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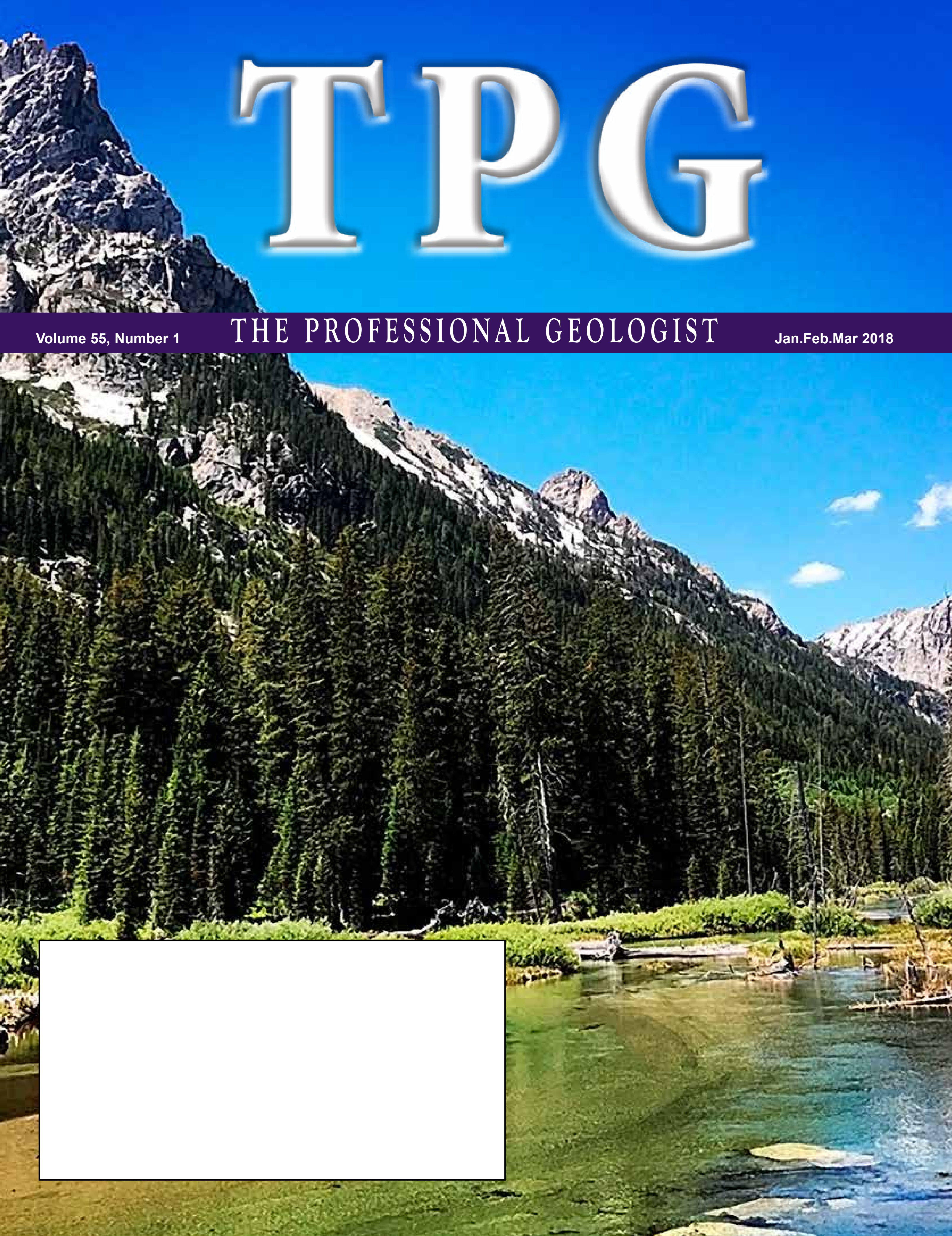

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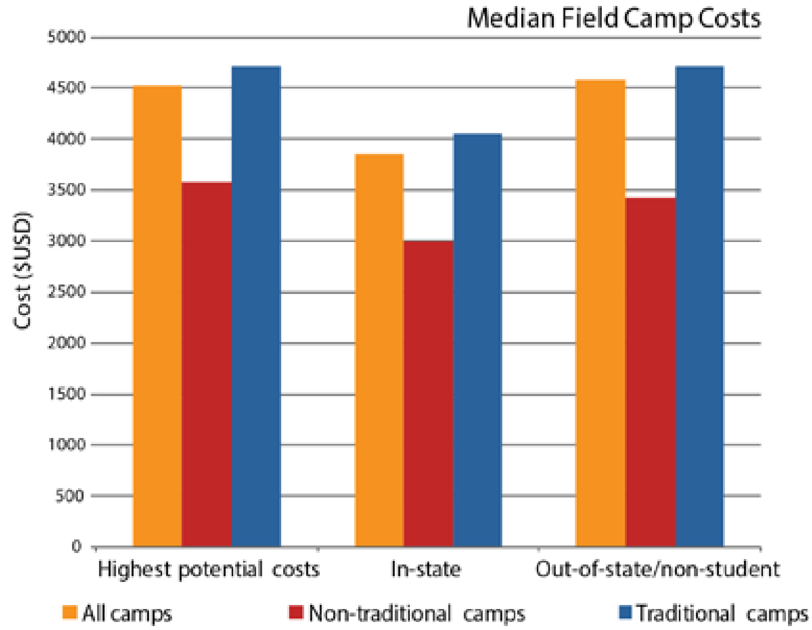
GEOSCIENCE CURRENTS
No. 122

Median Costs of Field Camp Attendance at US-based Institutions



Range of Field Camp Costs by Region ($USD)

	Minimum Individual Cost	Maximum Individual Cost
Midwest	2,893	6,838
Northeast	3,565	7,873
Pacific	Insufficient data	
South	2,450	8,954
West	1,550	5,427

Field camp costs (all in U.S. Dollars) were pulled from syllabi and webpage sources for 63 US-based institutions offering a field camp course. These sources provided varying levels of detail in regards to the cost of their respective camps. 'In-state' costs (in-state students or students enrolled at institutions offering camp) and 'Out-of-state/non-student' costs (for out-of-state students or students not enrolled in the institutions offering camp) were used when cost details were available. Highest potential cost includes the highest overall cost to attend field camp through an institution, regardless of the students' status at the institution. The median cost to attend field camp at all US-based institutions as an in-state student is $3,850, with overall costs ranging from a minimum of $1,550 to a maximum of $7,425. The cost for an out-of-state student is $4,581, with costs ranging from $1,550 to $8,000. The median highest potential costs a student could expect to pay is $4,518, with values ranging from $1,550 to $8,954.

The differences in field camp costs between traditional camps (4 to 6 week summer field experience) and non-traditional camps (any camp not classified as a 4 to 6 week summer field experience) were also examined. Of the 63 total camps, 14 were classified as non-traditional and 47 as traditional. Costs for traditional camps are overall higher than for non-traditional camps, with median costs ranging from $4,062 to $4,713 while non-traditional camp costs range from $3,000 to $3,575, depending on student classification. Individual costs range from a minimum cost of $2,100 (traditional) or $1,550 (non-traditional) to a maximum cost of $8,954 (traditional) or $6,450 (non-traditional).

In addition, the range of field camp costs varied regionally across the US. The South has both the institution with the highest cost, at $8,954, and the largest range in field camp costs with a range of $6,504. Conversely, the West has the institution with the lowest cost, at $1,550, and the smallest range ($3,877) between values. This difference in regional costs could be potentially impacted by built-in transportation costs needed to travel to field camps in the West, the region with the highest number of field camps.

- Caroline C. Kelleher

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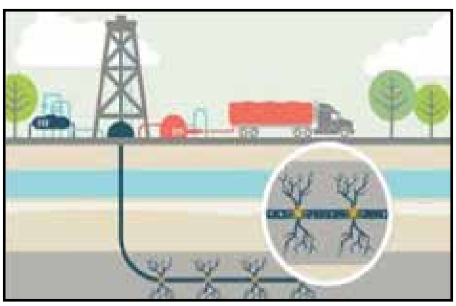

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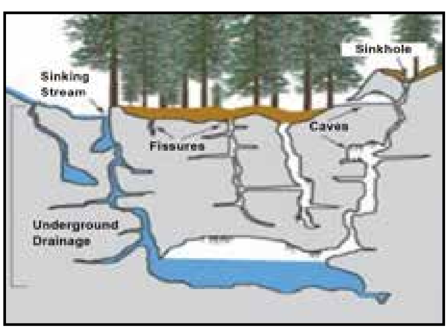

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FEATURES

On the Cover: Scenes of Cascade Canyon, formed by glaciers more than 15,000 years ago. Photographed during a voluntary Teton backpacking trip submitted by Student Voice contributor Anna Stanczyk, SA-6099.

DEPARTMENTS

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Characterization of Metamorphosed Shales Across the Miller Cove Thrust, Southeast Tennessee

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Jonathan grew up in rural northeast Tennessee and is attending the University of Tennessee: Chattanooga to pursue his passion in geology. Specializing in economic geology, mineralogy, geochemistry, and structural geology, he hopes to begin his career as a traveling exploration field geologist and continue into geochemical research later in life. Jonathan was awarded first place in the 2017 AIPG National Student Poster Undergraduate Competition.

Abstract

Since the initial mapping of the Blue Ridge province (BR), the Precambrian age of the Ocoee Supergroup (OS) and its metamorphic history have become controversial. Fossils found within the last 30 years suggest that the OS in the western part of the BR is Silurian or younger. It has been proposed that the entire OS could be of similar age. Subsequent mapping separated the fossil-bearing western BR part from the rest of the BR, which includes the Wilhite formation, by faults. Of these, the most notable is the Miller Cove Thrust (MCT) Fault, with well foliated and metamorphosed rocks in the Miller Cove Thrust sheet (hanging wall), and less metamorphosed rocks in the footwall.

This research characterized the shales and slates on either side of the Miller Cove Thrust in terms of the illite clay crystallinity using X-ray Diffraction. Proper characterization of these units will help refine current understanding of the petrology and geologic history of this region. Considering the uncertainty in placing these units, this research was intended to determine if the MCT is reasonably placed based on the measurable differences in metamorphism on either side of the MCT. Such findings aid in deciding if a discrepancy exists regarding when the fault occurred relative to regional deformation and if it is properly located. Measured crystallinities were mostly consistent with previous work; however, interpretations suggest that the MCT's location should be adjusted and that it may predate regional metamorphism.

Introduction

It was a consensus for decades that the western BR was entirely Precambrian in age. The Great Smokey Mountains National Park (GSMNP) was originally mapped by King (1964) who described the OS as having been deposited in the Precambrian and metamorphosed in Ordovician-Silurian Taconic orogeny. However, this idea has become increasingly controversial in recent decades

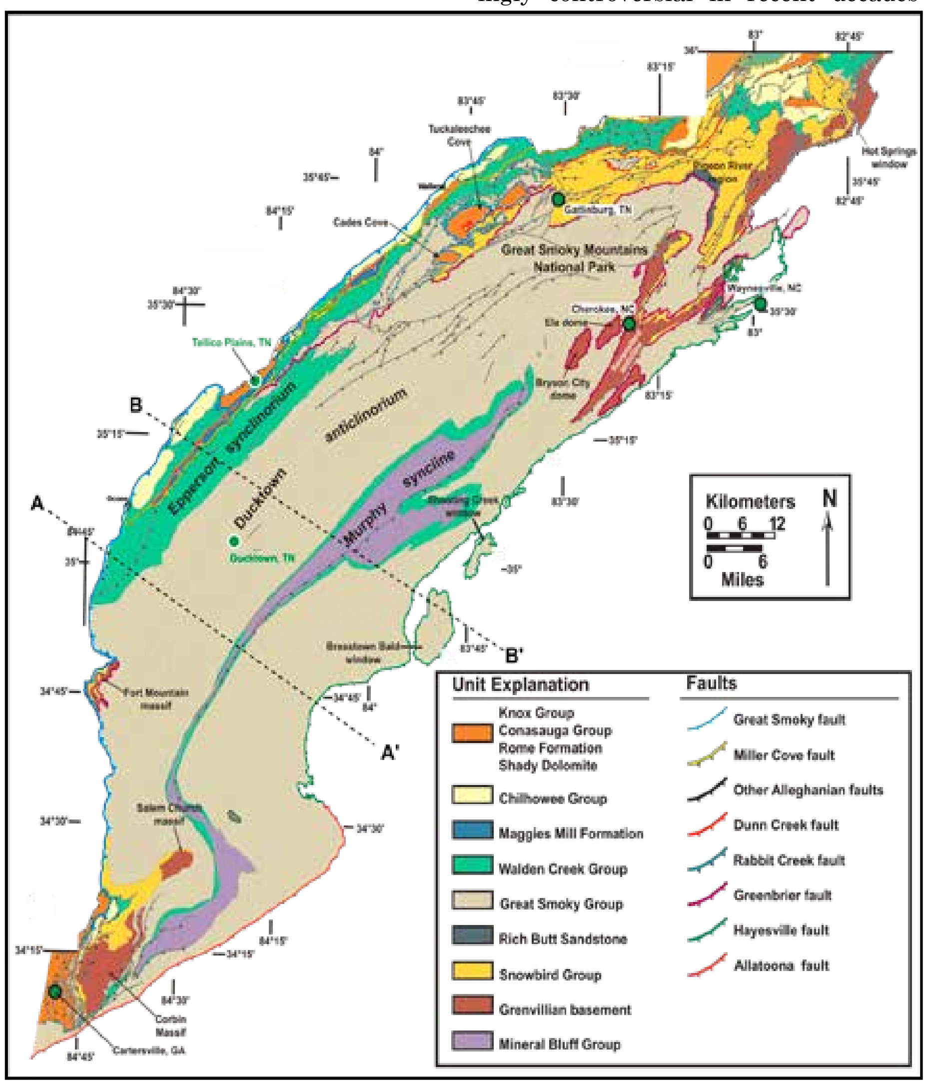


Figure 1 - Regional geologic map of the southern Appalachian western Blue Ridge Province and portions of the Valley and Ridge modified from Thigpen and Hatcher, 2009 and 2016. The Miller Cove Thrust lies near the northwest border of the map.

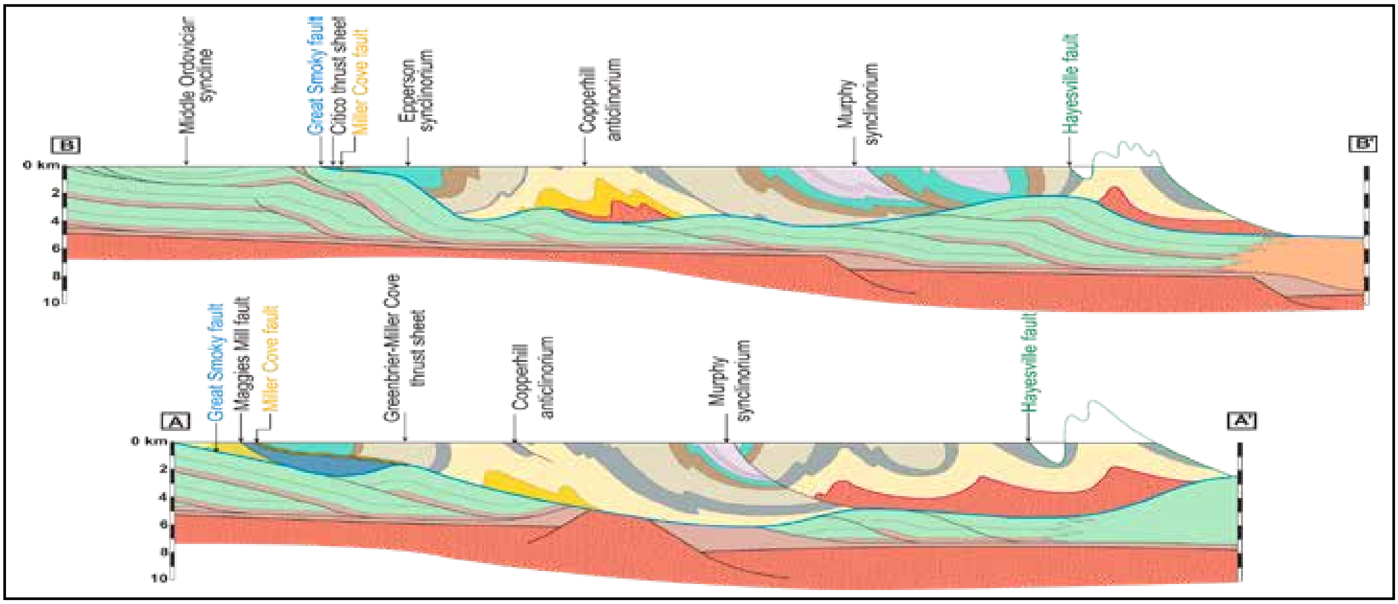


Figure 2: Cross sections A-A' and B-B' from Figure 1. Present-day structural positions of Citico, Maggies Mill, and Miller Cove thrust sheets are shown (Thigpen et al, 2016).

(Costello and Hatcher, 1991). Unrug et al. (1991) reportedly found Silurian or younger microfossils in Walden Ridge, and, to emphasize the reported "absence of unconformity", concluded the Walden Creek Group (WCG) to be Silurian or younger. They further suggested that since the WCG, including the Wilhite Formation, are Silurian then the entire OS is to be Silurian. Many workers have tried to find the fossils from those sites where Unrug et al. reportedly found some, but with little success. However, Repteski (2006) and Thigpen et al (2016) reported finding conodont elements to support the Unrug (1991) conclusion.

Miller Cove Thrust, Southeast Tennessee

The age of the OS has since become more controversial regarding the age of deposition, the age of metamorphism, and where the boundary of the Wilhite Formation lies on Geologic maps of southeastern Tennessee (Hatcher, 1991 and 2012). Tull et al (2012) examined the Valley and Ridge and its metamorphism, and they further developed an isograd to assess the paleodepths and strain magnitudes of the Blue Ridge. They used the crystallinity index (a.k.a. Kubler Index or KI) of dioctahedral illite clay (muscovite) in shales and slates to determine the boundaries of the very low grade (anchizone, KI > 0.42) and the low grade (epizone, KI <0.25). In response to these findings, Hatcher (2012) proposed the existence of the MCT to separate the less metamorphosed strata to the west from the more metamorphosed strata to the east. Later work by Thigpen et al (2016) better defined this region by placing a Devonian sea west of the OS, which was later thrust between older rocks during the Alleghenian Orogeny as a horse. They also concluded that the metamorphosed OS was transported to the northwest into its current position in the Blue Ridge during the Alleghenian orogeny by a fault system associated with the Great Smoky thrust fault. This in turn suggests the Miller Cove Thrust is also Alleghenian. Figure 2 above shows a modern cross section through the Miller Cove Thrust and its neighboring thrust sheets.

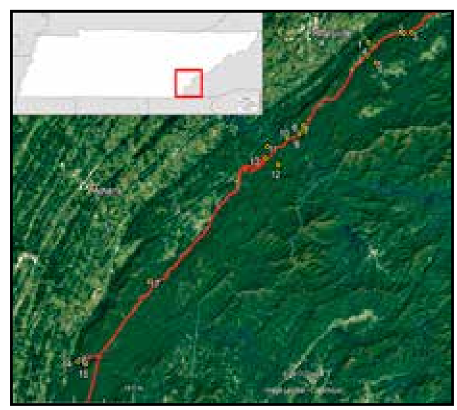


Figure 3: The 17 site locations in the study area along the border of Southeastern Tennessee from the Ocoee River to Walland. MCT is outlined in red.

Table 1:
Site Coordinates. Highlighted locations were analyzed in this study.

1. 35°44'6.48"N 83°49'21.15"W	10. 35°32'50.92"N 84° 2'57.25"W
2. 35°45'15.79"N 83°43'20.93"W	11. 35°31'45.72"N 84° 6'14.75"W
3. 35°45'16.04"N 83°41'56.25"W	12. 35°29'41.93"N 84° 4'24.14"W
4. 35°42'35.82"N 83°49'27.67"W	13. 35°30'21.80"N 84° 6'31.82"W
5. 35°41'44.42"N 83°47'59.06"W	14. 35° 6'12.71"N 84°37'49.05"W
6. 35°34'20.63"N 84° 0'12.09"W	15. 35° 5'57.99"N 84°36'25.73"W
7. 35°33'55.08"N 84° 0'16.42"W	16. 35° 5'54.20"N 84°36'41.65"W
8. 35°33'26.47"N 84° 0'29.38"W	17. 35°15'45.56"N 84°25'55.22"W
9. 35°33'18.86"N 84° 0'53.85"W	

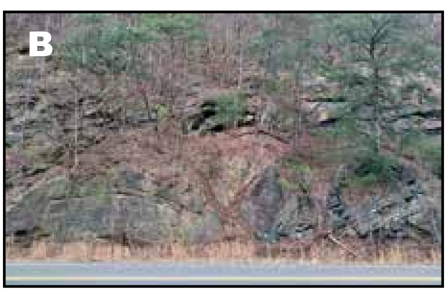
This undergraduate research effort was conducted in order to characterize the rocks on either side of the MCT. The characterization includes field examination of outcrops and laboratory work including making thin sections for petrographic work, and powdered samples for XRD work.

Methodology

Field Observations

Samples were collected from 17 observed locations (Figure 3 above);

persons present were Dr. Habte Churnet and classmate JD Mallory, who was searching for conodonts. GPS coordinates of each collection site are given in Table 1 on the previous page. Of the 17 samples taken, one sample from each side of the MCT in four areas (for a total of eight) were chosen to be analyzed based on freshness and certainty of sample identity (highlighted in Table 1, photos in Figure 4). Visually, locations on the west side of the MCT appeared less metamorphosed than those of the east side. However, some areas did appear more metamorphosed than was expected. For example, the black limestone at site 7, a location where foraminifera and conodont fossils were reportedly found by Unrug et al (1991) and Repteski (2006) contained bands of calcite parallel to the bedding, suggesting fluid movement due to directional stress. Notably, conglomeratic units were found in Walland site 2, the Chilhowee dam sites 9 and 10, and at Repteski's fossil sites 6 and 7.



Petrographic Microscopy

Thin sections were made of site 1 (an unaltered shale near Walland, TN) and site 8 (meta-shale with disjunctive cleavage and diagenetic alterations near Happy Valley, TN). These sites were chosen for comparison between the least metamorphosed shale and the most metamorphosed shale that was not yet slate (Figures 4A and 4D).

Figure 4: (A) Site 1, shale west of Walland, TN. (B) Site 5, slate just east of Walland, TN. (C) Site 6, black shale and limestone along Happy Valley Road, TN. (D) Site 8, meta-shale* at the intersection of Happy Valley and Hwy 129. (E) Site 12, green slate, Mt Pleasant Rd, TN. (F) Site 13, conglomerate with lightly metamorphosed limestone and shale, Citco Rd, TN. (G) Site 15, meta-shale* along US 64. (H) Site 17, meta-shale along Tellico Reliance Rd 315. *"meta-shale" here is used to denote an anchi-metamorphosed shale, one that has not reached the degree of alteration denoted by "slate".

X-Ray Diffraction Clay Analysis

The 8 chosen samples were pulverized and settled in water with sodium-meta-hexa-phosphate (separator) for two hours. Approximately 1mm of settled solution was pipetted onto three 1"x2" glass slides per sample for analysis. One of each sample slide was air dried, heated to 550C for two hours, and treated w/ ethylene glycol for twelve hours to better distinguish illite clay. Crystallinity was determined using the full-width-half-maximum (Kubler Index, K.I.) of the 10 Å illite peak (Kubler et al 2001). It is important to note that the machine began to malfunction and go offline prematurely during the measurement of heated samples (red). Therefore, the heated sample measurements were designed to just scan the range of kaolinite clay. A specific hardware modification to refine the clay peaks was applied by using 0.5-degree slits in the diffractometer and goniometer rather than the standard 1-degree slits.

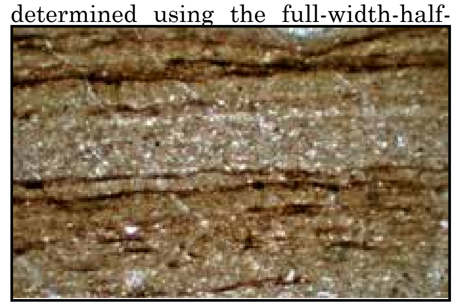


Figure 5: Site 1 Sand Suck shale near Walland shows no metamorphism, fines upward, and is lightly altered.

