

Dr. Paul Kelso Sabbatical Report

Sabbatical 2022-2023 academic year

Title:

How does the Earth work? Developing 3D geophysical models of the early Earth. Science education research and application: scientific uncertainty, digital field data and 3D modeling

I would like to thank Lake Superior State University for the opportunity to undertake a sabbatical during the 2022-2023 academic year. I had a very busy and productive sabbatical. I undertook a project that provide LSSU student research opportunities and has impacted student learning inside and outside of the classroom. **LSSU students and I presented six abstracts** at national and regional geoscience meeting in 2022-2023 related to work during my sabbatical, citations listed below.

A primary focus of my sabbatical was understanding plate tectonics in some of the oldest rocks on earth and determining the processes that created and modified Australia's Pilbara craton 3.2-3.5 billion years ago. My sabbatical research involve field and laboratory data collection, processing and/or modeling of gravity and magnetic data collected in the best exposed example in the world of preserved early Earth crust, the Pilbara region in northwest Australia. This was the first detailed 3D study of early Earth tectonic plates anywhere in the world.

My sabbatical allowed myself and two LSSU students, Nyla Rechtzygiel and Trevor Moran, to participate in a National Science Foundation sponsored project studying tectonic processes of the early earth in Western Australia in collaboration with Dr. Basil Tikoff (University of Wisconsin-Madison). It was only through my sabbatical that LSSU students and I had the opportunity to participate in this international research project.

My sabbatical started early, in June 2022, with a 4 day excursion to University of Wisconsin-Madison with LSSU geology students Nyla Rechtzygiel and Trevor Moran for training and logistic purposes to prepare us for field work in the Pilbara region of Western Australia. At the University of Wisconsin-Madison we met with Dr. Basil Tikoff and student Will Hazeltine who were also part of the field team in Australia. We were trained to use and care for the gravimeters and differential GPS units we would be using in the field. We worked with faculty, staff and students at UW-Madison to collect field data and develop instrument and data protocols. We transported field equipment back to LSSU which we would be taking on the airplane to Australia. Nyla, Trevor and I practiced using the equipment and software at LSSU in June to further prepare for the upcoming field work in Australia

Nyla, Trevor and I traveled to Australia in early July 2022. We meet up with the rest of the Australia field research participants in Port Hedland, Western Australia. The field research team consisted of undergraduates Nyla Rechtzygiel (LSSU), Trevor Moran (LSSU), Will Hazeltine (UW-Madison), Ann Everest (University of Nevada-Reno), Dr. Basil Tikoff (UW-Madison) and

myself. We spent most of July and August 2022 conducting field work in the East Pilbara region of Western Australia which primarily included collecting gravity data, GPS data, magnetic susceptibility data, geologic field data and rock samples. Dr. Tikoff departed at the end of week 2 after which I lead the student team as we continued the Australian field work through late August. The data and samples collected during this field work formed the basis for much of my sabbatical work. Samples and data were collected both for research purposes and to be used in my classroom/laboratory activities.

While in Australia I also meet with the Klaus Gessner, head of the Western Australia Geological Survey along with other geologists and geophysicists at the Western Australia Geological Survey to discuss our project and to coordinate and share information with them related to data they have from the region and ongoing projects. I meet with geologists Steve Sheppard and Nicolas Meriaud from Calidus Resources who operates a gold mine within our study region and are very knowledgeable about the local geology. I also meet in Perth, Australia with Michael Hitch, a LSSU geology alumnus, who is currently Head of School (i.e., Dean) Western Australian School of Mines: Minerals, Energy and Chemical Engineering, Curtin University.

During fall 2022 I focused on data processing of the GPS and gravity data collected. We collected gravity and GPS data at over 500 sites in the Pilbara of Western Australia. There is extensive data processing necessary to complete differential correction of GPS data and to undertake all the corrections necessary for gravity data. I also worked with the Western Australia Geological Survey following up on our discussion from when I was in Australia. They shared with me Western Australia Geological Survey data and information which we used to in our project. I also visited the UW-Madison in October 2022 to work with Dr. Tikoff, students and staff on the processing of the data we collected in Australia and had discussions related to geology and incorporating technology and scientific uncertainty into undergraduate curriculum. I worked with Nyla Rechtzygiel and Trevor Moran as they made measurements in the LSSU geology lab of magnetic and density properties of samples collected in Australia. I meet with Nyla and Trevor nearly weekly as they collected, recorded and processed gravity, magnetic and GPS data. Nyla and Trevor both developed independent research projects based on the data and samples they collected in Australia.

During fall of 2022 I also worked on a project studying the tectonics of western Idaho and eastern Oregon. This is a project that we have been working on for many years. The paleomagnetic data LSSU students and I collected over the years was combined with geochronology and seismic data from the region to develop a new model to explain the deformation and tectonics of the region. I presented the results of this study at the American Geophysical Union annual meeting in Chicago, IL in December 2022.

