DEG Spheres of Influence December 2016

President's Column

The DEG already is halfway through its year, which begs the timely questions: What have we accomplished, and what does the future have in store for us?

Division of Environmental Geosciences Mission Statement and Purpose

What is the DEG? Get a refresher of the mission statement and purpose of the Division of Environmental Geosciences.

New Officer Bios

Meet the Vice-President and Managing Editor for 2016-17.

Movie Review – Deepwater Horizon

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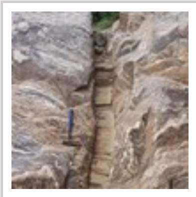
The Good, the Bad and the Ugly – The Strategic Petroleum Reserve

The U.S. Strategic Petroleum Reserve (SPR) is facing significant challenges related to the storage and availability of its crude oil resources. Approved for construction by the 1975 Energy Policy and Conservation Act (EPCA), the storage sites were envisioned to be needed for 25 years and are subject to an estimated five drawdown cycles (Shages, 2014). In retrospect, the design has not matched actual use, and this has led to degradation of the SPR and impacted its ability to perform its function.



Beauty in Geology

Geoscience students, survey workers and a professor conducted a one-month field project in southern Malawi to better understand the role of pre-existing structures on the architecture of new faults created by rifting.

President's Column

December 2016 | By Timothy Murin

The DEG already is halfway through its year, which begs the timely questions: What have we accomplished, and what does the future have in store for us?

Our Executive Committee and Advisory Board members continue to have monthly meetings to discuss items ranging from DEG's involvement at ACE, Section and Region meetings (technical sessions, co-sponsoring luncheons, short courses and field trips), to membership (currently at 925, down about 30 percent from last year) to a restructuring of the standing committees – while at the same time forming new ad hoc committees ("Centers of Excellence") to address current environmental issues facing the petroleum industry.

How does the future look?

We should first take a look at the past.

The United States Energy Policy is based on regulations from federal, state and local entities. It was initially formed during the Organization of Petroleum Exporting Countries (OPEC) oil embargo during 1973-74. The immediate concern of adequate supply resulted in a significant increase of domestic drilling. Since then, several cycles of boom and bust have occurred.

Current energy policy focuses on adequate supply, providing low costs and protecting the environment while producing and consuming energy. There is considerable public debate regarding hydraulic fracturing, induced seismicity and fugitive emissions from oil and gas operations and their potential impact to climate change.

There should be some clarity over the next few months on the future of our energy policy. While the new administration will take office next month, it also is likely there will be new individuals heading the Department of Energy and the Environmental Protection Agency.

Will fossil fuels continue as our primary energy source?

Will research, development and commercialization of renewables continue?

And what about nuclear energy?

The world certainly has a large appetite for energy. In both the near- and long-term, how will we satisfy the need of providing adequate supply at low cost while protecting the environment?

Be involved with doing good science and educating others about the potential environmental impacts of energy development. Your ideas and contributions on these topics may help to develop public opinion – and policy – going forward!

Division of Environmental Geosciences Mission Statement and Purpose

December 2016

- EDUCATING the membership of AAPG and the general public about important issues that affect petroleum energy minerals exploration and production.
- COMMUNICATING to the general public and government agencies the Association's commitment to protect the environment while developing the world's natural resources in a responsible manner.
- APPLYING the expertise developed in the petroleum/energy minerals industries and hydrogeology to resolve environmental problems.
- PROMOTING environmental self-regulation within the petroleum/energy minerals industries.
- PROVIDING relevant educational opportunities and services for professional development of the AAPG membership through seminars and conferences in environmental geosciences, hydrogeology and related fields.

