
University of Utah
Seismograph Stations
THE
UNIVERSITY
OF UTAH
2014 Annual Report

Dear Friends,

It is a pleasure to present you with the 2014 Annual Report of the University of Utah Seismograph Stations (UUSS). Reflecting on recent UUSS accomplishments, I was struck by the importance of partnerships in pursuing our dual mission of academic research in earthquake science, and communication to the residents of Utah of the latest information on earthquake risk.

As always, a key UUSS partner in 2014 was our home academic unit, the Department of Geology and Geophysics. A nice example of the support shown by our department is the recent hire of a new tenure-track faculty member in seismology, Dr. Fan-Chi Lin. Although Dr. Lin's expertise is in seismic imaging, he has already expressed interest in collaborating with UUSS faculty on projects related to earthquake science in Utah and Yellowstone.

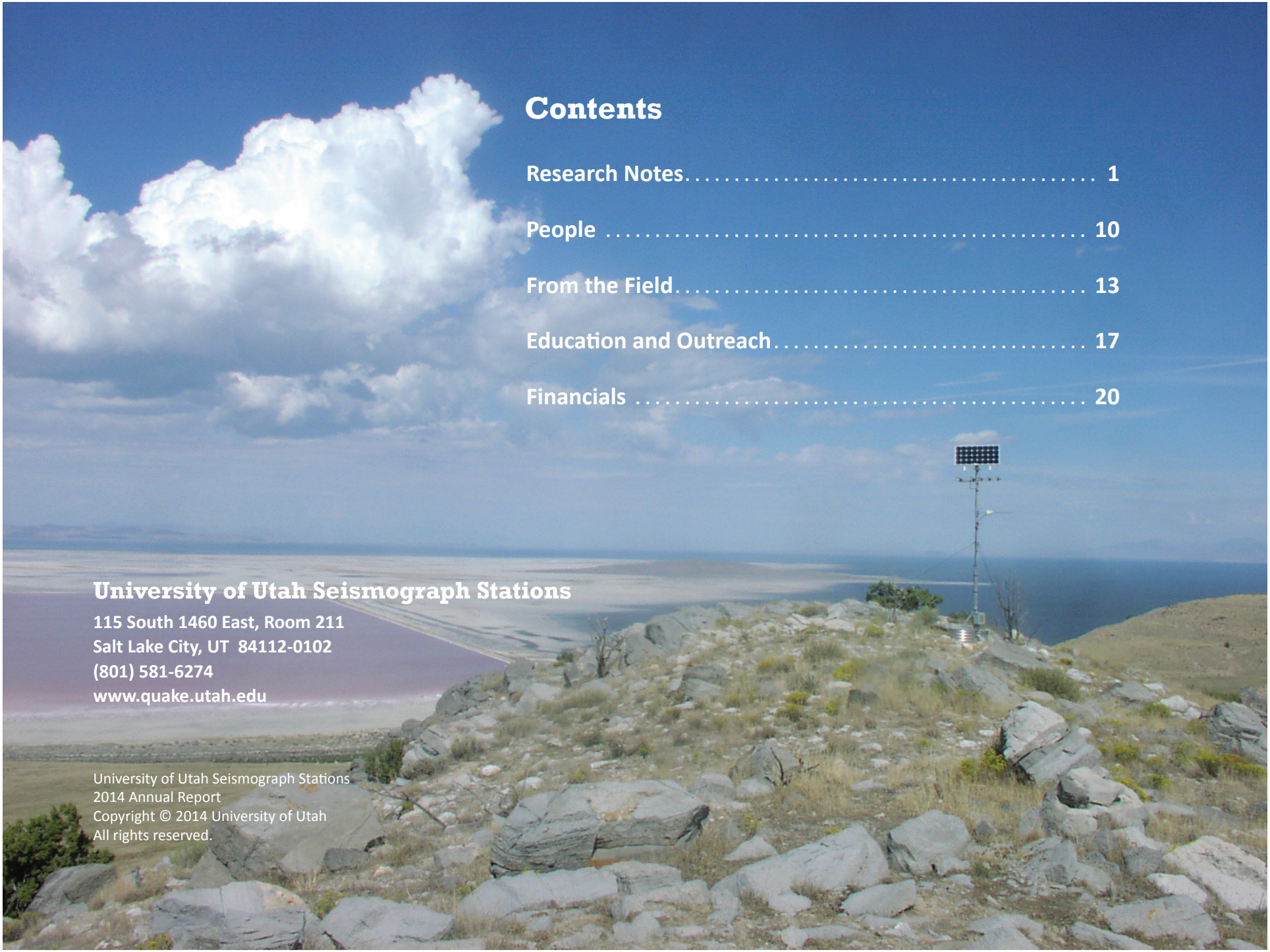
A second important UUSS partner is the Utah Division of Emergency Management (DEM). This agency administers Utah's earthquake program and has the responsibility for mitigating and responding to earthquake hazards in the state. The DEM earthquake program funds the UUSS traveling earthquake exhibit, which visited 25 elementary and middle schools throughout Utah in 2014. The DEM also provides financial support for the Utah Seismic Safety Commission, the state's official earthquake advisory board.

A third partner that is essential to the success of UUSS is the United States Geological Survey (USGS). The USGS routinely and consistently supports UUSS by providing the latest seismic equipment—and the funding to operate and maintain this equipment. In 2014, USGS funding enabled over 115 seismic stations to be operated in the State of Utah. As with all of our seismometers, these instruments operate 24 hours a day, 7 days a week, and transmit data to the UUSS earthquake information center within seconds of it being recorded.

Many people at the university, and within state and federal agencies, contribute to the success of UUSS. To learn more about all of our partners, and the achievements they have contributed to, please take a few moments to browse through this year's Annual Report.

Keith D. Koper
Director, UUSS

Cover Photo: UUSS Electronics Technician, Ken Whipp, and Megan Thompson, an undergraduate student from the University of Wisconsin - River Falls, discuss equipment operation at station YLA (Lake Butte, Yellowstone National Park, Wyoming). Photo by Dave Drobeck.



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2014 Annual Report

National Earthquake Hazard Maps

On July 17, 2014, the U.S. Geological Survey (USGS) released a new version of the National Seismic Hazard Maps. These maps incorporated input from many earthquake scientists and engineers around the country, including UUSS seismologists Dr. Walter Arabasz, Dr. Jim Pechmann, and University of Utah Professor Emeritus of Geology and Geophysics, Dr. Bob Smith.

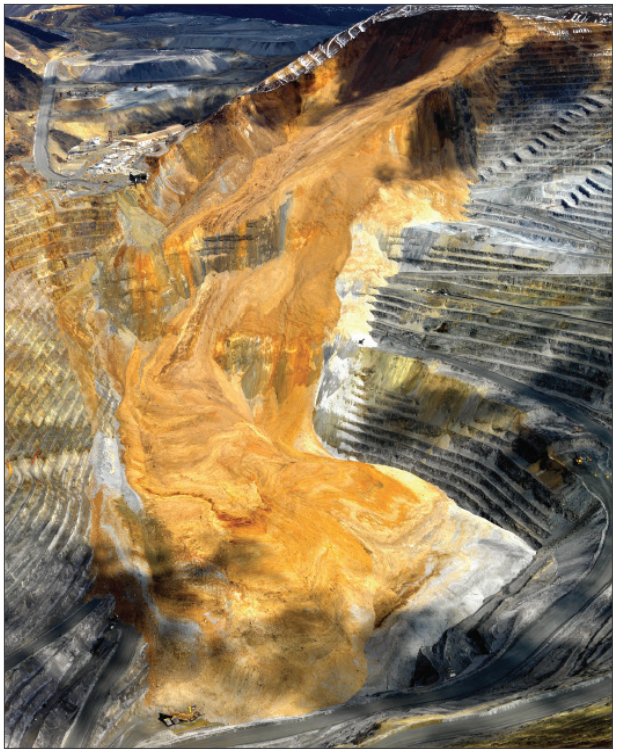
Dr. Arabasz and Dr. Pechmann gave talks at two USGS-organized workshops on the maps that were held in Salt Lake City in 2011 and 2012. In addition, Dr. Pechmann and Dr. Smith attended two workshops in California in 2012-2013 on the use of geodetic data in the seismic hazard calculations for the maps. Dr. Pechmann's talk at the second Salt Lake City workshop, and subsequent discussions with USGS and paleoseismologists from the Utah Geological Survey (UGS), led to major changes in the way that the Wasatch fault stepover in downtown Salt Lake City is treated in the maps.

Bingham Canyon Landslides

Work continued this year on the analysis of the seismic and infrasound data generated by the April 10, 2013, Bingham Canyon landslide. Research efforts focused on three main areas: (1) understanding the dynamics of the landslide; (2) analysis of earthquakes induced by the slide; and (3) detection of infrasound from additional smaller scale landslides.

The research team consisted of UUSS staff members Dr. Kris Pankow, Dr. Keith Koper, and Mark Hale; Dr. Jeff Moore (UU Geology and Geophysics), Tex Kubacki (UU Mining Engineering graduate student), and Sean Ford (Lawerence Livermore National Laboratory).

Results related to the landslide induced earthquakes were presented in an invited talk at the 2014 Geological Society of America meeting in Vancouver, and published as the featured science article in the January 2014 issue of *GSA Today*. Results were also presented by Dr. Kris Pankow at the Southern Methodist University (Dallas, TX) Department of Earth Sciences Seminar Series in October.



The Bingham Canyon open-pit copper mine following the April 10, 2013 landslide. The mine had been evacuated prior to the landslide and no casualties were suffered. Photo courtesy of Rio Tinto Kennecott

Transition from EIDS to PDL

One of the main changes in the UUSS operations is related to the migration from Earthquake Information Distribution System (EIDS) to Product Distribution Layer (PDL) on July 30, 2014, following a period of testing with USGS software developers. PDL is a USGS platform for standardized earthquake data exchange that uses digital signatures that are encrypted using a private key and verified with a public key.

The ANSS Quake Monitoring System (AQMS) earthquake alarms were modified to support the PDL integration. The PDL client, installed on the UUSS AQMS machines, is being used in conjunction with qml—a Perl program to generate Quakeml xml compliant messages from the AQMS database. The output from qml is transferred to the PDL directory polldir, through dedicated AQMS real time and post-processing earthquake alarms, and the PDL client transfers the information to a USGS PDL hub. Additionally, the migration to PDL allows UUSS to use the same data exchange mechanism for earthquake data and ShakeMap.

