



# Arizona Geological Society Newsletter

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JULY 2019

## August 6th, 2019 DINNER MEETING

**Who:** Gregory J. Leonard is the featured speaker. See abstract below.

**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 online reservation (\$10 without).

**RESERVATIONS ARE REQUIRED:** Reserve on the AGS website (<http://www.arizonageologicalsoc.org/events>) by 11 am on Friday, August 2nd. Please indicate Regular (Braised Short Ribs with Creamy Polenta), Vegetarian (Spinach and Mushroom Polenta), or Salad (Greek Salad) meal preference. Please cancel by **Friday, August 2nd at 11 am** if you are unable to attend - no shows and late cancellations will be invoiced.

### The August dinner meeting is sponsored by:

There is no sponsor for the August dinner meeting. If you are interested in sponsoring the August dinner meeting, please contact:

[vpmarketing@arizonageologicalsoc.org](mailto:vpmarketing@arizonageologicalsoc.org)

### Arizona Geological Survey presents:

## The Planetary Perils and Economic Promise of Near-Earth Asteroids

by Gregory J. Leonard,  
Lunar & Planetary Laboratory, Department of Planetary Sciences, University  
of Arizona

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## ABSTRACT

Near-Earth Objects (NEOs) primarily include asteroids (NEAs) whose orbits bring them into close proximity to Earth; NEAs have been pummeling our planet since its formation ~4.5 Gy ago. Although asteroid impacts are sparsely recorded in the geologic rock record, they have profoundly affected Earth's biologic evolution, variably bringing life-essential compounds to Earth (e.g. H<sub>2</sub>O, amino compounds) or severely disrupting widespread biotic communities. Large NEAs, ~100m to >1000m diameter continue to pose regional to global-scale threat; and despite being low probability events, they are high consequence.

Juxtaposed with the narrative of NEAs as a planetary threat NEAs are mineral-rich and compositionally diverse, this gleaned from thousands of geochemical evaluations of their offspring meteorites. NEAs range in composition from naturally-alloyed Fe-Ni-Co stainless steel (M-type) to organic carbon- and water-rich bodies (C-Type) reflecting their primitive pre-planetary solar nebula makeup. The mineral-rich inventories of NEAs render them attractive targets for future exploration and mining exploitation. For example, the often-touted inventories of PGMs contained within the NEA population, including Pt-Pd-Os-Ir-Rd are measured in billions of tonnes, with present (Earth surface) values measured in quadrillions of \$US. However, the compound of primary exploitation interest will be water required for rocket fuel, servicing Earth orbiting satellites and spacecraft, and for deep space exploration. The importance and necessity of extracting asteroidal metals for space-based construction, particularly ultra-pure iron will logically follow establishment of space-based fuel sources. Additionally, by virtue of their 'near-Earth' orbital character, many NEAs are energetically less costly to visit than the moon, further amplifying their appeal. However, considering the micro-gravity, hard vacuum, and extreme temperature environments within which NEAs exist, development of novel mineral exploration, extraction, and transport technologies are required for exploitation.

Understanding the population, distribution, and character of NEAs begins with their discovery and tracking. The Catalina Sky Survey (CSS) is a NASA-supported project, managed under NASA's Planetary Defense Coordination Office. Since its formation in 1998 CSS has discovered nearly half of all known NEAs (current total ~20,500 objects). CSS operates four telescopes in the Santa Catalina mountains north of Tucson, Arizona where astronomers both discover and track NEAs. Longstanding success of the project is attributed to CSS' comprehen-

sive sky coverage, continued development of innovative software and the detection pipeline, and the inclusion of real-time human attention to the NEO discovery and tracking process.

Gregory Leonard will review the basic character and properties of the NEA population, how they are discovered and tracked, and discuss their dichotomous role as both agents of planetary change to their existence as mineral-rich bodies available to humans in support of future space exploration.



