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Geothermal Heat Flow Map of Sumatra, Indonesia

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ABSTRACT

Heat flow maps are valuable across a broad spectrum of the geosciences. Governments and researchers alike use heat flow maps for understanding tectonic processes, which in turn can lead to better understanding of processes such as earthquakes, volcanism, geothermal energy, petroleum and mineral exploration.

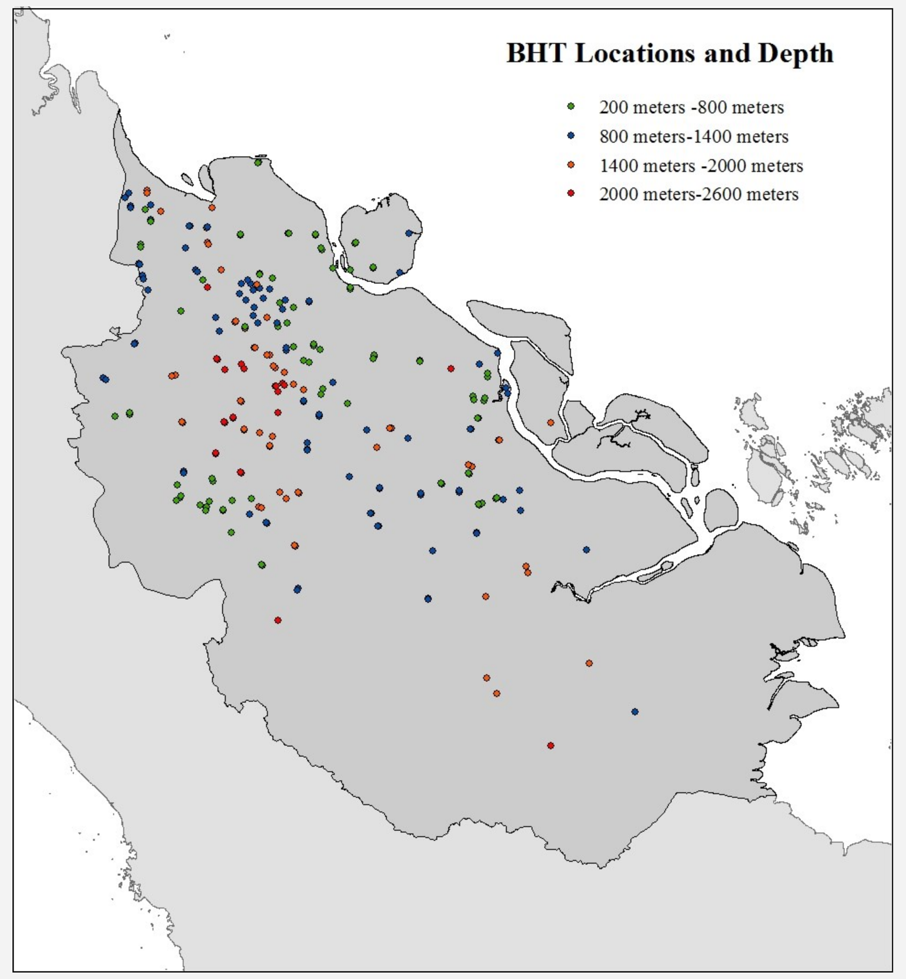
We are compiling a geothermal map of the Sumatra Basins of Indonesia. In 2014, Indonesia ranked 24th globally in oil production, with most of the oil produced in Sumatra. Sumatra is the largest island in Indonesia, with three main oil producing basins: North, Central and South. The region has been subjected to intense tectonic activity, specifically subduction of the Indian-Australian Plate under the Sunda Plate and rifting. The subduction zone, located southwest of Sumatra is responsible for earthquakes and volcanism, extends from the Himalayan front through Myanmar and into the Sumatran islands. The region is further complicated by interactions between strike-slip faults and fore-arc basin evolution. There are two major forearc basins in the area; Simeulue and Aceh, and two major fault zones; the Mentawai and Sumatran. The area also contains a large number of structural-rift basins, ideal for oil accumulation; however, it is complicated by volcanism and geothermal activity.

