TPG

Volume 51, Number 3

THE PROFESSIONAL GEOLOGIST

Jul/Aug/Sept 2014

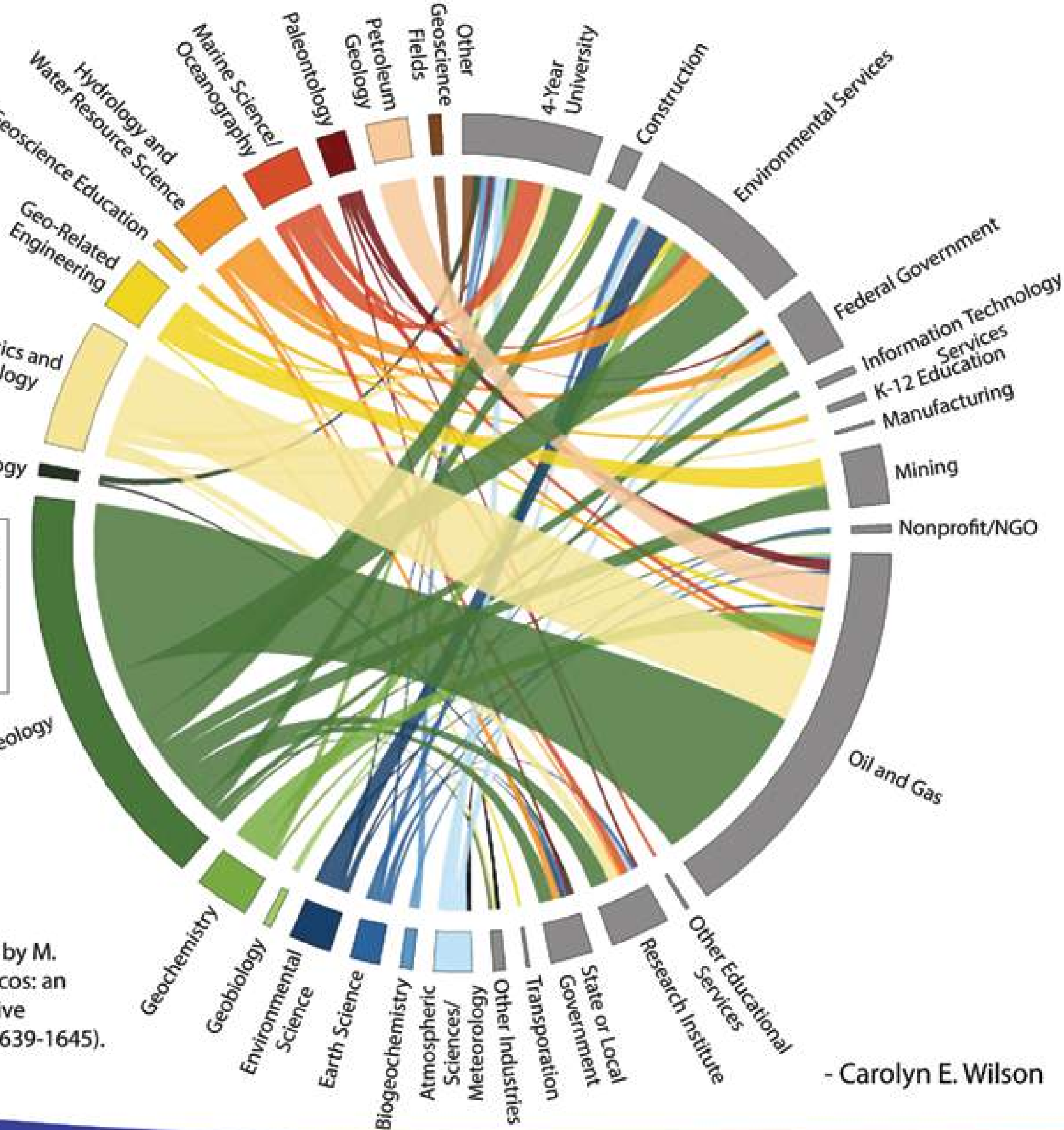
AGI american geosciences institute
connecting earth, science, and people
24 July 2014

GEOSCIENCE CURRENTS
No. 90

The Industries of Geoscience Graduates' First Jobs by Degree Field

The circular[1] diagram below displays the connection between the degree fields of recent geoscience graduates (in color) to the industries where these geoscientists found their first job after graduation (in gray). The size of the bars along the outer edge of the circle represent the number of recent graduates that pursued a particular degree field and entered a particular industry. Each colored, inner ribbon connects a particular degree field with the various industries where graduates found jobs. The thickness of each ribbon is determined by the number of graduates within each degree field with a job in a particular industry. This visualization shows the variety of industries available to graduates with a geoscience degree, as well as the complexity of the workforce and knowledge needed in the distinct industries.

The data presented here came from the 2013 and 2014 results of AGI's Geoscience Student Exit Survey. Look forward to the Status of Recent Geoscience Graduates 2014, which will detail the survey results for the 2013-2014 academic year, available in September.



The Status of Recent Geoscience Graduates 2013 can be found at **http://www.american geosciences.org\workforce\ reports.**

[1] The visualization code was created by M. Krzywinkski (Krzywinski, M. et al. Circos: an Information Aesthetic for Comparative Genomics. **Genome Res** (2009) 19:1639-1645).

- Carolyn E. Wilson

TPG

Volume 51, Number 3 Jul/Aug/Sep 2014

INSIDE THIS ISSUE

22

35

35

Cover Photo: Soft sediment deformation features within the Upper Browns Park formation, south-central Wyoming. Photo by Mark Zellman, CPG-11582.

Coal, Just Not for Burning

Michael D. Campbell, P.G., P.H., CPG-3330
M. David Campbell, P.G.
Jeffrey D. King, P.G.
Henry M. Wise, P.G., CPG-7691

This is the rest of the story. As industry has begun to pull carbon dioxide out of the atmosphere and store it in underground reservoirs, we also have the option to not burn the coal of fossilized dead forests. Alternative sources of energy to generate electricity are available. We also have the option to prevent the destruction of the living forests (and their associated ecosystems) that produce much of the oxygen that humans and other organisms need to exist. The carbon in coal can also be used to make other common "clean" products. Coal may then become "clean coal" after all and not just an oxymoron with visions of becoming germane economically.

China, Australia, Russia, India, the Asia Pacific region, and the United States have large coal resources, but they are currently committed for burning to generate electricity, putting huge quantities of particulates, carbon dioxide, carbon monoxide, mercury and other contaminants into the atmosphere (see Figure 1).

Figure 1. A Coal-Fired Power Plant.

The United Nations has formalized bold opposition to burning coal in a recent press release,[10] but the Asia Pacific region is largely dependent at present on coal, rather than wind and solar resources, and even these currently have serious drawbacks.[25]

Coal in its most common natural form is composed primarily of carbon consisting of decomposed and fossilized organic material from plants and animals that lived millions of years ago. This material has been metamorphosed into rock or densely packed sediment by heat and pressure from being buried thousands of feet below the surface. Coal forms in stages, starting with organic mud, progressing through metamorphism successively (given sufficient heat and overlying pressure) to lignite, bituminous coals, and ultimately anthracite coal (the metamorphic version of carbon). Graphite forms as a result of organic material or limestone undergoing even greater heat and pressure at depth over an even longer period of time.

In discussions with an associate a few months ago (James L. Conca, Ph.D.), as we were finishing a report on our investigations of using nuclear systems to generate electricity to power the 2nd space race that has just begun [4, 5, page 182], we realized the importance of carbon-based materials that were on the verge of replacing many products made of less sturdy materials, especially those applications requiring materials that provide superior strength and protection from radiation. These materials have applications in products on Earth as well. [7]

A shift in the paradigm is afoot it seems. Carbon derived from coal is becoming more important than wood and petroleum products as feedstock to make common products that society uses every day.

Carbon formulations can replace wood, some metals, and some plastics, the latter once considered to be "the future" by a family friend providing advice in the movie *The Graduate*. The new material of the future comes from coal and other carbon-rich materials such as graphite. One word, carbon, will carry many present graduates to a rewarding future but plastics will still be needed as well.

We discovered the merit of using carbon products to replace the need to harvest trees and to produce the petroleum used currently to manufacture most of the wood-based and plastic-based products, such as furniture, utility poles, building construction materials, and a host of other products. Carbon-rich natural resources no longer need to be burned for the purpose of generating electricity but can be used as a feedstock to formulate carbon fiber and carbon nanotubes and cages (microscopic structures of *graphene* that we'll define later) that are already used in reinforced plastics, heat-resistant composites, cellphone components, batteries, fishing rods, golf club shafts, bicycle frames, sports car bodies, the fuselage of the Boeing *787 Dreamliner*, pool cue sticks and to reinforce concrete and gray cast iron and many other products. This also includes carbon rods used as a neutron moderator in nuclear reactors to control the rate of fission.

Carbon is also used in components for heating nuclear fuel and in the cool-down process, and can absorb heat up to 3,000 degrees C without any significant deterioration.[22] Refractory crucibles for high-temperature are also made of graphite as well as in the manufacture of electrodes for many industrial applications, e.g., the aluminum and steel smelting industries.

Chairs and other furniture could be made from reformulated coal that could seat an elephant, last a hundred years, and be of any form and shape conceived of by the designer.

Using high-carbon materials formulated for building materials would also minimize building fires and damage by high winds, and even replace gypsum wallboard to improve energy conservation within homes and interior strength of materials.

Even as we move off-world in the coming decades, carbon products of high density and strength will likely become more useful in exploration activities to protect human habitation and electronics from radiation and from various types of inherent stresses in orbit or encountered in building structures on or under the surface of the Moon, asteroids, and even Mars.[8] Some form of carbon material will also be needed to make the 28,000 miles of carbon-fiber belts required in building the first space elevator, see Figure 2. [5, page 201]

Figure 2. Artist's Conception of the Space Elevator Hoagland.[15]

The production of carbon for use in consumer products would likely maintain or increase employment in the current coal and graphite industry and in the associated new carbon-based industries that formulate and manufacture new carbon products.

Underground mining of coal could be put off until it could be accomplished by robotic miners without the need for the continuous presence of humans underground in typically methane-rich and therefore potentially explosive environments.

It is apparent that coal and associated carbon-rich natural resources such as lignite can be converted to high-grade carbon through industrial heat and pressure, producing material similar to the naturally occurring anthracite coal and graphite.[18, 24, and 33] Graphite is a natural mineral that consists of carbon that forms only two bonds with other carbon atoms. This means it has free electrons, and for that reason it is a good conductor of electricity as well as a strong material. In addition, graphite exists in layers. This enables one layer to slip over another layer, making graphite an excellent lubricant. Also, since there are free electrons to absorb light, graphite is black.

Blocks of formulated, fine-grained carbon (like *carbon black* used in copying machines) could also be used in new 3-D printing that has been developed recently to make all manner of large and small products out of carbon materials.

Graphite is composed of thousands of layers of graphene. It is used in pencil "leads" (the lead's hardness is adjusted by altering the associated clay content). One can split the microscopic layers of graphene in graphite by marking with a pencil on paper and applying *Scotch Tape* over the mark and then pulling off the tape. You will see a graphene layer showing on the tape and on the paper.[23] For scale, there are still thousands of layers of graphene below those one can see.

There are other forms of carbon, but these are not commonly available on Earth. These forms include *Buckminster fullerene* and several cage and tubular varieties that can be made artificially and offer promise for future applications.[9] Meteorites also contain graphene in the form of "buckyballs", and lunar soils consisting of meteorite impact dust will likely also contain large amounts of graphene (and carbyne to be discussed later), in addition to helium-3. [5, page 182]

It is clear that these carbon materials are becoming increasingly important natural resources and are useful resources driving the expansion of a new carbon-based industry, not only in the nuclear industry but in many other industries as well.[26]

Graphene appears at the atomic-scale like chicken wire made of carbon atoms and their covalent bonds (see Figure 3). Most importantly, graphene is the strongest material widely available in nature.[1]

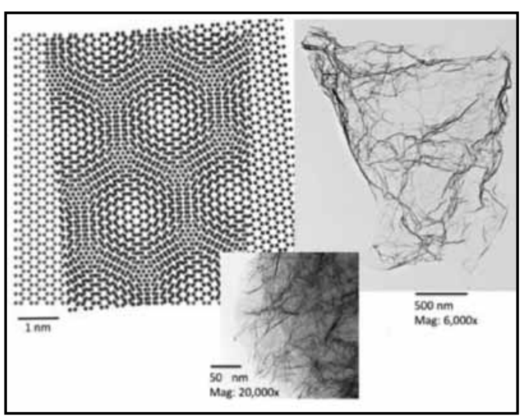


Figure 3. The regular framework structure of carbon atoms in graphene sheets. (TEM images). Image credits - NIST (National Institute of Standards and Technology) and Cabot Corporation.[3]

The regular framework structure of stacked graphene sheets show patterns upon larger periodic Moiré patterns (see Figure 3). Discontinuities and defects in the stacked sheets can produce subtle strains, bulges or wrinkles as seen in transmission electron micrographs of graphene nanoplatelets consisting of only a few layered graphene sheets. These structures impart different properties to materials that can enhance performance in composites, batteries, electronics, and many other products (see Figure 4).

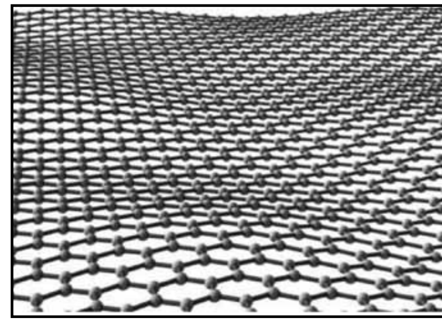


Figure 4. Chicken Wire Pattern with Variations in the Grid.

Graphene is an incredible submicroscopic material, and is:

- the strongest material in nature (200 times stronger than steel by weight),
- able to be mixed with other materials like plastics and cements,
- highly flexible,
- the thinnest useable material in the world (100,000,000 stacked sheets is less than an inch),
- a better heat and electricity conductor than copper,
- a material that can replace silicon in semi-conductors,
- a material that revolutionizes solar-power collection, and
- a material that dramatically improves the performance of lithium-ion batteries.

The race is now on to commercialize graphene as an integral part of the nanotechnology industry. China is leading the race at present. American companies have entered the race as well, especially since there are substantial security implications and increasingly important applications of graphene.[11] Its ultra-thin structure allows for sheets of the material to be stacked to increase energy storage and possibly double the current capacity of the new ultracapacitors.[12]

A graphene-based core additive has been developed for various types of high-energy density lithium-ion battery applications. This is a new technology platform that helps lithium-ion battery manufacturers achieve superior performance.[3]

Graphene-based products are in development and are actively being studied in Europe, but Asia and the U.S. are currently leading when it comes to patent publications - even though it was pioneered in Britain.[9] Universities, corporations (IBM and others) and governments in Asia, Europe and North America are leading the effort. Industry and Wall Street are beginning to gear up for a new materials future (Example: Cabot Corporation,[2] and others [1 and 21]).

In another university-industrial effort, a successful demonstration of a new direct carbon fuel cell design was carried out recently at the University of Queensland and by Direct Energy in Australia.[31] The demonstration indicated the apparent commercial integrity and viability of the unit, together with its scalability. The carbon fuel cells operate through a simple electrochemical reaction without excessive fumes and without combustion.

The University researchers have refined the extrusion and manufacture of the fuel cell tubes to commercial grade quality. These tube extrusions contain the essential anode, electrolyte and cathode materials that are the key component in the conversion of gasified coal to power. A relatively small unit can replace large boilers, turbines and generators – noise free, no moving parts, minimal emissions and using half the amount of coal for the same output (which means double the electrical efficiency of a traditional coal-fired power plant).[32] This is another approach to using carbon but without combustion to generate electricity; the costs for such clean energy appear to be reasonable after all.

So it is now apparent that carbon can be used to generate power and manufacture everyday products including those utilizing microscopic electronics that will have a large impact on society in the years to come.[14 and 29] But that's not the whole story. The strongest known material in the world may have recently been replaced with an even stronger material. Researchers from Rice University have calculated the properties of a little-studied form of carbon known as carbyne, and they've determined that it should have a specific strength surpassing that of any other known material. [1 and 16]

The new study shows that *carbyne,* made up of a chain of carbon atoms linked by alternate triple and single bonds or consecutive double bonds, is actually twice as strong as graphene, and exhibits unusual characteristics that make it appealing for a wide range of uses.[17 and 20] However, carbyne has also been detected in inter-stellar dust and meteorites, likely the result of the high temperatures and pressures experienced in those environments, and the Rice study indicates synthesizing it here on Earth has proven to be difficult. It may be in more abundance on the lunar surface and on passing asteroids. Sampling will tell us when we visit those sites sometime this decade.