### ABOUT THE SPEAKER

Gregory Leonard is a field geologist, planetary scientist, and glaciologist who has provided research and consultation services for industry, government, and academia for 30 years. He holds BSc and MSc degrees in Geosciences and Geography from the University of Arizona. He is currently a Senior Researcher in the Department of Planetary Sciences at the University of Arizona and associated with the NASA-funded Catalina Sky Survey, the world's most productive Near-Earth Object (NEO) survey where he has discovered >750 near-Earth asteroids and 4 comets. His current research also includes Mars and Mercury geologic studies, and planetary analog studies. His initial training with NEO surveys began with the USGS Branch of Astrogeology (Flagstaff, AZ) in the early 1990s working under the mentorship of Gene and Carolyn Shoemaker at the Mt Palomar Observatory, California.

Prior to his return to planetary sciences Gregory conducted multispectral satellite-based remote sensing and field investigations of glacierized terrains for the Global Land Ice Measurements from Space project (GLIMS). He has explored on glaciers in Alaska, the Cascades, the Andes, the Nepalese & Indian Himalayas, and the Mongolian Altids. He has co-authored many publications on alpine glacier responses to climate change, glacier-related mountain hazards, and seismic-induced landslides.

Additionally, he has vast experience in the mineral exploration industry in North America, Asia, and the Asia-Pacific region. He has extensive field geologic and project management experience and has contributed to the discovery of world class precious and base metal deposits in Indonesia (Gosowong low-sulphidation epithermal Au-Ag deposit) and Mongolia (Zuun Mod porphyry Mo-Cu deposit). He now dreams of the day when a rewarding geologist's career includes near-Earth asteroid prospecting.

## Society Announcements



**For anyone attending the Geological Society of America national conference in Phoenix this year, the Arizona Geological Society is sponsoring the following GSA 2019 Conference sessions and activities:**

### Topical Session - Poster Session and Oral Presentations:

**Porphyry Copper and Related Mineral Deposits of Arizona, the Basin and Range Province, and Beyond**  
- Hosted by Sarah Elizabeth Baxter and Michael Conway of the Arizona Geological Society

This session focuses on the geology of porphyry copper deposits, their related (and much larger) magmatic-hydrothermal systems, and their temporal evolution within and without the Basin and Range Province.

### Field Trip:

**Lava and Pyroclastic Flows of the Miocene Goldfield-Superstition Volcanic Province, Central Arizona—Saturday, September 21st** - Led by R.V. Fodor of North Carolina State University, Michael T. Mohr, and Brian A. Dombroski.

Examine the volcanic rocks of the Miocene Goldfield-Superstition volcanic province east of Phoenix. Discussions at each field trip stop will include the volcanic geology, petrography, and petrology, and sharing of the most recent geochemical, petrological, mineralogical, volcanic stratigraphy, and geochronological research conducted by the co-leaders over the past decade. Rock types to see and sample during six field stops include rhyolite lava domes, crystal-rich and crystal-poor rhyolite ash-flow tuffs, andesite, basalt, and basement granite and conglomerate.

Register for GSA 2019 Conference here:

