

Christian Lynn Hardwick

Department of Natural Resources, Utah Geological Survey
1594 W. North Temple, Suite 3110, Salt Lake City, UT 84114 • (801) 538-5412 •
christianhardwick@utah.gov
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EDUCATION AND TRAINING

University of Utah **Salt Lake City, UT**
Master of Science in Geophysics, Aug. 2013

University of Utah **Salt Lake City, UT**
Bachelor of Science in Geoscience with Geophysics emphasis, May 2010

RESEARCH AND PROFESSIONAL EXPERIENCE

Utah Geological Survey **Salt Lake City, UT**
Head Geophysicist, Senior Geologist, Geothermal Section Manager (June 2011 – present)

Resource assessment and geologic characterization of Utah

- Exploration geophysics focused on locating and characterizing geothermal and groundwater resources, as well as the delineation and mapping of subsurface geologic structures.
- Specialize in applied geophysical methods of gravity, magnetotellurics, transient electromagnetics, and heat flow.
- Digital modeling and interpretation of geophysical data integrated with borehole information, temperature data and downhole geophysical logs.
- Utilization of MATLAB, python, COMSOL, Fortran, WinGLink, ViewTEM, ArcGIS, LaTeX, MS Office suite, Inkscape, GIMP, Adobe Illustrator and Acrobat to perform and present research efficiently and effectively.
- Manager of the UGS Thermal Geophysics Research Lab where physical properties are measured on cuttings, core and field samples, and prototype equipment is designed, built and tested.
- Oversees use and maintenance of all geophysical equipment, its data acquisition, data processing and preservation.
- Lead sUAS pilot in UGS division managing aerial equipment, mission logistics, pilot training, and post-processing of data to create high-resolution orthomosaics and 3D terrain models.

Thermal Geophysics Research Lab, University of Utah **Salt Lake City, UT**
Laboratory Research Assistant (July 2009 – June 2011)

Research assistant

- Laboratory measurements of physical properties on drill core, drill cuttings and field samples including thermal conductivity.
- Computations, processing, programming, modeling and data archiving using Linux based programs and MATLAB software.
- Working with colleagues on projects involving microgravity, paleoclimate, hydrology, geothermal systems, heat flow and isostasy.

CERTIFICATIONS

Professional Geologist, State of Utah Department of Commerce, Jan. 2015

14 CFR Part 107 sUAS Remote Pilot, Federal Aviation Administration, June 2018

SYNERGISTIC ACTIVITIES

- Create and conduct laboratory exercises for geoscience courses at the University of Utah and Brigham Young University in applied geophysical methods
- Peer reviewer for Geothermics, Journal of Volcanology and Geothermal Research, Geothermal Energy Journal