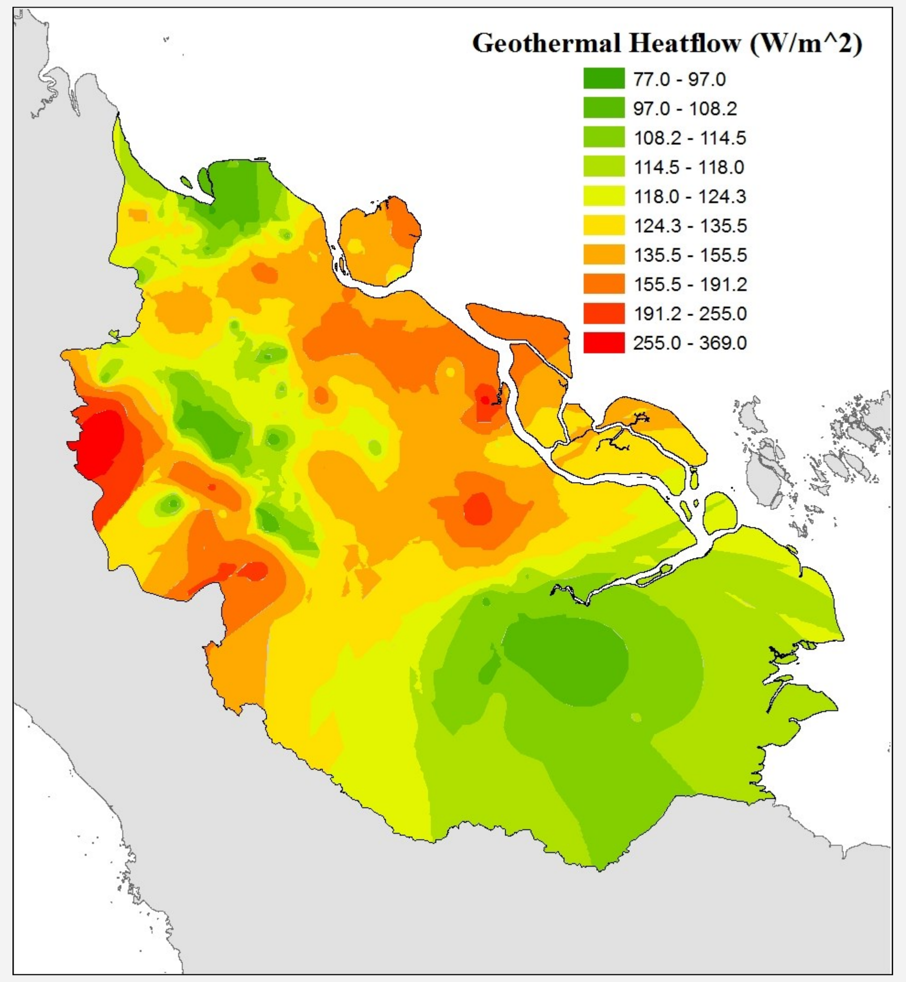
A geothermal map is a heat flow map illustrating the natural heat loss from the interior of Earth to the surface. Our methods are based on previously published work in North America (Dr. D. Blackwell from SMU Geothermal Laboratory), which uses both the temperature gradient at a specific location and the thermal properties of the rocks at the same location to calculate heat flow values. This information can be calculated from well log data available at Ball State University. This data is part of the geophysical database of the South East Asia- Pacific region, donated by L. Bogue Hunt; commonly known as the "LBH Database". It contains physical, lithological, and paleontological logs, seismic sections, structural maps and detailed geological reports of many exploration sites.

