

Arizona Geological Society Newsletter

January 2017

January 3, 2017 DINNER MEETING

Who: David A. Sawyer will present "Dating Geologic Time in the Cretaceous: Integrating Biostratigraphy, Isotope Geochronology, and Astrochronology in sedimentary deposits of the Cretaceous Western Interior Seaway."

Where: Sheraton Tucson Hotel and Suites, 5151 East Grant Road, (at the intersection of Grant and Rosemont on the North side of Grant in the *SABINO BALLROOM* (enter at northwest corner of the building) and go upstairs to the meeting room.

When: Cash Bar at 6 p.m.—Dinner at 7 p.m.—Talk at 8 p.m.

Cost: Members \$30, Guests \$33, Students Members free with <u>on-line</u> reservation (\$10 without).

RESERVATIONS ARE REQUIRED: Reserve on the AGS website (www.arizonageologicalsoc.org) by 11 a.m. Friday, December 30. Please indicate Regular (Braised Short Ribs, natural jus, sautéed vegetable, boursin mashed potato), Vegetarian (stuffed bell peppers) or Grilled Chicken Cobb Salad meal preference. Please cancel by Friday, December 30 at 11 a.m. if you are unable to attend - no shows and late cancellations will be invoiced.

Dating Geologic Time in the Cretaceous: Integrating Biostratigraphy, Isotope Geochronology, and Astrochronology in sedimentary deposits of the Cretaceous Western Interior Seaway

David A. Sawyer, University Colorado, Boulder

The Upper Cretaceous was a time of global high stand of sea level and was the last time that the central North American continent experienced widespread marine deposition, with the Western Interior Seaway extending from the Gulf of Mexico to the Arctic Ocean. The marine deposits begin with the well-known near-shore Dakota Sandstone at about 100 Ma, extend through the Greenhorn Limestone, Niobrara Chalk, Pierre Shale, to the regressive Fox Hills Sandstone a few million years before the end-Cretaceous asteroid impact in the Yucatan at 66 Ma. These deposits are rich in fossil invertebrates (especially ammonites and inoceramid bivalves) that provide some the highest-resolved biostratigraphic zones in the world, in addition to significant marine vertebrates, and contain some of the most widespread organic-rich source rocks for world petroleum accumulations.

Much of the ammonite biostratigraphy was developed by Bill Cobban, who worked on ammonite paleontology and biostratigraphy at the USGS for almost 70 years before his death in 2015.

These widespread marine deposits are well exposed in the Colorado Plateau, Great Plains, and Northern Rockies and contain many volcanic ash deposits deposited in a marine environment, where they were altered to smectite clay-rich bentonite. Geochronologist John Obradovich, also of the USGS, worked closely with Cobban and published a several dozen 40Ar/39Ar

Abstract Continued on Page 2

Abstract Continued from Page 1

bentonite ages to constrain the Cretaceous timescale between 1993 and 2002. Since then, two major changes in Ar geochronlogy have taken

place. The first has been a developing consensus, stimulated by the Sam Bowring at MIT and the NSF-funded Earth Time project, to move the Ar monitor age from 28.02 Ma to the significantly older age of 28.201 Ma. Albian-Cenomanian Ar bentonite ages reported are shifted consistently 0.6-0.7 Ma older; however, this brings Ar ages into concordance with U/Pb zircon ages. Second, the increased sensitivity of the 5-collector Noblesse mass spectrometer at University of Wisconsin has reduced analytical uncertainties to \pm 50 ky in most samples, allowing better correlation than \pm 0.4 My uncertainty of Obradovich's Cretaceous geochronology.