Working Group on Utah Earthquake Probabilities (WGUEP)

As part of a Working Group on Utah Earthquake Probabilities (WGUEP), organized under the auspices of the Utah Geological Survey and the U.S. Geological Survey, Dr. Walter Arabasz and Dr. Jim Pechmann have contributed more than a man-year of effort in data compilation and analysis. These efforts have included the development of a moment magnitude catalog for the Utah region, calculations of earthquake recurrence rates based on this catalog, the lead role in a comparison of seismic moment rates estimated from crustal deformation measurements ("geodetic moment rates") with geological/seismological moment rates predicted by the WGUEP model, analysis of focal depth variations, and work on characterizing the Oquirrh-Great Salt Lake fault zone. The two UUSS WGUEP members also contributed to other

aspects of the project, in part during 12 Working Group meetings of 1-2 days each from 2010–2015.

In late 2014, the WGUEP completed a draft final report, "Earthquake Probabilities for the Wasatch Front Region in Utah, Idaho, and Wyoming." The report includes an extensive appendix authored by Dr. Arabasz, Dr. Pechmann, and Relu Burlacu, "A Uniform Moment Magnitude Earthquake Catalog and Background Seismicity Rates for the Wasatch Front and Surrounding Utah Region." Review and publication of the report is expected during 2015.

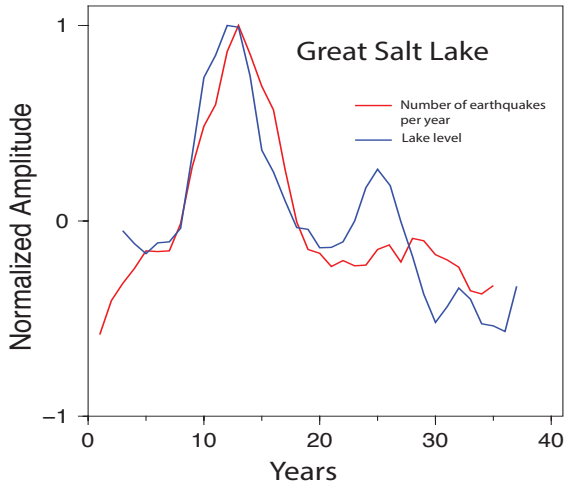
Partnering with Montana

In 2014, UUSS made a major effort to incorporate Montana Bureau of Mines and Geology (MBMG) earthquake data into the ANSS Quake Monitoring System (AQMS) located at the University of Utah. Together with MBMG staff, computer hardware and software were upgraded; Earthworm configuration files were optimized; station metadata were updated and imported into the database; and an end-to-end data exchange was set-up. By the end of 2014, MBMG were fully integrated into AQMS. MBMG will be migrating to AQMS for operations in 2015.

MBMG
Montana Bureau of Mines and Geology

Seismicity and Lake Water Levels

Mindy Timothy and Kristel Hansen worked at UUSS during the summer of 2014 to complete the research component of their Masters of Science for Secondary School Teachers degrees. For their research projects, they analyzed the relationship between changes in water level at the Great Salt Lake (Mindy) and Utah Lake (Kristel) and earthquakes from the UUSS earthquake catalog, for possible effects of induced seismicity. They were mentored by Katherine Whidden and Dr. Kris Pankow. The results of their analyses prompted additional research that was presented at the 2014 Fall American Geophysical Union Meeting.



Further analysis revealed a positive correlation between historical Great Salt Lake water levels and seismicity surrounding the lake (see figure above), with seismicity changes following lake level change by 2-3 years. More research is needed to determine if changes in lake level directly cause changes in seismicity. At Utah Lake, no correlation was seen between water levels and seismicity.

Visiting Scientists and Guests

Dr. Kevin Mayeda from the University of California Berkeley/Weston Geophysical Corporation, presented a guest lecture in March, "The Apparent Stress Controversy: Does Earthquake Self-Similarity Hold and Who Cares?"

In early September, Lingling Ye, a PhD student from the University of California Santa Cruz traveled to the University of Utah to study a new technique for inferring the rupture properties of large earthquakes with Dr. Keith Koper.

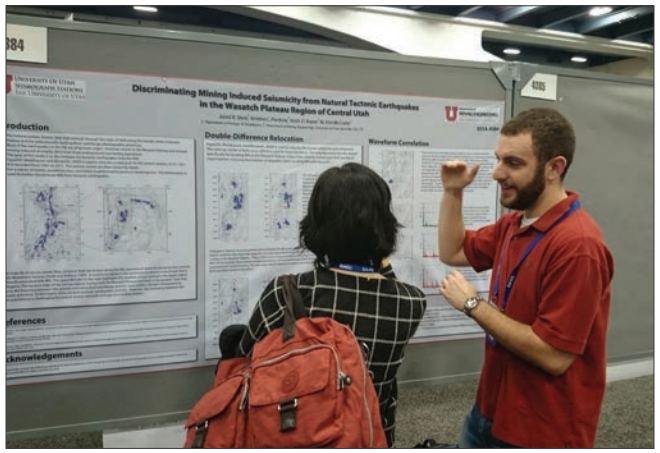
Qiaoxia Liu, a visiting scholar from the University of Science and Technology in Hefei, China, arrived in December. She will be studying seismology with Dr. Koper during her year-long visit.

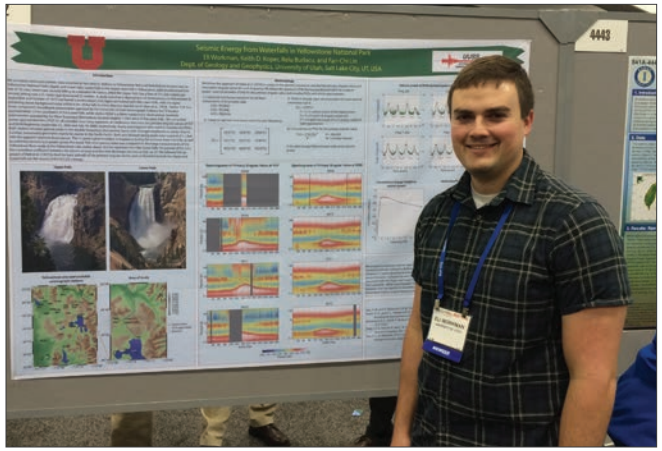
Removal of Infrasound Arrays

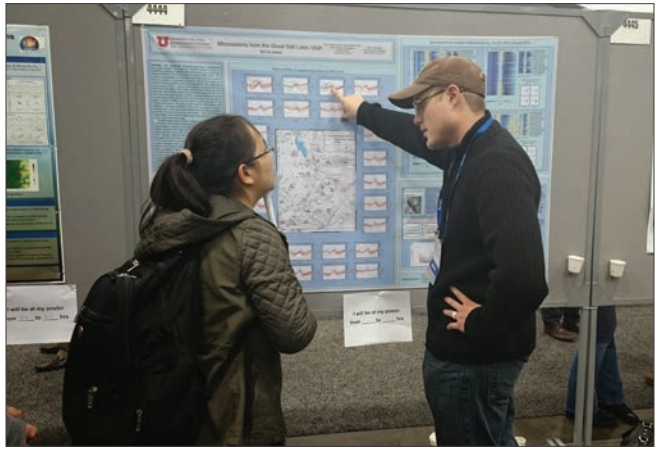
2014 brought the end of funding for many of the infrasound arrays in Utah. As a result, six of the nine arrays were decommissioned. In partnership with Southern Methodist University, UUSS continues to operate the arrays BRPU, PNSU, and NOQ.

Top: "Spider" of soaker hoses attached to an infrasound microphone at station BRPUi. The hoses act as a type of low-pass filter for the microphone.

Bottom: Manifold, soaker hoses, and infrasound microphone at station NOQi.







Students Jared Stein (top), Eli Workman (center), and Kyler Goddard (bottom) share their research during AGU poster sessions.

Research Presented at Annual Professional Meetings

Seven scientists and students from UUSS presented research at the fall meeting of the American Geophysical Union (AGU), held December 15-19 in San Francisco, California. In its 47th year, the meeting now attracts more than 20,000 attendees interested in the latest earth and space science research. UUSS students Jared Stein, Eli Workman, and Kyler Goddard participated in the meeting's poster sessions. Dr. Jamie Farrell, Katherine Whidden, Dr. Kris Pankow, and Dr. Keith Koper each presented talks during the general sessions. Seven other meeting presentations featured studies with UUSS co-authors.

In addition to AGU, UUSS contributed several presentations to the annual meeting of the Seismological Society of America (SSA), held April 17-19, in Anchorage, Alaska. Dr. Jim Pechmann, Dr. Jamie Farrell and Oner Sufri gave talks. Two additional presentations featured UUSS co-authored research.

2014 AGU Presentations:

Farrell, J., D. R. Shelly, R. B. Smith, C. M. Puskas, W. L. Chang (2014). The Mw 4.8 Norris Geyser Basin earthquake of 30 March, 2014 and its relationship to crustal deformation and seismic activity of the Yellowstone volcanic system, Abstract S11E-4400.

Goddard, K. J., K. D. Koper, V. Burlacu (2014). Microseisms from the Great Salt Lake, Abstract S41A-4444.

Koper, K. D., V. Burlacu (2014). Splitting of the double-frequency microseismic peak at land-based seismometers in North America, Abstract S44A-04.

Pankow, K. L., M. Stickney, K. D. Koper, K. M. Whidden (2014). The 2014 Challis, Idaho Earthquake Swarm, Abstract T13B-4639.

Stein, J. R., K. L. Pankow, K. D. Koper, M. K. McCarter (2014). Discriminating mining induced seismicity from natural tectonic earthquakes in the Wasatch Plateau region of central Utah, Abstract S51A-4384.

Whidden, K., K. Hansen, M. Timothy, M. Boltz, K. Pankow, K. Koper (2014). Natural reservoirs and triggered seismicity: a study of two northern Utah lakes, Abstract S51A-4404.

Workman, E. J., Koper, K. D., Burlacu, R., Lin. F-C. (2014). Seismic energy from waterfalls in Yellowstone National Park, Abstract S41A-4442.

