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Department of Geosciences

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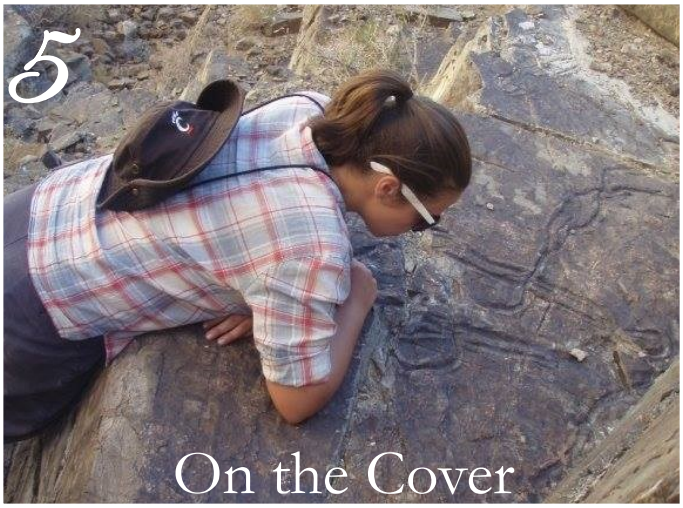

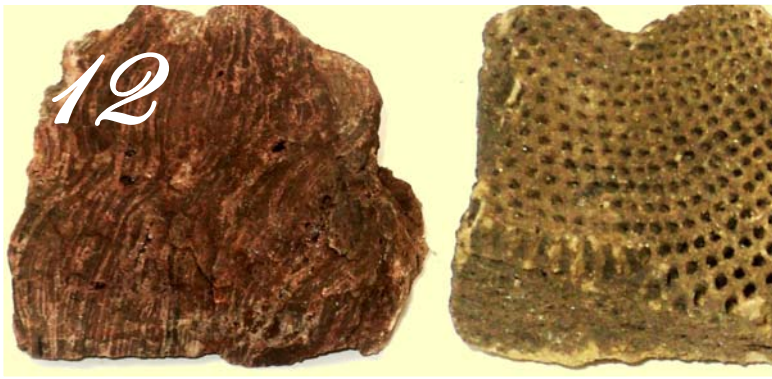

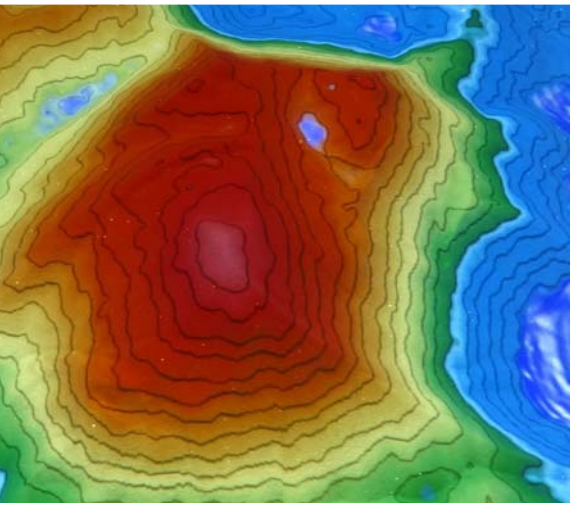

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Buffalo Rock Magazine

A magazine for alums and friends of North Dakota State University Geosciences Department.

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Dept. Chair

Greetings GeoAlums and Friends! It's been another great year here in the Department. We made remarkable goals this year including: (a) securing three new NSF (National Science Foundation) grants, with the department's first ever career grant (Page 5), (b) first department to meet its fundraising goal during the first annual Giving Day held on November 29, 2016, (c) hosting the first ever EarthScope speaker in North Dakota (Page 14) and (d) increased S.T.E.M. (Science Technology Engineering Math) outreach (Page 18). I extend my sincerest gratitude to all those who generously donated to the department on our first annual Giving Day especially Jerrold "Jerry" Mayers who matched every dollar donated. Jerry and Dave Fischer (pictured below) were also the pioneers of the department Alumni fund and have supported the department in many facets of its teaching, research and outreach programs.

Jerry Mayers and Dave Fischer

I also extend my sincerest appreciation to all the first time donors. Again, while the size of donation is great, the number of donors is an even better metric. Your donations help us offer merit-based scholarships to outstanding students and field-trip scholarships to all students.

Dr. Allan Ashworth's research was featured on BBC (British Broadcasting Corp.) under the article, " Rare Antarctic beetle find delights" and the excerpt can be found on the site's science and environment section. The research discusses Ball's Antarctic Tundra Beetle, a fossilized specimen discovered on the Beardmore Glacier, a well-known passageway through the Transantarctic Mountains. The small (< 1 cm long) brown beetle lived more than 14 million years ago (mid-Miocene period), when Antarctica's climate was much different than it is today.

We always love when Mrs. H is in town. Who could ever forget Camaro rides to Dairy Queen?

Mrs. H, Allan, and I

Many of you may not know the late Dr. William B. Treumann. § Also known as "Bill" to friends and family, played his last bridge game on Tuesday, July 26, 2016. He died peacefully at Regions Hospital in St. Paul, Minnesota on Tuesday, August 2, 2016. Born February 26, 1916, in Grafton, North Dakota, he was 100 years old. For a fuller and public account of his life written by family look for Bill Treumann on Facebook. § Dr. Treumann was one of four professors who fought for the rights of two Geology professors who were abruptly fired by the then president of NDAC (North Dakota Agricultural College) Dr. Fred Hultz. From NDSU University Archives, this controversy was the biggest news in 1955 pitting state legislature and other North Dakota institutions against each other, and polarizing NDAC and the Fargo community. Further news from newspaper articles mentioned that the president and his allies mounted a counter campaign specifically charging Dr. Treumann and his three colleagues with "insubordination." Dr. Treumann had served NDAC for only nine years before being dismissed.

We all enjoy hearing from GeoAlums and hope you will drop us a line, become a fan of the department's Facebook page, or stop by for a visit! We have had several alums visit the department including Reuben Panchol, Darin Slusher, Damion Knudsen, Lance Loken etc. I feel blessed having the opportunity to interact with you, parents, students, and friends of the department. If you have any interesting story to share, please feel free to email me (Peter.Oduor@ndsu.edu). On behalf of the students, staff, and faculty, thank you for your support – and best wishes from all of us at NDSU Geosciences!

Section encapsulated with the section sign § was from Fargo Forum courtesy of Nichole Seitz.

Cover Story

Dr. Lydia Tackett

Dr. Lydia Tackett was recently awarded an NSF CAREER grant (Award Number: 1654088) of $512,000 for the project title: A Late Triassic origin for modern marine predator-prey interactions. In modern oceans, shelly animals have many predators, such as crabs, lobsters, sharks, and other fishes. Many of these are specialized to crush hard prey shells to consume the soft tissue inside. Most clams and other marine invertebrates have adaptations to avoid being eaten by these predators. For example, different groups of clams can avoid predation by living beneath the seafloor, in dangerous environments like rocky shores by cementing onto rocks, while other clams grow spines or even swim! Dr. Tackett will study these ecological relationships by looking at marine fossils from the Triassic Period, over 200 million years ago. This is when many of the predator animal groups appear and when many anti-predator adaptations also appear in shelly prey. Dr. Tackett will collect fossils from Triassic age rocks, in Nevada, Italy, and New Zealand.

NSF Career Grant

Shallow marine taxa experienced an unprecedented explosion of convergent adaptations during the Norian Stage (Late Triassic) that ultimately changed benthic paleoecological structure, with more burrowers, cementers, and swimmers than ever before. This coincided with a proliferation of shallow marine predators, but the extent to which predator-prey interactions induced the widespread adaptive responses is not known. The overall research objective in this proposal is to (a) quantify antagonistic relationships between predator and prey taxa in three distinct ocean basins and (b) identify spatial and temporal patterns at the onset of these trends during the Late Triassic. The central hypothesis is that coupled radiations of: (a) shallow marine predators specialized for shell-crushing, and (b) shelly prey specialized to resist or avoid shell-crushing resulted in a dramatically altered ecological structure, with complex infaunal ecosystems and highly specialized surface taxa. The objectives in this research are to (1) calibrate the degree of similarity (in terms of age, depositional environment, and preservation) within and between the three localities (as assessed by a series of fossiliferous bulk samples), (2) analyze shifting ecological dominance of shelly invertebrates during the Norian Stage, and (3) assess ecological dominance of predators in the same deposits using calcified microfossils. This project is unique in its broad temporal, spatial, and taxonomic scope, use of dual predator-prey datasets from single bulk samples, and application of paleoecological niche modelling to test the concept of escalation.

