COLORADO GEOLOGICAL SURVEY

Map Series MS-45
Colorado Heat Flow Database Description

DATABASE DESCRIPTION

The Colorado Geological Survey's (CGS) Map Series 45, Colorado Heat Flow Database is a compilation of heat flow data from Southern Methodist University, University of North Dakota, and University of Michigan with additional heat flow data collected and calculated from temperature-depth logs. The SMU, University of North Dakota, University of Michigan datasets include the geothermal gradient, thermal conductivities, heat flow value, and other parameters for each drill hole; however, they do not include the original down hole temperature-depth numbers. CGS calculated heat flow values for 40 additional records from temperature-depth logs and other published data. These data points include points with CGS IDs 1 (MAPCO well), 2-4 (Baca wells), 5-10 (from CGS Spec. Pub. 10), and 25-54 (AMAX data). Basic information for AMAX points was provided by SMU; however, the AMAX heat flow values presented in this database were calculated by the CGS from temperature-depth logs.

Heat flow values are a measure of the heat flux moving from the Earth's interior to the Earth's surface. High heat flow values can indicate various geologic situations such as 1) an area of relatively thinner crustal rock above the mantle. 2) presence of an igneous pluton at depth, 3) resident heat from geologically recent volcanism or plutonic activity, or 4) upwelling of deep, heated groundwater.

Heat flow values are calculated for each well by multiplying the composite rock thermal conductivity by the geothermal gradient for a given area. This is represented by the equation $Q = k \cdot A \cdot dT/dz$, where Q=heat flow, k=rock thermal conductivity, A= area, dT=change in temperature, and dz=change in vertical depth. Geothermal heat flow is commonly displayed in units of milliWatts (mW)/square meter (m2). Most thermal conductivities are measured from rock samples representative of the down-hole lithologies. These samples come from in-hole cores or from outcrops of the lithologies encountered during drilling. Geothermal gradient is a measure of change in temperature with depth. Geothermal gradients can be determined several ways and compared for consistency, but the most accurate gradients are obtained from the slope of the temperature-depth log. Deviations of temperature from a relatively uniform increase with depth usually indicate areas of thermal conductivity changes or groundwater movement. Gradients calculated for intervals between temperature-depth measurements can be selectively averaged to generate a representative gradient for the hole.

FIELD DESCRIPTIONS

GENERAL DATAPOINT/HOLE INFORMATION

The following fields include the basic data point information. Specific depth interval test data is included in the "DEPTH INTERVAL TESTING" section below.

CGS ID - Identification number assigned to records in CGS database

HOLE/SITE NAME - The most common name for data point used in reports. Some holes have more than one name and the other name(s) are given in the comments section.

SOURCE - Source of the original data included in CGS database; SMU=Southern Methodist University,

UND=University of North Dakota, Mich=University of Michigan.

NAME ORIGIN DATASET - Name of dataset from which data originated.

AVG HF (mW/m2) - Average heat flow value calculated from depth interval measurements; heat flow value used for contouring. Values are in milli-Watts/square meter.

AVG DEPTH (m) - Average depth of intervals used in calculating average heat flow value. Depth values are in meters below the ground surface or collar elevation.

LATITUDE – Latitude given in decimal degrees.

LONGITUDE – Longitude given in decimal degrees.

UTM E (NAD83) – Easting coordinate (in meters) given in Universal Transverse Mercator Zone 13, North American Datum 1983 projection.

UTM N (NAD83) – Northing coordinate (in meters) given in Universal Transverse Mercator Zone 13, North American Datum 1983 projection.

TWN/RNG-SEC - Township/Range-Section - This is the breakdown of the hole location by the township, range, and section numbers and their respective compass direction. The section is sub- divided from 1/4 section down to as small as 1/32 of a section. The subsection divisions are indicated by a combinations of the letters A,B,C,D. This is done using the following codes.

