CGNHS Miscellaneous Map MM-2013-03
Connecticut Geothermal Map Series No. 3 of 8

Connecticut Geothermal Energy Project:
Inferred Heat Flow
2013

About This Map

The Connecticut and Massachusetts Geological Surveys collaborated on a National Geothermal Data Project funded by the US Department of Energy through the Association of American State Geologists. The goal was to develop information to assist in locating deep geothermal resources and provide data for better design of Enhanced Geothermal Systems in bedrock and unconsolidated sediments. Bedrock units suspected capable of producing radiogenic heat at depth were the primary focus of this study. Additional bedrock units were analyzed to provide a regional view of the geothermal potential across the State. A total of 55 bedrock units were targeted and 242 samples were collected for this study

This map shows the location of surface outcrop samples from which heat flow is inferred. The typical sample size is between 0.2 to 1.0 kg. An inferred heat flow (Q) in mW/m^2 can be obtained from the empirical linear relationship between heat flow and heat production (A) in $\mu W/m^3$ established by Birch and co-workers for the New England Appalachian region *(Birch et al.*, 1968; *Roy et al.*, 1968).

$$Q = A \times 7.506 + 33.1$$

Independent studies by *Jaupart et al.* (1982) and *Decker* (1987) confirmed this relationship to ±15% for plutonic rocks in New Hampshire and Maine, respectively. The heat production (A) in $\mu W/m^3$ is calculated from the density (D) of the samples and from the concentrations in weight percent of Potassium reported as the oxide (K_2O) and theconcentrations in parts per million (ppm) of the elements Uranium (U) and Thorium (Th) in the samples.

$$A = ((K_2O) \times 0.0297) + (U \times 0.0967) + (Th \times 0.0263)) \times D$$

The concentration of K_2O, U, and Th are determined by X-ray Fluorescence Spectroscopy (XRF) following modifications of the methods of Norrish and Chappel (1967) outlined in Rhodes and Vollinger (2004). The lower limits of detection are 0.001 weight percent for K_2O and 0.3 ppm for both U and Th. Results for standard rocks are typically within ±0.04 weight percent for K_2O and ±0.4 ppm for U and Th.

References

Birch, F., Roy, R.F. and Decker, E.R., 1968. Heat flow and thermal history in New England and New York. In *Studies in Appalachian Geology; Northern and Maritime,* eds., E-an Zen, W.S. White, J.B. Hadley, and J.B. Thompson, Interscience Publishers, New York, pp.437-452.

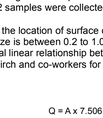
Decker, E.R., 1987. Heat flow and basement radioactivity in Maine: First-order results and preliminary interpretations, *Geophysical Research Letters*, v.14, pp.256-259.

Norrish, K., and Chappell, B.W., 1967. X-Ray fluorescence spectroscopy. In Zussman, J., ed., *Physical Methods in Determinative Mineralogy.* Academic Press, London, pp. 161-214.

Philpotts, A.R. and Ague, J.J., 2008. *Principles of Igneous and Metamorphic Petrology.* Cambridge University Press, pp.6-13.

Rhodes, J.M., and Vollinger, M.J., 2004. Composition of basaltic lavas sampled by phase-2 of the Hawaii Scientific Drilling Project: Geochemical stratigraphy and magma types. *Geochemistry, Geophysics, Geosystems,* v.5, Q03G13, doi: 10.1029/2002GC000434.

Roy, R.F., Blackwell, D.D., and Birch, F., 1968. Heat generation of plutonic rocks and continental heat flow provinces. *Earth and Planetary Science Letters,* v.5, pp.1-12.



