Heat Source

Recent U.S. Geological Survey Compilations of Regional Temperature and Heat-Flow Data from the U.S. Great Basin

Editor's Note: The following article is adapted from online versions of U.S. Geological Survey (USGS) Open-File Report 99-425 and the more recent (USGS) Open-File Report 05-1207. The reports were prepared by John H. Sass, Susan Priest, and colleagues. The reports incorporate a large database with numerous tables, figures and interactive maps that cannot be offered by this article. To view the large volume of data offered by the reports, visit the USGS websites at: http://pubs.usgs.gov/of/1999/of99-425/webmaps/home.html and http://pubs.usgs.gov/of/2005/1207/.

Geothermal Industry Temperature Profiles from the Great Basin – Open-File Report 99-425

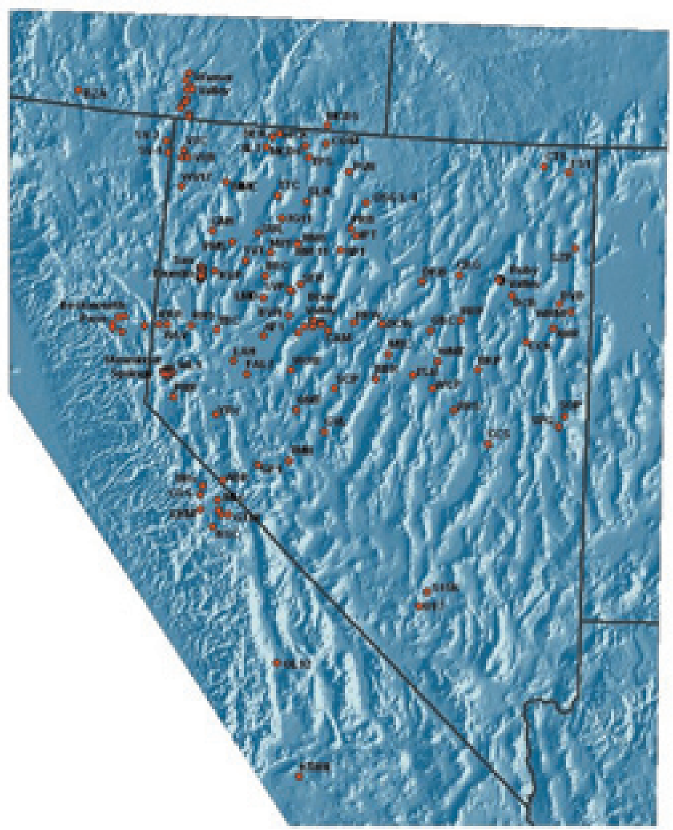
The Great Basin region of the western United States was the focus of concerted exploration and leasing activity by the geothermal power industry beginning in the 1970s. Chevron Geothermal and Phillips Petroleum Co. together evaluated more than 75 geothermal prospects with a potential for accessible temperatures of 150° C or greater. More than 25 additional sites were assessed by other companies, bringing the total number of potential high-temperature sites evaluated by industry to more than 100.

Most of the subsurface temperature data from the Chevron/Phillips projects were purchased by CalEnergy, Inc. During the summer of 1998, the CalEnergy holdings were inventoried by U.S. Geological Survey (USGS) personnel, and subsurface temperature data from several hundred of those boreholes were purchased by the U.S. Department of Energy for curation by Idaho National Engineering and Environmental Laboratory (now the Idaho National Laboratory – INL). As part of that transaction, the USGS agreed to digitize the data and make them available online.

In this report, the authors combine the data set acquired from CalEnergy, with miscellaneous data from Geothermal Resources International, Aminoil USA, AMAX and other companies that were acquired in 1995 by the USGS from INL.

All data were obtained using calibrated thermistor probes having an accuracy of about 0.1° C. The data as received were in a variety of formats and units, with most locations listed as Section, Township, and Range. They were primarily copies of field data sheets, but some were in interpretive reports, and others were analogue temperature-depth plots at various scales. Gradient values shown in the database were obtained directly from the field data sheets or plots. These were usually based on a visual straight-line fit of the data from the lowermost section of the hole. After a few random checks of these estimates, the authors adopted these values for presentation.

Figure 1 – The Great Basin. USGS website users can click on the image for a full view, showing well locations, and "clickable" access to well data.