<https://community.geosociety.org/gsa2019/attend/registration>

## Society Announcements

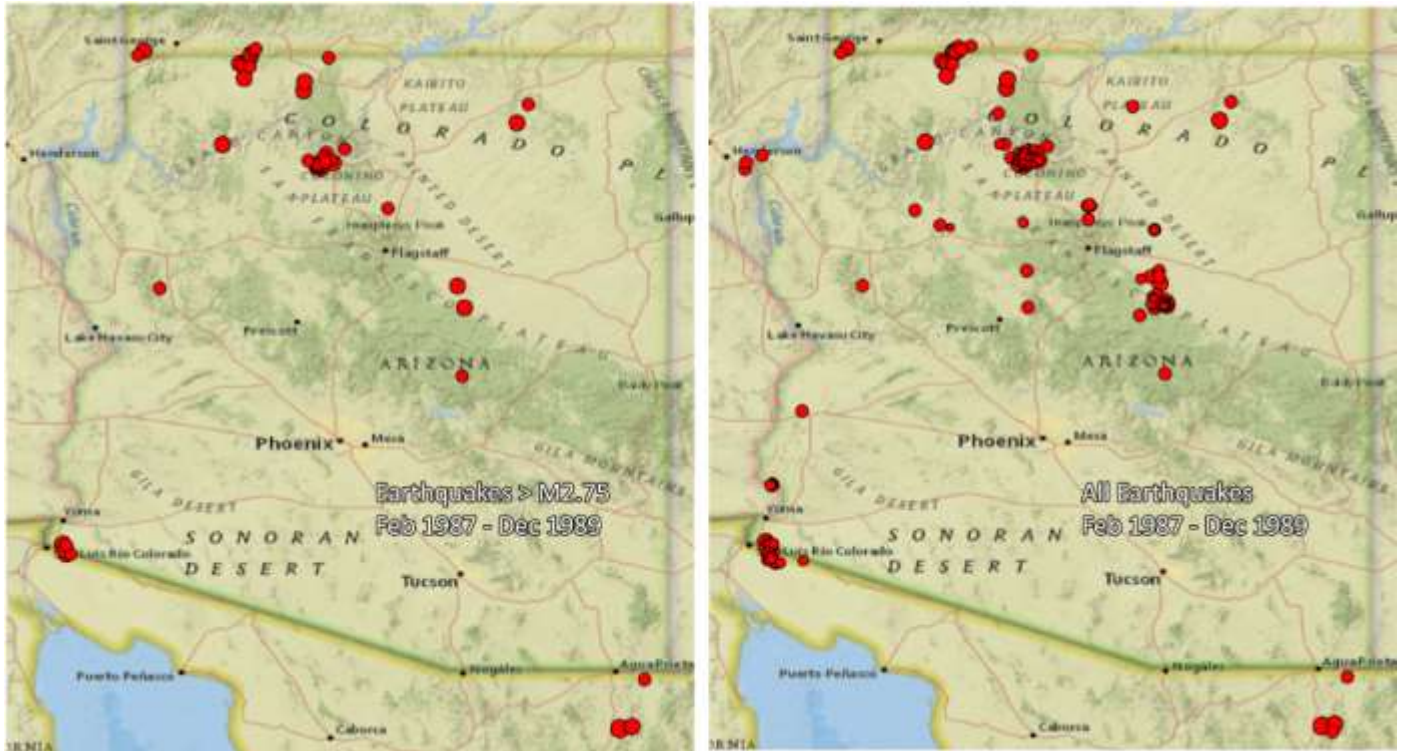


On **September 25-27, 2019**, Arizona Hydrological Society will hold its Annual Symposium at Casino del Sol in Tucson on Sept 25-27, 2019. This annual event will feature a plenary session, over 50 talks, poster sessions, workshops, social events, and more! To learn more about this event, visit AHS 32nd Annual Symposium web page below:

<https://www.ahssymposium.org/2019/>

## Fresh Time-Lapse Videos Of Historic Arizona Earthquakes 1860-2019

by Arizona Geology E-Magazine, Arizona Geological Survey



Earthquake activity from Feb. 1987 to Dec. 1989. Left - EQ's with M2.75 or greater; right - all earthquakes

The recent M7.1 and M6.4 Ridgecrest, CA, earthquakes, and the 10,000+ aftershocks, caused some consternation among Arizona's media about the likelihood of earthquakes impacting Arizona's people, property, and infrastructure. In the days following the M7.1 event, we entertained conversations and interviews with media staff in Flagstaff, Prescott, Phoenix, Tucson and Yuma.

Our response was always the same: Arizona is Earthquake Country. Unlike California, large magnitude earthquakes in Arizona are few and far between. But each year about 100 earthquakes originate in Arizona. Nearly all of those are less than M 2.5 and are not felt. But seismometers of the Arizona Broadband Seismic Network (ABSN) record the events and AZ-GS' Jeri Young Ben-Horin adds them to the existing catalog. These small magnitude events are instrumental in better understanding Arizona's seismic hazard and risk.

To illustrate Arizona's earthquake activity, we made three time-lapse videos of felt earthquakes and earthquakes recorded by the ABSN. The 1860 – 2019 >M2.75 earthquake video begins in 1860 and ends in mid-July 2019 and includes events equal to or greater than M2.75. The two other videos include all seismic events, including events less than M2.75 and

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illustrate earthquake activity from 1860-2019, and rolling backwards through time from 2019-1860. The videos are just over 1-minute in length and individual scenes reflect 2.5 years of activity.

Beginning in the 1960s, there is an apparent increase in earthquake activity that ramps upward through the first decades of the 21st century, this is particularly noticeable in the two videos that include all seismic data. This is an artifact of improved seismic monitoring in Arizona and throughout the Western U.S. The videos reveal, however, that concentrations of earthquakes have shifted around the state during the past 150 years, and earthquakes can occur anywhere in Arizona.