Native American Indians are underrepresented in STEM fields and at 4-year universities. Research-driven intervention programs can play an active role in recruitment by targeting students at points that are critical in their decision to attend 4-year universities as STEM majors. The PI will host Earth Science research cohorts of 2-3 juniors per year from tribal high schools through the EPSCoR NATURE program, developing research projects that are continued in the following two years through the NATURE program and as undergraduate field researchers. The proposed program will encourage the participants to enter universities as STEM majors and familiarize them with research tools in the Earth Sciences though cohort collaboration, peer mentorship, and field work.

Intellectual Merit

The paleoecological restructuring event in the Late Triassic represents one of the most significant ecological transitions in the history of animal life; however, the biological or environmental drivers remain poorly understood. This research will be a significant contribution as it will characterize the ecological responses to intensifying biological interactions at multiple trophic levels in deep time, and inform a framework-based understanding of the interplay between environmental, biological, and ecological drivers in marine ecosystems. Furthermore, this project is likely to facilitate further research on predicting biotic response to more catastrophic environmental perturbations by defining and differentiating faunal turnovers leading up to the end-Triassic mass extinction.

Broader Impacts

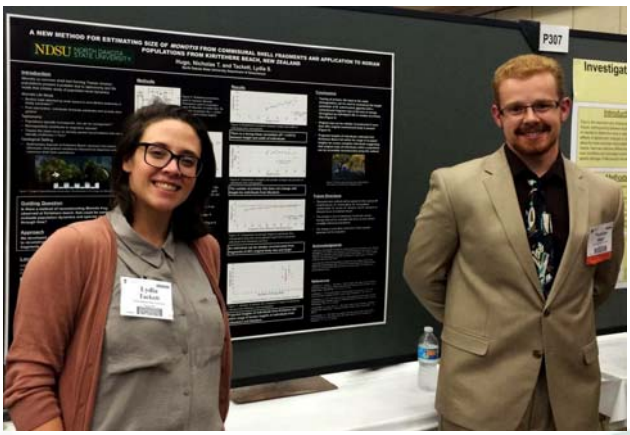
The proposed research will integrate geological research and mentorship activities in multiple student groups, and will have positive societal impacts by contributing to a wider understanding of causal agents of ecological change. Broader impacts of the proposed research include: (1) contributions to conservation models based on biological interactions as driving agents of change, (2) a multi-year, scaffolded summer research program that targets Native Americans in the critical years before deciding to attend 4-year universities that builds independent research skills,

collaboration, and field participation/skills/experience, (3) facilitation of a multi-tier mentorship and research cohort program, (4) dissemination of effective active teaching methods to science faculty in workshops, and (5) student presentation at scientific meetings and in scientific publications by underrepresented groups and early career students. The proposed activities are expected to attract 15 undergraduates from underrepresented minority groups to STEM career paths. Greater diversity in STEM careers benefits society by cultivating scientific talent from a greater pool of participants and facilitating collaborative approaches to problem-solving, leading to excellence in the scientific workforce.

Students working with Dr. Lydia Tackett

Stephanie Clark is an Anthropology major/Geosciences minor who did an Independent Study in the 2017 Spring semester in the Tackett Lab. She extracted shelly marine fossils from a Cretaceous-age butte, and examined the shells for evidence of predation by crabs, snails, and fish that were adapted for eating shelled organisms. The traces these predators leave behind on their prey include breakage scars, peel and puncture marks, and drill holes. This project has the potential to constrain the timing for when modern predation modes evolved and had ecological impacts on the prey populations.

Nicholas Hugo is drafting a manuscript for the research he did in New Zealand in December 2014 and presented preliminary results at the Geological Society of America annual meeting in November 2015. Nick and Dr. Tackett devised a method to estimate original shell size of fossil clams using small shell fragments by triangulating the location of the umbo. He applied this method to Triassic shell beds from New Zealand, and this project may have wide-reaching applications, for example, allowing researchers to reconstruct destroyed modern populations of clams based on shell fragments.



Samuel Marolt **(featured on Page 7)**

Research in Action

Samuel Marolt

Sam is an undergraduate researcher who has been working with Dr. Lydia Tackett on a microfossil research project. Many marine animals make shells, like clams do, but some other animals produce very small skeletal components that are called microfossils, including sponges and echinoderms. Sam has been carefully extracting these microfossils from a sequence of rock samples collected from the early Mesozoic oceanic rocks now found in the deserts of Nevada. By quantifying the changing numbers of these microfossil groups that are made from different minerals, Sam can determine how available minerals were in the ocean water at that time. One of these minerals, silica, is very rare in shallow modern oceans, so the animals that make skeletons from this material are not common in shallow seas. Sam has found these groups in great abundance in some of the Triassic samples, which suggests that these microfossils may be a good proxy for enormous weathering events due to volcanism! Sam also collected additional samples to study.

Research Experience

Freshman year was a whirlwind of learning and narrowing down my future career choices. I was fortunate enough to begin my 1st year at NDSU by getting a tour of the Geology Department from Dr. Peter Oduor. He personally took the time to introduce me to the handful of professors that happened to be in their offices, and explained the purpose of each room. I had mentioned to Dr. Oduor, during the tour, that I had work study and wasn't sure what jobs qualified. He told me about the many things I could do for work study, it mostly depended on who I wanted to work for. The first professor he introduced me to was Dr. Lydia Tackett. When Dr. Oduor asked if she had anything I could do for work study, she gladly said that I could help in her research.

Researching under the guidance of Dr. Tackett was one of the many things I enjoyed during my freshman year. After my classes I would go to her lab and research for a few hours each day. During that time, I would look for spicules and desmids of ancient sponges. At first I had no idea what to look for and was nervous dealing with such small and fragile specimens. Dr. Tackett didn't get upset when I accidentally dropped or shattered one into pieces. She'd patiently tell me not to worry about it and then we'd continue researching like nothing ever happened. I soon became pretty adept at spotting organic microfossils. I also started noticing things that weren't sponge-related like denticles, teeth, and foraminifera. Whenever I found something new and exciting I would notify Dr. Tackett. She would tell me what I had found, or if she wasn't sure, we would research within geology books to see if we could figure it out. After finding enough microfossils, we proceeded onto the hard part, extrapolating the data. At that point I had a solid grasp of the ecosystem these microfossils had lived in. Dr. Tackett always respected my ideas and made my input feel valuable. Usually my ideas were flawed, but throughout our discoveries, we would come up with different theories. When I wouldn't understand a word or theory, she would take the time to explain and show me how it related to the theories we were discussing. I enjoyed asking her difficult questions! She would never make the comment "You'll learn about this in some later class," and evade the question. Instead she would always calmly explain with long and complex answers. I always enjoyed our spirited debates and obtaining explainable results.

I was also fortunate to work with Dr. Allan Ashworth. The skills I acquired in Dr. Tackett's lab came in handy in Dr. Ashworth's lab. Dr. Ashworth challenged me to find even smaller microfossils called diatoms. He taught me a lot about the past and present environment of Antarctica. I loved the thrill of finding new organisms. I thoroughly learned how to sieve down field samples, sort through them, and store the specimens. He always told me to be on the lookout for bones of an always elusive small rodent like animal, which we unfortunately never found!

I have been very fortunate for the opportunities that NDSU has provided me! Even though I learnt a lot in a classroom setting, it was the "hands on" experience that excited me the most. My early school year doubts about majoring in geology have now been 100% dispelled. This truly is the major for me! I would like to thank the NDSU geology department, especially Drs. Tackett and Ashworth, for helping me discern out which areas of research I would love to pursue further. I look forward to spending the next 3 years learning all NDSU has to offer geology majors.

Thank you Geology department!

