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ABSTRACT
The Sigma Gamma Epsilon, an academic honor society for students of the Earth Sciences, is an important tradition at GSA annual meetings. Sigma Gamma Epsilon's goal in sponsoring this session is to provide a student-friendly forum for young researchers to present on undergraduate research; this session has seen increasing interest and participation over the years. The session is open to students (regardless of membership in Sigma Gamma Epsilon) and faculty co-authors working in any area of the geosciences. Those posters authored by student members in good standing of active chapters of Sigma Gamma Epsilon will be judged for two (2) best-poster awards given annually by the Society.

KEY WORDS: Austin A. Sartin award, Sigma Gamma Epsilon National Council’s best poster award.

National Council Best Poster Award
The 2017 National Council Best Poster Award was presented to Katie Gurnicz of the Theta Omicron Chapter at Indiana University Northwest. Her paper was titled: An Analysis of Potential Regional Sources of Atmospheric Ca\(^{2+}\) and Mg\(^{2+}\) Suspected to Contribute to the Formation of Decomposition Chimneys in Mount Baldy Dune at Indiana Dunes National Lakeshore. Abstract: Dune decomposition chimneys are temporarily stable voids in modern dunes that form by the decay and collapse of trees buried during dune migration. Argyilan et al (2015) investigated these features at the Mount Baldy dune of the Indiana Dunes National Lakeshore (INDU) on the southern coast of Lake Michigan. An unexpected finding was the presence of authigenic carbonate precipitating in the siliciclastic sands directly in contact with buried trees. A carbonate-rich deposit was also observable after heavy rainfall events, occurring as both a surface coating and in association with sedimentary features (pin stripe laminations) in foreset beds, suggesting an atmospheric source of Ca\(^{2+}\) and Mg\(^{2+}\) to the system. This study investigates possible sources of Ca\(^{2+}\) and Mg\(^{2+}\), focusing on ion analyses of local precipitation. Two precipitation datasets were utilized; annual precipitation-weighted means (1985-2013) from the National Atmospheric Deposition Program for sites surrounding INDU and precipitation samples collected via a civilian sampling network established throughout northwest Indiana. The maximum annual mean concentration of Ca\(^{2+}\) (0.676 mg/L) occurred in 2012 for INDU and the data suggest that widespread drought conditions contributed to the elevated ion concentration. However, cluster analysis and an ANOVA test on the full time series indicated that values from
INDU are statistically different from nearby stations. Liquid phase ion chromatography yielded concentrations for Ca\(^{2+}\) and Mg\(^{2+}\) ions in precipitation samples collected across the civilian sites. Elevated concentrations of Ca\(^{2+}\) and Mg\(^{2+}\) likely reflect atmospheric absorption of byproducts released from industrial sources including coal-fired power plants, cement factories, and coke and steel manufacturing in the region. Another possible local source of Ca\(^{2+}\) and Mg\(^{2+}\) is a basal fossiliferous clay layer that could contribute to authigenic carbonate formation via ongoing weathering, erosion, dissolution, and re-precipitation within dune sediments. These data can aid in authenticating the initial hypothesis that a localized atmospheric source of Ca\(^{2+}\) and Mg\(^{2+}\) is contributing to the formation of decomposition chimneys at Mount Baldy. Findings will impact risk assessment for similar migrating dunes along the Great Lakes and elsewhere.

Katie Gurnicz is presented the National Council Best Poster Award by SGE President Aaron W. Johnson.

**Austin A. Sartin Award**

The 2017, Austin A. Sartin Best Poster Award was presented to Lukas Harvey of the Eta Xi Chapter at St. Lawrence University. His paper was titled: *Facies, Depositional Environments and Sea-Level Trends Within the Upper Ordovician Stony Mountain Formation, Western North Dakota.* Abstract: The Upper Ordovician Stony Mountain Formation in subsurface North Dakota was deposited in the epicratonic Williston Basin during transitional climatic conditions preceding the end-Ordovician Gondwana glaciation. The formation is subdivided into the Stoughton and Gunton Members in ascending order. This study, based on continuous core data, coupled with wireline-logs, thin-section analysis and structure/isopach maps, evaluates how the
stacking of depositional facies relate to the latest Ordovician glacio-eustasy and transitional climates. The facies identified include, from deepest to shallowest: argillaceous skeletal mudstone and wackestone with cm-thick skeletal packstone-grainstone interbeds (deep subtidal around storm-weather wave base), argillaceous skeletal wacke-packstone (rare; deep subtidal, sub-fair-weather wave base), burrowed skeletal dolomudstone (shallow euphotic subtidal below fair-weather wave base), barren dolomudstone (restricted euhaline to mesohaline shallow subtidal), flat-pebble breccia (rare; lag deposit); (dolo)thrombolite (shallow mesohaline subtidal), laminated dolomite (shallow mesohaline subtidal to intertidal), and nodular and laminated anhydrite (shallow penesaline subaqueous setting, sabkha). Skeletal grains are abundant in the Stoughton Mbr. and include crinoids, bryozoans, brachiopods, trilobites and corals; bioclasts are rare in the overlying Gunton Mbr, and occur only in its lower part. The facies are stacked into several-meters-thick cycles (=parasequences) (3-12 m), most of which are subtidal, asymmetric, and shallowing upward. A change from more humid (Stoughton) to semi-arid (Gunton) conditions is suggested based on an upward trend from argillaceous limestone to finely crystalline (early?) dolomite and anhydrite, and capped by a thin arenaceous dolomudstone. Contrary to the thicker subtidal parasequences of the Stoughton Mbr, the peritidal parasequences in the upper Gunton Mbr. lack any deeper subtidal facies. They also lack any evidence for prolonged subaerial exposure and are likely indicative of small amplitude, high-frequency sea-level oscillations that coupled with semi-arid climatic conditions favored early diagenetic dolomitization.

Lukas Harvey is presented the Austin A. Sartin Best Poster Award by SGE President Aaron W. Johnson.
Posters Presented at the 2015 Sigma Gamma Epsilon Poster Session

ARSENIC LEVELS IN RURAL DUST OF A SETTLEMENT SURROUNDED BY AGRICULTURAL FIELDS IN A SEMIARID REGION OF NORTHWESTERN MEXICO

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Arsenic is one of the ten chemical substances that represent a potential risk to human health. This element can be incorporated into the environment by diverse anthropogenic activities such as mining, agriculture, waste disposal, livestock, etc. Prolonged exposure or high concentrations of arsenic may pose a potential high risk to human health. The El Poblado Miguel Alemán (EPMA) is a dusty, mostly unpaved, rapidly growing, and a high degree of marginalization human settlement in northwestern Mexico. The EPMA is surrounded by the agricultural fields of La Costa de Hermosillo (LCH), which have been productive since the decade of 1940’s. Some agricultural fields have been abandoned due to a saltwater intrusion as a result of an overexploitation of groundwater. Therefore, active and abandoned fields can serve as potential source of contaminants, mainly due to the semi-arid environmental conditions of the region that favors erosion and re-suspension of dust, with final destination into rural areas. This is the first investigation that explores the arsenic concentrations in road dust, backyard soils, and schoolyard soils of the EPMA. The arsenic concentrations were determined using a portable X ray fluorescence in two particle size fractions (44 to 20, and <20 μm). The minimum and maximum arsenic concentrations in road dust samples for the analyzed fractions are 12.3-28.3 and 17.4-64.6 μg/kg, respectively. The results for backyard soils are 15.6-22.5 and 21.1-35.9 μg/kg, respectively. As concentrations in schoolyard soils are 14.9-20.9 and 22.5-28.9 μg/kg, respectively. Preliminary arsenic concentration in the studied samples exceeded the maximum permissible limit (22 μg/kg) for residential and rural soils according to the Mexican regulation (NOM-147). Therefore, dust re-suspension may be exposing the population to potentially harmful concentrations of arsenic.

GEOCHEMISTRY OF ABANDONED MINE TAILINGS AND RURAL DUST FROM A NEARBY TOWN: A CASE OF IGNORED POLLUTION IN SEMI-ARID ZONES OF NORTHWESTERN MEXICO

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Abandoned mine tailings are considered as one of the main sources of potentially toxic elements. Because of the lack of control of abandoned mine tailings from small-scale or artisanal mining, the tailings have become part of the natural landscape for decades, especially in rural areas from developing countries. Abandoned mine tailings represent a latent problem in terms of the possible affectations to human health and environment. An example of this is the small-sized (~200 x ~300 m) abandoned mine tailings located ~500 m from the San Felipe de Jesús town, Sonora, in northwestern Mexico. In order to determine the possible impact of the tailings, concentrations of potentially toxic elements were measured using a portable X-ray fluorescence in samples from mine tailings, unpaved roads soils, and road dust from San Felipe de Jesús. Enrichment Factor, Geoaccumulation (Igeo), Contamination Index (CI) and Hazard Average Quotient (HAQ) were calculated in order to assess contamination and risk. The Igeo values for road soil samples indicate no pollution to moderately contamination in order of importance as follows As> Pb> Cu> Zn> Sb, while moderately contamination in order of importance (Pb> As> Zn> Cu> Sb) for road dust samples. In general, EF values suggest minor enrichment of As, moderate enrichment for Pb and Zn, lower enrichment for Cu, and finally no enrichment for Sb. The CI values suggest that mine tailing materials have the highest probability of emitting contaminants into soils/sediments in the following order: Efflorescence minerals (CI=285), non-oxidized tailing (CI=106), road soil (CI=23), and road dust (CI=3). These contaminants can be transported due to the semi-arid conditions in the region, and potentially can have a negative impact on the surrounding agricultural fields and population. The HAQ values (for soluble elements) from efflorescence minerals (5169-38100) and mine tailings (143-2891), indicate that the potential of toxicity is very high, and can potentially affect the quality of groundwater and drinking in the region.

METAL CONCENTRATIONS OF DUST IN RURAL AREAS FROM ARID REGIONS OF THE SONORAN DESERT

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One of the main arid regions of Mexico is located within the Sonoran Desert, in the northwestern of Mexico, which includes the states of Sonora, Arizona, and California. Despite its arid climatic conditions, Sonora contains some of the main agricultural fields such as La Costa de Hermosillo,
Mayo Valley, Yaqui Valley, Caborca, among others. The misuse of the hydrological resources along the La Costa de Hermosillo caused a problem of saltwater intrusion, resulting in the abandonment of some agricultural fields. The El Poblado Miguel Aleman village is surrounded by agricultural fields of La Costa de Hermosillo, and is characterized by high dust concentrations. The arid conditions, saltwater intrusion, and desertification processes, suggest that these fields are important sources of dust, affecting both rural and urban areas. The present investigation carried out a geochemical characterization and evaluation of contamination of both rural dust and agricultural topsoil. Dust samples were collected on roads, courtyards, schoolyards of the village and surrounding agricultural surface soils, both abandoned and active. The concentrations of metals (Ba, Cd, V, Hg, Cu, Zn, Ni, Ag, Pb and Se) were measured from <44 and <20 µm size particle fractions, using a Portable X-ray Fluorescence (PXRF). Additionally Enrichment Factor (EF) indexes were calculated. Among all elements analyzed in all matrices, V in all samples is exceeding (78 ppm) the Mexican regulation (NOM-147). Mostly all elements showed EF values less than 1.5. However, moderate enrichment was found in all samples for Sr, Zn and Pb.

TRACING OF THE COPPER SULFATE SOLUTION SPILL IN THE RÍO SONORA BASIN, NORTHWESTERN MEXICO: INSIGHTS FROM Pb-ISOTOPE SYSTEMATICS

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Mining activity is classified as high risk because of the use, handling, transportation, and storage of chemicals. In fact, mining chemical emergencies cause high costs whose consequences are reflected in material damages, adverse health and environmental effects, and socio-economic problems. The failure of mine tailings is the main cause of release of fluids with metals into the environment. In the last five decades, at least 63 major emergencies related to mine tailings have been recorded globally. In August of 2014, the failure of the Tinaja 2 dam of the Buenavista del Cobre mine in Cananea, Mexico, caused a copper sulfate leachate spill, whose volume was estimated about 40,000 m3 of solution, which was drained into the Río Sonora Basin. In order to trace the copper solution, the systematics of Pb-isotopes was used to determine the isotopic signatures of the lithology and sediments of the Río Sonora Basin. The Pb-isotopic ratios of the studied samples were measured MC-ICP-MS. The lead isotope ratios of the lithology are

\[ ^{206}\text{Pb}/^{204}\text{Pb} = 18.455-19.675, \quad ^{207}\text{Pb}/^{204}\text{Pb} = 15.587-15.706, \quad ^{208}\text{Pb}/^{204}\text{Pb} = 38.504-39.089. \]

The Pb-isotope ratios for the sediments are

\[ ^{206}\text{Pb}/^{204}\text{Pb} = 18.559-19.171, \quad ^{207}\text{Pb}/^{204}\text{Pb} = 15.602-15.666, \quad ^{208}\text{Pb}/^{204}\text{Pb} = 38.530-39.148. \]

The lead data for the sediments of the tailings dam is

\[ ^{206}\text{Pb}/^{204}\text{Pb} =\]
18.505, $^{207}\text{Pb}/^{204}\text{Pb} = 15.606$, $^{208}\text{Pb}/^{204}\text{Pb} = 38.568$. The results suggest a linear arrangement from a less radiogenic member characterized by the sediments of the tailings dam, and a more radiogenic member characterized by granitic and altered rocks of the Río Sonora Basin. There is a strong correlation between the Pb-isotope signatures between the sediments and lithology exposed along the basin. The preliminary data suggest that the Pb-isotope signatures in sediments from the dam are not recorded in studied sediments along the Río Sonora.

ENVIRONMENTAL ASSESSMENT OF ABANDONED MINE TAILINGS FROM NACOZARI DE GARCÍA, NORTHWESTERN MEXICO: INSIGHTS FROM GECHEMISTRY AND UNMANNED AERIAL VEHICLES

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Mining is known as one of the primary economic activities where exploitation of minerals and other materials of the earth’s crust have become essential for human development. However, this activity represents a risk for the environment, starting from deforestation and ending with the production of a mineral residue that may contain potentially toxic elements. Mine tailings are an example of mining residues that may represent an environmental passive when abandoned and exposed to environmental conditions. Therefore, characterization of abandoned mine tailings is of great concern in order to assess risk of population and environment. Nacozari de García city, Sonora, in northwestern Mexico, is characterized by three abandoned mine tailings within the urban area, and represent important sources of dust and pollutants. In the present study, unmanned aerial vehicles (UAV) in conjunction with geochemical studies are used in order to have a geographical and geochemical perspective to assess the environmental impact. Digital elevation models of the abandoned mine tailings (I, II, and III) were obtained using the photogrammetry with UAV. A total of 47 surficial samples were collected from the three mine tailings to obtain the metal concentrations using a portable X-ray fluorescence (PXRF). The obtained surfaces of mine tailing I, II, and III, are 167336, 70569, and 404075 m², respectively, which accounts for a total of 641980 m² and represent around 11% of the urbanized area. The calculation of actual and loss of volume of the mine tailings will be determined from the digital elevation models. According to the metal concentrations, the contamination indexes for the mine tailings I II, and III, are 48.046, 42.333, and 17.104, respectively. These values are considered very high in toxicity and may be representing a risk to the surrounding population and environment.
AIR POLLUTANTS AND INCIDENCE OF ACUTE RESPIRATORY AND GASTRO-INTESTINAL INFECTIONS IN A CITY SITUATED ON A SEMI-ARID REGION OF NORTHWESTERN MEXICO