Publications and Presentations

- Hardwick, C.**, Gettings, P. and Chapman, D. S., Geophysical Delineation of Geothermal Resources in Southern Utah using High-Precision Gravity, Abstract H33D-1172 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec., 2010.
- D'Alfonso, D., **Hardwick, C.**, Hollingshaus, B., Kordy, M., Shurtleff, R., Smith, K. and Smith, S., Geothermal Assessment of the Rio Grande Rift, NREL Student Competition, Santa Fe, New Mex., 21-25 Jun., 2011
- Chapman, D.S., D'Alfonso, D., **Hardwick, C.**, Hollingshaus, B., Kordy, M., Shurtleff, R., Smith, K. and Smith, S., Geothermal Potential of the Rio Grande Rift: From Exploration to Production, Abstract presented at 2011 Annual Meeting, GRC, San Diego, Calif., 23-25 Oct., 2011.
- Hardwick, C. L.** and Chapman, D. S., 2011. Geophysical Delineation of the Crater Bench, Utah, Geothermal System, Geothermal Resources Council Transactions, Vol. 35, p. 801-804.
- Hardwick, C.** and Chapman, D. S., Characterization of Geothermal Resources in Southwestern Utah, Abstract IN33C-1479 presented at 2011 Fall Meeting, AGU, San Francisco, Calif., 5-9 Dec., 2011.
- Chapman, D.S., D'Alfonso, D., **Hardwick, C.**, Hollingshaus, B., Kordy, M., Shurtleff, R., Smith, K. and Smith, S., A Regional Geothermal Assessment of the Rio Grande Rift: All Data Are Not Created Equal, Abstract IN33C-1478 presented at 2011 Fall Meeting, AGU, San Francisco, Calif., 5-9 Dec., 2011.
- Allis, R. G., Moore, J., and **Hardwick, C.**, High Temperature Aquifers Beneath the Great Basin – A New Target for Geothermal Power Production, Abstract IN31D-05 presented at 2011 Fall Meeting, AGU, San Francisco, Calif., 5-9 Dec., 2011.
- Hardwick, C. L.**, Chapman, D. S. and Allis, R. G., Investigating Geothermal Resources in Utah, USA, using MT and Gravity. Abstract SP4.1-6 presented at 21st Electromagnetic Induction Workshop, Darwin, NT, Australia, 25-31 July, 2012.
- Allis, R., Blackett, R., Gwynn, M., **Hardwick, C. L.**, Moore, J., Morgan, C., Schelling, D. and Sprinkel, D., 2012. Stratigraphic Reservoirs in the Great Basin – The Bridge to Development of Enhanced Geothermal Systems, Geothermal Resources Council Transactions, Vol. 36, p. 351-357.
- Hardwick, C. L.** and Chapman, D. S., 2012. Geothermal Resources in the Black Rock Desert, Utah: MT and Gravity surveys, Geothermal Resources Council Transactions, Vol. 36, p. 903-906.
- Hardwick, C. L.**, Chapman, D. S. and Gettings, P., Thermo Hot Springs: MT and Gravity observations of a producing geothermal field in Utah, USA, Abstract V13C-2865 presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec., 2012.
- Jiracek, G. R., Feucht, D. W., Brown, D., Castro, B., Chang, J., Goff, D., **Hardwick C.**, Hollingshaus, B., Bowles-martinez, E., Nakai, J., Wilson, C., Bertrand, E. A., Bennie, S., Caldwell, G., Hill, G. J., Wallin, E., Bedrosian, P. A., Hasterok, D. P. and Pellerin, L., 2012. Magnetotelluric Phase Tensor Applications to Geothermal Assessment in New Zealand and New Mexico, Abstract GP33A-1080 presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec., 2012.
- Hardwick, C. L.**, 2013, Geothermal Resources in Southwestern Utah: Gravity and Magnetotelluric investigations, Master's thesis, University of Utah, 67p.
- Gwynn, M., Blackett, R., Allis, R. and **Hardwick, C. L.**, 2013. New geothermal resource delineated beneath Black Rock Desert, Utah. Proceedings, Thirty-Eighth Workshop on Geothermal Reservoir Engineering, Stanford University, 1511-1519, SGP-TR-198.
- Hardwick, C. L.**, Allis, R. G. and Chapman, D. S., Investigating Geothermal Resources in the Black Rock Desert, Utah, using MT and Gravity, Abstract presented at 2013 American Association of Petroleum Geologists Rocky Mountain Section Meeting, Salt Lake City, Utah, 22-24 Sep., 2013.
- Hardwick, C. L.**, Gwynn, M., Blackett, R. and Allis, R., Black Rock Desert, Utah - an Example of a Hot Basin, Abstract presented at the 2013 GSA Penrose Conference, Park City, Utah, 19-23 Oct., 2013.
- Langenheim, V. E., Willis, H., Athens, N. D., Chuchel, B.A., Kraushaar, S.M., Knepprath, N. E., Rosario, J., Roza, J., Hiscock, A. I. and **Hardwick, C. L.**, 2013. Preliminary isostatic gravity map of the Grouse Creek and east part of the Jackpot 30' x 60' quadrangles, Box Elder County, Utah, and Cassia County, Idaho, Utah Geological Survey Miscellaneous Publication 13-2.

