Minneapolis, Minnesota, February 4, 2013.
- Allison, M. Lee, 2013, AASG update, AIPG Board, Mid-year Meeting, Tucson, Arizona, February 15, 2013.
- Allison, M. Lee, 2013, AZGS update, AIPG Arizona Chapter, Annual Business Meeting, Tucson, AZ, February 16, 2013.
- Allison, M.L. and G. Pearthree, 2013, EarthCube governance framework- A proposal to the community, (webcast), XSEDE Minority Research Council, February 22, 2013.
- Allison, M.L., 2013, Havasu Canyon Flood, Apache Junction Unified School District 2013 Arizona Lecture Series, Apache Junction, Arizona, March 4, 2013.
- Allison, M.L., 2013, An NGDS model for Canada, CanGEA Annual Meeting, Calgary, Canada, March 21, 2013.
- Allison, M.L., 2013, NGDS: transforming geothermal exploration, Canadian Geothermal Energy Association Annual Meeting, Calgary, Alberta, Canada, March 21, 2013.
- Allison, M.L. and G. Pearthree, 2013, EarthCube governance framework- A proposal to the community, (webcast), Sedimentary Geology Community Workshop on EarthCube Cyberinfrastructure, Salt Lake City, Utah, March 25, 2013.
- Allison, M.L., S.M. Richard, R. Clark, D. Love, K. Patten, C. Coleman, C. Caudill, E. Pape, G. Chen, J. Day and L. Musil, 2013, The National Geothermal Data System: A National, Sustainable, Distributed, Interoperable Data Network, Research Data Access and Preservation Summit 2013, Baltimore, Maryland, April 4, 2013, [http://www.slideshare.net/assist\\_org/lt-title-nationalgeothermal-data-system-a-national-sustainable-distributed-interoperable-data-network](http://www.slideshare.net/assist_org/lt-title-nationalgeothermal-data-system-a-national-sustainable-distributed-interoperable-data-network), Research Data Access & Preservation Summit 2013, Baltimore, MD, April 4, 2013.
- Allison, M.L. on behalf of EarthCube Governance Steering Committee and Collaborators, 2012, A governance roadmap and framework for EarthCube (poster), European Geophysical Union General Assembly, Vienna, Austria, April 8, 2013.
- Allison, M.L. and S.M. Richard, 2013, AASG state geological survey contributions to the NGDS, Geothermal Technologies Office Annual Peer Review, Denver, Colorado, April 22, 2013.
- Allison, M.L., 2013, Hutchinson (KS) natural gas explosions: a geologic mystery, Cornell University geosciences lecture, Ithaca, New York, April 30, 2013.
- Allison, M.L., 2013, The Digicene: the age of digital geosciences, Cornell University Lecture Series, Ithaca, New York, May 1, 2013.
- Allison, M.L., 2013, The NGDS overview seminar, Cornell Energy Institute & Atkinson Center for a Sustainable Future, Cornell University, Ithaca, New York, May 1, 2013.
- Allison, M.L., 2013, National Geothermal Data System – An AASG success story, Association of American State Geologists Annual Meeting, Deadwood, South Dakota, June 10, 2013.
- Allison, M.L., moderator, Web accessibility strategies (online simulcast), Association of American State Geologists Annual Meeting, Deadwood, South Dakota, June 10, 2013.
- Allison, M.L., 2013, NGDS project annual meeting: sustainability and additional funding options, Association of American State Geologists Annual Meeting, Deadwood, South Dakota, June 11, 2013.
- AZGS, 2012, Updated Data Delivery Tools for AASG NGDS, October 4, 2012.
- AZGS, 2013, Hosting the Western Regional Partnership