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High concentrations of particulate matter (PM) and polluting gases in urban areas are related to anthropogenic activity. This fact is even more evident when environmental conditions, such as those characterizing arid and semi-arid zones, favor the re-suspension of PM, resulting in the incapacity of the atmosphere to clean and eliminate pollutants. The city of Hermosillo, capital of Sonora, located in northwestern Mexico, is characterized by: 1) a rapid growth and increase in the vehicular park in the last decades; 2) a lack of vehicle emission regulations; 3) import used vehicles from the USA; 4) high concentrations of PM; and 5) high incidences of respiratory and gastrointestinal diseases. The combination of all these features favors a poor air quality in the urban area of Hermosillo. The present investigation uses the 2015 data from University Network of Atmospheric Observatories (RUOA) station situated in Hermosillo, which includes concentrations of particulate matter (PM2.5 and PM10), as well as ozone, carbon monoxide, sulfur dioxide, nitrogen monoxide, nitrogen dioxide. In addition, climate data is used to evaluate the correlation of these pollutants with a database of incidences of respiratory and gastrointestinal diseases from a Hospital in Hermosillo. A principal component analyses (PCA) was carried out and the data suggest that there is an increase of respiratory diseases when the atmospheric pressure, PM and gases (SO₂, NO₂, NO, CO) are high, particularly during the period comprised between November and February. Ozone is the only gas that is not correlated with the incidence of respiratory diseases. The data also suggest that the increases of pressure, PM and gases, are inversely related to decreases in the wind speed, temperature and radiation. A third component suggest that gastrointestinal diseases are not related to none of the environmental factors, although they are inversely correlated to humidity and directly correlated to atmospheric pressure. This supports the evidence that mixtures of pollutants can affect population health, as oppose to what was previously thought in Hermosillo, that increment in particulate matter was the reason of incidence of respiratory diseases.
GEOCHEMICAL CHARACTERIZATION OF STREAM WATER AND SEDIMENT QUALITY IN THE RIO BLANCO WATERSHED, PUERTO RICO

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The Rio Blanco watershed begins in El Yunque National Forest (EYNF), a rainforest at the eastern end of Puerto Rico. It’s tributaries flow southward out of the National Forest into coastal lowlands dominated by agriculture. Stream sediment is investigated for phosphorus concentrations and fractionation, while water is analyzed for major cations, anions, nitrate and total phosphorus. Sediment P fractionation is determined using the Psenner method. Stream water major element analyses show samples roughly falling into two groups. Samples from EYNF show lower concentrations of cations with Na concentrations in the 5 to 6 mg/L range while samples from outside EYNF have higher concentrations in the 8 to 19 mg/L range, for example. Anions show similar patterns with SO\textsubscript{4} (5.06 to 17.1 mg/L) and NO\textsubscript{3} (0.24 to 1.95 mg/L) concentrations two to four times higher outside EYNF. Total P concentrations were generally low, 0.1 mg/L or less, in most samples. One notable deviation from this pattern is a tributary draining a heavily agricultural area with livestock where total P was found to be 0.21 mg/L. Sediment P fractionation show total sediment P concentrations ranging from 47.9 to 178 mg/kg. The highest concentrations were found in segments were slope was lower or behind flow control structures, resulting in slightly more fines in the less than 2 mm fraction which was used for extractions. Distribution among the various physicochemical phases found variable results. In most instances, the sum of Al associated P and organic matter associated P was dominant, with values ranging from 57.4 to 65.4%. Results show some anthropogenic influence on stream water quality, but less so with respect to sediment quality.

PETROLOGIC INVESTIGATION OF MAGMA MIXING BENEATH SMALL QUATERNARY VOLCANIC CENTERS, NORTHERN OREGON CASCADE RANGE

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The northern Oregon Cascade Range has been dominated by andesite to rhyodacite lavas at both Mt. Jefferson (Conrey, 1991) and at Mt. Hood (Cribb and Barton, 1996) during the Quaternary period. Eruptive sequences at both Mt. Hood and Mt. Jefferson have been attributed to open-system magma mixing (Kent et al., 2010) (Ferrell et al., 2015), and the narrow range of lavas erupted at both centers has been derived from repeated cycles of magma mixing-fractionation (Cribb and Barton, 1996). This research examines major and trace element geochemistry as well as the petrographic characteristics of Clear Lake Butte (CLB), Pinhead Butte (PB), and Olallie Butte (OB), all of which are located between Mt. Hood and Mt. Jefferson, and have been active in the Quaternary period. The research investigates whether the same type of open-system magma mixing known to have occurred at Mt. Hood and Mt. Jefferson has also occurred at CLB, PB, or OB, or whether those systems were closed to mixing and dominated by fractional crystallization. One of the main goals of this project is to highlight the similarities and differences exhibited by neighboring magmatic systems of similar age, but different scale. Disequilibrium textures observed in thin sections from CLB, OB, and PB suggest open-system magma mixing is likely
occurring beneath all three buttes. This petrographic evidence includes plagioclase and pyroxene zoning, embayed margins, sieving, and reaction rims. Major element oxide trends at all three buttes are consistent with fractional crystallization, but show narrow concentrations and non-overlapping compositions between PB, CLB, and OB. All three buttes are characterized by narrow ranges of incompatible and compatible trace element concentrations. CLB, PB, and OB all exhibit LREE enrichment and lack significant HFSE depletions, with PB exhibiting greatest enrichment in REE.

PETROGRAPHIC INVESTIGATION OF MAGMA BATCHES AND CYCLING OF THE AKAROA VOLCANIC COMPLEX

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A volcanic complex consists of multiple calderas, cinder cones, lava domes, and craters, which form due to multistage eruptive events. Eruptive events are well recorded in the textures of mineral grains in igneous rocks because as magmas ascend, magmas entrain crystals from a variety of depths and from magmas in various ages and states of crystallization. Detailed petrographic analysis of individual phenocryst can provide details of magmatic and eruptive processes. This study analyzes a stratigraphic sequence of lava flows of the Akaroa Volcanic Complex, and investigates plagioclase textures to interpret the magmatic processes, and further discuss these in the context of magmatic evolution and geochemistry.

Two transects through a series of eighteen lava flows, were examined, as this sequence has geochemical analysis which indicates eruptive cycles and evolving magma batches. To further investigate this trend, textures within plagioclase phenocrysts and creation of a petrographic guide for plagioclase textures allow interpretation on magmatic processes and events. Primary plagioclase phenocryst textures observed are sieved, resorption surface, and melt inclusions. Sieved rim, patchy cores, zoning, swallow-tailed, synneusis, glomerocrysts, broken crystals and crystal clusters were also observed to a lesser extent within the transects.

Evolutionary paths of phenocrysts were constructed for each thin section, extracted from their petrographic textures, with most of the samples have experienced multiple magma recharge events and decompression. Through broadscale observation and petrographic guide interpretation of magmatic processes, combined with geochemistry data and magma batches information, a conceptual model of an effusive feeding system of the AVC is constructed.


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The Bloodgood Canyon Tuff and the tuff of Triangle C Ranch are contemporaneous rhyolite ignimbrites in the western Mogollon-Datil Volcanic Field (MDVF) of southern New Mexico, erupting during the peak of volcanism in the region. The MDVF erupted 12,000 km$^3$ of rhyolite ignimbrite between 36 and 24 Ma. The ignimbrite flare-up is attributed to the relaxation of compressional stresses related to the Laramide orogeny ending between 35 and 55 Ma which initiated the extension in the Rio Grande rift and Basin and Range. In the Mogollon-Datil volcanic field, there are more than 30 recognized ignimbrites and 15 calderas are dispersed over an area of 40,000 km$^2$. Here we present a comparison between the Bloodgood Canyon and the tuff of Triangle C Ranch using whole rock major and trace element geochemistry and thin section petrography to determine the relationship between the tuffs and to establish if the Triangle C Ranch tuff is a unique eruptive unit.

The composition of the volcanic rocks are bimodal basalt and rhyolite lava flows and ash flow tuffs. Both the tuff of Triangle C Ranch and the Bloodgood Canyon tuff have been dated within error at 28.05±0.04 Ma and 28.15 ±0.14 Ma respectively, but the Bloodgood Canyon Tuff and the tuff of Triangle C Ranch have different magnetic polarities. The Bloodgood Canyon Tuff is a single cooling unit crystal-rich, high silica ash-flow rhyolite with low FeO, Sr and CaO contents. The phenocryst phases include alkali feldspar, quartz, biotite and hornblende in variable percentages throughout the stratigraphic section. Pumice contents are variable, and range in size from ~1 cm to 0.5 m. The Bloodgood Canyon Tuff is the most extensive eruptive unit in the MDVF with an estimated extent of 15,000 km$^2$ and an estimated eruptive volume of ~1300 km$^3$.

Petrographically similar, the tuff of Triangle C Ranch overlies the Bloodgood Canyon Tuff and is only distinguished where a thin volcaniclastic sandstone is present. The tuff of Triangle C Ranch is primarily a non-welded tuff, rich in silica and fine grained, with the exception of pumice and lithic fragments ranging in size from 0.1 to 0.5 cm. In some locally exposed outcrops the two units are separated by pumiceous sandstone ranging in thickness from 1 to 2 meters, but in other exposed outcrops, the sandstone is not present and the two units are nearly indistinguishable in the field.

THE PETROLOGY AND GEOCHEMISTRY OF THE KNEELING NUN TUFF, MOGOLLON-DATIL VOLCANIC FIELD, NEW MEXICO

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The Kneeling Nun Tuff is an ash flow in the Mogollon-Datil Volcanic field (MDVF) of southern New Mexico dated by $^{40}$Ar/$^{39}$Ar at 34.89 ±0.05 Ma. Ignimbrites of the 40,000 km$^2$ MDVF were erupted episodically from 36 Ma to 24 Ma with the Kneeling Nun erupting in the first of four identified volcanic episodes. The eruption source, the Emory Caldera, is located about 30 km southwest of the town of Winston, New Mexico. The Kneeling Nun consists of more than 900
km$^3$ of volcanic material with disagreement on whether the tuff is a single cooling unit or multiple flows. Previous work on the tuff has focused on field descriptions and stratigraphy around the source caldera. Here we focus on stratigraphic and lateral chemical and mineralogical variation throughout the Kneeling Nun Tuff. We present new thin section petrographic analysis and major element geochemistry of 20 whole rock samples representing six stratigraphic sections. Stratigraphic sections were measured along two traverses, the first a north-south traverse covering the maximum extent of the tuff. The second traverse is east-west through the caldera. Our overall goal is to: 1) determine if the Kneeling Nun was deposited as a result of a single eruptive cooling unit or multiple eruptive units. 2) Contribute to the “big picture” understanding of the complex volcanic history of the Mogollon-Datil volcanic field through a description of the petrology, stratigraphy, and geochemistry of the Kneeling Nun Tuff.

Stratigraphic description of the six sections suggest only minor phenocryst variation, but extreme variation in matrix color. The color of the matrix ranges from whitish grey to dark red, with the white colored matrix being more common. In hand sample, only slight variations in the phenocryst assemblage is observed with the dominant phases being quartz, sanidine, and plagioclase. Lithic and pumice fragments are common in throughout each section. Petrographic analysis suggests that the most distal reach of the flow had a greater modal percent matrix, while the most proximal samples had a greater modal percent of phenocrysts. The most proximal samples contain more phenocryst-sized quartz, while the most distal samples had more groundmass-sized quartz. These relationships were observed regardless of lateral or stratigraphic position suggesting a single cooling unit.

THE PRE-ERUPTIVE MAGMATIC CONDITIONS OF THE BLOODGOOD CANYON TUFF: INSIGHTS FROM ALKALI FELDSPAR AND QUARTZ CRYSTAL SIZE DISTRIBUTIONS AND MINERAL CHEMISTRY

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The Bloodgood Canyon Tuff (28.05 ±0.05 Ma) is the largest single ignimbrite erupted within the boundaries of the Mogollon Datil Volcanic Field (MDVF) in southern New Mexico. The MDVF erupted 12,000 km$^3$ of rhyolite in 30 ignimbrites from an estimated 15 calderas between 36 and 24 Ma. Ignimbrite flare-up occurred as a result of the relaxation of compressional stress at the end of the Laramide orogeny. The tuff is sourced from the Bursum caldera and covers an area of ~15,000 km$^2$ with an estimated volume of ~1300 km$^3$. Stratigraphically and laterally the Bloodgood Canyon tuff is a geochemically variable high silica rhyolite with a consistent mineralogy, but variable crystallinity. Phenocryst phases include alkali feldspar, quartz, biotite and hornblende with minor Fe-Ti oxides and apatite. Groundmass phases include quartz, biotite, zircon, Fe-Ti oxides and apatite. Here we present crystal size distributions (CSD) of alkali feldspar and quartz from 30 thin sections representing stratigraphic section at variable distances from the source to assess the conditions of the pre-climatic magma chamber. We separate pumice hosted crystals from ash-hosted crystals. We combine this information with textural analysis and mineral chemistry data from three sections representative of the stratigraphic
column to assess the thermal state of the magma chamber and present a model for the pre-eruptive conditions of the Bloodgood Canyon tuff magma plumbing system.

CSD patterns for the Bloodgood Canyon tuff samples record three crystallization periods and textures of the feldspars suggest thermal disequilibrium in the chamber. The textures along with the concave up pattern of the CSDs suggest injection of hotter mafic magma into a crystal mush early in the eruptive history. Samples at the top and middle of the section trend towards larger crystal sizes and higher percent crystallinity. Quartz CSD patterns are similar to alkali feldspar suggesting co-crystallization of both alkali feldspar and quartz. Mineral chemistry of alkali feldspar show little variation in %Or and FeO. Sr, Ba and Pb trace element compositions are more variable, suggesting that the mixing magma was of similar composition to the mush.

PETROLOGY AND GEOCHEMISTRY OF RHYOLITE TUFFS OF THE BELL TOP FORMATION, DONA ANA COUNTY, NEW MEXICO

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The Mogollon-Datil Volcanic Field (MDVF) in Southern New Mexico has many exposed ignimbrites of Eocene-Oligocene age. During this time, subduction of the Farallon Plate beneath the North American plate transitioned to extension of the Rio Grande Rift, leading to an ignimbrite flare-up in southern New Mexico. The caldera forming eruptions produced numerous ash flow tuffs including the Bell Top Formation tuffs, which are divided into four members. The Bell Top Tuffs have been dated by $^{40}$Ar/$^{39}$Ar with ages ranging from 31.4 Ma to 42.1 Ma. These tuffs are suggested to have come from two calderas during the first episode of volcanism of the MDVF ignimbrites. Here we present new thin section petrography and major and trace element geochemistry from 16 samples representing Tuff 2-4 and compare these data with samples from the Kneeling Nun Tuff (Bell Top 5) and similar age ignimbrites from southern New Mexico. Samples were collected from two stratigraphic sections in the Sierra De Las Uvas Mountains, consisting of six ridge defined outcrops. The Bell Top Tuffs 2-5 are defined as small-volume ignimbrites (<100 km$^3$). Geochemically, the Bell Top Tuff samples are trachyte to high silica rhyolite (67-75 wt% SiO$_2$). Tuffs are crystal poor with phenocryst phases consistent through the members to include quartz, K-spar, plagioclase, biotite and trace hornblende, apatite, and zircon. Tuff 2 is a vitric ash flow tuff with well-developed eutaxitic texture and locally contains spherulitic zones. The hand sample contains 30% ash 25% quartz, 20% biotite, 10% lithics, 10% pumice, and 5% plagioclase. Tuff 3 is distinct with a large volume of pale-red pumice making up ~20% of the total volume; it contains 80% pumice, 15% quartz, and 5% biotite with a pink matrix that is about 72% of the hand sample. The outcrop has a gradual incline that leads up to a steep face. Tuff 3 looks pinkish-orange on the weathered face. Tuff 4 contains a lower volume of pumice, but the pumice have been flattened and are larger, up to 30 cm along the long axis. The hand sample contains 35% quartz, 20% glass, 20% biotite, 10% lithics, 10% pumice, and 5% plagioclase. We suggest that the three Bell Top Tuffs (2-4) represent eruptions from at least two different sources. The Bell Top 2 and 3 are sourced from the Organ Caldera and the Bell Top 4 tuff sourced from a similar magma chamber to the Kneeling Nun Tuff.
INTERMEDIATE VOLCANIC ROCKS OF THE WESTERN MOGOLLON-DATIL VOLCANIC FIELD, SOUTHERN NEW MEXICO: A CHANGE IN MAGMATIC SOURCE AFTER IGNIMBRITE FLARE-UP

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The Mineral Creek and Last Chance andesites located in the western Mogollon Datil Volcanic Field (MDVF) of southern New Mexico are indistinguishable in hand sample. These units are regionally extensive throughout the Mogollon Mountains and are some of the stratigraphically youngest intermediate composition volcanic rocks in the MDVF. The Mineral Creek andesite has been dated at 25.0 ±0.5 Ma. It is reddish brown to gray crystal-poor andesite and basaltic andesite lava flows with interbedded mudflows and alluvial sandstones at the base of the unit. Lava flows contain a few percent phenocrysts of plagioclase, CPX and rare olivine. The Last Chance andesite has been dated between 25.0 to 23.2 Ma. Basaltic andesite and andesite lava flows and breccias are crystal-poor but contain approximately 5% phenocrysts including flow aligned plagioclase (An₃₀-An₅₀) > oxides + olivine and CPX.