Some examples of these new multicollector 40Ar/39Ar ages with 0.03-0.07% analytical uncertainties (average ± 50 ky) agree with tight stratigraphic stacking constraints. New ages include 97.52 Ma for the key Clayspur bentonite marker bed atop the Mowry Shale near Kaycee, Wyoming. Ages of 99.49 to 99.58 Ma were determined for Newcastle Sandstone from the NW Black Hills. Mid-Newcastle bentonite is indistinguishable from a 99.62 Ma age on lower Shell Creek Shale Member in the Wind River Basin. A lower middle Shell Creek bentonite from the Soap Creek Dome area, northern Bighorn Basin, south-central Montana is 100.07 Ma, very close to the Albian/Cenomanian boundary age of 100.2 Ma (new monitor age) determined by Obradovich and Matsumoto in Hokkaido, Japan. The age of the Newcastle is 1.6 My younger than 101.23 Ma Muddy Sandstone in the Wind River Basin. Uppermost Thermopolis Shale beneath the Muddy at Greybull, Wyoming, is just slightly older at 101.36 Ma. In the Sweetgrass Arch area of northwest Montana, the 102.11 Ma Vaughan Member of the Blackleaf Formation is much (2.5 My) older than the Newcastle Sandstone, and yet a million years younger than Taft Hill Member at 103.36 Ma. Older ages for the Skull Creek Shale (104.87 Ma) in the Black Hills and 106.37 Ma on Thermopolis Shale in the Bighorn Basin are clearly distinct. Surprises in correlation revealed by these high-precision (<100 ky, part per thousand) 40Ar/39Ar ages place significant new constraints on paleogeography and sequence stratigraphic interpretation of these widespread and important petroleum source and reservoir sedimentary rocks.

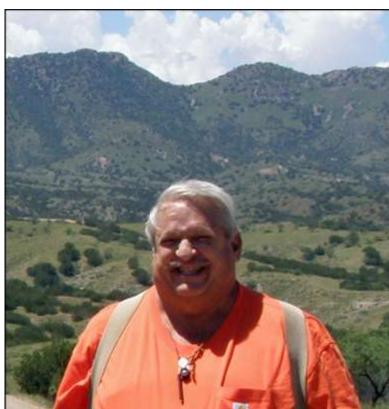


About the January Dinner Speaker

David Sawyer began his geologic career with the USGS in 1980 studying the deposits formed during the 1980 Mount St. Helens eruption. He received his B.A. from Colorado College and his Ph.D. from the University of California, Santa Barbara, studying the Cretaceous volcanic deposits containing the Silver Bell porphyry copper deposit near Tucson. During the first part of his USGS career he researched (mostly) old and cold volcanoes (in the San Juan Mountains, Colorado) and the geochronology, petrology, and geochemistry of the Miocene SW Nevada volcanic field regional hydrogeology in Nevada/ California Death Valley region. Later studies of the Rio Grande rift, New Mexico led to investigations of ammonite/inoceramid biostratigraphy, bentonite geochronology, and regional stratigraphy of Cretaceous Western Interior Seaway deposits with Bill Cobban and John Obradovich. He retired from the USGS in 2014 and is currently a research associate at the University of Colorado, Boulder, and is working closely with University of Wisconsin and American Museum of Natural History geochronologists.

A Message from the 2017 AGS President: Where Do We Go From Here? by David F. Briggs

Over the last six years, my tenure on the AGS Executive Committee as Vice Secretary and Secretary has been



one of the most rewarding experiences in my career as a geologist. It has provided me an opportunity to work with diverse group of talented scientists and lay-persons, who are interested in promoting the geosciences and the geology of Arizona. I am honored my peers have chosen me to serve as President of the Arizona Geological Society.

Since its formation in 1948, the Arizona Geological Society has depended on members, who have volunteered their time to manage the Society's business and other functions such as organizing symposiums, field trips and outreach activities. As older members retire, younger members have filled their positions. A smooth transition from the old to the new has allowed the introduction of fresh ideas that have benefited the Society throughout its history.

Success of this system is dependent on a pool of younger members to replace older members. They represent the future leaders of the Arizona Geological Society. As President, I will work to mentor younger members and find ways to encourage their participation in AGS activities.

J. Harold Courtright Scholarship

Bob Powell, head of the Arizona Geological Society's Scholarship committee awarded the J. Harold Courtright Scholarship to Daniel A. Favorito during the AGS December dinner meeting. Two M. Lee Allison Scholarships will be awarded at upcoming dinner meetings—to Anna Schuh and Phil McFarland.