# PRESENTATIONS & OUTREACH

## Professional Presentations (Continued)

- (WRP) Southeastern Arizona/New Mexico project meeting at its offices, Tucson, Arizona, April 17, 2013.
- Clark, R., Kuhmuench, C., Richard, S., 2013, NGDS node deployment adoption of CKAN for domestic and international data deployment, 38th Stanford Geothermal Workshop on Reservoir Engineering, Stanford, California, February 11, 2013.
- Clark, R., Genhan, C., Kuhmuench, C., 2013, An open source stack for the National Geothermal Data System, Free and Open Source Software for Geospatial North America (FOSS-4G), Minneapolis, Minnesota, May 22, 2013.
- Clark, R., 2013, Faster, more responsive web GIS: Three technologies to watch, Digital Mapping Techniques 2013, Denver, Colorado, June 3, 2013.
- Conway, B. and J. Cook, 2012, Monitoring evaporite karst activity and land subsidence in the Holbrook Basin, Arizona using interferometric synthetic aperture radar (InSAR), Arizona Hydrological Society, Phoenix, Arizona, December 11, 2012.
- Conway, F.M., 2012, Tour of Microsoft Research's World Wide Telescope, Webinar, Tucson, Arizona, July 2, 2012.
- Conway, F.M., 2012, AZGS Geologic Extension Service, 2012, The Arizona Experience for teachers, Arizona Historical Society's Summer Science Institute, Papago Park Museum, Tempe, Arizona, July 10, 2012.
- Conway, F.M., 2012, Earth Fissures in Central and Southern Arizona, Keller Williams Realty, Tempe, Arizona, July 18, 2012.
- Conway, F.M., 2012, The Arizona Experience: An online resource for K-12 teachers, (4 sessions), Yavapai County Educational Technology Consortium's (YCETC) 1st Annual Distance Learning Showcase, Yavapai College, Prescott, Arizona, July 24-25, 2012.
- Conway, F.M., 2012, The Arizona Experience- An online resource for Arizona K-12 teachers, Astronomical Society of the Pacific 2012 Annual Meeting: Communicating Science: A National Conference on Science Education and Public Outreach, Tucson, Arizona, August 8, 2012.
- Conway, F.M., 2012, Volcanoes and Arizona Geology, (2 sessions), Arizona-Sonora Desert Museum's Warren Oasis Theater, August 11, 2012.
- Conway, F.M., 2012, The Arizona Experience – an online resource for teachers, Central Arizona College, Coolidge, Arizona, August 25, 2012.
- Conway, F.M., 2012, Introduction to Microsoft Research's WorldWide Telescope, Arizona-Sonora Desert Museum, August 25, 2012.
- Conway, F.M., 2012, The Arizona Experience: An online resource for K-12 teachers, Arizona Geographic Alliance Fall GeoConference, Scottsdale, Arizona, September 8, 2012.
- Conway, F.M., 2012, Panel Discussion – How to bring cutting edge research to the community, Arizona SciTech Festival 2013 Kick-off Reception, ASU Scottsdale Innovation Center, Scottsdale, Arizona, September 10, 2012.
- Conway, F.M., 2012, The Arizona Experience: An online resource for K-12 teachers, APS Back to School Resource Fair and Reception, Arizona State University, Tempe, Arizona, September 22, 2012.
- Conway, F.M., 2012, AZGS- Earth Fissures, Geologic Mapping and more, Casa Grande Rotary Club Luncheon, Casa Grande, Arizona, October 9, 2012.
- Conway, F.M., 2012, Volcanic systems of Arizona webinar with North Canyon High School, Ms. Shannon World's Earth Science classes, Scottsdale, Arizona, November 20, 2012.
- Conway, F.M., 2012, Arizona's Wealth: minerals and mining, Osher Livelong Learning Institute, Florence, Arizona, December 7, 2012.
- Conway, F.M., 2012, Arizona's Wealth: minerals and mining, part II, Osher Livelong Learning Institute, Florence, Arizona, December 14, 2012.
- Conway, F.M., The state of seismicity in Arizona, National Earthquake Program Managers meeting in Seattle, Washington, April 30-May 3, 2013.
- Conway, F.M., 2013, Arizona Experience Online: Embracing digital resources to enrich lesson plans and stimulate learning, Arizona Department of Education Leading Change Conference, Westin La Paloma, Tucson, Arizona, June 25, 2013.
- Conway, F.M., 2013, Connecting with the Virtual Arizona Experience, Arizona Historical Society Making Connections: Science and Social Studies Workshop, Papago Museum, Tempe, Arizona, June 27, 2013.
- Day, J., 2013, Integrating GeoSciML with OneGeology, Digital Mapping Techniques 2013, Denver, Colorado, June 4, 2013.
- Day, J., 2013, Streamlining geologic map production and archiving with NCGMP Tools, Digital Mapping Techniques 2013, Denver, Colorado, June 5, 2013.
- Gootee, B.F., "Lava Dams and Lepidodendrons –

