Return Report: Sabbatical Leave

1. Name of Professor: Dr. Paul Kelso

2. Department: Geology and Physics

3. Time Frame of the Sabbatical Leave: 2011-2012 academic year

4. Title of Sabbatical Leave Proposal:

Collaborative Research: An EarthScope project to study deformation and magmatic modification, Western Idaho - Eastern Oregon, And,
Collaborative Project: Laboratory activity development related to the Idaho-Oregon EarthScope project, And,
Collaborative Research: Localization of deformation in lithologically heterogeneous lower crust, Arunta block, central Australia, And,
Collaborative Project: Geology curriculum development: A project centered and student centered approach to student learning

5. Narrative of Sabbatical Leave:

I would like to thank Lake Superior State University for the opportunity to undertake a sabbatical during the 2011-2012 academic year. I had a very busy and productive sabbatical. I undertook several projects that provide student research opportunities and will impact student learning inside and outside of the classroom. I discuss the results of each of the projects I worked on below.

My sabbatical allowed me to participate in the National Science Foundation sponsored EarthScope project "Deformation and Magmatic Modification of a Steep Continental Margin, western Idaho-eastern Oregon (IDOR)." I am part of the multidisciplinary team working on this project that includes: Dr. Basil Tikoff (University of Wisconsin-Madison), Dr. John Hole (Virginia Technological University), Dr. Ray Russo (University of Florida), and Dr. Jeffery Vervoort (Washington State University). I am the magnetic specialist on the team. It was only through this sabbatical that my students and I had the opportunity to participate in this large EarthScope project.

My sabbatical started early with three weeks of field work in Idaho and Oregon in July-August 2012. The samples collected during this field work formed the basis for much of my sabbatical work. Samples were collected both for research purposes and to be used in classroom laboratory activities.

Research samples collected were prepared for magnetic analysis at LSSU. Sample analysis was conducted at LSSU and at the Institute for Rock Magnetism (IRM) at University of Minnesota in Minneapolis, MN. The Institute for Rock Magnetism is a one of just a few National Centers supported by the National Science Foundation and the only center with a focus on the magnetism of rocks, my research specialty. I was selected as a visiting fellow at the Institute for Rock Magnetism through a competitive application processes. This fellowship allowed my access to the IRM's facilities, which are the most comprehensive collection of equipment in the world for studying the magnetic properties of rocks, and use of an office while I was visiting.

I visited the IRM three times during my sabbatical for approximately two week visits each time.

At the IRM I often met Dr. Tikoff and/or his graduate students from the University of Wisconsin – Madison who are also working on the EarthScope project in Idaho. I worked in the IRM laboratories with the IRM staff, Dr. Tikoff and his students. Wanting to take full advantage of the opportunity, my typical day at the IRM was 16+ hours working in windowless labs collecting as much data as possible in their state of the art facilities. My focus at the IRM was collecting critical data that it was not possible to collect with the facilities at LSSU. Magnetic measurements at the IRM included hysteresis loops, low temperature (down to 10°K) field and magnetic remanence data, high temperature (up to 700°C) field and remanence data, magnetic susceptibility anisotropy and temperature dependent data, and demagnetization of the samples' natural magnetic remanence by low and high temperature and alternating field. The samples measured at the IRM included samples from the EarthScope and Australian projects. Between visits to the IRM a variety of data analysis and interpretations was undertake on the data collected, sample preparation and selection for the next IRM visit completed and complementary data collection in the LSSU magnetics laboratory.

Initial magnetic results from the Oregon and Nevada components of the EarthScope project were presented at the IRM in January. Initial results from the Idaho component of the EarthScope project and associated emplacement of the Columbia River Basalts were presented at the IRM in late February 2012. A summary of the results of this magnetic work was presented to the principle investigators and other scientists and students that are part of this EarthScope project during a workshop associated with the American Geophysical Union annual meeting in San Francisco, CA on December 8, 2012. These preliminary magnetic results suggest that the rocks along the bend in the margin of what was continental North America 100 million years ago has not rotated as many people currently believe. The magnetic results from Oregon suggest that the igneous intrusions to the south and west were likely rotated relative to the plutons to the north and east toward the Oregon-Idaho boarder which was not previously recognized. These results, while interesting, indicate that further sampling is necessary to adequately constrain the amounts and types of rotations with the statistical significance required for publication. The need for additional data meant that my sabbatical work continued past the end of the academic year and through the summer of 2012 and included two additional two week field sampling excursions to Idaho and Oregon, one in June/July and a second field excursion in August.