- Blackett, R. E., Gwynn, M., **Hardwick, C. L.**, Thomas, K., Weaver, L. and Allis, R., 2013, Utah contributions to the National Geothermal Data System: Geothermal Resources Council Transactions, Vol. 37, p.559-563
- Wannamaker, P. E., Marris, V. and **Hardwick, C. L.**, 2013, Basin Rift Structure of the Central Black Rock Desert, Utah, and Initial Thermal Implications, from 3D Magnetotellurics, Geothermal Resources Council Transactions, Vol. 37, p. 41-44.
- Langenheim, V.E., Willis, H., Athens, N. D., Chuchel, B.A., Kraushaar, S. M., Rosario, J., Roza, J. and **Hardwick, C. L.**, 2013. Preliminary isostatic residual gravity map of the Newfoundland Mountains and east part of the Wells 30' x 60' quadrangles, Box Elder County, Utah, Utah Geological Survey Miscellaneous Publication 13-4
- Inkenbrandt, P. C., Thomas, K. and **Hardwick C.**, 2013, Cache Valley aquifer storage and recovery - Phase II: Utah Geological Survey Open File Report 615, 45 p.
- Hardwick, C. L.**, Kirby, S. and Gwynn, M., Geothermal Prospecting in Utah: A new thermal model of the Black Rock Desert, Abstract H51D-1229 presented at 2013 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec., 2013.
- Langenheim, V. E., Oaks, R. Q., Willis, H., Hiscock, A. I., Chuchel, B. A., Rosario, J. and **Hardwick, C. L.**, 2014. Preliminary residual isostatic gravity map of the Tremonton 30' x 60' quadrangle, Box Elder County, Utah Miscellaneous Publication 14-2
- Hardwick, C. L.**, Willis, H. W., and Gwynn, M. L., Geothermal assessment and modeling of the Uinta Basin, Utah, Abstract presented at 2014 American Association of Petroleum Geologists Rocky Mountain Section Meeting, Denver, Colorado, 20-22 July, 2014.
- Hardwick, C. L.**, Kirby, S., and Gwynn, M., 2014. Geothermal prospecting in Utah: A new thermal model of the Black Rock Desert, Geothermal Resources Council Transactions, Vol. 38, p. 1041-1045.
- Blackett, R. E., Gwynn, M. L., **Hardwick, C. L.**, and Allis, R. G., 2014. Preliminary studies of geothermal resources- Northern Great Salt Lake region, Utah, Geothermal Resources Council Transactions, Vol. 38, p. 1017-1027.
- Gwynn, M., Allis, R., Sprinkel, D., Blackett, R., and **Hardwick, C.**, 2014. Geothermal potential in the basins of northeastern Nevada, Geothermal Resources Council Transactions, Vol. 38, p. 1029-1039.
- Hardwick, C. L.**, and Kirby, S., Potential for a significant deep basin geothermal system in Tintic Valley, Utah, Abstract NS42A-02 presented at 2014 Fall Meeting, AGU, San Francisco, Calif, 15-19 Dec., 2014.
- Hardwick, C. L.**, Wannamaker, P. E., and Allis, R., Application of Geophysical data for resolving Stratigraphic Reservoirs: A target beneath the Black Rock Desert, Utah, USA, abstract 38025 presented at 2015 AGU-SEG Workshop, Keystone, Colorado, 25-27 Aug., 2015.
- Hardwick, C. L.**, Willis, H. W., and Gwynn, M. L., 2015. A Basin-Scaled Assessment of Co-Produced Waters in Oil and Gas Fields: Uinta Basin, Utah, USA, Geothermal Resource Council Transactions, Vol. 39, p. 661-669.
- Hardwick, C. L.**, Allis, R., and Wannamaker, P. E., 2015. Observations and Implications of Magnetotelluric data for resolving Stratigraphic Reservoirs beneath the Black Rock Desert, Utah, USA, Geothermal Resources Council Transactions, Vol. 39, p. 593-601.
- Allis, R., **Hardwick, C.**, Gwynn, M., and Johnson S., 2015. Pavant Butte, Utah Geothermal Prospect Revisited, Geothermal Resources Council Transactions, Vol. 39, p. 379-387.
- Allis, R., Gwynn, M., **Hardwick, C.**, Mines, G., and Moore J., 2015. Will stratigraphic reservoirs provide the next big increase in U.S. geothermal power generation?, Geothermal Resources Council, Vol. 39, p. 389-397.
- Wannamaker, P. E., Moore, J. N., Pankow, K. L., Simmons, S. D., Nash, G. D. Maris, V., Batchelor, C. and **Hardwick, C. L.**, 2015. Play Fairway Analysis of Eastern Great Basin Extensional Regime, Utah: Preliminary Indications, Geothermal Resources Council Transactions, Vol. 39, p. 793-802.
- Hardwick, C.L.**, Willis, H.W., and Gwynn, M.L., 2015, Geothermal Assessment and Modeling of the Uinta Basin, Utah, *in* Vanden Berg, M.D., Resselar, R., and Birgenheier, L.P., editors, Geology of Utah's Uinta Basin and Uinta Mountains: Utah Geological Association Publication 44, p. 337-353.
- Allis, R., Moore, J., Davatzes, N., Gwynn, M., **Hardwick, C.**, Kirby, S., McClennan, J., Pankow, K., Potter, S., and Simmons, S., 2016. EGS Concept Testing and Development at the Milford, Utah FORGE Site, Proceedings, Forty-First Workshop on Geothermal Reservoir Engineering, Stanford University, 886-898, SGP-TR-209.
- Hardwick, C. L.**, Gwynn, M. L., Allis, R., Wannamaker, P. E., and Moore, J., 2016. Geophysical Signatures of the Milford, Utah FORGE site, Proceedings, Forty-First Workshop on Geothermal Reservoir Engineering, Stanford University, 1509-1519, SGP-TR-209.
- Wannamaker, P. E., Pankow, K. L., Moore, J. N., Nash, G. D., Maris, V., Simmons, S. F., and **Hardwick, C. L.**, 2016. A Play Fairway Analysis for Structurally Controlled Geothermal Systems in the Eastern Great Basin