# PRESENTATIONS & OUTREACH

## Professional Presentations (Continued)

- Techniques in dating rocks of Grand Canyon, Grand Canyon National Park Community Building, February 9, 2013.
- Gootee, B.F., 2013, Salinity and sequestration of CO<sub>2</sub> throughout Arizona and the Higley Basin: a geologic perspective, Arizona Hydrological Society, Phoenix, Arizona, April 9, 2013.
- McDowell, S., C. Miller, C. Ferguson (AZGS), C. Fisher, W. Frazier, J. Miller, R. Mundil, S. Overton, and J. Vervoort, 2012, Geochemical insights into the evolution of a supereruptive volcanic center: magmatic precursors and successors of the Miocene Peach Spring Tuff, Southern Black Mountains, Western Arizona, Geological Society of America conference, Charlotte, North Carolina, November 5, 2012.
- Miller, C., W. Frazier, S. McDowell, A. Pamukcu, T. Carley, G. Gualda, J. Miller, C. Ferguson (AZGS), C. Fisher, and J. Vervoort, 2012, Peach Spring Tuff, Az-Ca-Nv: Supereruption of a stratified, mush-based magma chamber, Geological Society of America conference, Charlotte, North Carolina, November 5, 2012.
- Moosdorf, N. and S.M. Richard, 2012, A lithology based map unit schema for Onegeology regional geologic map integration (poster), American Geophysical Union Fall Meeting, San Francisco, California, December 5, 2012.
- Niemuth, N., Central Arizona Mining and Exploration Activity, Central Arizona Geology Club Speaker Series, Prescott, Arizona, September 9, 2012.
- Niemuth, N., 2013, Mining and Exploration in Central Arizona, Arizona Leaverites at ASU's Physical Science Building F in Tempe, Arizona, January 22, 2013.
- Niemuth, N., 2013, Mining and Exploration in Central Arizona, Arizona Prospectors Association Meeting, Saint Andrews Episcopal Church, Glendale, Arizona, February 19, 2013.
- Patten, K., M.L. Allison, S.M. Richard, R. Clark, D. Love, C. Coleman, C. Caudill, J. Matti, L. Musil, J. Day, G. Chen, E. Pape, National Geothermal Data System: state geological survey contributions to date, American Geophysical Union Fall Meeting, San Francisco, California, December 3, 2012.
- Patten, K., 2013, Arizona's geothermal energy potential and the NGDS, Arizona Governor's Office of Energy Policy's Geothermal Energy Workshop IV, Phoenix, Arizona, May 2, 2013.
- Patten, K., 2013, NGDS user interface, Association of American State Geologists Annual Meeting, Deadwood, South Dakota, June 10, 2013.
- Pearthree, P., 2012, Seismic hazard in Arizona: New insights from research in the past 15 years, Association of Environmental & Engineering Geologists Annual Meeting, Salt Lake City, Utah, September 20, 2012.
- Pearthree, G. and M.L. Allison, 2012, Mayor of EarthCube: cities as an analogue for cyberinfrastructure (poster), American Geophysical Union Fall Meeting, San Francisco, California, December 4, 2012.
- Richard, S.M. and Allison, M.L., 2012, Access to state geological survey data for geothermal energy development in the United States, 34th International Geological Congress, Brisbane, Australia, August 7, 2012.
- Richard, S.M., R.C. Clark, K.J. Patten, D.S. Love, C. Coleman, G. Chen, J. Matti, J. Day, E. Pape, L. Musil, and C. Caudill, A geothermal data system for exploration and development, Geothermal Resources Council Annual Meeting, Reno, Nevada, October 1, 2012. [GRC Best Presentation Award]
- Richard, S.M., 2012, A geologic unit scheme for regional geologic map integration (poster), Geological Society of America conference, Charlotte, North Carolina, November 5, 2012.
- Richard, S.M., 2012, GeoSciML portrayal – a path to interoperable web map services (poster), Geological Society of America conference, Charlotte, North Carolina, November 5, 2012.
- Richard, S.M., 2012, Interoperability Working Group Commission for the Management and Application of Geoscience Information, IUGS, GeoSciML and EarthResourceML Update, 2012 (poster), American Geophysical Union Fall Meeting, San Francisco, California, December 5, 2012.
- Richard, S.M., 2013, Future of Canadian & global databases, CanGEA Annual Meeting, Calgary, Canada, March 21, 2013.
- Richard, Stephen, "Mapping & Database Workshop," CanGEA Annual Meeting, Calgary, Canada, March 21, 2013.
- Richard, S.M., 2013, NGDS system design, CanGEA Annual Meeting, Calgary, Alberta, Canada, March 21, 2013.
- Richard, S.M., R. Clark, G. Chen, and A. Anderson, 2013, U.S. National Geothermal Data System: web feature services and system operations, European Geophysical Union General Assembly, Vienna,