A = NE quarter
B = NW quarter
C = SW quarter
D = SE quarter

The location should only be divided down to its most detailed known actual position based on the quad used or surveyed location. If the hole is in the center (or nearly) of the section then no sub-section division is given. This is also true of any hole that is known to be in the section but otherwise has no exact location. Ex: 2N/15E - 2AAC indicates that the site is located in the SW quarter of the NE quarter of the NE quarter of Section 2 in Township 2 north, Range 15 east.

AREA/AMS SHEET - General location based on either the closest geothermal area or the

AMS sheet (1x2 deg, 1:250,000-scale) topographic maps.

TECT PROV - The tectonic province or physiographic region where the hole is located.

STATE - The State where the hole is located.

CGS REF NUMBER – Source of original data coded by number in the CGS list of references.

MEAS DATE (m/d/y) – Date of temperature log measurements from which the thermal results were derived given in the form MM/DD/YY. Ex: 5/6/85 indicates that the temperature log measurements were made on May 6th, 1985.

DRILL DATE (m/d/y) - Date drilling of hole was completed given in the form MM/DD/YY.

COL ELEV (m) - Elevation of the surface location of the hole (or the elevation of the drill collar) given in meters above sea level.

DRILL DEPTH (m) - Total drilled depth of hole in meters below surface (or drill collar).

WAT TABLE (m) - Measured or inferred water table depth in the hole given in meters below surface (or drill collar).

SURF TEMP (C) - Calculated surface temperature of the hole in degrees Celcius.

MAX TEMP (C) - Measured maximum hole temperature in degrees Celcius.

MIN TEMP (C) - Measured minimum hole temperature in degrees Celcius.

BOT TEMP (C) – Measured temperature at bottom of the hole in degrees Celcius.

LITH INFO - This is a generalized listing of the formations starting at the surface and working down hole.

COMMENTS - This is additional information about the data point.

NUM SITES - The number of nearby drill hole locations from which this data was created. This is not the same as the number of test intervals within an individual drill hole.

DEPTH INTERVAL TESTS

The following fields each have prefixes (T1…T6) indicating the respective test number/depth interval. For example, T1 Depth Start (m) refers to the starting depth of the first depth interval tested. Not all holes have all the types of information given below. When there are multiple depth intervals for one hole, it is often just the gradient that has more than one depth range.

DEPTH START (m) - Starting depth of the gradient test interval indicated. Values are in meters below the ground surface or drill collar. When there are multiple depth intervals, usually the deepest interval is given first, with additional intervals provided in order of increasing depth. This is done because the deepest interval is given as an average of the entire well.

DEPTH END (m) - Ending depth of the gradient test interval indicated. Values are in meters below the ground surface or drill collar. When there are multiple depth intervals, usually the deepest interval is given first, with additional intervals provided in order of increasing depth. This is done because the deepest interval is given as an average of the entire well.

AVG TCU (W/m/K) - Laboratory or estimated in situ average thermal conductivity value for the depth interval indicated. Values are in Watts/meter Kelvin.

AVG TCU Sym - Symbols "<", ">", or "*" refer to greater than, less than, or estimate of the average thermal conductivity value, respectively, for the depth interval indicated.

AVG TCU SE - Standard error, if a statistical method is used in determining the average thermal conductivity for the depth interval indicated.

BULK TCU (W/m/K) - Three-directional average thermal conductivity for the depth interval indicated. Values are in Watts/meter Kelvin.

TCU - This is the number of measured conductivity values used to determine the thermal conductivity value for the depth interval indicated.

UNCORR GRAD (C/km) - Calculated or estimated uncorrected thermal gradient value for the depth interval indicated. Uncorrected refers to non-terrain corrected thermal gradient. Values are in degrees C/km.

UNCORR GRAD Sym - Symbols "<", ">", or "*" refer to greater than, less than, or estimate of the uncorrected thermal gradient value, respectively, for the depth interval indicated.

UNCORR GRAD SE - Standard error, if a statistical method is used in determining the uncorrected thermal gradient for the depth interval indicated.