Lisa Linville, Katherine Whidden and Kristine Pankow connect with fellow scientists during dinner at AGU.

2014 SSA Presentations:

Farrell, J., R. B. Smith, and F.-C. Lin (2014). Dynamics of the Yellowstone volcanic system using 4D seismic imaging, *Seismol. Res. Lett.* **85,** no. 2, 479.

Pechmann, J. C., K. D . Koper, R. B. Herrmann, K. M. Whidden, H. M. Benz, K. L. Pankow, F.-C. Lin, and D. S. Chapman (2014). An M4.8 earthquake in the upper mantle beneath the Wind River Range, Wyoming, *Seismol. Res. Lett.* **85,** no. 2, 507.

Sufri, O., K. D. Koper, and R. Burlacu (2014). A microseism catalog based on broadband data from the US Transportable Array, *Seismol. Res. Lett.* **85,** no. 2, 434.

Raspberry Pi

Starting in 2013, UUSS began experimenting with Raspberry Pi micro Linux computers (about the size of a credit card). These computers can run the Earthworm software suite to acquire and store seismic data. Specifically, UUSS is using them with K2 and Etna instruments used for recording strong ground motion. The instruments lack the ability to store continuous data for extended periods of time; the Raspberry Pi acts as a buffer for the data.

Raspberry Pi circuit board.

Field testing for these computers began In 2014. They have performed better than expected, surviving both high and low temperature extremes. The computers make it possible to buffer 12-14 days of continuous data using the Ringserver software from IRIS and to archive 100+ days of data in miniSEED format. The buffering prevents the loss of continuous data during unexpected communication outages. The ability to record many days of data can be essential in later scientific and engineering evaluation of the data.

Additionally, the Raspberry Pi board is very inexpensive compared to many of the serial-to-ethernet converters that would otherwise be used. In 2014, nine stations were upgraded to the Raspberry Pi. This will continue until all K2/Etna instruments that can accommodate a Raspberry Pi are upgraded.

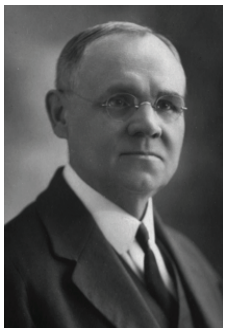
Mining-Induced Seismicity (MIS)

In continued work on MIS, Dr. Kris Pankow and Dr. Keith Koper worked with Geology and Geophysics graduate student Jared Stein and UU Mining Engineering graduate students Derrick Chambers and Tex Kubacki to detect and discriminate seismic sources in the mining environment and to improve the three-dimensional locations. Results from these studies have included a catalog of MIS with an improved magnitude of completion and locations for the time bracketing the 2006 Crandall Canyon Mine collapse; discrimination of surface blasting and MIS for southwestern Wyoming using the EarthScope Transportable Array; and relative relocation of seismic events in the Wasatch Plateau to determine if depth can be used to discriminate MIS. Results from this work have been published in the Journal of Geophysical Research, presented at the 2014 Fall Meeting of the American Geophysical Union, and also presented at the 2015 Meeting of the Society for Mining, Metallurgy, and Exploration.

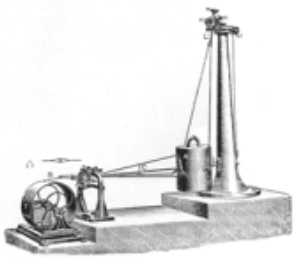
In related work, Dr. Kris Pankow worked with UU Mining Engineering graduate student Meagan Shawn Boltz, who developed a three-dimensional finite difference model using (FLAC3D™) for the Trail Mountain Mine located in central Utah. Results from this model were compared to MIS recorded at the mine from October 2000–April 2001. Conclusions of the study included the observation that peaks in the maximum shear stress are followed by peaks in the seismic moment. However, it was found that stresses alone are not a sufficient indicator of the occurrence of future MIS, in space or time.

Utah's Earthquake History

The first seismographs in Utah (and among the earliest operating seismographs in the country) were installed over a century ago, in Salt Lake City, by Dr. James E. Talmage, Deseret Professor of Geology at the University of Utah. Dr. Talmage was aware of the threat to Utah citizens posed by earthquake activity on the Wasatch fault. With considerable effort, he succeeded in procuring the latest equipment available at the time—two modified Bosch-Omori type pendulum seismographs. The instruments were installed on the University of Utah campus in the basement of the Geology department's museum building, one instrument placed in a North-South orientation, the other in an East-West orientation. On June 29, 1907, Dr. Talmage recorded in his journal: "This day has been announced as a day open for demonstration of seismographic apparatus at the University of Utah. I have labored long and arduously to have an earthquake-recorder installed at the University of Utah. For five biennial periods past I have persistently recommended such installation." Local newspapers carried announcements of the installation and were on hand to observe and report on Dr. Talmage's demonstrations of the equipment.

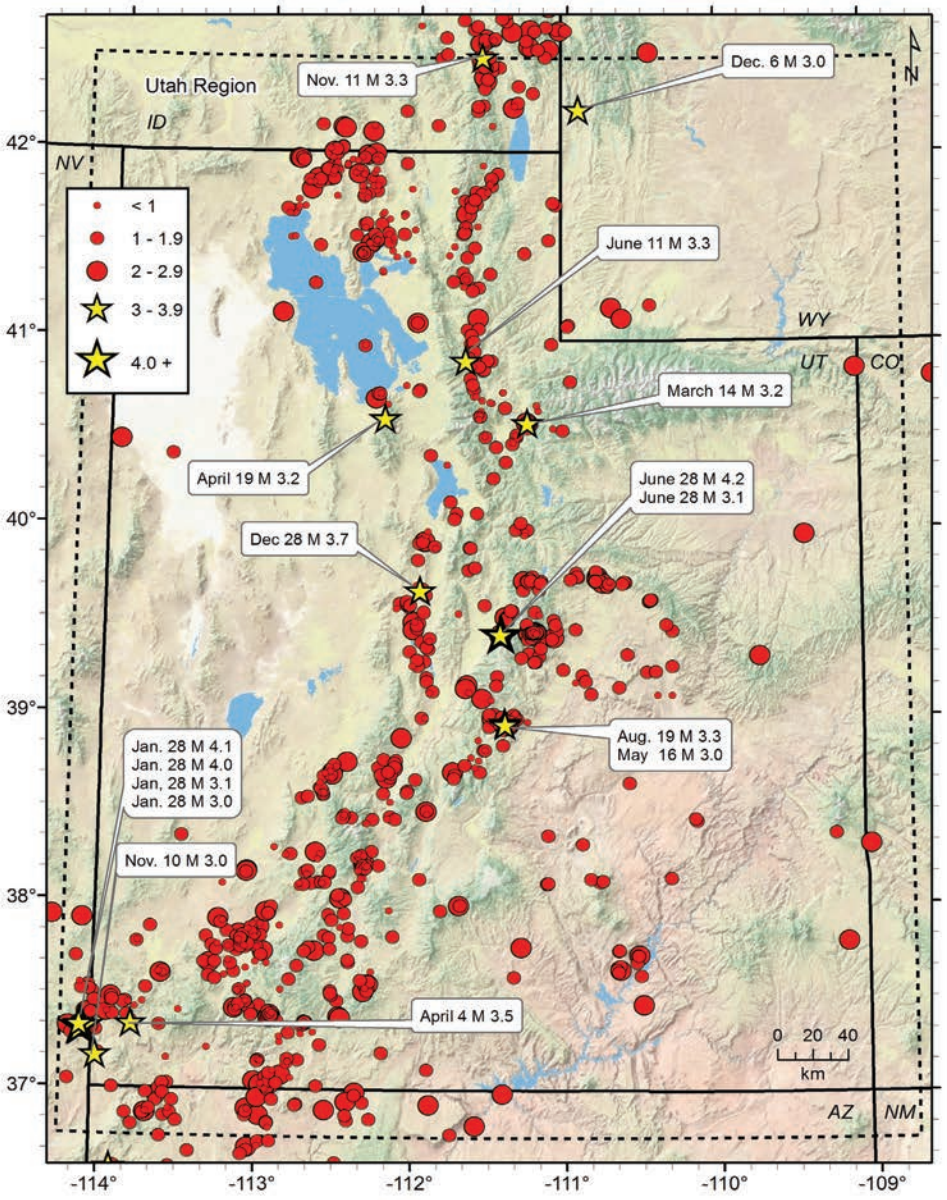


Dr. James E. Talmage. Photo courtesy of the University of Utah.



Bosch-Omori pendulum seismograph (early 1900s).