# PRESENTATIONS & OUTREACH

## Professional Presentations (Continued)

- Austria, April 8, 2013.
- Richard, S.M., 2013, Terminology development to support geoscience information interoperability: the CGI Geoscience Terminology Working Group, IUGS Commission for Management of Geoscience Information (CGI) GeoSciML and GTWG workgroup meetings plenary session, St. Petersburg, Russia, June 1, 2013.
- Spencer, J.E., S.J. Rauzi and B. Gootee, 2012, Geologic carbon-sequestration potential in Arizona, WESTCARB 2012 Annual Business Meeting, Bakersfield, California, October 17, 2012.
- Spencer, J.E., 2012, A brief geologic history of the Santa Rita Mountains, Discovery Saturday Series, Florida Station, SRER Headquarters, Green Valley, Arizona, October 20, 2012.
- Spencer, J.E., 2013, Federal lands and mineral resources: Colorado Plateau uranium deposits and the Sonoran Desert Heritage proposal, Arizona Geological Society monthly dinner meeting, May 7, 2013.
- Van Daalen, T. and M.L. Allison, 2012, OneGeology – a geoscience exemplar for worldwide cyberinfrastructure capacity-building and scientific innovation (poster), American Geophysical Union Fall Meeting, San Francisco, California, December 4, 2012.
- Youberg, A., 2012, Introduction to hydrology, watersheds and wildfires, BIA Water Resources Technician Training Workshop, University of Arizona's Hydrology and Water Resources Department, Tucson, Arizona, July 10, 2012.
- Youberg, A. and J. Young, Arizona Department of Emergency Management (ADEM) panel presentation at the County and Tribal Directors meeting. Discussion focused on post-fire and seismic hazards and ongoing efforts to address these problems, July 26, 2012.
- Youberg, A. and R. Ryan of Coconino County Flood Control, 2012, Panel discussion of wildfire trends and post-fire geomorphic responses, and flooding specifics in the downstream communities after the Schultz Fire, 2012 APA Arizona Conference, Flagstaff, Arizona, September 20, 2012.
- Youberg, A., 2013, Floods, debris flows and erosion following the fire, Southwest Society of American Foresters annual meeting, Willcox, Arizona, February 22–23, 2013.
- Young, J., 2013, An update on Arizona seismicity, Southwestern U.S. Ground Motion Characterization, Oakland, California, March 19-21, 2013.