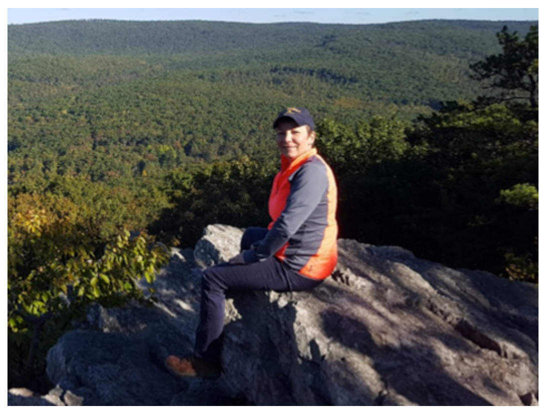
New Officer Bios

December 2016 | By Kristin Carter, Barbara Kutchko

Meet Kristin M. Carter, Vice President (2016-17)

Kristin Carter serves as assistant state geologist for the Pennsylvania Geological Survey and manages the Survey's Economic Geology Division. Kristin has worked as a petroleum geologist for the Survey since 2001, and her current research efforts include carbon capture utilization and storage, enhanced oil and gas recovery, unconventional reservoirs and deep brine injection opportunities. In addition, she is the business manager of Pennsylvania's oil and gas well database, known as EDWIN (Exploration and Development Well Information Network). Prior to joining the Survey, Kristin worked as a consulting hydrogeologist in the private sector for almost a decade, first with Environmental Resources Management Inc. (Annapolis, Md.) and then Crouse & Company (Monroeville, Pa.). As a consultant, Kristin worked on many projects involving groundwater flow and quality at sites throughout the Mid-Atlantic region, contaminant fate and transport in bedrock and unconsolidated aquifers, beneficial use of coal combustion by-products for mine reclamation and spring water source characterization. Kristin holds a master's degree in geological sciences from Lehigh University and a bachelor's degree in geology/environmental science (double major) from Allegheny College.

In addition to her full-time work, Kristin is a certified Master Water Well Owner; an advisor to the board of directors of the Friends of Drake Well Inc.; and a member of the Pittsburgh Association of Petroleum Geologists, Pittsburgh Geological Society and Women's Energy Network-Appalachia Chapter.

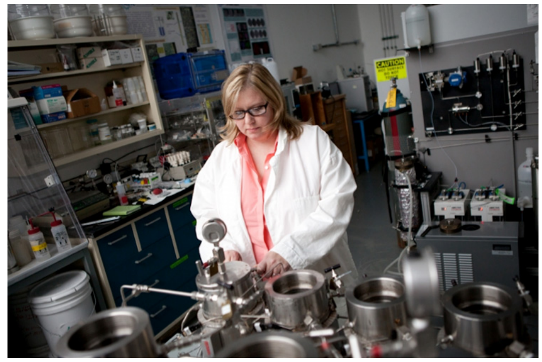

Kristin M. Carter Vice-President of DEG 2016-17

Kristin is a member of the Division of Environmental Geosciences (DEG), Energy Minerals Division (EMD) and Division of Professional Affairs (DPA). She also previously served as DEG's the Special Issues editor (2009-10), editor-in-chief (2010-14) and managing editor (2014-16).

Meet Barbara G. Kutchko, Managing Editor (2016-17)

Barbara Kutchko is a senior research scientist with the National Energy Technology Laboratory (NETL), specializing in wellbore isolation, oil well cementing and subsurface materials characterization. She has a doctorate from Carnegie Mellon University's Civil and Environmental Engineering and a master's in geology from the University of Pittsburgh.

Barbara works with oil and gas companies, government agencies and universities to evaluate current cementing practices and research needs, to ensure the safe placement of cement related to offshore drilling, shale gas production and carbon storage. This includes leading and collaborating with teams of diverse researchers, professors, students and industry experts to plan, manage and execute research related to energy production.