New technology being developed from old resources (i.e. coal and graphite) is paving the way in some unexpected directions.[10] They will likely be important to industry for years to come in producing new building materials, developing new nanotechnology for the electronics industry, or in the field of medicine. The possible uses are vast. Flat screen TVs as thin as *Saran Wrap*... nanotechnology devices that would put the power of a supercomputers in the palm of your hand... and very small brain implants that may combat Alzheimer's,[19] as well as a graphene-scale radio,[28] to name just a few new applications under development today.

The carbon present in refined coal tar has been used for many years in the manufacture of industrial chemicals, such as creosote oil, naphthalene, phenol, and benzene. Ammonia gas recovered from coke ovens is used to manufacture ammonia salts, nitric acid and agricultural fertilizers. Thousands of different products have coal or coal by-products as common household constituents: soap, aspirins, solvents, dyes, plastics and various fibers, such as rayon and nylon.[27]

Coal is also an essential ingredient in the production of specialist products, such as:

- **Activated carbon** - used in filters for water and air purification, in kidney dialysis machines, and in gold and silver recovery operations associated with mining,
- **Carbon fiber (Graphene Assemblies)** - an extremely strong but light weight reinforcement material used in construction, mountain bikes and tennis rackets, etc.,[33]
- **Silicon metal** – carbon is used to produce silicones and silanes, which are in turn used to make lubricants, water repellents, resins, cosmetics, hair shampoos and toothpastes, etc.

Not only are many products derived from reformulated coal useful in the world today, but by moving away from burning coal, the transitioning to additional nuclear power systems in the form of either large-scale plants or in the form of small modular reactors that will soon be coming down the road on a trailer truck or rail-road car, will finally come into their own, driven by the merits of their economy and outstanding safety record (see Figure 5).

Figure 5. A Nuclear Power Plant with Water-Cooling Towers and the Beginning of the Electrical Grid in the Area.

The alternative energy sources of wind and solar will continue to be tested to determine if they can have a significant place in the energy picture (after government subsidies are removed), and whether they can be scaled up to meet the needs in other than remote areas away from national power grids and meet the operation and maintenance demands of their moving parts. The transition from burning coal to other reliable energy sources (like natural gas and nuclear power) will likely be slow because industry cannot change quickly unless companies are placed on an emergency footing. However, a large number of coal-fired plants are still in the planning stage for construction in the U.S.[30] Such changes may not become obvious in this decade, but they certainly will be apparent in the decades ahead.

So, in the big picture, coal has been used since the days of the cave man.[6] Coal (in making steam) drove the industrial revolution. It is useful today, and will be more so in the foreseeable future in driving a new, repurposed carbon industry, but just not for burning.

References

1. Anon, *Science Daily*, "Graphene News". December 13, 2013. Accessed Internet on December 13, 2013 via: *http://www.sciencedaily.com/news/matter_energy/graphene/*.

2. Cabot Corporation, 2013, "New Product Development: Graphenes," Accessed Internet on December 13, 2013. via: *http://www.cabot-corp.com/New-Product-Development/Graphenes.*

3. Cabot Corporation, 2013, "Cabot Launches First Graphene-Based Additive to Improve Energy Density of Lithium-Ion Batteries," Accessed Internet on December 13, 2013. via: *http://investor.cabot-corp.com/phoenix.zhtml?c=94559&p=irol-newsArticle&highlight=&ID=1788701.*

4. Campbell, M. D., and W. A. Ambrose, 2010, "Significant Uranium and Other Discoveries on the Moon May Indicate New Space Race is Afoot," A Press Release, April 16, 2010, Accessed Internet on December 10, 2013 via: *http://www.mdcampbell.com/SpaceRace04172010.pdf.*

5. Campbell, M. D., J. D. King, H. M. Wise, B. Handley, J. L. Conca, and M. David Campbell, 2013, "Nuclear Power and Associated Environmental Issues in the Transition of Exploration and Mining on Earth to the Development of Off-World Natural Resources in the 21st century," *in Energy Resources for Human Settlement in the Solar System and Earth's Future in Space:* AAPG-EMD Memoir 101, (eds) W. A. Ambrose, J. F. Reilly II, and D. C. Peters, eds., pp. 163–213. Accessed Internet on December 11, 2013 via: *http://www.i2massociates.com/downloads/Memoir101-CHAPTER09Rev.pdf*

6. U. S. Department of Energy, 2014, A Brief History of Coal Use," Accessed Internet on February 11, 2014 via: *http://www.fe.doe.gov/education/energylessons/coal/coal_history.html*

7. Conca, J. L., 2013, "Coal Doesn't Have To Die - We Can Make Furniture Out of It," Accessed Internet on December 11, 2013 via: *http://www.forbes.com/sites/jamesconca/2013/07/14/coal-doesnt-have-to-die-we-can-make-furniture-out-of-it/.*

8. Conca, J. L., 2013, "Beyond Earth's Atmosphere: Energy Needs For Space Colonization," Accessed Internet on December 8, 2013 via: *http://www.forbes.com/sites/jamesconca/2013/05/05/beyond-earths-atmosphere-energy-needs-for-space-colonization/*

9. Dodson, B., 2013, Graphene: Electronics – "New lithium/sulfur battery doubles energy density of lithium-ion," *GizMag*, December 1, 2013. Accessed Internet on December 7, 2013 via: *http://www.gizmag.com/tag/graphene/.*

10. Edmonds, R., 2013, "Windows Phone Central: Nokia Embracing New 'Miracle Material' for Future Hardware Development," Jan 28, 2013, Accessed Internet on December 6, 2013. via: *http://www.wpcentral.com/nokia-investing-new-material-future-hardware-development.*

11. Figueres, Christiana, 2013, Speaking to the International Coal and Climate Summit, organized by the Polish government and the World Coal Association, Executive Secretary of the UN Framework Convention on Climate Change, Warsaw, 18 November 2013. Accessed Internet on December 5, 2013 via:*https://unfccc.int/files/press/press_releases_advisories/application/pdf/pr20131811_cop19_coalassociation.pdf.*

12. Graphite Investing News, 2013, "Featured Stock: Grafoid Inc. – A Global Graphene Platform," Accessed Internet on December 13, 2013. via: *http://graphiteinvesting-news.com/2951-grafoid-graphene-research-investment/*

13. Graphene Energy, Inc., 2013, Corporate Website, Accessed Internet on December 1, 2013. via: *http://www.grapheneenergy.net/technology.html.*

14. Graphene-Info.com, 2013, "Graphene-Info is the Web's Leading Resource on Graphene Material Technology, Accessed Internet on December 6, 2013 via: *http://www.graphene-info.com/.*

15. Hoagland, R. C., 2005, "Moon with a View: Or, what did Arthur know and when did he know it? Part 5," Accessed Internet on February 7, 2014 via: *http://www.enter¬prisemission.com/moon5.htm*

16. International Science Times, 2013, "Carbyne Beats Graphene As World's Strongest Material: What Can The 'Super' Substance Do For Engineering?" Accessed Internet on December 9, 2013 via: *http://www.isciencetimes.com/articles/5919/20130820/strongest-material-carbyne-property-graphene.htm.*

17. Kastrenakes, J., 2013, "New form of carbon said to be strongest material ever found," in *The Verge* August 15, 2013. Accessed Internet on December 6, 2013 via: *http://www.theverge.com/2013/8/15/4625542/carbyne-determined-strongest-material-ever-found*

18. McLeod, C., 2013, "Scientists Create Graphene Quantum Dots from Coal, in Graphite Investing News, December 9, 2013. Accessed Internet on December 6, 2013 via: *http://graphiteinvestingnews.com/4728-scientists-create-graphene-quantum-dots-from-coal/.*

19. Money Morning Staff, 2013, "Massive Breakthrough For Graphene Investors," in Money Morning, Accessed Internet on December 11, 2013 via: *http://moneymorning.com/active-premiums/graphene-forecast/.*

20. Owano, N., 2013, "Carbyne is stronger than any known material," in the WebLog, August 20, 2013. Accessed Internet on December 10, 2013 via: *http://phys.org/news/2013-08-carbyne-stronger-material.html.*

21. Plimsoll Publications, 2013, "Carbon & Graphite Global - Industry Report," Accessed Internet on December 6, 2013 via: *http://www.reportlinker.com/p01908632-summary/Carbon-Graphite-Global-Industry-Report.html*

22. Prasher, R., 2010, "Graphene Spreads the Heat," *Science 9* April 2010: Vol. 328 no. 5975 pp. 185-186 DOI: 10.1126/science.1188998. Accessed Internet on December 7, 2013 via: *http://www.sciencemag.org/content/328/5975/185.short.*

23. Next Graphite, Inc., 2014, "Positive Industry Outlook - Graphite Uses Due to Increase Demand on Mining of Natural, Flake Graphite," Accessed Internet on August 7, 2014 via:*https://uk.finance.yahoo.com/news/next-graphite-inc-provides-positive-121000317.html*

24. Updates on Graphite Exploration and Mining:, 2013, Accessed Internet on December15, 2013 via: *http://graphiteinvestingnews.com/*

25. Clemente, F., 2013, "IEA recognizes reality: Coal is the path out of pov-

erty in Southeast Asia," November 6, 2013. Accessed Internet on December 18, 2013 via: *http://www.energy-facts.org/*

26. *New Scientist,* 2013, "Graphene Search Results," Accessed Internet on December 18, 2013 via: *http://www.newscientist.com/search?doSearch=true&query=Graphene.*
27. World Coal Association, 2013, "USES OF COAL," Accessed Internet on December 27, 2013 via: *http://www.worldcoal.org/coal/uses-of-coal/*.
28. *New Scientist*, 2014, "First Graphene Radio Broadcast is a Wireless Wonder," Accessed Internet on February 7, 2014 via: *http://www.newscientist.com/article/mg22129553.100-first-graphene-radio-broadcast-is-a-wireless-wonder.html.*
29. Red Orbit, 2013,"Scientists: Coal Is Better, Cheaper For Making Graphene Quantum Dots," Accessed Internet on February 7, 2014 via: *http://www.redorbit.com/news/science/1113022163/coal-graphene-quantum-dots-gqd-medical-imaging-120613/#Mo9pgbRO2RfJEX2z.99.*
30. Ambrose, W. A., 2013, "Unconventional Energy Resources: 2013 Review," Chapter 1: COAL – See Figure 3, Accessed Internet on February 15, 2014 via: *http://www.i2massociates.com/Downloads/EMD_AAPG_2013_NRR_online.pdf*
31. Direct Energy Holdings Pty Ltd., 2014, SHAREHOLDER UPDATE – February 25, Accessed Internet on February 27, 2014 via: *http://www.i2massociates.com/Downloads/DE_Shareholder_Update_2%2026a.pdf* .
32. Direct Energy Holdings Pty Ltd., 2014, Corporate Website, Accessed Internet on February 27, 2014 via: *http://www.dehpl.com/*.
33. Ruquan Ye, Changsheng Xiang, Jian Lin, Zhiwei Peng, Kewei Huang, Zheng Yan, Nathan P. Cook, Errol L.G. Samuel, Chih-Chau Hwang, Gedeng Ruan, Gabriel Ceriotti, Abdul-Rahman O. Raji,Angel A. Martí, and James M. Tour, 2013, "Coal as an Abundant Source of Graphene Quantum Dots," Accessed Internet on February 28, 2014 via: *http://www.nature.com/ncomms/2013/131206/ncomms3943/full/ncomms3943.html* For the References in separate PDF: See: *http://www.i2massociates.com/Downloads/2014AIPGRefs.pdf.*

Michael D. Campbell, P.G., P.H., CPG-03330, is the Executive Vice President and Chief Geologist /Hydrogeologist for I2M Associates, LLC, Houston and Seattle.

M. David Campbell, P.G. is a Project Manager and Senior Geologist for I2M Associates, LLC, in Fort Pierce, Florida.

Jeffrey D. King, P.G. is President and CEO for I2M Associates, LLC in Seattle.

Henry M. Wise, P.G., CPG-07697, is the Remedial Services Senior Specialist for SWS Environmental Services, La Porte, Texas.

For more about the Authors, *http://www.i2massociates.com/Downloads/AbouttheAuthorsFeb2014Coal.pdf.*

Ramon E. Bisque
CPG-01595
Member Since 1967
June 9, 2014
Golden, Colorado

Donald C. Haney
CPG-04053
Member Since 1977
June 8, 2014
Lexington, Kentucky

Bobby J. Timmons
CPG-02736
Member Since 1975
June 7, 2014
Jacksonville Beach, Florida

Frederick N. Murray
CPG-04755
Member Since 1980
July 20, 2014
Tulsa, Oklahoma

IN MEMORY

Dr. Ramon Edward Bisque (Ray), CPG-01595, 82, passed away in Golden, Colorado on Monday, June 9, 2014 of natural causes. Ray lived every moment to the fullest, up to his very last. Ray grew up in Iron River, a small mining town in Michigan's Upper Peninsula. He went on to earn his undergraduate degree at St. Norbert College, and advanced degrees from Iowa State University, where he met his wife, Marie Livingston Young. After marrying in Algona, Iowa, Ray and Marie re-located to Colorado in 1959. He became a professor at Colorado School of Mines, an entrepreneur, an innovator, and a writer. Early in his career, he was the director of a curriculum project which involved contributors in what was arguably the most interdisciplinary gathering of geoscientists ever convened in the United States. Activities from his home base at the Colorado School of Mines earned him recognition as a Fellow of the American Association for the Advancement of Science, a Distinguished Lecturer, and a feted Native Son in his home town.

Bobby Joe Timmons, CPG-02736, 83, died at his home in Jacksonville Beach, FL, on June 7, 2014. He served in the U.S. Navy aboard the USS Buck during the Korean War. A 1962 graduate of the University of Kentucky, he enjoyed a long and distinguished career as a geologist and geophysicist, working in both the public and private sectors and eventually establishing an eponymous consulting business. Mr. Timmons was a long-time member of the Forum of Geology on Industrial Minerals and the American Institute of Professional Geologists. He was honored by the AIPG for his contributions to the field of geology with the Martin Van Couvering Memorial Award.

He shared his fascination with science, particularly rocks and minerals, with any interested audience. He especially enjoyed interacting with Cub Scout groups and elementary-school students. Having earned a pilot's license as a young man, he loved flying and fiercely supported the exploration of space. While those who knew Mr. Timmons well might describe him as gruff, exacting, and at times irascible, he was an old softy when it came to children, animals, and waitresses.

Answers on Page 28

Robert G. Font, CPG-03953

1. Which of these would be best described as a "pyroclastic flow"?
   a) Aa
   b) Pahoehoe
   c) Nuée ardente

2. We are working with a soil that has a liquid limit (LL) of 55% and a plastic limit (PL) of 20%. Classify this earth material under the "unified soil classification system".
   a) CL
   b) CH
   c) MH

3. One of the worst natural disasters in recent history involving loss of life due to volcanic gas emissions occurred in Cameroon, Africa in 1986 associated with Lake Nyos. Which of the following gases was the main culprit in this tragic event?
   a) CO_2
   b) H_2S
   c) HCl

4. Heavy rains trigger landslides in a given area undergoing some urban development. A massive rock slab is suddenly detached and slides down a long slope (assume a frictionless slip surface) reaching a velocity of 50 feet per second in 3 seconds. What is the acceleration of the slab and how far would it move in 6 seconds?
   a) $a = 12.10$ ft sec^{-2} and $S_6 = 503$ ft
   b) $a = 16.67$ ft sec^{-2} and $S_6 = 300$ ft
   c) $a = 18.76$ ft sec^{-2} and $S_6 = 240$ ft
   d) Run for your lives! The slabs are coming!

Communication

Raymond W. Talkington, CPG-07935
rtalkington@geospherenh.com

I am at my desk in my office and I looked over at the monitor on my desk and noticed several new emails. I have turned off the sound on my computer in order not to hear the email notification each time a new email arrives. I scan my desk and there is my land line telephone and next to it my cell phone. I think for a fleeting second that I can send and receive emails, texts, and all other types of electronic communications from this small device. We have "tools" that allow us to be in communication with anyone in the world just by pressing a few keys on our computer or phone.

Thinking back just a few years when I was in the field in northern Canada our only communication was a two way radio. We would have "sched checks" with other field parties a couple times a day at pre-determined times. Why? Just to communicate to make sure that all is fine with each field party. This was never more important when we had to perform a rescue of a research party from the Crater de Nouveau Quebec located in the Ungava Peninsula. The group of researchers was caught in a terrible wind, rain, and snow storm (and everything else Mother Nature could throw at them) that blew away their camp and destroyed their communications directly with us. The rescue took over 24 hours and required multiple helicopter trips to rescue the 18 researchers. All of their gear was lost and it took a couple of weeks for them to recover from this storm. Although we could not communicate directly with the researchers after their antenna was destroyed in the storm, we were able to speak with another field party on Hudson Bay who could communicate with them throughout most of this three day storm and rescue event. If it were not for the communication links that were set up, the rescue may not have gone as smoothly as it did. We all can share stories like this and communication is always a critical component to all.