### CONFERENCE BOOTHS

- September 24–26, 2012 | MINExpo International 2012, Association of American State Geologists booth, Las Vegas, Nevada.
- September 30–October 3, 2012 | Geothermal Resources Council Annual Meeting, Reno, Nevada.
- November 4–7, 2012 | Geological Society of America Annual Meeting, Charlotte, North Carolina.
- December 3-7, 2012 | American Geophysical Union Fall Meeting, San Francisco, California.
- February 16, 2013 | Geothermal Energy in Arizona: the role of the National Geothermal Data System, Science in the City, Tech in Tucson Showcase, Tucson Electric Power Headquarters, Tucson, Arizona.
- April 22-24, 2013 | U.S. Department of Energy, Geothermal Technologies Office Annual Peer Review, Denver, Colorado.
- May 19-22, 2013 | American Association of Petroleum Geologists (AAPG) Annual Meeting, Pittsburgh, Pennsylvania.

### WORKSHOPS

- July 26, 2012, Imagine Arizona: WorldWideTelescope Workshop for Teachers, Phoenix, Arizona, M. Conway, July 26, 2012.
- September 5–6, 2012 | AASG State Geological Survey's Contributions to the National Geothermal Data System Hub Training Workshop, Tucson, Arizona.
- September 6, 2012 | Lee Allison presented his paper, 2012, "Arizona contributions to the National Geothermal Data System" at the Arizona Governor's Office of Energy Policy's Geothermal Workshop.
- June 26, 2013 | Arizona eLearning Networking Workshop hosted at AZGS offices in Tucson.
- May 2, 2013 | Kim Patten presented an overview on geothermal resources at the Geothermal Workshop IV hosted by the Governor's Office of Energy Policy at the State Capitol building, Phoenix.
- May 14, 2013, Association of American State Geologists National Geothermal Data System Western Regional Hub, Reno, Nevada.



# PRESENTATIONS & OUTREACH

## Outreach

### PUBLIC PRESENTATIONS

- Allison, M.L., 2013, Mining records digitizing project, Arizona Mining Alliance, Tucson, Arizona, July 13, 2012.
- Allison, M.L., 2012, Arizona gold mining activity – 2012, Arizona Mining Alliance, Tucson, Arizona, September 14, 2012.
- Allison, M.L., 2012, EarthCube governance, EarthCube Early Career End User Domain Workshop, Washington, DC, October 16, 2012.
- Allison, M.L., 2012, Carbon sequestration potential in Arizona, Arizona Mining Alliance, Tucson, Arizona, November 16, 2012.
- Allison, M.L., 2012, AZGS 125th Anniversary, Arizona Mining Alliance, Tucson, Arizona, December 14, 2012.
- Allison, M.L., 2013, Havasu Canyon Flood, Performing Arts Center of Apache Junction High School, March 4, 2013. Dr. Allison's lecture was part of the Apache Junction Unified School District's (AJUSD) 2013 Arizona Lecture Series.
- Allison, M.L., 2013, Arizona rankings in the Fraser Institute Survey, Arizona Mining Alliance, Tucson, Arizona, March 8, 2013.
- Allison, M.L., 2013, Report on NSF advanced cyber-infrastructure, Advisory Committee for Geosciences, National Science Foundation, Arlington, Virginia, April 11, 2013.
- Allison, M.L., 2013, Arizona coal resources, Master Energy Plan Task Force, Environment, Natural Resources and Land Use Work Group, Phoenix, Arizona, May 8, 2013.
- Allison, M.L., 2013, Sonoran Desert Heritage Area mineral resources, Arizona Mining Alliance, Tucson, Arizona, May 10, 2013.
- AZGS, 2013, The Arizona Experience website, Sky Bar for a stellar evening in an astronomy themed science café along with the National Optical Astronomy Observatory and Tucson Amateur Astronomy Association, Tucson, Arizona, April 25, 2013.
- Bellassai, R., 2013, Information about the Arizona Experience website and store, El Presidio Neighborhood Association, Tucson, Arizona, January 21, 2013.
- Conway, F.M., 2012, The Arizona Experience: Your passport to Arizona's public lands, Destination AZ Showcase Luncheon, 2012 Arizona Governor's Conference on Tourism, Arizona Biltmore, Phoenix, Arizona, July 12, 2012.
- Conway, F.M., 2012, Earth Fissures in Central and Southern Arizona, Keller Williams Realty, Tempe, Arizona, July 18, 2012.
- Conway, F.M., 2012, Volcanoes and geology, a virtual tour of Arizona's volcanoes, Arizona- Sonora Desert Museum, Tucson, Arizona, August 11, 2012.
- Conway, F.M., 2012, Introduction to Microsoft Research's WorldWide Telescope, Arizona-Sonora Desert Museum, Tucson, Arizona, August 25, 2012.
- Conway, F.M., 2012, The Arizona Geological Survey – Earth Fissures, Geologic Mapping & More, Casa Grande Rotary Club luncheon, Casa Grande, Arizona, October 9, 2012.
- Conway, F.M., 2012, Arizona's Wealth: Minerals and Mining, Osher Lifelong Learning Institute, Florence, Arizona, December 7, 2012.
- Conway, F.M., 2012, Arizona's Wealth: Minerals and Mining, Part 2, Osher Lifelong Learning Institute, Florence, Arizona, December 14, 2012.
- Conway, F.M., The origin and distribution of earth fissures of Cochise County, Wings Over Willcox, Willcox Community Center, Willcox, Arizona, January 18, 2013.
- Conway, F.M., 2012, Exploring Maps" at the annual Arizona Renaissance Festival Student Days, Gold Canyon, Arizona, February 12- 14, 2013.
- Day, J., 2013, Best practices and the state of the GIS industry in Tucson, panel, University of Arizona Geographic Information Systems Career Day, March 6, 2013.
- Gootee, B., 2013, Lava dams and lepidodendrons – Techniques in dating rocks of Grand Canyon, Community Building, Grand Canyon National Park, February 9, 2013.
- Niemuth, N., 2012, Central Arizona mining and exploration activity, Central Arizona Geology Club, Prescott, Arizona, September 11, 2012.
- Niemuth, N., 2013, Mining and exploration in central Arizona, Arizona Leaverites, Arizona State University Physical Science Building F, Tempe, Arizona, January 22, 2013.
- Niemuth, N., 2013, Mining and exploration in central Arizona, Arizona Prospectors Association, St. Andrew's Episcopal Church, Glendale, Arizona, February 19, 2013.
- Spencer, J.A., 2012, A brief geologic history of the Santa Rita Mountains, Discovery Saturday illustrated talk at the Florida Station, SRER headquarters in the Santa Rita Mountains east of Green Valley, Arizona,