Seismicity of the Utah Region
January 1, 2014 - December 31, 2014

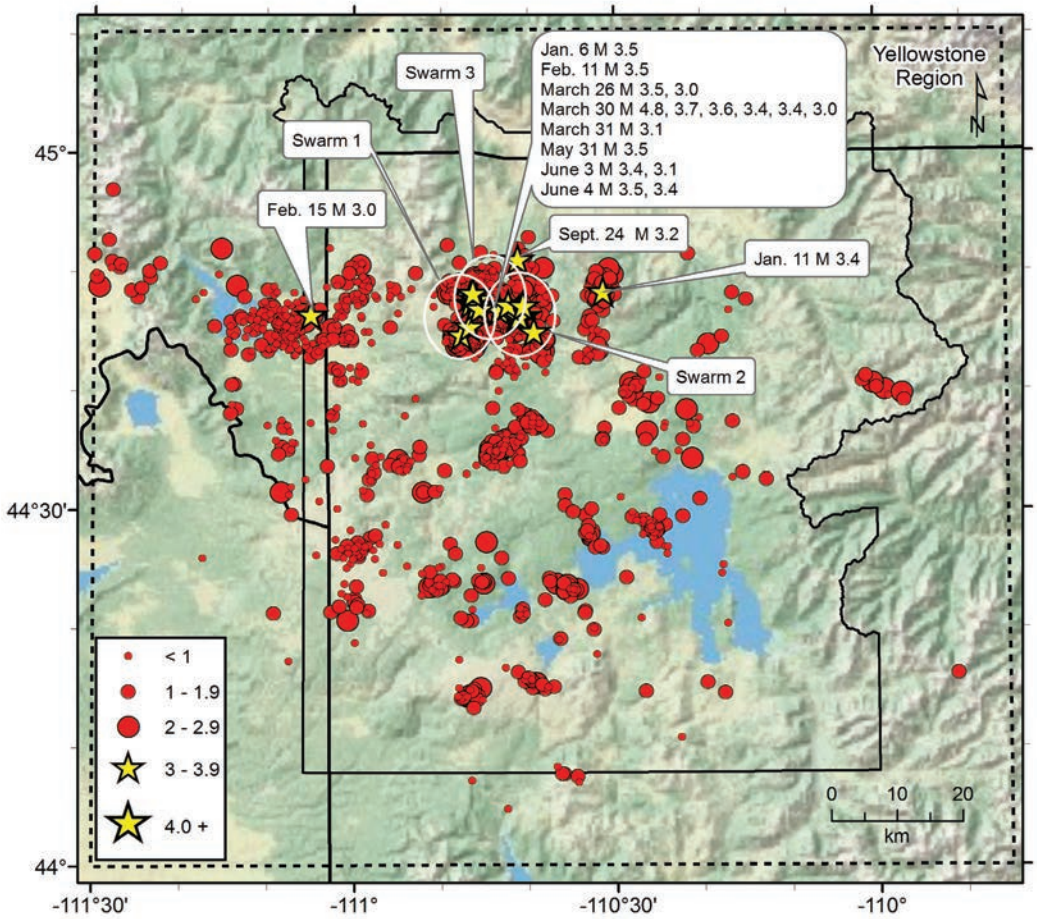


During the twelve-month period January 1 through December 31, 2014 the University of Utah Seismograph Stations located 1474 earthquakes within the Utah region. The total includes 3 earthquakes in the magnitude 4 range, 13 earthquakes in the magnitude 3 range, and 161 earthquakes in the magnitude 2 range. Earthquakes of magnitude 3.0 or larger occurring in 2014 are plotted as stars (see map at left).

M_L 4.1	Jan 28 09:20 MST	28 mi SW of Enterprise, UT
M_L 4.0	Jan 28 18:30 MST	28 mi SW of Enterprise, UT
M_L 3.1	Jan 28 18:39 MST	28 mi SW of Enterprise, UT
M_L 3.0	Jan 28 18:39 MST	28 mi SW of Enterprise, UT
M_L 3.2	Mar 14 10:03 MDT	6 mi SSE of Kamas, UT
M_L 3.5	Apr 4 03:38 MDT	16 mi S of Enterprise, UT
M_L 3.2	Apr 19 21:22 MDT	6 mi NE of Tooele, UT
M_L 3.0	May 16 10:54 MDT	9 mi W of Emery, UT

M_L 3.3	Jun 11 22:34 MDT	10 mi E of Centerville, UT
M_L 4.2	Jun 28 18:56 MDT	4 mi ESE of Spring City, UT
M_L 3.1	Jun 28 22:52 MDT	4 mi ESE of Spring City, UT
M_L 3.3	Aug 19 22:05 MDT	9 mi W of Emery, UT
M_L 3.0	Nov 10 07:47 MST	21 mi W of Santa Clara, UT
M_L 3.0	Dec 6 2:32 MST	10 mi N of Cokeville, WY
M_L 3.7	Dec 28 23:08 MST	8 mi SW of Nephi, UT
M_L 3.2	Dec 28 23:56 MST	8 mi WSW of Nephi, UT

Seismicity of the Yellowstone National Park Region
January 1, 2014 - December 31, 2014



During the twelve-month period January 1 through December 31, 2014 the University of Utah Seismograph Stations located 1998 earthquakes within the Yellowstone National Park region - which reflects a relatively normal rate of earthquakes for the region. The total includes one earthquake in the magnitude 4 range, 18 earthquakes in the magnitude 3 range, and 181 earthquakes in the magnitude 2 range. Earthquakes of magnitude 3.0 or larger occurring in 2014 are plotted as stars (see map at left).

There were three significant swarms in 2014 (indicated by ovals on map at left). All three occurred in the Norris Geyser Basin area. The first occurred 5 miles WNW of Norris Geyser Basin from February 7-20 and consisted of 142 earthquakes. The second occurred 4 miles NNE of Norris Geyser Basin from March 27 - April 1. This swarm contained 156 earthquakes, including a magnitude 4.8 earthquake (the largest earthquake to occur in Yellowstone in over 30 years) that was felt throughout the Yellowstone region. The third significant swarm occurred 6 miles NNW of Norris Geyser Basin from May 31 - June 12 and consisted of 248 earthquakes. In addition to these 3 largest swarms, there were numerous smaller swarms in the Yellowstone region. Overall, swarm seismicity constituted 61% of the total seismicity for 2014. A swarm is a series of earthquakes clustered in space and time with no outstanding main shock.

M_L 3.5	Jan 6 02:14 MST	4 mi NW of Norris Geyser Basin, YNP
M_L 3.4	Jan 11 18:46 MST	5 mi NNW of Canyon Junction, YNP
M_L 3.5	Feb 11 16:03 MST	5 mi WNW of Norris Geyser Basin, YNP
M_L 3.0	Feb 15 03:23 MST	8 mi N of West Yellowstone, MT
M_L 3.0	Mar 26 13:14 MDT	6 mi NW of Norris Geyser Basin, YNP
M_L 3.5	Mar 26 17:59 MDT	6 mi NW of Norris Geyser Basin, YNP
M_L 3.0	Mar 30 00:23 MDT	4 mi NNE of Norris Geyser Basin, YNP
M_L 3.4	Mar 30 04:36 MDT	3 mi NNE of Norris Geyser Basin, YNP
M_w 4.8	Mar 30 06:34 MDT	3 mi NNE of Norris Geyser Basin, YNP
M_L 3.6	Mar 30 07:30 MDT	3 mi NNE of Norris Geyser Basin, YNP
M_L 3.4	Mar 30 09:07 MDT	4 mi N of Norris Geyser Basin, YNP
M_L 3.7	Mar 30 09:12 MDT	4 mi NNW of Norris Geyser Basin, YNP
M_L 3.1	Mar 31 22:32 MDT	3 mi NE of Norris Geyser Basin, YNP
M_L 3.5	May 31 16:25 MDT	6 mi NNW of Norris Geyser Basin, YNP
M_L 3.4	Jun 3 03:33 MDT	6 mi NNW of Norris Geyser Basin, YNP
M_L 3.1	Jun 3 03:52 MDT	5 mi NNW of Norris Geyser Basin, YNP
M_L 3.5	Jun 4 06:16 MDT	5 mi NNW of Norris Geyser Basin, YNP
M_L 3.4	Jun 4 15:22 MDT	5 mi NNW of Norris Geyser Basin, YNP
M_L 3.2	Sep 24 03:41 MDT	9 mi N of Norris Geyser Basin, YNP

Publications

Peer Reviewed

Boltz, M. S., K. L. Pankow, M. K. McCarter (2014). Fine details of mining-induced seismicity at the Trail Mountain Mine coal mine using modified hypocentral relocation techniques, *Bull. Seism. Soc. Am.* **104,** doi:10.1785/0120130011.

Farrell, J., R. B. Smith, S. Husen, and T. Diehl (2014). Tomography from 26 years of seismicity revealing that the spatial extent of the Yellowstone crustal magma reservoir extends well beyond the Yellowstone caldera, *Geophys. Res. Lett.* **41,** 3068-3073, doi:10.1002/2014GL059588.

Gal, M., A. M. Reading, S. P. Ellingsen, K. D. Koper, S. J. Gibbons, and S. P. Näsholm (2014). Improved implementation of the fk and Capon methods for array analysis of seismic noise, *Geophys. J. Inter.* **198,** 1045-1054.

Badger near station RSUT (Red Spur, UT), Rich County

Kanu, C., R. Snieder and K. Pankow (2014). Time-lapse monitoring of velocity changes in Utah, *J. Geophys. Res. Solid Earth* **119,** 7209-7225, doi:10.1002/2014JB011092.

Kubacki, T. , K. D. Koper, K. L. Pankow, and M. K. McCarter (2014). Changes in mining induced seismicity before and after the 2007 Crandall Canyon mine collapse, *J. Geophys. Res. Solid Earth* **119,** 4876-4889, doi:10.1002/2014JB011037.

Linville, L. M., K. L. Pankow, D. L. Kilb, and A. A. Velasco (2014). Exploring remote earthquake triggering potential across EarthScopes' Transportable Array through frequency domain array visualization, *J. Geophys. Res. Solid Earth* **119,** 8950-8963, doi:10.1002/2014JB011529.

Pankow, K. L., J. R. Moore, J. M. Hale, K. D. Koper, T. M. Kubacki, K. M. Whidden, and M. K. McCarter (2014). Massive landslide at Utah copper mine generates wealth of geophysical data, *GSA Today* **24,** 4-9, doi:10.1130/GSATG191A.1.

Reading, A. M., K. D. Koper, M. Gal, L. S. Graham, H. Tkalcic, and M.A. Hemer (2014). Dominant seismic noise sources in the Southern Ocean and West Pacific, 2000-2012, recorded at the Warramunga Seismic Array, Australia, *Geophys. Res. Lett.* **41,** 3455-3463, doi:10.1002/2014GL060073.

Sufri, O., K. D. Koper, R. Burlacu, and B. de Foy (2014). Microseisms from Superstorm Sandy, *Earth Planet. Sci. Lett.* **402,** 324-336.

Ye, L., T. Lay, K. D. Koper, R. Smalley Jr., L. Rivera, M. G. Bevis, A. F. Zakrajsek, and F. N. Teferle (2014). Complementary slip distributions of the August 4, 2003 Mw 7.6 and November 17, 2013 Mw 7.8 South Scotia Ridge earthquakes, *Earth Planet. Sci. Lett.* **401,** 215-226.

Reports

Burlacu, R., P. M. Roberson, J. M. Hale, N. S. Mohammad Jamaal, K. D. Koper, J. C. Pechmann, and K. L. Pankow (2014). *Earthquake Activity in the Utah Region Preliminary Epicenters October 1 - December 31, 2013,* Quarterly Report, University of Utah Seismograph Stations, Salt Lake City, Utah, 34 pp.