Whether you are employed in industry, government, or the private sector, check how many hours of your day are devoted to communication. I think you will be surprised.

Let us not forget the "old fashioned" type of communication which is often lost these days – oral or face to face communication. When you are composing an email or text message who are you looking at? A piece of electronic equipment. It has no feelings. It does not make weird faces at you as you speak or begins to fall asleep. The electronic equipment is always awake and alert and ready to do what you want. There is no emotion. You are now in a meeting, your meeting, your agenda, with a group of business colleagues, new client, or regulators. The dynamic is different. Body language is important. The way you, yes you, run the meeting is critical in many ways. You must be on top of your game in a face to face meeting and expect anything and any question.

At AIPG communication is also important. All at Headquarters and the Executive Committee must be available to communicate with the thousands of AIPG members as well as the public. How do we do this? Our two major outlets are *TPG* and AIPG eNews. We also have a web page, send out email blasts to members, and yes, the occasional snail mail. I encourage you to pick up the phone and make a call to Headquarters and enjoy the welcome you receive by one of the staff members. Let me know how this goes.

I look forward to seeing and communicating with as many members as possible at the Annual Meeting in Prescott, Arizona. Look for some exciting new activities such as the Young Professionals (YP) Technical Session. This is an activity AIPG is promoting through both AIPG and the Foundation. Please come and meet the YPs and communicate with them. We also have a new program to launch so be there to find out what it is.

Since I last spoke with you, AIPG had an Executive Committee meeting in Thornton, Colorado. I also had the privilege to attend the European Federation of Geologists Meeting in Palermo, Sicily. My Mother's mother was born in Sicily, so it was nice to visit the home of my ancestors. What was nice is that I understood the Sicilian dialect which was what I remember as a child growing up. I will be heading to Georgia to make a presentation to the Student Chapter of the Year at Columbus State University. Thank you for all of your hard work and dedication! I will also visit the Student Chapters at Georgia State University and University of West Georgia. We still need 24 more student chapters. Let me know if you would like a visit to your Section. Let's keep up the communication.

GSA has an Opening for the Position Of Executive Director

Would you please forward this information to any of your members or other individuals you believe would be good candidates. If you would like to apply for this position, please provide the following documents: resume, the names, addresses, and e-mail addresses of three references and a letter describing your interest in the position.

The individual may send their information as attachments to hr@geosociety.org. For more information please see the link provided:*http://www.geosociety.org/humanres/1408ExecDirector.htm*

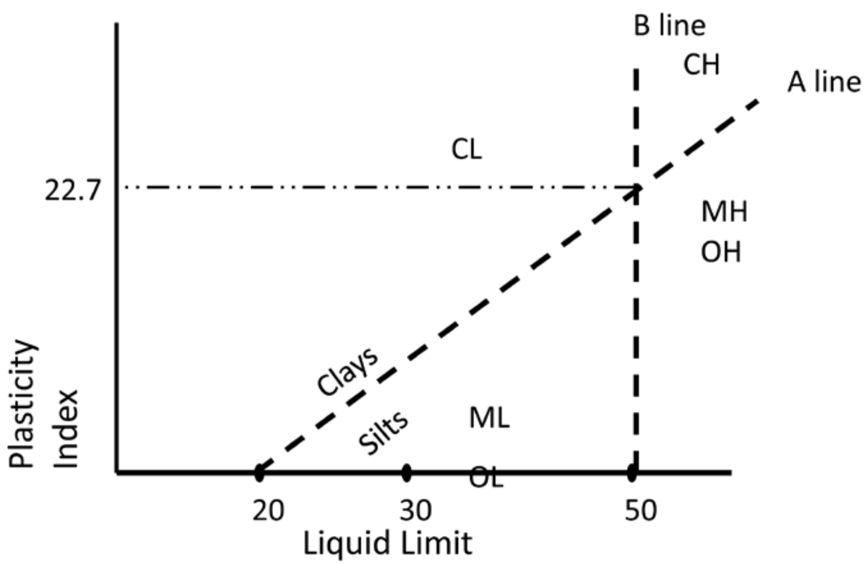
Answers:

1. The answer is choice “c” or “nuée ardente”. A nuée ardent defines a swiftly-flowing cloud of incandescent gas, volcanic ash and other pyroclastic material ejected from a volcano in an explosive eruption. The 1902 eruption of Mt. Pelée on the Caribbean island of Martinique resulted in a nuée ardente which buried the city of St. Pierre killing about 29,000 people.

   “Aa” describes a lava flow that has a broken and jagged surface.

   Pahoehoe defines a lava flow with a ropy, smooth, billowy surface.

2. The answer is choice “b” or “CH” (clay of high plasticity). Recall that the “plasticity index” (PI) is defined as the liquid limit minus the plastic limit. Thus, PI = LL – PL. In our case, PI = 55 – 20 = 35. Based on “Casagrande’s Plasticity Chart” (shown below), our soil plots to the right of the “B line” and above the “A line” placing it within the (CH) category. Clays of low plasticity (CL) plot above the “A line”, but to the left of the “B line”. In comparison, silts of high compressibility (MH) plot below the “A line” and to the right of the “B line”.



3. The answer is choice “a” or carbon dioxide (CO_2); the main culprit in this tragedy which suffocated about 1,700 people and around 3,500 livestock!

4. The answer is choice “b” or [$a = 16.67$ ft sec^{-2} and $S_6 = 300$ ft]. The proof follows:
   The key equations from physics are:
   $V_f - V_o = at$ (1)
   $S = ½ at^2$ (2)
   For the above, V_f = final velocity, V_o = initial velocity, a = acceleration and t = time.
   In our problem:
   $V_f = 50$ ft sec^{-1} (3)
   $V_o = 0$ (4)
   $t = 3$ sec (5)
   Substituting (3), (4) and (5) into (1) we obtain:
   $a = (V_f - V_o) / t = [(50 - 0)$ ft sec$^{-1}]$ /3 sec = 16.67 ft sec^{-2} (6)
   Equation (6) gives us the acceleration of the slab. To solve for the distance traveled by the slab in a 6-second time frame, we plug in the “a” value in equation (6) into equation (2):
   $S_6 = ½ at^2 = (0.5)(16.67$ ft sec$^{-2})(6$ sec$)^2 = 300$ ft (7)
   Equation (7) shows us the distance traveled in 6 seconds; equivalent to the length of approximately one football field. How fast can you run the 40?

Serving the Profession – Now and Into the Future

Robert A. Stewart, CPG-08337

AIPG as well as many of our peer organizations have embraced programs to assist students and young professionals (YPs) in the geosciences. The demographic problem is well known to most practitioners, as the present and future demand for geoscientists is not being met by a sufficient number of recent graduates to offset the impending wave of retirements. The American Geosciences Institute (AGI) does an excellent job tracking and publicizing this issue through its Geoscience Currents (GCs), which AIPG regularly publishes in TPG. The latest GC (No. 90), inside the front cover of this TPG, shows a circular diagram that links the degree fields of recent geoscience graduates with the industries where those graduates found their first jobs after graduation. This is an exciting depiction of the diverse academic and professional subdisciplines available to geoscience students and YPs.

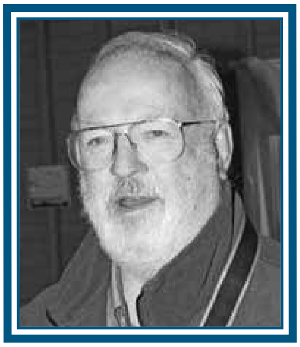
GC No. 90 is also the general goal of professional outreach programs to students and YPs, in which practitioners share their experiences with students, provide suggestions and encouragement for YPs entering the work force, and thereby link academic training with specific geoscience careers. AIPG's early approach was to geoscience students, beginning with our first student chapter at Wright State University in 1996. Other chapters followed in 1998 (James Madison University) and 1999 (Colorado School of Mines). In 2003 AIPG inaugurated the annual student issue, which began a highly successful forum for students, and particularly undergraduates, to present their research and views in a traditional print format. Since 2003, the number of AIPG student chapters has grown to over 20, with more chapters in the works for 2014. Contributions to the annual student issue typically spill into the Spring issue of TPG, and our annual meeting is increasingly popular with students and YPs. Our sections have done outstanding outreach to student members through scholarships, career days, short courses, field schools, technical sessions at national and regional meetings of the Geological Society of America (GSA), and other events. At headquarters we are constantly assessing how and where we can effectively represent the profession and encourage geoscientists to join AIPG to join our mission. So far in 2014 headquarters staff have attended meetings with the Society for Mining, Metallurgy and Exploration (SME) in Salt Lake City; Colorado Mining Association (CMA) in Denver; European Federation of Geologists (EFG) in Palermo, Sicily; Association of American State Geologists (AASG) in Lexington, Kentucky; American Association of Petroleum Geologists (AAPG) in Snowbird, Utah; Council of Engineering and Scientific Society Executives (CESSE) in Spokane; Energy Exposition in Billings, Montana; American Rock Mechanics Association (ARMA) in Minneapolis, and the National Conference of State Legislatures, also in Minneapolis. Through the end of 2014 this list will include the Unconventional Resources Technology (UrTec) Conference in Denver, GSA and AGI at the GSA annual meeting in Vancouver, British Columbia, and the American Geophysical Union (AGU) annual meeting in San Francisco.

Annually, AIPG can be proud of its accomplishments through the efforts of our members and headquarters staff. So what's the next step? AIPG is developing a YP program to take to colleges and universities as a means of introducing geoscience students to the profession and all the ancillary matters of employment – job searches, networking, resumes, interviewing, and so forth. Our intention is to offer the YP program to academic geoscience programs at no cost to them. This is the general concept, and the specific program is under development, for a one-day event. We know from experience that this program will be of interest and value to students.

There are three critical parts necessary to the program: volunteers, time, and sustaining financial support. AIPG has volunteers in abundance. One advantage of the bimodal age distribution of geoscientists is that those of us now in the – ahem – established period of our careers can easily provide the intellectual capital deriving from long and diverse experiences. Our early-career members are well-positioned to share their experiences with students and recent graduates, particularly in the context of their practical use of the amazing new technical tools with which older members may not have the same familiarity.

Time off is usually an easier sell to employers than a request for a monetary contribution to a cause such as AIPG's YP program. We all have full lives with many commitments outside our profession, putting our volunteer time at a premium. The YP program will be portable, with the hope that our members will use it on a local basis. Additionally, consider acting as a mentor to a geoscience student. If you would like AIPG's assistance, let us know! To begin the process, check the appropriate box on the 2015 membership renewal form, on-line or paper, as a mentor or a mentee.

Last but not least, the YP program will need sustaining support as a long-term program, as there will be development costs, and support to our volunteers to defer expenses for travel, accommodations and subsistence. AIPG plans to fund the YP program with support from the Foundation of the AIPG ("the Foundation"). Our goal is to build the assets of the Foundation to a level that will fund the YP program on an annual basis from investment income. Please consider a contribution to the Foundation, or volunteering your talents as a fund-raiser.



**Compiled by David M. Abbott, Jr., CPG-04570,
5055 Tamarac Street, Denver, CO 80238,
303-394-0321, fax 303-394-0543, dmageol@msn.com**

Topical Index-Table of Contents to the Professional Ethics and Practices Columns

A topically based Index-Table of Contents, "pe&p index.xls" covering columns, articles, and letters to the editor that have been referred to in the PE&P columns in Excel format is on the AIPG web site in the Ethics section. This Index-Table of Contents is updated as each issue of the TPG is published. You can use it to find those items addressing a particular area of concern. Suggestions for improvements should be sent to David Abbott, dmageol@msn.com

Social License to Operate and Fracking

In column 148 (Nov. '13) I reported on the American Geoscience Institute's Forum on Ethics in the Geosciences and the increasing awareness that geoscientists, regardless of specialty or employer, have an ethical obligation to weigh the societal benefits of their research against the costs and risks to human and animal welfare and impacts on the environment and society. One of AIPG's primary purposes is to monitor and weigh in on laws and regulations that affect geoscience practice. For many years, such monitoring focused on state licensing laws, an effort that continues today. Licensing laws and regulations are a form of social license to operate. Laws and regulations also affect the industries we work in, mining, oil and gas, environmental regulation, water law, and geotechnical practice. These laws and regulations are another aspect of the social license to operate.

Fracking is a hot topic in many parts of the country now and the political debates about whether fracking should be allowed and, if so, under what conditions.[1] These debates are clearly another and dramatic form of social license. Those in the oil and gas business have known about hydraulic fracturing (fracing) for decades and it's no big deal. But the expansion of horizontal drilling and fracing in shales, often in parts of the country that had not previously had extensive oil and gas drilling and production activity, has brought the whole subject to the public's attention. For the public, fracking is something new and unknown that potentially impacts society in a variety of ways. Fracking, as used by the general public, covers all aspects of drilling, completion, and production. Because the public has only recently become aware of fracking, there are lots of questions, concerns, fears, and misinformation being passed around and efforts to regulate this "new" fracking industry are being proposed.

In Colorado, most of the state's population lives along the Front Range mountain front from Colorado Springs north to close to the Wyoming line. I-25 traverses this corridor at varying distance east of the mountain front. The mountain front also coincides with the western boundary of the Denver Basin, which covers much of northeastern Colorado and adjacent Wyoming and Nebraska, and which has been an area of active oil and gas drilling since the 1950s. Because of the asymmetric shape of the Denver Basin, steep on the west side and shallow on the east, most of the oil and gas drilling has occurred in the rural areas east of I-25. However, for those who bothered to recognize what they were seeing, drill rigs, pump jacks, and tank batteries have been visible adjacent to I-25 for years once one drove north out of the Denver metropolitan area. What is new along the I-25 corridor are housing developments. What for years has been rural is becoming suburban. The appearance of a drill rig that operates 24/7 near new homes and schools is alarming to the residents of these new communities. The fact that many of the mineral rights have been severed from the surface rights means that these new residents in the oil patch are not receiving royalty payments, exacerbating the frustration.

Demonization of the oil and gas industry and others is also continuing, and is perhaps cranking up as we approach the fall elections and the attack ads are starting to occupy more TV time. Attack ads are a prime source of demonization. Candidate A is bad because he/she supports Obamacare (the demonizing term for the Affordable Care Act) and worked with the health insurance industry (demonized) in developing Obamacare, which has caused millions of Americans to lose the health insurance they had, and is receiving campaign contributions from the health insurers. Candidate A's opponent is bad because he/she wants to dismantle the Affordable Care Act and is receiving campaign contributions from health insurance companies who want to protect their record profits (demonization). "Big oil" is a favorite demonizing term in ads attacking a candidate that is alleged to support the oil and gas industry.

Fracking is a current political issue. Traditionally, regulation of oil and gas drilling has been done at the state level. Now, efforts are being made to allow county and local governments to further regulate, or to ban, oil and gas drilling (*i.e.* fracking) on a local basis.

What is the appropriate response to these political efforts? The geoscientist's common first reaction is to look up lots of technical information that can be distributed. But this is not what most people want. They want to know the technical

1. In this paragraph I spell the abbreviated term for hydraulic fracturing two ways, "fracing" as used for decades in the oil and gas industry for a specific completion technique and "fracking" as used in news media and by the public when referring to the whole process of drilling, completing, and producing hydrocarbons from tight shales commonly using horizontal drilling techniques. It is clear that the specific meanings of the terms are different, something geoscientists need to recognize and respect.

issues have been studied by reputable, independent parties (not "big" oil) and that there is either not a problem or that particular issues, such as distances from homes or schools or noise, can be resolved. Unfortunately, the web, that source of so much information these days, is not a good place to find simple, clear, and unbiased answers to questions about fracking. Certainly, there are some whose minds are made up and cannot be changed. But most people are puzzled and want summary information and reassurance from someone they view as knowledgeable and that they trust. I've experienced this personally. Listen to the questions and answer them with a minimum of technical detail (unless specifically requested). Talking to our neighbors and others in groups we associate with will be the most effective way we can provide answers to people's questions.

Geoscience Ethics and Social Responsibility

Roger Dunshea published a short piece, "The only way is ethics," in the May 2014 issue of the *Geoscientist*, the Fellowship magazine of the Geological Society of London. Dunshea opines that geoscientists have an ethical responsibility to the environment and to society to "consider fully the geo-strategic, ethical, and economic sustainability factors before pointing out where to drill and blast" in the exploration for and exploitation of natural resources. Dunshea notes that "while our peers in the medical and life sciences are developing new ethical standards to protect the wellbeing of current and future generations, is it not now time to start discussing and developing a set of geological scientific ethics that can support very long-term global sustainability?" Dunshea appears to be suggesting that we curtail the exploitation of natural resources now so that they will be available for future generations.