APPROXIMATE MEAN
DECLINATION, 2013

Sources

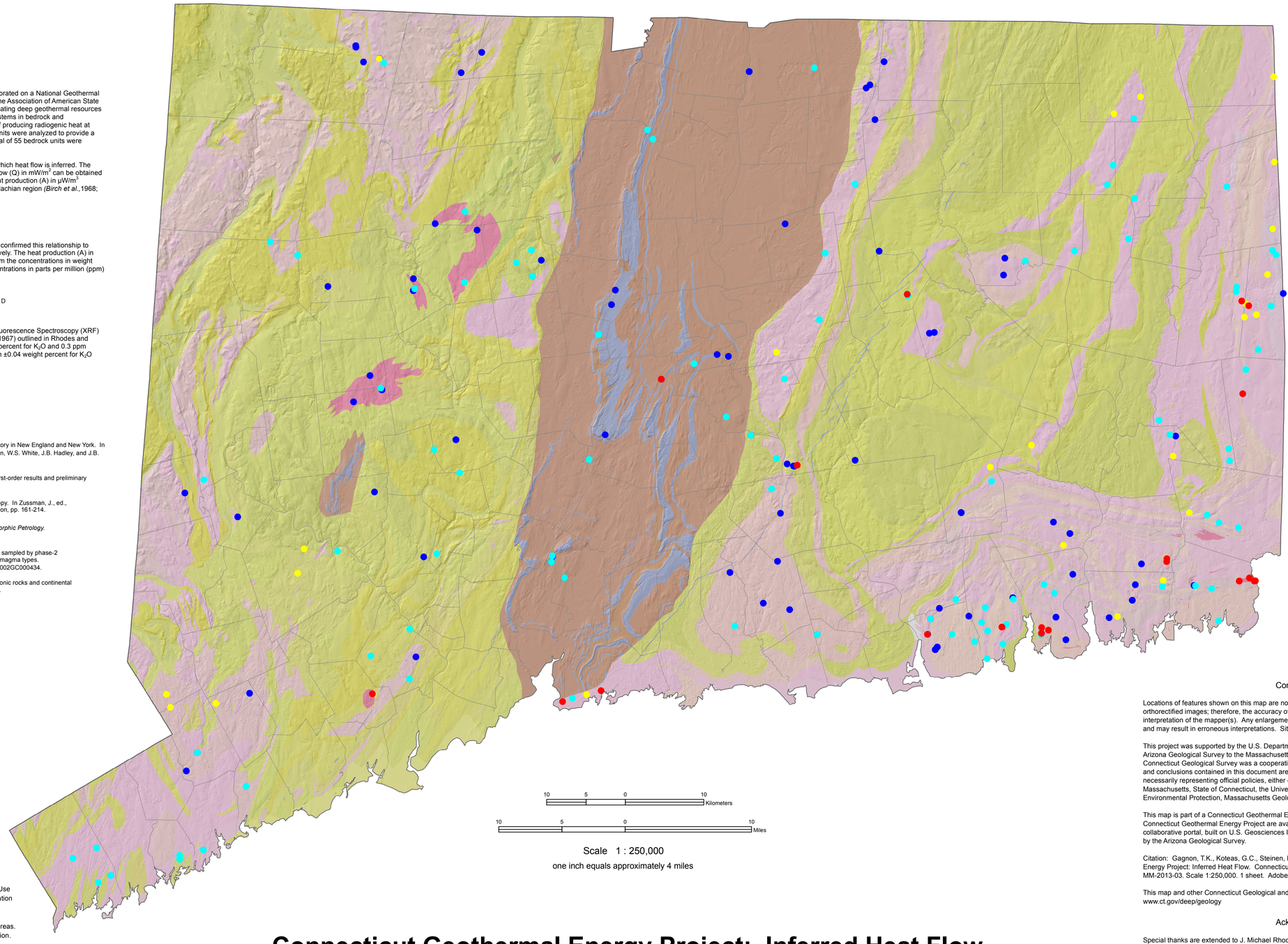
Hillshade base was produced by the University of Connecticut, College of Agriculture and Natural Resources, Center for Land Use Education and Research (CLEAR). It is derived from point elevation data captured during the year 2000 using Light Detection And Ranging (LiDAR) technology. Note, the 2000 LiDAR data for Connecticut is incomplete, necessitating interpolation in some areas. See http://cteco.uconn.edu/data_guides.htm for further information. This data is available for download at www.ct.gov/deep/gisdata

Geologic units are generalized from the Bedrock Geological Map of Connecticut, Rodgers (1985)

Field sampling by T.K. Gagnon, R. Steinen, G.C. Koteas and A. Ryan (2010-2012).