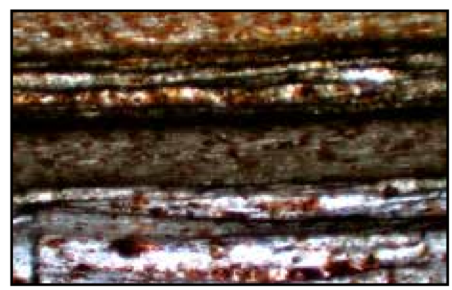


Figure 6: Site 8 meta-shale (Wilhite Fm.) near Happy Valley Rd. Shows signs of foliation, flattened grains, and diagenetic iron alterations.

Results

Crystallinity index (KI) values obtained from the XRD measurements (Table 2 on the following page) are classified in Figure 8 on the following page as increasing grades of metamorphism vs KI value. An isocryst (a type of isograd specifically related to crystallinity) graphically displays these values in Figure 9 and again, regionally, in Figure 10.

Discussion

Considering that a K.I. of 0.42 and below represents the lower limit of metamorphism, Hatcher appears correct in placing less metamorphosed units to the west of the MCT. Tectonic collisions in this area would have occurred from east to west so metamorphism is expected to increase toward the east, but samples from the west were more metamorphosed than expected. Furthermore, a value of 0.25 or lower represents Greenschist facies (substantial metamorphism), and the map shows the isocryst cutting across the MCT traces near Walland and the Ocoee Gorge. Elsewhere, the trace of the MCT is at or proximal to the 0.2 to 0.25 KI, which would indicate that the MCT is the western limit of the epizone (low grade metamorphism). Near Walland and at the Ocoee Gorge, the trace of the MCT lies in a region of very low-grade metamorphism. The implication is that either the MCT is not the western limit of Greenschist facies or its location requires an adjustment such that it can correlate with a relevant isocryst at KI=0.25. Furthermore, the isocryst suggests a metamorphic gradient, implying that movement on MCT may have occurred before regional metamorphism, which wouldn't result in stark contrasts of crystallinity. Or, perhaps, it simply does not exist.

Conclusions

Observations and analyses show that there is in fact a measurable difference in the degree of metamorphism on either side of the MCT. Furthermore, based on the data presented here and its interpretation, it appears that either the MCT predates regional metamorphism or further work needs to be performed to refine its proper location. Looking for fossils in the localities identified by the Unrug (1991) paper may not yield fossils, and general field work, classical field examination, and the use of petrographic microscopic study may not yield definitive results either. However, conducting further in-depth XRD studies of illite crystallinity index may be used to characterize outcrops on either side of a fault that is reported to be well metamorphosed on one side and less so on the other. Furthermore, determining the proper location of the fault not only has academic implications but is impor-

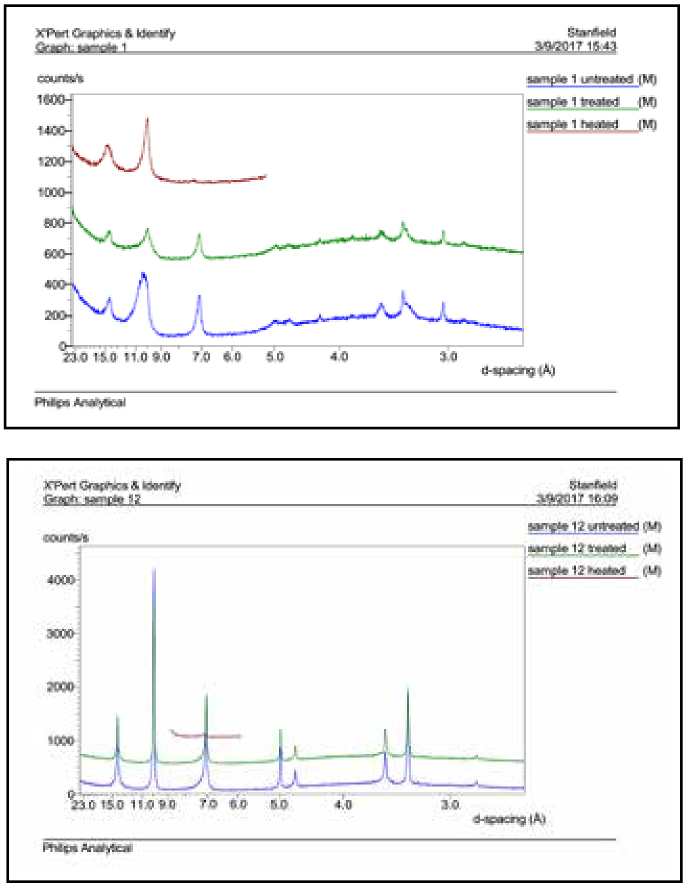


Figure 7: XRD patterns of Sample 1 (west side, least altered) and Sample 12 (East side, most altered). Blue is air dried, green is glycolyzed, and red is heated. Illite clay is easily distinguishable as the large 10 Å peak. The wider the peak, the higher the KI, and the less metamorphism the sample underwent. Likewise, the higher and sharper the peak the more metamorphosed the sample. Curvature occurred on the right half of the patterns due to interference of the glass slides used to hold the clay samples. Full width half maximum was taken using integrated software measurement tool.

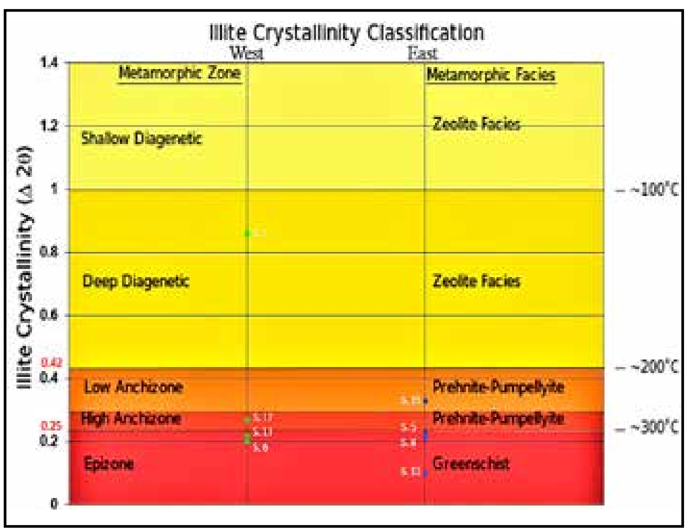


Figure 8: Metamorphic classification of sample KI values based on International Union of Geological Sciences nomenclature and systematics (Árkai et al, 2003). Values were obtained by calculating the full-width-half-maximum of the 10 Å illite peak, and are divided by West on the left and East on the right.

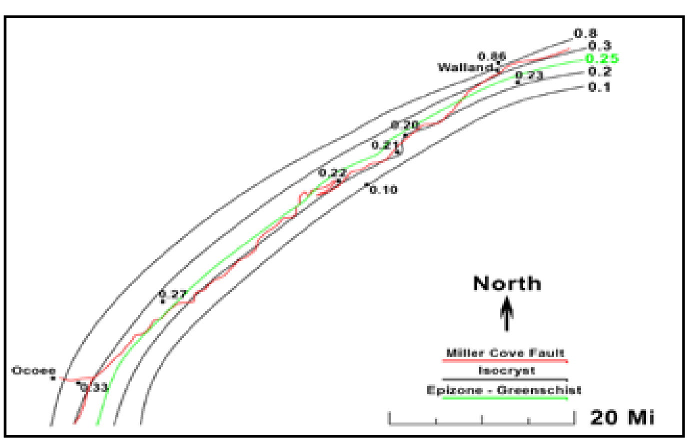


Figure 9: Isocryst and the Miller Cove Thrust Fault from the Ocoee River to Walland, TN. KI values from Table 2 are shown here and rounded to nearest hundredth of a decimal

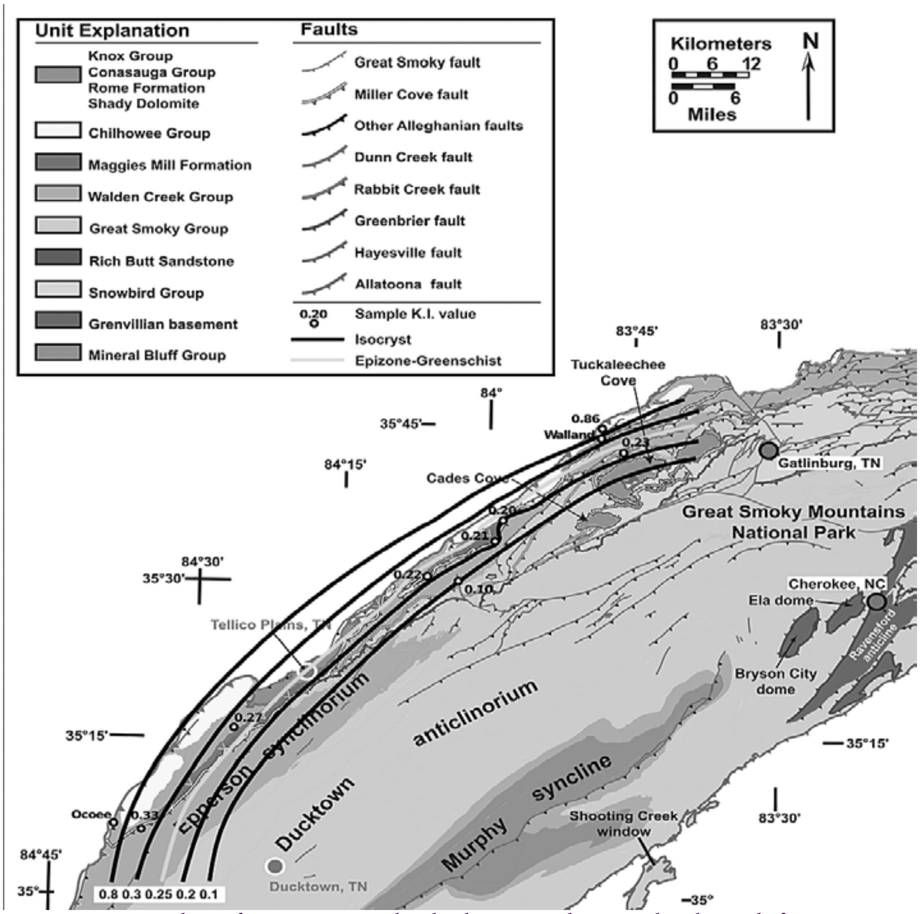


Figure 10: Regional map from Figure 2 overlain by the isocryst determined in this study from Figure 9. The isocryst cross cuts the fault line which suggests the fault line either predates regional metamorphism or further work needs to be done to properly place the fault. (Modified from Thigpen and Hatcher, 2009 and 2016)

tant in determining safe construction of roads and buildings.

Acknowledgements

Dr. Habte Churnet and Dr. Jonathan Mies of the University of Tennessee: Chattanooga - Division of Geology for their subject area expertise, critique, support, and fantastic sense of humor.

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Rare Metal Bearing Granites in the Eastern Desert of Egypt

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The rare metals comprise all economically important chemical elements such as Nb, Ta, Sn, Mo, W, Li, Be, Zr, REEs, U and Th (Pollard, 1995). Most of these rare metals are considered as strategic metals that are widely used in manufacture of electronic, electric, petroleum and nuclear products. In general, these elements occur naturally with variable concentrations in different rare metal bearing minerals including wolframite [$(Mn,Fe)WO_4$], columbite-tantalite [$(Fe,Mn)(Nb,Ta)_2O_6$], monazite [$(Ce,La,Nd,Th)PO_4$], zinnwaldite[$KLiFe_2$+$Al(AlSi_3)O_{10}(F,OH)_2$], pyrochlore[$(Na,Ca)_2Nb_2O_6(OH,F)$], allanite [$(Ce,Ca,Y)_2(Al,Fe^{3+})_3(SiO_4)3(OH)$], and pitchblende [$(UO_2)(UO_3)$]. However, there are important rare metals that occur in minerals of fixed composition, including tin (in cassiterite, SnO_2), molybdenum (in molybdenite, MoS_2), thorium (in thorite,$ThSiO_4$), uranium (in uraninite UO_2), and zirconium (in zircon, $ZrSiO_4$). The rare metal minerals are crystallized as accessory and sometimes as major mineral phases in peralkaline, metaluminous and peraluminous granites, rhyolites, greisens, aplites and pegmatites in different orogenic belts worldwide.

The Arabian-Nubian Shield represents one of the most widespread and exposed Neoproterozoic (900-530 Ma) continental crust belt on the Earth. Moreover, it is characterized by the widespread occurrence of some economic and subeconomic post-collisional rare metal granites. The Eastern Desert of Egypt occupies the northern part of the Arabian-Nubian Shield (Fig. 1a). It contains more than 17 rare metal bearing granitic plutons (Fig. 1b). In the field, the rare metal granites occur as small sized bodies in the outer part of a composite or a multi phase granitic massif. Moreover, they exist in different shapes including domal (Nuweibi, Mueilha, Zabara), lensoid (Hommret Waggat, El-Ineigi, Umm Naggat) and stock-like (Igla, Abu-Dabbab) bodies (Abu El-Rus et al., 2017). Moreover, a large number of these late Neoproterozoic highly fractionated rare metal granitic plutons are concentrated in the Central Eastern Desert (CED)

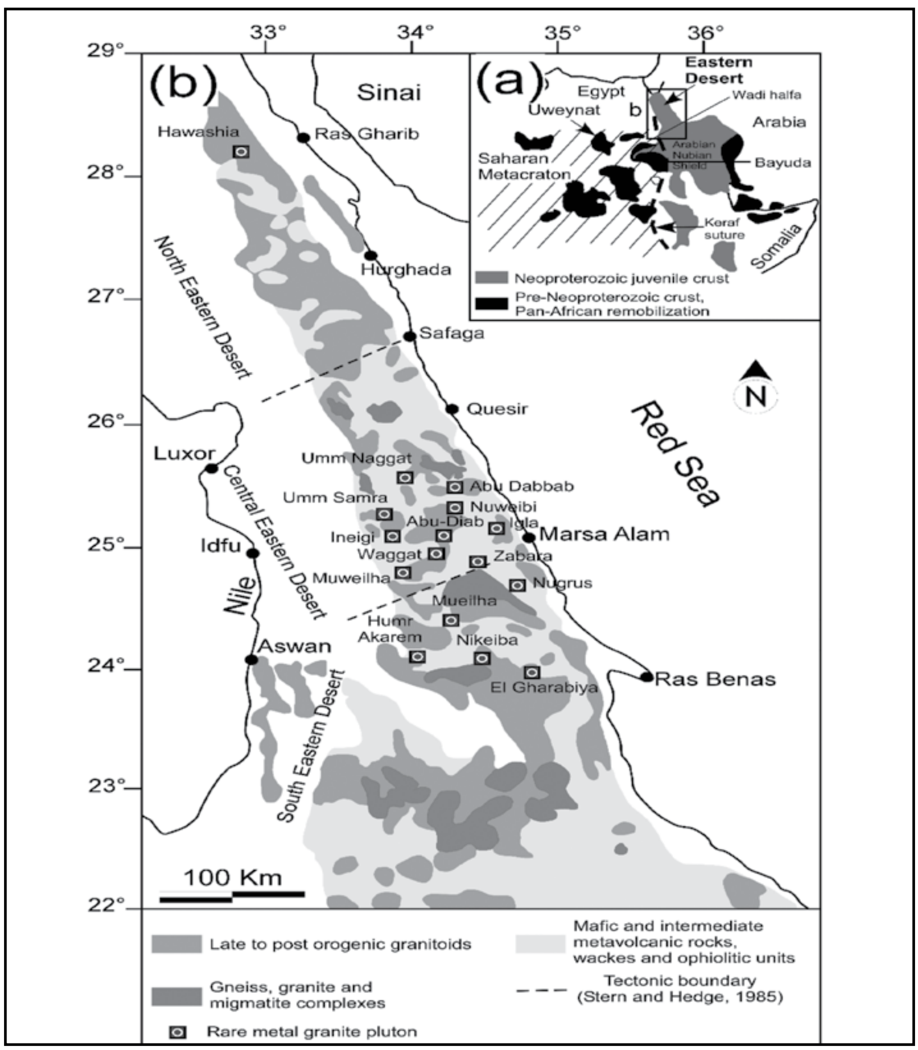

Fig. 1.a) Schematic map of NE Africa showing the Arabian–Nubian Shield, the Saharan Metacraton, and Archaean and Paleoproterozoic crust that was remobilized during the Neoproterozoic; b) Geological map of the Eastern Desert of Egypt, showing the distribution of the most important rare metal-bearing granitic intrusions.

of Egypt. Most of these plutons are considered as geochemically specialized granitic plutons, which means that although they host disseminated rare metal minerals, they are not mature enough to become economically important orebodies. However, the Central Eastern Desert contains two well-known plutons (Abu-Dabbab and Nuweibi) that have strategic and economic reserves of Ta and Sn in the bed rock and associated stream sediments.

Petrographically, these granites generally consist of orthoclase, albite, Li-F-rich mica and fluorite as major phases and columbite, tantalite, cassiterite, wolframite, molybdenite, zircon, rutile, uraninite, monazite and thorite as accessories (Helba et al., 1997; Melcher et al., 2015). Most of these minerals are of magmatic origin and sometimes they may have been affected by metasomatic and/or hydrothermal solutions. Geochemically, these granites range in composition from metaluminous to peraluminous, highly fractionated calc-alkaline with A-type affinity. They are characterized by their high content of SiO_2, Na_2O, Nb, Ta, Zr, Rb, Ta, Sn, U and REEs, but they contain lower concentration of CaO, Sr and Ba (Sami et al., 2017). Their REE pattern is characterized by a well-developed pronounced negative Eu anomaly and lanthanide tetrad effect ($TE_{1-3} > 1.1$). The rare metal granites in the Eastern Desert of Egypt could be formed by 1) partial melting of pre-existing granodiorite; 2) extensive fractional crystallization of late evolved magmas; 3) dehydration melting of pelitic rocks and 4) metasomatic and/or hydrothermal processes. In general, the rare metal granites were formed during the post-collisional stage of the Arabian-Nubian Shield (Farahat et al., 2011). This stage, because of lithospheric delamination processes, is characterized by the occurrence of deep strike slip faults that acted as a passage for the rising asthenospheric melts. This melt is saturated with F and Cl fluids/volatiles and provides enough heat to melt the lower to middle crustal rocks of the Arabian-Nubian Shield to finally produce the rare metal granites by partial melting and/or fractional crystallization processes.

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Mabrouk Sami is currently a PhD student at the Department of Lithospheric Research, University of Vienna, Austria and is assistant lecturer at Department of Geology, department of Geology, Minia University, Egypt. His PhD thesis discusses the geochemistry and economic potentiality of some rare metal bearing granitic plutons from the Central Eastern Desert of Egypt. Mabrouk is a student member of American Institute of Professional Geologists (AIPG) and member in the European Geosciences Union (EGU), European Association of Geochemistry (EAG) and the International Association of Geochemistry (IAGC).

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TEXAS SECTION NEWS

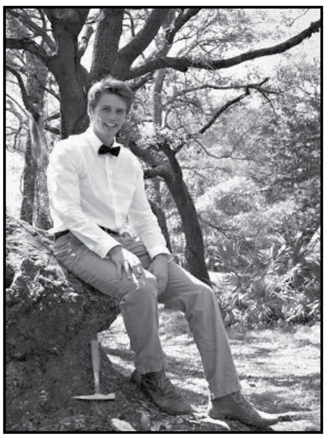
Henry M. Wise, PG, CPG-7697

This December 30, 2017 news release is reprinted from the Texas Section's website.

The Texas Board of Professional Geoscientists (TBPG) adopts an amendment to 22 TAC §851.21 to establish guidelines for applicants requesting to sit for a licensing examination. Adopted changes add language to provide that an applicant who does not fully meet the education requirement for licensure may sit for a licensing examination as long as the applicant has submitted certain documents and has acknowledged that the applicant does not meet the education requirement. The applicant will then need to resolve the education deficit once the applicant has received passing scores on the licensing examination in order to obtain a Professional Geoscientist license.

Resolving the education deficit may include obtaining a waiver of the education requirement, obtaining a substitution of experience for education, or by the Board's determination that the education requirement was met with "equivalent education," as provided by §1002.255(a)(2)(B). An applicant may choose to sit for the examination knowing that the education deficit will not be reviewed by the Board until after the applicant has passed the required examination(s) for licensure, and that the resolution the applicant presents may not be approved. For more information go to http://www.sos.state.tx.us/texreg/archive/December222017/Adopted%20Rules/22.EXAMINING%20BOARDS.html#115

Determining the Effects of Fresh Water Releases on the Maritime Environment: A Case Study of Florida's Caloosahatchee Estuary



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Abstract

It can be argued that the geology of Florida is dominated not by rocks, but by water. Florida was largely an untamed landscape full of wetlands and standing water before European settlement. However, in 1947, Congress authorized the Central and Southern Florida Project which included the development of 2,000 miles of levees and canals in Southern Florida. The development of these canals fundamentally changed the water regime in South Florida to make room for agriculture and urbanization. However, changing the water regime in South Florida has had serious environmental effects including the release of millions of gallons of nutrient rich water into the Caloosahatchee Estuary through freshwater releases from Lake Okeechobee. Previous studies have shown that this nutrient rich water has had significant negative effects on the environment within the estuary as well as on macrobenthic communities (Doering 1999; Buzzelli 2014). However, little to no research has yet quantified the possible effects of Freshwater Releases (henceforth FRs) on the maritime environment outside the estuary. This study gives a preliminary quantification of the possible effects that FRs have on the maritime environment by comparing the diversity indices of past and modern gastropod assemblages outside the Caloosahatchee estuary. The results suggest that FRs are impacting the maritime environment, but due to limited statistical data further research is needed to better quantify the results. However, this study serves as a warning of the unseen damage current water management practices may have caused to Florida's maritime waters.

Introduction: Water Management in Florida

In Florida, water management is one of the state's biggest concerns. In 2016,

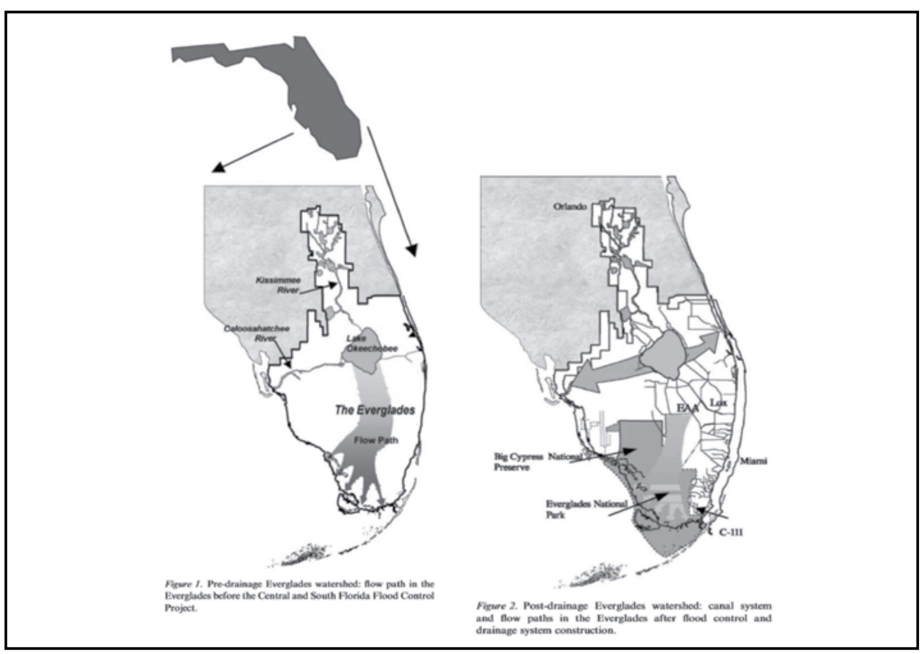

Figure 1: A comparison of the historic versus current water flow through the Everglades watershed (Perry 2004, 186-188). Of note for this study is the increase in water flow west through the Caloosahatchee River and east through the Indian River Canal (not labeled) after the completion of the Centraland Southern Florida Project.

the state declared a state of emergency that lasted for 242 days when freshwater releases from Lake Okeechobee caused a toxic algal bloom in the Indian River Lagoon (Klas, 2017). Florida's economy and the quality of life of its citizens are directly affected by the management and the quality of its water resources. With the advent of environmental issues such as climate change and urbanization certain water management techniques should be looked at through a closer lens with a view towards limiting possible economic impacts as well as environmental ones (Stanton 2007). One such management technique that requires further review is the practice of FRs or "Flushings" from Lake Okeechobee into the Caloosahatchee estuary.