Barbara G. Kutchko - Managing Editor Spheres of Influence 2016-17

Barbara also serves as the principal investigator for a groundbreaking evaluation of foamed cement systems at in situ wellbore conditions. She works to mitigate the environmental impacts associated with offshore and onshore drilling and cementing. She supports the development of environmentally and socially sustainable shale resources and researches the effects of carbon storage and acid-gas injection on well cements. Her research has informed federal policy and increased scientific understanding of the chemical reactions that occur in geological formations under carbon sequestration conditions. She currently represents NETL on the American Petroleum Institute's (API) Cement Subcommittee 10C, which develops and maintains standards on various oil and gas wellbore cementing procedures for the U.S. petroleum industry and is actively involved in the foamed cement work group.

In addition, she is a member of the Pennsylvania Department of Environmental Protection's Oil and Gas Technical Advisory Board. She is the recipient of a 2016 Pittsburgh Women in Energy award and a 2015 Energy Award in Upstream. In 2014, she received a Federal Executive Board (FEB) Excellence in Government Award for outstanding contributions to science and/or information technology.

Movie Review – Deepwater Horizon

December 2016 | J. A. Turley - SPE Distinguished Lecturer

I've seen the movie "*Deepwater Horizon*" three times. My emotions are mixed, none involving humor.

Yes, the movie may get an Oscar for spectacular visual effects. Yes, noteworthy actors play key wellsite leaders who will shock viewers with disturbing actions and decisions. Yes, the movie treats with great respect those who survived and the 11 who died.

But no, an abundance of ambiguous technical snippets, both verbal and visual, do little to inform those who want and need to know the answer to … what caused the blowout?

So, why this note? As a 2015-16 SPE Distinguished Lecturer (DL) on the cause of the Macondo-blowout in the Gulf of Mexico, my passion is to ensure every member of our industry learns from and works toward never allowing a repeat of the catastrophe. I trust you will see the movie, but I invite you to also read "The Simple Truth: BP's Macondo Blowout." The book focuses on the cause of the disaster (no politics, no hearsay, no finger pointing, no Hollywood) and is available through Amazon.

Movie Review — "*Deepwater Horizon*"

I wrote the above succinct review of the movie "*Deepwater Horizon*" as an introductory comment for my new connections on LinkedIn. But for those in the industry who truly do care, a review of such a critical movie deserves more detail; hence, the following.

I'll use a recent experience as the basis for my review.

On 13 October I joined 100 Colorado School of Mines (CSM) petroleum engineering students and faculty for a private screening of the movie. I was invited to emcee the event, where I watched the movie for the third time and then led an energetic hour-long discussion and Q&A session.

Every attendee had a vested interest in the career-related movie, and each is intellectually capable of understanding every aspect of what appeared on the screen.

Afterwards, audience comments ranged from "OMG" and "unbelievable" to "how could anybody have survived?" Some comments were in the form of body language only, without words to describe tear-moistened emotions.

We discussed three aspects of "*Deepwater Horizon*."

The Movie

First, for the film as a whole: The setting, working families, onshore and offshore facilities and the massive Deepwater Horizon drilling rig are exactly right. Even as the story unfolds on the rig we get to see good renditions of the actual control room, shops, the galley, offices, the rig floor, a workboat and working personnel everywhere. Then, once the disaster unfolds, with fluids — mud, oil, gas — blowing violently over the derrick, followed by explosions and fire throughout the facility, the situation on the rig could not have been more horrific, nor could the visual effects have been more stunning or more realistic. For those who have ever been on, or will ever be on, a rig, whether onshore or offshore, the movie is a harsh view of a world we should strive to never see again.

So, with strong agreement from students and faculty, the bottom line for the film as a whole: kudos, job well done.

People

Also important to those who care are the relationships among the players, on several fronts. First, there's a well-portrayed rig worker (key to the story) and his wife and daughter as he prepares to go to the rig for his 21-day hitch. Associated scenes do a good job of showing family dynamics, and remind the audience that all persons out there – and those they leave at home – are real people with emotions, concerns and love for life.