The problem is who selects what natural resources will be made available now, which segments of the population can have access to them, and who gets left out? For example, concerted efforts are being made to restrict or eliminate the use of coal for power generation by mandating the use of increasing percentages of "clean" energy. What is not discussed by the advocates of clean energy is increased cost of electricity resulting from these efforts. We already have a significant percentage of the population that has trouble paying their energy bills. The mandates for increasing the percentage of clean energy exacerbate this problem. Is it socially responsible to ignore this consequence of these mandates? Dunshea notes that the medical and life science professions have or are developing professional ethics codes that recognize the need for the ethical treatment of living organisms in research and practice. Dunshea's suggestion that we restrict natural resource exploitation now is not unlike requiring the medical profession to stop vaccinating against some disease for some segment of the population or that various expensive medical procedures not be available to those over a certain age because they are likely to die soon anyway.[2] The ethical uproar against adopting such medical proposals ensures they will never be adopted, at least in some mandated form. Are placing restrictions on the use of identified natural resource deposits any different?

Software License Restrictions

Adam Heft, CPG-10265, sent me the following question: "Here is the situation. I've purchased an electronic version of several ASTM standards (for ESAs, in this case) for use here at the company using company funds. The standards are applicable for several of us within our group, which is spread over several offices. The ASTM standards list who downloaded the standard, and indicate that no reproduction of the document is permissible. We keep the documents on one of our local computer drives, and those of us locally can access it. After initially reviewing it to see how it affects some of our work products/methods, we rarely do anything with it other than keep it in our files. I have a hard copy of the document in my office that I occasionally refer to.

"The question is to what degree (if any) is it permissible to share the document with colleagues in another office? I've been pretty conservative in that I don't like to provide it to others given the limited use declaration on it. One of my colleagues looks at it a bit differently. He thinks it can be treated like a bound book that can be passed around to others. I'd agree if it were likely that a) it was likely not to be copied, and b) I would not need it again before it was 'returned' to me. Granted, anything can be copied, but this actually has my name on it as the one that ordered/downloaded it.

"This came up again this morning with a slightly different situation. One of our other offices was asking to 'borrow' two historical standards (there are more recent versions of each available that we have purchased). It seems that in this case, one of our clients needed to have them available for a period of time to go with a document that would be on public display. They would have a hard copy available in a "records room" situation where people could look at it but not copy it. This entity has apparently ordered a hard copy of the standards that won't arrive for a length of time, and our version would be a stand-in until they receive them. I've been assured that once they receive their purchased copy, they will destroy my version. Given this assurance, and the fact that these are old standards I no longer refer to, I'm not concerned with a copyright violation in this case. If it were a current standard, I'd be more concerned.

"Can you shed some light on this for me?"

Heft sent me a copy of the license agreement for this software, which fairly clearly states that one can only temporarily transfer the electronic file of an ASTM standard to a computer and that only one printed copy can be made for internal use. Not surprisingly, ASTM wants everyone to purchase his/her personal copy of each ASTM standard regardless of whether the company or the individual paid for the software. I visited the ASTM website where one can buy "pay per use options" for internal use or for external use. The prices depend on the number of copies desired. These uses are for hard copies only; no emailing or other electronic distribution is permitted. The text of the ASTM standards is the issue here. This differs from the license to use software that allows one to do something like create a document or drawing.

What do you think of this situation? How would you handle it? Have you ever quoted an ASTM standard in a report? If so, what was the source?"

2. A number of years ago, former Colorado Governor Richard Lamm created a great deal of furor by suggesting that the terminally sick and elderly had a "duty to die" rather than demanding the use of scarce and expensive medical resources.

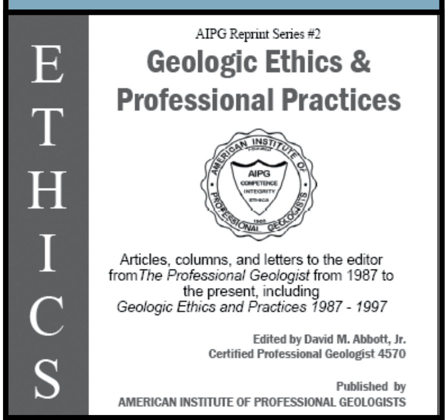
IN MEMORY

Dr. Frederick Nelson Murray, CPG-04755, of Tulsa, Oklahoma died July 20, 2014. The former Air Force officer, professor of geology and meteorology, land and exploration manager for energy companies, geologic consultant, and local community volunteer will be remembered by many for his knowledge, experience, and time that he shared with others. Fred was a graduate of Tulsa University, the University of Washington, and the University of Colorado. He obtained a B.S. in Geology, a B.S. in Meteorology and Climatology, and an M.S. and PhD. in Geology respectively. He served two years as a Second Lieutenant in the U.S. Air Force from 1958-1960. Based at Ben Guerir AFB, he served as a weather forecaster for pilots who flew missions and made surveillance during the Cold War. An extensive traveler, Fred enjoyed adventure, being outdoors, and working with the land. Whether he was surveying the land, improving the landscape, or maintaining cabins, he spent time either at his farm in Creek County, Oklahoma or in Scholfield, Colorado at the family cabin. Fred was actively involved with Will Rogers HS Class of 1953 and served as Westminster Class treasurer at First Presbyterian Church of Tulsa. He was a weekly volunteer for Helping Hand, Eastern Oklahoma Community Food Bank, and affiliated with local and national geological associations that brought enrichment pro grams to Tulsa youth to encourage their endeavors in physical and geological science.

Geologic Ethics & Professional Practices is now available on CD

This CD is a collection of articles, columns, letters to the editor, and other material addressing professional ethics and general issues of professional geologic practice that were printed in *The Professional Geologist*. It includes an electronic version of the now out-of-print *Geologic Ethics and Professional Practices 1987-1997*, AIPG Reprint Series #1. The intent of this CD is collection of this material in a single place so that the issues and questions raised by the material may be more conveniently studied. The intended 'students' of this CD include everyone interested in the topic, from the new student of geology to professors emeritus, working geologists, retired geologists, and those interested in the geologic profession.

AIPG members will be able to update their copy of this CD by regularly downloading the pe&p index.xls file from the www.aipg.org under "Ethics" and by downloading the electronic version of *The Professional Geologist* from the members only area of the AIPG website. The cost of the CD is $25 for members, $35 for non-members, $15 for student members and $18 for non-member students, plus shipping and handling. To order go to **www.aipg.org**.



INSURANCE PROGRAMS

Available to
AIPG MEMBERS

GeoCare Benefits Program
For information:
Life, Dental, Disability, Supplemental Insurance, and Cancer Expense
GeoCare Benefits Insurance Plan
http://www.geocarebenefits.com/
Phone: 800-337-3140 or
805-566-9191

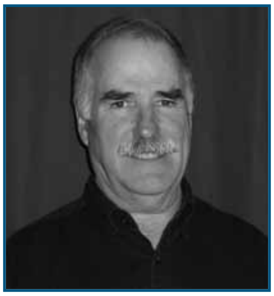
Liberty Mutual Insurance
Auto and Home Insurance
http://www.libertymutual.com/lm/aipg
Phone: 1-800-524-9400
Please mention client #111397 when you contact Liberty Mutual.

The Wright Group
Professional Liability Insurance
General Liability Insurance
http://www.thewrightgroupinc.com
Phone: 303-863-7788

Financial Services
The Consulting Group at RBC Wealth Management
David Rhode, Senior Investment Management Specialist/Financial Advisor
http://rbcfc.com/david.rhode/
dave.rhode@rbc.com
Phone: 1-800-365-3246
Fax: 303-488-3636

Is Your Profile Correct?

It is important to keep your address, phone numbers, and e-mail information up to date in our records. Please take the time to go to the AIPG National Website, ***www.aipg.org,*** login to the member portion of the site and make sure your information is correct. You can edit your record online. If you do not know your login and password you can e-mail National Headquarters at *aipg@aipg.org* or call (303) 412-6205.



What Are You Trying To Show Again?

William J. Stone, MEM-2164

A constant challenge in technical writing is to say what you mean and to mean what you say. This also goes for what is shown versus what is intended in figures. Common map errors include having an inadequate or inaccurate legend, incorrect or unclear labels, and insufficient base information (scale, roads, features, location grid, etc).

Environmental agency personnel review many reports. Justly or unjustly, they tend to judge the quality of the work done by the quality of the report submitted. Who could blame them? Illustrations in the report contribute greatly to the general impression of the work.

When employed by a state environmental agency I once reviewed a troublesome report of a petroleum pipeline leak. What should I have concluded from a figure labeled as a "contour map of free-phase hydrocarbons" that showed zones rather than contours and was poorly labeled even for that?

More specifically, the focus of labels was inconsistent, alternating between zones and boundaries of zones. For example, the label, "surface soil staining at the time of the spill," clearly appropriate for a zone, was applied instead by arrows to the line edging a zone. On the same map, a dashed line around the area of soil contamination was labeled "line of soil contamination." This seems to be describing a boundary, but if that was the intended focus it would be better labeled, "extent of surface contamination."

Furthermore, water-level contours were labeled with values less than 100 (units unspecified ?!) in an area where ground-surface elevation alone is in the thousands of feet. When the consultant who prepared the report was questioned about this, the response was, "the water–level contour values were derived by reference to an arbitrary datum." Unfortunately, neither the process nor the datum was ever discussed in the report. If a map only serves to confuse the reader or expose the carelessness of the author, it is not useful. Furthermore, such illustrations reflect poorly not only on the author but also on the consulting company and client he/she represents. TIP: Make illustrations clear and correct or leave them out.

Dr. Stone has more than 30 year of experience in hydroscience and is the author of numerous professional papers as well as the book, Hydrogeology in Practice – a Guide to Characterizing Ground-Water Systems (Prentice Hall). Feel free to argue or agree with him via email at *wstone04@gmail.com*.

Natural Hazards and Disasters: Mini-Case Reviews 2010-2014†

Michael J. Urban, MEM-1910

†Disclaimer: Clearly not a comprehensive list.

During the past couple of years I have had the opportunity to teach an undergraduate *Environmental Geology* course at a community college and teaching the course always serves as a reminder to me of all the "natural hazards" we must contend with in the United States. I decided to write a little bit about the topics covered in the course, recent examples of some natural disasters (or near-misses), and some of the resources I used in the class. Teaching the class is a lot of fun and the discussions are always stimulating!

For those who may need a refresher, *environmental geology* (EG) is a branch of geology concerned with a variety of topics, primarily related to solving environmental problems and dealing with lithosphere-human interactions; for example, preventing or mitigating natural hazards (e.g., earthquakes, landslides, etc.), cleaning up pollutant spills or contaminated groundwater, and managing natural resources like water, minerals, and fossil fuels, are all applied activities of the environmental geologist. While I greatly enjoy teaching other geology courses too (e.g., physical geology and planetary science), I really appreciate the potential value an EG course can have on opening the eyes of our students to the true power of geology in general – both in terms of the effects of nature on us and in how we come to adapt to living on our dynamic planet. We cover some of these issues in our other geology classes, however in few others is the point so clearly driven home: we are at the mercy of the Earth, so understanding our surroundings and the potential dangers they bestow on us is a critical component to living safely. After all, it has been said that "chance favors the prepared mind." If I'm unaware of the dangers of building on a floodplain or swelling soils, in an earthquake zone or on an active volcanic island, at the base of steep topography, or in an area with Karst topography, I'm much less likely to effectively plan for the unthinkable.

Several of the class topics to which considerable time is devoted include: avalanches, earthquakes (and tsunamis), flooding, mass wasting, oil spills, swelling soils, volcanic eruptions, and water contamination. Unfortunately, there have been numerous examples of most of these events to study lately. [I suppose one of the only positive aspects of these natural disasters' occurrence is that they further drive home the point that they can and do happen.] Excepting typically earthquakes and volcanoes, each of these hazards is prone to one or both of the two states I am most familiar with (and have recently taught in): Colorado and Minnesota. I have often thought taking a "case study" approach to teaching EG might be a very good way to go, but have not yet fully implemented such a curriculum (something to think about…).

A few of the specific events and their relationship to EG, are explored next:

Asteroid Impacts

My absolute favorite topic to teach is extraterrestrial impactors – I think it's because of the sheer respect such a hazard commands; no other potential calamity can do so much damage so quickly with the utter destructive capability to wipe out all life on the planet. Students enjoy learning more about the probable extinction event that doomed the dinosaurs and the catastrophic effects of even a small asteroid striking the Earth. Just a week after covering "solar system hazards" in class this past semester (Feb. 2014), the near-Earth asteroid 2000 EM_{26} made a close pass by the planet (see video link in references).[1] [Although I find it interesting, and therefore teach it to the students, understanding the nomenclature for provisional designation of asteroids does not seem to be high on their list of priorities!] Incidentally, just about exactly a year earlier, a very small asteroid made contact with Earth's atmosphere (meteor) and exploded over Chelyabinsk, Russia (see references for video link and article), which also made for a curious aside in class.

Flooding

The devastating floods of Colorado in September 2013, and of Minnesota in June 2014, serve as terrifying examples of the effects soil and rock composition, topography, and ground capacity have when combined with torrential rainfall. Seldom immediately obvious are the downstream consequences resulting from localized flooding, but nevertheless, the danger exists and students studying EG become better aware of associated concerns. Current events are typically replete with examples of floods making national news during spring and summer months.

1. The preliminary designation 2000 EM_{26} means the object was discovered in the first half of March in the year 2000 and was the 662nd object discovered during that time frame. See the International Astronomical Union (IAU) *Minor Planet Center* for details.

Debris flow on the south flank of Porphyry Mountain near Jamestown, Colorado. This flow began as a small rockslide due to highly fractured porphyritic bedrock and turned into a hyperconcentrated flow as precipitation and runoff increased. It came within a few feet of a residence in its path. Photo by Matt Morgan, MEM-2480, Colorado Geological Survey.

Massive pile of debris in Jamestown, Colorado left in the wake of torrential flooding in mid-September. Photo by Matt Morgan, MEM-2480, Colorado Geological Survey

Portion of Lefthand Canyon Drive that was washed out by a debris flow, Boulder Colorado. Photo by Jon White, Colorado Geological Survey.

Car-sized boulders litter this debris fan on Lefthand Canyon Drive, Boulder Colorado The debris flow ran over 3,000 feet down the mountainside before crashing into and removing part of the highway. Photo by Matt Morgan, MEM-2480, Colorado Geological Survey.

Oil Spills

Certainly ecologically tragic, the April 2010 British Petroleum (BP) oil spill in the Gulf of Mexico, referred to now as "the worst oil spill in US history," is a central theme for discourse in the EG class and enables us to broach a wide range of environmental topics of biological, economic, geological, and societal interest. Peripherally related, discussions about gas prices, nonrenewable resources, and water contamination all arise due to the widespread influences of this singular event. Similarly noteworthy are localized events affording scientists long-term water quality research opportunities, like the August 1979 pipeline burst near Bemidji, Minnesota, that spewed some 1.7 million liters of crude oil into the surrounding environment. Events such as these, when combined with even rudimentary in-class experiments involving attempts to remove motor oil from a simulated environment (i.e., sand in the bottom of a bowl, or aquarium, filled with water), leave students with a lasting impression of our possible impacts on the resources of the Earth.

Landslides

The unusually large, nearly square-mile, March 2014 landslide (mudslide) affecting the towns of Oso and Darington, in Washington State, made news headlines for claiming the lives of several dozen victims. The peculiarities of this particular event, including its unanticipated extent, made it worthy of study for a number of reasons besides its relative recency. Other local and less impactful landslides occur regularly in many places, so finding meaningful examples are typically fairly easy to come by (depending greatly on individual location).

Sinkholes

A pretty memorable event, if you like classic cars, occurred in February 2014 in Bowling Green, Kentucky, at the National Corvette Museum, and may be immortalized as a permanent display. A sinkhole underneath the museum opened up and swallowed eight (mostly classic) corvettes. These kinds of events happen in various places across the country, often making the news in Florida, but are restricted to very specific underlying rock conditions, namely limestone. These events further exemplify the seemingly random and almost instantaneous nature of natural disasters, and therefore, serve to reinforce that no matter where one may happen to live in the United States (and world, for that matter) there is a natural hazard encouraging our conscious vigilance.

Tsunamis

I will end this series of mini-case reviews with a recap of the April 2011 Fukushima Daiichi Nuclear Power Plant disaster in Japan instigated by the tsunami produced from a nearby underwater earthquake. Ensuing (non-nuclear) explosions caused the release of radioactive material and the contamination of the local and regional environment. [Global effects were observed too, with dilute atmospheric radiation having reached the west coast of the US in mere days and contaminated ocean waters arriving three years later.] This specific event allows for an examination of a number of natural hazards, from earthquakes and tsunamis to nuclear reactors and pollution transportation.