And Arizona is not immune to moderate and large magnitude earthquakes. In 1887, the Great Sonoran Earthquake caused ground shaking that was felt throughout the Southwestern U.S. and northern Mexico (DuBois and Smith, 1980). More than 50 people were killed and numerous buildings were damaged across the region. The groundshaking in Tucson knocked people right off their feet and shook the Santa Catalina Mountains severely enough to raise a cloud of rock dust so thick that people believed that a massive wildfire had broken out.

The Northern Arizona Seismic Zone extending from south of Flagstaff north to Utah is a hotbed for seismic events. Between 1906 and 1912, Flagstaff was rocked by three M~6 earthquakes. Yuma has been shaken by numerous large earthquakes centered in southern California and northern Mexico. The April 2010 M7.2 El Mayor – Cucapah earthquake damaged the historic Gandolfo Annex in downtown Yuma. Some other Arizona communities that felt earthquakes in the past decade include: Phoenix Metro Area, Tucson, Duncan, Sedona, Flagstaff, Cottonwood, Jerome, Safford and Morenci.

Watch the Arizona Geological Survey earthquake time lapse videos on the Arizona Geological Survey YouTube page here:

<https://www.youtube.com/user/azgsweb/videos>

**Note:** Since 2012, on the third Thursday in October, the Arizona Geological Survey and the Arizona Dept. of Emergency and Military Affairs host the Great Arizona ShakeOut earthquake preparedness event. To register for this year's ShakeOut, visit this website:

<https://www.shakeout.org/arizona/register/index.php>

Original blog post located here:

<https://blog.azgs.arizona.edu/blog/2019-07/fresh-time-lapse-videos-historic-arizona-earthquakes-1860-2019>

## New Land Cover Maps Depict 15 Years of Change across America

by U.S. Geological Survey

The U.S. Geological Survey released the latest edition of the National Land Cover Database (NLCD) for the U.S. – the most comprehensive land cover database that the USGS has ever produced. The NLCD 2016 documents land cover change in the Lower 48 states from 2001 to 2016. During this 15-year period, 7.6 percent of the conterminous U.S. changed land cover at least once.



Read the full article and access the land cover database here:

<https://www.usgs.gov/news/new-land-cover-maps-depict-15-years-change-across-america>

**Please contact the AGS Secretary if your company is interested in advertising in this monthly newsletter.**



**Arizona Geological Society is grateful to Freeport-McMoRan, Inc. for their generous support of our student members!**

**Freeport-McMoRan has sponsored student dinners for the 2018-2019 AGS monthly meetings.**



**FREEPORT-McMoRAN**

### AGS MEMBERSHIP APPLICATION OR RENEWAL FORM

YOU CAN RENEW OR SIGN UP as a new member and pay online. Please go to our website, [arizonageologicalsoc.org](http://arizonageologicalsoc.org). Or use the form below if you are more comfortable with the old school approach.

Please mail check with membership form to: Arizona Geological Society, PO Box 40952, Tucson, AZ 85717

Dues (check box)  1 year: \$35;  full-time student (membership is free)

NEW MEMBER or RENEWAL? (circle one) Date of submittal \_\_\_\_\_

Name: \_\_\_\_\_ Position: \_\_\_\_\_

Company: \_\_\_\_\_

Mailing Address: \_\_\_\_\_

Street: \_\_\_\_\_ City: \_\_\_\_\_ State: \_\_\_\_\_ Zip Code: \_\_\_\_\_

Work Phone: \_\_\_\_\_ Home Phone: \_\_\_\_\_

Fax Number: \_\_\_\_\_ Cellular Phone: \_\_\_\_\_

E-mail: \_\_\_\_\_ Check this box if you do not have an email address

***All newsletters will be sent by email. If you do not have an email address, we will mail a hard copy to you, but we cannot guarantee timeliness.***

If registered geologist/engineer, indicate registration number and State: \_\_\_\_\_

Enclosed is a \_\_\_\_\_ tax-deductible contribution to the  J. Harold Courtright or the  M. Lee Allison Scholarship Funds.