Dr. Benjamin Laabs

The Department of Geosciences is happy to have Dr. Laabs as a colleague and a friend! Dr. Laabs was previously a faculty member at SUNY-Geneseo and was also the Geology Department Chair. Dr. Laabs was the top candidate in a pool of talented applicants for the Sedimentary / Stratigraphy / Paleontology Geologist position. He replaced Dr. Adam Lewis. Drs. Laabs and Day put together a successful proposal to acquire a Bergen Hexacopter Unmanned Aerial System (UAS) from Dr. Bruce Rafert upon his retirement from NDSU (Department of Physics and Office of the Provost). The UAV will be used by NDSU Geosciences faculty and students in a variety of studies including: low-relief glacial geomorphology, fluvial geomorphology, snow and ice surveys, and repeat aerial photography. New FAA regulations require a remote pilot certification for any UAS use in professional research. Drs. Laabs and Day are currently working towards earning this certification, and will be trained in the operation of the Hexacopter during the upcoming year.

Meet Our New Faculty

Hello, Geoscientists and Geofriends! I am excited to introduce myself as the newest faculty member of NDSU Geosciences. I moved to Fargo in summer 2016 with my spouse (Nancy) and my son (Caleb, 4 years old). We moved from western New York, but we are Midwest natives and excited to be back!

I am a Quaternary geologist interested in stratigraphic and geomorphic records of environmental change. Since completing my Ph.D. in 2004 (University of Wisconsin-Madison), most of my research has involved studying glacial and lacustrine responses to Pleistocene climate change in the western Americas.

During my first year at NDSU, I worked with geology major Alex Reimers (2016) to establish a lab in Geosciences Hall for cosmogenic exposure dating with beryllium-10 and aluminum-26. I chiefly use this tool for developing chronologies of glacial deposits. Last fall, Alex completed a study of cosmogenic exposure ages of glacially scoured bedrock in select mountains in the western U.S., and used the results to reconstruct the pace of ice retreat at the end of the last glaciation. Now that my lab is up and running, I am continuing work on glacial chronologies (including in the Dakotas and Minnesota) and getting into new applications in volcanology and paleoseismology.

Another facet of my research involves numerical modeling of surface processes, which is especially useful for reconstructing Pleistocene climate change. This year, I worked with Gabriel "Gabe" Ferragut on applying glacial and watershed hydrology models to the northeastern Great Basin, in which we limited temperature and precipitation change during the last glaciation and deglaciation. This research will continue in collaboration with colleagues and students at Middlebury College, thanks to a new NSF grant from the Paleo Perspectives on Climate Change program.

Moving to NDSU has brought about great opportunities for collaborative research, and I am excited to work with Dr. Stephanie Day this summer on an experimental survey of a rock glacier in Great Basin National Park. Using Dr. Day's Terrestrial Laser Scanner (TLS), we will begin a series of repeat surveys to test for movement of the rock glacier. The degree of movement will be combined with a snow water balance model and stream discharge data to infer the contribution of buried ice to streamflow in the park. We hope to use the new Bergen Hexacopter UAV to survey the rock glacier in future studies.

In addition to engaging in research, I taught Structural Geology, the Eastern North Dakota Geology Field Course, Glacial Geology, and Earth Through Time this year. I assisted Dr. Lydia Tackett in leading the spring break fieldtrip to Southern California, which was great fun!

Thanks to everyone who have welcomed me so far. I am thrilled to be working among truly excellent faculty and students in NDSU Geosciences, and I look forward to meeting its many alumni and friends!

Augmented Reality

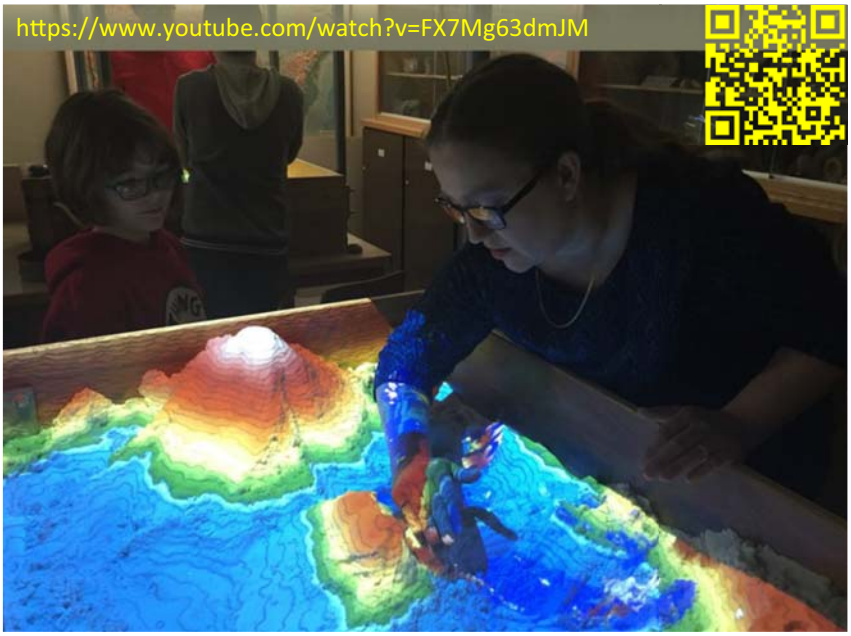
Jessie Rock

Jessie Rock was a co-PI on a funded project to acquire Augmented Reality Sandboxes (ARSs). Other co-PIs included Dr. Stephanie Day (Geosciences); Ben Bernard, and Dr. Dominic Fischer (Architecture & Landscape Architecture). The award from Student Technology Fee Advisory Committee (TFAC) was used to purchase five ARSs. The primary goal of TFAC is to build technology capabilities at NDSU. A secondary goal is to improve the quality of education through information technology. Visual Acuity has been widely recognized as a critical component of HCI (Human-Computer Interaction) and ARSs facilitate this. Visual Acuity in HCI enables interoperability between the computer and the end user. The ARSs technological components enable students to visually interpret simulated landforms in real-time. The co-PIs plan on using the ARSs in more than 7 courses impacting more than 490 students and for outreach activities including Expanding your Horizons, KidFest, Pop-up museums, and K-12 classroom visits.

Augmented Reality Sandbox

Who designed the Augmented Reality Sandbox (ARS)? Oliver Kreylos, a computer scientist studying 3D scientific visualizations and computational geosciences at University of California-Davis designed and programmed the ARS software. He was inspired by a prototype of an interactive sandbox visualization made in the Czech Republic.

How does it work? ARS comprises of: (i) a computer projector, (ii) a Kinect 3D camera that detects motion, and (iii) a box of sand. The user interacts with the exhibit by shaping the sand. An elevation model with contour lines and a color map assigned by elevation from relative distance to the sand is cast from an overhead projector onto the surface of the sand. As users move the sand, the Kinect 3D camera perceives changes in the distance to the sand surface, and the projected colors and contour lines change accordingly. When an object (for example, a hand) is sensed at a particular height (~2 ft.) above the surface of the sand, virtual rain appears as a blue, shimmering visualization on the surface below. The water appears to flow down the slopes to lower surfaces. The water flow simulation is based on fluid dynamics. Users can press and hold a "Drain" button to remove the virtual water.