On a different scale, the dynamics of relationships among leaders on the Deepwater Horizon are entirely different, albeit handled quite well in the movie. Though there are four key leadership positions on the rig (plus four visiting executives), the conflict is simple:

1. The well belongs to BP, who pays all the bills, and BP's senior guys (company men) on the rig make all technical and operating decisions about the well.
2. The rig owner, Transocean, has three senior leaders – the toolpusher, who is in charge of the drilling rig and all its functions and personnel; the offshore installation manager (OIM), who is responsible for the non-drilling facilities (i.e., the "hotel"); and the captain, who is in charge of keeping the floating rig (considered by the U.S. Coast Guard as a vessel at sea) on station (above the well head).

In a departure from reality, the OIM is given a major speaking/debating role throughout the movie, including rig-related matters (normally handled by the toolpusher), likely due to the fact that the real OIM survives while the toolpusher does not.

The rig status on the critical day is that the discovery well has been drilled, cased and cemented. In preparation for temporary abandonment, the well must be pressure-tested to ensure casing and cement integrity. The high-pressure test goes well, but the negative-pressure test (designed to manually reduce the wellbore pressure to ensure there are no leaks from outside the casing) fails to prove the well is secure and generates anomalous data.

The predominant heated argument in the movie is that:

1. The BP leaders (company men) agree that the test data was bad, but argue it was bad only because of the "bladder effect." The movie does a good job with characters arguing about the technical aspects of the bladder effect (which, in the real world, does not exist, leaving an unnecessary open issue with the audience).
2. Every other non-BP leader, even the workboat captain, argues that the test data prove the well has a leak (though they would not know) and that the BP leaders don't want to admit the failure, as it would lead to a major time-and-money cement repair job.

The audience doesn't know what's right or wrong, but by now they rank the BP rig leaders as bad guys, an apparent goal of the movie. The movie shows BP's fallback decision is to rerun the test in a different way (using the kill line), which does successfully show the well has pressure integrity. An argued one-liner in the movie proposes it's possible the second test was invalid, because the kill line might have been plugged. In reality, it was – with catastrophic results, though not mentioned again in the movie.

The false "good" test justifies for BP (and reluctantly for the other rig leaders, at least in the movie) the next step in the abandonment process — pumping seawater into the well to displace heavy drilling mud from the 5,000-foot-long drilling riser. Given that the well had a serious undetected casing/cement leak (a documented, albeit off-screen, failure of the company men to correctly interpret the negative pressure test), such displacement of riser mud with seawater allowed the well to flow (aka, a kick … though unseen), even as more seawater was being pumped, exacerbating the accelerating flow.

The result was BP's Macondo blowout.

As soon as the well commences blowing out, rig personnel rightfully actuate a BOP unit (blowout preventer), but they panic verbally to each other, making the point that the BOP, in apparent total failure, did not stop the violent flow. The flow of oil and gas finally explodes and burns, from the moon pool to the top of the derrick and throughout the living facilities – the cataclysm seemingly beyond belief, but very real.

Understandably, as the fire escalates, personnel conflicts go away, replaced by individual instincts for survival. The choices were few — either fight your way through the fire and get to a lifeboat, or jump overboard. Yet, as well-portrayed in the movie and as supported by testimony during the USCG depositions after the disaster, injuries were abundant, as were individual acts of heroism that saved lives and deserve military-type honors. And though the viewing audience likely will not recognize real-life names unless they live and work on the Gulf Coast, they will have watched 11 good men, played by surrogate actors in the movie, just doing their jobs on this, their last day. Their bodies were never found.

From the student perspective, the film vividly portrayed the importance of understanding data, reacting to change, respecting authority, standing up to incompetence and accepting and executing technical job responsibilities, without fail.

Technical

The third aspect of the limited 100-minute movie that needs clarification is the necessarily rapid coverage of abundant technical issues that took place during the rig's 12-hour countdown to disaster. A number of issues were visual only, or introduced as one-liners, requiring attendees to ponder the significance.