In the Caloosahatchee estuary, FRs occur intermittently during times of high flood risk to drain excess water stored in Lake Okeechobee (Doering 1999). Previous studies have shown that the nutrient rich water that is released from Lake Okeechobee into the Caloosahatchee estuary via the Caloosahatchee River has significant effects on salinity and water quality, as well as varying effects on turbidity and Chlorophyll-a count (Doering 1999), (Buzzelli 2014). Furthermore, higher levels of marine and macrobenthic diversity are believed to be directly related to lower amounts of freshwater releases into the estuary (Palmer 2015). Findings such as these influenced the founding of the Estuaries Protection program in 2007 (Section 373.4595, Florida Statutes) which is responsible for establishing minimum inflow levels within the estuary (Sections 373.042 and 373.0421 of Florida Statutes).

However, establishing the optimum minimum inflow levels is still an area of active research within water management, and the current findings are limited in two ways. First, no significant studies have provided any quantification of the effects of freshwater releases outside the estuary into the maritime environment. Second, the issues of increased levels of urbanization and flooding frequency have not been adequately addressed in relation to how they will affect the management of freshwater releases in the future.

Introduction: The solution

To address the first issue, a preliminary quantification of the effect of freshwater releases over time in the maritime environment can be inferred through paleo-ecological study of modern and past molluscan assemblages. Various diversity indices and metrics have been shown to quantify changes in specific assemblages over time (Schipper et al 2016). These methods have become increasingly important as investigative techniques that quantify anthropogenic impacts within specific environments (Schipper et al 2016; Kidwell 2013). In the maritime environment, it is important to be able to accurately compare dead communities with their live counterparts, therefore molluscan assemblages act as important paleontological proxies as their hard body parts are well preserved and they represent a limited range of time (Kidwell 1996).

Introduction: The study

In this study, the live-dead fidelity and live-dead rank order abundance of gastropod communities were analyzed from dredge localities taken within two different maritime zones outside the Caloosahatchee estuary. "Molluscan live–dead fidelity studies investigate the influences of anthropogenic activities on marine ecosystems by comparing the taxonomic composition of a living community to its corresponding death assemblage" (Korpanty 2014, 113). The two different maritime zones represent areas that are either at high or low risk of being influenced by FRs. Risk was assessed based on two factors, distance from the estuary, assuming that freshwater becomes more diluted as it is transported farther from its source, and the analysis of ocean current charts which depict the movement of water from the estuary into the maritime environment. The areas deemed low risk act as the control group in this study as an analysis of ocean currents suggested that it is less likely that freshwater that enters the estuary is transported towards these dredge localities. Conversely, areas deemed high risk are close to and 'downstream' of the source of freshwater pollution, and therefore they act as the experimental group. However, ocean currents are variable, and the conclusions of this study would be better supported if the full geographic extent of freshwater pollution into the maritime environment from the Caloosahatchee River were to be researched in future experiments.

As it is commonly accepted that global diversity is decreasing, any change in fidelity or rank order abundance across the control group was treated as background noise when being compared to the experimental group (Schipper et al 2016). Therefore, changes in the experimental group (high risk) must differ in some significant manner from those that occur in the control (low risk) for conclusions to be drawn. Furthermore, the relationship of the effects of freshwater releases to the issues of urbanization, wetland reduction, and increased flooding frequency due to climate change are addressed within the discussion.

Methods: Materials

The Gastropod assemblages used in this study were all acquired via dredges taken by the research vessel R/V Bellows as part of ongoing research in the Gulf of Mexico by the Paleo-ecology Lab at the University of South Florida (USF) (Herbert 2016). Dredges were taken at 20-minute intervals and shell assemblages were brought back to the lab to be processed. To preserve live-dead agreement and remove taphonomic bias a sieve size of 1.5 mm was used (Kidwell 2002). The gastropods were then divided into their respective species, and then further subdivided based on live or dead classification. Due to the ongoing nature of this research, specific data from the survey for species count and location had to be withheld until publication as part of a larger study being conducted by the Paleoecology Lab.

Ocean Current data published by PODAAC, an extension of NASA's Jet Propulsion Laboratory, was used to help classify 29 different dredge localities as possible stations of interest (ESR 2009). These dredge localities were then grouped into eleven zones with each zone retaining a large enough sample size to limit taphonomic bias (Kidwell, 2001). The zones were grouped based on the relative distance between them, with a maximum separation of eight miles, to meet a minimum threshold count of 45 live specimens. The zones were then characterized according to their total distance from the mouth of the Caloosahatchee estuary which is the parameter of interest, since the river is the main source of freshwater releases (Doering 1999). Zones within 45 miles of the mouth of the estuary were deemed high risk for anthropogenic impact as these zones were the most likely to encounter excess freshwater released from Lake Okeechobee, conversely areas further from this cutoff were deemed low risk. As such, hypotheses concerning anthropogenic impact focused on the possibility of significant degradation to molluscan communities in the high-risk areas.

Methods: Quantitative Statistical Analysis

These two different types of localities, high and low risk, were subsequently analyzed via live-dead fidelity analysis and live-dead rank order abundance. Both metrics are used to quantify how closely the live and dead communities within a given locality approximate each other. The two metrics approach this quantification by different pathways, live-dead fidelity is based on the total number of species both live and dead while live-dead rank order abundance is focused solely on the highest-ranking species based on abundance (Lockwood 2006).

Live-dead fidelity readings for each zone were plotted as a function of distance from the mouth of the Caloosahatchee estuary. A linear regression was then performed to infer a possible trend as well as analyze statistical power.

Live-dead fidelity

The live dead fidelity metric is calculated as follows:

$$Live - Dead\,Fidelity = (N_S \times 100)/(N_L + N_S)$$

Where N_S is equivalent "to the number of species found in both the live community and death assemblages", and N_L "is equivalent to the number of species found in the live community only" (Lockwood 2006). This study was limited in its ability to calculate live dead fidelity as each location was only a single snapshot of both the live and the dead communities which limited overall fidelity (Lockwood 2006). However, the aim of this study is to quantify possible anthropogenic effects of freshwater releases, therefore a comparison of live-dead fidelity between the high and low risk localities should be sufficient enough to reach relative conclusions about environmental or anthropogenic contributors.

To optimize the strength of a live-dead fidelity study a threshold size of 100 individuals is optimal in order to account for factors such as time averaging and sample bias (Kidwell 2001). In this study, live individuals were rare, therefore a threshold size of 45 was set to make inferences from the datasets currently available. Furthermore, dredge localities with similar coordinates were combined into zones that could meet the minimum threshold requirement set for this study. These "zones" are represented by a single GPS coordinate that was tabulated through an online calculator, GeoMidpoint©, that transformed all GPS coordinates into Cartesian coordinates which were then multiplied by a weighting factor and added together to determine the best fit location for the average of a given set of GPS coordinates.

To interpret the results of this study it is important to understand that a perfect live-dead fidelity would be represented by a score of 50, while a score of 100 would represent a community with no live-dead fidelity. Examples for such calculations are shown in Figures 1 and 2.

$$Live - Dead\,Fidelity = \frac{N_S \times 100}{N_L + N_S} = \frac{40 \times 100}{0 + 40} = 100$$

Figure 1: Live-dead fidelity calculation where the total number of species present in both live and dead assemblages, NS, is equal to 40, and the number of species present in the live assemblage, NL, is equal to 0. This represents no fidelity.

$$Live - Dead\,Fidelity = \frac{N_S \times 100}{N_L + N_S} = \frac{40 \times 100}{40 + 40} = 50$$

Figure 2: Live-dead fidelity calculation where the total number of species present in both live and dead assemblages, N_S, is equal to 40, and the number of species present in the live assemblage, NL, is equal to 40. This represents perfect fidelity.

Rank Order Abundance

Rank order abundance is used in ecology to rank the most prominent species in a chosen parameter by abundance (Kidwell 2001). In this study, the parameter under study is gastropod diversity. Previous studies involving Spearman Rank Correlations have shown that rank order abundance between live and dead molluscan species in a pristine, unchanged environment with a threshold size of 100 should correlate significantly (Kidwell 2001, Lockwood 2006). Therefore, any strong deviations in rank order abundance between live and dead species of gastropod datasets suggests possible environmental impacts within a given locality. Due to time constraints, rank order abundance was not calculated, however given an extended deadline this study could have included such statistical information.

Results

The results in this experiment are limited since limited abundances of live assemblages were available to calculate live-dead fidelity. Furthermore, only minor sampling efforts have been undertaken outside of the Caloosahatchee Estuary, therefore the number of zones available for study was limited. Further work is necessary to better quantify the results.

However, Figure 3 does show a trend line that exhibits an increase in live-dead fidelity as the distance from the estuary is increased. The figure plots the linear regression of live-dead fidelity for each zone against the distance from the mouth of the Caloosahatchee River.

The trend line could be an artifact of variance, as the R2 value is distinctly low at .029. This drastically decreases the power of the study to make significant conclusions. However, it does serve as the basis for justifying further inves-

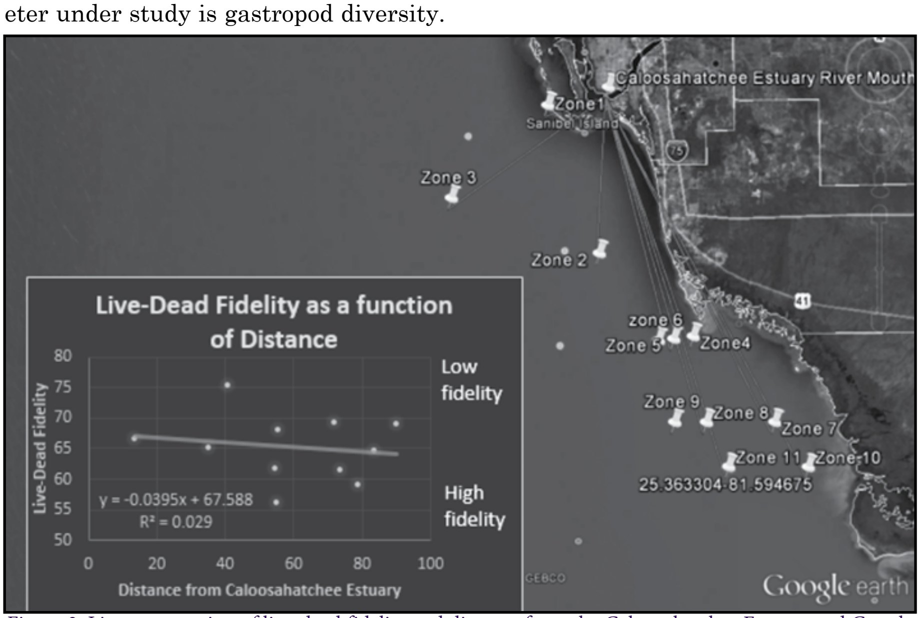

Figure 3: Linear regression of live-dead fidelity and distance from the Caloosahatchee Estuary and Google earth coordinates with each zone shown.

tigation into the effects of freshwater releases in the maritime environment.

Discussion

The purpose of this study was to investigate the possibility of freshwater releases impacting the maritime environment. However, due to constraints on sample size, this study does not have the power to make statistically significant conclusions. However, the data does highlight the possibility of freshwater releases acting as a negative anthropogenic factor on molluscan communities outside of the estuary. As humans continue to impact the natural environment in a myriad of ways, it is important to begin the quantification of anthropogenic factors to limit potential impacts (Steffen W. et al. 2007).

Freshwater releases are currently a strategy implemented to relieve strain from large flooding events (Finkl 1995). However, due to wetland reduction, urbanization, and climate change it is unclear if the releases will remain a viable method in the future as flooding frequency and strength will likely continue to rise. This year, in response to these issues and as part of the Comprehensive Everglades Restoration Plan, Congress recently passed Senate Bill 10, which seeks to divert water south of Lake Okeechobee to be stored in a reservoir and released to Everglades National Park through Water Conservation Areas in times of need. However, there is considerable debate among various organizations regarding the effectiveness of this solution to reduce freshwater releases into the Caloosahatchee Estuary (Owosina, 2016; Van Lent, 2017). Further research into this subject could have far reaching applications as acrimonious dialogues concerning urban development, water management, and climate change are prominent in Florida's politics.

The current system that Florida employs in draining water into the gulf is a broken one. It was designed in the early 20th century when environmental issues were not yet an important factor (Finkl, 1995). This ignorance has led to the negative effects we currently see in the Caloosahatchee estuary due to freshwater releases (Doering 1999), (Buzzelli 2014). If there is evidence that these effects extend into the maritime environment, appropriate steps should be taken to either limit or reverse them. The issues regarding freshwater releases and their effects in the maritime environment should be addressed while the problems still appear to be emerging.

Unfortunately, multiple factors, including wetland reduction, urbanization, and climate change, point to there being a need to increase the amount of water that will be drained through the Caloosahatchee River in upcoming years. Across the world, over half of the wetlands have been lost while the remaining portion continues to diminish (Zedler 2005). Florida is no exception to this and has seen a continued decrease of wetlands over recent years (Dahl, 2005). These wetlands play a key role in ameliorating flooding events as they act as natural flood mitigation devices thus alleviating the need for storage through canals that bring the water to Lake Okeechobee (Brody 2007), (Ming 2007). Furthermore, Florida has been experiencing rapid population growth and urbanization and with that growth the conversion of natural resources such as wetlands for human use has always occurred (Reynolds 2001). Finally, accelerated sea level rise due to increases in global temperature may play a role in how freshwater releases are managed as there has already been a significant increase in flooding frequency related to sea level rise in Florida (Wdowinski 2016). This trend is expected to increase dramatically over the next fifty years, which may place strain on Lake Okeechobee (Wdowinski 2016). These factors and others like them should be considered in planning that seeks to limit the negative environmental effects that surround freshwater releases. If they are not considered, some of Florida's natural systems may be unnecessarily damaged.

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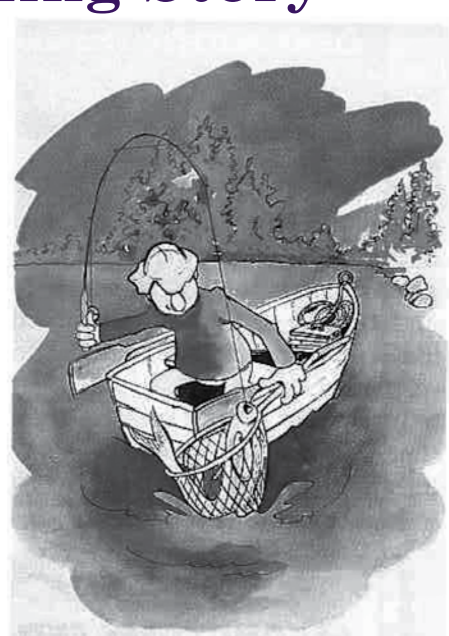
Reserve Definitions as a Fishing Story

POSSIBLE

Prospective ore: ore which cannot be included in the [other] classes, nor definitely known or stated in any terms of tonnage.

PROBABLE

Probable ore: ore where there is some risk, yet warrantable justification for assumption of community.



PROVEN

Proven ore: ore where there is practically no risk of failure of continuity.

Reprinted from the January 1994 edition of the TPG. Drawn by Rex Byan based on an idea from David M. Abbott, Jr., 1990. The definitions are from H.C. Hoover, 1909, Principles of Mining: McGraw-Hill Book Co., p. 19.

The Robert Lessard Memorial Chapter

The brainchild of club president Nicholas "Nico" Harrison, the Robert Lessard Memorial Chapter of the AIPG is the newest club on campus at New Mexico Tech. Founded in the fall semester of this year, initial turnout, interest, and club growth have all exceeded expectation. With a stated goal of helping budding geologists gain employment and familiarity with the earth science industry, and professional guidance of the highest caliber, this arm of the AIPG is sure to prosper.

I'm Nico Harrison, president of the Chapter.

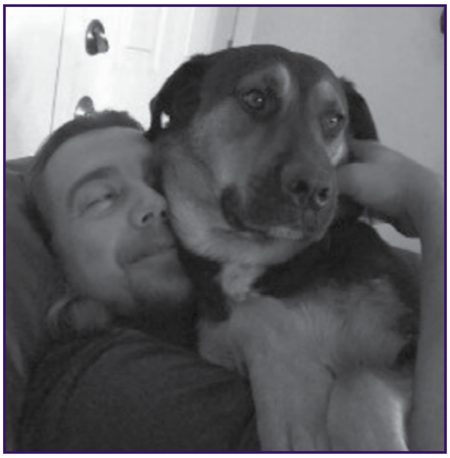
Dr. Robert H. Lessard, the namesake of our chapter, was adjunct professor of geology at Santa Fe Community College. In mid-2012, I was at a crossroads in my life. I was a biology major at SFCC, hoping to go into zoology, but I hated cell biology. I was casting around for which direction to go when my mother suggested I take a geology course, since I had been interested in geology when I was younger, before my interests had shifted. That summer I took a course with Dr. Lessard. I received an A in his course, the first A I had received in a science course in some time, and decided that I wanted to take my career in a direction that would allow me to pursue geology. I switched my major to physical sciences and took the remaining two geology courses that Dr. Lessard offered. On May 18, 2013, I took my last final with him. Afterwards I was talking to him and asked him how I could pursue geology. He told me I was a good student and recommended that I transfer to either New Mexico Tech or UNM and get a Bachelor's in Earth Science. Two days after that conversation, Dr. Lessard passed away unexpectedly at the age of 77.

I stayed on at SFCC for a few more semesters to finish (most of) my Associate's Degree before transferring to NMT as an Earth Science major, just as Dr. Lessard had recommended. He is the reason I am where I am today, and I therefore thought it fitting to name the chapter after the man without whom I would never have taken this effort.

My name is Cheyenne Holt, and I'm the treasurer for the AIPG chapter here at the Institute of Mining and Technology. I'm currently enrolled as a student here at New Mexico Tech and my major is in earth science, I plan to minor in geochemistry as well. I've collaborated on a poster with other students in spring of 2017. The poster is known as Mitigating Erosion in a Desert Watershed. I am 20 years old and always had a fascination for rocks since I was little and I don't think that will change. I graduated high school in spring 2015 and have been focused on making my career dream job a reality since then.

Chapter officers. L to R: Marcus Silva, Chair of Program Committee; Nicholas "Nico" Harrison, President; Johnny Ray Hinojosa, Chair of Membership Development Committee; Cheyenne Holt, Treasurer; Connor Whitman, Secretary; Eddie Humetewa, Chair of Publicity Committee. Vice President Keith Diegel pictured below, Not Pictured; Virginia McLemore

My name is Keith Diegel (one of the two figures pictured left) , I serve as Vice President of the chapter. At 34, I am a classic "non-traditional student" and the ranking old-man of the group. I am now pursuing a B.S. in Geology with a focus on mineral resources. When I'm not acting in my role for the club or being a taxed and harried student, I am a proud husband and father living in a quiet community in mid-state New Mexico. My boys (17 and 18 now) are starting their collegiate careers, as is my wife, so we're well on our way to creating a whole cadre of educated Diegels.



Vice President - Keith Diegel

Virginia "Ginger" McLemore is the Principal Senior Economic Geologist with the New Mexico Bureau of Geology and Mineral Resources, a research division of New Mexico Tech, and our Faculty Club Sponsor. She holds B.S. degrees in Geology and Geophysics (1977) and M.S. degree in Geology (1980) from New Mexico Tech and received her Ph.D. in Geoscience from University of Texas at El Paso in 1993. She also is an adjunct professor at New Mexico Tech and teaches Geology of the Industrial Minerals, Uranium Geology, and Geology of Strategic and Critical Minerals, graduate level courses for the Department of Earth and Environmental Sciences and Department of Mineral Engineering in New Mexico. She is a Certified Professional Geologist (#CPG-07438) with the American Institute of Professional Geologists. Currently she is the faculty advisor for the AIPG student chapter and the New Mexico Shooting Sports Club.

Throughout the coming year for our club we will be hosting resume' writing workshops, setting up and participating in student mixers, taking tours of mines and mining facilities, and hosting information sessions with industry professionals. We hope to help prepare our members for prosperous, productive careers in the Earth Science industry for many years to come.

Lassen Peak Plagioclase Electron Microprobe Analysis

Katherine Landoni, SA-7770

Katherine grew up in Sequim, Washington and is currently an undergraduate Honors Scholar at Oregon State University double majoring in Geology and Environmental Science. She plans to pursue a graduate degree in natural hazard research and planning and ultimately loves the outdoors.

Introduction

Lassen Peak, located in Northeastern California, is one of many volcanoes that are the result of an oceanic plate being subducted under a continental plate.

The goal is to learn more about the magma in the 1915 eruption at Lassen Peak through analyzing mineral zoning in Plagioclase crystals. To do this, crystals were analyzed along a rim to core transect using Oregon State University's Electron Microprobe.

Geologic Background

Lassen Peak is the southernmost volcano in the Cascade Volcanic Arc. It is located within the Lassen volcanic center, an area containing many other volcanic domes. Volcanism has occurred in this area for the past 3 million years, and can be attributed to subduction of the Gorda plate under the North American plate. The domes surrounding the main feature, Lassen Peak, formed over the last 300,000 years. Lassen peak itself formed about 27,000 years ago in a single silicic eruption. However, there was no further indication of eruptive activity at Lassen Peak until late May, precipitation of 1914. For a whole year steam explosions persisted at the surface, and in mid-May of 1915 magma rose to the surface forming a black dacite dome with andesitic inclusions. A few days later, the volcano erupted explosively. The sample selected for this project is from this eruption.

Current models suggest that the dacite and andesite present at Lassen Peak formed from the cooling of a hybrid magma composed of a basaltic magma and a more silicic body. These magmas form near subduction zones where basaltic oceanic crust melts and rises through a silicic body within the overlying crust.

Electron Microprobe Techniques

The Electron Microprobe (EMP) determines the chemical composition of a mineral in situ. This is done by bombarding a sample with free electrons accelerated down a column with a 15 kV difference between the sample and the tungsten filament. The sample emits x-rays that are characteristic of a specific mineral due to electrons in the outer shells of atoms replacing electrons in their inner shells. The emitted wavelengths are analyzed with wavelength dispersive x-ray spectroscopy (WDS) using diffraction of crystals from Bragg's Law ($2d\sin\theta=n\lambda$) by comparing them to the known values of plagioclase (see https://en.wikipedia.org/wiki/Bragg%27s_law for a quick review of Bragg's Law).

I measured the sample from rim to core, which can provide valuable information about the history of the crystal's formation by showing the change in elemental composition. Backscattered electron imaging produces a grey-level image in which heavy minerals are darker and light minerals lighter in tone.

Discussion

The data collected show that the samples contain both normal and oscillatory zoning. Normal zoning is characterized by a Na-rich rim and a Ca-rich core; this suggests crystal fractionalization is occurring as the plagioclase cools. Oscillatory zoning in these samples is displayed by the alternating layers of Na and Ca ultimately ending with Ca-rich rims

The data collected suggests that this oscillatory zoning is probably due to the repeated intrusion of a basaltic magma into the already silicic body, forming a hybrid magma. This would cause precipitation of a Ca-rich rim around the normally zoned plagioclase. The other chemical constituents present at the analyzed points show further evidence of the introduction of a basaltic magma into the silicic body. Thus, according to the data, wherever there is a spike of Ca (notable at the rims) there is also a corresponding increase in FeO content as well as a decrease in SiO. Basaltic magmas have high CaO and FeO content, while being SiO deprived. This introduction of a basaltic magma can cause the changes seen in the samples. The tectonic environment also supports this hypothesis. In addition, the data collected matches the current models for the evolution of a hybrid magma.

Conclusion

- Evidence of a basaltic magma being introduced into a cooler silicic body forming a hybrid magma is confirmed by the zoning changes of the plagioclase crystals.

- Further proof is shown by changes of FeO and SiO content within these plagioclase samples.

• This addition of basaltic magma and other volatiles led to the 1915 Lassen Peak eruption.