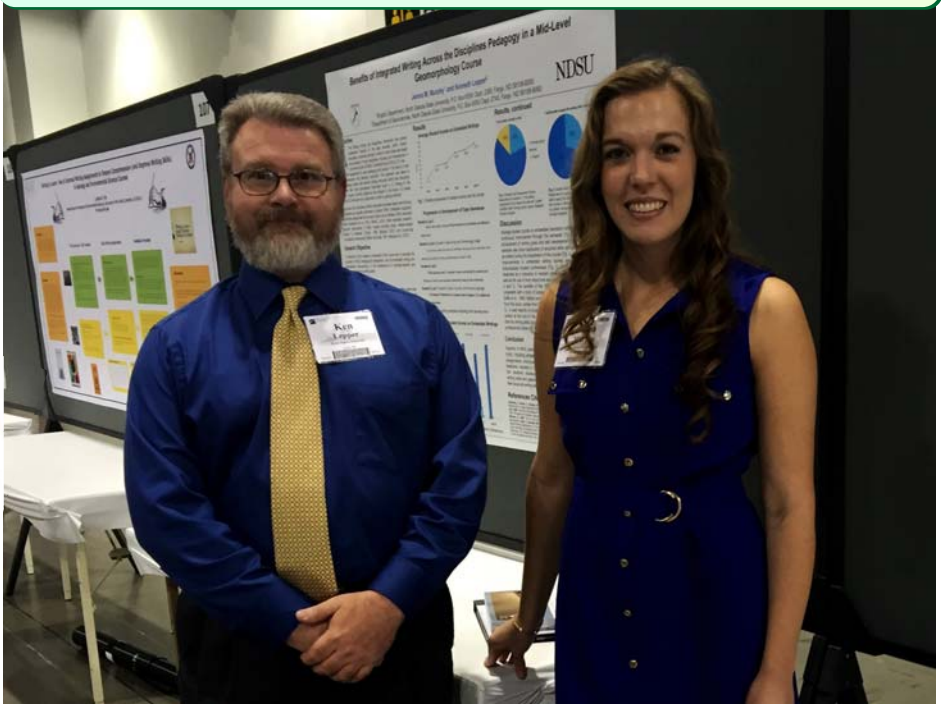
What are students learning? ARSs used at NDSU to teach concepts in geology, geography, hydrology, landscape architecture, architecture, and other concepts involving watersheds and land-use. While students interact with the ARS, they are learning the basics of topographic maps and the use of contour lines in representing elevation. When they create 3-dimensional models from topographic maps, they learn how 2-dimensional representations of landforms are constructed. Students learn how the earth's surface changes through natural processes like erosion and deposition, which are driven by the movement of water. They learn how landforms found on the earth's surface were created by a variety of processes such as erosion, tectonics, and glaciation. Students learn how liquid water moves on the earth's surface and how its flow relates to land surface elevation and shape.

The distribution of water which leads to regions called watersheds plays a key role in the type and distribution of ecosystems around the world. The students are able to discern elements of watershed flow regimes. Since the shape of the earth's surface also influences watersheds, students are able to grasp elements of topological relationships.

Integrated Writing

Jenna Murphy

Jenna recently graduated from NDSU with a major in English and a minor in Philosophy. She was the valedictorian at the Spring 2017 commencement. Jenna was a member of Phi Kappa Phi honor society earned through recognition for superior academic performance. Jenna graduated in 3 years with a 4.0 GPA! Jenna worked with Drs. Kenneth Lepper (Geosciences) and Amy Rupiper Taggart (English) in mentoring, guiding, and assisting geology students in writing and communicating science in discipline-specific projects. Jenna's main role was to help students in the Geomorphology class communicate their project findings in an articulate manner and write up their projects using proper phrasing. In this way the students would be able to communicate their research to a wider audience. Jenna also presented the results of her working with Geomorphology students at NDSU EXPLORE and won a First Place award. She also presented her research at GSA entitled, "Benefits of Integrated Writing across the Disciplines Pedagogy in a Mid-Level Geomorphology Course."



Dr. Kenneth Lepper has introduced Writing Across the Curriculum in his Geomorphology class. Writing Across the Curriculum involves two pedagogical approaches: (i) Writing to Learn, and (ii) Writing in the Disciplines. Both approaches share the inherent premise that writing is an integral component of the learning process. Writing as a lifelong skillset that will be needed, is therefore introduced in an esoteric environment. Students acquiring this skillset can therefore be able to communicate and articulate science first within the discipline and to a broader audience. In practice, the students write a series of essays, reports, critiques, or articles which are periodically graded and feedback provided on subject matter and writing style. Over the past year, Dr. Lepper has worked with Dr. Taggart and Jenna Murphy from the English Department. Jenna was assigned as a co-mentor, peer-tutor, and Teaching Assistant for the Geomorphology course. Jenna applied and integrated these pedagogical approaches over an entire semester with tremendous success. She implemented writing goals that each student was to attain. Each student in the class therefore had a customized knowledge and skillset to attain. Each student from the Geomorphology class had different writing competencies. Each assignment was dually graded for both content and writing components. Thereafter, Jenna met with each student to discuss the assignment post-grading. This positive reinforcement and setting enabled each student to improve on critical areas, e.g., syntax, grammar, passive speech, and general writing skills. Jenna also emphasized the need to avoid hackneyed expressions! The specific goals stipulated in a related study utilizing results from the integrated writing project included: (i) the use of specific and precise language, (ii) appropriate topic sentences, (iii) logical organization, (iv) adequate development and supporting evidence, (v) appropriate transitions, (vi) unity of ideas and coherence, and (vii) sentence variety. From the results of the study, Dr. Lepper and Jenna found that students responded positively to the stipulated objectives, writing had significantly improved within a short time span, and students displayed increased confidence in applying the skillsets to future professional presentations or report writing.

Source / More Information: Murphy, Jenna, M., Lepper, Kenneth, Benefits of Integrated Writing across the Disciplines Pedagogy in a Mid-Level Geomorphology Course, GSA Annual Meeting in Denver, Colorado, USA – 2016; Geological Society of America Abstracts with Programs. Vol. 48, No. 7. doi: 10.1130/abs/2016AM-278584

Congratulations!

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Spring

Spring

Brian Kaeter

Kevin R. McKenzie

Sean A. Ternes

Andrew J. Van Sickle

Fall

Jacob D. Crompton

Chase L. Hillebrand

Tyler S. Kuehn

Mellissa K. Maertens

Benjamin S. Osman

Andrea L. Oswald

Fall

Paleontolog

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EarthScope Speaker

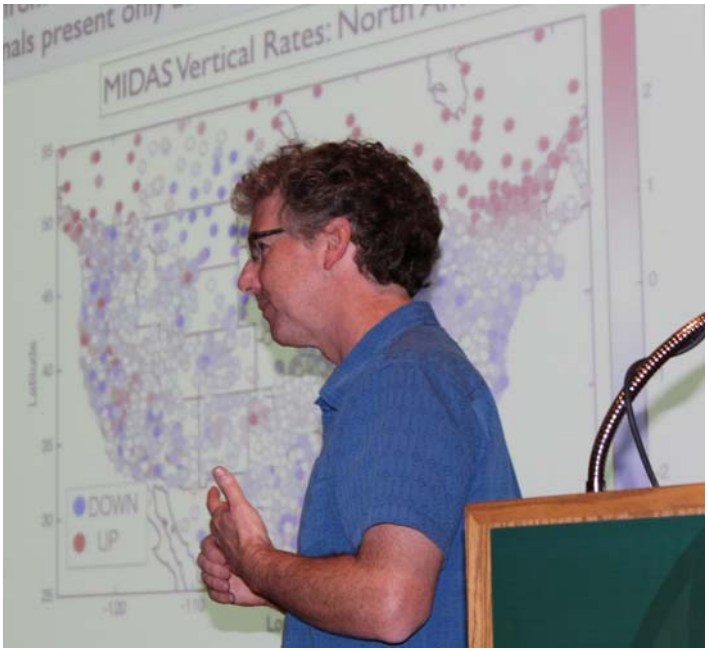
Dr. William Hammond

The Department of Geosciences hosted Dr. William "Bill" Hammond, an EarthScope Speaker, in 2016. EarthScope, funded by National Science Foundation (NSF), is an Earth science program to explore the 4-dimensional structure of the North American continent. The EarthScope Program provides a framework for broad, integrated studies across the Earth sciences, including research on fault properties and the earthquake process, strain transfer, magmatic and hydrous fluids in the crust and mantle, plate boundary processes, large-scale continental deformation, continental structure and evolution, and composition and structure of the deep Earth. Dr. Bill Hammond is a Professor of Geodesy and Geophysics at University of Nevada — Reno, who does research using space geodetic techniques such as GPS and InSAR to study tectonic deformation of the continents, mountain building processes, active faults, dynamics of the lithosphere, and structural controls on geothermal systems. The EarthScope Speaker Series is part of the larger EarthScope Education and Outreach program and seeks to present the scientific results of EarthScope researchers.