The AGS Scholarship and Executive committees would like to thank the students who applied for the scholarships. The generosity AGS members who donate to the scholarship funds make these awards possible. To learn more about the Arizona Geological Society's scholarship program and how to make a tax-deductible contribution, please visit the AGS website's student outreach page.



FIELD TRIP REPORT

Peach Spring Tuff and its Source Caldera, Mohave County, Arizona, and San Bernadino County, California

By Charles Ferguson

The only bad news to report from the Peach Spring Tuff field trip to northwestern Arizona in October, 2016 was that a couple of side-wall punctures killed two tires. One, at least, happened on the first afternoon during a scenic excursion down Sawmill Canyon in Kingman. Here (Figure 1) some of the participants rightly complained that the rocks are too deeply weathered to appreciate petrographically. Adding to this frustration, the final stop of the day was at a City park where hammers are not allowed. Because of this, no one got a chance to collect decent samples of the main body of the Peach Spring Tuff. Realizing this need, two alternative stops have been added to the guide. The first is at the mouth of Sawmill Canyon where a quarry wall exposes fresh ignimbrite of that zone, and the second is the classic, monster road cut that looms over the west-bound lane of I-40 at Cook Canyon near old downtown Kingman. Good samples for teaching and/or research collections can be obtained at both of these stations, and by not taking the risky, shrapnel-ridden scenic drive down Sawmill Canyon, groups can save at least an hour on future trips.

Directions for the scenic drive are still in the guide where it is identified as a specialty excursion for those keen to familiarize themselves with the ignimbrite's weathering profile and geomorphic expression.

For the rest of the trip, five significant questions/ dissenting opinions were specifically addressed while completing the guide. The guide now includes a regional geologic map and cross-section. Special thanks to University of Arizona economic/bedrock geologists Max Larkin, Roy Grieg, Eric Seedorff, and Jon Spencer, Prescott professional geologist Don White, and Cal Tech geologist Joann Stock for their challenging and constructive input.

At "early bird" optional stop O-2 Paleoproterozoic gneiss in contact with Kessler's (1976) Mesoproterozoic (1335 +/- 35 Ma Rb/Sr) coarse-grained K-feldspar megacrystic Holy Moses Grantite produced an interesting discussion



Figure 1 Geomorphic expression of the two main cliff-top zone transitions within typical Kingman, Arizona sections of the Peach Spring Tuff. Hilltop (4) overlying Slaughterhouse Canyon (3) above, and Slaughterhouse Canyon (3) overlying Sawmill Canyon (2) below.

and well-founded dissenting opinion. As it turns out, even though much of the contact shows clear evidence of metasomatic overprint, it is also clear that the granite intrudes the gneiss (Figure 2).

An interesting dissenting opinion regarding the origin of the Oatman epithermal gold district was offered by Eric Seedorff on the morning of the second day just prior to examining the classic Gold Road vein along old route US 66 just east of Oatman (Stop 10). Gold mineralization at Oatman clearly post-dates two phases of caldera-related alteration that are, by themselves, devoid of gold mineralization: first, a pervasive propylitic alteration of pre-caldera, dacitic/lacustrine rocks, and second, an advanced argillic alteration associated with a post-caldera, bi-modal granitic-monzonitic hypabyssal intrusive suite. Optimistically, one might suppose that the older alterations served to prepare the host rock for gold mineralization during emplacement of a suite of rhyolitic dikes and stocks ~ 1 million years after caldera formation. Eric suggested that gold mineralization might be totally unrelated to

the caldera. A quick and dirty review of the literature inspired by a dissenting opinion to Eric's suggestion (sent to me after the trip by Don White) suggests that there is in fact a close, if not always direct, association between silicic calderas and epithermal gold mineralization world-wide. Certainly, there are places where lowsulfidation quartz-calcite-adularia +/- fluorite like the ones at Oatman have no connection with a caldera. How many of those however, might be like the mid-Cenozoic Akarca district in western Turkey where veins (Figure 3) remarkably similar to the Oatman veins, are hosted in a volcaniclastic conglomerate many 10s of km away from any similarly aged volcanic field? Since the veins at Akarca are now known to be truncated and carried in the hanging wall of a major detachment fault (Ferguson, Polat, and Akbayram, in progress), it is entirely possible that they may have been peripheral to a silicic caldera during mineralization.