Burlacu, R., P. M. Roberson, J. M. Hale, N. S. Mohammad Jamaal, K. D. Koper, J. C. Pechmann, and K. L. Pankow (2014). *Earthquake Activity in the Utah Region Preliminary Epicenters January 1 - March 31, 2014,* Quarterly Report, University of Utah Seismograph Stations, Salt Lake City, Utah, 32 pp.

View of the Sawtooth Mountains above the Salmon River in Stanley, ID - near the site of the Challis, ID temporary network.

Burlacu, R., P. M. Roberson, J. M. Hale, K. J. Goddard, N. S. Mohammad Jamaal, K. D. Koper, J. C. Pechmann, and K. L. Pankow (2014). *Earthquake Activity in the Utah Region Preliminary Epicenters April 1 - June 30, 2014,* Quarterly Report, University of Utah Seismograph Stations, Salt Lake City, Utah, 36 pp.

Burlacu, R., P. M. Roberson, J. M. Hale, K. J. Goddard, K. D. Koper, J. C. Pechmann, and K. L. Pankow (2014). *Earthquake Activity in the Utah Region Preliminary Epicenters July 1 – September 30, 2014*, Quarterly Report, University of Utah Seismograph Stations, Salt Lake City, Utah, 33 pp.

Dinter, D. A., and J. C. Pechmann (2014). *Paleoseismology of the Promontory segment, East Great Salt Lake fault*, Final Technical Rept.,

U.S. Geol. Surv. Award No. 02HQGR0105, 23 pp, http://earthquake.usgs.gov/research/external/reports/02HQGR0105.pdf

Farrell, J., R. Burlacu, P. M. Roberson, J. M. Hale, N. S. Mohammad Jamaal, K. D. Koper, J. C. Pechmann, and K. L. Pankow (2014). *Earthquake Activity in the Yellowstone Region Preliminary Epicenters October 1 - December 31, 2013,* Quarterly Report, University of Utah Seismograph Stations, Salt Lake City, Utah, 23 pp.

Farrell, J., R. Burlacu, P. M. Roberson, J. M. Hale, N. S. Mohammad Jamaal, K. D. Koper, J. C. Pechmann, and K. L. Pankow (2014). *Earthquake Activity in the Yellowstone Region Preliminary Epicenters January 1 - March 31, 2014,* Quarterly Report, University of Utah Seismograph Stations, Salt Lake City, Utah, 28 pp.

Farrell, J., R. Burlacu, P. M. Roberson, J. M. Hale, K. J. Goddard, N. S. Mohammad Jamaal, K. D. Koper, R. B. Smith, J. C. Pechmann, and K. L. Pankow (2014). *Earthquake Activity in the Yellowstone Region Preliminary Epicenters April 1 - June 30, 2014,* Quarterly Report, University of Utah Seismograph Stations, Salt Lake City, Utah, 23 pp.

Farrell, J., R. Burlacu, P. M. Roberson, J. M. Hale, K. J. Goddard, K. D. Koper, J. C. Pechmann, and K. L. Pankow (2014). *Earthquake Activity in the Yellowstone Region Preliminary Epicenters July 1 - September 30, 2014,* Quarterly Report, University of Utah Seismograph Stations, Salt Lake City, Utah, 19 pp.

Invited Presentations

Farrell, J., "The Yellowstone Hotspot: One of the World's Largest Volcanoes," *University of Bergen Student Society*, Bergen, Norway, September 30, 2014.

Farrell, J., "Seismicity and Crustal Structure of the Yellowstone Hotspot," *Norwegian Geological Society*, Bergen, Norway, September 30, 2014.

Koper, K. D., "Source Physics - An Academic Perspective," *Review of Monitoring Research*, Albuquerque, NM, June 19, 2014.

Koper, K. D., "Seismic Monitoring at Yellowstone," *Consortium Meeting of the Yellowstone Volcano Observatory*, Mammoth Springs, MT, May 7, 2014.

Pankow, K. L., "Induced Earthquakes from the 2013 Bingham Canyon Landslides," Annual Meeting of the Geological Society of America, Vancouver, BC, October 21, 2014.

Pankow, K. L., "The Bingham Canyon Rock Avalanche: Dynamics and Induced Earthquakes," Southern Methodist University Department of Earth Sciences Seminar Series, Dallas, TX, October 24, 2014.

Pankow, K. L., "Monitoring Seismic Sources in the Intermountain Region," Boise State Department of Geosciences Invited Guest Speaker Series, Boise, ID, April 14, 2014.

Dr. Jamie Farrell presents an invited lecture "The Yellowstone Hotspot: One of the World's Largest Volcanoes," to the University of Bergen Student Society, Bergen, Norway, September 30, 2014. (Photos courtesy of the Bergen Student Society)

Committee Service

Dr. Keith D. Koper

- Vice-chair, Utah Seismic Safety Commission, 2010-present.
- Member, US Air Force Seismic Review Panel, 2011-present.
- Member, Editorial Advisory Board, EOS Transactions of the American Geophysical Union, 2010-present.
- Co-convener, Special Interest Group on Global Arrays, Incorporated Research Institutions for Seismology (IRIS), Sunriver, Oregon, June 8-11, 2014.

Dr. Kristine L. Pankow

- Member, Board of Directors, Earthquake Engineering Research Institute (EERI) - Utah Chapter, 2013-present.
- Chair, Utah Earthquake Scenario Committee, Earthquake Engineering Research Institute (EERI) - Utah Chapter, 2014-present.
- Member, Ground Motion Relations Workshop Organizing Committee, Earthquake Engineering Research Institute (EERI)- Utah Chapter, 2014-present.
- Voting Member, Utah Mine Safety Technical Advisory Council, 2011-present.
- Intermountain West Regional Coordinator, Advanced National Seismic System (ANSS), 2010-present.

Dr. James C. Pechmann

- Member, Program Committee, 2015 Basin and Range Province Seismic Hazards Summit III, Utah Geological Survey and Western States Seismic Policy Council, 2013-present.
- Member, Utah Quaternary Fault Parameters Working Group, Utah Geological Survey, 2003-present.
- Member, Utah Ground-Shaking Working Group, Utah Geological Survey, 2003-present.
- Member, Working Group on Utah Earthquake Probabilities, Utah Geological Survey, 2010-present.

Dr. Walter J. Arabasz

- Member, Working Group on Utah Earthquake Probabilities, Utah Geological Survey, 2010-present.
- Member, Working Group on a “Scenario for a Magnitude 7.0 Earthquake on the Wasatch Fault—Salt Lake City Segment,” Earthquake Engineering Research Institute (EERI), Utah Chapter, 2014-present.

People

Faculty

• Dr. Keith D. Koper	Director Associate Professor of Geology and Geophysics
• Dr. Kristine L. Pankow	Associate Director Research Associate Professor of Geology and Geophysics
• Dr. James C. Pechmann	Research Associate Professor of Geology and Geophysics
• Dr. Walter J. Arabasz	Emeritus Director Emeritus Research Professor of Geology and Geophysics

Full-time Staff

• William Blycker	Systems Administrator
• Valeriu Burlacu	Research Manager
• David Drobeck	Seismograph Technician
• Jamie Farrell	Postdoctoral Research Associate
• Mark Hale	Earthquake Information Specialist
• Corey Hatch	Seismic Network Engineer
• Martha Knowlton	Administrative Manager
• Sheryl Peterson	Communications Specialist
• Paul Roberson	Earthquake Information Specialist
• Jon Rusho	Seismic Network Engineer
• Katherine Whidden	Research Seismologist

Part-time Staff

• Gordon Johansen	Field Assistant
• Barry Morse	Station Attendant
• Kevin Kwong	Research Assistant
• Peter O'Neill	Field Assistant
• Marcela Torres	Exhibit Coordinator
• Ken Whipp	Electronics Technician

Graduate Student Affiliates

Chase Batchelor
MS - Geophysics

Jared Stein
MS - Geophysics

2014 Graduates

M. Shawn Boltz
MS - Mining Engineering

Thesis: "Mining-Induced Seismicity and FLAC3D Modeling at the Trail Mountain Mine"

Kristel Hansen
MS - Science for Secondary School Teachers

Project: "An Investigation of Utah Lake and Reservoir Induced Seismicity"

Tex Kubacki
MS - Mining Engineering

Thesis: "Changes in Mining Induced Seismicity Before and After the 2007 Crandall Canyon Mine Collapse"

Lisa Linville
MS - Geophysics

Thesis: "Dynamic Earthquake Triggering Potential Across Earthscope's Transportable Array"

Sheryl Peterson (Staff)
MA - Professional Communication
(Weber State University)

Thesis: "An Exploration of Athlete Perception of Coach Communicator Style"

Oner Sufri
PhD - Geophysics

Dissertation: "Characteristics of Microseisms Recorded by the Earthscope Transportable Array"

Mindy Timothy
MS - Science for Secondary School Teachers

Project: "Comparison of Seismicity Rates to the Great Salt Lake Elevation Fluctuations"

Stefanie Whittaker
MS - Geophysics

Thesis: "Seismic Array Constraints on the D" Discontinuity Beneath Central America"

New Endeavors

Oner Sufri - Seismologist
MicroSeismic, Inc. - Houston, TX

M. Shawn Boltz - Mining Engineer
National Institute for Occupational Safety and Health (NIOSH) - Spokane, WA

Jamie Farrell - Postdoctoral Research Associate
University of Utah Seismograph Stations - Salt Lake City, UT

Tex Kubacki - Mining Engineer
National Institute for Occupational Safety and Health (NIOSH) - Spokane, WA

Kevin Kwong - PhD Geophysics
Southern Methodist University - Dallas, TX

Sheryl Peterson - Communications Specialist
University of Utah Seismograph Stations - Salt Lake City, UT

Stefanie Whittaker - PhD Geophysics
University of Alaska Fairbanks - Fairbanks, AK