# PRESENTATIONS & OUTREACH

## Outreach (Continued)

October 20, 2012.  
Youberg, A., 2013, Geomorphic responses of burned watersheds in Arizona: Floods, debris flows and long-term recovery, Learning to Live with the Heat: Adapting to a Changing Climate in the Sky Island Region, Tucson, Arizona, May 22, 2013.

### **PUBLIC EXHIBITS**

July 11–13, 2012 | The Arizona Experience booth, 2012 Arizona Governor’s Conference on Tourism, Arizona Biltmore, Phoenix, Arizona.

August 25, 2012 | The Arizona Experience booth, Arizona-Sonora Desert Museum’s Teacher Appreciation Night, Tucson, Arizona.

October 13–14, 2012 | The Arizona Experience Store booth, 38th Annual Huachuca Mineral & Gem Club’s Gem Show, Sierra Vista, Arizona.

October 16, 2012 | The Arizona Experience Store hosted its first book signing with Sarah Andrews, author of Rock Bottom, who presented “CSI Grand Canyon: Murder on a Raft Trip Down the Colorado Can Make Learning Geology Much More Interesting,” Tucson, Arizona.

October 23, 2012 | The Arizona Experience website exhibit, AZBio Awards celebration, Phoenix, Arizona.

November 2, 2012 | AZGS Geologic map construction, 15th Annual Pima County GIS Fair, Tucson, Arizona.

February 12 & 14, 2013 | AZGS exhibit “Exploring Maps,” annual Arizona Renaissance Festival Student Days, Gold Canyon, Arizona.

February 14–17, 2013 | AZGS booth, Tucson Gem & Mineral Show, Tucson Convention Center, Tucson, Arizona.