There is no shortage of historical natural disaster "cases" to consider when teaching environmental geology. Nor will there be a foreseeable reduction in the number of future events we will have to investigate. In fact, recent events continue to suggest that incidences of flooding, tornadic activity, hurricanes, and other climate-induced events will persist and perhaps worsen. Mother Nature will continue to tax our ingenuity and resolve for dealing with the dangers of living on our very geologically active and dynamic Earth. The value of a basic understanding of geoscience, and particularly environmental geology, cannot be overemphasized to the citizens of our world.

Featured Resources

A number of governmental agency and media web resources are included in the references section of this article. Many of them include images or video clips of events worth sharing with students in educational settings, while others provide more of a listing of facts or details about specific events. Additionally, I use Google Earth – a very powerful visualization tool for geology – and KML files of disasters and other features, some of which are available directly through Google at < *http://sitescontent.google.com/google-earth-for-educators/classroom-resources*> with others identified by the National Geophysical Data Center at <*http://www.ngdc.noaa.gov/hazard/*>.

References

Association of Environmental and Engineering Geologists. (2013). Environmental geology. Accessible at *http://www.aegweb.org/students-educators/student-resources/aeg-for-students/geologic-hazards/environmental-geology*.

Black, P., Milanova, B., & Smith-Spark, L. (2013, February 16). Russian meteor blast injures at least 1,000 people, authorities say [w/ video clip]. *Cable News Network (CNN).* Accessible at: *http://edition.cnn.com/2013/02/15/world/europe/russia-meteor-shower/?hpt=hp_t1*.

Boxley, M. (2014, February 13). Watch sinkhole swallow 8 corvettes [w/ video clip]. *USA Today*. Accessible at: *http://www.usatoday.com/story/news/nation/2014/02/12/corvette-museum-sinkhole/5417171/*.

Ford, D. (2014, February 18). A close call in space tonight: Asteroid zips by Earth [w/ video clip]. *Cable News Network (CNN).* Accessible at: *http://www.cnn.com/2014/02/17/us/asteroid-earth-close-call/*.

Japan: Before and after shots reveal devastation. (2011, n.d.). *The Telegraph*. Accessible at: *http://www.telegraph.co.uk/news/worldnews/asia/japan/8383522/Japan-before-and-after-shots-reveal-devastation-caused-by-earthquake-and-tsunami.html*.

National Aeronautics and Space Administration. (2014). *JPL small-body database browser:* 2000 EM26. Accessible at *http://ssd.jpl.nasa.gov/sbdb.cgi?orb=1;sstr=2000+EM26*.

National Aeronautics and Space Administration. (2014). Near earth object program. Accessible at http://neo.jpl.nasa.gov/ca/

Smithsonian National Museum of Natural History. (2010). Ocean portal: Gulf oil spill. Accessible at: *http://ocean.si.edu/gulf-oil-spill*.

United States Geological Survey. (2014). Minnesota Water Resource Center: Bemidji crude oil research project. Accessible at: *http://mn.water.usgs.gov/projects/bemidji/*.

United States Geological Survey. (2014, March 26). *Science Features: Landslide in Washington State*. Accessible at: *http://www.usgs.gov/blogs/features/usgs_top_story/landslide-in-washington-state/*.

Siberian Monsters

Stephanie Jarvis, SA-1495,
stephaniekjarvis@gmail.com

On July 15th, the Siberian Times reported that a mysterious large hole had been discovered in the Yamal peninsula, an important natural gas production region at the northern edge of Siberia.[1] The hole is about 30 meters across and has an icy lake that starts approximately 70 meters down and is of unknown depth.[2] Within a couple of weeks, two more holes were reported, one also in the Yamal peninsula and another in Taymyr Peninsula, east of Yamal.[3]

As one would expect, there were a lot of theories floating around. The more entertaining included: monsters emerging from the ground to take over the world, a UFO landing, giant moles and gophers, angels coming to earth, some mysterious new Russian weapon, the opening of an entrance to another world, and—probably the most baffling to me—a prank. More realistic explanations included a meteor or sinkhole, though both were ruled out fairly quickly due to the shape of the hole. From the beginning, however, the leading theory was that it was related to warming: an 'extreme' collapsed pingo or the release of gas from melting permafrost.[1] Pingos, hills formed when a block of ice grows under the sediment, are common periglacial features that form characteristic circular-shaped lakes when the ice block melts.[4]

My first thought when I read the released methane theories was of the positive-feedback role of methane hydrates in run-away global warming scenarios. Of potential energy production interest, methane hydrates are structures in which methane molecules are encapsulated by ice—a relationship dependent on a temperature-pressure balance that could be upset by warming.[5] While only a small percentage of methane hydrates are likely to dissociate with continued warming,[6] detection of large methane releases along the East Siberian Arctic shelf and slope, and dispersion of the methane into the atmosphere by bubbles and storms, have recently been made.[7,8]

Sure enough, preliminary investigations reported in a Nature news article found that air near the bottom of the first hole contained very high concentrations of methane—up to 9.6%.[9] Such a catastrophic release of methane could be due to the recent "abnormally hot" summers in the area melting permafrost, indicating a short-term cause and effect scenario.[9] The release could also be a result of a long-term warming, either by trapping methane released by melting permafrost until overlaying ice could not hold the pressure or destabilizing methane hydrates trapped in the permafrost.[9] A short warming-time scenario could indicate that this is a rather normal phenomenon that we are just now observing in its early stages. A longer-term scenario, however, could mean that a critical balance has been upset. While the study of these mysterious giant holes is still in preliminary stages and thoughts on the implications of their formation for climate change are, for the most part, still in the overly-sensational stage, it is definitely a story to keep tabs on. Regardless of the implications of their formation on our understanding of climate processes, those living and working in the region have a definite interest in understanding the formation of these large, potentially dangerous, holes. As always, more research is needed.

References

1. "Large crater appears at the 'end of the world'." The Siberian Times, July 15, 2014 at *http://siberiantimes.com/other/others/features/large-crater-appears-at-the-end*-of-*the-world/*. Accessed August 11, 2014.
2. Liesowska, A.,"First pictures from inside the 'crater at the end of the world'." The Siberian Times, July 17, 2014 at *http://siberiantimes.com/science/casestudy/news/first-pictures-from-inside-the-crater-at-the-end-of-the-world/*. Accessed August 11, 2014.
3. "Now two NEW large holes appear in Siberia", The Siberian Times, July 28, 2014 at *http://siberiantimes.com/science/casestudy/news/now-two-new-large-holes-appear-in-siberia/*. Accessed August 11, 2014.
4. Cosier, C. and Morris, S., "Opinions divided over mysterious 80-metre wide crater in northern Siberia." The Sydney Morning Herald, July 16, 2014 at *http://www.smh.com.au/world/opinions-divided-over-mysterious-80metre-wide-crater-in-northern-siberia-20140716-ztqvi.html*. Accessed August 11, 2014.
5. Methane Hydrate, U.S. Department of Energy, Office of Fossil Energy. URL: http://energy.gov/fe/science-innovation/oil-gas-research/methane-hydrate. Accessed August 11, 2014.
6. Ruppel, C. D., 2011, Methane hydrates and contemporary climate change: Nature Education Knowledge 3(10):29 at *http://www.nature.com/scitable/knowledge/library/methane-hydrates-and-contemporary-climate-change-24314790*. Accessed August 11, 2014.
7. Papadopoulou, S. "SWERUS-C3: First observations of methane release from Arctic Ocean hydrates", Department of Applied Environmental Science, Stockholm University at http://www.swerus-c3.geo.su.se/index.php/swerus-c3-in-the-media/news/177-swerus-c3-first-observations-of-methane-release-from-arctic-ocean-hydrates. Accessed August 11, 2014.
8. "Bubble trouble for East Siberian Arctic Shelf." The Siberian Times,

Continued on page 38

Expect the Unexpected

Kristina Pourtabib, SA-3410
pour1824@vandals.uidaho.edu

Before beginning a graduate program in geology (or any other program for that matter) it is generally expected that you will be conducting the research that you discussed with your prospective advisor prior to beginning your program. Although it would be amazing if everything in graduate school, let alone life worked out this way, think again. Graduate students and professionals alike have to possess the necessary skill set to be able to think quickly on their feet and roll with the punches so to speak, whether a research project evolves into something completely different from its infancy, funding falls through, sample preparation problems, or waiting on fellow collaborators, there are many obstacles that can hinder your progress. As cliché as the phrase "expect the unexpected" sounds, this type of adaptability is crucial to your success as a graduate student, and is a skill not often touched upon in an undergraduate curriculum.

So far, in just my first year of working towards my doctorate I have experienced my fair share of setbacks. Before my first semester of graduate school even started, I was faced with my first string of changes. I had originally come to graduate school with the expectation that I would be primarily working with a certain mineral, but my advisor had a change of heart a week before abstracts for GSA were due. He broke the news to me that I would now be working on a completely different group of minerals and that I was to make an abstract to be ready for the GSA submission, despite the fact that I had not even begun to do any background reading on my new mineral group. After hearing the news, I will admit that I was initially shocked, this must be what graduate students are faced with all the time, I remember thinking to myself, but after the initial surprise wore off I was determined more than ever to jump into my new program head first. For me, the initial change up in my area of study was a great way to test out my adaptability as a new graduate student, and I was exposed to a new community of people a lot earlier than I would have been if I stuck to my initial research topic. Since undergoing my first research impediment I have been faced with countless more. Looking back at the completion of my first year in graduate school, it feels as if I haven't been able to catch a break with plans working out smoothly. I have become used to hearing the phrase "well I've never seen this before" or "I don't know if we're going to be able to get your samples," not particularly things that people ever want to hear, but I have found ways to still develop my research despite being faced with a series of problems.

After discussing similar experiences that my fellow colleagues have encountered in their own research I have learned to accept the dogma that research isn't research without overcoming some sort of barrier. Encountering walls and testing yourself with how well you circumvent the problem is a way to prove yourself as a successful researcher and to see if you're fit to be a self-sustaining individual who can establish their own unique road of inquiry and discovery in the future. As frustrating as encountering barriers in your research can be, each obstacle should be looked upon as being a new beginning. An opportunity to try something new, and to come up with a new plan of attack, I wouldn't doubt that some of the most successful geologic researchers experienced their fair share of setbacks, and it was probably those setbacks that pushed them to work even harder and make some incredible discoveries and theories that have helped to shape the geologic community today. So for you new researchers out there, be on your toes, prepare for the worst, and remember to not let setbacks discourage you from being successful.

Continued from page 37

November 27, 2013 at *http://siberiantimes.com/science/casestudy/news/bubble-trouble-for-east-siberian-arctic-shelf/*. Accessed August 11, 2014.

9. Moskvitch, K., "Mysterious Siberian crater attributed to methane." Nature, July 31, 2014 at *http://www.nature.com/news/mysterious-siberian-crater-attributed-to-methane-1.15649*. Accessed August 11, 2014.

Interpreting Geology in an Art Museum

G.H. Edwards, CPG-2570, and A.F. Martin

Abstract

In an outreach effort to communicate geology to the general public, a "discovery table" in the central rotunda of a major art museum presents visitors with several representative art objects, displayed in conjunction with the earth materials from which they were made. Interpreters guide visitors to an understanding of how feldspars weather to kaolin clay (for example), and how the clay is located, mined, and processed into porcelain. Similar connections are shown between silica sand and stained glass, and between precious metal ores and jewelry. The presentation enables the interpreters to help curious visitors gain a greater understanding of the objects of art in the museum's collection, and of the importance of earth minerals beyond the museum's walls. The interpreters also explore how inventions of artists such as the development of three-dimensional linear perspective, have heavily impacted the development of the sciences as well. Visitors are permitted to handle the objects of art and the ore mineral samples, adding a unique interactive approach relative to the rest of the museum. The program is presented on a weekly basis and at Museum Night events, and has been well received by the public.

Introduction

At the western edge of the University of Florida campus stand two large museums: to the south is the Florida Museum of Natural History, and 50m to the north, the Harn Museum of Art. These institutions are both agencies of the State of Florida, operating under the management of the University.

Yet, interaction between the two Museums has historically been small. Visitors to one tend not to also visit the other. Generally, there has been a dichotomy between Art and Science, implicit in the separation between the two buildings. Recognizing this, and inspired to begin a public outreach program to once again link Art and Science-in this case, geology-the Harn Museum of Art approached one of the authors (Edwards) in early 2012 for assistance in developing the program. Basing our approach on some of the work of G.D. Rosenberg (Rosenberg, 2009), we prepared a proposal to the Harn staff, suggesting an informal teaching approach using a "discovery table" with various objects intended to stimulate visitor curiosity about the variety of ways in which an artist's work depends on prior work by geologists. Our intent was to create a greater understanding of geology and how it relates to art, and, by extension, to everyday life.

After several meetings to develop the concept, the formal proposal was accepted by the Harn staff in April of 2012, and we began to collect objects for display, with a primary emphasis on ore minerals and the objects of art into which they are fashioned. Most of the items on display came from a private collection of one of the authors, and a few others were acquired specifically for this program. No items from the Harn collection were used. The project launched in May 2012. We staff the table every Sunday during Museum opening hours.

The basic theme for interpretation is that everything the artist has to work with comes from the Earth. Our posted motto is that "Geology Is Destiny, " and we remind visitors that before the artist can reduce creative inspiration to a physical reality, someone, somewhere, has to dig something out of the ground. We call the overall philosophy "Metageology," which, in itself, stirs curiosity by analogy to metaphysics.

The Table

We use an eight-foot, folding table from the Museum's stock, covered with a white banquet cloth, and surrounded by a black pleated skirt. Tall stools are provided behind the table for the interpreters, usually two persons.

The table holds an array of paired objects-ore minerals and the resulting work of art crafted from them-each labeled, and organized with small arrows indicating the relationship between the source and the final product. In addition, a number of labels contain questions intended to trigger curiosity in the visitors' minds, such as, "*What does galena have to do with American Brilliant cut crystal?*" or, *"What does this limestone have to do with Tiffany stained glass?"* Small stands hold some items and labels above the table surface adding something of a three-dimensional aspect to the display, and glass domes help protect rare and valuable specimens.

There is no linear theme in the layout of the objects-although glass objects tend to dominate the right end of the table, and the sole oil painting resides on the left – the concept rather being that a visitor can begin at any point that piques his/her interest, allowing the interpreters the opportunity to steer the conversation from object to object.

Figure 1. Entrance to the Harn Museum of Art;Gainsville, Florida. The interpretive program table is located just inside the front doors.

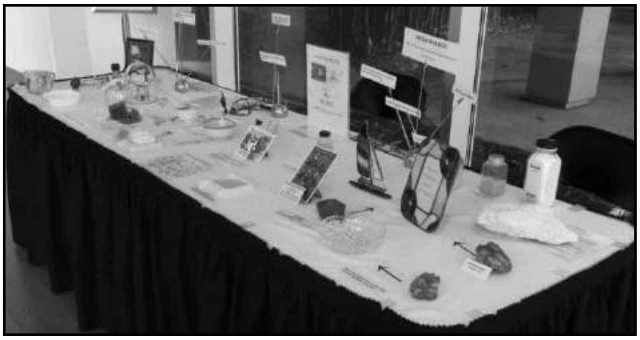


Figure 2. Overview of the Metageology table.

The objects presented for interpretation change somewhat from time to time, partly to keep the display fresh for returning visitors, and partly for the benefit of the interpreters.

This is a "touching table, "in the sense that, unlike most of the galleries in the Museum, we allow visitors to handle certain items. This aspect is particularly popular with children who can be frustrated by the general museum rule of "Do Not Touch." To control the handling of objects, we do have a sign admonishing visitors to not touch to objects, but we are quick to point out that this is negotiable.

In fact, we encourage touching in some cases. For example, we ask visitors to place their hand on a large fragment of petalite ore from Western Australia, and guess how old the sample is. Most are surprised and impressed to hear that it has been U/Pb dated to 2.65 billion-"yes that's billion, with a "b"- years old". Upon telling them this, we open a chance to illustrate the magnitude of geologic time. This is an important topic, because the average educated individual appears to have little to no grasp of the vastness of Time. The demonstration of such an ancient mineral is a worthwhile teaching moment.

Object Pairs

In no particular order, examples of some of our most popular pairs include:

Native gold in quartz from the Ashanti Mine in Ghana and Lapis Lazuli from Afghanistan paired with a set of gold and lapis lazuli cufflinks (Early 20th Century). This specimen has been sawn with a diamond saw to make the veins of gold easier to see.

Argentite from the Silver Queen Mine in the Aspen District of Pitkin County, Colorado, paired with a small sterling silver liqueur glass.

Lepidolite, from the al Hayat Quarry of the Bikita Mine in Zimbabwe (Cooper, 1964), ground and polished into the shape of a decorative egg. Like the petalite (above) this specimen is from an orebody dated to over 2.5 billion years.

Heavy mineral sands, from Stake, Florida, and a tube of Mixing White oil paint, which uses titanium dioxide as a pigment. This heavy mineral sand mining operation is within 50 miles of the Harn Museum, and thus allows us to weave in a local source concept, and to initiate a discussion of the geological history of Florida and the formation of heavy mineral sand deposits along the coastlines.