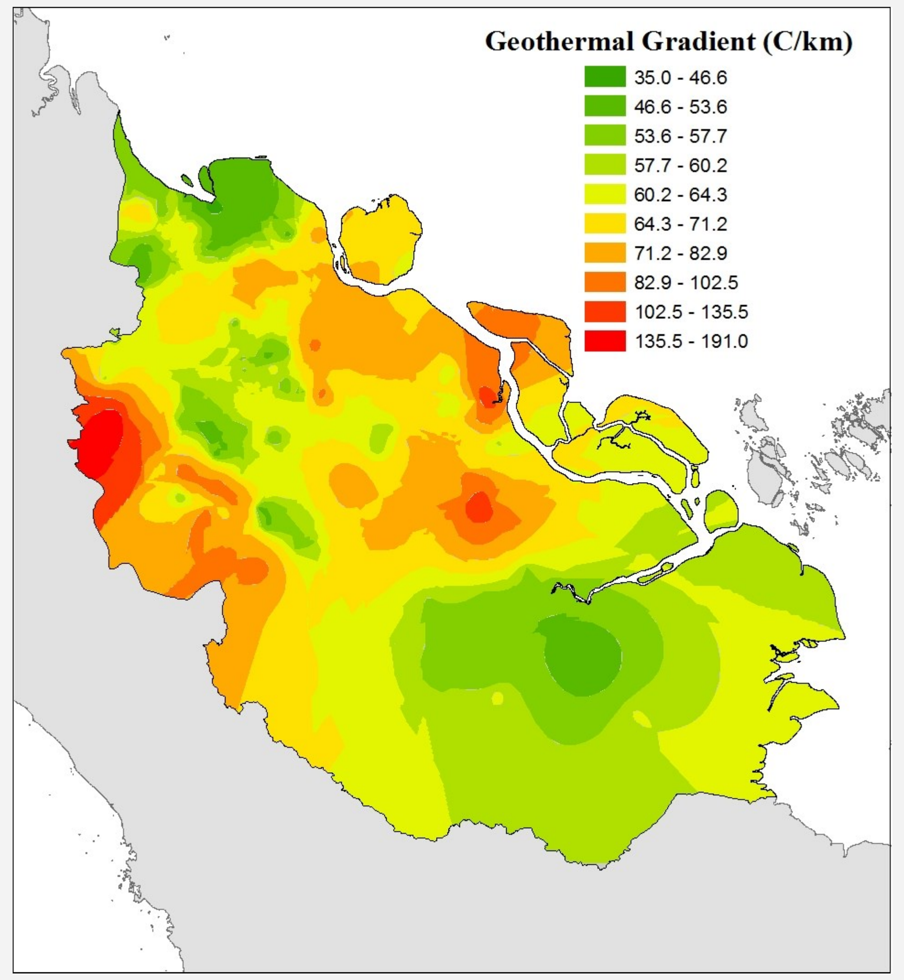
Specific data collected and compiled into an excel document for this study will include: well name/number, well location with datum (e.g. longitude/latitude WGS84; easting/northing UTM zone 32 south), basin name, operator, total vertical depth (meters), bottom hole temperature (°C), mudline or ground surface mean temperature, method of correction (if data have been corrected), geothermal gradient (if computed), heat flow measurement method (probe, interpolation, model, etc.) and thermal conductivity per unit (if available).

Our initial study, focus on the island of Sumatra, covers an area roughly $600km^2$. Bottom hole temperatures (BHT) will only be used from wells deeper than 100m. Preliminary analyses suggest the map will be based on more than 1000 BHT points. When available, geothermal spring data will be incorporated into the map. Contouring and gridding will be completed using Golden Software ® program Surfer. Given the regions intense tectonic activity, contours will be inferred at times along tectonic, physiographic and thermal margins due to absence of data and/or data altered due to these forces. As such, a geothermal (heat flow) map of the region is important not only for petroleum exploration, but also for mineral exploration and alternative (geothermal) energy development.