Here we present new major and trace element data combined with mineral textural and field data to distinguish between these units for 11 whole rock samples. We also present a working geochemical model to decipher the relationship of the two units to one another and how the units are related to bimodal magmatism associated with the Mogollon Datil ignimbrite flare-up. Both andesites are monotonous medium-K, calc-alkaline rocks with 51.0-62.7 wt.% SiO₂, FeO_T from 4.7 to 10.9 wt.% and display similar major element abundances. Trace element contents are variable between the units (Sr= 290-787 ppm; Rb= 36-238 ppm) and Sr isotopic ratios (⁸⁷Sr/⁸⁶Sr= 0.70495-0.70994) suggest at least two unique sources. Eu anomalies (0.91-.083) of all samples suggest plagioclase fractionation in a variable garnet stable source. The Mineral Creek Andesite is higher in SiO₂ content (SiO₂= 58.5-62.7 wt.%), lower FeO_T (4.7-8.9 wt.%) and higher Rb/Sr ratio (0.17-0.68) than the Last Chance Andesite (SiO₂= 51.0-53.2 wt.%; FeO_T= 9.16-10.9 wt.%, Rb/Sr= 0.05-0.08). Sr/Y ratios versus Y concentration and Rb/Sr ratios versus Sr concentration suggest that two geochemically distinct sources for the Last Chance and Mineral Creek andesites. The Mineral Creek Andesite is sourced from a garnet stable, plagioclase-free unstable source, while the Last Chance Andesite is sourced from a plagioclase stable, garnet free source.

ANALYSIS OF PETROFABRICS IN THE JURASSIC TUTTLE LAKE FORMATION NEAR GRASS LAKE; MOUNT TALLAC ROOF PENDANT, EL DORADO COUNTY, CA

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Three-dimensional R/phi analysis of petrofabrics in exposures of the Jurassic Tuttle Lake Fm in the southernmost Mt Tallac roof pendant reveals an interesting pattern of generally subhorizontal oblate fabrics. Our analysis was conducted in the vicinity of Grass Lake in the Desolation Wilderness Area of Eldorado National Forest. Here, the Tuttle Lake Fm is characterized by a weakly metamorphosed sequence of debris flows of matrix-supported volcanioclastic breccia and conglomerate. These rocks are cut by at least five sets of Jurassic dikes, the Keiths Dome pluton, and an array of predominantly sinistral ductile shear zones and brittle faults. We hypothesized that penetrative fabrics observed in the Tuttle Lake Fm were associated with either subduction-related convergence or with the intrusion of local plutons. To test these hypotheses, we measured petrofabrics in at least three near-orthogonal faces containing clasts with discernable boundaries at 22 locations in the area between Grass Lake and the Keiths Dome pluton. Outlines of at least 60 clast boundaries were traced from each face onto clear plastic overlays. Photo-registration marks and the strike and dip of each face were also recorded onto overlays. Photographs of overlays were adjusted, rectified, and reoriented in Adobe Photoshop. The software program EllipseFit (Vollmer, 2017) was used to conduct the R/phi analysis of the clasts in each tracing and to compile mean fabric ellipsoids at each location. Our results reveal a range of fabric intensities (E = 0.15-0.79) and symmetries (ν = -0.43-0.71), and weakly oblate to moderately prolate shapes (k = values 0.28-3.05). When bedding is restored to horizontal, oblate fabrics appear to be roughly consistent with vertical flattening associated with deposition and compaction. Two locations exhibit stronger prolate fabrics with subhorizontal long (X) axes that trend N-S, and subhorizontal short (Z) axes that trend E-W. The X axes of these two samples correlate poorly and with trends of dikes, shear zones, and faults in the Grass Lake area. Oblate fabrics are likely either related to deposition and compaction or are associated with the intrusion of a pluton at depth. The slight SW-NE distribution of the short (Z) axes of these fabrics may support the latter hypothesis.

GEOBAROMETRY OF GRANITOIDS AND U-PB DETRITAL ZIRCON GEOCHRONOLOGY OF OVERLYING SEDIMENTARY COVER IN THE NORTHERN SALINIAN BLOCK, CALIFORNIA

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The Northern Salinian block (NSB) preserves a contact between early Mesozoic to late Cretaceous crystalline basement and Tertiary sedimentary rocks. The plutonic basement ranges from biotite- and hornblende-bearing tonalite to granodiorite, intruded into Sur Series pendant and screen metasedimentary rocks. Sedimentary rocks rest on the basement, and consist of conglomerate, chert, and turbidite sequences, which range from Paleocene to Miocene in age. The NSB originated some 150-200 km southeast of its current location, and is conjectured to be the upper plate of the Late Cretaceous Southern Sierra Nevada detachment system.
To determine the nature of the basement-sedimentary contact and the original tectonic setting of these rocks, we conducted a field, geochemical, and geochronological study of the granitoid basement and Paleocene deep-marine sedimentary cover at Montara Mountain and Bodega Head. At both locations, granitoids display early brittle-ductile shear zones crosscut by a late brittle deformation. Preliminary petrographic observations of the shear zone rocks show undulose extinction in quartz and brittle fracture in plagioclase, overprinted by a cataclastic fabric. It is not clear whether this deformation occurred during San Andreas-related deformation or during unroofing of the Southern Sierra Nevada. To approximate the paleogeographic location of the NSB, the Al-in-hornblende geobarometer of Schmidt (1992) was used on the granitoids, yielding crystallization pressures of 6.8 to 7.6 kbar at Montara and 3.9 kbar at Bodega Head. While the Bodega Head pressure is consistent with both the previously published data for the Southern Salinian block and the hypothesized upper crustal section in the Cummings Valley area east of Bakersfield (Wood and Saleeby, 1997), the Montara Mountain pressures are surprisingly high, similar to rock found in the footwall of the Southern Sierra detachment located in the Techachapi mountains. Additional data will be presented on U-Pb geochronology of detrital zircons from sandstones collected at Montara. Together, the NSB granitoid basement and overlying sedimentary rocks may preserve some of the history of extension and formation of a supradetachment basin during exhumation of the Southern Sierra Nevada.

COMBINING REMOTE SENSING AND PETROLOGY DATA IN THE NORTH QIADAM UHP TERRANE, CHINA

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ASTER images collected of the Qaidam basin in northern Tibet show exposures of ultra-high-pressure (UHP) metamorphic rocks interfolded with an ophiolite sequence. These units are both thought to be large bodies of consistent age formed by a single tectonic event, with a genetic relationship proposed to exist between them. However, this is still speculative due to a lack of detailed geologic data and mapping in these remote areas of Tibet. Using ASTER imagery and spectral properties, more data about the potential genetic link between these exposures can be obtained. Four localities along the north Qaidam margin were examined; Dulan Shan, Xitie Shan, Luliang Shan, and Qing Shan. Specific focus was placed on Luliang Shan, as fieldwork done in that area provided a detailed field map and petrologic samples of the rock units to us as a comparison to spectral data. These rock units were spectrally analyzed with bandwidth ratios and band-math, then compared with the field samples to confirm where the different rock units were present and what factors caused the distinct contacts visible in the ASTER images. Isolating the factors that distinguished between the UHP metamorphics, granitic intrusions, and the Ophiolite sequence in the ASTER imagery could allow these factors to be applied to imagery of other remote areas in the Himalayas, providing geologic data without needing to reach these areas to do fieldwork.
A STUDY OF LUECOBANDS IN THE WAX FACTORY LACCOLITH, BIG BEND RANCH STATE PARK, TX

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The Wax Factory Laccolith (WFL) is located in Big Bend Ranch State Park, TX. The WFL is approximately 32 Ma in age, and is part of the Trans Pecos Magmatic Province (TPMP) which was formed between 48 and 17 Ma. The WFL is composed mostly of monzonite, but has numerous light colored bands (“luecobands”) of syenite with various shapes including irregular “blebs” up to 2 meters in size and horizontal bands approximately 10 cm thick. Prior studies of the laccolith lacked an adequate interpretation of the light colored bands. A previous hypothesis (Farmer, 2017) suggested that the bands were caused by alteration of the rock by local spring water. Scanning Electron Microscopy (SEM) and X-Ray Fluorescence (XRF) analysis conducted on the luecobands reveals that the syenitic luecobands have an overall similar mineralogy to the monzonite, but a distinct difference in mineral composition, contradicting the hypothesis by Farmer. The variation is concluded to have been caused by crystal fractionation. This hypothesis has been supported by major and trace element models. The models use a parent monzonite composition that evolves to the syenite composition with the removal of approximately 50% by mass of the observed minerals plagioclase, pyroxene, Fe-Ti oxides and apatite. In this model, the host monzonite magma formed originally and crystallized to a partially solid crystal framework. Subsequent evolved syenitic magma intruded into this framework in the form of the blebs and horizontal bands. This study contributes to our understanding of the petrogenetic history of the WFL and of our overall understanding of the TPMP.

ASSESSING QUATERNARY TECTONIC UPLIFT IN THE ARROYO INFIERNO, SANTA ROSALIA BASIN, MEXICO, USING FIELD MAPPING AND MORPHOMETRIC INDICES

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The Santa Rosalía basin is located on the eastern shore of the Baja California peninsula in México. Strike-slip faulting and extensional rifting caused basin subsidence and offset during the Late Miocene through Pliocene epochs. During the Pleistocene, volcanic activity in the region included buildup and collapse of La Reforma caldera. After eruption of extensive ignimbrites from 1.4–1.1 Ma (Schmitt et al., 2006), fluvial and marine terraces formed along the arroyos and on the coast. The main research objective of this project is to quantify neotectonic activity in Arroyo Infierno by measuring terrace characteristics such as stability of the surfaces, degree of soil development, and landscape position. In the field, strath and fill terraces were digitally mapped using QGIS on field tablets, and older and modern channel stream long profiles were
plotted to identify changes in elevation with distance upstream. Soil properties were described for both the fluvial and marine terraces. In the lab, soil grain size analyses were combined with the field properties to develop a chronosequence of the terrace surfaces. A set of three distinct terraces, separated by 30–50 m of elevation gain, was observed. Younger terrace soils have a higher sand to clay content, the latter increasing in older, higher terrace soils. Bk soil horizons are thicker on the higher elevation fluvial terraces, confirming that they are older. An area of higher than average stream slope gradients was detected in upstream tributaries of Arroyo Infierno. A harder, more resistant volcanic rock type upstream of this area is the most probable explanation for this observation, rather than a migrating knickpoint. It is concluded that Arroyo Infierno has a history of relative uplift and base level change that has caused not only vertical incision and terrace preservation, but also a stream capture that displaced the location from the ~125 ka lower Arroyo Infierno about 1 km north to the present-day canyon.

KINEMATIC ANALYSIS OF NEOGENE AND QUATERNARY FAULTS IN THE SANTA ROSALIA BASIN ALONG THE MARGIN OF THE GULF OF CALIFORNIA, BAJA CALIFORNIA SUR, MEXICO

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The Santa Rosalía Basin is located on the western shore of the Gulf of California in central Baja California Sur, México. This study identifies fault types and orientations and differs from previous investigations by taking advantage of excellent new exposures created by Minera Boleo mining operations. Volcanic rocks were measured in arroyo outcrops, and most other measurements were collected from mine cuts. Fault rocks including fault gouge and breccia were sampled and analyzed with petrographic, XRD, and SEM methods, revealing abundant mineralization of sepiolite within fault zones. We collected orientation data on over 250 faults and slickenlines in multiple unconformity bounded formations in the Santa Rosalía Basin. Fault orientation data were processed in QGIS, Microsoft Excel, Stereonet 9, and Fault Kin 7. Most faults are oblique faults with a normal component, and very few were thrust faults. The data suggest temporal changes in fault orientations and slip directions. Middle to Late Miocene volcanic rocks are dominated by NW- to N-striking oblique-normal faults that dip dominantly SW with moderately-plunging slickenlines. Late Miocene sedimentary rocks (Boleo Formation) are cut by steeply-dipping, NNW- to NNE-striking oblique-slip faults, with a wide range in plunge of slickenlines. Faults that cut the Pliocene sedimentary rocks (Tirabuzón and Infierno Formations) are mostly steeply-dipping NW-striking faults with dominant normal displacement determined from stratigraphic offset and steep plunge of striations. Quaternary marine terrace deposits are cut by predominantly NNE-striking normal faults with no preserved striations on the fault plane. The changes in fault orientations record evolving stress directions during development of the Pacific-North America plate boundary through time. The data are generally consistent with a proposed change from late Miocene ENE-WSW extension to the modern phase of ESE-WNW extension related to dextral offset on NW-striking transform faults in the Gulf of California (Angelier et al., 1981; Stock and Hodges, 1989). This tentative conclusion needs to be tested with future fault-kinematic analysis.
DETRITAL ZIRCON U-Pb GEOCHRONOLOGY OF THE WASATCH FORMATION, POWDER RIVER BASIN, WYOMING

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The lower Eocene Wasatch Formation is more than 1500 m thick in the Powder River Basin of Wyoming. The Wasatch is a Laramide synorogenic deposit that consists of paludal and lacustrine mudstone, fluvial sandstone, and coal. U-Pb geochronologic data on detrital zircons were gathered for a sandstone unit in the middle part of the succession. The Wasatch was collected along Interstate 90 just west of the Powder River Basin rest area, which is about 50 km east of the Bighorn Mountain front. The sandstone is lenticular in geometry and is a feldspathic arenite. The detrital zircon age spectrum ranged (n=100) from 1433-2957 Ma in age, and consisted of more than 95% Archean age grains, with an age peak of about 2900 Ma. The 2900 Ma age peak is consistent with the age of Archean rocks at the core of the Bighorn Mountains. The sparse Proterozoic grains were likely derived from the recycling of Paleozoic sandstone units. Three conclusions can be drawn from these data. First, the Wasatch sandstone is a first cycle sediment. Second, the Archean core of the Bighorn uplift was exposed and shedding sediment into the Powder River basin during Wasatch time. Very little recycling of Paleozoic strata is evident. Third, the Powder River Basin Wasatch detrital zircon age spectra are distinct from the coeval Willwood Formation in the Bighorn Basin west of the Bighorn Mountains. The Willwood was derived from the Sevier highlands to the west, which indicated that Laramide sediment transport off the Bighorn uplift was strongly asymmetric and directed largely to the east.