Dr. Hammond began his talk by mentioning that there has been a lot of talk lately about climate change and human-induced impacts on oceans, atmosphere, and biosphere. His talk was about how human beings are going beyond that to the point of influencing the shape of the solid earth. He started by mentioning GPS networks and how his research group is getting to the point where they can measure very small changes in earth's shape. Geodesy is the science of the measurement of earth's shape and how it changes over time. Geodetics involve radar, Lidar, and SAR (InSAR, IfSAR). Dr. Hammond's talk was funded by EarthScope. He mentioned that EarthScope is essentially: (i) a community, (ii) facility (set of networks that measures properties of the North American continent), and (iii) a science research program funded by National Science Foundation (NSF). EarthScope GPS networks are operated by IRIS (Incorporated Research Institute for Seismology) and UNAVCO. UNAVCO is a non-profit university-governed consortium that facilitates geoscience research and education using Geodesy. IRIS brings together a consortium of universities dedicated to the operation of science facilities for the acquisition, management, and distribution of seismological data. UNAVCO operates the National Earth Science Geodetic Facility, known as the Geodesy Advancing Geosciences and EarthScope (GAGE) Facility. USArray, is part of the EarthScope experiment, and is a 15-year program to place a dense network of permanent and portable seismographs across the US (lower 48 and Alaska) consisting of four observatories:- (i) Transportable Array, (ii) Flexible Array, (iii) Reference Network, and (iv) Magnetotelluric Array. There are a number of components to these observatories which together comprise EarthScope including: (i) USArray, (ii) the Plate Boundary Observatory (PBO) with approximately 2,000 continuously recorded GPS stations distributed across the contiguous US and Alaska but also includes Geophysical instruments e.g. GNSS (Global Navigation Satellite Systems) receivers, Accelerometers, long-baseline Laser Strainmeters (LSMs), Terrestrial Laser Scanning (TLS) Instrumentation, and (iii) the San Andreas Fault Observatory at Depth (SAFOD) which is a deep borehole observatory that will directly measure the physical conditions under which plate boundary earthquakes occur. There is a denser network in the western US compared to the rest of the contiguous US. Other agencies that have contributed to material support include: USGS, NASA, and EarthScope office responsible for coordination of education and outreach. Dr. Hammond also mentioned that EarthScope office is the face of EarthScope and for the next 5 years, will be organizing EarthScope series of lectures. To learn more about EarthScope, you can visit the webpage: http://www.earthscope.org/. You can read more about the networks, programs, instrumentation used, and maps where sensors are located.

Dr. Hammond mentioned that he is involved with UNAVCO on the geodetic side, so they are a separate consortium and a non-profit organization that helps support geodesy for earth science. Dr. Hammond also mentioned that before he came to present at NDSU, the President of UNAVCO mentioned to him that there is currently no membership from North Dakota in the UNAVCO community/consortium. For folks that are doing geodesy, it is easy for anyone becoming involved with UNAVCO. A UNAVCO membership helps you participate in decisions on how UNAVCO is run and also provides discounts on equipment. Dr. Hammond mentioned that they are processing massive amounts of GPS data that are coming in from stations all over the world. For example on portable devices e.g. smart phones and tablets there are inbuilt GPSs and billions of users use these GPS systems every day. Dr. Hammond and his research consortium have established continuous stations (geodesy net-

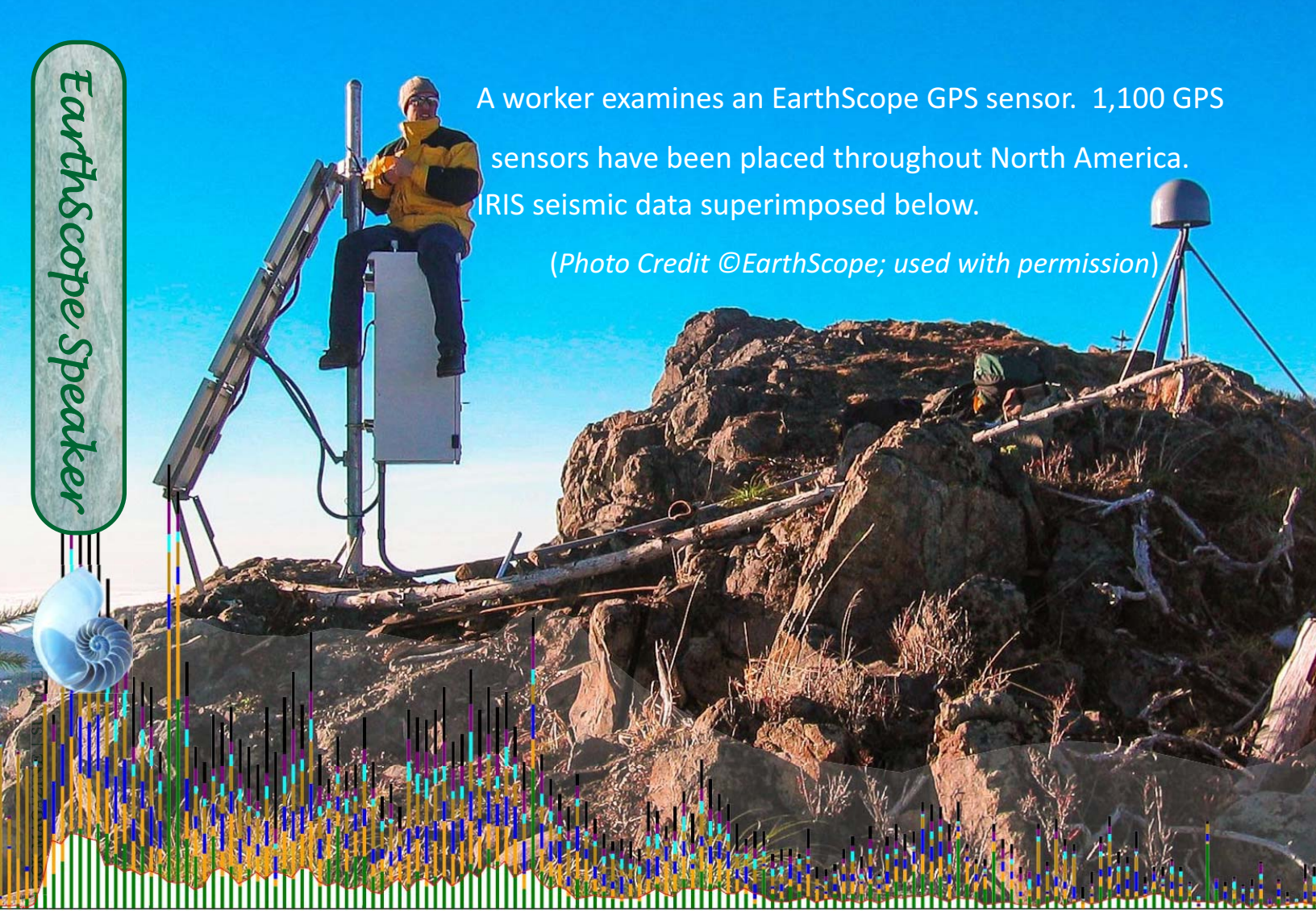
works) which are generally built for scientific research but also for surveying applications. Any GPS data users upload online or on File Transfer Protocol (ftp) server, is utilized for research. Dr. Hammond talked about the explosive growth of this data, availability of the data, reliability of the data, accuracy of the data, and a GPS initiative that they just started with UNAVCO. This data helps gauge uplift and subsidence across North America. Newer analyses are allowing them also to generate images of spatial continuous uplift from GPS observations which had been a challenge up to this point. Images derived from these GPS points can be used to gauge mechanical stress and strain of the uplift where there is overburden. Dr. Hammond mentioned that there are about 15,000 GPS stations globally distributed, hundreds of networks, hundreds of separate municipalities, governments, universities, and agencies operating these stations. These stations are not evenly distributed over the land surface and high concentrations exist where there is research funding e.g. in US, Canada, Europe, and Japan. They are also seeing extensions of these networks in other continents.



He mentioned that there is a pretty good GPS coverage of islands in the Pacific and Indian Oceans. These stations can be used to track motions of plates and many other aspects related to deformation. All this information is brought in to the Nevada Geodetic Laboratory and processed using JPL GIPSY (GPS Inferred Positioning SYstem) software. This software is one of the highest precision codes for processing and analyzing GPS data with a sub-inch/mm precision in latitude, longitude, and elevation.