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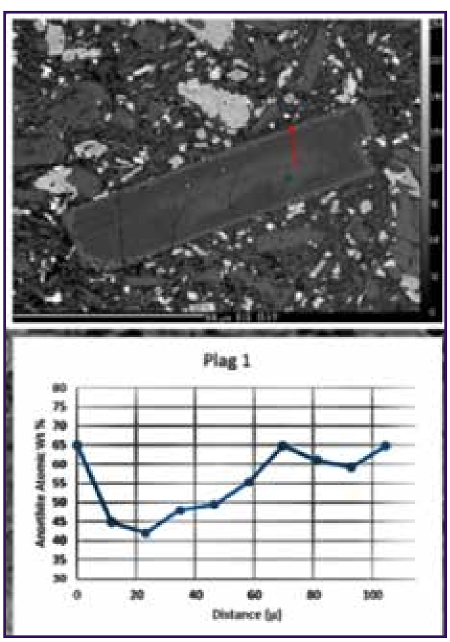
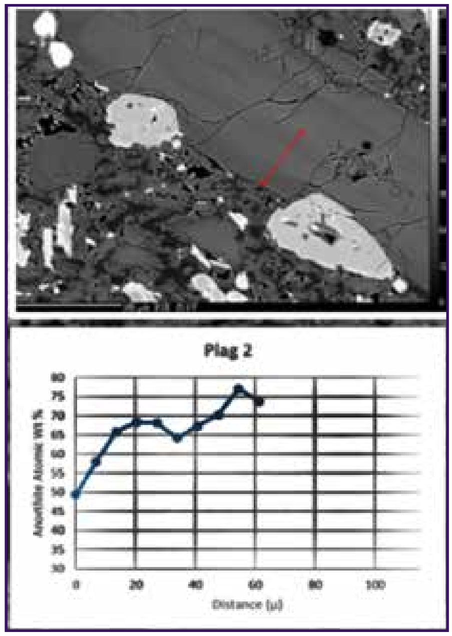
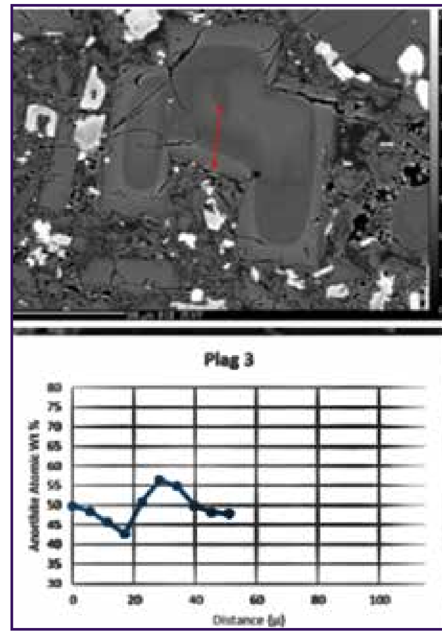
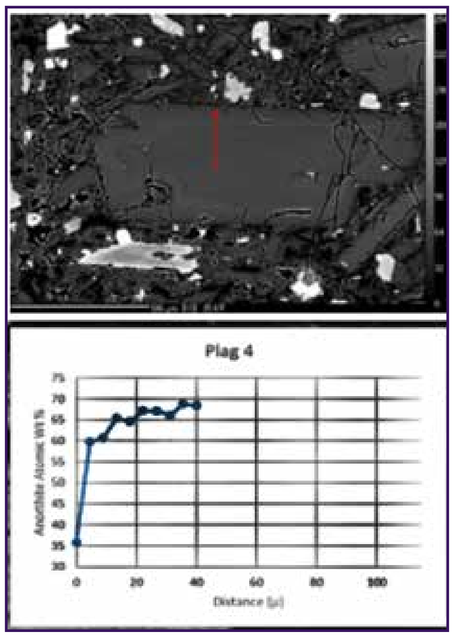
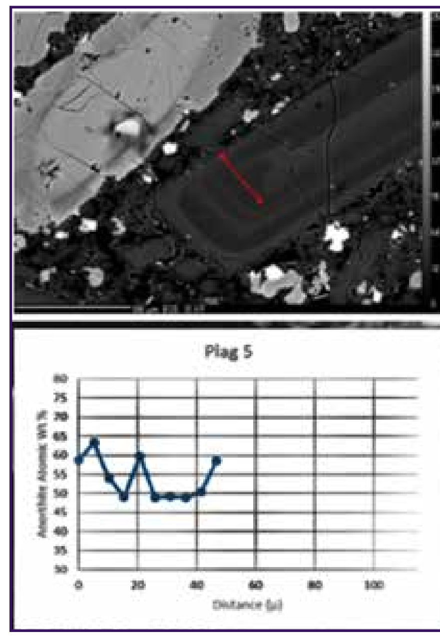
Figure 1 - Electron Microprobe backscatter images and the paths analyzed.











AIPG Membership Totals

	As of 12/1/2016	As of 12/1/2017
CPG / Active	3,111	2,969
CPG / Emeritus	447	462
Prof. Member	922	912
Associate Member	23	35
Young Professional	117	119
Student Adjunct	3,346	2,791
TOTALS	8,017	7,350

Members,

Please notify headquarters if you know of a member who has passed. We would like to honor our members in remembrance.

Cobalt on the Rise

James R. Burnell, Ph.D., CPG-11609

Jim Burnell, PhD, has 45 years of varied experience in the geosciences, from academia to research to consulting. He spent his last 7 years as the Minerals Geologist for the Colorado Geological Survey, with a special interest in resource geopolitics. He is now mostly retired, with some activity with his company Mineral Strategies LLC. Jim has held numerous positions on the executive boards of the Colorado Section and the AIPG National Board.

Publicity surrounding Tesla and the company's large battery factory in Nevada has recently magnified the public awareness of lithium-ion batteries and the need for lithium. The author himself has been contacted by several companies and individuals thinking they could leap the line in to get involved in the lithium market. (As I've seen before, many entrepreneurs outside the mining space underestimate how forward-thinking that industry is at times.) Of course miners have been actively pursuing all aspects of the lithium trade - from exploration to sales - for a long time now. Public knowledge, however, has lagged on the recognition of the other components of lithium ion batteries. Not only lithium, but nickel, manganese, graphite and cobalt are needed, depending on the battery formulation for electric vehicles (EVs). None of those four are without their supply issues, but cobalt has particular supply-chain concerns.

Cobalt the Metal

Cobalt is a shiny, grey, brittle metal in its metallic form. Cobalt is multivalent, and is ferromagnetic. While not a particularly rare element (33rd in abundance), it seldom occurs alone, but rather with other metals, such as nickel and copper. The source of the name is unknown. According to the Cobalt Institute, the name cobalt originates from the Greek, and came to German as "kobelt" and referred to legendary gnomes living in the Schneeberg Mountains where they (it) interfered with the refining of nickel and silver (Cobalt Institute, 2017).

Combined with silica, cobalt produces an intense blue color, hence the term "cobalt blue," and has been used historically as a colorant. In fact, that was the first and only use of cobalt for many years. The unique properties of cobalt, however, proved to be a valuable alloying agent to hardness, and resistance to corrosion and physical wear. Hence, it has become indispensable in the aerospace and metal tool industries. In recent years, the value of cobalt alloyed with lithium in the cathodes of batteries has enhanced its demand.

Supply - Demand

While the battery industry has commanded the spotlight, the traditional uses of cobalt have also helped increase demand. Predictions aren't uniform, of course, as some in the field predict a much healthier future for EVs than others. The CRU Group - a London metals consultancy - "refined chemical applications" (i.e. batteries) are fueling the demand increase, going from half of cobalt demand to 2/3 by 2026 (CRU Group, 2017). Bloomberg New Energy Finance (2017) predicts an even rosier future for the metal, seeing the demand rise 150% by 2030 (to ~20 million tonnes) and to 70 million tonnes by 2040. Macquarie Research sees the demand rising from slight oversupply in 2015 to slight undersupply by 2021 (Hamilton, 2017).

This demand growth is, of course, accompanied by price growth. The US Geological Survey reports the price had drifted downward to $11.50 per pound during the oversupply to more than $30/pound in December 2017 (Northern Miner, Dec. 2017).

Cobalt Deposits

As noted above, cobalt is seldom recoverable as a primary commodity, but is a by-product of mining of other metals - copper and nickel normally. Cobalt is associated with mafic rocks (those rich in iron and magnesium). It is strongly chalcophile, partitioning into a sulfide phase where sulfur is present.

Cobalt is recovered from four types of deposits - sedimentary, hydrothermal, magmatic and lateritic.

Most of the world's cobalt is currently mined from sedimentary deposits as a by-product of copper mining, mostly from the Central African Copper Belt (CACB). Several models for the formation of these deposits have been presented (e.g. Theron, 2013, Hitzman, et al, 2005) but in general it is accepted that the metals were deposited from sulfate-rich brines in isolated sedimentary basins. Grades are generally 1 to 3% copper, with 0.2% cobalt. The CACB lies within the Katanga Basin, with mines in the southeast corner of the Democratic Republic of Congo (DRC) and adjacent Zambia. Other sediment hosted cobalt occurs in Australia (British Geological Survey, 2009, Commodity Profiles.)

A second broad category is that of hydrothermal deposits in which hot metal-bearing fluids deposited cobalt minerals in veins associated with volcanic activity. These deposits are mostly copper-nickel sulfides containing by-product cobalt of around 0.1%. Deposits of this type are found in Finland, Norway, Sweden, Canada, Australia (the famous Olympic Dam deposit) and Morocco. In fact the Moroccan deposit - Bou Azzer - is unique as a primary cobalt deposit, with cobalt in arsenide ores. A deposit in Idaho is also in the development stage.

Magmatic sulfide deposits are the third type. In these, high-temperature mafic magma containing copper, nickel and cobalt encounters sulfur-bearing rock, often when injected into a sedimentary pile, melting the sedimentary rocks. Those metals (and others), as chalcophile elements, partition into an immiscible sulfide liquid. That liquid then crystallizes in layers or cupolas in the larger silicate magma body. Also included are platinum group metals (platinum, palladium, iridium). These deposits comprise the main source of these precious metals, and the cobalt nickel and copper occurs with them. Examples include in Russia (the massive Noril'sk deposit), Canada (the equally famous Sudbury deposit), South Africa, Zimbabwe, Australia and Viet Nam. At least one of these is believe to have been an extrusive ultramafic magma body - a komatiite.

The fourth deposit type is the laterite. These deposits are formed when weathering breaks down the primary minerals (silicate and sulfide minerals), allowing dissolution and removal of the more soluble components. Left behind is a concentration of less soluble elements, such as nickel and cobalt. Laterites typically form in hot, humid climates. Cobalt is recovered from laterites in the following countries: Australia, Brazil, Cuba, Madagascar, New Caledonia, Papua-New Guinea, Philippines and Turkey.

A fifth type of deposit is recognized but not yet mined. Deep-sea precipitates, traditionally known as manganese nodules, could provide a large resource of cobalt, along with other metals. Currently, many problems accompany the development of sea floor mining. The technology is developing, but legal and moral questions arise as to who has the right to mine the oceans. Environmental ramifications have-not been fully explored. Some companies are working on technologies for recovery, but the practice still lies in the future.

Problems

A geopolitical discomfort for the US is the vulnerability of cobalt to supply chain disruptions. Shedd, et all (2017) estimate that half the cobalt produced originates from the Democratic Republic of Congo. The Norther Miner (Stokes, 2017) describes the three largest known reserves of cobalt as occurring in that country. The Mutanda Mine lists proven and probable reserves of 1.5 million tonnes of cobalt (with 3.7 million tonnes of copper). The Tenke-Fungurume Mine, the majority shares recently sold to China Molybdenum by North American companies, estimate reserves at ca. 522 million tonnes cobalt (with 3.4 mT copper). The Mashamba East Mine touts 192,600 tonnes cobalt (with 684,730 tonnes copper). The 4th and 5th largest reserves are the Murrin Murrin laterite deposit in Australia and the Ambotovy laterite deposit in Madagascar. The DRC is an unstable source. Armed conflict has plagued the country and continues to plague the people.

The instability has contributed to the poverty of the local populace of the region. Many families are supported by what is euphemistically called "artisanal" mining. Large quantities of cobalt is hand-cobbed under dangerous and unhealthy conditioned. Cobalt production is reported to support and arm rebel groups. Child labor and slave labor is reportedly used by rebel groups (e.g. Humanium; UNICEF, Jones, 2017). An investigative report by the Washington Post (Frankel, 2016) detailed many of the problems. Sacks of concentrated hand-picked cobalt ore is delivered to shipping centers, mostly to feed refining operations in China. Most western companies that utilize cobalt have tried to disassociate themselves with these artisanal operations, but the Washington Post writer points out, the number just don't add up.

Cobalt is extremely valuable in today's economy. Much of it is obtained in a manner that makes westerners uncomfortable, but the market is thriving. Exploration and development are proceeding in the US and Canada, which could help the supply. The demand should continue to increase in the mid-term, however.

Looking Ahead

On the demand side, an increase in the production of EVs will increase the demand for cobalt into the future. Other uses of Lithium-ion batteries will, of course, increase demand also, but the amount of cobalt required for the EV batteries far outstrips that of other applications. Formulations of batteries using less cobalt are being researched but nothing appears on the near horizon.

For the U.S., our situation is that we consume ten percent of the world's cobalt supply, while producing less than one percent.

Regarding supply, a number of factors are in play. As discussed, fifty percent of cobalt currently originates from the CACB. The resolution of political conflicts there seems an unlikely development. To further complicate the supply chain issues, most of the cobalt raw material goes to China for processing. Given that nation's extremely active position in Africa, that, too, is unlikely to change.

Because cobalt constitutes a small proportion of ores mined for copper and/or nickel, the amount produced is a function of the demand for, and price of, those commodities. When the copper price is high, cobalt production in Africa increases; when nickel prices are high, cobalt production in Russia and Canada increases. Unfortunately, most of the cobalt production that can be increased independently is from the artisanal mining in the CACB, which carries the stigma of "conflict cobalt" and is presumably not purchased by western companies. So for the most part, regardless of demand, cobalt supply is inelastic.

New mines are in the development stage in Australia (the Sunrise Mine) and in the U.S. (the Idaho Cobalt Project) which both contain very high cobalt content compared to copper. These projects promise to be primary cobalt mines, with copper and nickel as by-products. The amount of time required to permit mines in those countries means that the earliest production would be 2020.

A pilot project is being pursued for the sea-floor mining of cobalt, copper and nickel off the coast of New Guinea, but that project has attracted the attention of the international environmental community. Cobalt consumers will be closely watching developments there. Another company is researching technology to effectively recycle cobalt from spent battery packs and failed batteries, which could help U.S. supply to some extent.

The conclusion is that cobalt is increasingly important and valuable in today's economy, while the supply is less secure. It is a good time to be mining cobalt.

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Networking and Communications Important for Successful Events!

Christine F. Lilek, CPG-10195

National AIPG and WI Section hosted the May 11 – 13, 2017 Sand Mine Life Cycle Seminar, Nonmetallic Mining Permit Process Seminar and Industrial Sand Resources of SW Wisconsin Field Trip in Eau Claire, Wisconsin with the cooperation of AIPG Minnesota Section, WDNR, Wisconsin Geologic Natural History Survey (Survey), and the Wisconsin Industrial Sand Association.

The event gathered over 125 presenters, exhibitors, sponsors, professionals and students from many states across the nation and from Canada, and raised $14,500!

The event planning committee learned some crucial lessons with networking and communications. We'd like to share these with others. So, these helpful hints can help others create successful events in the future.

Sponsors Are Crucial

Two kinds of sponsors are always helpful:

In-Kind Sponsorship

(Non-monetary assistance like groups who can market and provide educational resources)

- Colleges
- Training Companies
- Environmental Organizations
- State Geological Survey
- Engineering Associations
- Land Use Planners
- Federal, State and County Regulators
- Economic Development Groups (State and Local)

Monetary Sponsors

(Groups who want the marketing visibility in exchange for a donation)

- Environmental Consultants
- Drilling and Sampling Equipment Companies
- Legal Firms who represent consultants
- Finance companies who finance the projects
- Mining Companies
- Real Estate Companies (specializing in brownfields sales)
- Computer companies selling GIS and drone programs

Get the Word Out!

Another thing that is important is to write up a short summary with some photos and get the word out through newsletters, webpages, social media, magazine articles, physical posting in building where employees and students would be interested in the event.

National will post on their event webpage and their Facebook and LinkedIn pages; you just have to send them your announcement.

We had good coverage for our May 12-13, 2017 event on our sponsor webpages and announcements from various industry news outlets.

For example:

https://www.aggman.com/industry-education-on-permits/

http://www.wspe.org/cpc.shtml

http://mail.rockproducts.com/frac-sand/16332-wisconsin-groups-to-hold-industry-seminars.html#.Wib5de-WxMw

http://newssan.com/2015-Feb-16/industrial-sand-mining.html

http://www.gza.com/news-events/conferences

https://allevents.in/eau%20claire/wgnhs-at-wi-aipg-frac-sand-conference/179209455898606

http://www.chennaicarpenters.in/grindingplant/11691/seminar-on-limestone-mining.html

On-line Registration Tools

Ask your on-line registration provider (if you have one), if there is a way for registrants to be listed on the registrations page and for the registrants to post "I'm going to this event" on LinkedIn, Facebook and Twitter. When people see that other people are going, then they are more likely to sign up for the event.

Make sure you have an email link for people to ask questions about your event on your registration page (or invite) and then be dedicated in answering the questions that come in within 24 hours.

Speaker Marketing

Whoever is a designated speaker or presenter for your event, get them to agree to send out event information to their contacts not one time, but at least twice! Sometimes the message gets lost. 50% of our registrants registered in the last week before the event, because they had to see the announcement at least twice before signing up.

Have Fun

Don't schedule things your organizing committee isn't interested in. Your enthusiasm for what you are planning will spill into all the contacts you make. Have fun with this or don't do it. Sounds severe, but it is true. Good luck and share with us your new networking and communication ideas for your future events!

Student Field Trip Experience

Jennifer James, SA-6132, Northern Illinois University

This article is reprinted from the Winter 2017/2018 Illinois/Indiana Section Newsletter.

The Lead Zinc Mining District of Southwestern Wisconsin and Northwestern Illinois was an economic driver in the mid to late 1800's. Prospectors operated hundreds of mines which dotted the landscape throughout the region. This summer I was fortunate enough to participate in the AIPG Illinois/Indiana Chapter's annual field trip, which took us to this region. Our group visited sites in Shullsburg, Platteville, and Mineral Point, Wisconsin, touring non-operating mine sites to better understand reclamation processes and the rich history of this district.

Our first stop took us to the Shullsburg Mine and Mill Reclamation Site. Once the site of an active and highly productive zinc mine, passersby would not recognize it as such today. This site has undergone an extensive reclamation process beginning in the late 1970's. Upon closure of the mine Inspiration Company, the owner, began the process of reclaiming and remediating the land. The site was restored to the pre-settlement habitat of a grassland. Reclamation processes included removal of some of the waste rock and buildings, grading and reseeding of the tailings pile, introduction of native species, and restoration of surface drainage patterns, among others. An unanticipated effect of the project was the return of native song birds to the site. Aerial imagery is taken every 5 years to document the progress of the reclamation. The site contains more mineable material, especially zinc, but due to the extensive permitting that would be required and the high cost, the mine remains closed.

Learning about the Reclamation Site

The second stop of the day was the Badger Lead Mine and Shullsburg Mining and Historical Museum. This mine produced an extensive amount of lead, which was mostly mined during the early to mid-1800s. Our group was able to go underground and tour a few of the mine tunnels to learn about the mining conditions during operation. Miners worked in near darkness with only candles for light, using hand tools and occasionally black powder to blast out larger areas. The mine exhibited examples of the hand tools and carts used by the workers, as well as the skull of one unfortunate dog. Visible in one section of a tunnel was a fault and the associated slickenfibers. Industry professionals who were on the tour explained the processes behind the hydrothermal fluorite deposits that were associated with the faults. The history museum contains examples of items and materials used every day by miners and the people who moved into the area.

Stop three was a visit to a nonworking lead and zinc mine located at the Platteville Mining Museum. The mine is much larger in size than the Badger Mine and allowed the group to move about more freely. Our group was led down an incline that opened up into the main chamber of the mine. Below ground we observed mining relics as well as every day tools and mining components. The site has also serves as an opportunity for field experience for students at the local university. On site was also a museum containing a work house, shaft, and equipment used to hoist and process the lead, zinc, and waste rock.

The day ended with our fourth stop in Mineral Point at a road cut along US Highway 151. The road cut was made through the Galena and Platteville Formations, which contain sphalerite, barite, calcite, and galena. Throughout the formation there is evidence of mineralization of the various constituent elements. Hand samples on site showed various stages of crystal formation of the different mineral types. Waste rock from the site as well as minerals present were used as fill for the overpass which spans the Highway.

I would like to thank Craig McCammack for his kind offer to attend the trip and submit this article. I would also like to thank all the industry professionals who I met throughout the day. They were only too happy to explain and discuss mining and mineralization. I felt most welcome on the trip and gained valuable insight and information about the mining history and processes in and around the area.

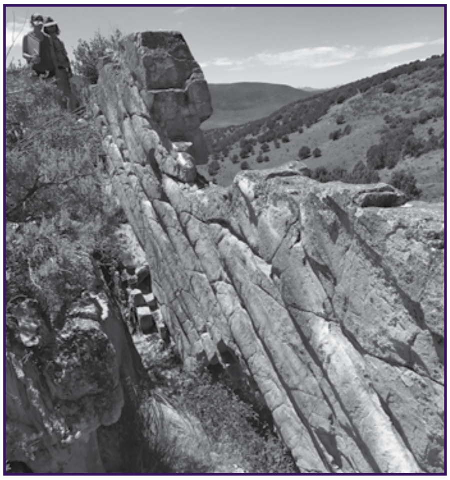
A tour of the Platteville Mine. Photo Credit: Rosann Park-Jones

A mineralized zone of the Platteville formation photo credit, James Adamson

On Going to Field Camp and Leaving Your Comfort Zone Behind

Anna Stanczyk, SA-6099

As a geosciences undergraduate, I was required to earn six field-based credits for graduation. My university offered a combination of Field Methods and Field Camp to achieve these credits and although more than one source advised me to go elsewhere for my field courses, it was tempting to take what was offered at "home". Not only would it be cheaper, but I would also be with my peers and my professors whom I had gotten to know over the years. I actually went so far as to enroll in Field Methods at my university. But then, on the last day to drop classes for the spring semester, a friend got into the Wasatch Uinta Field Camp (WUFC). She told me that the final costs would not be significantly higher than what we would pay at our home university and advised me to reach out to the director. I quickly did so and within a few hectic hours I applied, was accepted, and dropped my enrollment in Field Methods with only minutes to spare. Although I did not know it at the time, it proved to be the best academic decision I could have made.



Mega-ripple casts near Coalville, UT.

Before leaving for field camp I was exceedingly nervous. Not only would we be surrounded by over 60 other students whom we did not know, we would also be led by professors and TAs new to us. I envisioned field camp as a 6-week test of all the geologic knowledge we had gained during our undergraduate work to date. How would this work? What if those 60+ students knew more than me or had different classes? What if I failed? Eventually the day of departure arrived and with nothing but a backpack and duffel bag stuffed with field gear and textbooks, I headed to the airport. My stomach was in knots on the plane to Salt Lake City, but at least that my friend and I were in it together. And just like that, field camp began.

Evening views from our first campsite in the San Rafael Swell.

Within days, I realized that this was nothing like what I had feared. Field camp is not a six week test, it is a six week class. The professors and TAs at WUFC recognize that students come in with different backgrounds and they teach you everything you need to know. Throughout the six week course we focused on field mapping including bedrock, outcrop, float, and isograd mapping. We hiked six days a week while learning to write rock descriptions, construct cross sections, and measure stratigraphic sections. We visited the renowned Book Cliffs and the San Rafael Swell, camped in the middle-of-nowhere desert under the Milky Way, explored the open pit gold mines of Nevada, and celebrated an early Fourth of July in the Grand Tetons. Going elsewhere meant I made new friends and new professional connections with faculty. Field camp was not a cake walk, but it was one of the most rewarding experiences I have had to date, academic or otherwise. I loved (almost) every minute of it.

My advice? Go to field camp, even if it is not a requirement. It's akin to studying a foreign language and then finally visiting its country of origin. This is where it all comes together. Also, go somewhere outside your home university (unless, of course, your home university sends you to WUFC). There's no need to be nervous and there's no need to pack your own textbooks. Go with an open mind and an eagerness to learn. Ask questions. Volunteer answers. Be prepared to hike hard, work hard, make new friends, and have the time of your life.

Walking to our field site at Soldier Hollow, adjacent to the Deer Creek Reservoir.

Anna is a non-traditional student who succumbed to a familial love of earth sciences only after completing a degree in French Literature at University of Colorado Boulder. Anna recently completed her B.S. in Geology at the University of Alaska Anchorage and is continuing on to graduate school at the University of Utah where she will study an ancient landslide deposit in Zion National Park, under the guidance of Dr. Jeff Moore."

Students: Gazing Darkly into the Future—Career, Life, and Everything

David M. Abbott, Jr., CPG-04570

Douglas Adams in *The Hitchhiker's Guide to the Galaxy* asserts that the answer to the ultimate question about life, the universe, and everything is 42. He also notes that if you don't understand the question, you won't understand the answer. This article reverses that Geology 101 maxim, "the present is the key to the past," by believing that the past—the experiences of those who have been out of school for a couple of decades or more—have something to tell you about your future.