Figure 3. A small oil painting by Robert Hall, RA, with tubes of cobalt blue and mixing white, cobalt nitrate and a specimen of heavy mineral sand to show the sources of the pigments, and a vial of linseed oil.

Tubes of oil paint, and accompany miniature oil painting by British Royal Academy artist Robert Hall. This small but fine oil painting (which we keep under glass for safety) allows us to talk about how oil paints get their pigment colors, in part, from metallic ore minerals, ground and compounded with various oils and hardeners. Beside them on the table lie a small bottle of linseed oil and a very fine brush, matching the tiny brush-strokes of Hall's painting. These objects also enable the interpreters to discuss the invention of the paint tube in London in 1841 by John Rand (Hurt, 2013), and how that invention freed the artist from the burden of grinding pigments in a mortar and pestle, and boiling linseed oil in a pot, thus emancipating the artist from the confines of the studio and allowing him to go outside to paint. With a little imagination, we can steer the visitor to seeing how this simple invention allowed for *de pleine air* painting, and how it led to the development of the Impressionist Movement.

We also remind visitors that they used Rand's invention, intended for his fellow painters, that morning when they brushed their teeth-a fine example of how the arts have given back to society in unexpected ways.

Nephrite jade specimen from Wyoming, USA, and small carved jade objects: The Harn collection is rich in Chinese jade carvings, so it is valuable for visitors to see raw jade and have a chance to discuss how hard the jade minerals are (about 6.5) and how difficult it must have been to carve the intricate and beautiful objects to be seen in the Asian Wing of the Museum.

Kaolin clays from both Deepstep, Georgia and Edgar, Florida paired with some porcelain objects: We have a signed Wedgewood cup and saucer (first half of the 20th Century), a small Chinese rice-grain porcelain bowl (second half of the 20th Century), and a small hand-painted porcelain statue (Germany, 20th Century). The Harn Museum collection is rich also in ancient Chinese and Japanese porcelain, as well as in contemporary porcelain works.

Beside the Wedgewood cup and saucer is a small bone with a question label reading "*Bone china is really made with bones. T/F?*" Surprisingly, many visitors will answer in the negative, giving the interpreters a chance to relate the story of the invention of bone china in England, 1748, by potter Thomas Frye, and to speculate on how he was inspired to burn bones from a nearby slaughterhouse to produce calcium phosphate, or bone ash. If this intelligence sparks some curiosity, we can then extend the discussion into Bronowski's conclusion that inspiration and creativity are the same intellectual process in art and in science (Brownowki 1958).

Glass Raw Materials, and an assortment of glass objects, including stained glass: The glass raw materials include glass-grade sand from a deposit near Davenport, Florida, soda ash, feldspar, and limestone, along with various coloring oxides represented by their ore minerals and by refined chemicals. The metal ores include chromite from Montana, erythrite from Morocco, and even a sample of galena (Illinois) adjacent to an American Brilliant cut crystal bowl, which allows us the change to discuss the use of lead in glass.

Figure 4. Glass raw mineral, and examples of glass objects of art.

The glass objects include some small stained and leaded glass items, and a photograph of a major Louis Comfort Tiffany window from his estate, Laurelton Hall, on Long Island, New York. This window, entitled "The Tree of Life," illustrates six things Tiffany felt were of fundamental importance to human life. Geology is the first of the six panels.

Lithographic limestone, and various examples of lithographic reproductions of art. The specimen is from the Solnhofen limestone of Bavaria, the same source Alois Senenfelder used for his limestone slabs when he invented the process of lithography in 1796 (Meggs, 1998).

Reproduction of DaVinci's "View of the Arno Valley." This small drawing is said to be the oldest DaVinci extant, and illustrates the basic principles of the Law of Original Horizontality and the Law of Superposition. Also illustrated is the lateral continuity and correlation, as made clear in DaVinci's field notes when he drew this sketch.

Nearby is a diagram illustrating geometric perspective, which allows the interpreters to expand on the concept that this artistic technique was critical to the advance of Western thought into the Scientific Revolution (Rosenberg, 2009), a basic point of Rosenberg's discussions, and one disputed by many Orientalist scholars (Monastersky, 2004).

In interpreting geology for the public, we use the importance of three-dimensional linear perspective and the works by DaVinci to further connect Art and Science. One of our "teaser questions" on the table is *"Was Leonardo DaVinci and artist or a scientist?"* which has led to lengthy discussions of the relation of science to art. A common answer to the question is "both," which is, of course, correct.

The periodic table, which relates to everything on the table: With the copy of the period table is a card with the question *"Where did the chemical elements in your body come from?"* which leads the inquisitive visitor into cosmology and the formation of the Universe. In a way, this is the most profound question on the table.

Interpretive Technique

We decided at the beginning of the program not to do it as a formal, scheduled presentation, but instead to keep it informal and as close to one-on-one as possible. Of course, on busy afternoons at the Museum it becomes one –on –several, but this seems to work quite well.

Informal interpretation allows us to engage the individual interest of each visitor. Often our visitors are artists themselves and want to learn more about their particular field. Ceramists query us about clays, jewelers ask about the gold and silver ores, and painters are interested to know more about the sources of different pigments.

One of the teaser questions" on the table is *"Can you make a pot from any old clay that sticks to your shoes?"* and this intrigues many ceramists, who generally obtain clay for their craft from a supply company, not pausing to consider the ultimate origin of the material with which they are creating. It helps us that one ceramics instructor at the University of Florida has a class assignment requiring her students to dig up some clay from a local creek, and form and fire an object from it. This often leads us to a discussion on the nature and origins of clays.

Contact with the individual visitors can be as brief as answering a single question in a minute or so, or can develop into longer, and stimulating, discussions, with one answer leading onto another questions. "Always the beautiful answer that asks the more beautiful question", as the poet e.e.cummings put it. One well-informed visitor once took the point about DaVinci, and debated that DaVinci was an artist, while the interpreter maintained that he was a scientist, a geologist, and an engineer. This went on for half an hour, and then the two debaters switched sides and defended the other's prior argument. Both the visitor and the interpreter were delighted with this outcome.

The interpreters are well prepared with details about the various object pairs, but the initial engagement with the visitor can take several forms. If the visitor has no immediate question, or if the initial question falls something along the lines of "What's all this about?" we have a standard introduction that explains that this is a discovery table that illustrates the concept of Metageology-by which we mean the philosophy which links the science of geology with the Arts-and that present on the table are various examples of these connections. We can then direct the attention of the visitor to the specimen of kaolin, and point out that before the artist, working in her studio, can begin to shape the clay into a porcelain figure, someone unseen by our artist, had to dig into the Earth and extract and process the clay. If the visitor has a little innate curiosity, this will lead to further questions. Some do not, and the interpreters let the conversation end there, thanking them for visiting the Museum.

Figure 5. Interpreters engaging Museum visitors.

Results

Over the nearly two years we have operated this program, we have interacted with some 4,500 visitors to the museum. Not all visitors respond to our presentation in the same way; the visiting population divides itself into three groups: the first group is apparently uninterested (Gelertner, 2014), and may pass by the table without a glance. The second group expresses minor interest, may stop and look at some of the objects and perhaps ask a question or two, but remain only briefly before passing on into the galleries of the Museum. The third group consists of people with more curiosity, stopping and asking many questions about the display. This last group, of course, is our real audience, and it is for them we have a chance to clarify the importance of Geology in the Museum, and in their daily lives.

Other expressions of appreciation include repeat visits-those who come back again, sometimes with specimens of minerals or objects of art of their own which they want to discuss at greater length.

Quantifying these responses is difficult, and we have discussed several methods, including evaluation forms and interviews. Such an approach is of questionable value, if for no other reason than the self-selection error implicit in voluntary questionnaire participation.

We have had several spontaneous expressions of appreciation directed to the Staff, including the Director of the Museum. To receive such a letter of thanks from a spontaneous source is gratifying.

Acknowledgements

The authors are grateful to the Staff at the Harn Museum of Art for their support and encouragement. The Security Guards have been particularly helpful in the set-up and take-down of the display every Sunday. Erin Brown and Brigit Tuschen served as faithful interns on the program, and have gone on to important work in graduate school, preparing for careers in the teaching of science. Anthony Gray was instrumental in the initial concept and development of the program.

References

Bronowski, J. The Creative Process, *Scientific American*, vol 199, Num.3, 1958.

Cooper, D.G. The geology of some ore deposits in Southern Africa, the geology of the Bikita pegmatite, Geology Society of South Africa (II), 441-461, 1964.

Hurt, Perry., Never Underestimate the Power of a Paint Tube, *Smithsonian Magazine*. Smithsonian Institute. Retrieved 18 May 2013.

Gelertner, D., The Closing of the Scientific Mind, *Commentary Magazine*, 2014.

Meggs, P.B., A History of Graphic Design (1998), J. Wiley & Sons, Inc.,

Monastersky, Richard. Lack of Perspective, *Chronicle of Higher Education,* 25 January 2002.

Rosenberg, G.N., The measure of man and landscape in the Renaissance and Scientific Revolution, Geological Society of America Memoir 203, 2009.

George Edwards was born and reared in Kansas City, and earned his professional degree in Geology at the University of Kansas. After jobs in mineral exploration and mapping in Argentina, a stint as Mine Geologist for a copper mine in Michigan, and several years doing research for the Federal Government, he joined Corning Glass Works, retiring after nearly 30 years as Chief Geologist. He now serves as President of G.H. Edwards & Associates, Inc., and on several professional society committees.

AIPG Membership Totals

	As of 9/23/13	As of 8/7/2014
CPG / Active	3386	3302
CPG / Non-Practicing	362	371
Prof. Member	991	948
Associate Member	45	40
Young Professional	61	70
Student Adjunct	2,262	2,741
Corporate Member	1	1
TOTALS	7,108	7,472

New Applicants and Members can now be found on the AIPG website at *http://aipg.org/membership/newapps-mems.html*

Section News can now be found on the AIPG website at *http://aipg.org/sections/sectionnews.html*

This service is open to AIPG Members as well as non-members. The Professional Services Directory is a one year listing offering experience and expertise in all phases of geology. Prepayment required. Advertising rates are based on a 3 3/8” x 1 3/4” space

ONE YEAR LISTING FOR ONLY:

AIPG Member	**$300.00**
Non-Member	**$400.00**

Space can be increased vertically by doubling or tripling the size and also the rate.

ADVERTISE

ADVERTISE

ADVERTISE

TTL
geotechnical • analytical • materials • environmental
www.ttlusa.com

Lawrence C. Weber, P.G.
Vice President
5010 Linbar Drive, Suite 153
Nashville, TN 37211
lweber@ttlusa.com | 615.331.7770

*Providing innovative solutions and results for our clients for more than **45 years.***

Want to purchase minerals and other oil/gas interests.
Send details to:
P.O. Box 13557, Denver, CO 80201.

Downhole Flow Control Valves
Inflatable Packers
Hydrofracture Packers
Pitless Units

Baski Inc. info@baski.com www.baski.com
1586 South Robb Way Denver, CO 80232 USA
Ph. 303 789-1200 or 800 552-2754 Fax: 303 789-0900

GEOSPHERE
ENVIRONMENTAL MANAGEMENT INC.
Professional Groundwater & Environmental Services Nationwide Since 1997

www.geospherenh.com
603.773.0075
888.838.6571

- Water Supply
- Geology
- Environmental
- GIS

MCD Geosciences and Engineering
Geology • Geotechnical • Geophysics • Structural

Matthew Cain, P.G.
Senior Geologist, V.P.

P.O. Box 747
Lake Wales, FL 33859

Phone 863-676-2600
Fax 863-676-2699

www.sinkhole-expert.com

SONIC
DRILLING SERVICES
INC.
9406 Massillon Road SW • Dundee, Ohio 44624

Jim Nidzgorski CWD
Vice President

330.359.0079 work • 937.477.3055 cell
jnidzgorski@sonicdrillingservice.us • www.sonicdrillingservices.us
Environmental - Geotechnical - Geothermal - Exploration - Dewatering - GeoConstruction

HAGER-RICHTER GEOSCIENCE, INC.

Surface & Borehole Geophysics
for Engineering & Environmental Projects

National Reputation / Nationwide Practice
Take a closer look. You'll like what you see!

www.hager-richter.com
(603) 893-9944—NH
(732) 661-0555—NJ

Certified WBE

ADVERTISE

ADVERTISE

ADVERTISE

Practical Petroleum Geoscience

An online course - AIPG accredited (4 to 8 CEUs)

For Novice **AND** Experienced Oil-Finders

by Robert G. Font, Ph.D., CPG, PG, EurGeol

rgfont@cs.com --- www.rgfont.com

Deepen Your Understanding of Your Industry

800+ Power Point Slides

Reference CD Available

To order the course or for more information contact AIPG (www.aipg.org)

Online Course: Basic Reservoir Engineering for Geoscientists

AIPG Accredited – 3.5 to 5 CEUs

- Review of G&G in E&P.
- Development geology.
- Reservoir properties.
- Reservoir drives.
- Oil and gas well production.
- Petroleum reserves.
- EOR techniques.
- Rock deformation; fractured reservoirs.
- Rules for appraisal of oil and gas properties.
- Self-assessment questions and problems.
- Helpful references.

Robert Font, PhD, CPG, PG, EurGeol – Author

rgfont@cs.com --- (www.rgfont.com)

To order, please contact AIPG: www.aipg.org

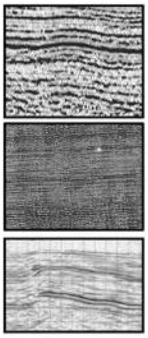
Basics of Seismic Petroleum Exploration for New Hires

by

Robert Font, PhD, CPG, PG, EurGeol

rgfont@cs.com --- www.rgfont.com

- Review of world hydrocarbon reserves, production, consumption and goals and methods in petroleum exploration.
- Seismic waves, rock deformation and elastic versus plastic behavior.
- Elastic properties, density and seismic wave velocities.
- Seismic wave propagation and key travel time equations.
- Single fold versus multi-fold coverage, horizontal versus dipping reflectors, offsets, multiples and diffractions.
- Seismic acquisition, processing, corrections and velocity terminology.
- Integrating seismic with well control, reflection coefficients, synthetic seismograms, check shot surveys and VSPs.
- Seismic interpretation and steps in prospect development.
- 2-D and 3-D seismic methods, basic information and possible pitfalls. 4-D seismic analysis or 3-D through time.
- Hydrocarbon Indicators (HCI), AVO analysis, pore pressure prediction, seismic inversion, seismic stratigraphy and coherence.



AIPG accredited online course (0.8 to 1.0 CEU)

To order, please contact AIPG (www.aipg.org)

Geotechnical Properties and Engineering Problems of some of the North Central Texas Clay-Shales – Regional Geology Case History Series

- Cretaceous shales in the north-central Texas area give rise to engineering problems. This online short course covers:
  - Regional geologic setting, structure and stratigraphy.
  - Specific material geotechnical properties including:
    - Clay mineralogy, values of Atterberg limits and indices, potential volume change, shear strength, etc.
  - Engineering problems and solutions concerning:
    - Accurate shear strength determination as dictated by field conditions, mass wasting, swell pressures and more.

Robert Font, PhD, CPG, PG, EurGeol – Author

rgfont@cs.com --- www.rgfont.com

AIPG accredited online course (0.5 CEU)

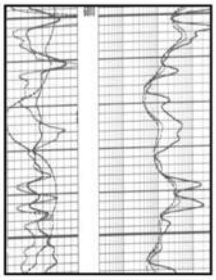
To order, please contact AIPG (www.aipg.org)

Introduction to Well Logs and Log Analysis for New Hires

Robert G. Font, Ph.D, CPG, PG, EurGeol – Author

rgfont@cs.com --- www.rgfont.com

- A review of well logs in exploration and development
  - Prerequisites for finding commercial reserves
  - Exploration techniques
  - Integration of geophysical exploration records with log data
  - Calculating reserves and field size
  - Importance of economics and risk analysis
  - Drilling and logging
- Lithologic and mud logs
- Electric logs
- Basic and specialized porosity logs
- Other logs & log curves used in exploration & production work
- Selecting log suite
- Basic log analysis (recognizing pay zones)
- Identification/classification of logs & well log data management



AIPG accredited online course 0.5 to 1 CEU)

To order the course or for more information contact AIPG (www.aipg.org)

An Introduction to Landslides and Mass Wasting

An online course - AIPG accredited (0.5 to 1 CEU)

- Landslides classification
- Soil and rock mechanics principles
- Strength of earth materials
- Geologic considerations
- Case histories
- Factors influencing mass wasting
- Control and prevention of mass wasting problems
- Slope stability analysis

To order the course or for more information contact the AIPG (www.aipg.org)

Robert Font, Ph.D., CPG, PG, EurGeol - Author

rgfont@cs.com --- www.rgfont.com

On Demand Webinars

- **Global Energy Resources: Current Trends and Short Term Predictions.**
  Presented by Ronald J. Wallace,
  .01 CEU's
- **Critical and Strategic Minerals: Concepts and Status.**
  Presented by Jim Burnell,
  .01 CEU
- **Making a PowerPoint Presentation into a Work of Art.**
  Presented by Chris Mathewson,
  .01 CEU

For more information go to *www.aipg.org*, select Store, then Events, or contact AIPG Headquarters at 303-412-6205.