View west from station SNUT (Stansbury North, UT), Tooele County

Views en route to station FSUi (Fish Springs, UT), Juab County

Undergraduate Student Affiliates

- Kyler Goddard — BS-Geophysics

2014 Graduates

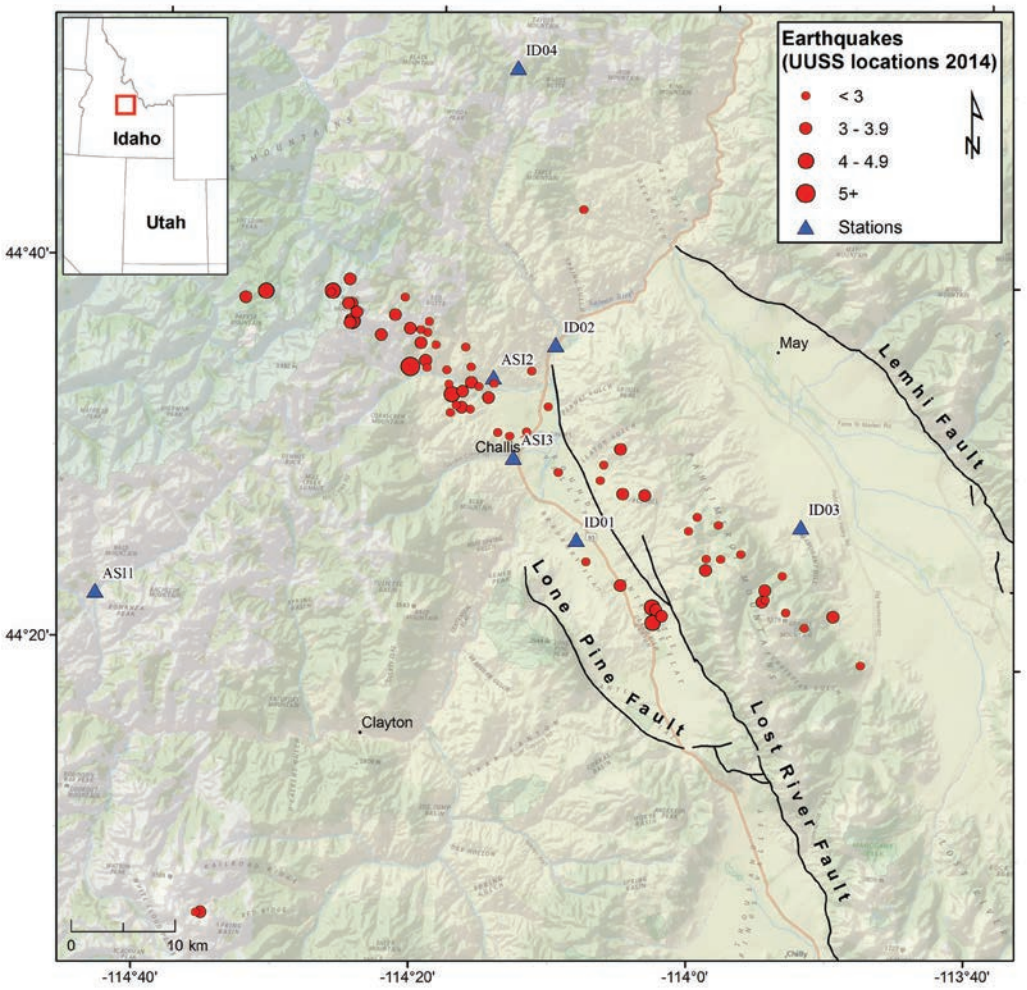
- Derrick Chambers — BS - Mining Engineering
- Shaz Mohammad Jamaal — BS-Geoscience
- Yeou Hui Wong — BS-Geoscience
- Eli Workman — BS-Geoscience

Challis, Idaho Earthquake Sequence

In late March 2014 an energetic sequence of earthquakes began occurring near Challis, ID, in an area 20-30 km to the northwest of the M6.9 1983 Borah Peak earthquake fault zone. Many events in the sequence were felt by local residents. UUSS partnered with the U.S. Geological Survey, the Idaho Geological Survey, Boise State University, Montana Bureau of Mines and Geology (MBMG), and Idaho National Laboratories to install a temporary network of 5 seismic stations (broadband and strong-motion) near the source region in mid-April, adding two additional stations in early July. The addition of these stations decreased the minimum distance between events and closest stations, from over 70 km to under 12 km, for nearly all events. All but one station were removed in September in preparation for winter.

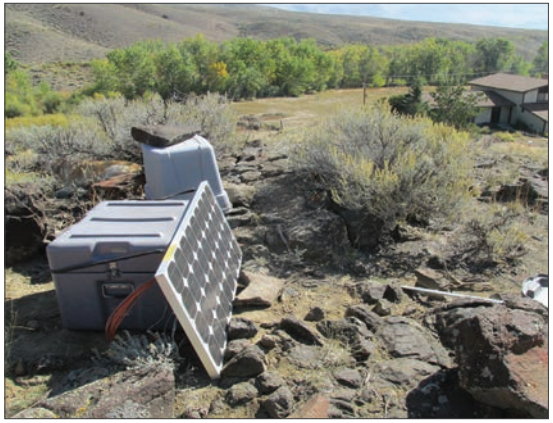
Initial processing results were presented at the 2014 Fall Meeting of the American Geophysical Union in a study led by Mike Stickney (MBMG); UUSS contributing authors included Dr. Kris Pankow, Dr. Keith Koper, and Katherine Whidden. The locations and focal mechanisms determined in this initial analysis suggest that the 2014 sequence is consistent with a northwestern continuation of the Lost River Fault, which ruptured in the 1983 Borah Peak earthquake.

View from Station ASI1. Building is the old Bonanza guard station at the Yankee fork of the Salmon River.



Above: Map showing seismic events associated with the 2014 Challis, ID earthquake sequence (red circles). Blue triangles indicate locations of the seven stations deployed as a temporary network. Earthquake faults are traced in black.

Left: The network consisted of seven stations. ASI1, ASI2, ASI3 were outfitted with UUSS supplied instrumentation. USGS supplied instruments were deployed at stations ID01, ID02, ID03, ID04. Instruments were placed in water proof buckets, covered with tight fitting lids, and buried.



Top left: At station ASI1, small shallow holes were chiseled into the frozen ground and self-leveling cement was used to make a platform for the sensors, which were then covered with a plastic tub. No telemetry was available in this remote location so monthly visits were made to retrieve data recorded on-site, and to check station state-of-health.

Top right: Station ASI2 located about 8 km NE of Challis, ID.

Bottom: Station ASI3. Integrated accelerometer and data logger installed in the Challis Fire station. A bullet antenna mounted to the wall allowed for live data transfer via cell modem.

Supervisor "Ziggy" oversees installation of station ID03.

Top left: At station ID01, sensors were buried in buckets. Orange crate was camouflaged with a brown tarp and solar panels laid flat because of low vegetation cover.

Top right: Station ID02 located 6 miles north of Challis. Sensors were buried in buckets. Datalogger and telemetry electronics were housed in orange case.

Bottom left: Completed station ID04.

Bottom right: Vandalism at station ID04. Trillium compact seismometer was damaged and had to be replaced.

Installation of Broadband Station at Hawk's Rest

Located in the Teton Wilderness area, Hawk's Rest is the most remote station maintained by UUSS. The station fills an important gap in regional seismograph coverage. The station is co-located with a U.S. Forest Service (USFS) radio repeater. Access to the area is restricted by the USFS to either foot or horseback (a distance of approximately 30 miles). Special permission to install the station and simultaneously upgrade the Forest Service solar power system required several years to obtain.

Above: General view of the station site with helicopter lifting off to return for a second load of equipment and supplies; technicians installing the station's large solar panel; equipment inside cinder block shelter: Q330 data logger (orange), telemetry radio (blue),voltage regulator (white); and Trillium seismometer (green) to be covered with black insulating cap.

At left: Forest Service personnel arrive at station with mules packing fresh batteries. Each battery weighs 125 pounds and has 150 Amp-hours capacity.

Installation of WPUT

This year a new broadband seismic station, WPUT (Wasatch Plateau, UT), was installed in the coal mining area of central Utah as part of a joint project with the University of Utah Department of Mining Engineering. This station will allow for closer study of mining-induced seismic sources and aid in discrimination of mining-induced and tectonic seismicity. Jared Stein, a graduate student in geophysics, assisted UUSS Seismograph Technician Dave Drobeck with the station installation.

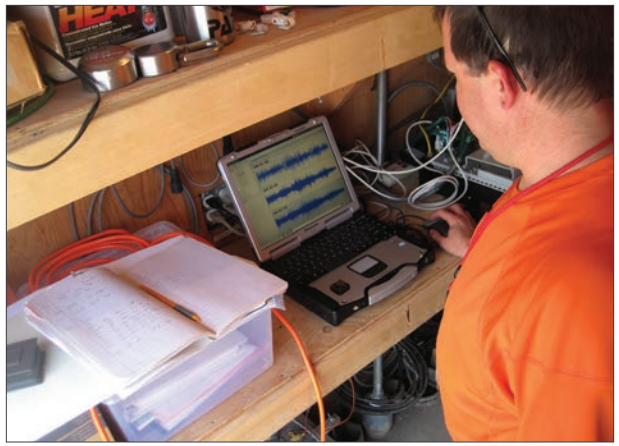
Student Jared Stein with newly excavated electronics and sensor enclosures at station WPUT (top). Completed station antenna and solar panel mast (bottom).

Freeway Bridge Sensors Tested

During July 2014, UUSS partnered with the Utah Department of Transportation (UDOT) and Utah State University (USU) to test parts of the seismic instrument array on the I-15/I-80/SR201 interchange in the Salt Lake valley. The site was instrumented several years prior and provides a unique geophysical and engineering laboratory: sensors on the bridge, borehole sensors and a strong-motion earthquake sensor on the ground. In 2011, the shed housing some of the instrumentation and digitizers had to be relocated to accommodate expansion of light rail in Salt Lake.

As there had been no record of validating the connections with the sensors on the bridge, UUSS and Utah State University leveraged a routine bridge inspection by UDOT to test the sensors, cabling, and the response of the instruments.