Some of the results are posted at: http://geodesy.unr.edu/NGLStationPages/gpsnetmap/GPSNetMap_MAG.html. Dr. Hammond also mentioned that they have time series data from certain GPS stations spanning up to 20 years so they are able to see how the position of a station has changed over time. They can therefore address if the plate relative slip motion is comparatively faster than previously estimated, if the shape of earth is changing at a discernible rate, or even if these processes are primarily driven by tectonic processes. This information can be analyzed real-time from 2,000 stations in as little as 2 hours. The number of stations they have access to, has grown exponentially from late 1990s to early 2000s. The EarthScope Plate Boundary Observatory, Dr. Hammond's network in Nevada, and 400 stations were installed during this decadal period. They are still rapidly expanding with new networks and stations. GPS for EarthScience is another initiative that University of Nevada – Reno (UNR) and UNAVCO have collaborated on to create what is essentially a service that people can access. One of the barriers that people have with setting up a new GPS network is the fact that processing the data is a lot of work. It requires getting someone with a level of expertise involved so that they can get the data processed and analyzed. Plug & Play GPS is intended to remove this barrier in order to maximize the incentive to install Geodesy networks in the world especially in the third world countries where that expertise is hard to find. Plug & Play GPS is a NASA ROSES ACCESS funded project to provide no-cost services for generating high precision GPS position time series products from continuously operating GPS/GNSS stations from around the globe. Dr. Hammond reiterates that, "If you set up the network, we will process the data for free, the only catch is that all the data and processed time series has to go online and be accessible to everyone, so you become a part of our online system where everyone will have the benefit of that data and this will hopefully maximize the impact of getting that data online." If one searches for Plug & Play GPS UNAVCO in Google search, they will be directed to a web form, prior to downloading the App. Dr. Hammond added that, "There are just three questions to answer and UNAVCO will contact you."

Pictured with Dr. William Hammond (center) are: from left, Drs. Debasree Chatterjee-Dawn, Benjamin Laabs, Lydia Tackett, Bill Hammond, PhD Graduate students Zachary Phillips (adviser:- Dr. Day), Papia Rozario (adviser:-Dr. Oduor) and Dr. Stephanie Day.



A worker examines an EarthScope GPS sensor. 1,100 GPS sensors have been placed throughout North America. IRIS seismic data superimposed below.

(*Photo Credit ©EarthScope; used with permission*)

As part of the Plug & Play project, UNAVCO will accept high-quality GPS data from contributors who desire data processing by the University of Nevada. Contributed data and derived time series products will be publicly available following the UNAVCO Data Policy. UNAVCO service includes archiving and generation of data and product Digital Object Identifiers (DOIs). For example, they have someone who has set up a base station on a landslide in San Francisco bay area to monitor the creep and determine how fast the landslide is moving with respect to the North American plate movement. Since each base station has a unique identifying code, they can quickly query results from one station to another. Dr. Hammond also said that, "the method of geocoding GPS points is very much looking at every data point and making sure that it is correct, looking at outliers, noting equipment changes, and checking for data that may cause discontinuities occurring for various reasons."

Access to the benefits of having high precision, low-latency position time series from global GPS networks is currently limited by the need to have advanced expertise and systems for data acquisition and processing. Dr. Hammond's team is taking steps to remove these barriers by developing a GPS data analysis system capable of processing all openly available data from over 13,500 continuously operating stations from around the globe. This rigorous and automated system will provide processing free of charge and will greatly ease access to GPS position time series that can be used for rapid modeling and analysis of natural hazards from earthquakes, tsunamis, volcanoes, hydrologic changes, and other applications. It is envisioned that availability of this unique resource will encourage open sharing of data and analyses, and enable building scientific capacity in areas that are currently sparsely sampled with GPS devices such as in Africa. They hope to provide daily and 5-minute position time series and quality control analyses, with latency between 2 hours and 1 day. Global Navigation Satellite System (GNSS) data submitted to the UNAVCO archive undergoes data analysis, access, formatting and cataloging of accurate metadata including proper source attribution. The Nevada Geodetic Laboratory at the University of Nevada, Reno, (UNR) will pick up hourly and/or daily data files from the UNAVCO archive and process the data using products provided by the Jet Propulsion Laboratory (JPL), including ultra-rapid GPS orbits and clock parameters, and JPL's GIPSY OASIS II software. The processed time series are presented in global (IGS08) and North America (NA12) reference frames and post-processed station

quality control factors, are cataloged in a Geodetic Seamless Archive Centers (GSAC) database that is searchable and accessible via web browsers or via newly developed simple RESTful (REST stands for Representational State Transfer) web services. To ensure utility of the products, AfricaArray, USGS, and JPL collaborators are included in the testing and evaluation and short courses will provide training on how to provide data to the system and utilize products. A beta version of the UNR Plug and Play product GSAC is now available for open testing and this service will be moved when UNR GSAC becomes fully operational. Dr. Hammond stated that, "there is so much that is coming and is not a reason for us to get persnickety in modeling every time series individually. The method of GPS Geodesy processing in the past is looking at every point ensuring every data point is correct and weeding out outliers and positions during equipment changes." "MIDAS (Mixed Data Sampling) is a new technique that allows us to go through a lot of data nicely with trends in a time series," he added. Dr. Hammond's team introduced a new non-parametric method where it is not necessary to know any trends beforehand. For example, with their method it is possible to parametrize the time series in detail for a seismic event occurring on January 01, 2010 and a repeat event on January 15, 2015. Although, it is a labor intensive process requiring knowing where all the discontinuities occur for varying reasons, it can be done automatically. This can be done by noting locations and time series developed. You calculate the spatial difference divided by the time between these to get a rate and then do this for every possible data pair that is about a year apart. This allows one to generate a distribution of these velocities and the median of that distribution represents the overall rate. Dr. Hammond mentioned that, "it appears clunky especially to scientists that love least squares and matrices but it is extremely robust where there could be 29% of the data that may be garbage or outliers, you will still get this stable estimated trend." "This method gives you almost the regular answer for a time series but if you hate time series that has wiggles, bumps, and peculiarities, it is much easier to then average trend," he postulated. They tested this method in various ways and also set up computations where they can estimate the trend.


GPS Satellite
(*© NASA*)

Spatial Imaging

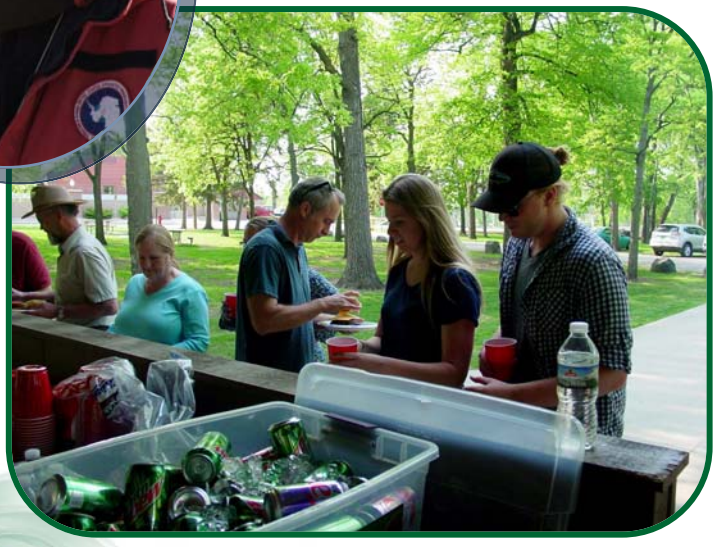
The next step in GPS imaging is the spatial part where Dr. Hammond's research group performs statistically appropriate interpolation of the data in a way that does not impose any smoothing of the spatial data at all. Both GPS imaging and spectral imaging incur speckle noise and is usually treated with weighted mean type filter or kriging. They use a spatial structure method that involves Delaunay Triangulation which can be used to generate a "surface" of GPS stations but is also sensitive to outliers just like MIDAS. One of its inherent advantages is that it preserves the integrity of resolution of the stations. He mentioned that, "If we have one GPS station in North Dakota that is all we have, if the data is dense then we want the field to be equally spatially dense." GPS imaging helps them isolate changes at a finer scale of ± 3mm/year, isolate large scales/signals, and despeckle noise in order to generate a lucid view. In one of their studies, they used stations that had long temporal records (>5 years) of data and applied a filtering technique. From their study, they concluded that there is an upward motion in Northern Canada that depicts glacial isostatic rebound following melting of the Laurentide Ice Sheet; so the ice mantle acts like a visco-elastic material, such that, after the load of the glaciers disappears there is a corresponding rebound. They estimated the rate to be about 2mm/year. To the south of the upward part of this area showing rebound there is a corresponding downward motion at 2mm/year and this extends all the way from Northern Montana to Albany in New York, and also along the US east coast. And so from the Georgian coast upwards towards Massachusetts is the downward motion presenting a hinge line and south of the hinge line is a four-fold collapse. The visco-elastic response in the lithosphere, the equations of an elastic plate, predicts this downward feature on top of the hingeline. This is Glacial Isostatic Adjustment (GIA) in reverse. "This is a big signal since it covers such a large area!" exclaimed Dr. Hammond. Also they noted that uplift patterns in the western US are consistent with groundwater extraction, elastic bedrock uplift, plus slower background tectonic uplift. A discontinuity in the velocity field across the southeastern edge of the Sierra Nevada also reveals a contrast in lithospheric strength, suggesting a relationship between late Cenozoic uplift of the southern Sierra Nevada and evolution of the southern Walker Lane from their study.