For example, natural gas was seen erupting on a number of occasions from the seafloor around the BOP, increasing in frequency and violence proportional to the tension of the movie and the ticking clock. Not true. No gas evolved around the wellhead, either before, during or after the blowout. Sorry to say, this was for show, and looked really ominous, but detracted from movie credibility.

There also was a conflict about a service company leaving the rig before running a CBL, or cement bond log. Every named player on the rig (and again, even the workboat captain) was astounded that BP had released the logging team without the CBL, while the BP leaders, when challenged, were confident with their decision. The concern was that the 18-hour-old cement, outside the casing, 18,000 feet deep (not the structural-casing cement at 5,000 feet, just below the seafloor, as wrongly shown in a diagram during the argument), could be bad, and the CBL would tell them so. Not true. The CBL does not test the cement. In reality, the tool is used in limited circumstances when there's been a significant problem during a cement job (and more so during completion operations). That was not the case on Macondo, where BP showed the deep cement job met the criteria for no CBL. Conversely, the negative-pressure test directly tests the pressure integrity of the deep cement and the rest of the wellbore. Unfortunately, so much movie time was spent on the CBL debate that attendees were surely wrongly convinced that it was one of the leading causes of the blowout.

The BOP also got a lot of attention. Two key items here:

- First, deepwater operations require the BOP stack (comprised of several BOP units) to be on the seafloor. For Macondo, that's about a mile below the rig. And that means when the Macondo well kicked, unseen, and was enhanced by the continued pumping of seawater to further displace heavy mud, the entire wellbore – casing and riser – filled with oil and gas. That means when flow was first seen on the rig floor and the first BOP unit finally was closed, there were almost 1,600 barrels of oil and gas already in the riser between the rig and the closed BOP (actually two closed BOP units). To make matters worse, the gas in the riser had risen to be so shallow that the low hydrostatic pressure allowed the gas to break out of solution. The resulting explosive expansion of the gas mimicked a Mentos-Diet Coke experiment – unstoppable, because it was above the BOP. It was that oil and gas, from the riser, that blew over the top of the 244-foot-tall derrick, just before gas and atomized oil were sucked into the engine room — the catalyst for the first explosion and resulting fire.
- The second BOP-stack issue centers on a third BOP unit, the blind shear ram (BSR), located between the two other closed BOP units. Closure of the BSR is the critical first half of a last-ditch emergency operation designed to release the rig from the BOP stack (to get away from the fuel source and stop the fire). A serious consequence of the massively flowing Macondo blowout was that the drillpipe between the two closed BOP units was so severely uplifted and deformed that the BSR was unable to close. The movie tempts the audience with "a big red button" that would save the day. When the red button is finally pushed (after much debate), we see sharp blades move toward each other … then stop. Consequently, the pipe is not cut, the well is not sealed and the rig is stuck on location, burning on top of the fountain of oil and gas. No further mention in the movie about the BSR, other than that the BOP failed.

Summary

The CSM students in the theater were hungry for real data, wanted to understand the nuances of the one-liners and did not want to be taken in by misinformation, which made for lively Q&A. And yes, because they wanted and needed to know, we thoroughly discussed what caused the blowout, which, to be candid, was beyond the scope of the movie.

Nevertheless, though there are other technical sub-topics worthy of debate, it's fair to say the "*Deepwater Horizon*" writers, producers and consultants did a credible job of creating dialog, building tension and revealing important issues before anybody on the rig knew there was any chance of a blowout – then wrapped it up with spectacular visual effects. And that takes true creativity.

Bottom line. For the movie, the people and the technology: Job well done – with a few caveats.

"Deepwater Horizon" is a must-see movie.