GEOLOGIC EVOLUTION OF THE GULF OF CALIFORNIA NEAR MULEGÉ, BAJA CALIFORNIA SUR: RESULTS FROM BAJA BASINS NSF-REU (RESEARCH EXPERIENCE FOR UNDERGRADUATES)

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This study examines the stratigraphy and structure of volcanic and volcanioclastic rocks in the Gulf of California rift ten km east of Mulegé, BCS, Mexico. The volcanic rocks had not been divided and nothing was previously known about this region’s structure. A 390 km² mapped area is divided into two distinct regions by a N-S, steeply dipping fault: (1) West of the fault, an >820 m thick, volcanioclastic red bed sedimentary formation. The red beds include an eastern section of polymict volcanioclastic debris flow deposit and massive sandstones, interfingering westward with fluviually deposited conglomerates, fine-grained sandstones and siltstones. The red beds are interpreted to be a clastic wedge shed into a half graben separated from an uplifted arc to the east by a west-dipping normal fault. Block-and-ash-flow tuffs are interstratified with proximal (eastern) parts of the red bed graben fill, suggesting collapse of lava domes plumbed up the
graben-bounding fault to the east. The red beds were then cut by a NE to ENE-striking dike swarm. (2) East of the fault lies a lava shield complex. Each lava shield has lavas and flow breccias that dip radially away from the center, with primary dips of 20-30°, and a radius of 1.2 – 2.5 km. The composition of the lavas on the east side of the fault is similar to that of the dikes on the west side of the fault. The base of the lava shield complex is exposed in one area, where it rests on the proximal red bed sequence. Based on this, we infer that the N-S fault that divides the map area has a >800 m down-to-the-east normal component of slip, and that lava shields on the west were eroded away, leaving the feeder dikes exposed. Finally, planation occurred across a broad surface, and widespread mesa-forming aphyric lavas were deposited on the surface. ⁴⁰Ar/³⁹Ar geochronology in progress on the block-and-ash-flow tuffs, the dikes, the lava shields and the mesa-forming lavas will test this model.

DEFORMATION AND KINEMATICS IN THE TOXAWAY DOME, EASTERN BLUE RIDGE

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The Toxaway Dome (TD) is composed of Grenville aged granitic gneiss, located northwest of the Brevard fault zone in the Eastern Blue Ridge of North and South Carolina. The dome is surrounded by metasedimentary rocks of the Tallulah Falls Formation (TFF). Previous authors suggest that the TFF unconformably overlies the dome, and that dome formation can be attributed to complex multiphase refolding of previous structures. However, the formation of gneiss domes elsewhere have been associated with faulting. This latter interpretation is consistent with some authors’ observations of a shear zone along the TD boundary. We use optical microscopy, electron backscatter diffraction (EBSD), and extensive field work to better determine the nature of the boundary and the possible role and conditions of faulting in the formation of the TD.

Deformation conditions can be constrained from quartz and feldspar recrystallization fabrics using optical microscopy and EBSD. Samples throughout the Toxaway Dome contain quartz that is elongate with pinned recrystallized quartz grains between layers of micaceous minerals, amoeboid grain boundaries, and grains with incipient chessboard extinction. These microstructures suggest fast grain boundary migration recrystallization in quartz. Feldspar grains in the Toxaway samples contain subgrains, undulose and patchy extinction, and serrated and finely recrystallized grain boundaries. These textures indicate bulging recrystallization in feldspar. The recrystallization textures seen throughout the dome and across the dome boundary suggest temperatures of deformation range between 500 - 650 °C.

Rock units within and immediately surrounding the Toxaway Dome have been mylonitized and contain kinematic indicators including, S-C fabrics, C’ fabrics, sheared garnet porphyroblasts, and feldspar porphyroclasts. Kinematic indicators throughout the area indicate a complex pattern of strain and are most consistent with the presence of a shear zone at the dome boundary that was active under amphibolite facies conditions.
DETRITAL ZIRCON GEOCHRONOLOGY OF THE PERMIAN ABO FORMATION AND PERMIAN LABORCITA FORMATION, SACRAMENTO MOUNTAINS, NEW MEXICO, USA

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The exposures of Paleozoic strata, which are more than 2500 m thick and range in age from Cambrian to Permian, in the Sacramento Mountains of New Mexico reveal important information for understanding of the paleogeography and timing of the late Paleozoic Ancestral Rocky Mountain orogeny in general, and the Pedernal Uplift in particular. The lower Permian (Wolcampaian) strata consists of two formations: the Laborcita and the Abo Formations, resting above the Ancestral Rocky Mountain Unconformity. The late synorogenic Laborcita is an ~300 m thick succession of gray and red limestone pebble conglomerate, sandstone, siltstone, shale and limestone deposited in fan delta or deltaic systems. The flat-lying, post-tectonic Abo Formation ranges from 120-450 m in thickness and consists of dark-red mudstones, arkoses, and basal quartzite cobble conglomerate. Otte (1959) recognized that paleocurrent data indicated that Abo sediment was transported south and west along the axis of the Pedernal uplift. U-Pb geochronology on detrital zircons were conducted on both the Laborcita (n=103) and Abo Formation (n=103) sandstones to determine the sedimentary provenance and sediment dispersal patterns. Zircons in the Laborcita ranged in age 1125-1865 Ma, and have a unimodal peak age of 1220 Ma, and about 80% being Grenville in age. Zircons in the Abo were exclusively Grenville in age, ranging from 1193-1308 Ma with a peak age of 1235 Ma. The most likely source for these zircons are recycling Grenville synorogenic strata that were exposed to the south during the late Paleozoic. These include the Lanoria Quartzite, which occurs in the Franklin Mountains, and the Hazel Formation, which occurs near Van Horn, Texas. The protolith sandstone of the Lanoria Quartzites was derived from the central Texas Llano region before being transported west to the Rodinian continental margin ~1110 Ma where it was buried and metamorphosed into quartzite. The similarity of the age spectra for these two units indicates that the same source area supplied sediment during and after the local compressional tectonism.

PRELIMINARY ANALYSIS OF ANISOTROPY OF MAGNETIC SUSCEPTIBILITY AND PALEOMAGNETIC FABRICS WITHIN EXHUMED PORTIONS OF THE NANKAI ACCretIONARY COMPLEX, KII PENINSULA, JAPAN

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Since the early Miocene, the Nankai margin has experienced periods of oblique subduction, resulting in changes in the pace of accretion and the development of trench-slope-basin depositional environments. We collected samples from the Kii Peninsula NNW of the NanTroSEIZE focus area in a feasibility study for the use of anisotropy of magnetic susceptibility (AMS) and/or paleomagnetism to provide kinematic constraints on the evolution of the Nankai margin. In particular, we aim to test the hypothesis that depositional environments evolve progressively with deformation. Preliminary analyses were conducted on seven hand samples of very fine-grained sandstone and siltstone collected from exhumed sections of the accretionary complex on the Kii Peninsula. Analysis of mean coercivities and dispersions suggests the magnetic mineralogy includes pedogenic magnetite, detrital magnetite, magnetofossils, hematite, and goethite. Six samples fall within the range of a pseudo-single domain magnetite (Mr/Ms 0.1-0.5, Hr/Hc 2-4), but one falls in the range of superparamagnetic domain magnetite (typical Mr/Ms values << 0.01, Hr/Hc > 10). Analysis of AMS cores prepared from the same samples yields highly consistent results. Most AMS ellipsoids are characterized by oblate shapes (i.e. T > 0). The corrected degree of anisotropy (Pj) is low and varies from 1.00-1.06. Within most samples, the variation in Pj was <0.01. Five of seven sites yield consistent orientations with respect to the orientation of the AMS ellipsoids. The long and short axes (K1, K3) roughly plot along steeply dipping great circles, while the intermediate axes (K2) tend to cluster shallow, NS orientation. Paleomagnetic results were far less consistent. All samples were subject to alternating field demagnetization up to 200 mT. Only three of seven sites analyzed yielded internally consistent results (a95 < 15°). These sites are characterized by single or two component systems, but the high coercivity components were not orientated in the same direction. Our preliminary results indicate the targeted units are solid candidates for AMS analysis. The lack of consistency in the paleomagnetic analyses suggest (1) a large volume of samples from these are needed to produce statistically significant results and/or (2) alternate formations should be targeted.

CONSTRAINTS ON UPLIFT FROM GEOMORPHIC ANALYSIS OF A DIGITAL ELEVATION MODEL OF THE CENTRAL RANGE MOUNTAINS, TRINIDAD

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Trinidad is located on the boundary between the South American continent and the Caribbean Plate, which translates eastward approximately 20 mm/yr, relative to a fixed South American. This movement is primarily expressed in the Central Range Fault zone (CRFZ), which accommodates 12 mm/yr of strike-slip motion and 4 mm/yr of convergence. The transpressional nature of the CRFZ is reflected in the rise of the Central Range Mountains, which likely began forming at the same time the CRFZ became active. We used ArcGIS to analyze an ASTER-based digital elevation model (DEM) to characterize 23 drainage basins within the CRFZ. Elevation and area data for each basin were imported into MATLAB to generate hypsometric curves, used as a proxy for the maturity of the basins. Twenty-one basins displayed mature curve profiles, while the remaining two were characterized by less mature, more linear hypsometry. The relatively small size of these two drainage basins, along with the weakly resistant siltstone and shale bedrock characteristic of the CRFZ, may account for the variation in basin maturity. Erosional processes in larger stream basins may be occurring at rates that rapidly eliminate any
significant changes to hypsometry created by tectonic uplift. Long profiles from each basin suggest that knickpoints are preserved throughout the CRFZ. Analysis of the frequency distribution of elevations in the long profiles suggest a local base level of approximately 20 m elevation and an uplifted surface at approximately 70 m in elevation. Together these values imply the Central Range has experienced at least 50 meters of uplift. The Central Range Mountains have an average divide height of 150 m which equates to a mean erosion rate of 0.01 mm/yr following the relief vs. erosion rate data compiled by Montgomery and Brandon (2002). Removal of 50 m at 0.01 mm/yr implies that uplift in the CRFZ began 5 Ma. The true rate of erosion, however, is likely higher than that suggested by the global data set presented by Montgomery and Brandon (2002) because of the tropical climate in Trinidad and weakly-resistant bedrock. This age estimate could be improved greatly by local constraints on erosion rate (e.g. cosmogenic studies). Regardless, both the hypsometric and long profile analyses indicate that a tectonic signal is preserved in the topography of the CRFZ.

PALEOMAGNETISM OF AN ARCHEAN HARZBURGITE, BIGHORN MOUNTAINS, WYOMING, USA

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A circular harzburgite intrusion (1 km diameter) intrudes 3000 Ma gneisses in the hangingwall of the Laramide Bighorn uplift in Wyoming. The harzburgite is composed of pristine orthopyroxene (bronzite), clinopyroxenite, olivine and accessory Fe-oxides with little outcrop fabric other than joints. A preliminary U-Pb zircon (n=12) Concordia age of 2926 ± 11 Ma (MSWD = 5.5), and a weighted mean average age of 2919 ± 10 Ma (MSWD = 3.6), has been determined. The harzburgite is crosscut by a hydrothermally altered ultramafic dike (N20°E, 90°, 1 meter wide) with no zircons recovered. Anisotropy of magnetic susceptibility (AMS) was used as a proxy for magmatic intrusion and the harzburgite preserves a sub-vertical K\textsubscript{max} fabric (n=18) suggesting vertical intrusion. The ultramafic dike preserves a K\textsubscript{max} fabric (n=19) that plots along the great circle of the dike and is difficult to interpret. Alternating Field (AF) demagnetization for the harzburgite yielded a paleopole of 177.7 longitude, -14.4 latitude (α\textsubscript{95}=3.4). There is a two-component magnetization preserved in the harzburgite which suggests a younger Cretaceous chemical overprint that may indicate a 90° clockwise vertical axis rotation of the Clear Creek thrust hangingwall, a range-bounding, east-directed thrust fault responsible for uplifting the Bighorn Mountains in Eocene the Laramide Orogeny.

NEW COSMOGENIC AND VML DATES AND REVISED EMLACEMENT HISTORY OF THE ICE SPRINGS VOLCANIC FIELD IN THE BLACK ROCK DESERT, UTAH

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The development of robust dating methods (Cosmogenic Dating & Varnish Microlamination (VML)) makes it possible to date young lava flows in the Ice Springs Volcanic Field (ISVF) in the Black Rock Desert, Utah. ISVF is hypothesized to be a compound polygenetic volcano due to multiple cinder cones (Miter, Terrace, Pocket, & Crescent), eruptions, and magma batches. This study aims to determine the flows’ emplacement sequence and ages in order to place the ISVF in geologic context and improve understanding of its eruption history. Two pahoehoe samples were collected from the Miter/Terrace boundary and within the Miter flow for whole-rock cosmogenic \( ^{36}\text{Cl} \) dating at the Purdue PRIME Lab. The CRONUS calculator was used to find minimum and maximum ages that are in disagreement with Valastro et al.’s (1972) radiocarbon age of 660 ± 170 years. New cosmogenic ages for the Miter/Terrace boundary range 9.4 (±1.3) - 10.9 (±1.6) kyr and 10.9 (±1.6) - 11.3 (±1.5) kyr for the Miter flow. VML ultra thin sections were made from 3 samples of the Miter/Terrace flows to independently estimate the age, dating the samples as old as ~12.5 kya. Earlier studies found that Crescent and early Miter flows contain high silica (>51 wt.%) while later Miter and Terrace lavas contain low silica (<51 wt.%). Early Miter and Crescent are distinguished by differences in FeO* and TiO\(_2\). New whole-rock geochemical data (XRF, The College of Wooster) show that some “early Miter” samples overlap with the Crescent lavas in their SiO\(_2\), FeO*, and TiO\(_2\) compositions, and may have been erupted from Crescent. Samples collected north of the Miter/Crescent boundary contain low silica, suggesting that the Miter lava flow continues north of the formerly hypothesized boundary. The geochemical boundary corresponds to a change in the lava morphology. Crescent flows form a’a lava with rafted cinder material. Miter lavas comprise slabby, disrupted terrain with a distinct lava channel. Additional geochemical, cosmogenic, and VML work will help clarify the nature of the Miter/Crescent boundary. Our new dates and revised flow boundaries are consistent with the compound polygenetic volcano classification and further enhance our understanding of the ISVF in the geologic history of the Black Rock Desert.

EXPLORING PALEOMAGNETISM AS A TOOL FOR RESOLVING THE TIMING OF IGNEOUS INTRUSIONS IN THE MOUNT TALLAC METAMORPHIC ROOF PENDANT; DESOLATION WILDERNESS AREA, ELDORADO NATIONAL FOREST, CA

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An important chapter in the history of the subduction-related volcanic arc along western North America is recorded in the metamorphic roof pendants in the Sierra Nevada. Among these remnants, the Mt Tallac pendant is the largest and most well exposed. Outcrops near Grass Lake in the southern Mt Tallac pendant include the polymict, matrix-supported volcanic breccia of the Tuttle Lake Fm, which is interpreted as Middle Jurassic (166-163 Ma) based upon fossils in the
underlying Sailor Canyon Fm. The Tuttle Lake Fm is first cut by at least five sets of intermediate dikes and finally by the Keiths Dome quartz monzonite pluton. While not directly dated, the Keiths Dome pluton is estimated to be Late Jurassic (158-148 Ma) based upon contact relationships elsewhere. Taken altogether, the relationships at Grass Lake suggest that in as little as 10-20 Ma, the area underwent an incredibly rapid geologic evolution from the deposition of debris flows in intra-arc submarine basins, to the intrusion of hypabyssal networks of dikes feeding stratovolcanoes, and ultimately the intrusions of the plutos supplying magma to the arc. In an attempt to further resolve the timing of events in the Mt Tallac pendant, we present results of a paleomagnetic analysis of the youngest of the Grass Lake dikes. Seven samples were collected at ~20 m intervals along the length of a single porphyritic andesite dike. The dike strikes perpendicular to and is cut by the contact with the Keith’s Dome pluton, which provides an opportunity to determine if the thermal pulse from plutonism altered and/or reset the primary thermal magnetization carried by the dikes. Analysis of mean coercivities and dispersions suggests the samples contain magnetite, hematite, and goethite. Analysis also suggests that six of the seven samples contain single domain magnetite (Mr/Ms ~ 0.5, Hr/Hc 1-2) while one is dominated by single domain hematite (Mr/Ms 0.5-0.7, Hr/Hc 1.45-1.62). Six of seven sites responded well to alternating field demagnetization up to 200 mT, all of which display one or two component systems. The high coercivity component for individual sites are well clustered (a05 = 4-13˚), with no statistically significant variation in site mean orientation as a function distance from the pluton contact. Orientations are consistent with emplacement in the Late Jurassic (158-146 Ma).