Please visit: http://www.earthscope.org/

The following are our outreach initiatives and programs:

- Synergies with NATURE Program: NATURE is an educational outreach designed to attract and retain North Dakota American Indian college and high school students in science, technology, engineering and mathematics (STEM) degree programs.
- Cub Scout Geology Badges: The department in collaboration with various local Boy Scout chapters enables Tiger Cubs, Cub Scouts and Webelos Scouts complete their Geology Badge requirements. The scouts collect and identify rock samples, minerals, and articulate the basics of geology to a broader audience for the Belt Loop requirements.
- NDSU Darwin Days Hallway of Biodiversity Museum: The department also participates in Darwin Days' displays, and keynote presentations.
- National Fossil Day at the Fargo Public Library, Downtown Branch, and Carlson Branch: The department through local community participation also headlines the National Fossil day at the Fargo Public library.
- North Dakota Science Olympiad: All departmental faculty, staff, and students are equally involved in North Dakota's Science Olympiad program in areas like geology, geography, paleontology, and meteorology events. The Science Olympiad is a K-12 program designed to foster teamwork and group learning as required skills in scientific careers.
- The department has participated in: (a) Expanding Your Horizons in Science and Mathematics™ conferences. (b) Presenting as guest lectures in various institutions on topics on Evolution, Mass Extinction, and Paleontology. (c) NDSU Science Café as guest lecturers. The Science Café is designed to communicate significant scientific questions to the general public. (d) Lake Agassiz Rock Club as guest speakers. (e) Identifying rocks, minerals, and fossils collected by community members. (f) Pop-up Science Technology Engineering Arts & Mathematics (STEAM) Museum at the Fargo Public Library. (g) West Fargo Public Library Geology Mini-Museum, One Book, One Community Series.
- Articulating Science to K-12 students: The department has presented: (a) Minerals, rocks, and fossils information to Glyndon-Dilworth-Felton Public School, 1st graders. (b) Topics in minerals, rocks, and fossils; to Casselton Public Schools, 4th graders. (c) NDSU Stem Kids Summer Camp, geology event. (d) Math and Science Night Geology Event at Eastwood Public school. There were 115 families and a total of 346 people attended this event. (d) Fargo Public Library Summer Reading Program Science Events.
- Multi-Media / Audio-Visual Communications: The department has been featured in various news outlets on emerging topics and key discoveries including National Geographic, PBS (Share-A-Story).

Dr. Lewis' Farewell Album



Sophomore Scholarship

Kayleigh Alme

Kayleigh Alme received the Sophomore Scholarship (formerly the Brophy Family Scholarship). This is a $250 scholarship given to the outstanding Geology major at the sophomore level.

"Green Hammer" Scholarship

Samuel Marolt

Samuel Marolt received the "Green Hammer" Scholarship. This is a rock pick and a $200 scholarship to the outstanding Geology major at the first-year level. Heidi Hansen (not pictured) also received the "Green Hammer" Scholarship.

John & Margaret Brophy Scholarship

Kevin McKenzie

Kevin McKenzie received the John & Margaret Brophy Scholarship. This is a $1,000 scholarship given to a Geology major (any level) as named by the faculty of Geosciences. His nomination notes included: Enthusiasm in Geology, Improved academic performance, Engaged and helpful in Geology-based projects & assignments.

Lake Agassiz Rock Club Scholarship

Melissa Maertens

Melissa Maertens received the Lake Agassiz Rock Club Scholarship (formerly the Agassiz Scholarship). This scholarship includes the Glossary of Geology and a $350 cash scholarship given by the Lake Agassiz Rock Club to the Geology major at the junior level on the basis of scholastic achievement.

Allan C. Ashworth Scholarship

Gabriel Ferragut

Gabriel Ferragut received the Allan C. Ashworth Scholarship (formerly the GeoAlumni Scholarship). This is a scholarship of $1,000 to the Geology major at the senior level with the highest academic standing. Funds provided by alumni and friends of the Geosciences Department.

2017 Scholarship Recipients

Kayleigh Alme:- John & Margaret Brophy Scholarship

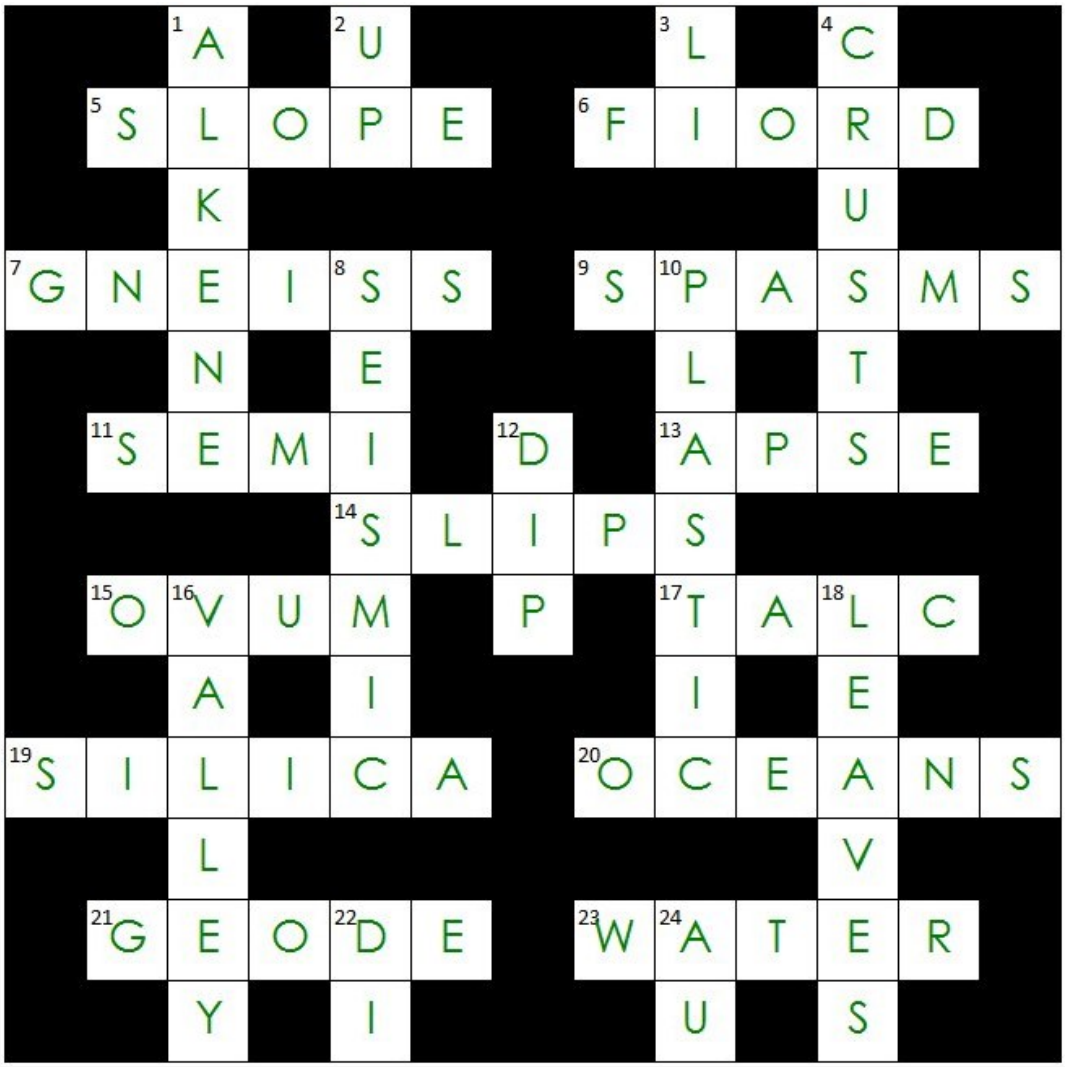
Haley Marston:- Lake Agassiz Rock Club Scholarship

Tristan Anderson & Samuel Marolt :- Sophomore Scholarship

Max Kittock:- "Green Hammer" Scholarship

Sean Ternes:- Brophy Scholarship. This is a $300 scholarship given biennially to the Geology major submitting the outstanding report for Field Geology.