Participating in Undergraduate Geoscience Research Builds Skills that Employers Value

Barbara EchoHawk, Claire M. Hay, Uwe Richard Kackstaetter, MEM-2437, and Stella W. Todd,
Metropolitan State University of Denver
Dept. of Earth & Atmospheric Sciences
Campus Box 22, P.O. Box 173362
Denver, CO 80217

Abstract

The value of participation in undergraduate research (UR) in preparing students for future employment or graduate school is reaffirmed through an assessment of employer-identified essential learning outcomes (ELOs) and their relationship to skill sets learned through traditional courses compared with those gained through UR at Metropolitan State University of Denver (MSU Denver), a four-year liberal arts institution of higher education. Traditional coursework required for the geoscience degree may not fully support the development of employer-valued essential learning outcomes (ELOs) unless it is enhanced by the integration of UR into the geoscience curriculum. Embedding UR-based modules throughout the geoscience curriculum, emphasizing quality faculty mentorship for students in UR, promoting active engagement by potential employers in UR internships and projects, and encouraging students to take ownership of their own UR opportunities all can enhance UR as a meaningful component of undergraduate education. The additional time commitment required to participate in UR in the geosciences is more than offset by the development of skill sets that benefit both students and employers by expanding the intersection between skills sought by employers and skills possessed by new graduates.

Key Words: undergraduate research, UR, geoscience, employer, graduate school, essential learning outcomes, ELO, Metropolitan State University of Denver, student benefits, employer benefits

Introduction

Participation in undergraduate research (UR) as a college student requires a time commitment greater than that required for a "traditional" degree awarded solely for the satisfactory completion of a specific set of courses. Is participating in UR worth the extra time? Do students who participate in UR gain skill sets that enhance their opportunities for employment in geoscience careers after graduation? In order to assess these issues for undergraduate geoscience students at Metropolitan State University of Denver, the relationships between skill sets emphasized in "traditional" undergraduate geoscience courses, skill sets emphasized in geoscience-based undergraduate research, and skill sets identified as essential learning outcomes (ELOs) by employers were examined. In this paper, we consider courses to be "traditional" if they are lecture-, laboratory-, or field-based but not designed around individualized undergraduate research.

Methods

For this study, we concentrated on students enrolled in undergraduate geoscience courses in the Department of Earth and Atmospheric Sciences (EAS) at Metropolitan State University of Denver (MSU Denver), a four-year liberal arts institution in Denver, Colorado.

As our proxy for skill sets that are highly desirable to employers, we adopted essential learning outcomes (ELOs) identified in recent surveys of employers conducted by Hart Research Associates (2007, 2010, 2013) for the Association of American Colleges and Universities (AAC&U).

We evaluated which of these employer-identified ELOs are emphasized in a variety of geology courses and closely allied geographic information systems (GIS) courses offered by our EAS department. Through this assessment, we identified the intersection of employer-identified ELOs with the skills gained through the "traditional" coursework that leads to the completion of a four-year geoscience-based degree at MSU Denver.

Next, we evaluated which of the employer-identified ELOs are emphasized in undergraduate geoscience research undertaken by students in geology concentrations in our department and assessed the intersection of employer-identified ELOs with the skills gained through participation in UR.

We also conducted an anonymous survey of students in upper-division geology courses in EAS at MSU Denver to obtain informal data on student perceptions of undergraduate geoscience research.

Results

Skills Employers Want

A survey of employers who have hired recent two- or four-year college graduates, conducted on behalf of the Association of American Colleges and Universities (AAC&U) by Hart Research Associates (2010), indicates that "a candidate's demonstrated capacity to think critically, communicate clearly, and solve complex problems is more important than their undergraduate major."

More specifically, top skills desired by employers include written and oral communication skills; critical thinking and analytical reasoning; applied knowledge in real-world settings; complex problem solving; teamwork skills in diverse groups; and information literacy (Table 1).

Desirable Skills in Recent Graduates	% of Employers Surveyed
Written and oral communication skills	89
Critical thinking and analytical reasoning	81
Applied knowledge in real-world settings	79
Complex problem solving	75
Teamwork skills in diverse groups	71
Information literacy	68

Table 1. Top-rated learning outcomes identified by employers as needing "more emphasis" in undergraduate education. Data from Raising the Bar: Employers' *Views on College Learning in the Wake of the Economic Downturn*, a survey conducted by Hart Research Associates (2013) for AAC&U.

In an extensive, multi-year ethnographic study unrelated to the AAC&U survey, Laursen et al. (2006) collected data from undergraduate students participating in summer UR programs in biology, chemistry, and physics. Their results indicate that students who complete the summer UR program report gains in knowledge, skills, attitudes, and behaviors related to virtually each of the employer-identified ELOs in Table 1. In the Laursen et al. (2006) study, 92% of 1,230 student observations and 90% of 55 faculty advisors reported positive benefits to students from participation in UR, including increased technical and scientific knowledge and skills; increased ability to apply knowledge and skills to scientific research; enhanced ability to transfer knowledge and problem-solving skills to new situations; increased "intellectual engagement and initiative"; enhanced capacity as "independent and creative" problem solvers and decision makers; and increased skills in communication, information literacy, teamwork, and organization.

We anticipate that gains for students who participate in geoscience undergraduate research will be consistent with those for students participating in biology, chemistry, and physics in the Laursen et al. (2006) study, but we do not yet have the data to support that conclusion. As initial steps toward examining these issues in more depth, we conducted an anonymous informal survey of geology students to gather data on their perceptions of undergraduate research, and we examined the skill sets emphasized in "traditional" undergraduate geoscience courses and in geoscience-based undergraduate research. The results of each of these efforts are described below.

Student Survey

We conducted an anonymous survey of students in upper-division geology courses in EAS at MSU Denver to obtain informal data on their perceptions of undergraduate geoscience research. Although a senior seminar is expected as a capstone experience for graduating seniors, the questionnaire is focused primarily on undergraduate research experiences outside the senior seminar requirements, such as independent study ("directed study"), student-initiated research within other courses, independent research, or internships involving focused problem solving and research.

The survey divided the volunteer participants into two sets of upper-division students in the geoscience programs, "Group A" (n=32) which comprises students who have NOT participated in any recognized form of undergraduate research and "Group B" (n=11) which comprises students who are involved or have been involved in one or more undergraduate research projects.

Students were asked to rate certain statements concerning undergraduate research on a scale from 1 (Strongly Disagree) to 5 (Strongly Agree). A summary of the results is given in Table 2, indicating the percent respective responses received for each rating category.

GROUP A – "Did NOT Do UR"	5	4	3	2	1
I am interested in doing undergraduate research	56%	28%	9%	6%	0%
The thought of doing undergraduate research is intimidating.	9%	47%	28%	9%	6%
I know how to get started doing undergraduate research.	3%	16%	22%	34%	25%
I should do undergraduate research.	59%	28%	9%	0%	3%
Doing undergraduate research could help me get a job after graduation.	71%	19%	3%	3%	3%
Doing undergraduate research could help me get into graduate school.	66%	25%	6%	3%	0%

Table 2. Results of informal student survey of upper-division students. N = 43 respondents, with n = 32 for Group A and n = 11 for Group B. See text for additional explanation of survey population and respondent groups.

5 = Strongly Agree; 4 = Agree; 3 = Neutral; 2 = Disagree; 1 = Strongly Disagree

GROUP B – "Did UR"	5	4	3	2	1
I enjoy doing undergraduate research.	64%	9%	9%	9%	9%
Doing undergraduate research was a valuable part of my education at MSU Denver.	45%	27%	9%	9%	9%
I plan to continue my undergraduate research after my coursework ends here at MSU Denver.	45%	9%	18%	9%	18%
Undergraduate students should take part in undergraduate research outside required senior experiences or similar.	64%	18%	9%	0%	9%
My undergraduate research could help me get a job after graduation.	64%	18%	9%	9%	0%
My undergraduate research could help me get into graduate school.	64%	18%	9%	0%	9%

5 = Strongly Agree; 4 = Agree; 3 = Neutral; 2 = Disagree; 1 = Strongly Disagree

Results of the survey indicate that students, whether or not they have participated in UR, perceive doing UR as important and as potentially beneficial in finding employment or in successfully applying to graduate school. However, although students in Group A are interested in participating in UR, they may be uncertain how to get started and may feel intimidated by the process.

Although the majority of students in Group B perceived their UR experience as enjoyable and valuable, certain UR experiences did not have the anticipated positive effect on student attitudes and perceptions, as indicated by some of the lower ratings among Group B respondents. While this internal finding needs further investigation, it aligns with results from a similar research survey compiled by Lopatto (2004) on a much larger scale. His observations indicate that poor mentor quality contributes to student responses that are less positive than anticipated, suggesting the pivotal importance of the quality and level of involvement and guidance provided by supervising faculty. While outside the scope of this paper, our institution of higher education needs to find better venues to attract and retain interested students in undergraduate research activities, as well as ways of increasing the quality of mentor-student interactions.

Results of the more pertinent findings for the focus of this study are displayed in Figure 1.

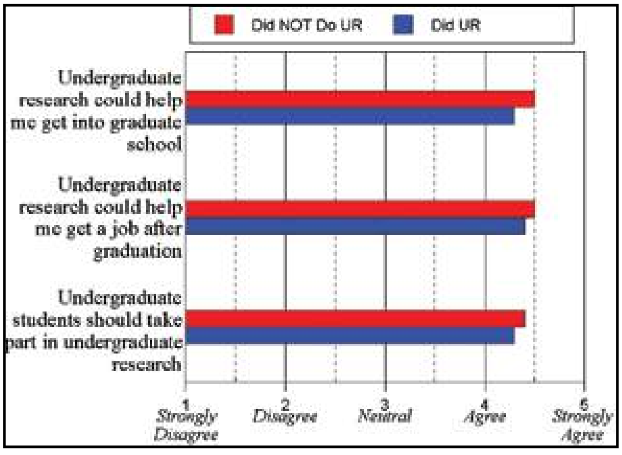


Figure 1 – Averages of upper-division student responses to UR statements measured on a 1 (Strongly Disagree) to 5 (Strongly Agree) scale. Respondents are divided into those who have not participated in UR (n=32) and those who were involved in UR (n=11).

Students in both groups agree that students "should" participate in undergraduate research: the average rating for this question by Group A respondents ("Did NOT Do UR") was 4.4, and the corresponding rating average by Group B respondents ("Did UR"), was 4.3. Both groups anticipate that involvement in UR will improve their chances for finding employment or for getting into graduate school. This expectation is underscored by the following written comment by one student respondent to the survey:

"Undergraduate research is a critical aspect of the undergraduate experience. Many students I know from across the United States who are students in the top tier universities all participate in undergraduate research as a requirement for their degrees. This is something that can really advance our school and students. It is very beneficial for getting into graduate school and critical in the job market as I know from firsthand experience when my undergraduate research experience was the determining factor for me getting a highly sought after job."

The indirect benefit of increased confidence for those applying to graduate school is indicated by the comment of another student:

"Doing undergraduate research made graduate school less intimidating and helped me have the confidence to apply. Without doing it I don't think I would have applied."

These anecdotal student observations are congruent with analyses by Lopatto (2010) and Laursen et al. (2006), which conclude that student gains through UR reveal an "extensive array of professional and personal benefits."

Skills our Traditional Geology Courses Emphasize

We examined selected significant activities and projects from four lower-division (1000- and 2000-level) geology courses and four upper-division (3000- and 4000-level) geology courses to determine which of the employer-identified top ELOs are emphasized in the "traditional" geology undergraduate program of study (Figure 2). Our compilation of skills includes only those emphasized in these geology courses.

The red solid line in Figure 2 indicates the percentage of geology courses addressing each ELO, while the blue dashed line refers to the percentage of ELOs addressed by specific undergraduate research-focused learning modules within

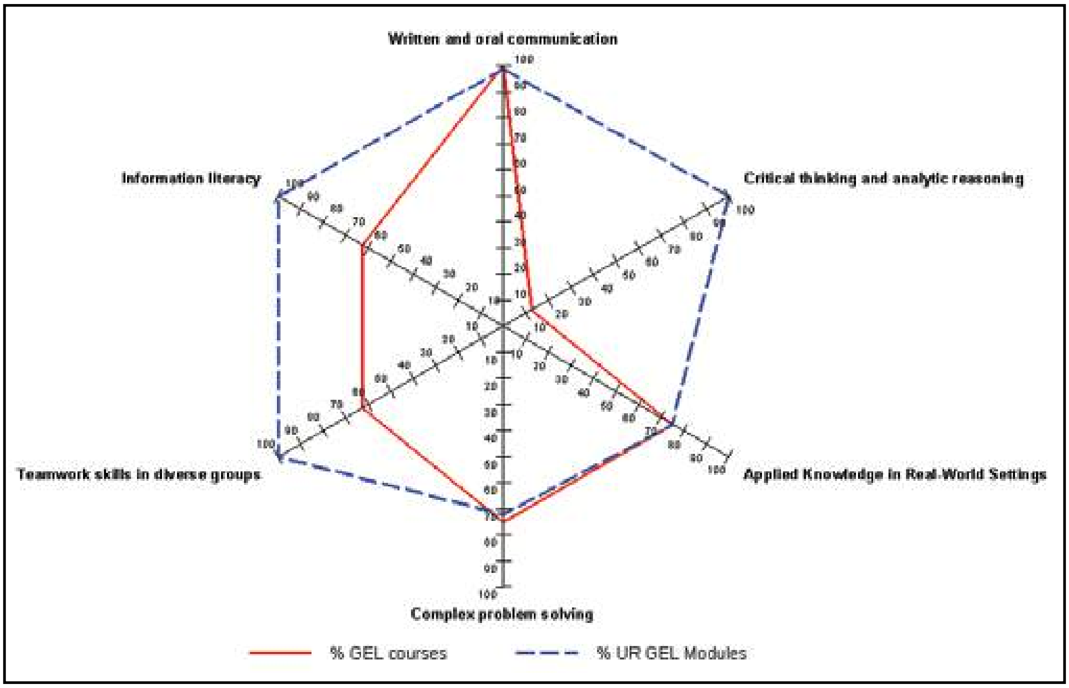


Figure 2 – Radar graph of percentage of MSU Denver geology courses assigned to a particular employer desired skill (red solid line), as well as MSU Denver geology UR modules embedded within courses (blue dashed line) addressing employer-desired skills.

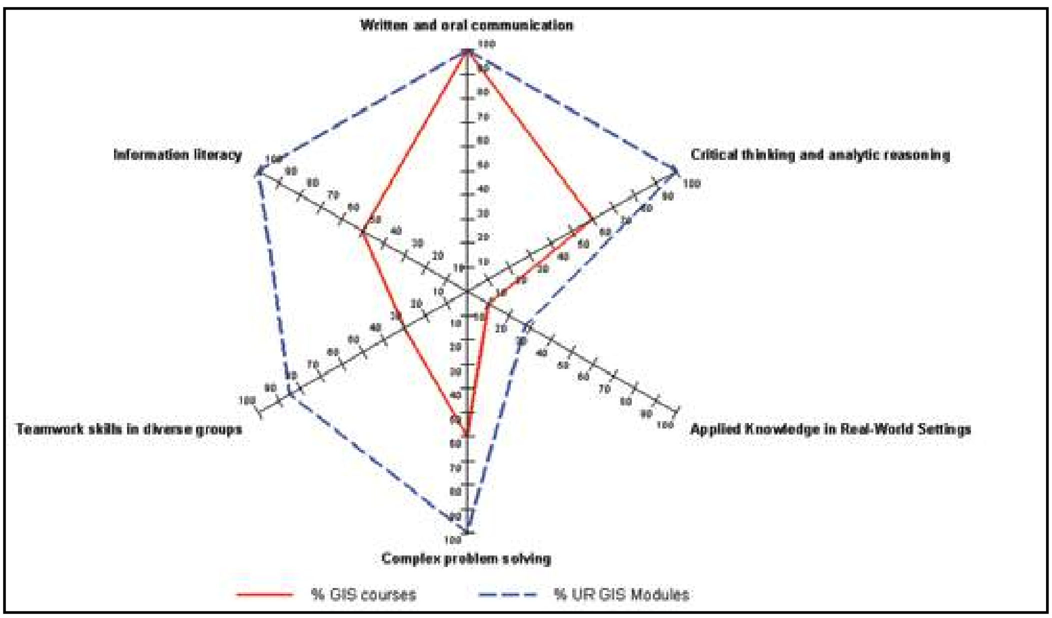


Figure 3 - Radar graph of percentage of MSU Denver GIS courses assigned to a particular employer-desired skill (red solid line), as well as MSU Denver GIS UR modules embedded within courses (blue dashed line) addressing employer-desired skills.

the same set of courses. Although not all geology courses are designed to emphasize particular ELOs, learning modules or exercises within each geology course do address all of the ELOs. Thus, the red solid line can indicate a "traditional" educational model in the geosciences, while the dashed blue line encompasses an undergraduate research-driven approach by modules within geology courses.