Sample preparation and lab analyses by G.C. Koteas, R. Weiss, S. Adams, C. League, M. Vollinger, M. Mnich and B. Leighton at the University of Massachusetts (2010-2012).

Digital cartography and editing by T.K. Gagnon, M.A. Thomas, J.M. Rhodes, S.B. Mabee, L.C. Belliveau (2013).



Scale 1 : 250,000

one inch equals approximately 4 miles

Bedrock Lithology

- Granite
- Granitic Gneiss
- Mafic Igneous rocks
- Metamorphic rocks (undivided)
- Sedimentary rocks

Inferred Heat Flow (mW/m^2)	Number of Samples
> 60	23
50 - 60	26
40 - 50	104
< 40	89
Sample Total	242

Connecticut Geothermal Energy Project: Inferred Heat Flow

By: T.K. Gagnon[1], G.C. Koteas[2], R.P. Steinen[1], A. Ryan[3], and M.A. Thomas[1]

Author Affiliations: [1] Connecticut Geological Survey, Connecticut Department of Energy and Environmental Protection, 79 Elm Street, Hartford, CT 06106, Email: deep.ctgeosurvey@ct.gov, [2]Norwich University, 158 Harmon Drive, Norwich, VT 05663, [3]University of British Columbia, 6339 Stores Road, Vancouver, BC U6P-1Z4 Canada

Comments to Map Users

Locations of features shown on this map are not surveyed, but are determined by GPS and verified using orthorectified images; therefore, the accuracy of feature locations depends on the scale of the mapping and the interpretation of the mapper(s). Any enlargement of this map could cause misunderstanding in the detail of mapping and may result in erroneous interpretations. Site specific conditions should be verified by field checking.

This project was supported by the U.S. Department of Energy through a subcontract award granted by the Arizona Geological Survey to the Massachusetts Geological Survey under award number MA-EE0002850. The Connecticut Geological Survey was a cooperative partner in the project for investigations in Connecticut.The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing official policies, either expressed or implied, of the U.S.Government, Commonwealth of Massachusetts, State of Connecticut, the University of Massachusetts, the Connecticut Department of Energy and Environmental Protection, Massachusetts Geological Survey, or the Connecticut Geological Survey.

This map is part of a Connecticut Geothermal Energy Project Map Series. All data and mapping products of the Connecticut Geothermal Energy Project are available through www.stategeothermaldata.org, a 50 State collaborative portal, built on U.S. Geosciences Information Network (USGIN) protocols and standards, and hosted by the Arizona Geological Survey.

Citation: Gagnon, T.K., Koteas, G.C., Steinen, R.P., Ryan, A., Thomas, M.A., 2013. Connecticut Geothermal Energy Project: Inferred Heat Flow. Connecticut Geological and Natural History Survey, Miscellaneous Map MM-2013-03. Scale 1:250,000. 1 sheet. Adobe PDF.

This map and other Connecticut Geological and Natural History Survey Publications are available at www.ct.gov/deep/geology

Acknowledgements

Special thanks are extended to J. Michael Rhodes and Stephen B. Mabee of the University of Massachusetts, and the Massachusetts Geological Survey for the conceptual design of the geothermal data collection and mapping project. The Association of American State Geologists and the Arizona Geological Survey were instrumental in bringing this U.S. Department of Energy program to the State Surveys.

Connecticut Geological Survey
Department of Energy & Environmental Protection

79 Elm Street, Hartford, CT 06106
deep.ctgeosurvey@ct.gov
www.ct.gov/deep/geology