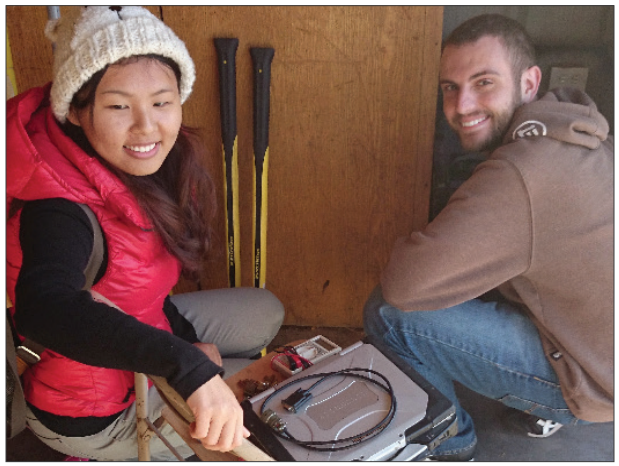
Dr. Marvin Halling, USU Associate Professor of Civil and Environmental Engineering, visited the sensors that are physically attached to the bridge in an under-bridge inspection vehicle. Jon Rusho from UUSS watched the signals come in and recorded the waveforms. All of the sensors appeared to be cabled properly and nominally working, though some of the enclosures were rusted shut from years of weather and salt applied to the road deck.



Dr. Marvin Halling and a UDOT representative inspect sensors located beneath bridges at the Salt Lake Valley I-15/I-80/SR201 interchange (top and center), while Jon Rusho records sensor waveforms in a nearby UDOT equipment shed (bottom).

Vigilant Guard 2014 - Emergency Response Exercise

The Utah National Guard and the Utah Department of Emergency Management spearheaded an exercise to assess capacity for emergency response of state, local and federal agencies as well as the public, in the event of a natural disaster or civil emergency.



Top: Corey Hatch and Jared Stein gather data at station BYP in downtown Salt Lake City.

Bottom: Yao Yao and Jared Stein download seismic data at station WHS.

"Vigilant Guard" activities were carried out at several locations along the Wasatch Front, November 3-6. During the exercise, two UUSS staff members participated in the State of Utah's Joint Information Center (JIC).

UUSS staff Dave Drobeck, Corey Hatch, and Jon Rusho along with students Jared Stein, Yao Yao, Eli Workman, Kyler Goddard used the exercise to practice retrieval of seismic data from field stations in Salt Lake City, and data processing. This hands-on experience would be useful in the event of an unplanned telemetry system failure.

In conjunction with Vigilant Guard, UUSS conducted a department exercise designed to provide hands-on experience with Incident Command Structure (ICS). In the event of a large earthquake, ICS could be implemented to help UUSS respond to the emergency in a more organized and efficient way.

Drills and exercises such as Vigilant Guard provide useful opportunities to prepare for the kind of real-life emergencies possible in the seismically active Utah Region.

Reaching Out

UUSS scientists filled several requests for media interviews such as the KSL Doug Wright radio show (Apr 8), University of Utah Chronicle (Apr 17), KSL Television (Apr 20), FOX Television (Apr 20), KCPW Public Radio (Apr 21) as well as numerous phone interviews.

Invited presentations at community events included the Cosgrill Science Fair (Jan 28), St. Catherine's Newman Center Men's Group (Mar 8), and the Desert News Disaster Recovery Committee (Sep 30). Presentations were also made to government and

Katherine Whidden joins Bob Carey (UT Division of Emergency Management), Brad Westwood (UT Division of State History), and KSL radio host Doug Wright for a live broadcast from the Rio Tinto Earthquake Information Center.

corporate groups including Goldman Sachs (Feb 3), Herriman, Utah Community Response Group (May 14), Dyno Nobel (May 21), the Utah Department of Workforce Services (Jun 25), and the Salt Lake City Office of Emergency Management (Nov 8).

UUSS also provided sixteen tours of the Rio Tinto Earthquake Information Center to groups of high school and university students—including a delegation of students from China; as well as other community groups. Each tour gives an overview of Utah's earthquake hazard as well as UUSS network operations and the role that UUSS plays in earthquake response.

Seismo Tea

Seismo Tea is an informal discussion session for graduate students to present their research before professional scientists and receive constructive feedback. As research topics are discussed students learn to critique and provide feedback on the research of others. Seismo Tea also provides students the opportunity to gather feedback from scientists

outside their thesis committee and to seek advice regarding career choices.

Graduate student Jared Stein was the Seismo Tea student chair for fall and spring semesters.

Presentations made by visiting doctoral students included Hongrui Qiu from the University of Southern California who presented research on fault zone head waves; Lorenz Grämiger from ETH Zürich who presented "Cyclic thermo-hydro-mechanical stresses and induced rock mass damage during Lateglacial and Holocene glacial cycles in the Aletsch region (Switzerland)"; and Daniel Bowden from The California Institute of Technology who presented "Attenuation and site amplification through ambient noise."

Presentations were also made by two visiting professionals: Dr. Gerard Schuster from King Abdullah University of Science and Technology who presented "Superresolution detection of a hidden fault along the Red Sea by a Seismic scanning tunneling macroscope," and a second presentation "Far-field superresolution by imaging of resonance scattering"; and Dr. Hsin-Hua Huang from the California Institute of Technology who presented "Adjoint tomography of Taiwan: from travel-time toward waveform inversion."

University of Utah scientists also contributed presentations including: Katherine Whidden, "Regional, local, and in-mine moment tensors for the 2013 Rudna Mine collapse, Poland"; Dr. Jaime Farrell, who presented on seismic activity in the Yellowstone region; Dr. Jim Pechmann, "An M 4.8 Earthquake in the Upper Mantle Beneath the Wind River Range, Wyoming"; and Dr. Keith Koper who led a discussion on "Iquique earthquakes off the coast of Chile April 2014," and also gave a joint presentation with Relu Burlacu on an ambient noise project.

University of Utah student presentations were made by: Tex Kubacki, "Cross-correlation and the Crandall Canyon Mine collapse"; M. Shawn Boltz, regarding an ongoing project examining induced seismicity in the Trail Mountain Mine; Jared Stein, who gave a demonstration of subspace detection software developed by Dr. Harley Benz of the National Earthquake Information Center (NEIC); Derrick Chambers, who presented on the python programming language in seismology (Obspy and Detex); and Eli Workman and Kyler Goddard, who presented their recent microseism research with the Yellowstone River and the Great Salt Lake.

Additional group discussions focused on earthquakes in Pakistan and the Scotia Sea, and two web presentations by the Incorporated Research Institutions for Seismology (IRIS).

Utah Seismic Safety Commission Celebrates 20th Anniversary

Established by the Utah Legislature in 1994, the Utah Seismic Safety Commission (USSC) advises state and local government officials, as well as the public, on issues related to earthquake safety. UUSS Director, Dr. Keith Koper currently serves as a vice chair with the Commission.

UUSS has been involved with the USSC since the founding of the Commission, 20 years ago. UUSS Director Emeritus, Dr. Walter Arabasz served as the Commission's first chairman from 1997 to 2001 and has been a continuing member of the Commission since 2001. Dr. Arabasz participated in the development and implementation of the USSC's first publication, "A Strategic Plan for Earthquake Safety in Utah." The plan outlined 35 objectives for improving earthquake safety in the State of Utah. Many of these objectives have been or are in the process of being addressed. This strategic plan continues to guide the commission's efforts today.

Partners and Sponsors

The Commission works to:

- Review earthquake-related hazards and risks in Utah
- Prepare recommendations to identify and mitigate the hazards and risk
- Prioritize recommendations for adoption as policy or loss-reduction strategies
- Act as a source of information for earthquake safety and promote earthquake loss-reduction measures
- Update the strategic planning document and other supporting studies or reports

Dr. Walter Arabasz with former commission members, Anne Von Weller and Scott Behunin, and current commission member Pete McDonough following a tour of the new Utah State Emergency Operations Center during a USSC quarterly meeting held July 17, 2014, the commission's 20th anniversary.

In the Classroom

The Department of Geology and Geophysics spring semester course, "Earthquake Seismology and Hazard Assessment" was taught by Dr. Keith Koper. In the fall, Dr. Koper was back in the classroom teaching a course in "Signal Processing." The Department's spring seminar, "Induced Earthquakes" was taught by Dr. Kris Pankow.

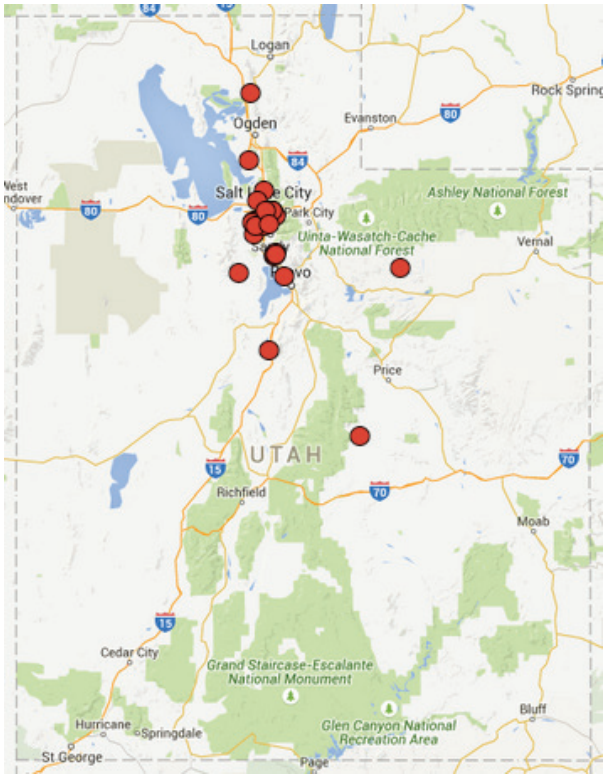
Quarterly Earthquake Bulletins Online

Four times a year, UUSS publishes quarterly earthquake bulletins for the Utah Region and the Yellowstone National Park Region. The reports provide a catalog and map of the regional recorded earthquakes for the quarter along with network maps, station data tables, and other operations and analysis information. Utah Region reports are available for the first quarter of 2001 forward. Reports for the Yellowstone Region are available beginning with the fourth quarter of 2013.