A COMPARISON OF RF/PHI AND AMS FABRICS WITHIN STRATA INVOLVED IN THE VARISCAN FOLD-THRUST BELT; WESTERN IRISH NAMURIAN BASIN, COUNTY CLAIRE, IRELAND

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Analysis and comparison penetrative Rf/Phi and anisotropy of magnetic susceptibility (AMS) fabrics in rocks deformed in fold-thrust belt deformation in western Ireland suggests that despite being involved in map-scale structures, Rf/Phi fabrics are generally consistent with deposition and compaction whereas AMS fabrics may provide a better proxy for tectonic shortening directions. Deformation in the Western Irish Namurian Basin (WINB) involves the thick sequences of siltstone and fine-grained sandstone of the Shannon and Central Clare Groups. Between the Loop Head Peninsula and the Cliffs of Moher, these strata are involved in an East-West trending array of nine first-order, kilometer-scale thrust-related folds. Rf/Phi and AMS fabrics were measured in five oriented samples collected from the Ross, Tullig, and Kilkee Formations. The results of 3D Rf/Phi analysis conducted using the EllipseFit (Vollmer, 2017) computer program indicate that grain-based fabrics are very weak (R 1.019 - 1.14) and predominantly oblate (k 0.19 - 0.71). Only one sample yielded a prolate fabric (k 1.21). X axes orientations in most of the Rf/Phi fabrics trend nearly perpendicular to the ENE structural grain
defined by the trends of thrust fault-related structures. Analysis of the mean coercivities and dispersions in these samples suggests the magnetic mineralogy includes magnetite, hematite, and goethite. Magnetite ranges from pseudo-single (Mr/Ms 0.1 - 0.5, Hr/Hc 2 - 4) to multi-domain (Mr/Ms values << 0.01, Hr/Hc > 10). AMS analysis measured strongly oblate in all samples except the prolate Rf/Phi sample. The corrected degree of anisotropy (P_j) is low and varies from 1-1.06. With bedding restored to horizontal, the long (K1) and intermediate (K2) axes of the AMS ellipsoids are subhorizontal and the short axes (K3) are subvertical. Interestingly, the K1 axes orientations measured at two of the sample locations do appear to loosely correlate with the ENE structural grain, which suggests that the AMS fabrics may reflect some component of layer-parallel shortening. In this case, AMS fabrics may be a more sensitive proxy for tectonic fabrics than those measured using traditional methods of grain-scale deformation.

**DIFFERENTIATING THE UNDIFFERENTIATED: MAPPING COMPLEX NEOPROTEROZOIC VOLCANIC AND GLACIOGENIC STRATIGRAPHY IN THE MOUNT ROGERS AREA, SW VA**

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Evidence of Cryogenian glaciation is found around the world; however, the triggers responsible for the onset of such intense climate change are complex. A number of glacial episodes, including those of the Neoproterozoic, occur during or soon after major episodes of continental rifting. One such example occurred during initial rifting of Rodinia along the eastern margin of Laurentia (present-day coordinates), which began with intracontinental rifting approximately 780-750 Ma. Evidence for this event is found in rift-related volcanic and sedimentary deposits of the Mount Rogers Formation (MRF) in SW Virginia and NW North Carolina. The MRF, a series of rhyolitic lavas, pyroclastic deposits, basalts and boulder conglomerates, is overlain by glacial deposits of the Konnarock Formation (KF). Representing some of the best evidence of Neoproterozoic glaciation along this margin, the KF consists of maroon, rhythmically layered, mudstone containing dropstones, arkose, conglomerate and diamictite. The age of the KF is uncertain, only bracketed between the youngest dated rhyolite of the MRF (~750 Ma) and the overlying sandstone of the latest Neoproterozoic to Early Cambrian Unicoi Formation. If the age of the KF is more accurately bracketed, its relationship to the global “Snowball Earth” episodes [i.e. Sturtian (715-700 Ma) and the Marinoan (680-635 Ma)] may be determined.

The purpose of our study is to better document the stratigraphic relationships and age constraints between the MRF volcanics and the overlying glacial deposits in SW VA. This region was mapped in detail by Rankin (1993), although in recent years other workers have revised some of his initial structural and stratigraphic interpretations. On Rankin’s map, the area of our research is shown simply as undifferentiated Mount Rogers Formation. Thus far, our mapping of this area has revealed a transitional relationship between MRF conglomerate and KF diamictite, as well as apparent interlayering of rhyolite and KF deposits (as previously suggested by Merschat et al., 2014). This implies that volcanism was still occurring during the glaciation event. If so, the KF is closer in age to the MRF than previously assumed, and therefore represents either a pre-Sturtian global event or a more local or regional glaciation.
A TRAVERSE GEOLOGIC MAP IN THE GLACIER PEAK WILDERNESS: FROM NORTH FORK SAUK RIVER TO GLACIER GAP

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Glacier Peak, the least accessible and one of the most active of Washington’s North Cascades volcanoes, is composed of Cenozoic volcanic rocks that intruded Cretaceous metamorphic rocks which record mid- to lower- crustal deformation during Cretaceous accretion of terranes to North America. To investigate the relationship between Glacier Peak volcanism and pre-existing structural boundaries within the underlying crystalline rocks, we completed a geologic mapping traverse from the North Fork Sauk River trailhead to Glacier Gap, the route typically used by recreational hikers to access the Glacier Peak summit. The traverse covered areas in the Sloan Peak, Glacier Peak East, and Glacier Peak West 7.5-minutes quadrangles.

Thick (>5 meter) river alluvium and rock fall colluvium were observed along the North Fork Sauk River, with exposures of the Nason Ridge Migmatitic Gneiss dominating ridgelines. To the east, garnet-bearing Chiauaukum Schist and intercalated orthogneisses are present. Pressure-temperature estimates will provide insight into the metamorphic and structural interaction between the Nason Ridge Migmatitic Gneiss and Chiauaukum Schist. Pegmatites increase towards the east and a small, intermediate, biotite-rich granodiorite stock is present southwest of White Chuck Glacier. Ignimbrites sourced from Glacier Peak are contained within the White Chuck valley and likely represent valley fill during a previous eruption cycle. Ignimbrites contain Chiauaukum Schist clasts. These ignimbrites are overlain by minor pumice observed atop Glacier Gap, suggesting that while an earlier eruption may have generated pyroclastic flows to the south, a more recent (late Pleistocene?) eruption correlated with Glacier Peak pumice deposits was directed easterly with little southward transport of ejecta. The White Chuck Glacier is significantly smaller than mapped, covering approximately 0.6 km\(^2\) as observed in 2017 compared to a map extent of 0.8 km\(^2\) in 2002 and 2.4 km\(^2\) in 1984 (based on the Glacier Peak West 7.5 minute quadrangle extent of the glacier). An unmapped glacial lake now occupies the foot of the glacier to the west; aerial imagery will be presented to further explore glacial trends in the area.

MAJOR ELEMENT AND NUTRIENT CHEMISTRY OF GREEN AND ROUND LAKES, NY

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Green and Round lakes are adjacent meromictic lakes near Fayetteville, NY. Profiles of Green Lake were completed at a 1 m interval to a depth of 30 m for temperature(T), specific conductance (SpC), dissolved oxygen (DO) and pH. Water samples were collected at seven depths from the surface to 23 m. This allowed access to the upper level of the monimolimnion.
Only surface water samples were collected on Round Lake as access to the lake is prohibited. A chemocline was found to be persistent between 17 and 20 m depth, based on SpC. Additionally, an increase in SpC is seen from the surface to approximately 4 m depth, with relatively constant values between 4 m and the start of the chemocline. Temperature profiles show a shallow epilimnion and a relatively thick metalimnion. Temperature increases at the base of the hypolimnion, then rapidly decreases in the chemocline. Values of pH range from 6.1 to 7.3 within the mixolimnion, but rapidly increase to near 8 below the chemocline. Dissolved oxygen concentrations typically range from 6.7 to 9.5 mg/L in the mixolimnion, but drop to concentrations below 0.6 mg/L below the chemocline. Major cations and anions are dominated by Mg and K, and SO_4^2- an Cl, respectively. Concentrations of Mg were found to range from 285 to 466 mg/L, and show an increasing trend with depth. Sulfate concentrations range from 234 to 678 mg/L, and show a similar increasing trend. Nitrate concentrations vary from 1.8 to 4.1 mg/L with the lowest values below the chemocline. Comparing surface samples from Green and Round Lakes found slightly lower concentrations of all solutes in Round Lake.

VARIATIONS IN SEDIMENT PHOSPHORUS FRACTIONATION ALONG AN ANTHROPOGENIC GRADIENT: EAST BRANCH CAZENOVA CREEK, NY

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Watersheds integrate processes that occur on the land surface in their catchment area and within the stream channel as sediment is transported through the system. The distribution of phosphorus within stream sediments may be influenced by a variety of factors throughout this continuum. This study focuses on an anthropogenic gradient found from the headwaters of the east branch of Cazenovia Creek to where is joins with the west branch in East Aurora, NY. The watershed shows a trellis drainage pattern with numerous small tributaries along its length. Eight sample locations were identified along the stream and sampled for sediment which was analyzed for P fractionation following a modification of the Psenner method. Land use within the watershed upgradient of each sample location was determined using Streamstats. Results show that the percentage of land in forest varied little throughout the watershed, typically ranging from 63 to 69 percent with one outlier. The percentage of urban land use and impervious surfaces was found to generally increase along the gradient. Phosphorus fractions were also found to vary, but not in a regular pattern with one exception. The sum of Al associated P and organic matter associated P was found to range from 192 to 336 mg/kg. There is an apparent progression of increasing P progressing from the headwaters downstream. The relationship between the sum of Al associated and organic matter associated P with urban land use or impervious surface area percentages is found to be significant with r^2 values of 0.69 and 0.63, respectively. These results suggest that urbanization and impervious surfaces have a large impact on stream sediment quality.

ASSESSING GEOTHERMAL ENERGY POTENTIAL IN SOUTHERN UTAH USING THE TRACE ELEMENT CHEMISTRY OF GRANITIC INTRUSIONS

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Enhanced Geothermal Systems (EGS) have been recognized by geothermal energy experts as a very large potential alternative energy source to help meet growing energy demands. The benefits of EGS are vast, not solely limited to energy production alone, that can be exploited for industrial and residential purposes. This project aims to advance the development of geothermal systems by analyzing the major and trace element geochemistry of the Mineral Mountains in Utah to determine the cause of the elevated geothermal gradient and consequent favorable geothermal setting of the region. The Roosevelt Geothermal Area is a designated geothermal resource area surrounding the Mineral Mountains. Several natural hot springs and the Blundell geothermal power plant are within the Roosevelt Geothermal Area. Additionally, a deep EGS experiment laboratory, the Frontier Observatory for Research in Geothermal Energy (FORGE), has been proposed for placement within the geothermal area. Many studies over the course of several decades have provided extensive geochemical, structural, hydrologic, and thermal data to compare to. Samples were taken across competent outcrops of the major granitic units in the Mineral Mountains and analyzed by XRF. Radiogenic heat generation produced by decay of the unstable isotopes $^{238}$U, $^{232}$Th, and $^{40}$K in Tertiary granites has been calculated from XRF and the results are favorable in certain units. Average radiogenic heat production at the surface is 2.86 microwatts/m$^3$ with several units approaching or slightly exceeding 4 microwatts/m$^3$. The strongly speculated presence of an active magma chamber in the region combined with favorable amounts of radioactive heat decay in granitic plutons are very likely the sources of heat in the Mineral Mountains.

CAN REDOX CHANGES IN LAKEBED SEDIMENTS TRIGGER ALGAL BLOOMS? A CASE STUDY OF CARLYLE LAKE, ILLINOIS

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Algal blooms are triggered by excess inputs of normally limiting nutrients, such as $P$, and can be responsible for a range of human health and environmental risks. Successful management of nuisance and harmful algal blooms requires an understanding of $P$ dynamics in aquatic systems. Of particular interest are reservoirs in agricultural landscapes that often provide local communities with drinking and irrigation water, flood control, and recreation, but also feature high $P$ inputs. Thus, this study aims to determine the role of lakebed sediments in triggering algal blooms, particularly the role of redox-sensitive metals (e.g., Fe and Mn) in the sorption and release of $P$. Our study site, Carlyle Lake, is a large, shallow reservoir (area: 105 km$^2$; mean depth: 3.4 m) located in an agricultural basin (~70% farmland) in Illinois. To assess spatial and temporal trends in lakebed geochemistry, sediments were collected using a Petit Pona sampler five times (June 2016 to May 2017) across 10 sites. Sediment subsamples were: 1) extracted with deionized water and 2.0 M KCl to characterize $P$ in porewater and loosely bound to sediment and...
2) heated to 550°C to determine organic matter (OM) content, then digested in 5.0 N HCl to find total P. The extracts and digests were run on a Westco SmartChem® 170 discrete analyzer. Additional subsamples were dried and analyzed for metals known to sorb P (e.g., Fe, Mn, and Ca) using an Olympus Delta portable x-ray fluorimeter. We observed strong positive correlations between total P and both Fe ($R^2 = 0.64$) and Mn ($R^2 = 0.74$); there was no correlation with Ca ($R^2 = 0.05$), which we use as a proxy for the carbonate fraction. There was a weak positive correlation between total P and OM ($R^2 = 0.28$). There were no significant changes in total P, Fe, or Mn over the study period ($p > 0.28$), but extractable P and OM did vary over time ($p < 0.05$). We observed a strong gradient in P, Fe, and Mn across the lake, with the highest concentrations occurring near the dam wall. This indicates that fine-grained sediments, which are rich in redox sensitive metals with adsorbed P, may move across the lake and accumulate near the dam. These Fe and Mn-rich sediments near the dam have the potential to release loosely bound P during anoxic conditions, increasing P in the water column. This suggests that algal blooms may be more likely to occur near the reservoir dam.

GEOCHEMICAL VARIATIONS IN BLACK SHALES OF NEW YORK STATE

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Several black shale formations, ranging from Ordovician to Devonian in age, outcrop in New York State. Although unconventional gas extraction is not currently permitted in NY, these formations may represent a future resource. Variations in major and trace elements, and organic matter, may lead to a better understanding of depositional environments, target certain areas for future gas potential and identify possible environmental issues with drill cuttings such as radionuclide concentrations. Eight samples from the Marcellus Shale were obtained from outcrops and quarries that span an east to west band in New York. As a reference, other black shale samples were also obtained from the Utica, Skaneateles, Maplewood, Hanover, Deepkill, and Geneseo formations. Whole rock analysis for major and trace elements and organic matter were determined for each sample. All samples showed negative Ce anomalies, indicating that anoxic conditions were present during deposition. These values, however, show no correlation with spatial distribution across the state. A correlation between organic matter and Ni, another indicator of anoxic conditions, is present, with an $r^2$ of 0.97 which is supported by Lewan, M. D., & Maynard, J. B. (1982). This indicates algae as the probable source of the organic matter. While the Marcellus Shale is known for its high concentrations of Th and U, concentrations are highly variable. Concentrations of Th range from 1.8 to 12.1 (mg/kg), and U values range from BDL to 68.3 (mg/kg). These lower values could suggest that toxic trace metal concentrations may not be as high as previously thought in all portions of the formation in New York, making it more accessible for natural gas extraction. Organic Matter content values range from 2.43 to 17.48 (wt%) as determined by loss on ignition, however, no clear trend could be observed related to distribution across the state. Overall, the Marcellus Shale appears to be highly variable, and further analysis, including 3D stratigraphic controls, are needed to fully understand the deposition environment and distribution of trace elements and organic content across New York State.
AN ANALYSIS OF POTENTIAL REGIONAL SOURCES OF ATMOSPHERIC Ca\(^{2+}\) AND Mg\(^{2+}\) SUSPECTED TO CONTRIBUTE TO THE FORMATION OF DECOMPOSITION CHIMNEYS IN MOUNT BALDY DUNE AT INDIANA DUNES NATIONAL LAKESHORE

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Dune decomposition chimneys are temporarily stable voids in modern dunes that form by the decay and collapse of trees buried during dune migration. Argyilan et al (2015) investigated these features at the Mount Baldy dune of the Indiana Dunes National Lakeshore (INDU) on the southern coast of Lake Michigan. An unexpected finding was the presence of authigenic carbonate precipitating in the siliciclastic sands directly in contact with buried trees. A carbonate-rich deposit was also observable after heavy rainfall events, occurring as both a surface coating and in association with sedimentary features (pin stripe laminations) in foreset beds, suggesting an atmospheric source of Ca\(^{2+}\) and Mg\(^{2+}\) to the system. This study investigates possible sources of Ca\(^{2+}\) and Mg\(^{2+}\), focusing on ion analyses of local precipitation. Two precipitation datasets were utilized: annual precipitation-weighted means (1985-2013) from the National Atmospheric Deposition Program for sites surrounding INDU and precipitation samples collected via a civilian sampling network established throughout northwest Indiana. The maximum annual mean concentration of Ca\(^{2+}\) (0.676 mg/L) occurred in 2012 for INDU and the data suggest that widespread drought conditions contributed to the elevated ion concentration. However, cluster analysis and an ANOVA test on the full time series indicated that values from INDU are statistically different from nearby stations. Liquid phase ion chromatography yielded concentrations for Ca\(^{2+}\) and Mg\(^{2+}\) ions in precipitation samples collected across the civilian sites. Elevated concentrations of Ca\(^{2+}\) and Mg\(^{2+}\) likely reflect atmospheric absorption of byproducts released from industrial sources including coal-fired power plants, cement factories, and coke and steel manufacturing in the region. Another possible local source of Ca\(^{2+}\) and Mg\(^{2+}\) is a basal fossiliferous clay layer that could contribute to authigenic carbonate formation via ongoing weathering, erosion, dissolution, and re-precipitation within dune sediments. These data can aid in authenticating the initial hypothesis that a localized atmospheric source of Ca\(^{2+}\) and Mg\(^{2+}\) is contributing to the formation of decomposition chimneys at Mount Baldy. Findings will impact risk assessment for similar migrating dunes along the Great Lakes and elsewhere.