During the winter/spring of 2023 I continued with data processing and data analysis but the research emphasis transitioned to developing 2D and 3D models of the gravity data we collected in Western Australia. During February/March 2023 I conducted laboratory research on the samples we collected in Australia at the University of Minnesota Institute for Rock Magnetism. The Institute for Rock Magnetism is one of the best laboratories in the world to collect detailed rock magnetic data. Data collected at the University of Minnesota was used to constrain models of the Australia crust and the associated tectonic processes. During February 2023 I again visited

UW-Madison to work with Dr. Tikoff, students and staff. This visit the focus including teaching geoscience (technology, scientific uncertainty, etc.) and on modeling of the gravity data we collected in Australia. I also gave a guest lecture to a graduate class on paleomagnetism while visiting UW-Madison.

During winter/spring 2023 I meet approximately weekly with undergraduates Nyla Rechtzygiel (LSSU), Trevor Moran (LSSU), and Ann Everest (University of Nevada-Reno) to discuss modeling of gravity data. Nyla and Trevor were modeling a subset of the gravity data we collected in Australia and Ann was modeling a gravity data set from Nevada. Usually Nyla, Trevor and I meet in person and Ann joined the meetings via zoom. I also meet periodically via zoom with faculty and students from UW-Madison. Nyla and Trevor presented the results of their research at a Geological Society of America meeting.

I met throughout the academic year with LSSU geology senior Stephanie Georgevich who I worked with on her senior project which was a Ground Penetrating Radar (GPR) study at a property in Harbor Springs, Michigan. This property was a speakeasy during prohibition, Club Manitou. There have been stories for years that there was a tunnel from the property basement, where the speakeasy was located, down the hill toward the local airport. Stephanie conducted a GPR study around the building to look for potential tunnels. Stephanie found good evidence for a tunnel leaving the basement and going down the hill toward the airport as stories had suggested. Stephanie presented the results of her study at a Geological Society of America meeting and to the Harbor Springs Historical Society.

Results of Sabbatical

It is exciting to be part of a research project where the results require a new or significantly modified interpretation of generally accepted geoscience models. My sabbatical study of the tectonic process modifying the Australian crust during the Archean 3.2-3.5 billion years ago provides new insights and likely models for early earth tectonic processes. The results of the projects I worked on during my sabbatical were presented by LSSU students (names in bold) and I at national and regional geoscience meetings and are listed below.

Kelso, P., Tikoff, B., Everest, A., Hazeltine, **W.**, **Moran, T.**, & **Rechtzygiel, N.**, 2023, Gravity survey and associated density models of the Warawoona Syncline region, eastern Pilbara craton, Australia: A test of Early Archean convective overturn, Geological Society of America Abstracts with Programs, Vol. 55, No. 6, Annual meeting Pittsburgh, PA, Oct. 15-18, 2023.

Rechtzygiel, N., Kelso, P., **Moran, T.**, & Everest, A., Hazeltine, W., & Tikoff, B., 2023, Geophysical study of the subsurface geometry of a granite-greenstone belt in the eastern Pilbara craton, Western Australia, Geological Society of America Abstracts with Programs, Vol. 55, No. 6, Annual meeting Pittsburgh, PA, Oct. 15-18, 2023.

Georgevich, S., & Kelso, P., 2023, Using ground penetrating radar to investigate the possibility of prohibition era tunnels at Club Manitou. Geological Society of America Abstracts with Programs, Vol. 55, No. 3, North Central section meeting, Grand Rapids, MI, May 4-5, 2023.

Moran, T., Kelso, P., Tikoff, B., **Rechtzygiel, N.**, Everest, A., & Hazeltine, W., 2023, Modeling gravity data in the eastern Pilbara craton, Australia. Geological Society of America

Abstracts with Programs, Vol. 55, No. 3, North Central section meeting, Grand Rapids, MI, May 4-5, 2023.

Rechtzygiel, N., Kelso, P., Tikoff, B., Moran, T., Hazeltine, W., & Everest, A., 2023, Gravity study of a granite-greenstone belt in the eastern Pilbara craton, Western Australia. Geological Society of America Abstracts with Programs, Vol. 55, No. 3, North Central section meeting, Grand Rapids, MI, May 4-5, 2023..

Kelso, P., Tikoff, B., Nelson, E. M., 2022, Paleomagnetic Determined Rotation of the Blue Mountains – Adjacent Laurentia (BMAL) Block in the Pacific Northwest during the mid-Cretaceous to Paleogene and its Tectonic Implications, Abstract T32F-0242 presented at American Geophysical Union Fall Meeting, Chicago, Dec. 12-16, 2022.

My sabbatical work has already impacted LSSU students. As noted above three LSSU students worked with me on independent research projects during my sabbatical and all three presented the results of their research at a Geological Society of America meeting. I have also incorporated a number of new things into my classroom building off my sabbatical experiences and this will continue to impact my teaching for years to come. I taught GEOL480 during summer 2023 and incorporated new technology in student field projects. Students in my GEOL121 course in fall of 2023 benefited from examples, photographs and field and laboratory activities/materials from my sabbatical that I incorporated into this class. Based on my sabbatical work students in my fall 2023 GEOL308 worked on activities and develop strategies to work with scientific uncertainty in new ways and studied samples, photographs and examples from my sabbatical. My sabbatical 2D and 3D modeling experiences will be incorporated into my GEOL431 class in Fall 2024.

The research and opportunities provided by my 2022-2023 sabbatical will continue to positively impact me and the education of LSSU students for years to come.