Crossword Puzzle



Across

5. Gradient

6. Anglicized version of *fjord*

7. A metamorphic rock composed prevailingly of quartz, feldspars and micas arranged in plane parallel structure

9. Sudden bursts of energy e.g. in volcanic eruptions

11. Prefix meaning half

13. Another term for apsis

14. Relative displacement of formerly adjacent points on opposite sides of a fault, measured in the fault surface (pl)

15. The female gamete of an *embryophytic* plant

17. An extremely soft, light green or gray monoclinic mineral

19. The chemically resistant dioxide of silicon

20. A very large expanse of sea (pl)

21. A rock containing a cavity lined with crystals or other mineral matter

23. A colorless, transparent, odorless, tasteless liquid

Down

1. Any unsaturated hydrocarbon containing at least one double bond

2. A higher position

3. Chemical symbol for lithium

4. Laminated, commonly crinkled deposits of algal dust

8. Pertaining to an earthquake or Earth vibration

10. Said of a body in which strain produces continuous, permanent deformation without rupture

12. Inclination

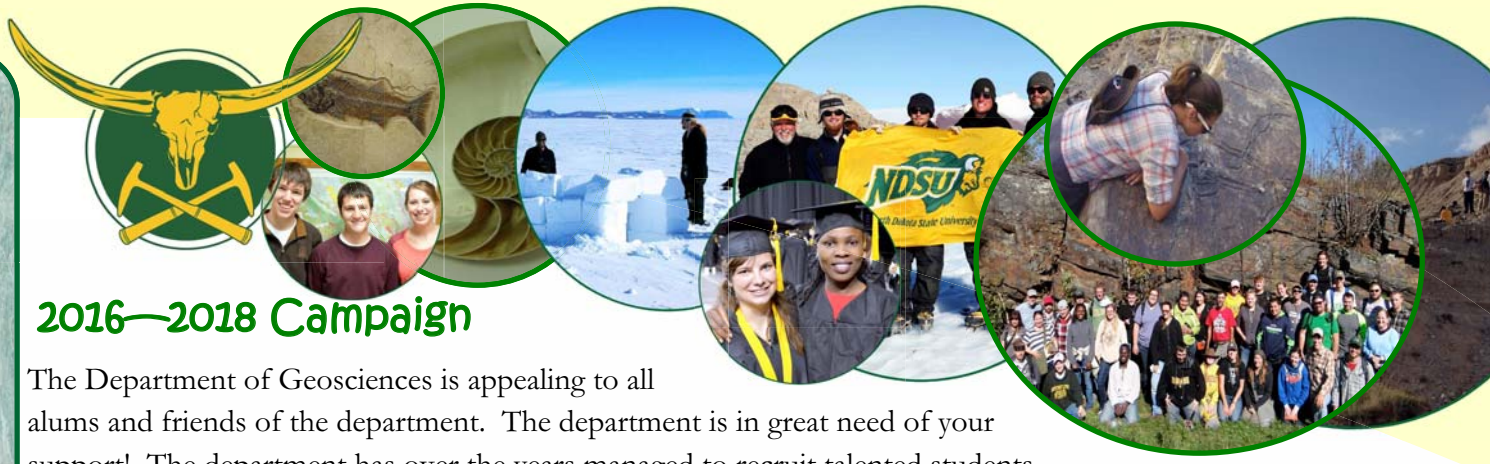
16. Any low-lying land bordered by higher ground

18. Fossil _____ can be used as paleoprecipitation indicators

22. Prefix meaning "two", "twice," or "double"

24. Chemical symbol for gold

Fund Raising



2016—2018 Campaign

The Department of Geosciences is appealing to all alums and friends of the department. The department is in great need of your support! The department has over the years managed to recruit talented students who have gone on to succeed in rewarding careers. This would not have been possible without the support of alums and friends of the department. The departmental faculty also advise graduate students in various capacities. The following are our priority areas for this second round of our funding campaign: (a) student support, and (b) laboratory support.

Student Support

We need your help in support of:

Field trips: The primary establishment of Geosciences Endowment funds was to subsidize field trip costs. Each student and supporting faculty receive a percentage subsidy. The support funds are used for any logistical support including campground fees, medical emergencies, various incidentals, and contingencies.

Undergraduate & Graduate Research: The department has had outstanding majors, and remarkable success in recruiting graduate students through the Environment & Conservation Sciences Program. We need your help to support field-work studies or travel to conferences to present their research.

Undergraduate Merit Scholarships: Every year we award various scholarships to deserving students. These include Allan C. Ashworth Scholarship, Lake Agassiz Rock Club Scholarship, Sophomore Scholarship, "Green Hammer" Scholarship, John & Margaret Brophy Scholarship, and Brophy Scholarship.

Laboratory Support

Paleontology & Sedimentology Laboratory Support: A one-time donation of $14,000 can be made to support an undergraduate student field trip to New Zealand, undergraduate research for a full academic year, petrography projects, light blocking outdoor tent, and travel to Earth Science Rendezvous.

Fluvial Geomorphology / Terrestrial Laser Scanning Laboratory Support: A one-time donation of $118,250 can be made to purchase a time lapse photography camera, tablet PCs e.g. iPads and an updated Laser scanner designed for outdoor applications. New equipment or single items donation can also be made, e.g., single iPads.

Mineralogy Laboratory Support: A one-time donation of $205,000 can be made to purchase a Buehler Petrothin thin section machine ($20K), a desktop Scanning Electron Microscopy (SEM) with EDS system ($150K), and a handheld XRF for field and laboratory rapid chemical analysis ($35K). Your help and support is greatly appreciated!

Optical Dating and Dosimetry (ODD) Lab support: A one-time donation of $300,000 to upgrade the primary research equipment to a fully integrated single-grain OSL/TL Dating system in support of geomorphology and Quaternary geology studies. This instrument will be used for geologic dating measurements from individual sand grains.

No amount is too small or great! Please contact me at: Peter.Oduor@ndsu.edu for details on how to support any of these projects.

NDSU NORTH DAKOTA STATE UNIVERSITY

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Parents/Guardians: If this issue of Buffalo Rock Magazine is addressed to your son or daughter who has established a separate permanent address, please notify us of the new address: 1-701-231-8455 of ndsu.geosciences@ndsu.edu.

DONATING TO NDSU GEOSCIENCES

Q: When I receive a mailing or that phone call from NDSU asking for a donation, can I target it to specifically support the educational and outreach programs in the Department of Geosciences?

A: Yes! Simply specify that your gift go to one of our four funds. All contributions to the fund are tax-deductible. Many employers will match the donations of employees; for information on how to provide a match, see: ***www.ndsufoundation.com/AnnualGiving***

Q: What is the purpose for each of the funds?

A: The *Geo-Alumni Endowment* supports field courses and student scholarships. Even a one-time contribution can generate income for years to come through interest accrued to the account.

The *Geosciences Fund* supports our outside speakers and outreach programs.

The *Mayflower Fund* (established by the late Dr. Warren D. Kress) provides scholarship and travel support for our students in Geography.

The *Schwert Endowment* (established by Dr. Donald Schwert) for Undergraduate Research in Paleontology supports aligned projects and programs and can be used for research supplies, field travel, and conference-related travel where the student is a presenter/co-presenter; or expenses for undergraduate students at NDSU who are working with faculty on paleontological research.

Please detach, and mail with your gift to:
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_____% Kress Mayflower Fund (Fund: SM25762)
_____% Donald P. & M. Charlene Schwert Endowment (Fund: SM30448)

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