You have begun your geoscience career by majoring in the subject. Perhaps you've already acquired experience in the field through summer and/or part-time jobs. Regardless of the specialty you are pursuing, you can expect that the cyclic nature of the business will result in your having several employers. If the experiences of those who went before you provide any guidance, it suggests that in order to stay employed, you must be flexible enough to switch specialties, perhaps more than once. For example, moving from the petroleum business to hydrology or environmental geology can build on the realization that fluids moving through rocks behave in similar ways. The analysis of fractured crystalline rock aquifers has similarities to the movement of mineralizing solutions through similar rocks. Coal is not only a fuel itself; it contains another fuel, methane. The point being that basic geologic skills are needed regardless of your current or future specialty. Some of you may even have done some specialty switching in school because of job opportunities or research support.

Reflections on a Geologic Career, which is available for free at the AIPG website, www.aipg.org under "AIPG Publications," contains a variety of papers addressing the issue of finding and retaining professional positions. Download a copy and read it for a wealth of practical advice. The authors provide answers to questions they wished they had known when they were your age. Key points are expecting that change will occur, being flexible, and networking through active participation in professional societies. An advantage AIPG offers as a professional society is that its members are from all specialties and employers, so you become part of a broader network when it comes time to switch specialty.

But your professional career is only a part of your life—at least I hope so. Joining with a spouse is a common big step in life. Some of you have already taken this step or have specific plans for doing so. For others of you, this is still something in your future, but probably enough of your friends have coupled up so that marriage is less of a theoretical concept than it was in high school.

Being part of a couple has a distinct impact on your career. You no longer have the flexibility you had when you were single. Do you want to travel as much? Where can your partner find work in his or her chosen field? Teachers, family practice MDs, and nurses are examples of professions with greater job

mobility than many others. Investment bankers generally do not. If your job moves you to a different town, can your partner find suitable satisfying work as well?

Whose career opportunities will be pursued when? Some couples have had successful marriages despite the frequent or prolonged absence from home by one or both partners, but this seems to be the exception rather than the rule. Does one of you work for a firm providing family health coverage? One of the problems of hooking up with another geoscientist is that you both will be in similar job cycles. But marrying someone in another profession does not guarantee against both of you being simultaneously caught in downturns. I know this from personal experience.

Being part of a couple usually leads to two other life characteristics (features or bugs), a house and children. The mortgage must be paid every month. Children have lots of ever changing needs and wants, most of which cost money. Your job provides the income but its location affects your style of life. Relocations are disruptive to a greater or lesser degree. Some locals have greater job opportunities than others. The same is true of educational, cultural, and other characteristics. Some people pick a place to live and do whatever is required to live in that place. Others follow their career, relocating whenever relocation is required. While only you can provide answers to the issues discussed above, they are very real issues that you should carefully consider in planning your career. A planned career is far more likely to be successful and rewarding than an unplanned one.

While no one can see into the future, you can learn to spot trends and make necessary adjustments in what you are doing. You should have goals in mind. Although being open to serendipity is worthwhile as well. All your opinions and choices have consequences. Think about the consequences of your choices as you move through life.

Wisconsin Chapter supports Student Research Symposium for 5th Year

Christine F. Lilek, CPG-10195

Riveredge Nature Center, Newburg, Wisconsin celebrated its 5th Student Research Symposium on November 4, 2017 with support from WI – AIPG Section and members. More than 40 undergraduate and graduate students, from 8 WI colleges and universities (including UW-Stevens Point, UW-Madison, UW-Platteville, UW-Milwaukee, UW-Manitowoc, Northland College and Carroll University) presented oral and poster presentations to an audience of their peers, family and the general public.

Students visit AIPG Table during Symposium Breaks.
Photo credit: *Riveredge Nature Center*

WI AIPG helped sponsor a student scholarship in the Land and Water Research presentation session and provided 3 judges for the presentations. While geoscience students did not receive the top presentation awards they were well represented with the following presentations:

- **"Water Quality Research and Management of a Lake Michigan Watershed"** by Matt Reed, Nick Wiedemann, Abby Adams, Bethanie Ebben and Alec Seguin from UW-Manitowoc;
- **"Variation of Groundwater Divides During Wet Years vs. Dry Years in the Wolf River Basin, Northeast Wisconsin"** by Susan Borchardt from UW-Milwaukee;
- **"Comprehensive Assessment and Management Plan for Beaver Dam Lake, WI"** by Haley Briel, Yu Li, Ryan McGuire, and Catherine Schumak from UW-Madison, Nelson Institute of Environmental Studies; and
- **"Reconstructing Groundwater Variability in the Driftless Area using Juniperus virginiana"** by Jonathan Ley, April Barr, Tia Federman and Elissa Bahr from UW-Platteville.

The AIPG table with organizational and job opportunity handouts was well received by the students and professors; many exclaiming that they were glad to know AIPG existed and that it provided so many opportunities to geoscience students and professionals.

WI AIPG provides 3 judges for Symposium: Thomas Kettinger CPG #11737, Christine Lilek CPG #10195 and Trevor Nobile CPG # 11666.
Photo credit: *Riveredge Nature Center*

Geofremtidology: Studying a Planet's Future

Steven M. Battaglia, SA-5246

Steven M. Battaglia is a freelance researcher, student, and previous author for TPG with educational roots at the University of Illinois and Northern Illinois University.

One subject that has been on my mind is extrasolar planets, or exoplanets, which are planetary bodies that exist outside of our solar system. The scientific community has discovered, and continues to search and find, a plethora of exoplanets in our nearest neighborhood of stars within the Milky Way galaxy. Some of these exoplanets are thought to be potential candidates for habitability—liquid water on the surface due to its distance from its star, a possible thin atmosphere composed of oxygen and nitrogen, and/or active plate tectonics; all of which we observe on Earth and currently consider important for life to develop or be sustained on a terrestrial-like planetary body.

Exoplanets are, however, light-years away, indicating that any observation made from Earth is a scene of the past. The examination of an exoplanet 1000 light-years from Earth is viewed as an object 1000 years ago from the present. All the light we see in the night sky is from the past. Consider that we have the aeronautical technology to travel to distant planets in a very short period of time. When we arrive at our destination, would we observe what we expected to observe on that planet? Would we have a glimpse of a completely different and unexpected environment? Would the state of that exoplanet's geology have changed? The two main focus points to consider are (1) how far away is the planet and (2) how dynamic is the planet.

Geological changes of state are always occurring on the Earth. We forecast meteorological thunderstorms, hurricanes, and weather fronts from changes in the atmosphere's pressure and temperature. We are additionally collecting more and more data in the attempt to improve our ability to forecast impending volcanic eruptions, earthquakes, and even impactor events, in order to minimize the risk of societal catastrophe. It can thus be assumed that geological changes would be continuously occurring on any active, and potentially, habitable exoplanet even though its chemical make up and surface environment may differ from that of Earth. The knowledge that is gained about any natural phenomenon on Earth is analytical information that can likely be applied to other planetary bodies.

Therefore, the current geoscience community, consciously or not, is striving not just to understand the geological past, but also to predict the geological and environmental future of Earth in an abundance of detail and create a more prosperous outlook for society. Approaches similar to those used on Earth can be utilized to anticipate the future of any planet, and I would like to propose that such efforts to predict the geological future be considered a separate sub-discipline of geoscience. I propose for the community's consideration the name Geofremtidology, derived from geology, the study of Earth processes, and fremtid, meaning future in Danish, for this new branch of geoscience.

Geofremtidology is currently happening and will continue to be expanded upon by coming generations of geologists, atmospheric scientists, and other earth scientists. Our ability to make predictions of probable or imminent geological events on Earth and, in the future, exoplanets is crucial to continue the advancement of our society. Relatively small shifts of state, such as a thunderstorm, may not make any lasting immediate impressions on a planet, but large-scale shifts of state, such as volcanic eruptions or climate changes, can have long term effects on a planet. It is thus imperative to continue conducting theoretical and experimental studies on planetary-scale occurrences that could affect both Earth and, potentially habitable, exoplanets.

All perspectives from insights gained on Earth should be considered to attain skill in predicting what our society's forthcoming generations can expect. This includes how life could evolve in a habitable planet and the plausible modifications to such an extraterrestrial civilization in the time it would take from observation of a planet to the time we actually, if conceivable, arrive at such a human-like haven. Let's say a hypothetical spacecraft that travels to an exoplanet 1000 light-years away at a speed of say, one-fifth the speed of light, would arrive at the planet in 6000 years after its state was observed from the time of departure on Earth. The interstellar travelers might find a carbon dioxide ridden atmosphere from climate change, or a large number of impact craters littering the surface, or deforestation and soil erosion, or an explosion of possible inhabitants. These are possibilities we can anticipate because we know from

Continued on page 38

The Path to Becoming a Geologist

Aaron W. Johnson, MEM-2783
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I went to college directly from high school, and I was a spectacularly awful college student. I think I was awful because school had always been easy, and I never had to develop the skills necessary to assimilate and understand complex information. I also struggled because I lacked self-discipline, often skipping class to play cards or video games, or sleep in. In addition, I had no idea what I really wanted to do. I majored in music, then changed my major to engineering, then to chemistry, and then to chemistry education. Following the last change I transferred universities, changed my major to sociology, and promptly flunked out of school. At the time I was suspended, my cumulative grade point average was 1.04 on a 4-point scale. I was so bad that a marginally funded state university did not want to take my money. Spectacularly awful might well be an understatement.

I went to work in factories and spent several years on assembly lines, mostly making windows and doors. I soon realized that I'd squandered a fantastic opportunity, and I began to plan to return to the university. About five years after I flunked out, I began the process to get reinstated and to return to school. Because I had been suspended, I had meetings with seemingly everyone on campus: Financial Aid, Health and Wellness, the Dean of Students, and finally with the Dean of the College of Arts and Sciences, Dr. William Cheek. The forecast for the morning of my meeting with Dr. Cheek was for a howling February snowstorm, so I called my brother and asked if I could ride the 30 miles to campus with him. As we arrived on campus, he encouraged me to come and sit in on his 8:00 am class (my meeting was at 9:15) because he thought I would really like the professor.

I sat down and the professor, a retired Marine named Tom Moeglin, walked in and began to talk about volcanoes. I was mesmerized. For the next hour, I was transfixed both by Dr. Moeglin, who was a fantastic lecturer, and the subject matter. I had never realized that you could major in Earth Science. In Missouri, as in most states, Earth Science was a half-year sometime in junior high school, never to be studied again. But Tom (he lets me call him that now) opened my eyes to geology. I went down to the front of the lecture hall afterward, introduced myself, and told him that if Dr. Cheek gave the ok for me to return to school, I wanted to major in Earth Science Education, and I wanted him (Tom) to be my academic advisor. Dr. Cheek gave me the green light, and I went from his office to visit Tom. I left that day with a planned fall schedule in my hand. The following semester, I changed my major to Geology (a total of 7 majors for those who are counting) and added minors in mathematics and chemistry. I went from being a terrible student, to graduating with honors, mostly because I'd finally found something I loved and I had grown up a bit.

When I talk to other geologists and geology students, I hear stories that are similar in many respects to my own. The student who was majoring in graphic design, took a geology class during her senior year as a general education requirement, and changed majors when she was less than 30 hours from graduation. The student who planned to major in wildlife management and during an introductory geology course realized that the geology dictates the soils and habitat, and THAT was what he really wanted to understand. The football player who took "rocks for jocks" thinking it would be an easy A and was so intrigued by what he learned that he took another geology class, and another, and another. Many of us can point to a particularly dynamic instructor that helped to kindle our interest in studying the Earth. Some of us have had that influence on others, and many of the students who are studying at universities today will have that same influence on students tomorrow.

This issue of TPG focuses on students, highlighting student achievement and accomplishment, and recognizes student chapters of AIPG. I hope that as you read this issue, you will reflect on your path to becoming a geologist. I also encourage you to share your journey with others.

Best Regards,

Aaron W. Johnson

Welcome New Student Chapters!

Youngstown State University

New Mexico Tech - Robert Lessard Memorial Chapter

It's about Time AIPG!

R. Douglas Bartlett, CPG-08433
dbartlett@clearcreekassociates.com

Just as astronomers have a unique relationship with distance; geologists have a unique relationship with time. As an example, I was recently standing at the base of a steep walled outcrop of reddish silt and clay of lacustrine origin. After scraping off the oxidation and weathering, I could easily see the fine details of the strata in the formation. Thin beds ranging from 2 to 5 mm defined the unit and suggested a seasonal depositional pattern such that each band represented a single year's worth of accumulation (varves). Looking up, I could see about 200 feet of this material and, from drilling information, I knew there was at least 2,000 feet of the same material below me suggesting a depositional time period exceeding 300,000 years. Not long after, I stood at the base of another cliff, this time one of tan volcanic rock. Above me was an impressive cliff about 1500 ft high. It was startling to realize that this entire depth of rock was deposited in just one day, maybe several at the most because this was a dacitic ash flow that had originated during a single, 40-cubic mile ash eruption from the Superstition Mountains caldera complex 15 miles to the west of this outcrop. This would have been a very bad place to be standing 18.2 million years ago! What a contrast in the timing of deposition between these two outcrops. It is a great example of what excites and thrills me to this day about geology!

My accumulation of geologic knowledge is akin to the silt and clay outcrop – slow and over a long period of time! My love of geology brought me to AIPG 25 years ago in an effort to further my understanding of geology through interactions with other professional geologists and thereby increase my learning "sedimentation rate". I have had a very rewarding experience with AIPG and am looking forward to increasing my involvement this year as AIPG's President. We have much work to do and I would like to take just a few minutes of your valuable time to describe what I see as our near term goals for this year.

Last year, Past President Heft conducted an excellent survey of AIPG membership in an effort to understand how AIPG members feel about the organization and how to keep the organization relevant into the future. One key finding was that a significant number of AIPG members either originally joined AIPG to obtain the CPG or find the CPG to be highly relevant and important to them. For some of us, the CPG is a key element to legally practicing geology in our state. Over time, however, the relevance of being a CPG has diminished as individual states have passed legislation that requires state licensure. Now, state licensure is under attack as I indicated in an article published in the 2016 Oct/Nov/Dec issue of TPG. Some state legislatures feel that professional licensure limits individuals from professional practice (government should not be in the business of deciding who should practice a profession) and licensure increases the costs of hiring professionals. In contrast, many of us feel licensure is necessary to maintaining the credibility of the profession. The question for AIPG is "what can or should be done to support the professional practice of geology?"

Should AIPG take on the burden of policing our profession through the development of a membership category that would meet or exceed the regulatory requirements for state licensure in all states? This is a question that has been debated often in AIPG's history. I firmly believe that now is the time to thoroughly debate and consider this important question. There are many of you that have valid concerns regarding whether AIPG has the legal standing to manage professional licensure, whether AIPG has the resources to enforce licensure rules, and even whether this should be AIPG's mission at all. Vigorous debate within AIPG is the only way to resolve these questions. I implore every member of AIPG to lend your voice to this debate so that the Executive Committee can make decisions regarding licensure that truly reflect the balance of opinion within AIPG. Whether you hate the idea, love the idea, or are unsure, please let us know. We must represent all of you but cannot if you do not let us know your opinions on important questions such as professional licensure.

In the past 15 years, AIPG has made a concerted and successful effort to reach out to students. There are now 32 student chapters and over 3,000 student members. As has so often been mentioned, students are the future of not just AIPG, but the profession of geology. During my 40 year career, I have seen many changes and the course of my own career has had numerous twists and turns mostly due to the changing marketplace for professional geologists. Whenever I talk to student groups, I tell them to enjoy their educational experience so that they fall in love with geology as a career and thereby stick with it. However, I also tell them, do not be surprised that what you focused on in school is not what you find yourself doing 20 years after graduation. We are in dynamic times; the challenges we face as a society are real, numerous, and ever-changing. AIPG has a wealth of highly experienced older geologists that can and should guide students through the early part of their careers. What I ask is that our older members get involved in mentoring students and young professionals. Volunteer to meet with student chapters, organize field trips, participate in student career days, etc. That is how AIPG can continue to be relevant to students and how we can move students from being student members to being young professionals, and finally to full membership as either members or CPGs.

I sincerely appreciate the opportunity to serve as AIPG's President. Our executive board is filled with enthusiastic and accomplished geologists from across the country. I look forward to working with Adam Heft (MI) as Past President, Keri Nutter (AK) as President-Elect, Jeff Frederick (Northeast Section) as Vice President, Ann Murray (FL) as Secretary, Jim Burnell (CO) as treasurer, and John Berry (TX) as TPG editor. Our Advisory Board includes Christine Lilek (WI), Mehmet Pehlivan (CA), John Stewart, (Carolinas Section), and Nancy Wolverson (NV). This year we have also added a Young Professional to the Executive Committee – Brandy Barnes (FL). I am equally looking forward to working with AIPG's excellent headquarters staff including Executive Director Aaron Johnson, Assistant Director Wendy Davidson, Professional Services Manager Cathy Duran, and the rest of the headquarters staff including Cristie Valero, Dorothy Combs, Mona Scott, Lindsay Mota, and AASG Administrative Assistant Rania Eldam Pommer. A fantastic team of hard working and dedicated individuals!

We have no time to waste AIPG! Get involved, meet new friends, have some fun, lend yourself to AIPG's vision and you will be rewarded with a fulfilling and productive career in geology! Together, let's enjoy 2018!!

intraw
International Raw Materials Observatory

PRESS RELEASE | BRUSSELS | 7 NOVEMBER 2017:

The INTRAW project consortium announces the official launch of the International Raw Materials Observatory, a new not-for-profit organization created to support international cooperation in the field of mineral raw materials.

The International Raw Materials Observatory is a new not-for-profit international association, created to enhance worldwide cooperation on mineral raw materials' research and innovation, education and outreach, industry and trade and recycling, management and substitution of strategic raw materials. The Observatory is one of the major outcomes of the Horizon 2020 funded project INTRAW* (2015-2018). Since its start in 2015, the project has mapped best practices on mineral raw materials policies in five reference countries (Australia, Canada, Japan, South Africa and the USA), and advanced a roadmap to foster the EU response to global challenges on mineral raw materials supply.

The Observatory has now officially been launched during the EU-Advanced Mining Countries conference, on 7 November 2017, organized in the framework of the European Commission's Raw Materials Week (6-10 November 2017). INTRAW coordinator Vitor Correia provided the audience with an overview of the services the Observatory will be offering to its members and the marketplace, namely foresight dialogues with key influencers and match-making services for organizations active along the minerals materials value chain. The Observatory will "foster dialogues among stakeholders and policy makers, in the intersection between political actors and society. […] We believe that policy makers need foresight analysis to plan ahead," said Vitor Correia. During a match-making session organized at the end of the conference, the participants had the opportunity to test one of the other services the Observatory will provide.

Mineral raw materials are hence the focus area of the International Raw Materials Observatory and diplomacy, dialogues, independent expert analysis and foresight will be the main tools used to advance international cooperation, informed policy making and better governance of mineral raw materials. The values of the International Raw Materials Observatory are built around the concept of honest broker since it will act as an impartial international mediator specialised in the minerals value chain to support international cooperation and exchange of best practice.

For more information on the Observatory also view the following short video: https://youtu.be/NGXVqTBnfEA

**INTRAW is funded under the European Commission's Horizon 2020 EU Research and Innovation Programme, for a period of 36 months (February 2015 – January 2018). Under the coordination of the European Federation of Geologists (EFG), INTRAW brings together an international consortium of 15 partners with extensive experience in research, innovation, education, industry, trade and international networking across the entire raw materials value chain. INTRAW also counts on the support of 24 third parties and more than 40 experts from across Europe, Australia, Canada, Chile, Japan, South Africa and the United States.*

Contact:

Coordinator – European Federation of Geologists (EFG) - Vítor Correia, President, efg.president@eurogeologists.eu, Isabel Fernández Fuentes, Executive Director, isabel.fernandez@eurogeologists.eu

Letters to the Editor

TPG Editor,

There were several points in Perry Rahn's letter proposing changes to the 1872 mining law which caught my eye.

First, the statement that 'All that is needed to make a claim is to fill out some paperwork and send the BLM an annual payment of approximately one hundred dollars" is false. But the actual cost is much more than the amount to be paid to the BLM and county on locating, there also is the amount of time and money spent getting interested in an area, which often includes multiple trips to check out and better define the specific target area, as well as assay costs and the cost of putting purchased posts in the ground. My experience is that the latter costs amount to significantly more time and money than simply locating.

I certainly hope the statement that "Today's prospectors have almost no probability of discovering a new economic mineral resource" would be news to the Australian and Canadian geologists who have reviewed and appreciated my various claims. More than myself, I can think of a continuous string of prospectors beginning with Dick and Ann Singer at Mesquite (California), who have certainly played their part and benefited financially from discoveries.

He concludes that "The 1872 mining law should be modified so that an evaluation of the mineral resource is required before a mineral claim can be established." My personal experience with real life exploration discoveries as different as the Cognac, N.C., glass sand deposit, Mesquite, CA, and Chimney Creek (now Twin Creeks), NV, gold and the Paguanta, Chile Zn-Pb-Ag deposits, is that initially any resource estimate can only be classified as a WAG (Wild Ass Guess), and thus could not be used establish a claim under his scheme. Thus my personal experience suggests that the supply of new leads and prospects could very quickly dry up. Finally, he feels that a review by a qualified engineer or geologist to estimate the size and concentration should be a requirement for staking a claim. I was amused that, when Donald Trump was asked during the campaign why, if he was such a good businessman, did he turn down what ultimately turned out to be a very profitable oil play. He answered that he could see and evaluate a building sticking out of the ground, but he could not see oil in the ground. I have encountered several geologists with all the right credentials who could not see what they could not see, and thus walked away from prospects that turned out to be bonanzas. I think that we as geologists have done a pretty good job, as Qualified Persons, and with our technical reports, of changing the conversations of Canadian juniors, but calling on us to quantify in detail what we cannot see and have not drilled out is too much.

Actually, thinking about how to answer Rahn's letter has given me a much deeper appreciation of the real world wisdom that went into that mining law.

William Feyerabend, CPG-11047

Mining Claims and the AIPG: a Response

Over the past several decades numerous talks and published papers have addressed the notable fact that discovery rates for economic mineral deposits have decreased as mineral exploitation rates have continued to increase. Virtually all of these sources note that the many decades of intensive mineral exploration by increasingly sophisticated teams and methods has considerably diminished the probability of discovering high-value outcropping deposits, especially in well-explored places like the western United States. These sources further state that the absence of obvious surface indications of mineralization in no way obviates the discovery potential of such areas somewhere at depth. Thus, mineral exploration has, for many decades, relied on increasingly sophisticated models of ore systems and geological terrains, and the use of geophysical and geochemical methods to detect buried mineral deposits. The application of these evolving models and methods in areas of non-outcropping has met with considerable success, from the 1950's discovery of the Viburnum trend in Missouri to the Pima-Mission porphyry copper deposit of Arizona, to the Kidd Creek VMS deposit in Ontario, Canada, to the Central Tennessee Zinc district and many, many others. In such modern exploration efforts, it is common for the discovery process from planning through geological mapping, geochemical sampling, geophysical testing, and drilling to go on for years or even decades in a given area before a discovery is made. Given the geological-technical reality and the costs of the modern mineral exploration process one must secure title to a mineral discovery before a discovery is made or rick the likelihood of spending tens of millions of dollars only to have a competitor or competitors swoop in and grab the land. Without the assurance that the company will own the deposit it will not invest the time and funds necessary for success. Mr. Rahn's letter calling for the granting of a claim only after a mineral deposit is verified to have been made signals that he is thoroughly ignorant of the entire process and financial structure of modern mineral exploration.

John Dreier, CPG-11190

Answers on Page 32

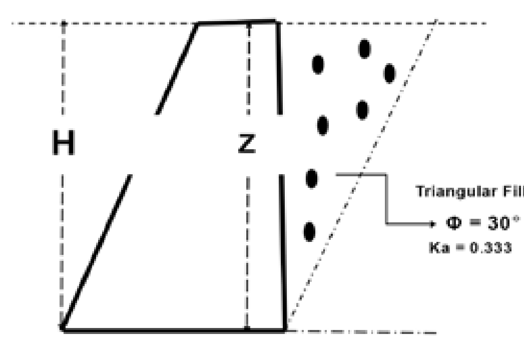
Robert G. Font, CPG-03953
rgfont@cs.com

1. 1. Which of the following is not featured or does not belong in the same depositional environment as the other choices given here?
   a) Till.
   b) Kame.
   c) Tombolo.
   d) Esker.
   e) What? What language is this? Hey man, just say it English!

2. Of the following choices, which defines a specimen which is not a silicate mineral?
   a) Analcime.
   b) Goethite.
   c) Sanidine.
   d) Nepheline.
   e) Dude, I don't dig mineralogy! Fossils rule!.

