COLORADO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES
DENVER, COLORADO

MAP SERIES 45
INTERPRETIVE GEOTHERMAL HEAT FLOW MAP OF COLORADO
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PLATE 1

Interpretive Geothermal Heat Flow Map of Colorado

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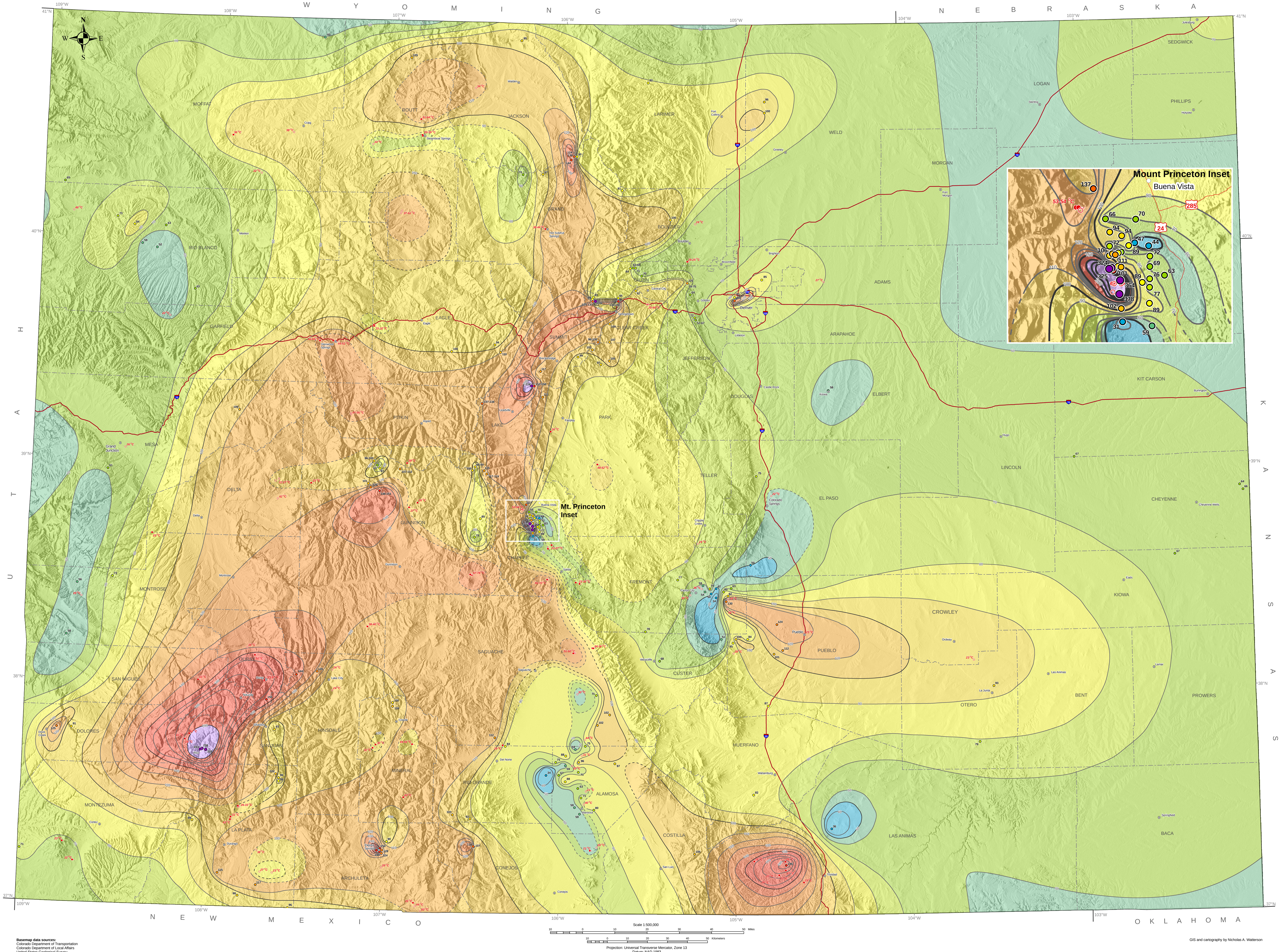

Explanation

Heat flow contour lines

(mW/m^2)

- Major contour (50 mW/m^2 interval)
- Minor contour (10 mW/m^2 interval)
- Major contour, inferred from thermal spring or well data
- Minor contour, inferred from thermal spring or well data

Heat flow value zones / Heat flow datapoints

Classified/labeled by heat flow value

(mW/m^2)
>200
150-200
140-150
130-140
120-130
110-120
100-110
90-100
80-90
70-80
60-70
50-60
<=50

Thermal reference points

Type, labeled with water temperature

- Thermal spring
- Thermal well

Explanation and Methods

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•A•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) per 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.

Thermal spring and well water temperature data were used to supplement available heat flow data. A relationship between spring/well temperature and expected heat flow value was derived by plotting spring temperature against nearby drill hole heat flow data for the Hortense, Pagosa, and Shaws hot springs. The resulting least-squares best-fit linear equation, Q=4.079*T-43.452, allows a rough estimate of heat flow using thermal spring/well temperatures in Colorado's mountainous areas where down-hole heat flow values are not available. Contour lines are dashed where values derived from thermal springs and wells influence the contour placement.

It is important to note that the heat flow data are not evenly distributed throughout the state. Small areas with clustered data surrounded by wide areas containing sparse data are characteristic of the heat flow map. As such, the user should keep in mind that the contours are well constrained in areas of clustered data and more interpretive in areas of sparse data.

The heat flow data used in generating this map come primarily from Southern Methodist University, University of North Dakota, and University of Michigan. These 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. In generating this map, an additional 40 heat flow values were calculated from temperature-depth logs and other published gradient data. The digital Colorado Heat Flow Database contains complete information on heat flow data points used in creating this map. Thermal spring and well temperature data are from *Cappa, J.A., and Hemborg, H. T., 1995, 1992-1993 Low-Temperature Geothermal Assessment Program, Colorado: Colorado Geological Survey Open File Report 95-1, 19 p.*

Bill Ritter Jr., Governor
State of Colorado

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Basemap data sources:
Colorado Department of Transportation
Colorado Department of Local Affairs
United States Geological Survey

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