The Good, the Bad and the Ugly – The Strategic Petroleum Reserve

December 2016 | By Barbara Kutchko

The U.S. Strategic Petroleum Reserve (SPR) is facing significant challenges related to the storage and availability of its crude oil resources. Approved for construction by the 1975 Energy Policy and Conservation Act (EPCA), the storage sites were envisioned to be needed for 25 years and are subject to an estimated five drawdown cycles (Shages, 2014). In retrospect, the design has not matched actual use, and this has led to degradation of the SPR and impacted its ability to perform its function.

The SPR stores crude oil (either sweet or sour) in 62 underground salt caverns located at four different sites in Texas and Louisiana. The official storage capacity is 727 million barrels, based on sonic measurements. A 2010 study concluded there was a significant mismatch in design and use of the storage caverns. Instead of the initial estimated five large drawdown cycles, a large number of small drawdowns occurred over the previous 20 years. From 1996 through 2014, there were 14 instances of oil removals less than 10 million barrels. These multiple drawdowns have caused cavern deformation, salt falls and other damage to the cavern integrity. In addition, these underground salt caverns are shrinking due to tectonic stresses. The cavern shrinkage (aka closure) is estimated to be approximately two million barrels per year – but may be significantly higher.

Salt is a unique geologic material with complex mechanical properties. It is often modeled as a non-Newtonian fluid. At high temperatures and pressures salt behaves like a plastic. It will behave more like a liquid in the sense that it flows even under small deviatoric stresses. Salt domes make a perfect storage medium in that they do not react with the oil and are self-healing. The plastic behavior of salt will cause it to naturally close fractures or gaps and prevent any leakage. However, salt domes also are under constant geologic pressure (i.e. salt creep) and these stresses are causing the caverns to shrink (Shages, 2014). The SPR attempts to manage the shrinkage by leaving a bed of salt brine at the bottom of each cavern and by keeping their caverns under a pressure of approximately 800 psi (personal communication, SPR personnel). Salt leaching offsets some of the shrinkage. Crude oil is extracted from the cavern by injecting fresh water or under-saturated brine down one well and produced in a secondary well. The injection causes, for example, 15 barrels (2.38 m3) of salt to be dissolved for every 100 barrels of oil removed from a cavern.

The mismatch between original design and actual utilization of the SPR's caverns has led to the development of significant negative impacts to cavern integrity, wellbore integrity and the ability to maintain optimal mission readiness. One operational limitation is that whenever work is done to the cavern or well, the caverns must be depressurized. Removing cavern pressure causes the rate of shrinkage to increase rapidly.

Thus, the repeated removal of small volumes of oil over the life of a cavern has led to serious consequences on the shape and integrity of the caverns:

- Dissolution of salt during a drawdown always begins at bottom of cavern.
- If cavern is only partially emptied,the shape of cavern will become distorted with a bulge at the bottom.

- Gravity puts stress on the overhanging salt formation.
- Massive falls can occur and damage hanging steel tubulars.
- Cavern deformation and shrinkage is damaging well casings and cement.

For more information regarding the Strategic Petroleum Reserve:

Park, Byoung Yoon. "*Interbed Modeling to Predict Wellbore Damage for Big Hill Strategic Petroleum Reserve*" Roch Mech Rock Eng 47 (2014): 1551–61.

Shages, John. "*The Strategic Petroleum Reserve: Policy Challenges in Managing the Nation's Strategic Oil Stock*" July 11, 2014. http://eprinc.org/wp-content/uploads/2014/07/EPRINC-Shages-SPR-July-11-2014.pdf

Stein, J.S. and Rautman, C.A., Conversion of the Big Hill Geological Site Characterization Report to a Three-Dimensional Model. SAND2003-3554. http://prod.sandia.gov/techlib/access-control.cgi/2003/033554.pdf

Beauty in Geology

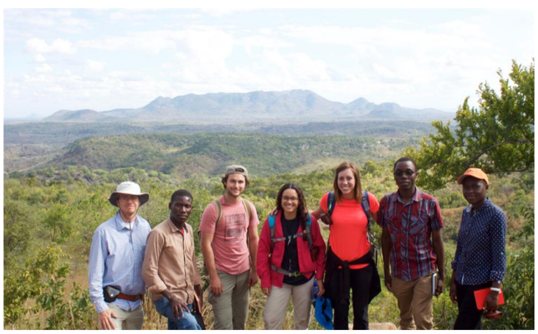
December 2016 | Daniel A. Laó-Dávila

Geoscience students, survey workers and a professor conducted a one-month field project in southern Malawi to better understand the role of pre-existing structures on the architecture of new faults created by rifting.