Central Sumatra Basin





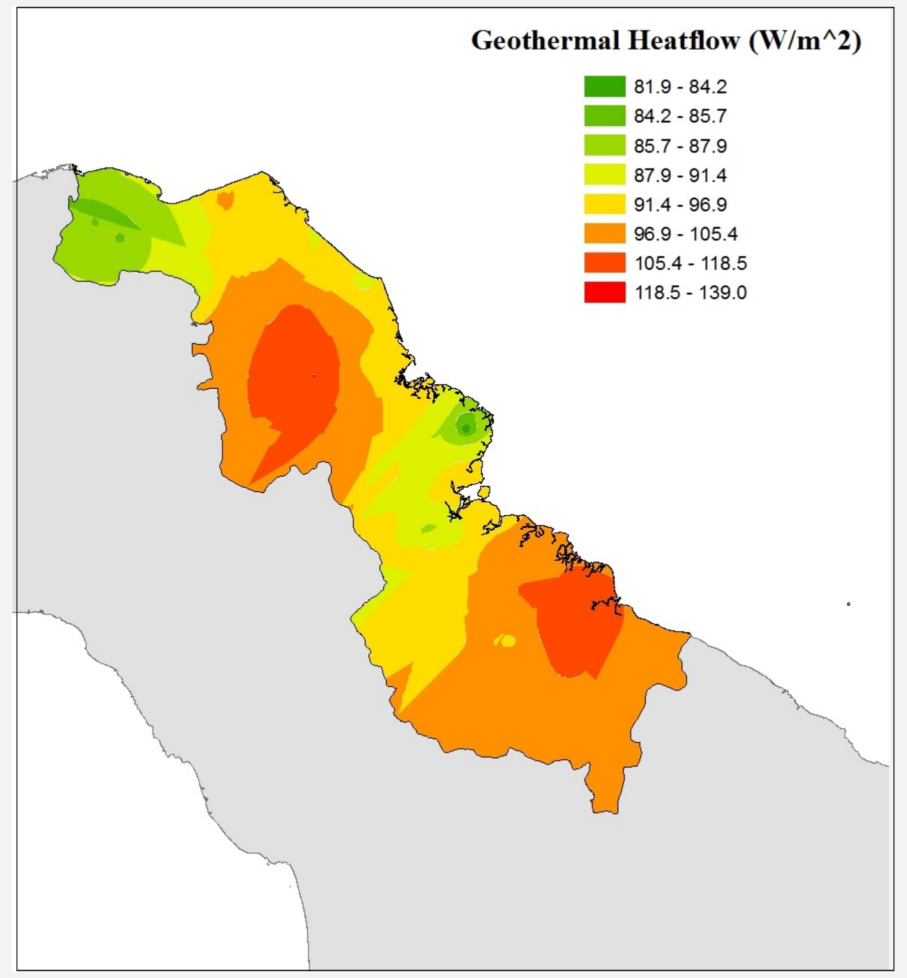


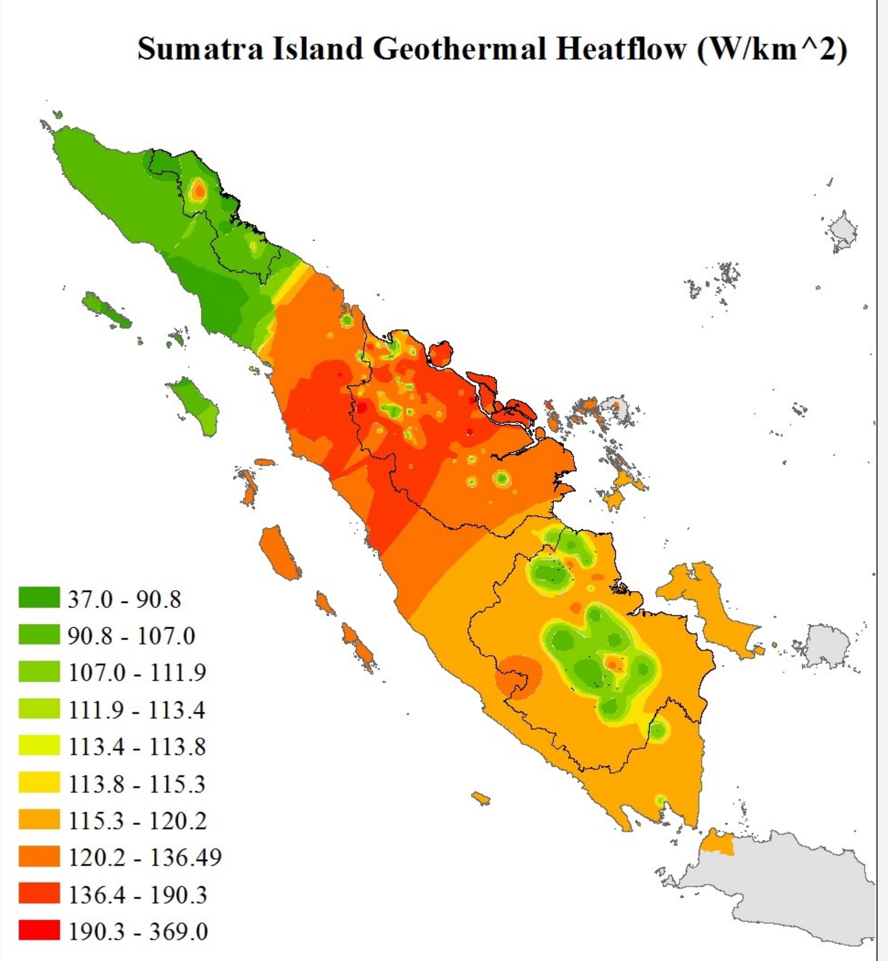
The Central Sumatra Basin contained 244 usable well logs. Maximum drilling depths range from 224 m – 2597 m, typically ending once basement rock is reached. The geothermal gradient values range from 35°C/km to 191°C/km. The highest geothermal gradients are found in the east central and west central region of the basin. There is a low geothermal gradient location extending from the southern region, progressing around two areas of higher geothermal gradients through the middle to the northern most extend of the basin. Areas with the higher geothermal gradients also were areas with the shallower well depths (200-1400m), and areas with lower geothermal gradients had deeper well depths.

The calculated heat flow for the Central Basin ranges from 77 W/km^2 to 369 W/km^2. The spatial distribution is similar to the geothermal gradient distribution, with higher heat flow occurring in the east central and west central region of the basin with the lowest heat flow values extending from the south, northward in between the two higher concentrated areas to the east and west until the northernmost edge of the basin.