The third significant question to be raised was again by Eric Seedorff who suggested that the Peach Spring Tuff's absence in the volcanic pile around Oatman was the result of post-caldera uplift and erosion. The main reason it took so long to recognize that Thorson's (1971) Alcyone caldera was source of the Peach Spring Tuff (as was astutely suggested by Thorson in the appendix of his dissertation) is that the ignimbrite is absent from the volcanic pile immediately east of the caldera. The guide suggests that pre-caldera uplift created a highland east of the caldera where the ignimbrite was never deposited, and to expand and explain this interpretation, the outflow sheet's zero isopach line, based on mapping of the Mt





the caldera where the ignimbrite was never deposited, and to expand and explain this interpretation, the outflow granite and banded gneiss at Stop 0-2.

Nutt quadrangle (Ferguson and Cook, 2017), is shown on Figure 2a of the guide. The ignimbrite near the zero edge consists of a condensed section of the uppermost zone(s) of the ignimbrite encased within a monotonous section of dacitic lava. Conglomerates that overlie the ignimbrite farther east contain sparse to zero clasts of the ignimbrite.

A dissenting view regarding the location of the cryptic, Peach Spring Tuff hiatus near the Gold Road vein (Stop 10) was brought up during a reprise of the field trip to a group from Cal Tech led by Joann Stock. The best known exposure of the caldera margin along Times Gulch was visited at a Stop (11) that was skipped during the original trip because it would have required a short but strenuous hike. The skipped Stop 11 visits exposures of a sharp contact between the intracaldera Peach Spring Tuff and the Oatman andesite, the unit that supposedly underlies the Peach Spring Tuff-aged hiatus at the Gold Road vein stop (10). The contact at Stop 11, like the semi exposure of contact that was visited along the road during the original field trip farther down the canyon, is interpreted to be a northwest-facing buttress unconformity. Suppose the contact at Stop 11 is, instead, an intrusion of hypabyssal Oatman andesite into the intracaldera ignimbrite. This, I reason in an expanded discussion inserted into the revised guidebook, is possible but, based on stratigraphic relationships established in the Boundary Cone quad (Spencer et al. (2006) just to the south of the Oatman area, highly unlikely. Still, it is possible and the implications are intriguing since placing the "hiatus" at a lower interval might explain why the Oatman andesite is not present in the pre-Peach Spring Tuff "Snagletooth Volcanics" of the Sacramento Mountains. The expanded discussion is also useful in that it emphasizes a fundamental difference between the caldera margins on either side of the Colorado River. In California, the caldera margin is a southeast-facing trap door mantled by a thick outflow of Peach Spring Tuff. In Arizona the margin is a scoured, highland rim devoid of outflow, bounded by a precipitous, west-facing escarpment.

The outline of a Pease et al.'s (1999) composite granodiorite-granite pluton of identical (18.8 Ma) age to the Peach Spring Tuff in the footwall of the Sacramento Mountains detachment (SMD) 30 km south-southwest of the main caldera fragment in Arizona is shown on Figure 2a of the new guide. Its location northeast of the tectonically dismembered segments of the caldera margin in the Sacramento Mts, and the lack of any known significant mid-Tertiary plutons in basement rocks to the southwest, constitute the two principal justifications for how the regional geologic cross-section shown in Figure 2b of the new guide was

drawn. The crosssection, which had been rejected by three of the four reviewers of the original Ferguson et al. (2013) Geology manuscript, is regurgitated principally to fulfill the request of Jon Spencer, who asked to see an alternative to the rolling hinge model. The cross-section shows the pluton of Pease et al. (1999) as part of a sub-caldera mesozonal pluton. Jon remarked that the exposure of the low-angle fault visited at Stop 15, a scant 5 km south of the limit of his mapping in 1983, is one the best examples of a detachment fault that he has ever seen.