Summary of Supporting Data for USGS Regional Heat-flow Studies of the Great Basin, 1970-1990 - Open-File Report 05-1207

The Great Basin of the western United States provides a large and accessible laboratory for the study of crustal extension and related tectonic processes. Although temperature-gradient measurements, such as those summarized in OFR 99-425 are useful indicators of significant geothermal anomalies, the thermal effects of crustal extension are best quantified through the measurement of surface heat flow. Early studies (Roy et al., 1968a; Sass et al., 1971b) revealed a complex thermal regime.

The Great Basin is characterized by high heat flow in relation to the continental craton, but it contains large sub-provinces of relatively low (< 60 mWm^{-2}) and elevated (> 100 mWm^{-2}) heat flow. With a small number of measurements, Roy et al. (1968b) defined a heat flow-heat production province based on an apparently linear relation between near-surface heat flow and radiogenic heat production of plutonic, intrusive rocks. Subsequent studies (Lachenbruch and Sass, 1977, 1978; Lachenbruch et al., 1985; Lachenbruch et al., 1994; Sass et al., 1994) revealed that the early apparent relation was fortuitous, and that many factors (in addition to radioactivity) are responsible for variations in near-surface heat flow.

The heat flow-heat production relation in the Great Basin is perturbed by a combination of tectonic and hydrologic processes that overwhelm the conductive thermal regime in the upper crust. These include tectonic extension often accompanied by magmatic underplating and/or crustal intrusion, and hydrothermal convection associated with young magmatic activity and deep circulation along Basin and Range faults (Lachenbruch and Sass, 1977, 1978).

Sass, et al. (1971b) published all of the heat flow values accumulated by the USGS for the western United States from the late 1950s through the 1960s. Details of temperature- and thermal-conductivity profiles for individual sites were included in Sass and Munroe (1974). Additional data were obtained by the USGS in the Great Basin during the 1970s and 1980s to support both tectonic studies and assessment of the geothermal potential of the region.

For the most part, these data were not published individually, but were included in site-specific geothermal reports or incorporated into generalized heat-flow contour maps of the southwestern United States (provided as a figure in the online version of the report). In a detailed study of the heat flow of the southern Basin and Range province, Lachenbruch et al. (1994) and Sass et al. (1994) compared average heat flows between the southern Basin and Range and the Great Basin to illustrate the differences between the two terrains. The averages for the Great Basin include almost all of the values presented here.

In this report, previously unpublished heat-flow measurements from about 100 sites are presented, along with values determined from a subset of the "temperature-gradient" data summarized in USGS Open File Report 99-425. The online version of the report includes a map with site locations, as well as summarized supporting data for each site in tabular form.

Sass and Walters (1999) presented generalized values of thermal conductivity for the unconsolidated sediments of playas and alluvial valleys, derived from several hundred conductivity values obtained by the USGS in the course of geothermal investigations in the western United States. These were high-quality determinations, made soon after retrieval (often in the field) of sediment cores or in situ employing a downhole heat-flow probe developed by Sass et al., (1979a, 1981). Some of these results have been published, but others (Warner Valley and Mono Lake) have not. In the online report, the authors present a series of histograms of these measurements illustrating the generality of the conductivity values adopted by Sass and Walters. These conductivities can be used with confidence to convert temperature gradients in unconsolidated sedimentary materials to heat flow.

The online version of this report offers numerous tables, figures, and histograms of locations and heat flow for the following areas of the Great Basin:

- Bodie Hills-Mono Lake, California
- NURE, Carson Sink (LAH), Nevada
- Warner Valley, Oregon
- Ruby Valley, Nevada
- Steamboat Springs, Nevada
- Surprise Valley, California
- Dixie Valley, Nevada
- San Emidio Basin, Nevada
- Yerington, Nevada
- Beckwourth Pass, California

Access to Database and Additional Thermal Data

Readers who access the Open File Report online can download the entire Microsoft Excel 2002 database file, as well as links to other online thermal data, including:

- USGS Borehole Temperature logs from Arctic Alaska, pre-1989
- Southern Methodist University Geothermal Lab
- USGS Publications Warehouse
- Great Basin Center for Geothermal Energy
- USGS Heat Flow Database for California

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