- Extensional Regime, Utah, Proceedings, Forty-First Workshop on Geothermal Reservoir Engineering, Stanford University, 308-324, SGP-TR-209.
- Gwynn, M., Allis, R., **Hardwick, C.**, Hill, J., and Moore, J., 2016. A New Look at the Thermal Regime Around Roosevelt Hot Springs, Geothermal Resources Council Transactions, Vol. 40, p. 551-558.
- Allis, R., Gwynn, M., **Hardwick, C.**, Kirby, S., Bowers, R., Moore, J., Simmons, S., and Wannamaker, P., 2017. Characteristics of the Cove Fort – Dog Valley – Twin Peaks Thermal Anomaly, Utah, Proceedings, Forty-Second Workshop on Geothermal Reservoir Engineering, Stanford University, SGP-TR-212.
- Simmons, S., Allis, R., Moore, J., Gwynn, M., **Hardwick, C.**, and Kirby, S., 2017. Conceptual Models of Geothermal Resources in the Eastern Great Basin, Proceedings, Forty-Second Workshop on Geothermal Reservoir Engineering, Stanford University, SGP-TR-212.
- Wannamaker, P., Pankow, K., Moore, J., Nash, G., Maris, V., Simmons, S., **Hardwick, C.**, and Allis, R., 2017. Phase II Play Fairway Analysis Activities for Structurally-Controlled Geothermal Systems in the Eastern Great Basin Extensional Regime, Utah, USA, Proceedings, Forty-Second Workshop on Geothermal Reservoir Engineering, Stanford University, SGP-TR-212.
- Wallace, J., Jordan, J. L., **Hardwick, C.**, and Hurlow, H., 2017, Water Salinity Study for the Southern San Pitch Drainage System in Sanpete County, Utah. Utah Geological Survey Special Study 158, 37p.
- Nash, G, Brandt, A., Pfaff, B., **Hardwick, C.**, Gwynn, M., Blake, K., Simmons, S., and Bennet, C., 2017. Phase 2: Updated Geothermal Play Fairway Analysis of the Tularosa Basin, New Mexico, Geothermal Resources Council Transactions, Vol. 41
- Wannamaker, P.E., Moore, J.N., Pankow, K.L., Simmons, S.F., Nash, G.D., Maris, V., Trow, A., and **Hardwick, C.L.**, 2017, Phase II of play fairway analysis for the eastern Great Basin extensional regime, Utah: status of indications: Geothermal Resources Council Transactions, Vol. 41, p. 2368-2382.
- Simmons, S., Allis, R., Moore, J., Gwynn, M., **Hardwick, C.**, and Kirby, S., 2017. Conceptual Models of Geothermal Resources in the Eastern Great Basin, Geothermal Resources Council Transactions, Vol. 41
- Allis, R., Gwynn, M., **Hardwick, C.**, Kirby, S., Bowers, R., Moore, J., Simmons, S., and Wannamaker, P., 2017. Characteristics of the Cove Fort – Dog Valley – Twin Peaks Thermal Anomaly, Utah, Geothermal Resources Council Transactions, Vol. 41
- Allis, R., Gwynn, M., **Hardwick, C.**, and Moore, J., 2018. The Challenge of Correcting Bottom-Hole Temperatures—An Example from FORGE 58-32, near Milford, Utah, Proceedings, Forty-Third Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA
- Hardwick, C.**, Hurlbut, W., Gwynn, M., Allis, R., Wannamaker, P., and Moore, J., 2018. Geophysical Signatures of the Utah FORGE Site, Northern Milford Basin, Utah, Abstract presented at American Association of Petroleum Geologists Rocky Mountain Section Meeting, Salt Lake City, Utah, 20-23 May, 2018.
- Allis, R., Gwynn, M., **Hardwick, C.**, Hurlbut, W., and Moore, J., 2018. Thermal Characteristics of the FORGE site, Milford, Utah, Geothermal Resources Council Transactions, Vol. 42, p. 1011-1025.
- Gwynn, M., Allis, R., **Hardwick, C.**, Jones, C., Nielsen, P., and Hurlbut, W., 2018. Rock Properties of FORGE Well 58-32, Milford, Utah, Geothermal Resources Council Transactions, Vol. 42, p. 1047-1070.
- Hardwick, C.**, Hurlbut, W., Gwynn, M., Allis, R., Wannamaker, P., and Moore, J. 2018. Geophysical Surveys of the Milford, Utah, FORGE Site: Gravity and TEM, Geothermal Resources Council Transactions, Vol. 42, p. 1071-1083.
- Miller, J., Allis, R., and **Hardwick, C.**, 2018. Seismic Reflection Profiling at the FORGE Utah EGS Site, Geothermal Resources Council Transactions, Vol. 42, p. 1115-1127.