3. In our engineering geology studies, consider a gravity retaining wall of height of height (H) = 6.3 meters and assume the following:
   - The "active Rankine Zone" is confined to the triangular backfill and the surface of the soil is horizontal and level with the top of the wall.
   - Geostatic conditions hold and the soil's unit weight (γ) remains constant with depth, where γ = 17.3 kNm^{-3}.
   - There is no friction between the back of the retaining wall and the fill material; the angle of internal friction (Φ) of the triangular fill is 30° and the active stress coefficient (Ka) is 0.333.

   Then, for the "active Rankine condition" find the total horizontal active thrust (Pah) on the wall:
   a) Pah = 151.92 kN per meter of wall.
   b) Pah = 114.32 kN per meter of wall.
   c) Pah = 73.57 kN per meter of wall.
   d) Man, I are a gigliligist, not an injunier!



4. In our studies of rock mechanics and the theory of elasticity, the ratio of stress over volumetric strain defines:
   a) The bulk modulus.
   b) The shear modulus.
   c) The Young's modulus .
   d) Poisson's ratio.
   e) I don't study elasticity. Crush everything, I say!

5. Which President of our country started the U.S Public Land Survey? (Question by David M. Abbott, CPG-04570).
   a) George Washington
   b) John Adams.
   c) Thomas Jefferson
   d) Abraham Lincoln.

Inside this Issue

John L. Berry, CPG-04032

The annual student issue of TPG lies in your hands, and this year the student members of AIPG have really come through with technical articles, opinion pieces, and just plain old bright ideas.

The students' technical submissions range across the entire United States. They include an investigation of the effects of the release of nutrient-rich floodwater from Lake Okeechobee on off-shore benthic communities; a comparison of geophysical techniques for mapping karst in Missouri; a very interesting study of a proposed thrust fault along the western edge of the Great Smoky Mountains, and finally a study of magma mixing at Lassen Peak in California. Two of these articles are from prize winners at the student poster competition at our annual meeting in Nashville. They are all impressive examples of the high quality of work that students can do when their enthusiasm is aroused and their faculty are fully involved. Finally, there is an article describing the rare metal content of a suite of highly differentiated granites in what we used to call the Pan-African terrain of Egypt's Eastern Desert – the preferred term nowadays seems to be Neoproterozoc terrain. The term "rare metals" covers REEs, tin, tungsten, titanium and a range of other elements that are also called "Strategic Minerals" by countries which don't have enough of them – i.e. they are vital for a modern industrial society because of their uses in electronics, military hardware and power generation.

The Student Voice articles are similarly varied: one proposes a name for the sub-discipline of geoscience that tries to predict the future courses of geological events on extra-terrestrial planets – now THAT is thinking ahead for you! A second extols the technical and professional value of attending a field camp other than the one put on by one's own institution, and the third points out the importance of conservation, and the need for community buy-in to conservation efforts before they begin.

Now that the students have come through so magnificently for their issue of the TPG, may I renew my appeal for articles from members. The most urgent need is for good technical articles which will be peer reviewed, but we also need articles that pass on business wisdom, that recount adventures ("Tales from the Field") or fill us in on the history of our profession. We get a steady stream of submissions from overseas, some of which are extremely interesting, but we'd rather hear from our own members.

I have a question for all of you out there: in the AIPG eNews, would you rather see only full articles, or do you also want to see articles that are only extended abstracts of articles for which you must pay to download? The compiler of the eNews has an unenviable job in trying to find a good selection of relevant articles each week, because many reports that are free to access come from sources that are not technically reliable, such as local newspapers, general readership magazines and press releases, generally because they are written by journalists who are not scientists. Other free articles come from universities (mainly in China) that pay Elsevier or whoever (Science Direct is an example) to put their publications on-line, which then gives rise to a skew away from North America in the topics covered. On the other hand most peer-refereed articles come from publishers (Elsevier, Springer, GSA, AAPG, etc). who demand rather excessive amounts to download the whole article. So, from our (AIPG members') point of view, is it more important to be able to read the whole article for free, or is it more important to be aware of an interesting development, even though we have to fork out filthy lucre to get the details? We have been having discussions about this, but the only really valuable input is that from our members. Please vote by filling my ears with a loud din of opinion!

AIPG Offers Mentor Program

Are you an AIPG Student or an AIPG Young Professional searching for a mentor?

or

Are you an AIPG member looking for a Student or Young Professional to mentor?

Be sure to update your information and check the membership directory at aipg.org

In Memory

William D. Rose, CPG-00783
Member Since 1965
Passed on December 23, 2017
Brookeville, Maryland

Answers:

1. The answer is choice "c" or "tombolo."

   A tombolo is a landform related to coastline depositional environments by which an island is attached to the mainland via a narrow piece of land such as a sand bar or spit.

   The other choices are related to glacial depositional environments. Till is unsorted or non-stratified glacial drift. A kame is a hill or mound of glacial till that accumulates in a depression on a retreating glacier; then being deposited on the land surface with further melting of the glacier. An esker is a long and winding ridge of clastic glacial sediment that forms within ice-walled tunnels by streams that flow underneath and within glaciers.

2. The answer is choice "b" or "goethite."

   Goethite ($HFeO_2$) is hydrogen iron oxide. It forms as a precipitate in bogs and springs or as the weathering product of iron-bearing minerals under oxidizing conditions.

   Sanidine is a high-temperature variety of the silicate orthoclase ($KAlSi_3O_8$). It is found associated with some felsic, volcanic igneous rocks (e.g., rhyolite, trachyte).

   Analcime [$Na(AlSi_2O_6)H_2O$] is a hydrous silicate of the zeolite family.

   Nepheline $(Na,K)(AlSiO_4)$ is a silicate in the feldspathoid group.

3. The answer is choice "b" or [Pah = 114.32 kN per meter of wall]. The proof follows:

   To calculate the horizontal stress at the base of the wall:

   Ka = (Ph) / (Pv) (1)

   Ph = (Ka) * (Pv) (2)

   Pv = (γ) * (z) (3)

   Note that Pv is the vertical stress. Substituting (3) into (2):

   Ph = (Ka) * (γ) * (z) (4)

   Inputting the numerical values given in our problem into (4), we obtain:

   Ph = (0.333) * (17.3 kNm^{-3}) * (6.3 m)

   Ph = 36.29 kNm^{-2} (5)

   Equation (5) shows the horizontal stress value at the base of the wall. Calculating now the total horizontal active thrust on the wall, from equation (4) and integrating from zero to H:

   Pah = (Ka) * (γ) ∫ z dz (6)

   Pah = (1/2) * (Ka) * (γ) * (H^2) (7)

   Inputting the numerical values in our problem into equation (7), we obtain:

   Pah = (0.5) * (0.333) * (17.3 kNm^{-3}) * $(6.3\ m)^2$

   Pah = 114.32 kN per meter of wall (8)

   Equation (8) is the answer to our problem. Please note that for the wall to be stable, (Pah) must be less than the resistance offered by the passive zone, the shear force at the base of the wall and the weight of the wall. The resistance must exceed the active thrust by a suitable factor of safety. Capisci?

4. The answer is choice "a" or "the bulk modulus." The bulk modulus (K) is the inverse of the compressibility and is defined as the ratio of stress (force per unit area) over volumetric strain (change in volume over the original volume):

   $K = (F/A) / (\Delta V/V)$

   The Young's modulus (E) is the ratio of stress (force per unit area) over linear strain (change in length over the original length):

   $E = (F/A) / (\Delta L/L)$

   The shear modulus (G) is the ratio of stress (force per unit area) to shear strain (transverse displacement over the original length).

   $G = (F/A) / (\Delta X/L)$

   Poisson's ratio (V) is the negative ratio of transverse to axial strain. It is a measure of geometric change of shape or the change in diameter over the original diameter divided by the change in length over the original length.

   $V = - [(\Delta D/D) / (\Delta L/L)]$

5. Answer by David M. Abbott, CPG-04570:

   The answer is choice "c" or "Thomas Jefferson."

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

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

The "Geoethical Promise"

The International Association for Promoting Geoethics (IAPG) approved the "Geoethical Promise" on 26 October 2016 as part of the results of the 35th International Geological Congress in Cape Town.[1] The IAPG defined **geoethics** as, "Geoethics consists of research and reflection on the values which underpin appropriate behaviors and practices, wherever human activities interact with the Earth system. Geoethics deals with the ethical, social and cultural implications of geosciences knowledge, education, research, practice and communication, and with the social role and responsibility of geoscientists in conducting their activities." The "Geoethical Promise" is intended to be like the medical profession's Hippocratic and should be adopted by early-career geoscientists to promote respect for geoethics values in geoscience research and practice; it states:

I promise…

… I will practice geosciences being fully aware of the societal implications, and I will do my best for the protection of the Earth system for the benefit of humankind.

… I understand my responsibilities towards society, future generations and the Earth for sustainable development.

… I will put the interest of society foremost in my work.

… I will never misuse my geoscience knowledge, resisting constraint or coercion.

… I will always be ready to provide my professional assistance when needed, and will be impartial in making my expertise available to decision makers.

… I will continue lifelong development of my geoscientific knowledge.

… I will always maintain intellectual honesty in my work, being aware of the limits of my competencies and skills.

… I will act to foster progress in the geosciences, the sharing of geoscientific knowledge, and the dissemination of the geoethical approach.

… I will always be fully respectful of Earth processes in my work as a geoscientist.

I promise!

The "Geoethical Promise" summarizes the "Fundamental Values of Geoethics" that the IAPG lists as:

- Honesty, integrity, transparency, and reliability of the geoscientist, including strict adherence to scientific methods;
- Competence, including regular training and life-long learning;
- Sharing knowledge at all levels as a valuable activity, which implies communicating science and results, while taking into account intrinsic limitations such as probabilities and uncertainties;
- Verifying the sources of information and data, and applying objective, unbiased peer-review processes to technical and scientific publications;
- Working with a spirit of cooperation and reciprocity, which involves understanding and respect for different ideas and hypotheses;
- Respecting natural processes and phenomena, where possible, when planning and implementing interventions in the environment;
- Protecting geodiversity as an essential aspect of the development of life and biodiversity, cultural and social diversity, and the sustainable development of communities;
- Enhancing geoheritage, which brings together scientific and cultural factors that have intrinsic social and economic value, to strengthen the sense of belonging of people for their environment;
- Ensuring sustainability of economic and social activities in order to assure future generations' supply of energy and other natural resources;
- Promoting geo-education and outreach for all, to further sustainable economic development, geohazard prevention and mitigation, environmental protection, and increased societal resilience and well-being.

While both the "Geoethical Promise" and the "Fundamental Values of Geoethics" are aspirational statements, that is, statements of goals geoscientists should strive to fulfill throughout their careers, the list of Fundamental Values strikes me as more specific than the "Geoethical Promise" even though the statement of Fundamental Values is only slightly longer (191 words) than the Promise (166 words).

Just how these aspirational statements apply to day-to-day geoscientific practice varies with the statement. Adherence to basic concepts like honesty, integrity, competence, transparency, strict adherence to scientific methods, and life-long learning have been part of geoscience ethics codes for a long time. The aspiration to ensure the sustain-

1. http://www.geoethics.org/ctsg, accessed 11/17/17.

ability of the supply of energy and other natural resources for future generations conflicts with the fact that the supplies of energy and other natural resources are depletable, that individual deposits have a limited extent. This conundrum appears in the various papers I've read that address resource extraction in the spirit of the geoethical values.

Kholoud Mohamed Ali's article, "Loss of geodiversity in the Bahariya and Farafra oases protected areas, Western Desert, Arab Republic of Egypt," in the Oct/Nov/Dec '17 *TPG* is an excellent example the problems associated with protecting geodiversity contained in the "Fundamental Values of Geoethics." Ali provides an excellent description of the unique character of these oases and the ways in which tourists are destroying them. Everyone should read this article.

I've previously commented on such destruction of outcrops although not in terms of geodiversity. But the concept is the same. See "Keep student hammering from destroying outcrops" in column 127, May 2010, and "Ban indiscriminate hammering and other outcrop destruction" in column 155, August 2015. We may not think of the roadside outcrop as a geoheritage or geodiversity site, but we should. That is why these outcrops are so popular. We need to respect and protect them.

Equal Pay for Equal Work

I initiated this topic in column 163 (Jul/Aug/Sep '17). **Guy Swenson** (CPG-07574) wrote that this topic "appears to try to show the complexities of the 'Equal Pay for Equal Work' issue, but instead highlights a fundamental lack of understanding of why 'Equal Pay for Equal Work' is a real issue in the work place. 'Equal Pay for Equal Work' is fundamentally about accepting and encouraging diversity by treating employees equally. This is not an issue of whether environmental geologists are worth more or less than petroleum geologists or whether a part time employee is equal to a full-time employee. This is about whether employers treat employees equally without regards to gender, race, national origin, or personal values. Equal treatment includes equal pay for the same work, but also equal opportunity for project assignment, advancement, and respect. Until employers can honestly claim that they treat employees equally in these areas, discussions about issues raised by Mr. Abbott are not relevant to those who are exposed to unequal pay, opportunity, advancement, and respect in their jobs. Those of us who because of gender, race, national origin, or personal values do not suffer discrimination should work to make sure their geologic colleagues all receive the same treatment we enjoy."

I concur with Mr. Swenson's comments as they apply to individual employers. However, when the topic appears in the news, the observation, "On a percentage basis, the average woman earns only 79% of what a man earns"[2] is frequently made. This statistic is not employer based; it compares all employed women with all employed men. This statistic hides a wide range of complexities including such things as job type, the female-to-male ratio in that job type, educational level, experience, etc. My initial discussion focused on these issues that also should be part of the discussion of equal pay.

The AGI's "Representation of Women in the Geoscience Workforce" appeared on the inside cover page of the Oct/Nov/Dec '17 *TPG* and contained graphs of male and female percentages by age groups and by employers, again with some age breakout. The data is from 2013. The percentage of women geoscientists was barely over 11% for the 60+-year age group. The percentage of women steadily increases with younger age decade cohorts. Among the 23- to 30-year old cohort, 49% were women. However, the percentages of men and women varied considerably by employer, even for the 23- to 30-year olds. At private for-profit firms 60% of the young employees were men while at private non-profit firms almost 60% of the young employees were women. Take a look at the graphs. Given wage disparities between employers that I discussed in column 163, I would expect that within the whole 23- to 30-year old cohort women make less than the men. I expect that the only way that the average woman will make as much as the average man is if some overseeing body arbitrarily sets wages for everyone regardless of type of employer, a Big Brother approach I view as an anathema.

Ethics for Working with Living Research Subjects

One of the major distinctions between geoscience ethics and the professional ethics of groups that work with living research subjects (medicine, psychology, biology, etc.) is that so far geoscience ethics have not included ethical provisions for working with the living. Even the "Geoethical Promise" and "Fundamental Values of Geoethics," discussed above, do not contain any substantive ethical provisions for working with the living. Therefore the "People and water: exploring the social-ecological condition of watersheds of the United States" item in the November 14, 2017 issue of the *AIPG eNews* caught my eye. This item linked to an article in *Elementa: science of the Anthropocene* https://www.elementascience.org/articles/10.1525/elementa.189/. The first two sentences of the abstract state, "A recent paradigm shift from purely biophysical towards social-ecological assessment of watersheds has been proposed to understand, monitor, and manipulate the myriad interactions between human well-being and the ecosystem services that watersheds provide. However, large-scale, quantitative studies in this endeavour remain limited." This is an example of the sort of study that some geoscientists may be becoming engaged in and for which the ethics of working with living subjects may well appropriate. Those geoscientists engaged in such studies should look to the ethical provisions of those professions that regularly deal with living research subjects. There may be a time in the future when enough geoscientists are working with living subjects that appropriate provisions may be added to geoscience ethics codes. For the moment, incorporation of such ethical principles by reference will be the recommended approach. This recommendation is like the similar incorporation by reference for the ethics of publication of scientific research discussed in the topic, "Submitting a paper to two or more publishers at the same time" in column 164 in the Oct/Nov/Dec 2017 *TPG*.

Gathering assault on professional licensure

Gerry Donohue's article, "Gathering assault on professional licensure," in the Oct/Nov/Dec '17 TPG is the latest article in a series on the topic; see "De-licensure of geologists coming soon?" by Doug Bartlett in the Oct/Nov/Dec '17 TPG, Letters to the Editor on this topic in the Jan/Feb/Mar '17 TPG, and in column 163 in the Jul/Aug/Sep '17 TPG. Donohue's

2. https://www.forbes.com/sites/clareoconnor/2016/04/12/equal-pay-for-equal-work-the-gender-wage-gap-by-the-numbers/#22b384351454. Accessed 11/4/17.

article is the most detailed discussion of the topic. When de-licensure is proposed in your state, your AIPG Section should take appropriate actions. Doug Bartlett (Arizona) and Helen Hickman (Florida) are also resources based on their experiences in their states. National AIPG's effort regarding de-licensure is the new Nationally Licensed Geologist program, see "AIPG introduces new member category 'Nationally Licensed Geologist'," by Doug Bartlett and Adam Heft in the Jul/Aug/Sep '17 TPG and Adam Heft's President's Message in the Oct/Nov/Dec '17 TPG. Efforts to de-license or otherwise change the regulation of the geologic profession will be continuing, so stay tuned.

Geology curriculum then and now

The article, "Geology curriculum then and now," in the Oct/Nov/Dec '17 TPG is actually based on my father, David Abbott, Sr.'s review questions for his Historical Geology exam in 1936. As Editor John Berry stated in his Editor's Corner, "A glance over these questions provides a sharp reminder of how far the science has come." I've sent copies to several colleagues, one of whom replied that he would have flunked the test. Another asked if there was an answer key—there isn't—and proposed developing one. I expect most of us would do poorly on the test as the emphasis on index fossils has waned and we no longer emphasize the primary economic product of each Period, something that's changed over the years anyway. For example, today the Berea Sandstone is an important oil producer but in 1936 it may have been an important building stone.

Science Literacy – It's work!

Michael J. Urban, MEM-1910

Speaking strictly for myself, it is work to stay up on all of the latest innovations and breakthroughs in the scientific world. And, honestly, it is actually quite impossible for anyone to do, but that doesn't mean we shouldn't try. The explosion of information currently gripping essentially all fields, disciplines, and sub-disciplines of the over arching umbrella we refer to as science, boggles the mind. As a science educator, it discourages me to know that when I research facts to share in my classes, and subsequently present them to my students, the particulars may already be obsolete. Perhaps the greatest gift a science educator can bestow on his or her students is the knowledge that science is dynamic, and forever changing. This serves not only to cover me in the event I should inadvertently present an outdated idea, but reminds students that what they learn about science in the here and now may not hold true tomorrow or in the near future. [Does anybody remember geosynclinal theory?] The second greatest gift may be helping students to realize that everyone – scientists and non-scientists alike – has misconceptions about science. This simple fact must be true, since nobody can know everything. These two ideas, namely that our understanding of science evolves through time and that we all hold misconceptions, can serve as our mantra in our dealings with students and the public at large. As scientists and science educators, we are called to promote and advocate science literacy.

We already know all too well that a state of general scientific ignorance persists in the average citizenship at the local, state, and national levels (probably the world over). To be fair, though, this should be expected, since most people are not specifically trained to think in scientific terms. However, in spite of this general deficit in overall scientific literacy – or, more specifically because of it – the scientists and science educators of our communities must, in addition to working their "day" jobs, assume the vital role of educating, or re-educating, the masses in scientific matters.

Some folks are inclined to read about science, but their sources for "facts" may not always be the most unbiased (e.g., popular media in the form of newspapers, magazines, etc.). We recognize this reality, and also that television and online resources may be subject to the same types of bias, over- or understatement, or misinterpretation of scientific fact. But knowing it means little, if we do nothing with the knowledge. So, as professional scientists and educators, we ask the question: what can we do about it? I believe one answer is that we need to be proactive in advancing scientific knowledge. [Bill Hoyt and I present a case study related to fracking in this same issue of TPG, wherein we similarly spur readers to action.]

What does it mean to be proactive? A good way to think about the word may be to contrast it with the word reactive. In many cases in our personal lives, we may be reactive, and I can immediately think of no better example than when the bills arrive (either electronically or by snail mail). Our reaction to the bill arriving is that we pay it. Taking a proactive stance on bills might involve sending a payment before the bill comes, or possibly sending more money than the bill requires. Another arguably proactive example might be setting up electronic payments to be withdrawn from our accounts for certain bills on specific dates. In any case, we are proactive in dealing with a foreseeable issue or problem requiring action, before it actually occurs. Pro-action requires us to take initiative, whereas reaction requires prompting.

We can be proactive with our advocacy of science. Rather than waiting for some event to take place, requiring our attention and a response, we could seek out opportunities to share scientific knowledge. We do this by talking about science with people we meet on the street (I don't know anybody who does not like to chat about the weather, even in passing – suppose we take the opportunity to make the conversation a tad more scientifically engaging or enlightening).

We do it by writing about science: in journals, magazines, newspapers, and blogs online. If you still get the local newspaper, check to see if there is a "science column" in it – if not, there's a great opportunity! Are you tech-savvy, and do you like to write? Then, why not create a science blog (i.e., a conversational website), or a personal one in which you share science once in a while? Even something as seemingly mundane as sharing a science article with your connections on Facebook counts. Putting on public forums to share science facts, either through your organization, at the local library, or even outreaching to teachers and public elementary, middle, or high schools, is a way to disseminate knowledge. The research we do to prepare for such outlets, not only serves our intended audience, but helps us expand, reinforce, and rejuvenate our own scientific expertise.

Instead of reacting to a political decision related to the environment, we might share scientifically valid facts about environmental stewardship or reclamation prior to it being needed. We are probably already aware of this need, and may already do something about it, but is it enough? One might take the stance that it is impossible to combat political agendas, especially when they take advantage of a society's ignorance about science. Personally, though, I am not convinced. I believe if enough people really understand science, then they can make more informed decisions; and, I also believe that everyday people do have a voice, and can bring about change when their voices are heard.

As the saying goes, "an ounce of prevention is worth a pound of cure." Or, so we hope. In any case, we can't know unless we try, or rather, try harder. To those who already do much, you know it is a relatively thankless endeavor – but, I know you recognize the value in what you do to advance science. For anybody not yet as involved as you could be, consider taking a moment to think about what you might do, no matter how small. [A regular part of my weekly routine includes a lesson in which my guitar teacher, as unlikely as it sounds, takes a moment (or two, or three, or more) to remind me that I should eat better, advocating both nutrition and the hard core science supporting dietary considerations. He does it with my best interest in mind. We can doubtless think of circumstances to do something similar with geosciences for people we know, for example.]

In conclusion, I'd like to leave you with a few thoughts to mull over. What should a scientifically literate society look like? What are three of the most important science-related ideas to you in your profession? How do you, or can you, advocate science literacy from where you are with what you have at your disposal?

TALES FROM THE FIELD

The Worst Day of My Life

John Berry, CPG-04032

In early summer 1985, I was leading a remote-sensing-based, helicopter-borne reconnaissance exploration program for gold in northern Nevada. On this particular week we were operating from the one-and-only motel in Austin, NV.

I had decided to stay in the "office" that day to update our maps and prepare samples for shipment. A violent thunder- and windstorm came through just before the crew of three were due back in the chopper, a Jet Ranger. Time went by, it grew dark, and there was no sign of my crew. I called the State Police and the helicopter company, and they had no word of anyone in difficulty. There were no cell-phones in those days, so all I could do was wait and pray.

As I grew more and more frantic, I got a call from my neighbor in Houston. He had found my wife wandering around lost and incoherent, and had taken her to hospital. My wife had had a brain tumor for several years, had an unsuccessful operation in 1978, and had been brought back from near death by radiation therapy in 1984: we had expected something like this, but not so soon.

Caught between a rock and a hard place, I made a reservation on an early morning flight back to Houston from Ely, NV, 152 miles away along US 50, the "Loneliest Road". In order to catch the plane, I would have to leave Austin at about 3:00 am.

Eventually, just before midnight, I got a call from the leader of the field crew. They were in a motel at Fallon, NV. They had been forced down by the wind in Dixie Valley. A Cessna with a family of four in it had also been forced down nearby. My crew chief told me that the Cessna's ground speed had been near zero on landing and that the pilot had landed near the helicopter because he knew that he might need assistance on landing.

When the storm had passed, everyone got back in the chopper, and the pilot started the engine. But a warning light came on telling the pilot that the rotor attachment might be failing. The Cessna also had some problem. So now there were 8 people, including two young children, on the ground, about 10 miles north of Hwy 50, and 12 miles from the fuel truck, which was awaiting them at Frenchman, an isolated gas station/restaurant on the main highway.

It happened that the team leader was a marathon runner and also that he preferred soft-sided field boots. So he was able to, and did, run to Frenchman, and ride back to the chopper on the fuel truck. There they loaded the family from the Cessna onto the truck and drove them to the nearest accommodation at Fallon, 45 miles away. The fuel truck then returned to the chopper, loaded my crew, and drove them to Fallon. All of that took 7 hours, and nobody had thought to call me to let me know they were safe, although their only opportunity might have been from Fallon on their first trip, by which 5 hours had already passed.