February 16, 2013, AZGS booth, Geothermal Energy in America: The role of the National Geothermal Data System, Science in the City, Tech in Tucson Showcase, TEP Headquarters, Tucson, Arizona, February 16, 2013.

March 9-10, 2013 | AZGS booths, Tucson Festival of Books, including drawing caricatures and filming personal histories at The Arizona Experience booth and selling uniquely Arizonan books and gifts at the Arizona Experience Bookstore booth, Tucson, Arizona.

April 25, 2013, Stars & Bar- The Clark Telescope, Arizona Experience Science Cafe with Lowell Observatory, Sky Bar, Tucson, Arizona.

April 27, 2013, F.M. Conway and R. Bellasai, The Arizona Experience website, Teacher Day at UA Programs

& Resources Expo, sponsored by Tucson Values Teachers, University of Arizona, Tucson, Arizona.  
June 24, 2013 | The Arizona Experience demonstration of the website’s education tools, FAIR for Education, Tucson High Magnet School, Tucson, Arizona.

### **NEWS MEDIA INTERVIEWS AND GENERAL INTEREST ARTICLES**

October 12, 2012, Michael Conway on the Great Arizona ShakeOut, Verde Independent, Verde, Arizona.

October 12, 2012, Michael Conway on the Great Arizona ShakeOut event, Prescott Daily Courier, Prescott, Arizona.

October 16, 2012, Michael Conway on earthquake risk in Arizona, KJZZ Radio (91.5), Phoenix, Arizona.

October 16, 2012, Michael Conway on earthquake potential in central and northern Arizona, AZTV-7, Cable 13, Prescott, Arizona.

October 16, 2012, Michael Conway on earthquake potential in southwest Arizona and the Great Arizona ShakeOut, Yuma Daily Sun, Yuma, Arizona.

October 17, 2012, Michael Conway on Arizona seismicity and earthquake preparedness, KTAR Talk Radio, Phoenix, Arizona.

October 17, 2012, Michael Conway interview by Cronkite News, Arizona Earthquakes and EarthScope.

October 17, 2012, Michael Conway interview by Mohave Valley News, Arizona participation in the Great ShakeOut of 2012.

October 18, 2012, Michael Conway on KVOA News, The Great Arizona ShakeOut, Tucson, Arizona.

October 18, 2012, Michael Conway, ShakeOut prepares 62,000 Arizonans for earthquakes, KSWT Radio, Yuma, Arizona.

October 18, 2012, Jeri Young on the Great Arizona Shakeout 2012, CBS-5 KPHO, Phoenix, Arizona.

October 28, 2012, Michael Conway interview, ShakeOut prepares 62,000 Arizonans for earthquakes, Red Rock News, Sedona-Cottonwood, Arizona.

October 29, 2012, Michael Conway interview, Earthquakes in Morenci, Arizona, KJZZ Radio, Phoenix, Arizona.

November 1, 2012, Michael Conway, Earthquake swarm in northern Greenlee County, Eastern Arizona Courier, Clifton, Arizona.

November 13, 2012 | Randi Bellasai on Arizona Public Media about the recent renovations and expansion of the Arizona Experience Store.

# PRESENTATIONS & OUTREACH

## Outreach (Continued)

November 17, 2012 | Randi Bellassai talked with Paul Birmingham of “Arizona Outdoors” about the recent additions to the Arizona Experience website and the Arizona Experience Store on KNST, AM 790, Tucson.

November 19, 2012 | Jeri Young described the October 2012 earthquake swarm near Morenci, Arizona in an interview with Arizona Public Media’s Mark Duggan.

December 6, 2012, National News: National Geothermal Data System aggregates nationwide info on wells, Geothermal Energy Weekly.

February 19, 2013, M. Conway interview with Arizona Highways, 125 Years of Arizona Geology.

February 25, 2013, Ferguson, W., New Geothermal Data System could open up clean energy reserves, Scientific American Online.

March 1, 2013, National Geothermal Data System covered by Scientific American, Geothermal Energy Weekly.