CORR GRAD (C/km) - Calculated or estimated corrected thermal gradient value for the depth interval indicated. Corrected refers to terrain-corrected thermal gradient. Values are in degrees C/km.

CORR GRAD Sym - Symbols "<", ">", or "*" refer to greater than, less than, or estimate of the corrected thermal gradient value, respectively, for the depth interval indicated.

CORR GRAD SE - Standard error, if a statistical method is used in determining the corrected thermal gradient for the depth interval indicated.

UNCORR HF (mW/m2) - Calculated or estimated uncorrected heat flow value for the depth interval indicated. Uncorrected refers to non-terrain corrected heat flow. Values are in milli-Watts/square meter (mW/m2).

UNCORR HF Sym - Symbols "<", ">", or "*" refer to greater than, less than, or estimate of the uncorrected heat flow value, respectively, for the depth interval indicated.

UNCORR HF SE - Standard error, if a statistical method is used in determining the uncorrected heat flow value for the depth interval indicated.

CORR HF (mW/m2) - Calculated or estimated corrected heat flow value for the depth interval indicated. Corrected refers to terrain-corrected heat flow. Values are in milli-Watts/square meter (mW/m2).

CORR HF Sym - Symbols "<", ">", or "*" refer to greater than, less than, or estimate of the corrected heat flow value, respectively, for the depth interval indicated.

CORR HF SE - Standard error, if a statistical method is used in determining the corrected heat flow value for the depth interval indicated.

HEAT FLOW (mW/m2) - Representative heat flow value (from uncorrected or corrected heat flow field) for the depth interval indicated. Values are in milli-Watts/square meter.

QUAL HF - Quality (or confidence) of the heat flow value for the depth interval indicated using the following code system.

A = high quality data - deeper than 100 meters, minimum 50-meter linear measurement
B = medium quality data - deeper than 50 meters, some problems
C = poor quality data - shallow, isothermal
G = geothermal system
D = check again
X = no hope

HEAT GEN (muW/m3) - Heat generated by radioactive decay, metamorphic reactions, and fault friction for the depth interval indicated. Values are in micro-Watts/cubic meter.

HEAT GEN Sym - Symbols "<", ">", or "*" refer to greater than, less than, or estimate of the heat generated value, respectively, for the depth interval indicated.

HEAT GEN SE - Standard error, if a statistical method is used in determining the heat generated value for the depth interval indicated.

HEAT GEN - The number of measurements used in determining the heat generated value for the depth interval indicated.

AQ TEMP (C) - Measured, calculated, or inferred aquifer temperature from temperature logging for the depth interval indicated. When provided, assumes that the given depth interval is part of the aquifer.

AQ TEMP Sym - Symbols "<", ">", or "*" refer to greater than, less than, or estimate of the aquifer temperature value, respectively, for the depth interval indicated.

AQ TEMP SD - Standard deviation, if a statistical method is used in determining the aquifer temperature value for the depth interval indicated.

POR (%) - Calculated or inferred conductivity porosity of sample for the depth interval indicated. This value is used to calculate in situ thermal conductivity values from measured cuttings. Values are in percentage of 100.

HEAT FLOW AVERAGES CALCULATIONS

The following fields include cell formulas for calculated heat flow averages presented in data point information section above.

AVG HF CALC (mW/m2) - Average heat flow value (with cell calculation formula) calculated from depth interval measurements. This field has the same resulting value as the field "AVG HF" but includes the formula used in making the calculation. Values are in milli- Watts/square meter.

AVG DEPTH CALC (mW/m2) - Average depth (with cell calculation formula) of intervals used in calculating average heat flow. This field has the same resulting value as the field "AVG DEPTH" but includes the formula used in making the calculation. Values are in meters.

SMU DATABASE ID

DATA NUM - Unique SMU data point identifier for use in cross-referencing with SMU databases.

For further information or assistance visit or call the Colorado Geological Survey at:

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