Dixie Valley is open to the public, but since shortly after this episode it has been used by the Navy as a bombing range and training area. It is (or was) full of old Soviet military equipment and fake Russian-style buildings so that it could be used in simulated attacks on Soviet lands. People lived there until 1995, though they loudly protested the increasing military impact on their lives beginning in the mid-1980s. It is likely that the restaurant was already abandoned by the time of this incident because the Navy bought it in 1985 and demolished it two years later.

I did not return to the field again that year, as I was needed in Houston to care for my wife until she died in October.

Reference:

http://www.clui.org/newsletter/summer-2004/nevadas-dixie-valley. Accessed 12/12/2017

www.onlinenevada.org/articles/frenchmans-station-aka-bermond Accessed 12/12/2017

Tales from the Field

Have an interesting field experience? Of course you do! Send in your field (or office) tale to us, and we will share it in the TPG. E-mail your tale to aipg@aipg.org.

our experience on Earth that they could occur on an exoplanet in this period of time.

The practical application of geofremtidology may be beyond our present-day technical capabilities. Nonetheless, it is a subject worth studying as part of ongoing investigations. I write this in the hope that the scientific community, specifically geoscientists and environmental scientists, continue to produce insights into the geological events that can be expected to unfold, in the ongoing present under our feet and over our heads in the night sky, to envision a future being created by both nature and human beings. James Hutton once said, "the present is the key to the past," in that the current-day investigations of geological insight can imply what had happened in the past. Perhaps, with the ongoing work within the geoscience community to predict the geological future, we can slightly modify Mr. Hutton's quote to: "the present below and the past above is key to recognizing the future."

Plan on attending AIPG's 2018 Annual Meeting in Colorado Springs.

Field Trips

Our field trips will explore central Colorado including the Cripple Creek & Victor gold mine, the Portland cement plant and adjacent Niobrara Formation quarry, the upper Arkansas geothermal systems, the latest in SW South Park geology, and the Wall Mountain Tuff, among others.

Technical Sessions

The technical sessions will cover the full spectrum of geosciences; start thinking about your presentation. We're planning short courses on being an expert witness, the use of Rockware's software, and preparing an AIPG/AGI GOLI course.

Student Career Day

We'll have a Student Career Day on Saturday, September 8th. Young professionals start working on a presentation on a project you're working on that will induce your employer to send you to the meeting; remember such presentations are also good marketing for your firm.

Pikes Peak

And we're arranging a trip on the Pikes Peak Cog Railway to the 14,115-foot summit of America's mountain.

Berry College
Founded in 2016
Chapter Sponsor: Ronald Wallace, CPG-08153

Bowling Green University -
Founded in 2004
Chapter Sponsor: Robert K. Vincent, MEM-0216

Central Michigan University
Founded in 2003
Chapter Sponsor: John Barkach, CPG-09121

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The Foundation of the American Institute of Professional Geologists is thankful for the many donations received during 2017, including monetary donations, donated gifts-in-kind for the silent auction, and funds collected from bid winners at the silent auction at the AIPG annual meeting in Nashville. The silent auction generated interest in the Foundation and resulted in more than $7800 in funds to the Foundation. We are very appreciative of these contributions and the interest in the Foundation. The Foundation provides funding for several undergraduate scholarships as well as the William J. Siok Graduate Student Scholarship. In 2017, the Foundation provided AIPG with $6000 for undergraduate scholarships, awarded two $1000 Siok graduate student scholarships, and provided funding toward the successful student workshop held at the AIPG annual meeting in Nashville, Tennessee in September. The Foundation is proud to be able to serve AIPG and the geosciences by providing financial support for these programs and other endeavors in support of AIPG and the geosciences. The Foundation is a 501(c)(3) organization. Contributions are tax deductible.

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Foundation of the AIPG Brief Summary of Activities in 2017

Barbara Murphy, CPG-06203
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The Trustees on the Foundation of the American Institute of Professional Geologists worked on increasing donations and contributions throughout the year while also providing more contact with AIPG members about the Foundation. Updates were provided in TPG, in emails, and included in the e-newsletters.

The Foundation hosted a silent auction at the evening welcome reception held with the AIPG annual meeting in Nashville in September 2017. AIPG members and annual meeting vendors and others were contacted in advance for donations of gifts-in-kind. The silent auction generated interest in the Foundation and resulted in more than $7800 in funds to the Foundation. The Foundation will be hosting another silent auction at the annual meeting in Colorado Springs in September 2018 so please be looking for items to donate that would be of interest to our members. Key items at the auction were mineral/rock specimens, fossils, historic books and maps, vacation visit opportunities, jewelry, and similar. So, please be on the lookout for items to donate to the next silent auction.

The Foundation provides funding for several undergraduate scholarships as well as the William J. Siok Graduate Student Scholarship. In 2017, the Foundation provided AIPG with $6000 for undergraduate scholarships, awarded two $1000 Siok graduate student scholarships, and provided funding toward the successful student workshop held at the AIPG annual meeting in Nashville in September. The scholarship applications are available on the AIPG web site and are due on February 15th each year. The applications are reviewed by a committee and awarded to deserving undergraduate and graduate level university students in late spring. The Foundation also contributed to a successful student day workshop at the annual meeting and looks forward to supporting these and other events for students and young professionals at upcoming meetings.

The Foundation is proud to be able to serve AIPG and the geosciences by providing financial support for these programs and other endeavors in support of AIPG and the geosciences. The Foundation is a 501(c)(3) organization. Contributions are tax deductible.

Please note that a list of contributors is provided on the Foundation web page on AIPG's web site at http://aipg.org/foundation.

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Michigan Section Awards $7,000 to Geology Students

Michigan Section Vice President Tim Woodburne awards Michigan Technological University student, Katelyn Kring, the Andrew Mozola Memorial Scholarship.

Students are the future of our profession, and the Michigan Section strongly supports geology education for students from kindergarten through college.

In 2017, the Michigan Section awarded Michigan Technological University student and aspiring geologist Katelyn Kring the Andrew Mozola Memorial Scholarship named after the first president of the section for outstanding achievement as an undergraduate.

The 2018 applications for the Andrew Mozola Memorial Scholarship are now available on the Michigan Section's website. The deadline is June 1, 2018.

The Michigan Section also hosted its annual poster contest for undergraduate and graduate students awarding $1,000 to the winners and $500 to the runners up. Two Grand Valley State University (GVSU) students took first place and runner up in the undergraduate category and two Western Michigan University (WMU) students took the top awards in the graduate category. It was a competitive contest this year with several great entries from students representing several Michigan universities.

The Michigan Section also awards up to $1,000 for a K-12 educational project. There were no submissions for this award in 2017.

The Michigan Section encourages all K-12 Michigan earth science educators to submit a brief description of a geologically-related project, activity, or materials/equipment for consideration for this award and further advance earth science education in Michigan.

AIPG 2017 President Adam Heft with Michigan Student Poster Contest Winners
From L to R: Adam Heft, Undergraduate winner - Connor Cain (GSVU), Undergraduate runner up - Danielle DeWeerd (GVSU), Graduate runner up - Matthew Hemenway (WMU), and Graduate winner - Sarah VanderMeer (WMU)

Michigan Section Announces 8th Annual Technical Workshop Emerging Contaminants and Pathways: A New Paradigm

The American Institute of Professional Geologists' (AIPG) Michigan Section is calling for abstracts for the 8th Annual AIPG Michigan Workshop to be held June 12-13, 2018, at the Ralph A. MacMullan Conference Center on Higgins Lake in Roscommon County,Michigan.

The Michigan Section is also proud to announce this year's keynote speaker, AIPG National Executive Director, Aaron Johnson, Ph.D.

This 8th workshop in the series of annual training events hosted by the AIPG Michigan Section focuses on providing quality technical information and case studies. These environmental workshops bring together a broad base of topic expertise from consulting, regulatory, academic, and owner perspectives. This unique workshop forum promotes collaboration for solving tough environmental problems through real site case studies as valuable technical learning tools to develop strategies for evaluating and managing risks associated with releases of hazardous substances to the environment.

The Environmental Risk Management Workshop's theme is Emerging Contaminants & Pathways: A New Paradigm. The discovery of new hazardous substances in the environment is becoming a driving force in the environmental industry with ever evolving information ranging from the discovery of the hazardous substances to finding remedies and management strategies to prevent exposure and protect human health and the environment. These emerging contaminants include substances like Per- and polyfluoroalkyl Substances (PFAS),pharmaceuticals, 1,4-dioxane, perchlorate, brominated flame retardants, energetics, insensitive munitions, etc.

As professionals working in the environmental industry sharing the latest information on the advances in the science as well as the regulatory requirements and other legal issues, we can make better, informed decisions regarding the risks associated with these substances in the environment.

Abstracts are due by January 19, 2018 and sponsorships are available. This is an event not to be missed, For more information, see the Michigan Section's website at http://mi.aipg.org/workshop.htm.

Online Course: Fundamentals of Professional Ethics: Elements and Examples

Everyone is in favor of good moral and professional ethical behavior but few have thought about them rigorously. What constitutes common morality and professional ethics? This course will explore the basic concepts and definitions of, and the differences between, common morality and professional ethics. This includes the distinction between moral rules and moral ideals. Case histories will illustrate the concepts presented and the methodology of ethical analysis.

Presented by: American Geosciences Institute staff serve as the facilitators for this course.

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Online Course: Critical and Strategic Minerals: Concepts and Status

Course Description: The term critical and strategic minerals has been around for some 90 years to describe those mineral commodities needed for the US economy that are mostly imported. The term originated during the First World War to include those materials needed for the war effort. We developed a new list appropriate for economy and technology of 2011. The webinar will review the history of the concept of critical and strategic minerals, look at the new list. Details of some of the key commodities will be reviewed, considering their uses, price histories, the U.S. import situation and their current status for U.S. dependence.

Both the National Academy of Sciences in the U.S. and a special commission of the European Union have conducted special studies and raised the concern over the future availability of many critical and strategic minerals to feed industry in their respective jurisdictions.

Presented by: Dr. Jim Burnell, Senior Minerals Geologist with the Colorado Geological Survey

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Online Course: Making a PowerPoint Presentation into a Work of Art

A review and demonstration of strategies for ensuring your use of PowerPoint strengthens your presentation, and does not distract from the message or the delivery to the audience.

Presented by: Dr. Chris Mathewson. He obtained a B.S. (Bachelor of Science) in Civil Engineering from Case Institute of Technology in 1963. After receiving his B.S from Case, he attended the University of Arizona and received his M.S. (Masters of Science) in Geological Engineering in 1965. In 1971 he acquired his Ph.D. from the University of Arizona.

Earn 0.1 CEU's (1 contact hour)
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Online Course: Basic Reservoir Engineering for Geoscientists

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-Rock Deformation; Fractured Reservoirs
-Rules for Appraisal of Oil and Gas Properties
-Self-Assessment Questions and Problems
-Helpful References

Presented by: Robert Font, Ph.D., CPG, PG, EuroGeol

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Online Course: Practical Petroleum Geoscience

This comprehensive survey course covers the principal geological, geophysical, engineering and economic principles and techniques that are used in petroleum exploration and production.

Practical Petroleum Geoscience is a survey course in PowerPoint format (approximately 800 slides), designed to cover topics of geology and geophysics specifically utilized in oil and gas exploration and production. The course also treats aspects of economics and risk analysis needed in the search for and development of oil and gas reserves.

Dr. Font developed this course to give petroleum geologists access to essential information, information often omitted or "glossed over" in various college curricula. He has included here facts that he wished he had available when beginning work as a petroleum geologist or that he could easily reference in later work.

Presented by: Robert Font, Ph.D., CPG, PG, EuroGeol

Earn up to 8 CEUs.

Register online at www.aipg.org

Online Course: An Introduction to Landslides or Mass Wasting

Landslides and mass wasting of earth materials occur globally and can result in catastrophic loss of life and property. In the United States alone, property damage caused by slides and flows has been estimated to exceed $2 billion annually. An Introduction to Landslides or Mass Wasting will provide the student with an understanding of the factors that contribute to slides or flows of earth materials, particularly in weak or poorly consolidated sediments.

Presented by: Robert Font, Ph.D., CPG, PG, EuroGeol

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Just the "fracts": Educating the public about fracking

Michael J. Urban, MEM-1910, Bemidji State University, Minnesota and William Hoyt, Ph.D, CPG-07015, University of Northern Colorado

Overview

Anyone could easily spend all of their waking hours in the next year reading just the peer-reviewed scientific and engineering literature on hydraulic fracturing. Then you would need several more years to read the opinions of various special interest groups and web-based organizations worldwide that promise to tell you all you need to know about it to choose their "side" of the debate. And just when you think you have a handle on all that, you really need a couple more years--and an army of lawyers--to understand and rightly interpret local, state, and federal regulations on fracking. We would be lying if we said you were done at that: all of the above is in constant flux, with substantial new changes each year. Such is the nature of virtually all of the science-related grand challenges that face humans! In the event you can spend the time reading a 35 page peer-reviewed paper that covers geological, economic, and environmental issues, we suggest *The Environmental Costs and Benefits of Fracking* (Jackson et al., 2014). The authors point out, among many other interesting things, that much of the cost savings from burning natural gas instead of coal are erased by the fact that we will likely burn *more* natural gas because it is lower priced than coal. Likewise, CO_2 production by burning more of that natural gas is likely to be about the same as if we burned the lesser amount of coal! So statements that only consider one factor typically fail to recognize the complex interplay between economics, environmental damage, geological supply of fossil fuels, environmental regulations, and alternative energy production costs.

So what is a person to do about such a complex and important issue? We feel that geoscientists—and especially geologists—have an important and crucial role to play in understanding and explaining perspectives that cut through some of the misinformation and misconceptions that dominate fracking debates. From a geological perspective, and in the simplest terms, we now are able to go after the ***source rocks*** that lock up the hydrocarbons, not just the ***reservoir rocks*** that naturally accumulate oil and gas. In other words, we can now get economic reserves out of tight, low permeability sands, siltstones, and shales. This revolutionizes the feasibility of hydrocarbon extraction way into the future, and at an economical price.

Technology Advances

Technological advances and inventions have transformed our energy production strategies from the beginning of the oil and gas industry—fracking is just one of the most recent ones humans have found to extend our capabilities in producing energy. The entire alternative energy industry owes its existence to technological advances and inventions unimaginable to Hoyt's great-grandfather: Carbon P. Dubbs. Speaking of Dubbs, he held 140 patents in the oil-cracking and refining arms race that happened 100 years ago between Universal Oil Products and all the major oil and gas companies. Carbon's dad had such confidence in the future of the oil and gas industry that he named his son after it. [Later Carbon added a middle initial "P." because he thought it sounded good—"euphonious" is the word he used. His friends started calling him Carbon Petroleum Dubbs and that is what everyone called him the rest of his life, though as a little kid I appreciated the shortening to C.P.]

Carbon's patents dealt mostly with shortening—that is, shortening the long-chained, heavy crude hydrocarbons into light aromatics such as kerosene and gasoline by recirculating natural gas (he called it the "Clean Process," in what now seems like an ironic name). The refineries around the world today are still using the basic technology of 1917 to make much more gasoline than nature started with.

Controversy and Carbon Conundrums

Fracking is a hot topic today, but many citizens are unaware of the true pros and cons involved in the issue. Many people are encouraged by advertising and a variety of special interests to be strongly for or strongly against fracking, without knowing much about the process. In this article, we'll provide examples of both the pros and cons, and also invite our colleagues in industry, consulting, and academia to embrace opportunities to educate the rest of society. Examples of how this might be accomplished are provided from the Wattenberg Field of the Denver-Julesburg Basin; Colorado is a place where almost all of the issues are playing out in real time, with a Democratic governor who was an oil and gas geologist—and also a person aligned with Colorado's environmental ethos. So we present a model of how these issues might be resolved in the future, by seriously considering both the benefits and the costs.

Though virtually everyone reading this article is using hydrocarbons to do so, perhaps it is geologists who best understand the wide range and scope of the products necessary to do such a simple thing! Consider the products and services made by hydrocarbons that you are using right now: plastics in your computer device or the eyeglasses on your head; the clothes on your back, many made partly of hydrocarbons; and the print media in your hands, the paper processed from trees or recycled fiber, and the vast network of transportation systems used to get these words on the page in front of you. Most will also be comfortably warmed or cooled while reading, having had something nourishing to eat—all thanks to hydrocarbons or their products. You get the picture! And you can doubtless come up with many more examples of our extensive dependence on hydrocarbons. Humans could simply not live in the numbers and fashion we do on this planet without this legacy of carbon dependence.

Today, the United States is one of the greatest producers of shale gas globally (Perkins, 2014), in large part due to the use of fracking. Although some advances in seismic processing and facies analysis have enabled us to locate previously unknown petroleum resources, the shale gas revolution primarily takes place in existing and well-known fields. Perhaps more important, though, are the advances in technology that enable us to tap already known—but difficult or cost-prohibitive to access—oil and natural gas reserves. Traditionally, rocks like oil and gas shales, were recognized as containing copious amounts of petroleum, but at economically exorbitant costs. Hydrofracturing enables the extraction of resources at profitable margins.

What is fracking?

We all may benefit from a bit more background, or a refresher, on fracking, so let's "drill down" a little deeper into how the process works. Hydraulic fracturing, known also as hydrofracturing or just fracking, involves pushing pressurized fluids into rock layers to access petroleum and natural gas in situations where conventional recovery methods will not work. In conventional petroleum extraction practices, a vertical pipe is bored down through impermeable caprock into oil-laden rocks with relatively large pore spaces and high permeability. Once unconfined, the oil, often under pressure, flows (or is pumped) up through pipes to the surface to be collected. Hydrofracturing is specifically used when oil and gas are concentrated in rocks with small pore spaces and low permeability (shale is the archetypical example). Other "tight" reservoirs like limestone may also be fracked (such as the Niobrara Limestone in our case study below; Sonnenberg, 2013). Vertical drill holes are used in fracking too, but once oil-bearing rock formations are tapped, horizontal or angled drilling methods gather oil and gas from several hundreds to thousands of feet outward. Because of this lateral steering ability, only a single vertical drill pipe is needed to service many, many horizontal bores, reducing the surface land use footprint – one of the appealing aspects of the process. See Figure 1.

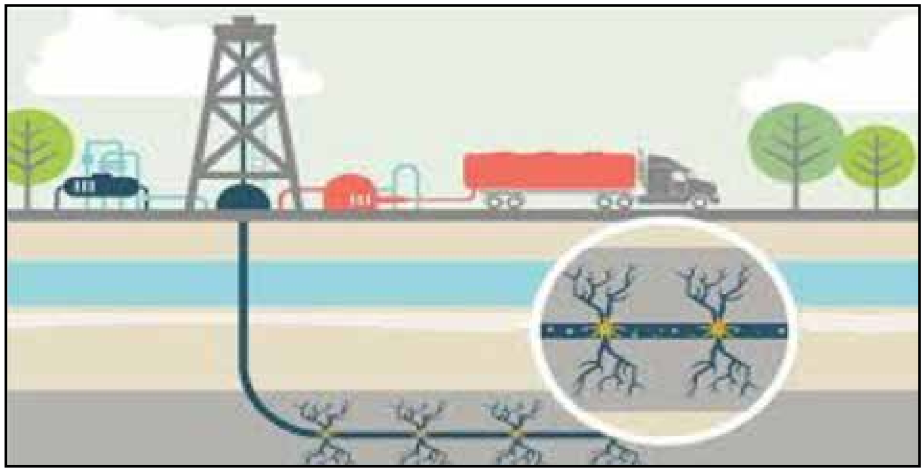

Figure 1 - Simple schematic of subsurface hydraulic fracturing in deep geologic media. From the same surface platform many horizontal wells may be drilled—this illustration shows only one. (Image from coosa.org)

The technique is called *hydraulic* fracturing because once a hole is drilled, reinforced with concrete, and a pipe emplaced, a muddy slurry called *slick-water*—consisting of water, proppant (quartz sand), and other chemicals—is forced down into the rock. The pressurized slurry finds its way into pore spaces and rock fractures, further expanding them to essentially "wash out" the desired hydrocarbons. Sand wedges into pore spaces propping them open and making them accessible for multiple fracks—or, fracking events—until there is no longer any oil or gas left to extract.

Purposes for water and proppant may be fairly obvious, but why are additional chemicals added to the mix? Chemicals are included for a variety of reasons, chief among them to reduce friction (i.e., lubricate), dissolve minerals, and kill microbes that feast on the rich organic compounds. Some of these ingredients are deemed dangerous or toxic if introduced into aquifers and surface waters, and some are completely unidentified, since for proprietary reasons, not all chemicals used by fracking companies are disclosed.

Where is fracking taking place or where can it be used?

Although fracking techniques were developed much earlier, what we call fracking today may be more accurately referred to as "deep fracking," first extensively used in 1999 in the Barnett shale in Texas (Hoffman, 2012). It is usually applied to previously unrecoverable tight gas formations of deep geological basins in old ocean-floor sedimentary deposits with fine-grained strata (e.g., shales). According to the Environmental Protection Agency (n.d.1), the fracking industry has been used in about 20 states (substantially in parts of Alaska, California, Ohio, Pennsylvania, West Virginia, New York, Texas, New Mexico, Utah, Colorado, Kansas, Wyoming, North Dakota, Montana, Oklahoma, Alabama, Arkansas, Louisiana, Virginia, Tennessee); other states have some reserves, but they are of lesser volumes (e.g. Michigan and Mississippi). There are many more places in the country, and around the world, for which deep fracking techniques could be used lucratively.

Fracking Hazards

Waste Water

Fracking is controversial because of poorly understood, or potentially detrimental, environmental and societal consequences. Produced and reclaimed waters, by-product and released gases (into the atmosphere), and induced seismicity are considered major challenges or concerns of the fracking process. In a time when climate change, water and air quality, and pollution woes dominate media circles, fracking falls under a microscope of close public scrutiny. Some unease is warranted, but misconceptions and misunderstandings have also propagated less well-founded anxieties.

A primary concern of fracking relates to the potential effects on water quality. Drilling into rock layers may inadvertently expose groundwater aquifers, used by municipalities for drinking and agriculture, to dirty slickwater and other water sources mixed with the fracking-targeted hydrocarbons. Any leaks in the pipes, casings, or storage facilities may lead to mixing or contamination. According to studies by the Environmental Protection Agency (n.d.2), slickwaters used in the fracking process typically consist of well over 80% water, but it's the other constituents of the mixture that pose a problem—especially considering many of them may be unknown. Potentially making matters worse, the hydrocarbons extracted from rock layers may already be mixed with watery solutions containing concentrations of salts or radioactive decay products (like radium; Engle, Cozzarelli, & Smith, 2014). The hydrocarbons must be separated from the waste water and the waste must be stored either temporarily (before treatment) or permanently.

In some cases, the waste water is treated and recycled. In other cases, it may be reused in the fracking process, or discarded. Because treatment can be an expensive option, sometimes the only economical choice is to get rid of the waste waters. Where can the waste water be stored to avoid potential contamination with clean surface and groundwater sources? Waste waters may be stored in surface ponds, or injection wells wherein water is forced back down deep into the ground either in a new location, or in a spent well to equalize the reduced pressure caused by the removal of the oil or gas resources.

Induced Seismicity

Seismic activity on a small scale (e.g., magnitude 2-3 quakes) has been linked to fracking activities, although many other human activities also induce earthquakes, and some to a greater extent (e.g., mining; Wendel, 2016). Oklahoma has seen increased incidence recently, more related to injection storage of produced and reclaimed waters in deep-seated wells (USGS, n.d.). Many of the large producers in the water-starved West are recycling the produced water from fracking operations instead of paying to have it injected into deep geologic disposal wells. In times of drought it seems particularly unwise to permanently remove water from the water cycle (even if it is a tiny percent each year).

Atmospheric Pollution

Principal atmospheric wastes generated in fracking include methane, a greenhouse gas and constituent of natural gas, and other by-products of the fracking process that come out with produced water and hydrocarbons—including volatile organic compounds (VOCs), and benzene, toluene, ethylbenzene, and xylene (BTEX) (Environmental Protection Agency, 2016; Hoffman, 2012). In addition, there are other combustion by-products from the engine exhaust of heavy machinery—trucks for hauling and pumps—and gases released through venting of wells (i.e., flaring; US Department of Energy, n.d.1). These types of atmospheric pollutants are typically no more common during fracking than from any other drilling activities.

Some of the impacts of fracking lead to societal concerns about noise, truck traffic, and local air quality, few to none of which would be absent from other oil-producing activities (US Department of Energy, n.d.2).