Figure 3: Banded, gold-bearing, quartz-calcite-adularia vein and details of encrust-

Sue Beard, who wrote the one positive (and highly constructive) review of the aforementioned rejected manuscript, reproduced the 215° slickenline lineation (she measured 216°) quoted for the fault at Stop 15 by Simpson et al. (1991).

References

Ferguson C. A., McIntosh, W. C., and Miller, C. F., Silver Creek caldera, 2013, The tectonically dismembered source of the Peach Spring Tuff: Geology, v. 41, p. 3-6.

Ferguson, C. A., and Cook, J. P., 2017, Geologic map of the Mt Nutt 7.5' quadrangle, Mohave County, Arizona: Arizona Geological Survey Digital Geologic Map DGM-118, 1 sheet, 24,000 scale.

Kessler, E. J., 1976, Rubidium-strontium geochronology and trace element geochemistry of Precambrian rocks in the northern Hualapai Mountains, Mohave County, Arizona: Tucson, University of Arizona, M.S. thesis, 73 pp.

Pease, V., Foster, D., Wooden, J., O'Sullivan, P., Argent, J., and Fanning, C., 1999, The northern Sacramento Mountains, southwestern United States: Part II, Exhumation history and detachment faulting, in Mac Niocaill, C., and Ryan, P. D., eds., Continental Tectonics: Geological Society of London Special Publication, v. 164, p. 199-237, doi:10.1144/GSL.SP.1999.164.01.11.

Simpson, C., Schweitzer, J., and Howard, K. A., 1991, A reinterpretation of the timing, position, and significance of part of the Sacramento Mountains detachment fault, southeastern California: GSA Bulletin, v. 103, p. 751-761.

Spencer, J. E., Ferguson, C. A., Pearthree, P. A., and Richard, S. M., 2006, Geologic map of the Boundary Cone 7.5' quadrangle, Mohave County, Arizona: Arizona Geological Survey Map DGM-54, 2 sheets, 24,000 scale, 10 p. text.

Thorson, J.P., 1971, Igneous petrology of the Oatman district, Mohave County, Arizona (Ph.D. thesis): University of California—Santa Barbara, 189 pp., 2 plates, 1:24,000 scale.

NOTE: The guidebook for this field trip, which is mentioned several times in the narrative, will be available on our website after final revisions are complete.



Arizona Geological Survey News Brief



Phil Pearthree, Ph.D., has been named permanent director of the Arizona Geological Survey. Dr. Joaquin Ruiz, Dean of the University of Arizona's College of Science, made the announcement on December 20, 2016. Pearthree is a longtime AZGS geoscientist and has been acting as interim director since Lee Allison's tragic death in August, 2016.

* * *

Mining, Mineral, and Natural Resources Educational Museum News!

On December 21, 2016, AZGS's Catie Carter unveiled a traveling exhibit, Minerals of Arizona's Historic Mining Community, at the Arizona Capitol Museum in Phoenix (see photo). The exhibit includes several dozen minerals and artifacts of the newly-formed Mining, Mineral and Natural Resources Education Museum. We gratefully acknowledge the logistical and design support of staff of the Arizona Capitol Museum.

If you would like to support the museum, please pledge your tax deductible support through the University of Arizona Foundation:

http://tinyurl.com/SupportMM-NREMuseum



Recently Released Publications

Allison, M.L. (AZGS), Keane, C., Robinson, E. and Davis, R. (AZGS), 2016, EarthCube – Results of Test Governance in Geoscience Cyberinfrastructure. American Geophysical Union, Fall Meeting 2016.

Dorn, K.M., Young, J. (AZGS) and 3 others, 2016, Aftershock Study of the 2014 Duncan, Arizona $M_w = 5.2$ Earthquake Using Local Seismic Data. American Geophysical Union, Fall Meeting 2016.