MINERAL CONTROLS OF ELEMENT MOBILITY DURING SODIC-CALCIC ALTERATION

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Sodic +/- calcic metasomatism occurs in diverse environments including regional and seafloor metamorphism, and is associated with IOCG and porphyry ore deposits. Element mobility and reaction mechanisms that occur during this style of alteration are of great interest. Alteration zones cut a granodiorite sill complex related to the Tertiary-aged Whiterock Pluton that intruded the Maroon Formation in the Elk Mountains of Colorado. Sodic +/- calcic alteration there consists of symmetrical selvages around fractures and bedding planes. Alteration envelopes are typically zoned from unaltered wall rock to a diopside-rich outer selvage and a white, plagioclase-rich central zone.

Guided by cathodoluminescence, EPMA and LA-ICP-MS mineral analyses help link whole rock chemical changes to specific mineral reactions. The green, outer selvage is characterized by igneous plagioclase, replacement oligoclase/albite after alkali feldspar, and diopsidic pyroxene or actinolite + titanite ± epidote after biotite, amphibole and Fe-Ti oxides. The white zone contains oligoclase/albite + titanite and relatively Na-rich relict portions of igneous plagioclase. Replacement feldspar compositions range from albite to oligoclase and span the peristerite gap. The presence of sharp reaction fronts, microporosity, and pseudomorphism indicate the feldspar replacement mechanism interface-coupled dissolution-reprecipitation.

Whole rock powder and in situ handheld XRF analyses across the alteration zones constrain elemental gain/loss. Sodium gain was accompanied by Fe, Mn, Mg, Ba, and K loss. Diopside-zone samples have gained Ca, Cr, and Sc, but there was loss of these elements in the diopside-free, most-altered zones. Rare earth elements show differential mobility. The most-altered zone preferentially gained HREE; elsewhere REE behaved similarly to typically immobile elements. LA-ICP-MS analyses show that titanite is the main reservoir of REE in the most altered-zone and controlled mobility behavior of these elements. Linking elemental gain/loss to specific minerals provides greater understanding of element mobility and is a powerful tool for deciphering reaction mechanisms.

EVALUATING THE SOURCE: USING DETRITAL ZIRCON TO INVESTIGATE PETROGENESIS IN SUBGLACIAL MAGMAS FROM VATNAJÖKULL, ICELAND

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Iceland formed from the interaction of the Mid-Atlantic Ridge and the Iceland hotspot. Overlying these magma-producing features is Iceland’s largest glacier, Vatnajökull, which conceals ~5 central volcanoes and associated fissures. Additional, unconfirmed, volcanic systems may exist beneath the ice, but lack of access hinders investigation of their existence and evolution. Glacially sourced river sediments permit sampling of bedrock that is otherwise inaccessible. Detrital zircons are especially useful due to their physical and chemical robustness, ability to preserve age and evidence of source magma compositional, and their common presence in silicic (rarely basaltic) rocks. To investigate the presence and nature of previously unrecognized subglacial systems, we present preliminary detrital zircon U-Pb age and trace element SHRIMP-RG results from two sites along Jökulsá í Lóni, one of Vatnajökull’s large
outflow rivers. U-Pb ages from the downstream sample range from ~1.7 to 6.2 Ma, while the upstream zircon ages are more restricted at ~4.8 to 5.4 Ma. Trace element analyses reveal a similar pattern, with more restricted compositions upstream (n = 30) than downstream (n = 84). Ti and Hf concentrations indicate upstream zircons generally crystallized from warmer, less-evolved magma(s) compared to downstream zircons: upstream Ti ~6-36 ppm vs. ~6-42 ppm downstream; upstream Hf 6500-9500 ppm vs. ~7000-12,500 ppm downstream). U/Yb in downstream zircon ranges from 0.06 to 0.5 and 0.03 to 0.21 in upstream sample grains, which extends the lower range of the previously recognized Iceland zircon array (Carley et al. 2014). Gd/Yb in upstream and downstream samples occupies the same range as the general Iceland zircon array (~0.08-0.2). It is unlikely that all grains originated from the same subglacial magmatic system based on the general spread in geochemical values and ages. It is likely that the more restricted compositions and ages of the upstream sample are most representative of any subglacial system(s). Future work will focus on sampling closer to the glacier, sampling catchment-bounding bedrock, and increasing the geochemical and chronological database to assess magmatic evolution trends in eastern Vatnajökull.

CYCLOSTRATIGRAPHY OF MICROBIALITES IN BACON COVE, NEWFOUNDLAND, CANADA AND THEIR IMPLICATION FOR DEPOSITIONAL ENVIRONMENTS AND PALEOCURRENTS OF THE LOWER CAMBRIAN

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In Bacon Cove, Newfoundland, Canada, rhythmic microbialites in siliciclastic–carbonatic sediments of the pre-trilobitic Bonavista and Smith Point Formation are exposed. They were deposited on the former microcontinent Avalonia during the Fortunian and Series Two in the early Cambrian. The rhythmic microbialites were scaled and statistically evaluated after a detailed bed-by-bed examination of the succession. Three, each other overlapping, cycles have been interpreted from the statistically evaluation and the lithologies. The cycles were in part probably induced by Milankovic cycles.

The Bonavista Formation also contains up to five percent hyoliths in part as shell debris, in part articulated oriented. With the latter, a paleocurrent analysis has been carried out and two different paleocurrents have been interpreted.

Based on the interaction of the microbialites with the hyoliths and the lithologies the depositional environment has been interpreted assuming that the appearance of the microbialites depends on the interaction of current, nutrient input and climate. This enables conclusions about sedimentary input, depth of the photic zone and current.
STRAITIGRAPHIC AND MINERALOGICAL CHARACTERISTICS OF CU-ZN-CO-MN MANTOS AT MINERA BOLEO, SANTA ROSALÍA, BCS, MEXICO

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Mantos at the Boleo Cu-Zn-Co-Mn deposit near Santa Rosalía, BCS, Mexico possess similar sedimentary and structural features that obscure their distinction. This study employs both stratigraphic and mineral analysis to characterize the mantos, permitting identification of individual mantos in the Boleo mine. Exposures of four of the mantos and their enclosing sediments near the Texcoco Mine adit were measured and described in detail. Bulk mineralogy of the samples was determined by X-ray diffraction analysis and SEM/EDS.

The manganese and iron oxide ores were deposited in clayey horizons overlaying polymitic clay breccias, tuffaceous claystones, and conglomerates. The host claystone is predominantly smectite clay. The individual mantos possess variations that may be useful distinguishing features. In Manto 1, sepiolite is abundant, and a lesser amount occurs in the base of Manto 2 and Manto 3a, which also contains pyrophyllite as detected by XRD. Mantos 1, 2 and 3a possess a feldspathic (sodic anorthite) clastic component. Manto 4 differs, being calcareous due to its replacement of and association with a basal limestone of the Boleo formation. It contains marine bivalves and gastropods replaced by Mn oxides and silica. Manto 1 is distinguished by the presence of the zeolite clinoptilolite in the upper sandy layers. Manto 2 possesses silica-rich minerals including quartz and cristobalite, and metal oxides including maghemite (Fe$_2$O$_3$) and minor possible cochromite (Co(Cr,Fe)$_2$O$_4$). Manto 3a possesses a thick layer of halloysite (Al$_2$Si$_2$O$_5$(OH)$_4$) in a bed in the middle of the sequence.

The EDS identification of Mn nodules found within the mantos indicates they are predominantly cryptomelane (K-Mn oxyhydroxide) and hollandite (Ba-Mn oxyhydroxide), with pyrolusite, ramsdellite (both MnO$_2$), and possibly bixbyite (Mn$_2$O$_3$), and hausmannite (Mn$_3$O$_4$). A crystallized cavity from Manto 1 exhibits a paragenetic sequence of Mn$_3$O$_4$, Mn$_2$O$_3$, MnO$_2$ from oldest to youngest, showing an increase in oxidation state during deposition.

Though these features might be useful for identifying individual mantos in the Texcoco mine area, lateral variation and depositional facies changes might limit their use over the entire area of Boleo mineralization.
PETROPHYSICAL PROPERTIES OF THE FORT PAYNE FORMATION (MISSISSIPPIAN), TENNESSEE AND KENTUCKY

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The Fort Payne Formation is a Middle Mississippian unit that outcrops in north-central Tennessee and south-central Kentucky. Two study locations are presented in this research: an outcrop south of Celina, Tennessee on TN 52 and an outcrop south of Burkesville, Kentucky on KY 61. In these locations, the formation consists of primarily mixed carbonate and siliciclastic shale lithologies. The most common facies observed in the Fort Payne are crinoidal grainstones and interbedded siliciclastic and carbonate mudstones. The purpose of this work is to characterize petrophysical properties of the Fort Payne Formation to assist with hydrocarbon exploration in the region.

A handheld gamma ray scintillometer was used to collect data from both study areas. In the Celina location, paleochannels are incised into carbonate and siliciclastic mudstones. The Burkesville site has been interpreted as a Waulsortian-type carbonate mound. In addition to measured stratigraphic sections, the scintillometer provides information on potassium, uranium, and thorium content as well as total gamma ray response. All data are plotted against rock type, allowing for stratigraphic analysis of the Fort Payne Formation using petrophysical properties (i.e. gamma ray response).

Radioactive elements (potassium, uranium, and thorium) increase when analyzing finer clay-rich siliciclastic and carbonate mud, and decrease when analyzing coarser grainstones. This likely reflects an increase in siliciclastic material into the system during periods of quiescence on the Mississippian slope. Given that the Fort Payne is a mixed carbonate-clastic system, analysis of petrophysical properties will allow calibration with drilling results in Tennessee and Kentucky, as well as provide a model for similar systems globally.

FACIES, DEPOSITIONAL ENVIRONMENTS AND SEA-LEVEL TRENDS WITHIN THE UPPER ORDOVICIAN STONY MOUNTAIN FORMATION, WESTERN NORTH DAKOTA

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The Upper Ordovician Stony Mountain Formation in subsurface North Dakota was deposited in the epicratonic Williston Basin during transitional climatic conditions preceding the end-Ordovician Gondwana glaciation. The formation is subdivided into the Stoughton and Gunton Members in ascending order. This study, based on continuous core data, coupled with wireline-logs, thin-section analysis and structure/isopach maps, evaluates how the stacking of depositional facies relate to the latest Ordovician glacio-eustasy and transitional climates.

The facies identified include, from deepest to shallowest: argillaceous skeletal mudstone and wackestone with cm-thick skeletal packstone-grainstone interbeds (deep subtidal around storm-
weather wave base), argillaceous skeletal wacke-packstone (rare; deep subtidal, sub-fair-weather wave base), burrowed skeletal dolomudstone (shallow euphotic subtidal below fair-weather wave base), barren dolomudstone (restricted euhaline to mesohaline shallow subtidal), flat-pebble breccia (rare; lag deposit); (dolo)thrombolite (shallow mesohaline subtidal), laminated dolomite (shallow mesohaline subtidal to intertidal), and nodular and laminated anhydrite (shallow penesaline subaqueous setting, sabkha). Skeletal grains are abundant in the Stoughton Mbr. and include crinoids, bryozoans, brachiopods, trilobites and corals; bioclasts are rare in the overlying Gunton Mbr, and occur only in its lower part. The facies are stacked into several-meters-thick cycles (=parasequences) (3-12 m), most of which are subtidal, asymmetric, and shallowing upward.

A change from more humid (Stoughton) to semi-arid (Gunton) conditions is suggested based on an upward trend from argillaceous limestone to finely crystalline (early?) dolomite and anhydrite, and capped by a thin arenaceous dolomudstone. Contrary to the thicker subtidal parasequences of the Stoughton Mbr, the peritidal parasequences in the upper Gunton Mbr. lack any deeper subtidal facies. They also lack any evidence for prolonged subaerial exposure and are likely indicative of small amplitude, high-frequency sea-level oscillations that coupled with semi-arid climatic conditions favored early diagenetic dolomitization.

INVESTIGATION OF THE DOLORES SALT ANTICLINE AND POTENTIAL EVAPORITE DISSOLUTION

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The Dolores Salt Anticline is the most southeastern salt feature in the Paradox Basin, a province of salt anticline and syncline structures in southwestern Colorado and eastern Utah. Unlike, other Paradox Formation salt features, the Dolores Salt Anticline is not breached or collapsed and therefore is far less studied. However, analysis of the Dolores River water chemistry may reveal that the core of the Dolores Salt Anticline is also dissolving at this moment. The Dolores River has eroded through several hundred feet of the Cutler Formation which overlies the Paradox evaporites. Additionally, the crest of the anticline is cut by multiple normal faults at the Glade Graben and Dolores Fault Zone, which may provide conduits for groundwater circulation. At Paradox Valley, one of the collapsed salt anticlines in the region, groundwater flows across the top of the Paradox evaporites and discharges directly into the Dolores River, contributing approximately 200,000 tons of salt annually. If groundwater discharge is similar at the Dolores Salt Anticline, the conductivity is expected to be notably high at base flows. Water samples and conductivity measurements will be collected from the Dolores River along a downstream transect through the Dolores Salt Anticline. While the Paradox Formation salt is the major evaporite source in the region, Mancos Shale also produces secondary gypsum. To differentiate Paradox Formation from Mancos Shale contributions, samples will be further characterized by Sulphur isotopes and major ion concentrations. Results of conductivity, Sulphur isotope, and major ion concentration analyses of the water samples will be reported. Results will give insight to the salt tectonics and groundwater-surface water interactions in the region.
STRATIGRAPHIC RECONNAISSANCE OF THE BUSH BAY FORMATION, ENGADINE GROUP, HIAWATHA NATIONAL FOREST, UPPER PENINSULA, MI

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Within the Upper Peninsula of Michigan lies the Hiawatha National Forest and the poorly understood, yet complex, Engadine Group. This mid-Silurian unit is directly situated above the Manistique Group and below the Salina Group. It is comprised of three formations of dolostone differing in composition and depositional environment. An attempt to better understand this group has been made over the past several years through field and lab work. The upper-most unit, the Bush Bay Formation, is the focus of this study. The Bush Bay Formation has a negligible dip and has a maximum thickness of 20m. For this reason, a stratigraphic section of the Bush Bay Formation was measured by walking up a slope over a distance of roughly 1.2 kilometers, gaining about 15m of elevation within the Pontchartrain Shores area, east of St. Ignace, MI. An auto-level and stadia rod were used to measure the formation along the shallow slope representing the paleo-lakeshore of glacial Lake Nipissing (ca. 7.5ka). Twenty hand samples were collected along with measurements for distance and elevation of the slope. The sampled outcrops were comprised of slope breaks, reef mounds, grike fields, and alvar. Hand sample analysis was conducted and showed a general increase in styolites going up section as well as variances in texture. Moldic porosity with infilling was consistent among the majority of samples and there was a general increase of identifiable fossils going up section (stromatoporids, corals, brachiopods, and crinoids). Standard petrographic thin section analysis will be conducted on the samples collected to identify microscopic scale changes in stratigraphy of the Bush Bay Formation.