March 4, 2013 | Randi Bellassai, Sales and Marketing Manager, was a guest on Tucson’s KVOI program “The Voice.”

March 6, 2013 | Randi Bellassai was interviewed by Arizona Public Media’s Mark Duggan about the Arizona Experience’s oral history project, Your Arizona Experience.

March 6, 2013 | Joe Cook, AZGS Earth fissure manager, was interviewed by Phoenix Channel 12’s Kim Covington and described the potential impact of earth fissures on homes and streets in Maricopa and Pinal County.

April 8, 2013 | M. Conway interviewed by KTAR talk radio, Phoenix, on earthquakes in Arizona.

May 7, 2013 | Arizona Public Media , Arizona Illustrated, interview with Lee Allison, “Tracking Geothermal Energy Sources”.

June 25, 2013, Arizona Public Media, Arizona Illustrated interview with Phil Pearthree, “Debris flows in southeastern Arizona”.

### INFORMAL COMMUNICATION OUTLETS

AZGS uses a number of informal outlets – social media, videos and websites – for communicating with our stakeholders. In January 2013, AZGS introduced the Arizona Mining Review (AMR), a new, monthly video e-magazine, providing regular news and updates on the state of mining in Arizona.

### 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

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

U.S. Geosciences Information Network  
About.USGIN.org  
USGIN.org

### Arizona Mining Review Monthly Summaries

January 23, 2013 | Lee Allison launches AMR. Nyal Niemuth summarizes the state of mining; Tucson Gem and Mineral Society’s Dr. Peter Megaw describes the upcoming show; Visit Tucson’s Jane Roxbury on the TGM Showcase.

February 20, 2013 | Lee Allison, Nyal Niemuth and Jon Spencer appeared. Topics: Nyal Niemuth discussed gold mining in Arizona; Jon Spencer on mineral resources of the proposed Sonoran Desert Heritage

# PRESENTATIONS & OUTREACH

## Outreach (Continued)

area; and wrap-up of the Tucson Gem and Mineral Society Show.

March 27, 2013 | Newest developments and trends in Arizona mining; Dr. Kenneth P. Green, Senior Director, Energy and Natural Resources at the Fraser Institute, discussed the recent “Survey of Mining Companies” report and what it means for Arizona mining; VP Dan Johnson talked with Lee Allison about Curis’s plans for in situ copper recovery on 160 acres of Arizona State Trust lands.

April 26, 2013 | Dorothy Kosich, Deputy Editor/Americas Editor for MineWeb.com, discussed budgets and mining in the Western U.S.; Dr. Kent Hill, ASU’s L. William Seidman Research Institute, discussed “The Economic Impact of the Mining Industry on the State of Arizona – 2011.”

May 31, 2013 | Lee Allison and Nyal Niemuth explored developments in POTASH in the Holbrook Basin: Lee Allison talked with Jerry Aiken (Passport Potash) and David Newlin (Business Manager and Watershed Projects Director at Little Colorado River Plateau RC&D); National Geothermal Data System: Lee Allison and guest discussed data available at NGDS and its potential for use in U.S. mineral exploration; Northern Vertex’s Moss gold property in Western Arizona: Lee Allison talked with Joe Bardswich, Project Manager of the Moss gold site.

June 26, 2013 | Mining News & Update with Nyal Niemuth; Game-Changing Solutions to modern mining challenges with Dr. Mary Poulton, Director of the Lowell Institute for Mineral Resources (IMR); Impacts on Land Management- Arizona Natural Resources Review Council.

### FIELD TRIPS

October 6–7, 2012 | Jon Spencer, co-leader of Arizona Geological Society field trip of the Wickenburg area, including the Vulture Mine and the Anderson Mine Project.

November 8, 2012 | Ann Youberg, co-leader of Southwest Fire Science Consortium field trip to the Horseshoe 2 Fire in the Chiricahua Mountains of southeastern Arizona, and led a discussion on postwildfire erosion.

April 14 & 16, 2013 | Brian Gootee, Marcus Landslide Trail field trip during the International Trails Symposium in Scottsdale, Arizona.



AZGS staff December 17th 2013.

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