During the August field excursion I was able to provide travel and living expenses for LSSU geology student Logan Roberts as a field assistant. Logan and I collected samples that form the foundation of his senior research project and the projects of five other LSSU geology majors this year.

Logan and I, in addition to sampling for the ongoing magnetic study, participated in the active source seismic survey that is a big part of this EarthScope project. As part of a team of over 60 scientists from 22 different institutions we assisted with the 450km long seismic survey. This was an incredible opportunity for Logan and me to work with scientists with different specialties from a variety of institutions and be part of one of the largest field geoscience projects in the United States this year. This provided a wonderful learning and networking opportunity for both Logan and me. In addition to our working and discussing science with these individuals, some of these scientists worked with Logan and me in the field where they learned about our magnetic study and helped collect samples for the paleomagnetic survey LSSU students are currently undertaking. This project has led to ongoing collaboration and a University of Wisconsin-Madison graduate student will be visiting LSSU in January to work in the LSSU magnetics lab. Thus additional LSSU students will have the opportunity to interact with him while he is here,

learn about his project and discuss graduate school. It was an exciting collaborative scientific study that Logan and I were able to be a part of and many other LSSU students are, and will, benefit from our involvement in this project. The paleomagnetic data I collected during my sabbatical and data collected by LSSU students and me this year is planned to be presented at the National EarthScope meeting in Raleigh, North Carolina on May 13-15, 2013.

Some of the samples and data collected through the EarthScope project will form the basis of laboratory projects that I will use in my classroom in the coming years. These sample/data suites make a great foundation for a plate tectonic project that integrates multiple sub disciplines of geology to answer complex geosciences questions. Thus my sabbatical work will impact many students as they learn science and learn to become scientists as they work with samples, data, activities and associated collaborations that were part of my sabbatical.

During my sabbatical I also worked with colleagues on a project to understand the deformation of the lower crust of central Australia. I measured sample for this project during my visits to the IRM at the University of Minnesota and completed the associated magnetic analysis. The initial results from my magnetic analysis were presented at a meeting at the IRM during January 2012. A more comprehensive presentation of the field, laboratory, petrology, geochronology and magnetic results related to this project were presented at the 34th International Geological Congress in July 2012 in Brisbane, Australia.

> Waters-Tormey, Cheryl, Paul Kelso and Daniel Jones, 2012, The >6-km thick Capricorn ridge shear zone: evidence of Paleoproterozoic NNE-SSW extension in the southern North Australian Craton, 34th International Geological Congress Brisbane, Australia.

Cheryl Waters-Tormey (Western Carolina University), Daniel Jones (Western Carolina University), and I are currently completing a manuscript detailing the results of this project and plan to submit this manuscript to the Journal of Structural Geology in 2013.

We have made major revisions to the geology undergraduate curriculum at Lake Superior State University over the past decade. The unique LSSU geology curriculum now emphasizes problem based learning where students solve real world geologic problems that often integrate information from multiple geoscience sub disciplines. These hands on activities simulate the types of problems that geoscientists often address in industry and at public institutions. During my sabbatical I worked with Dr. Lewis Brown to examine these changes and we have a manuscript in preparation to describe our new curriculum, explain the rationale for these changes and the impact that these changes have had on student learning. We plan to submit this manuscript to the Journal of Geoscience Education in 2013. Dr Brown and I also prepared an abstract and presentation on the teaching of sequence stratigraphy, one of the new courses in the geology curriculum. The presentation is titled “Introduction to Sequence Stratigraphy: A Project-Based Undergraduate Upper Division Course” and will be presented at the Geological Society of America – North Central section meeting in Spring, 2013.

Lake Superior State University and our students are benefitting from the research opportunities and curriculum activities associated with my sabbatical. These activities will continue to impact students for years to come as the samples, activities and research results are integrated into my courses. The contacts I developed during my sabbatical will be a resource as I continue to develop and revise curriculum, student activities and collaborate on research projects.