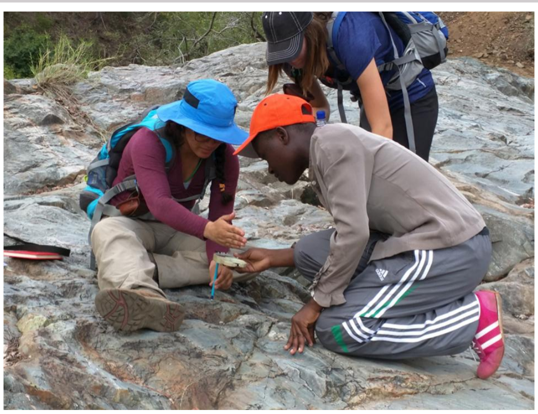
Participating were students Amy Pritt and Wesley Prater, and associate professor Daniel A. Laó-Dávila, all from the Boone Pickens School of Geology at Oklahoma State University; students Alejandra Santiago Torres and Kevin Vélez Rosado from the department of geology at the University of Puerto Rico at Mayagüez; and colleagues of the Malawi Geological Survey Department and the Malawi University of Science and Technology.

Structural and geological mapping characterized the structures in Precambrian metamorphic rocks close to the rift. Preliminary results of this research will be presented at the American Geophysical Union fall meeting and at the Geological Society of America's annual meeting at the end of the year. This material is based upon work supported by the National Science Foundation under Grant No. II-1358150.d

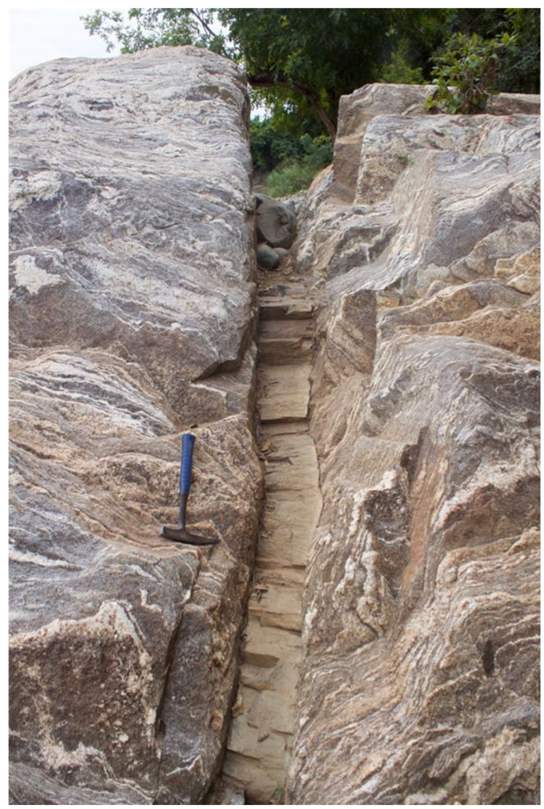
All photos courtesy Daniel A. Laó-Dávila.



The research team poses in front of the Salambidwe Ring Complex at the boundary between Malawi and Mozambique



Alejandra Santiago Torres, Lois Kamuyango and Amy Pritt measure the orientation of foliation in Precambrian gneiss near



Dike cutting Precambrian gneiss northeast of the Shire Valley, Malawi

Shire Valley, Malawi

A stream flows along mafic dike that cuts Precambrian gneiss northeast of the Shire Valley, Malawi