Case Study and YOUR Local Involvement

Since the authors have lived and worked in the Denver-Julesburg (DJ) Basin (Hoyt since 1981 and Urban as a graduate student there between 2002 and 2008), we use that particular oil- and gas-producing basin as an example of what has happened in the last decade or so. Though each geological setting has its own unique set of characteristics that impact fracking, most of the issues are common to all geological basins worldwide. But beyond the science, there are significant health concerns, social issues, and political considerations that we need to understand and be sympathetic to. What can we do as geologists to get out there in the public and government sectors to educate people?

Many workers have done considerable research on the DJ Basin, particularly in the Wattenberg Field. A colorful cross-section and stratigraphic column produced by Gus Gustason and Steve Sonnenberg (2003) is helpful in describing the geological setting (Figure 2).

In the Front Range of Colorado and increasingly out onto the High Plains, there has been a rapid growth of the economy and in the number of people that accompany it. In and around the Wattenburg Field, there are rapidly-growing cities such as Greeley, where there are now many who are nervous about fracking taking place within the city limits. In the past two years, as a geologist who knows a little about fracking, Hoyt has been invited by one of the Weld County Commissioners (who is a scientist herself familiar with the oil and gas business) to present on geologic resources to the County Planning and Zoning Board. On his first visit, he took a staff member who had worked in the oil and gas industry, and we had a very productive discussion. In order for fruitful communication to happen, Hoyt had to develop ties to county and city politicians and managers—developing those relationships can take months to years. He has found that counties and cities in the oil patch are very interested in the science of geological resources, and that they are hungry for reliable and unbiased information. Since Weld County produces some 80% of the total oil and gas in Colorado, it is considered the oil patch—and a very big part of the local economy.

Community and civic groups of various ilks are also hungry for information and engagement by geologists. Once the University of Northern Colorado sold its subsurface mineral rights in 2011, an

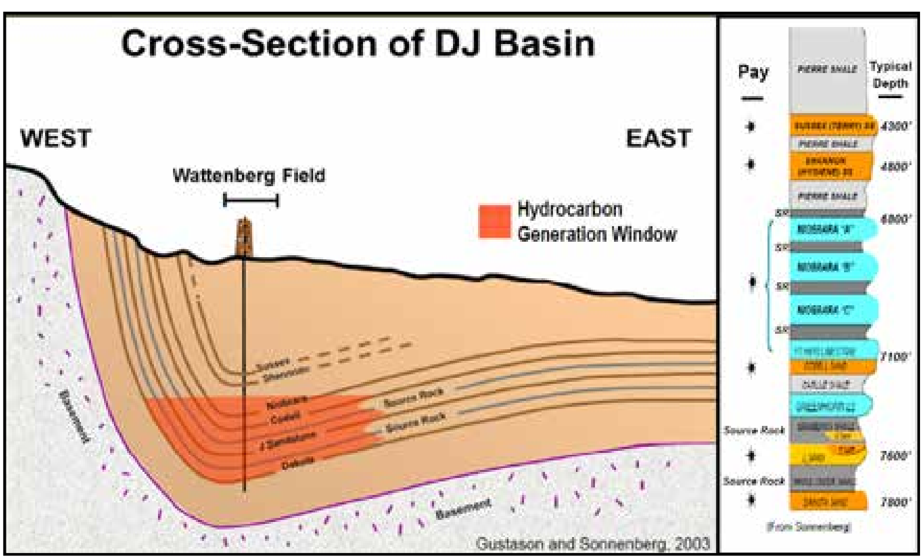

Figure 2 - Schematic cross-section and stratigraphic column of the Denver-Julesburg Basin, showing positions of the Niobrara and Codell Formations, which have played a leading role in revitalized production from the DJ Basin (Gustason & Sonnenberg, 2003; Sonnenberg, 2013).

informal, grass-roots group sprung up to evaluate what that might mean for the campus and surrounding communities where we live and work. Called the hydrofracturing task force in the early days, we have more recently focused our work in fracturing education (we now call ourselves FRAC-ED). Some members are educating local groups such as Earth Guardians on the processes. Several geoscientists and atmospheric scientists from the Department of Earth Sciences at the University of Northern Colorado participate in local educational events. What is the culture of your workplace about such engagement? Are you given or do you take opportunities to go out into public arenas to dialog with people? If not, it may be time for you to step out in some fashion. If geologists are not a part of the solution, we should not be too quick to complain about people not knowing facts about fracking.

When a deep geologic disposal fracking wastewater well induced an earthquake in Greeley in May of 2015, the Colorado Oil and Gas Conservation Commission (COGCC) shut down that well the next day. On that occasion, the COGCC determined that the geologic media into which the fluids were being injected should take less volume and at a slower rate. The science of these matters actually cut its teeth at the Rocky Mountain Arsenal property just north of Denver (Evans, 1966). That research showed, during injection well operation between 1962 and 1965, a strong correlation between the number of earthquakes and the volume of wastewater injected per month. On the last page of that article, a comment by Ben Parker entitled "Geology and the Citizen" pleads for geologists to share with the public what they know. Many of you will recognize that the American Institute of Professional Geologists named a medal after him in honor of Ben's high ethical and scientific standards. We are called to the same standards today.

Summary

Fracking is an economically important means of securing oil and gas today in the United States. Although some of the concerns about fracking may be warranted, others are not. Preserving municipal and agricultural water sources from any kind of contamination to fracking wastes should be an important objective. Contributions of methane and other atmospheric pollutants from fracking may be exaggerated in comparison to other oil-producing techniques. Seismic activity, while weakly associated with oil and gas recovery, is a more often and more significant consequence of deep well injection of fracking wastes.

In closing, we would like to invite our colleagues in academia and industry to seek out opportunities to inform local citizenry about the truths and fallacies of fracking. This is an emotional and economic concern as fracking activity nears or goes inside city boundaries. Difficult issues arise when a fracking operation and producing well goes in near neighborhoods—where property values drop as a result of that activity. Others speak of the great benefits in job production or tax revenues to the state, county, or city. Still others point to the atmospheric pollution, noise, traffic, or water quality concerns caused by the industrial activity. Others think of an energy future less tied to the burning of fossil fuels—and of natural gas as a bridge fuel to future energy-producing technologies.

Geologists should be leading the way into the future about all these issues—at least Carbon Petroleum Dubbs thought so! New technology waits for no one; as soon as there is a better way of doing things, the old ways become obsolete pretty quickly. Geologists should be ready to answer that call.

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Mapping Bedrock in Karst Terrain with the Use of Electrical Resistivity Tomography and Multi-Channel Analysis of Surface Waves. A case study in Southwest Missouri

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Nathainail was awarded second place in the AIPG National Student Poster Graduate Competition.

Abstract

Electrical Resistivity Tomography (ERT) is a versatile, fast and cost effective technique for mapping the shallow subsurface bedrock. It covers a wide spectrum of resistivity ranging from <1 Ohm.m to several thousands of Ohm.m. Active Multichannel analysis of surface waves (MASW) and ERT data are routinely acquired in karst areas in southern Missouri with the objectives of mapping the top of rock and determining the shear-wave velocities of shallow rock. We acquired ERT data along linear traverses at study sites. We also acquired MASW data at two locations along ERT traverses. MASW data were acquired using a 24-channel engineering seismograph and 2.5 feet geophone spacing. On the basis of the comparative analyses of MASW and ERT data, we determined that 2.5-ft geophone spacing with 10ft and 30ft offset generated depth to bedrock accurately. The bedrock characterization is divided into two groups: resistivity values between 1000 and 1500 Ω m indicating good rock quality, while values <250 Ω m indicate clay-bearing, unstable rock with fewer water problems. From our investigations, we conclude that the 2D resistivity method is a very good supplement to traditional methods for feasibility studies on mapping bedrock in karst.

1. Introduction

This case study is presented to illustrate how two-dimensional electrical resistivity tomography (ERT) can be used to accurately map the extent of bedrock in karst terrain. Karst terrain forms when a volume of sedimentary rock is dissolved by the action of groundwater (usually on limestone, dolomite, or marble), forming an area characterized by underground caves, fissures, and sinkholes, of which cover-collapse sinkholes are the most prevalent (Fig. 1). Missouri is widely known as "The state of caves". There are several major karst areas found in Greene County. Karst is the most challenging

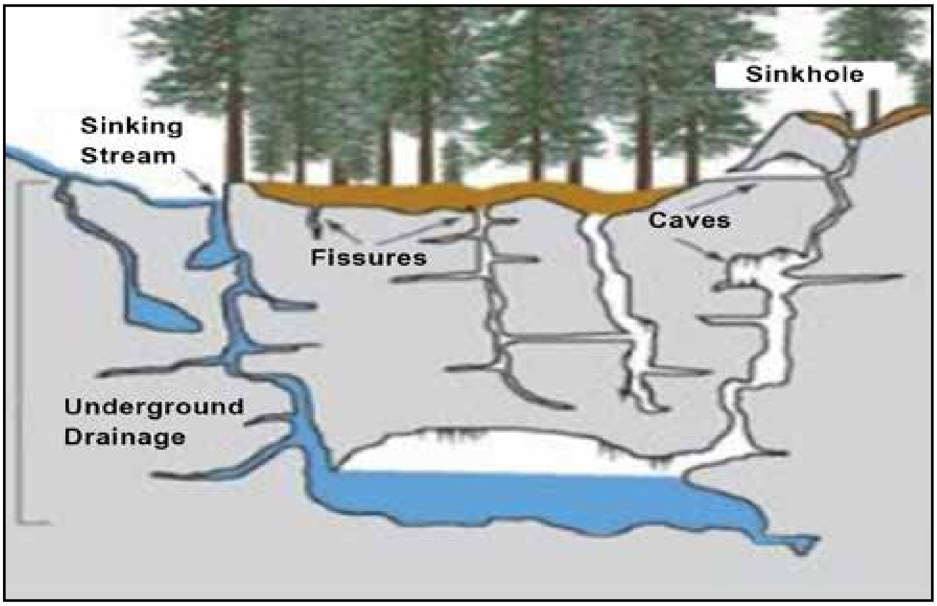

Figure 1. Karst Terrain Diagram (Environmental Science Institute, 2012).

environment in terms of groundwater engineering and environmental issues. Continual drainage through karst soil and subsoil changes the shape and size of karst voids and therefore significantly affects the strength of the soil itself. The strength variations of karst soils causes additional demands and concerns in the construction of various transportation infrastructure components. Therefore picking a correct geophysical method of investigation plays an important role in the acquisition of useful results in karst topography.

1.2 Study Area Geology

The study site is located in southwest Missouri close to the city of Springfield, Greene County. Bedrock in this study area is the Mississippian Burlington-Keokuk Limestone, about 150 ft-270 ft. thick. It is characterized by karstic features such as underground caves, losing streams, solution-widened joints and sinkholes. Below the limestones and cherty limestones of the Burlington-Keokuk are Ordovician and Cambrian-aged strata. The depth to top of rock is 5-35 feet. The strength variations of karst soils necessitate care in the selection of the parameters of a geophysical method.

2. Data Acquisition

2.1 ERT Data

The ERT data was acquired along a traverse trending East-West in order to have detailed subsurface coverage of the study area. A dipole-dipole array was selected due to the need for high lateral resolution. The total traverse length was 835 ft after measuring out the required length. 168 metal stakes were installed at 5-ft. interval along the 835 ft traverse. Eight cables each consisting of 21 electrodes were spread along the array and each electrode was attached to a metal stake (168 electrodes attached to 168 metal stakes). The metal stakes are made of steel and a SuperSting R8 instrument was used to measure the resistivities.

2.2 MASW Data

The MASW data were acquired at specific locations perpendicular to ERT traverse. Data were acquired using twenty-four 4.5 Hz geophones spaced at 2.5 ft intervals, a 20 pound sledge hammer source and an aluminum strike plate. Where necessary, MASW data acquisition locations were shifted because of access issues (ponded water, roadways, dense vegetation, etc.). The MASW data were acquired with the over arching goal of determining the engineering properties of the subsurface. Specific objectives included: mapping variations in the depth to top of rock; mapping variations in soil thickness; determining the engineering properties of rock; determining the engineering properties of soil; and constraining the ERT interpretation (especially with respect to depth to top of rock.

3. Data Processing

The MASW data processing was performed using the Surfeis software package, developed by the Kansas Geologic Survey. Processing begins by uploading SEG-2 field records into Surfeis. Records are processed and converted into KGS format. Algorithms in the Surfeis routine are used to analyze each KGS file and determine surface wave phase velocity and frequency properties, and used to plot representative dispersion curves. Each shot record has a unique dispersion curve, and each curve must be analyzed manually, by the processor, to identify and select best fit for the fundamental mode (Park et al., 2009).

The ERT data processing and inversion was performed using AGI Administrator software, which is used to download and convert field data into a form readable by the AGI EarthImager 2D analysis software. In the raw form, measurements of apparent resistivity can be plotted onto the respective pseudosection. The EarthImager 2D software uses the measured apparent resistivity pseudosection during the inversion process to recreate an earth model fitting the conductive characteristics of the recorded raw model (Advanced Geosciences, Incorporated, 2009).

4. Results and Discussion

Discussion will be focused on the comparison of depth to top of bedrock on ERT and MASW profiles. The interpreted bedrock is divided into two groups: values <250 Ω m indicate clay-bearing, unstable rock with fewer water problems while resistivity values between 1000 and 1500 Ω m indicate good rock quality. Moist soil is characterized by resistivity values less than 125 ohm-m and dry soil is greater than 125 ohm-m. The interpreted top of weathered rock has been highlighted on a west-east oriented ERT Profile (Fig 2A, 3A). The top of weathered rock on the ERT profile has been independently verified by MASW control (Fig 2B, 3B). The MASW array was centered at the 100 and 900 feet marks on the ERT Profile. As indicated in Table 1 and 2 above the MASW “acoustic” top of rock as determined at the MASW test location along ERT Profile is consistent with the top of rock as mapped at the corresponding 2-D ERT station location.

The results show that soil thicknesses on the ERT profile vary from approximately 10 feet to 25 feet. The overall average shear-wave velocity of soil varies between 800 feet/second and 1200 feet/second and averages about 1000 feet/second. The velocity of intact rock varies between 2000 feet/second and 2900 feet/second. Typically, thinner soils are characterized by higher average

Table 1: Comparison of ERT and MASW interpretations for MASW Line 1

Profile	Soil Thickness	Soil Velocity	Depth to Intact Rock	Velocity of Intact Rock
MASW	14.5 ft	900 ft/s	19 ft	>2050 ft/s
ERT ties @ 900 feet	13 ft		18 ft	

Table 2: Comparison of ERT and MASW interpretations for MASW Line 2

Profile	Soil Thickness	Soil Velocity	Depth to Intact Rock	Velocity of Intact Rock
MASW	9 ft	1200 ft/s	16.5 ft	>2900 ft/s
ERT ties @ 900 feet	11 ft		17 ft	

shear wave velocities (1100 feet/second). Thicker soils are typically characterized by lower average shear velocities (800 feet/second)

5. Conclusions

On the basis of comparative analysis of MASW estimated bedrock depths and imaging the subsurface (ERT), it is concluded estimated top of bedrock based on the resistivity and MASW data shows that it ranges from 18-ft to 19-ft. Generally, users of the MASW tool state that greater geophone intervals and greater shot-to-receiver offsets provide more accurate results. On the contrary in karst terrain smaller geophone spacing and off-set is recommended because of rapid lateral changes in depth to bedrock.

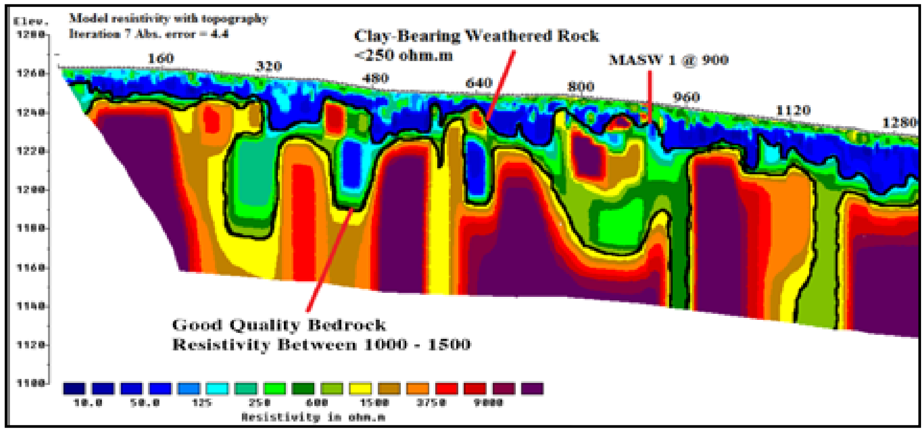

Figure 2a - ERT data profile along traverse trending East-West

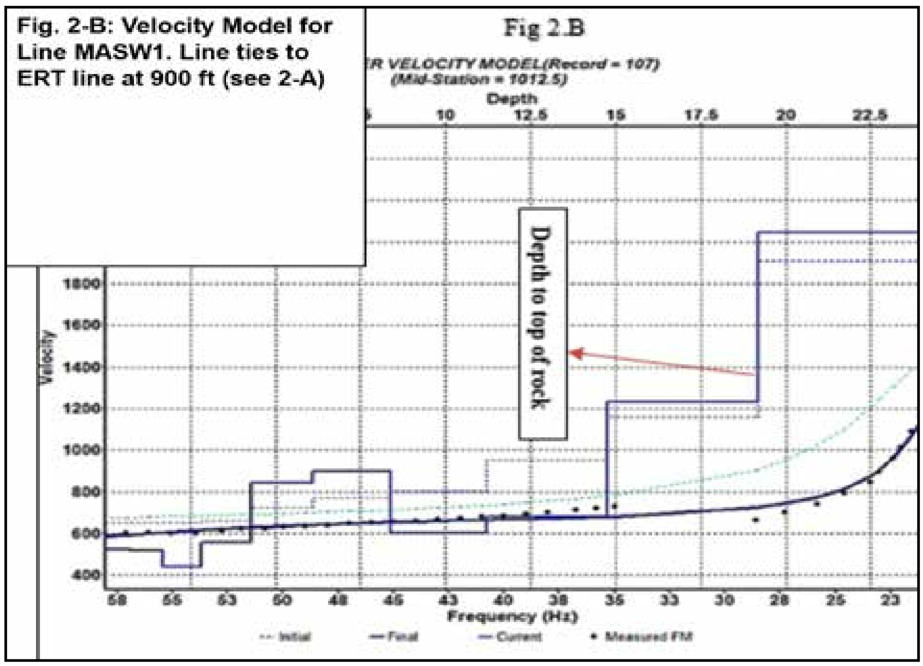

Figure 2b - 1-D shear-wave velocity profile 1 (velocity in feet per second; depth in feet) for MASW Line 1

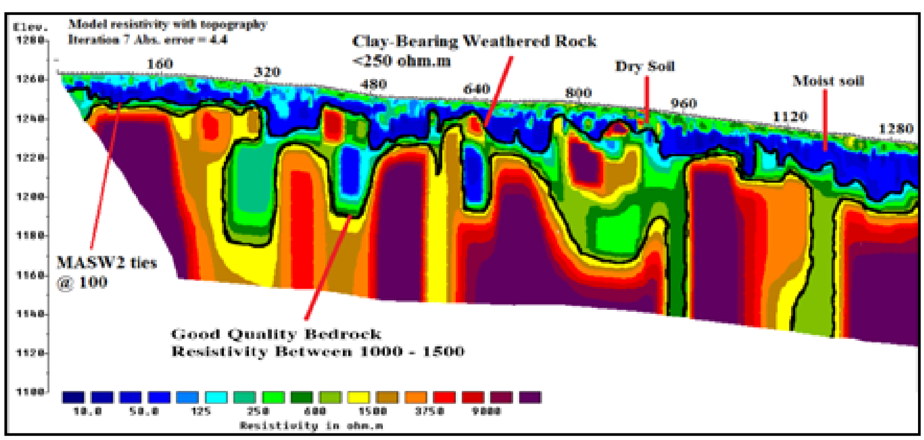

Figure 3a - ERT data profile along traverse trending East-West

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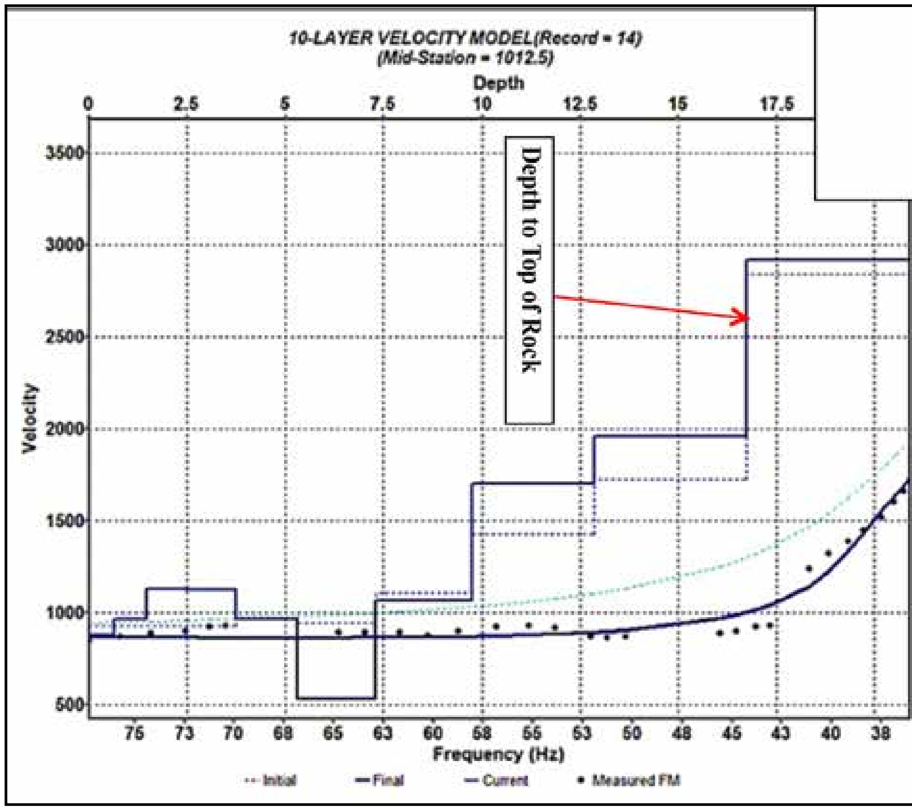

Figure 3b - 1-D shear-wave velocity profile 1 (velocity in feet per second; depth in feet) for MASW Line 2

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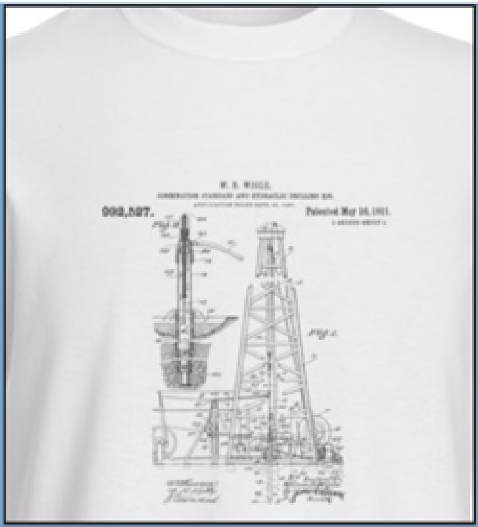

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Available colors: White, Ash Gray

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New Item

T-Shirt with Screen Print - Earth is our Coloring Book

Heavy Cotton Tee, 5.3-ounce, 100% pre-shrunk, open-ended carded cotton (except gray shirts which are 99% cotton and 1% other fibers), classic loose fit for all-day comfort, shoulder-to-shoulder tape and seamless collar, double-needle neck sleeve and bottom hem

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Member Price:$34.00

Zoom Checkpoint-Friendly Compu-Backpack Bag

Make your next plane trip much easier with the Zoom Checkpoint-friendly Compu-backpack. Specially designed to increase your speed through airport security, this laptop backpack includes a laptop-only section that unfolds to lay flat on the X-ray belt. This backpack has a side-entry 15" laptop compartment and an open main compartment that includes a dedicated zippered nylex-lined padded iPad pocket. It also features extra storage capacity with the zippered external pocket perfect for storing small items like power cords, USB drives, pens and business cards. Use the comfortably padded shoulder straps, the neoprene carry handle or just slip the bag over your suitcase and go catch your flight with effortless ease. Embroidered AIPG logo on front.

Available colors: Black

Member Price:$65.00

Baseball Cap

AIPG's baseball cap has a velcro enclosure and embroidered lettering.

Available colors: Black, Royal Blue, Tan, White, Navy

Price:$15.00