Earthquake Exhibit Tours the State

"Earthquakes in the Intermountain West" is a traveling educational exhibit funded by the State of Utah and maintained and administered by UUSS. The exhibit tells Utah's earthquake story including the history of earthquakes in the region, the science behind them, and how to prepare for future earthquakes. In 2014, exhibit displays were hosted by the following public schools and organizations:

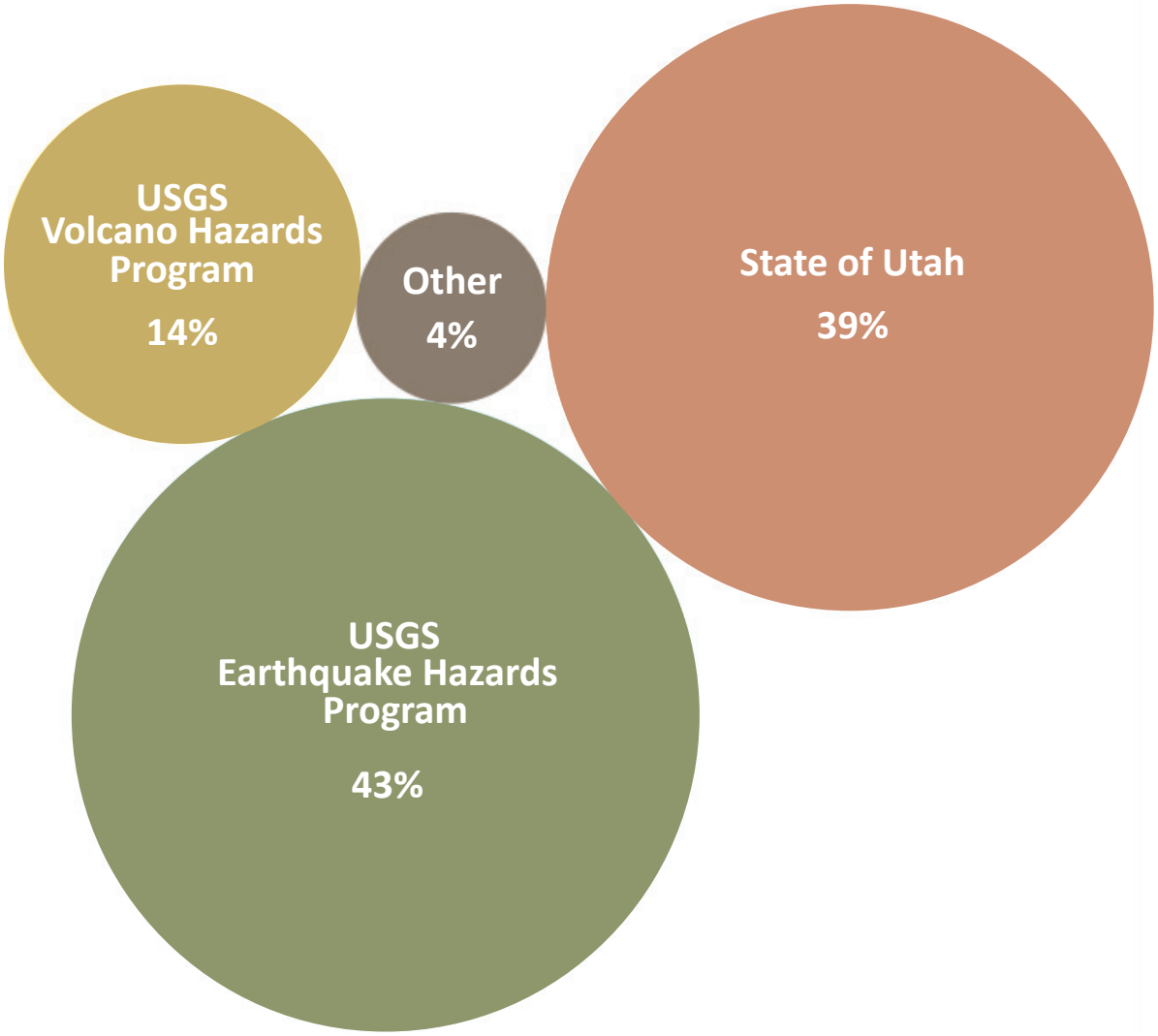
Adele C. Young Intermediate School - Brigham City
Arcadia Elementary - Salt Lake City
Beacon Heights Elementary - Salt Lake City
Boulton Elementary - Bountiful
Box Elder Middle School - Brigham City
Cedar Valley Elementary - Cedar Fort
Clayton Middle School - Salt Lake City
Cottonwood Elementary - Orangeville
Eastwood Elementary - Salt Lake City
Elk Meadows Elementary - South Jordan
Highland Elementary - Highland
Hillside Middle School - Salt Lake City
Kearns Junior High - Kearns
Legacy Junior High - Layton
Liberty Elementary - Murray
Mona Elementary - Mona
North Star Elementary - Salt Lake City
Ridgeline Elementary - Highland
Suncrest Elementary - Orem
Tabiona School - Tabiona
Timberline Middle School - Alpine
Westbrook Elementary - Taylorsville
Westfield Elementary - Alpine
Whittier Elementary - West Valley City
Woodstock Elementary - Murray



Red circles mark exhibit destinations throughout the state in 2014

UUSS Funding

January 1 - December 31, 2014

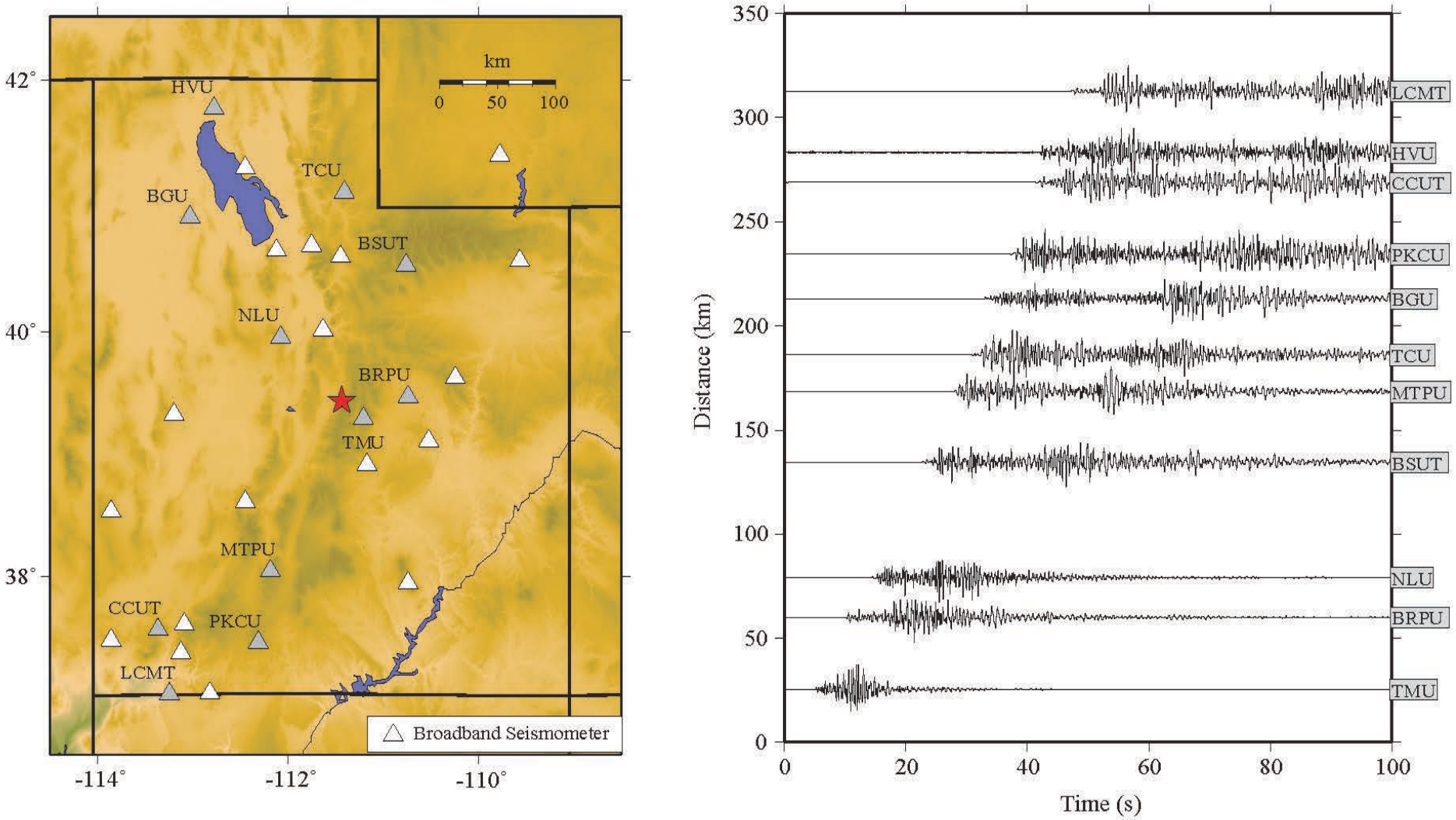


- **State of Utah**
  Earthquake monitoring, research, education and outreach in the Utah region

- **U.S. Geological Survey—Earthquake Hazards Program**
  Regional and urban seismic monitoring and research along the Wasatch Front urban corridor and Intermountain Seismic Belt

- **U.S. Geological Survey—Volcano Hazards Program**
  Earthquake monitoring and research in the Yellowstone National Park region

- **U.S. Department of Energy**
- **University of Utah Energy and Geoscience Institute**
  Analysis of structurally controlled geothermal systems in the Eastern Great Basin Extensional Regime, Utah
- **Los Alamos National Laboratory**
  Collaborative infrasound seismic research
- **Utah Department of Public Safety**
  Traveling educational earthquake exhibit
- **National Institute for Occupational Safety and Health**
- **University of Utah Department of Mining Engineering**
  Monitoring and research on mining-induced seismicity in Utah coal mines and graduate student training
- **National Science Foundation**
  Collaborative research of dynamic earthquake triggering using the US Array.
  Location and characterization of ambient seismic noise using the US Array.
- **Additional revenue from:**
  - Production of seismic data products
  - Consulting
  - Individual research grants



The largest earthquake in Utah during 2014 had a magnitude of 4.2 and occurred about 11 km south of Mt. Pleasant on the evening of June 28. It was felt throughout the Sanpete Valley but no damage was reported. The epicenter is indicated by the red star, and the locations of UUSS broadband seismometers that recorded the earthquake are indicated by triangles. Seismograms shown in the right panel correspond to the stations shown with a grey triangle, and labeled, on the map. Although the duration of the earthquake rupture was less than a second, seismic energy disperses as it travels through the Earth, leading to progressively extended seismic waveforms.

University of Utah
Seismograph Stations
THE UNIVERSITY OF UTAH