REVISED CONODONT BIOSTRATIGRAPHY OF THE KINDERHOOKIAN (LOWER TOURNAISIAN) STRATA IN SOUTHEAST IOWA

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The Devonian-Carboniferous Boundary Global Stratotype Section and Point (GSSP) is currently under revision by the International Commission on Stratigraphy-Subcommissions on Devonian (SDS) and Carboniferous (SCS) Stratigraphy. The tri-state region of Iowa, Illinois and Missouri...
contains some of the historically most important strata for this interval including the type area of the lowest Carboniferous North American Kinderhookian Stage of the Mississippian Subsystem. Unfortunately, high-resolution conodont biostratigraphy is largely unavailable due to either a lack of study or low resolution sampling by previous investigators that published biostratigraphic research on these strata, much of which was carried out more than 50 years ago.

As part of a broader study of the Devonian-Carboniferous boundary interval in Southeast Iowa in conjunction with the Iowa Geological Survey, we sampled Upper Devonian and Kinderhookian strata from Starr’s Cave Park and Preserve and Crapo Park, both located near Burlington, Iowa, and two other nearby outcrops. Conodont samples were taken from the Famennian “English River”, and the Tournaissian McCraney, Prospect Hill, and Wassonville formations. Samples from the latter three units yield a reasonably diverse conodont fauna, mostly conodonts belonging to the genus *Siphonodella*. When combined with legacy samples housed at the University of Iowa Paleontological Repository that were collected in the 1960’s, they provide an improved global chronostratigraphic correlation of Iowa Kinderhookian strata.

MICROPLASTICS IN BEACH SEDIMENT ALONG SOUTHERN SHORES OF LAKE MICHIGAN

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The presence of microplastics in marine coastal environments has been a concern since the mid to late 1970s, however it was not until recent years that much thought had been given to microplastics within the Great Lakes environment. Recent studies suggest that the concentration of microplastics within the Great Lakes may be equal too, or even greater than that within marine environments. The objective of this study is to determine the amount and types of microplastics along four Indiana beaches of southern Lake Michigan and see how these quantities compare with microplastics from beaches of other Great Lakes, and with microplastics from marine beaches. We used two methods – 1) volume reduced, swash line (5 m$^2$) collection, and 2) bulk sampling of quadrats (625 cm$^2$) perpendicular to shoreline – to determine amount of microplastics on four Lake Michigan beaches (Porter, Dunbar, Marquette, and Whihala). Microplastic (< 5mm) was classified into five categories: film, foam, fragments, fiber (line), pellets (beads). The most common type of microplastic found along the southern Lake Michigan shoreline was pellets/beads (44%), followed by foam (42%), fragments (12%), film (0.66%) and line (0.44%). Of the beaches studied, the beach with the most amount of microplastic was found to be Whihala with an average of 49.15 particles of microplastic per m$^2$. The beach with the least amount of microplastic was Porter with only 5.7 particles of microplastic per m$^2$. The average amount of microplastic contained per m$^2$ along the four beaches studied is 27.59. This number is five times higher than that found on the shoreline of Lake Huron by other researchers (5.43); it is even higher than that when compared to Lakes Erie and St. Clair. It is important to point out that factors such as plastic density, as well as natural factors such as currents, may cause variations in quantities amongst the different locations. This study will contribute to the growing body of knowledge on the presence of microplastics within the Great Lakes, an important part of
communicating the problem to the general public, as well as addressing it. Further work will consist of studying different parts of the coastal system.

ANALYSIS OF THECAMOEBIAN ASSEMBLAGES IN FALL CREEK FALLS STATE PARK

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Thecamoebians, or testate amoebae, are microscopic, single-celled organisms that produce, either through agglutination or secretion, a mineralized shell. As these microorganisms prefer particular environmental conditions, and are relatively short-lived, they function as excellent indicator species. By analyzing the diversity, number, and types of thecamoebian species present in a particular environment, the health of that environment can be assessed. This research project uses samples containing thecamoebians collected from Fall Creek Falls State Park, a heavily forested, temperate environment and the largest State Park in Tennessee. As State Parks are important to both the economy of the state and the health of the local ecosystems overall, it is crucial that they be monitored and protected against potential environmental threats. Through this project, the health of three main bodies of water in the park – Fall Creek Falls Lake, Fall Creek Falls waterfall, and Cane Creek – was analyzed for environmental degradation. The assemblage composition was analyzed and the Shannon diversity index (SDI) was measured for each sample. Unfavorable environments have SDI values below 0.5 and healthy environments have SDI values above 2.5. Calculated SDI values for all three water bodies were between .998 and 1.788, indicating moderately healthy environments. Diffugia oblonga was the most numerous species in all samples, along with D. urceolata. These species are indicative of healthier environments. One sample collected from the lake was dominated by Centropyxis constricta with abundant Cucurbitella tricuspis. The other sample collected from the lake had abundant Centropyxis constricta and C. aculeata. Centropyxid species tolerate unfavorable environments better than other species and Cucurbitella tricuspis has been associated with nutrient enrichment. Analysis of assemblages and SDI measurements appears to indicate possible eutrophication in Fall Creek Falls Lake, though the other water bodies appear to have healthy assemblages. Further study is required to determine the source of the eutrophication.

YELLOW CEDAR GROWTH RESPONSE TO DECADAL CLIMATIC SHIFTS AT CEDAR LAKE, JUNEAU, ALASKA

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Yellow cedar (*Cupressus nootkatensis*) are experiencing widespread mortality throughout the coastal regions of the Pacific Northwest. According to the leading hypothesis explaining the decline, warmer springs promote an earlier melting of the insulating snowpack covering shallow root systems, making them susceptible to frost damage. We travelled to Cedar Lake north of Juneau, Alaska and collected 28 cores to examine cedar’s response to climate. We used standard dendrochronological methods to create a well-replicated master chronology composed of 60 ring-width series including data from previous collections. The 250 year-long chronology shows a declining step function at about 1950 CE, which correlates to the yellow cedars’ changing relationship with precipitation, temperature, and Pacific Decadal Oscillation (PDO). Ring width correlations with monthly temperature and precipitation are positive before 1950 and change to negative after 1950. Correlations with temperature post-1950 are strongly negative for January through May. These results are consistent with the leading hypothesis for cedar decline. Our results also indicate a changing stress in the trees possibly linked to the inundation of the root systems during the high precipitation fall months. When comparing ring width to the PDO index before 1950 the correlations are generally positive, but after 1950 there are strong negative correlations suggesting the late 1940’s phase shift of the PDO is associated with unfavorable conditions. After 1950 the yellow cedar at Cedar Lake are not responding to the positive phase shifts of PDO (ie., the 1976-77 shift); instead they continue a downward trend. We found that Delta Blue Intensity (DBI), another parameter derived from the tree-rings, is consistent with and supports our findings from the tree ring width analyses. Overall, this study supports the leading hypothesis for cedar decline and provides a well replicated ring-width and BI record for further research. Environmental changes in the region are proceeding too rapidly for the yellow cedar to naturally adapt. This work provides a case study to understand how other species may respond to rapid climate change.

**PALEOCLIMATE AND PALEOENVIRONMENTAL RECONSTRUCTIONS FROM STRATIGRAPHIC ANALYSIS AND PALEOSOL DESCRIPTIONS FROM THE EARLY MIocene, KIAHERA FORMATION, RUSINGA ISLAND, LAKE VICTORIA, KENYA**

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Rusinga Island, Lake Victoria, Kenya has been studied for decades to gain a better understanding of the paleoecology and palaeoclimate that was the framework of the evolution of early hominoids, including the well-preserved ape *Ekembo*. Whereas the geology on Rusinga has been previously mapped, there are discrepancies regarding identification of geological formations and associated fossil localities distributed throughout the island. The majority of fossils from Rusinga...
have been found in the Rusinga Group, which is further subdivided into the Wayando, Kiahera, Rusinga Agglomerate, Hiweti and Kulu formations. Site R73, where the research presented herein was conducted, has been mapped by prior researchers as either the Wayando or Kiahera Formation. Here, we present a new stratigraphic section measured and described through the R73 locality to help resolve this discrepancy. Lithostratigraphic comparisons of the R73 section with other exposures of the Kiahera Formation on Rusinga indicate that the R73 gully is part of the Kiahera Formation rather than the Wayando Formation. More specifically, the strata at R73 can be correlated to the Red Grit, Tuff and Red Grit, and Pisolitic Clay Members of the Kiahera Formation. Conglomerates and sandstones with rip-up clasts that were cobble to boulder in size, scouring, fining-upward successions and both trough and planar-tabular cross-bedding, suggest a fluvial-alluvial setting with high stream velocity in the Red Grit and Tuff and Red Grit members. Paleosols identified in the Pisolitic Clay Member include Vertisols, Calcic Vertisols and Calcisols. These paleosols suggest a range of paleoclimates including seasonal and a semi-arid to arid climate in which evaporation was greater than precipitation. The sedimentological data suggest that the R73 fauna lived in a relatively open, fluvial system in a seasonal to dry climate. Recent paleontological collections from this locality—which include among other fossils of Gomphotheriinae, Rhinocerotidae, Anthracoatheriidae, Ruminantia, Crocodylia, Chelonia, and fish—support a fluvial or depositonal system with floodplain deposits.

SEARCHING FOR GEOCHEMICAL SIGNATURES OF STEP-WISE EXTINCTION LEVELS DURING THE IREVIKEN (SILURIAN) EXTINCTION EVENT

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A mass extinction event known as the Ireviken Event took place near the Llandovery/Wenlock boundary during the Silurian Period that affected conodonts, graptolites, and trilobites. The extinction interval is marked by a series of step-wise extinction datums that each left their own signature in the fossil record. Collectively, these closely spaced extinction levels comprise the Ireviken Extinction Event. This extinction event also coincides with a major perturbation to the global carbon cycle and the onset of the Ireviken positive carbon isotope excursion. What is currently unclear however, is if each of these extinction levels also left a distinct geochemical signature in the rock record and if they can be identified in the carbon isotopic record of this interval.

To investigate this, we sampled the Measley Ridge section in Southern Ohio at extremely high resolution to look for discrete isotopic events in the lead up to the onset of the Ireviken positive carbon isotope excursion. We took nearly 400 sample from the upper part of the Estill Formation and the lower part of the Bisher Formation with a sample spacing of 3-5cm over approximately 15 meters of section. We found the Ireviken Excursion well displayed with carbon isotope values in excess of +5‰. In addition, we also found several discrete features in the isotope data prior to, and during, the onset of the Ireviken Excursion that could be geochemical signatures of the extinction datums. This work is phase one, and the next step is to process the conodont samples.
collected from this outcrop to determine if the isotopic signals do, in fact, occur at the same stratigraphic levels as the extinction datums.

APPLYING PALEOBOTANICAL PALEOCCLIMATE PROXIES: A CASE STUDY OF TROPICAL AFRICAN FLORAS

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The climatic conditions of a region dictate the size and shape of woody dicotyledonous angiosperm leaves in a predictable pattern. For example, colder climates result in leaves with more teeth, while wetter climates result in larger leaves. Paleobotanists have used these relationships to develop proxies for paleoclimate. The univariate methods leaf margin analysis (LMA) and leaf area analysis (LAA) respectively use the relationship between the proportion of species with teeth and temperature and the size of leaves and precipitation to reconstruct mean annual temperature (MAT) and mean annual precipitation (MAP). Digital Leaf Physiognomy (DiLP) is a multivariate model that uses multiple characteristics of leaf size and shape to estimate MAT and MAP, and offers some improvement in climate estimates over the univariate methods. Studies of African floras have shown that they have a different climate-leaf shape relationship than floras from the temperate Northern Hemisphere. However, the DiLP model is best calibrated for the temperate Northern Hemisphere and the current database does not include any African floras, thus the applicability of DiLP to African floras is unclear. To test the effectiveness of DiLP for predicting climate using African floras, we measured modern leaves from multiple sites across tropical Africa. The DiLP model tended to overestimate MAT and underestimate MAP when compared to actual climate. However, the discrepancy between predicted and actual was not consistent: MAT overestimates varied from 2 to 10°C, while MAP underestimates varied from 800 to 1500 mm. In comparison, LMA and LAA more accurately estimated climate, but the methods still overestimated MAT and underestimated MAP. This inaccuracy has important implications for paleoclimate estimates using DiLP. Because the model’s calibration dataset is primarily restricted to the temperate Northern Hemisphere, it cannot accurately estimate climate in tropical Africa. Additionally, these results suggest that LMA and LAA cannot be reliably applied to African floras. Therefore, the DiLP calibration dataset must be updated to include African floras and/or a regional model for Africa must be developed before DiLP, LMA, and LAA can be reliably used to estimate the paleoclimate of tropical Africa.

EVIDENCE OF LATE PALEOCENE-EARLY EOCENE POSSIBLE OCEAN ACIDIFICATION RECORDED IN THE ADRIATIC CARBONATE PLATFORM

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The Paleocene-Eocene Thermal Maximum (PETM), a period of abrupt global warming events, is linked to a rapid release of large amounts of carbon into the Earth system. This sudden influx is hypothesized to have caused a mass acidification of surface ocean waters and a decrease in carbonate deposition in shallow water ramps and carbonate platforms. While rapid ocean acidification has the potential to devastate marine ecosystems, evidence of abrupt changes in pH and saturation have only been reported from deep-sea records. A well-preserved shallow carbonate platform from the Kras region of Slovenia records, continuous exposures of long term deposition, including the Paleocene-Eocene boundary, which manifests as a dissolution horizon. Through the analysis of dissolution surfaces found in this region, shallow platform ocean acidification is considered as a possible cause for the horizons. We analyze boundary samples to determine if the surfaces formed in an acidified ocean, subaerially, or are due to erosion diagenesis (i.e. stylolitic) using petrography and elemental mapping of the boundary. These surfaces have been analyzed using the Environmental Scanning Electron Microscope (ESEM) Energy Dispersive Spectra (EDS) to create a preliminary elemental map of the focus area. Then, samples will be mapped on the Electron Microprobe (EPMA) to gather more detailed data on the boundary composition to further explain the preserved surface of the PETM. The analyses of these dissolution surfaces in the Kras region will be used to determine whether ocean acidification occurred in this region during the PETM.

KETTLE-HOLE DEVELOPMENT FOLLOWING THE 2010 GLACIAL OUTBURST FLOOD AT GIGJOKULL, EYJAFJALLAJOKULL, ICELAND: AN ESTIMATION OF ICE LOSS?

