



Massachusetts Geological Survey
University of Massachusetts Amherst

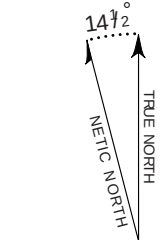
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Shaded relief (5-m resolution) is a mosaic of digital terrain models (DTMs) derived from digital orthoimages available from the Massachusetts Office of Geographic Information (MassGIS; www.mass.gov/mgis); geology modified from Zen et al. (1983).

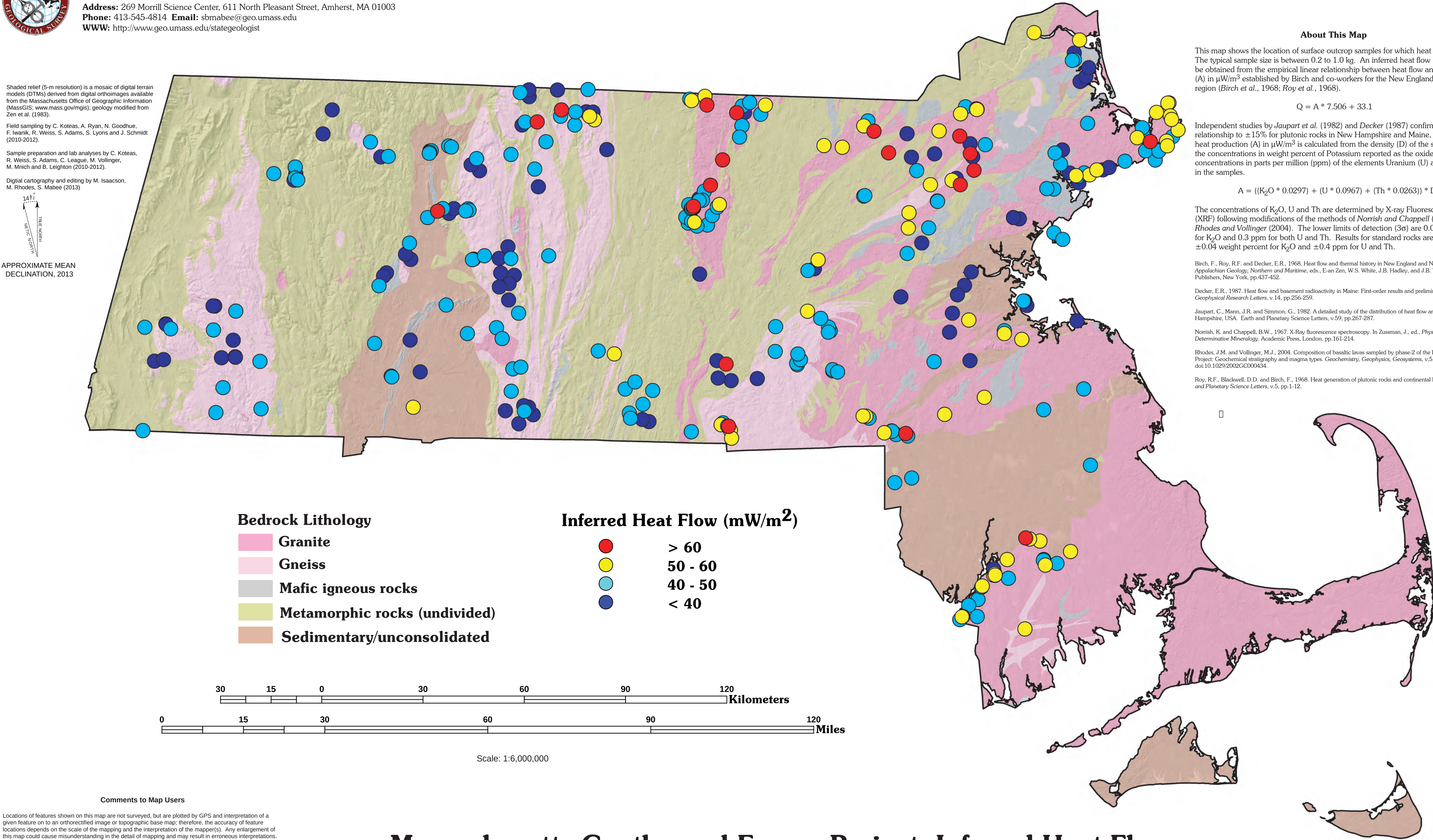
Field sampling by C. Koteas, A. Ryan, N. Goodhue, F. Iwanik, R. Weiss, S. Adams, S. Lyons and J. Schmidt (2010-2012).

Sample preparation and lab analyses by C. Koteas, R. Weiss, S. Adams, C. League, M. Vollinger, M. Minich and B. Leighton (2010-2012).

Digital cartography and editing by M. Isaacson, M. Rhodes, S. Mabee (2013)



APPROXIMATE MEAN DECLINATION, 2013



Comments to Map Users

Locations of features shown on this map are not surveyed, but are plotted by GPS and interpretation of a given feature on to an orthorectified image or topographic base map; 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 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, the University of Massachusetts or Massachusetts Geological Survey.

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This map was produced on request directly from digital files (PDF format) on an electronic plotter.

A digital copy of this map (PDF format) is available at http://www.geo.umass.edu/stategeologist.

MGS Miscellaneous Map M-13-03
Massachusetts Geothermal Energy Project:
Inferred Heat Flow Map
2013

About This Map

This map shows the location of surface outcrop samples for which heat flow is inferred. The typical sample size is between 0.2 to 1.0 kg. An inferred heat flow (Q) in mW/m² can be obtained from the empirical linear relationship between heat flow and heat production (A) in μW/m³ established by Birch and co-workers for the New England Appalachian region (Birch et al., 1968; Roy et al., 1968).

$$Q = A * 7.506 + 33.1$$

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 μW/m³ is calculated from the density (D) of the samples and from the concentrations in weight percent of Potassium reported as the oxide K₂O, and the concentrations in parts per million (ppm) of the elements Uranium (U) and Thorium (Th) in the samples.

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

The concentrations of K₂O, U and Th are determined by X-ray Fluorescence Spectroscopy (XRF) following modifications of the methods of Norrish and Chappell (1967) outlined in Rhodes and Vollinger (2004). The lower limits of detection (3σ) are 0.001 weight percent for K₂O and 0.3 ppm for both U and Th. Results for standard rocks are typically within ±0.04 weight percent for K₂O and ±0.4 ppm for U and Th.

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.

Jaupart, C., Mann, J.R. and Simmon, G., 1982. A detailed study of the distribution of heat flow and radioactivity in New Hampshire, USA. *Earth and Planetary Science Letters*, v.59, pp.267-287.

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.

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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.

Massachusetts Geothermal Energy Project: Inferred Heat Flow

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