Grubensky, M.J and Demsey, K.A., 1991, <u>Geologic map of the Little Horn Mountains 15' Quadrangle, Southwestern Arizona</u>. Arizona Geological Survey Map-29, map scale 1:50,000, 9 p. For the first time available online.

Gruber, D.G. and Gootee, B.F., 2016, <u>Citizen Scientist Quartz Vein Investigation Produces Significant Findings</u>. American Geophysical Union, Fall Meeting 2016 Poster (126892)

Pearthree, K.S. and Youberg A., 2016, <u>Geologic Map of Bonita and Rhyolite Canyons, Chiricahua National Monument</u>, Arizona Geological Survey Contributed Report CR-16-F.

Donations to the **Arizona Geological Society**

Donations to the Arizona Geological Society are used to fund the Courtright and M. Lee Allison Scholarship programs. The Arizona Geological Society is grateful for the generosity of the following individuals, whose contributions will help students achieve their professional goals. Please consider making a tax-deductible donation by the end of 2016.

Congratulations!

Long-time AGS member Douglas
Bartlett, was recognized with a 2016
Presidential Certificate of Merit by the
American Institute of Professional Geologists for supporting AIPG in a leadership role with his time and resources.
Doug is President of Clear Creek
Associates.





Mining Leadership Program - February 7-10, 2017

We are pleased to announce that the University of Arizona Lowell Institute for Mineral Resources and Vanto Group are jointly sponsoring a Mining Leadership Program. The inaugural offering of the four-day program "Leadership: Inventing the Future, A Breakthrough Leadership Program for the Mining Industry and Its Stakeholders," will be February 7-10, 2017, in Tucson, Arizona, and will be led by executives of the Vanto Group. Please go to the IMR home page at http://imr.arizona.edu, click on the Featured Project (Mining Leadership Program), then download the Information Packet for further information and instructions regarding registration. Please contact Rocío Brambila by e-mail at brambila@email.arizona.edu to register.

Arizona Geological Society Membership Stats (12/22/2016)

Total Membership	Professional Members	Student Members	Organizational Members
409	348	54	7

Upcoming Arizona Geological Society Dinner Meetings

Date	Speaker	Title of Presentation		
2/7/2017	Daniel Hummer	Mineral Ecology: Predicting and Discovering New Mineral Species		
3/7/2016	Derek Thorkelson	The Precambrian Tectonic Connection between Yukon and Arizona		

ARIZONA GEOLOGICAL SOCIETY

Welcome New AGS Members

Paula Allen Dave Bertuch Don Jenkins

Bill Elliott John Schieffer Allison McGraw

Wei Yan

Arizona Geological Society is grateful to Freeport-McMoRan, Inc. for their generous support of our student members! Freeport-McMoRan sponsored student dinners for the 2016 AGS monthly meetings.



2017 AGS MEMBERSHIP APPLICATION OR RENEWAL FORM

YOU CAN RENEW OR SIGN UP as a icalsoc.org. Or use the form below if yo		•	· ·	nageolog-	
Please mail check with membership for	m to: Arizona Geo	ogical Society, PO E	Box 40952, Tucson, A	AZ 85717	
Dues (check box) \square 1 year: \$20; \square 2	years, \$35; □ 3 ye	ars: \$50; □ full-time	e student (membersh	ip is free)	
NEW MEMBER or RENEWAL? (cir	cle one)	Date of submittal			
Name:	Posit	Position:			
Company:					
Mailing Address:					
Street:C					
Work Phone:	Home	Phone:			
Fax Number:	Cellula	Cellular Phone:			
E-mail:	Check	Check this box if you do not have an email address □			
All newsletters will be sent by email. If but we cannot guarantee timeliness.	you do not have ar	email address, we v	vill mail a hard copy	to you,	
If registered geologist/engineer, indicate	e registration numbe	er and State:			
Enclosed is a tax-deductible con Scholarship Funds.	tribution to the \(\Box	J. Harold Courtright	or the \square M. Lee	Allison	