Skills our Traditional GIS Courses Emphasize

We examined selected significant activities and projects from three lower-division (1000- and 2000-level) GIS courses and seven upper-division (3000- and 4000-level) GIS courses to determine which of the employer-identified top ELOs are emphasized in the "traditional" GIS undergraduate program of study (Figure 3). Our compilation of skills includes only those *emphasized* in these GIS courses. For the explanation concerning data compilation of the red solid line and blue dashed line, please refer to the explanation in the discussion of traditional geology courses. As with the geology courses, the red solid line in Figure 3 is an indicator for a "traditional" educational model in GIS courses, while the dashed blue line encompasses an undergraduate research-driven approach by modules within GIS courses.

Skills our Undergraduate Geoscience Research Opportunities Emphasize

In order to examine the benefit of skills obtained by participation in undergraduate research, we assessed skills emphasized in undergraduate research projects undertaken by two students who are in advanced stages of their research (Table 3). The skill sets gained, the processes learned, and the products generated during UR by our representative student-participants suggest a positive ratio of benefit vs. time investment.

ELOs	Student #1	Student #2
Written and oral communication skills	Poster and oral presentations at national conferences. Oral presentation at university UR forum. Current compilation of peer reviewed publication.	Poster presentation at national conference. Current compilation of peer reviewed publication.
Critical thinking and analytical reasoning	Finding approach for field and laboratory research. Guidance for additional research depending on outcome of initial results.	Finding approach for field and laboratory research.
Applied knowledge in real-world settings	Field and laboratory survey according to industry approach.	Consultation with client about new approach. Feedback for feasibility.
Complex problem solving	Relationship and interpretation between physical and geochemical data.	Innovation of new research techniques never before documented in the literature.
Teamwork skills in diverse groups	Connection with industry. Facilitation of collaboration	Communication with industry representatives. Collaboration with client.
Information literacy	Additional skill sets mastered, such as detailed XRD work and heavy mineral separation techniques.	Improved wet chemical lab skills beyond the scope of regular course lab work.

Table 3. Sample processes and products from two students' UR projects vs. employer-identified learning outcomes (ELOs). Processes and products listed are in addition to "traditional" course requirements.

The positive balance of "benefits gained" vs. "time invested" extends to UR across our student population, as illustrated schematically in Figure 4. The "UR Focused Approach" integrates undergraduate research into geoscience coursework by incorporating UR modules packaged as activities, independent studies, internships, and field and laboratory experiences that specifically address ELOs. Although embedding UR as an integrated focus across the geoscience curriculum increases the time commitment required of students, the increase in required time is more than offset by the expanded intersection of new graduates' skill sets with prospective employers' ELOs, as indicated by the student products summarized in Table 3 and by the expanded region of common benefits to employers and students in Figure 4.

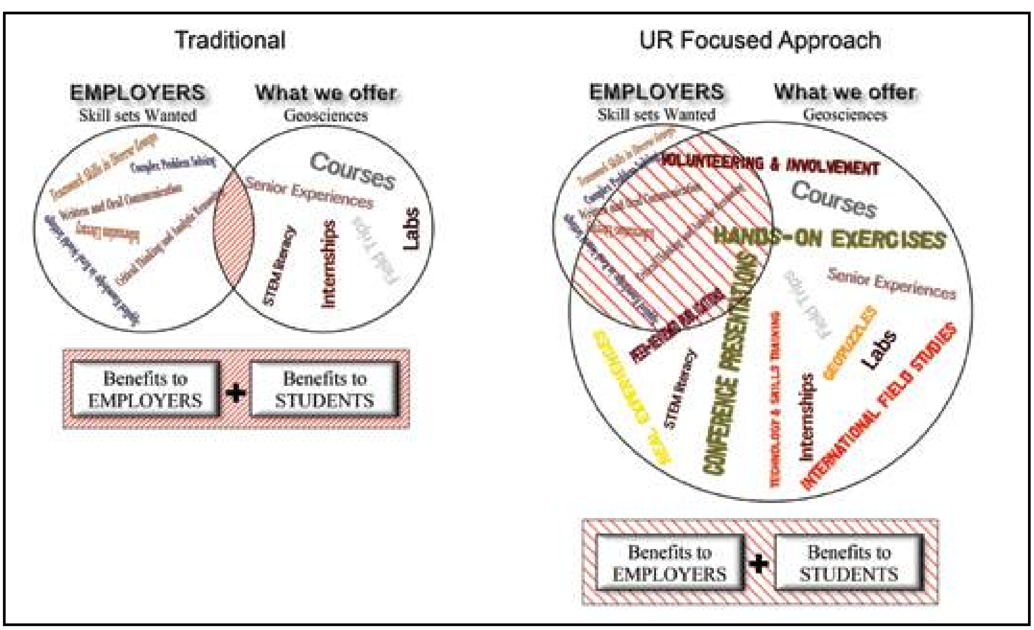


Figure 4 - Educational and employer benefit comparison between the "Traditional" and "UR Focused Teaching" approaches. The increased time commitment indicated by the larger circle in "UR Focused Teaching" also yields substantially more benefits for both prospective employers and students.

Discussion

Students who follow a "traditional" approach in earning a geology-based undergraduate degree at MSU Denver gain skill sets that incorporate each of the employer-identified desirable learning objects (ELOs) summarized in Table 1. Geology courses and GIS courses encompass the range of ELOs in general, but specific learning modules within these courses provide greater focus on particular ELOs (Figures 2, 3).

Students who commit to an undergraduate research project in a way that involves them deeply in UR develop greatly expanded skill sets (Table 3) over those gained through "traditional" courses. The UR-focused skill sets bring enhanced benefits to both students and their future employers (Figure 4) by increasing the intersection between employer-identified desirable learning outcomes and the skills students possess at the time they receive their undergraduate degrees. These findings are corroborated by Lopatto (2010) who lists the observed benefits for students involved in UR as gains in "a variety of disciplinary skills, research design, information or data collection and analysis, information literacy, and communication," typical for employer-advocated ELOs. Laurens et al. (2006) also conclude that "UR is a powerful experience for students, developing skills, knowledge, attitudes, [and] behaviors that have a profound impact on their emergent adult identity."

Although students in general, whether or not having participated in undergraduate research, agree that UR is important and might help them gain employment or graduate school admission after graduation (Figure 1), not all students – even those who have participated in UR – fully realize its benefits (Table 2). An additional appropriate role for faculty advisors for UR, as suggested by Lopatto's (2004) study, is to help students understand and value the gains and benefits offered by participation in UR. An important indicator of successfully implemented undergraduate research is the key element of "enthusiasm" infused by the UR mentor (Russell, Hancock, and McCullough, 2007).

Prospective employers can support efforts to expand the role of undergraduate research by providing internships or by sponsoring UR-related projects. An example of benefits derived from active employer support for UR is demonstrated by a European model in which students and industry work hand in hand by allowing a future graduate to engage in research of importance or benefit to a particular employer. The end product for the sponsoring entity is a bona fide, supervised, low-cost documentation of results. As Kammler (n.d.) reports, a side benefit is the commencement of a potential employer-employee relationship, which results in a direct job offer in as many as 50% of employer-student pairings. In this active-employer model, employers can proactively support the development of desirable ELOs in potential future employees, directly enhancing their pool of qualified and capable prospective personnel.

Conclusions

As an institution of higher education, we are on the front lines for providing meaningful undergraduate research experiences that benefit both employers and students. We can increase the positive impact of UR throughout students' geoscience coursework by incorporating UR modules packaged as activities, independent studies, internships, and field and laboratory experiences that specifically address employer-identified ELOs. UR-based modules can be coordinated across an existing undergraduate geoscience curriculum so that an individual student's research is extended over multiple courses and semesters. Embedding UR across a curriculum enhances its role within the undergraduate educational experience and may help students more accurately perceive and value the positive benefits of investing time in participating in UR.

While academia and employers can do much to facilitate good undergraduate research, the key element for students is involvement. The counsel is simple: Students, get involved in UR on your own, even if it is not offered at your institution. Talk to mentors or advisors at school or at a professional organization such as AIPG for help. For an enhanced experience, find someone who is enthusiastic about his or her profession and your UR research goal. The additional time and resource investment is well worth the effort.

References

Association of American Colleges and Universities (AACU). 2010. Percentages of Employers Who Want Colleges to "Place More Emphasis" on Essential Learning Outcomes. *https://www.aacu.org/leap/documents/MoreEmphasis_2010.pdf*.

Peter D. Hart Research Associates, 2007. "How Should Colleges Prepare Students to Succeed in Today's Global Economy?" Results of a national poll for the Association of American Colleges and Universities. *http://www.aacu.org/leap/students/employerstopten.cfm*.

Peter D. Hart Research Associates. 2013. It Takes More Than A Major: Employer Priorities for College Learning and Student Success, An Online Survey Among Employers Conducted On Behalf Of: The Association Of American Colleges And Universities By Hart Research Associates. *http://www.aacu.org/leap/documents/2013_EmployerSurvey.pdf*.

Kammler, Sara. n.d. Karriere: Türöffner: Die Diplomarbeit Im Unternehmen Schreiben - Karriere.de. [Career: Opening the Door: Writing the Undergraduate Research Thesis within Industry]. Karriere.de. *http://www.karriere.de/karriere/tueroeffner-die-diplomarbeit-im-unternehmen-schreiben-6699/*, accessed December 12, 2013.

Laursen, S., Hunter, A.-B., Seymour, E., DeAntoni, T., DeWelde, K., & Thiry, H. 2006. Undergraduate research in science: Not just for scientists any more. Ch. 6 in J. J. Mintzes & W. Leonard (eds), Handbook for College Science Teaching (pp. 55-66). Arlington, VA: NSTA Press.

Lopatto, David. 2010. Undergraduate Research as a High-Impact Student Experience. Peer Review, Spring 2010, Vol. 12, No. 2. *http://www.aacu.org/peerreview/pr-sp10/pr-sp10_Lopatto.cfm*.

Lopatto, David. 2004. Survey of Undergraduate Research Experiences (SURE): First Findings. Cell Biology Education 3(4): 270–277.

Russell, Susan H., Mary P. Hancock, and James McCullough. 2007. Benefits of Undergraduate Research Experiences. Science 316 (5824): 548–549.

This article was peer reviewd by Associate Editors Gail G. Gibson, CPG-9993 and Solomon A. Isiorho, CPG-7788.

Barb EchoHawk is a geology professor at Metropolitan State University of Denver, where she teaches physical geology, historical geology, geology of Colorado, energy and mineral resources, and stratigraphy and structure. She received a BS degree in earth sciences and secondary teaching certification from Michigan State University and MS and PhD degrees in geological sciences from the University of Colorado at Boulder, where she specialized in Western Interior Cretaceous stratigraphy. She has worked as an exploration geologist in the petroleum and minerals industries, as a project geologist in the engineering of large urban transportation projects, and as a consultant on a variety of geological and educational projects. Barb has taught geology and education courses at undergraduate and graduate levels, pre-service and in-service courses for K-12 teachers, and K-12 science and math. She holds certification for teaching English as a second language

and has taught science to mixed-grade junior high classes for students learning English as a second language.

Dr. Stella Todd is an Associate Professor of Geography in the Department of Earth and Atmospheric Sciences, Metropolitan State University of Denver. She teaches a variety of GIS and remote sensing courses and collaborates with undergraduate student researchers engaged in a variety of spatial analysis projects. Her interests are in cartography, conservation biogeography, and community planning.

Dr. Uwe Richard Kackstaetter, MEM-2437, a German native, received his M.S. in Geology from BYU, Provo and his Ph.D. in applied geology and mineralogy from the University of Würzburg, Germany. His professional expertise on two continents ranges from environmental testing of drinking water wells, groundwater flow modeling, site contaminant evaluations, as well as geologic and hydrologic field investigations. As an educator he has taught not only in college and secondary classrooms, he has also conducted numerous national and international geological field courses. Dr. Kackstaetter's current interests are in developing various practical approaches as advanced tools for the geosciences, such as automated percolation testers, new wavelength dependent night prospecting tools, improved processes of rock and mineral thin sectioning, and clay mineral analytical processing and computations. He currently works as Assistant Professor of Geology at Metropolitan State University of Denver where he teaches courses in Mineralogy and Optical Mineralogy, Hydrogeology, Applied Volcanology and Field Methods.

Rob Rohlfs, CPG-9999, volunteering at the AIPG booth at the North-Central GSA meeting in Lincoln, Nebraska. Thank you Rob for taking on this task.

Foundation of the AIPG – A Search for a Development Committee Chairman and Development Committee Members

The FAIPG has been in the process of establishing its internal structure and policies, which include the creation of a development arm. The FAIPG seeks a volunteer to become a member of the Foundation and undertake the key role as the Chair of the Development Committee. We are also seeking other volunteers to serve on that committee. Some have suggested that retired or semi-retired members of AIPG may best be suited for this role, but the FAIPG does not wish to exclude any person with a strong interest. Persons who have been active at the AIPG section level, and/or the national level, may be well suited, especially if such persons have non-profit development experience. However, previous close involvement in AIPG is not a prerequisite. Chairing the development committee will be a challenging, prominent role and very visible to the AIPG community. We ask that you consider filling this important need. For details, please contact John Bognar at 314-660-9968, or j***ohn.bognar@geosciencesolutions.net.***

2014 AIPG and AHS National Conference Hotel Information

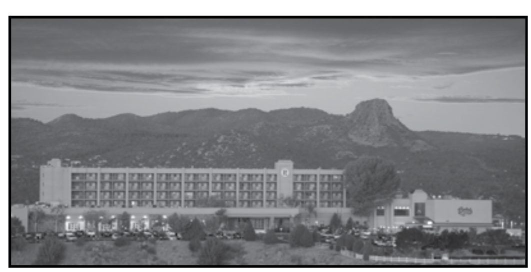
Prescott Resort & Conference Center
1500 State Route 69, Prescott, AZ 86301
(855) 957-4637
$119 Night with AIPG/AHS G3986 Room Block

Resting on the "Top of the Rock" offering picturesque views of the warmth and scenery of Prescott, the Prescott Resort and Conference Center is the choice hotel for those seeking a luxurious getaway in Northern Arizona. Located just 90 miles northwest of Phoenix, the Prescott Resort is a great escape for a relaxed weekend, corporate retreat, or conference meeting. Experience the charm of Northern Arizona at the Prescott Resort.

Our Prescott Resort hotel offers newly renovated guestrooms that share the culture of the Yavapai Prescott Indian Tribe. Each of our 160 guest rooms feature modern amenities that cater to our guests needs, i.e. High-Speed Wireless Internet and Flat-Screen Televisions. Each room was designed in the spirit of the Yavapai Tribe and offers artwork indicative to the majestic scenery of the Prescott area.

For more information go to ***www.aipg.org*** and select the conference website.

Please come join us in Prescott for our conference. For complete meeting information, visit the conference website on the AIPG home page at ***www.aipg.org***.



AGU FALL MEETING

San Francisco | 15–19 December 2014

See You in San Francisco!

Early-Bird Registration Now Open

5 Reasons to Attend

5. Advance Your Career

Boasting **more than 25 career-related events**, the AGU Fall Meeting can demonstrate your worth to potential employers.

4. Network With Your Peers

Kick-off the AGU Fall Meeting at the **opening ice breaker reception** and connect with people who specialize in your field during **AGU section and focus group events** and **daily networking breaks.**

3. Discover New and Cutting-Edge Research Tools

Gain insights about the latest scientific research tools. The AGU Fall Meeting has **more than 400 exhibitors,** ready to showcase technology and tools that can help you with your work.

2. Unparalleled Visibility for Your Science

With **nearly 24,000 attendees,** the AGU Fall Meeting draws both luminaries in their fields and up-and-coming talent. With participants ranging from students to academics to policy makers, there are plenty of opportunities to seek out funding for new research and get quality feedback.

1. The Best Value

Registration for the 2014 AGU Fall Meeting includes all general and breakout sessions; interactive and communication, educational outreach, and career workshops; and access to all presentations. **Register early to take advantage of discounted rates**.

Abstract Deadline: 6 August

Early-Bird Registration and Housing Deadline: 14 November

fallmeeting.agu.org