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Glacial outburst floods (GLOFs) are a complex geologic event arising from rapid ice melting or ice-dam failure with pitted outwash plains as a key identifier of their activity. Gígjökull, a northern outlet glacier of Eyjafjallajökull, experienced a series of GLOFs following a subglacial volcanic eruption in Iceland in early 2010. Gígjökull’s forefield went from a ~15 gigaliter proglacial lake to a braided stream network, a series of topographic inversions, known as kettles, and a developing desert pavement. Using kettles as a gauge for brittle-ice loss, ~80% of exposed kettles (n=118) were studied along a 315m transect, atop elevated desert pavement, starting approximately 500m from the glacier. Acquired kettle data included diameter and depth measurements (and calculated right-circular conical volumes), kettle hole stratigraphy, and observations of shape and/or evidence of recent sediment movement (e.g., tensional cracks, vertical walls). The mean kettle diameter was 2.9m (σ=1.7); mean depth was 0.9m (σ=0.4); mean calculated volume was 4.0m³ (σ=9.7). A positive linear trend between increasing kettle depth and increasing kettle diameter was found (r² = 0.7588). Despite localized clusters of 10-20 kettles showing a positive relationship between calculated volume and proximity to the glacier, no overall trend was found. Using available photogrammetric data since the GLOF (i.e., Google Earth, 2012 and 2013; TerraServer, 2016) combined with kettle data, three post-GLOF landscape-change maps were generated. Recorded kettle development, from 2012 to 2017, is diachronous with kettle count increasing with distance from the glacier. Assuming a 1:1 volume...
ratio of ice block to kettle depression, the minimum total of buried ice is ~500m$^3$; a negligible value confirmed by video footage of the GLOF. Because the GLOF at Gigjökull was volcanically induced, glacial ice was likely melted away rather than broken and buried. The use of pitted outwash plains as a key characteristic of GLOFs, therefore, is probably better suited to moraine- or ice-dam failures, which likely generate more ice blocks for kettle development.

**INFRASTRUCTURE PROJECTS AND THEIR IMPACT ON MASS MOVEMENTS: DENDROGEOMORPHIC EVIDENCE FROM THE TRANS-ALASKAN PIPELINE, TONSINA, ALASKA**

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Mass movements affect roadways globally and are especially problematic in Alaska due to their sporadic and austere climate conditions and extreme rural nature. A particularly steep stretch of the Richardson Highway (mileposts 80-82) near Tonsina, Alaska was “flagged” as a continued problem for repairs by the Alaska Geological & Geophysical Surveys and Department of Transportation. Originally, this stretch of highway required extensive cleanup and a realignment (1973-74) to support the emplacement of the Trans Alaska Pipeline (TAP; 1975-77). Using dendrogeomorphic evidence, or evidence left in trees that adjusted their growth due to a tilting event, we evaluated the 4D stability of the site. This evidence, or reaction wood (in conifers), includes apparent changes in trunk tilt and wood-anatomy changes to wider, darker, and structurally more sound radial growth rings. We sampled 30 tilted black spruce trees (*Picea Mariana* Mill.; n=60 samples) for reaction-wood analysis at two different angles (downslope and 90º offset), digitized them and annotated reaction wood years, which were summarized in an event-response diagram. Of the 60 cores, 40 had reaction-wood present, 65% of which were cored from the downslope angle. Tree-and-site data revealed that the greater the slope steepness, the greater the tree tilt, which explains the higher reaction-wood response from the “A” cores. Throughout the 115-year chronology (1900-2015), reaction wood accounts for only 11% (±9%) of recorded radial-tree growth prior to 1977, but from 1978 onward accounts for some 87% (±9%) of radial-tree growth. The highway realignment in 1973-74 and the emplacement of the TAP in 1975-77 occurred just before this sharp increase in reaction-wood disturbance. These infrastructure projects and the accompanying construction traffic are likely factors in the lasting problems on this stretch of highway. Additionally, rapidly warming climate at these high latitudes exacerbates these slope-stability issues because of permafrost thaw, which can destabilize a landscape that has otherwise been relatively stable for centuries.

**GEOMORPHIC AND SEDIMENTOLOGICAL EVIDENCE FOR DRAINAGE REORGANIZATION IN SOUTHWEST NORWAY’S DRIVA RIVER**

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The Driva River of southwestern Norway flows westward into Sunndal, a high relief glacial valley that transverses a 2,000km long near-coastal escarpment. Well-developed barbed tributaries with confluence angles systematically greater than 90° suggest an eastward flowing paleo-network with headwaters in the high elevation regions surrounding the Driva’s current mouth. Many high elevation glacial channels have low-relief divides and irregular drainage geometry, such as small tributary networks that flow into a central point from all sides before draining into the trunk stream, forming a star-shaped drainage pattern. Other landscape abnormalities include isolated topographic highpoints, which are scattered throughout the watershed and constrained on all sides by underfit and overfit glacial valleys with high confluence angles. Near Oppdal, a sharp change in the trunk stream’s course is situated across from a major wind gap, where terraced sediment deposits of uniform and rounded sand grains were observed in the field, necessitating a past fluvial environment with much higher discharge and sediment supply than currently present in the low-relief headwater streams occupying the area. Our geomorphic analysis suggests an eastward flowing glacial paleo-network, in contrast to the Driva’s modern day westward flowing trunk stream, suggesting a change in flow direction since the Last Glacial Maximum. Elevation data measured in the field and remotely using a 1m LIDAR DEM give incision estimates of ~100m since that time in some areas, or incision rates of 10 mm/yr for the last 10,000 years. In southwest Norway, domal isostatic uplift patterns appear to be perturbed by reactivated faults (Helle, 2007). Our data provides insight into this discussion, as fluvial systems are sensitive to changes in uplift patterns and their predicted responses to topographic changes allow landscape features to serve as a record of regional evolution.

USING DRAINAGE AREA POWER-LAW RELATIONSHIPS AS A METHOD TO TEST FOR POINTS OF RIVER CAPTURE

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The hydraulic geometry of a stream channel can be defined using power law equations linking various stream parameters at a given channel cross section, forming important determinants in how channel shape evolves downstream. These morphometric relationships make up some of the fundamental principles of geomorphology and are formed upon the basis that channel width, depth, and average velocity increase downstream as power-law functions of drainage area. Deviations from these established relationships would suggest non-steady state equilibrium within a system which could be due to processes like isostatic rebound or differential erosion; however, we predict abrupt jumps in the drainage area vs channel length relationship to possibly indicate river capture in regions where geomorphic indicators such as knickpoints, bedrock terraces, underfit river channels, barbed tributaries, and other drainage anomalies are present.

Like many ‘passive’ continental margin sectors worldwide, southwestern Norway exhibits a sharp, seaward-facing topographic escarpment. This high relief, high elevation morphology is considered atypical and has become a subject of intense study. Drainage networks found in this region display prominent evidence for river capture including barbed tributaries, downstream narrowing, wind gaps, and low relief headwaters frequently containing fluvial sediment.
Drainage reorganization and river capture have been previously proposed in the area, yet the exact location of if and where a capture event occurred has not been sufficiently investigated. We combine the geomorphic evidence found on the landscape with coding of power-law geomorphic relationships in order to test specific drainages for river capture. We specifically focus on the relationship between drainage area and channel length, because the addition of a captured river, and associated drainage basin, should result in an abrupt jump in drainage area at the capture point. Each anomalous jump in drainage area is then analyzed for geomorphic evidence in order to determine if that area is in fact a capture point, effectively utilizing the hydraulic geometry of a stream, as expressed by the power law equations, to pinpoint locations of river capture event.

COMPARISON OF WATER QUALITY OF TWO PARALLEL WATERSHEDS IN THE ADIRONDACKS OF NEW YORK STATE

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Approximately 43% of the Adirondack Park is classified as wilderness or wild forest area. These areas are interspersed with privately owned lands (50%), generally of low intensity development. This provides an ideal opportunity to assess the impact of various anthropogenic activities on surface water quality. In this study, two watersheds that originate in wilderness areas are studied. As these streams leave forested areas, one passes through an agricultural zone, followed by a golf course, with the other stream simply passing on the other side of the same golf course before they merge in the Village of Malone. Water samples were collected at points along the stream where a land use transition occurred, and from a pond on the golf course. Water was analyzed for major cations and anions, nitrate and total phosphorus. Stream water was found to have relatively consistent concentrations of Ca and SO$_4$ in the range of 8.0 to 16.1 and 3.1 to 8.0 mg/L, respectively. Sodium and Cl concentrations were highly variable within the watershed and temporally. With the watershed that contains the agricultural area, concentrations are typically higher ranging from 6.7 to 15.3 and 12.3 to 33.1 mg/L, respectively. Temporally, there is a trend of decreasing concentrations with time, suggesting a road salt source. Phosphorus concentrations are suggestive of natural or minimally impacted levels with a few notable exceptions. Concentrations were found to range from below detection limit (0.005 mg/L) to 0.19 mg/L with most samples (74%) at 0.1 mg/L or less. The notable exception is one sample from an upstream area with total P at 0.72 mg/L. Nitrate concentrations were found to show slight anthropogenic influence with concentrations ranging from 0.9 to 3.7 mg/L, and showing a trend of increasing values moving downstream. Overall, the parallel watersheds show a slightly increased influence of human activity on water quality.

HELLS CANYON WATER QUALITY MONITORING

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The purpose of this research project is to begin building an exploratory baseline database of water quality data in the wild and scenic river section of the Hells Canyon National Recreation
Area (HCNRA) for predicting climate change effects. The HCNRA is located in a section of the Snake River where there is a lack of accessibility, so existing data for water quality in the region is limited. A novel water quality monitoring protocol and deployment strategy was developed to assess worst-case water quality conditions, which occur during the hottest part of the year. This poster describes the monitoring protocol, deployment strategy, and results from initial baseline water quality data collection during worst-case conditions. The overall goal of this project is to further our understanding of past and present human impacts on an area that is presently managed to maximize its wildlife, cultural heritage, recreational, and economic values. It is our hope that results from this project will inform future management decisions in the face of climate change, economic pressures, and increasing recreational usage.

EFFECTS OF A RAPIDLY URBANIZING ENVIRONMENT ON WATER QUALITY: A CASE STUDY FROM MURFREESBORO, TN

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Murfreesboro, Tennessee is one of the fastest growing cities in the state and was the location of a six week undergraduate research project focusing on water quality. Black Fox Spring (BFS), Murfree Spring (MS) and the associated wetlands (MSW), and Todds Lake (TL) are water bodies that are connected through a groundwater system and affected by urban and residential runoff and impacted by the invasive plant species, parrot-feather or Myriophyllum aquaticum.

During this research project water quality was tested in two ways. First, traditional water quality indicator tests were conducted. These parameters include pH, dissolved oxygen (DO), ammonia, chlorine, copper, hardness, iron, nitrate, nitrite, phosphate, temperature and total dissolved solids (TDS). The second approach was the use of bioindicators known as testate amoebae. These microscopic unicellular protozoans are found in freshwater localities, have a mineralized shell, and have been shown in many studies to be responsive to environmental changes.

Results indicate eutrophication conditions in BFS with a spike in ammonia values and testate amoebae assemblages dominated by the opportunistic species, Centropyxis aculeata, which is tolerant of poor water quality environments. Chlorine concentrations are higher than the EPA freshwater threshold in most sampled locations with a spike in MSW. The coefficient of variation is very high (144%) in MSW suggesting the input of chlorine into the wetlands by in situ point sources. This location also had the lowest DO values (4.3 ppm). Testate amoebae populations were low in MSW and dominated by Diffugia oblonga “tenuis,” a species often found in areas with high levels of organic content. Even though the wetlands are relatively shallow, the density of the invasive parrot-feather, in addition to a dam, is allowing almost no water flow and is contributing to the stagnation of the water. DO in TL (i.e. 9ppm) and MS (i.e.
6.7ppm) is in the healthy range for most samples, which is reflected in healthier populations of testate amoebae with higher diversities dominated by a range of species including *Diffugia oblonga*, *Centropyxis acuelata* and *Mediolus corona*.

**WILL SEAWALLS DAMAGE CRITICAL HABITAT FOR ENDANGERED SPECIES IN HAWAII AS SEA LEVEL RISES?**

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The Northwestern Hawaiian Islands (NWHI) consist of low-lying atolls used by Neomonachus schauinslandi, the critically endangered Hawaiian monk seal, to bask and pup. Preserving habitat, which includes sandy shorelines of the Main Hawaiian Islands (MHI), is critical to protecting this species. Although migrating between the NWHI and the MHI is rare for monk seal populations today, this movement may become necessary if there is habitat loss among the low-lying sandy shoals of the NWHI due to sea level rise. O‘ahu, as a high volcanic island, has wide sandy coastal plains that provide enhanced potential for habitat preservation. However, narrowing and loss due to shoreline armoring threaten beaches in the MHI. Thus, modeling future beach vulnerability to armoring provides important data for developing species and resource management plans. We employ spatial analysis of monk seal critical habitat on O‘ahu to identify when and which beaches are most vulnerable to erosion. Using ArcGIS we model future erosion for 0, 0.15, 0.3, 0.6, and 0.92 meters sea level rise. Results show near-term sea level rise of 0.15 to 0.3 m triggering a cascade of seawall applications, risking sensitive beach resources. We conclude that current and near-term sea level rise, not future sea level rise, poses the greatest threat to critical habitat and therefore the greatest priority for management planning exists now.

**USING GIS TO CREATE HAZARD MAPS AND ASSES EVACUATION ROUTS AROUND "THE GATE TO HELL"; MASAYA VOLCANO, NICARAGUA**

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The volcano Masaya located near Managua, Nicaragua is part of a newer volcanic arc system derived from the Cocos plate subducting beneath the Caribbean plate. Masaya exhibits an anomalously mafic composition for the arc. The recent cycle of volcanism began 7000 years ago with lava flows and degassing events leading up to climactic Vulcanian eruptions. These eruptions have produced lava flows, ash flows, and ash falls that affect the many underdeveloped communities around Masaya. These communities are in need of a simple map and action plan to
use during an eruption emergency. While evacuation routes are in place, there are no known secondary options. Through the EDGE Program at Southern Utah University, we visited the study area to gather data by taking GPS Coordinates to create an evacuation route and hazard map to help prepare the surrounding communities. Preliminary maps were created using GIS software. With this information we were able to confirm possible alternative routes and hazardous areas. Thematic maps were compiled with three options. Option A, the preferred route. Option B, the secondary route with contained sections of caution, and option C that is not recommended. Our preliminary research of prior eruptions also gave us sufficient data to create hazard zones. With confirming research at the study site and our preliminary data, our map contains four zones of hazards. In gradients of red, orange, yellow, and green. Red being the most hazardous to green being the least. By consolidating our research and field data, these maps give the communities surrounding Masaya more insight as to the behavior of the eruptions. This gives the surrounding population options in evacuating areas and more knowledge about their environment. It is our hope that this work will make the hazards of Masaya more recognizable to the local communities.

NATURE UP NORTH, A COMMUNITY-BASED ENVIRONMENTAL EDUCATION PROGRAM FOR NORTHERN NEW YORK: INTRODUCING GEOSCIENCE ENGAGEMENT IN RURAL COMMUNITIES

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Screen time tends to replace outdoor experiences separating people from nature and inhibiting environmental curiosity and literacy. Recognizing technology as a barrier between people and the natural world, Nature Up North (NUN), a non-profit organization, has been introducing new ways for citizens to engage with the outdoors. Incorporating technology into environmental education efforts can be a tool to encourage experiences in and with nature. NUN incorporates a number of platforms for environmental engagement including citizen science projects, school and scout group programming, public events, trail mapping, and online platforms for learning and social interactions. NUN involves local communities in scientific data collection through citizen science projects, including the Ash Tree Tracker, an application that is used to map the potential infestation of Emerald Ash Borer. Since spring 2013, NUN has hosted nearly 100 public events, reaching over 1,800 people fostering positive and creative experiences in the local environment, which include papermaking with local plants, fishing workshops, and evening canoe trips. In addition, since spring 2014, NUN has engaged more than 1900 K-12 students in hands-on activities and citizen science projects. The NUN website features a platform for people to share their own outdoor experiences, contributing to a community of learning. Online engagement has been successful, with over 2,000 “encounter” posts on the website and over 2,100 likes on its Facebook page. There is also a growing online trail archive that currently contains 14 routes covering nearly 80 kilometers, which provides people with an accessible interface to get outside independently and confidently. Although NUN is largely biology-based, the introduction of geoscience-based content will broaden the organization’s reach; attracting additional support and engagement. Geoscience content will also give rural communities a better
understanding of the natural history of their region. The development of multiple digitized
geology tours throughout the Northern New York region will allow people an accessible and
engaging way to learn about their local geology and enhance their understanding and
appreciation for our dynamic earth.