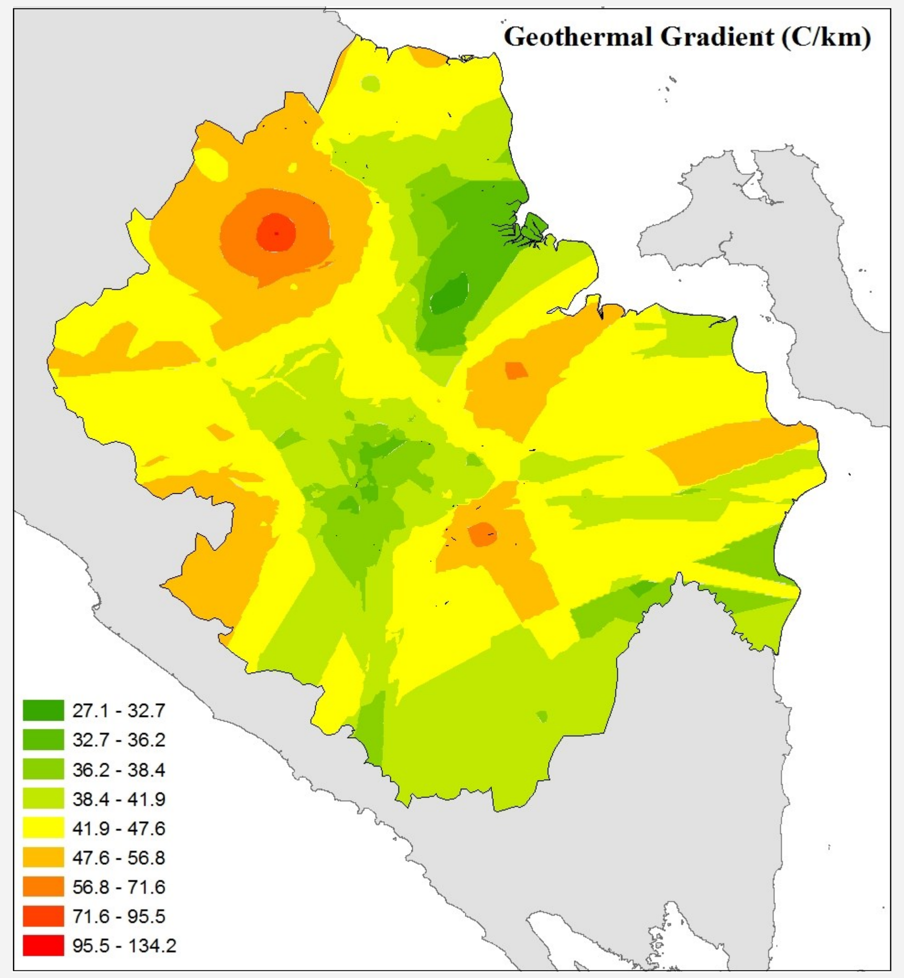
Regional Map of Indonesia

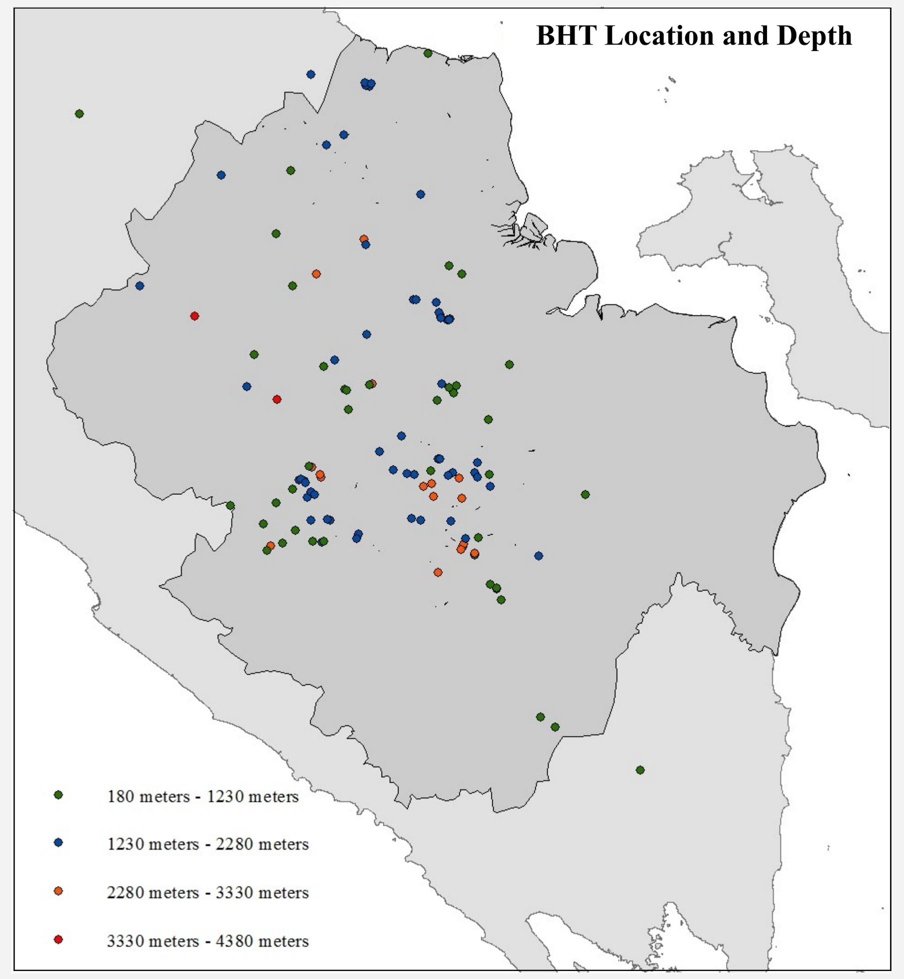
Sumatra Island, Indonesia

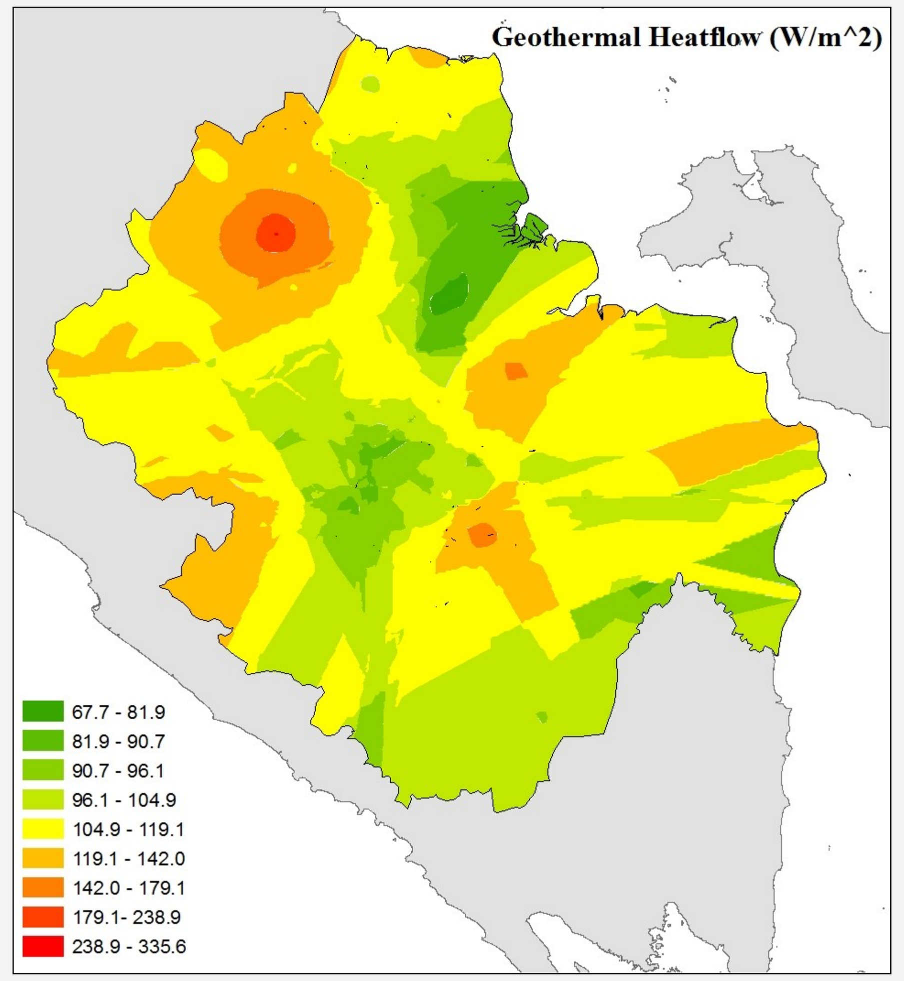




Southern Sumatra Basin







Heat flow values, measured in W/m^2, for the South Sumatra Basin were greater along the margins of the basin than within the interior. Heat flow values along the coast of South Sumatra ranged on average from 104.9 to 142.0 W/m^2, while heat flow averages from the interior of the basin ranged from 67.7 to 96.1 W/m^2. The highest recorded values were calculated from wells in the northwest region of the basin.

The geothermal gradient of the South Sumatra Basin, measured in Celsius degrees/kilometer, was greater along the margins of the basin, and lower within the interior. Along the coast of the South Sumatran Basin, the geothermal gradient ranged on average from 96.17 to 119.15 °C/km. The geothermal gradient for the interior of the basin ranged from 67.76 to 96.17 °C/km.

The wells in the South Sumatra Basin that are included in this study varied widely in depth from 0.18 km to 4.29 km. There were no clear correlation between the depth of the wells and their location within the basin. Additionally, there is a grouping of shallow wells in the interior of the basin, which are coincident with the area with the lowest calculated heat flow and geothermal gradient.