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3D thermal structure of the Hengill geothermal area (Iceland) revealed from electromagnetic sounding data and temperature well logs

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The indirect electromagnetic geothermometer based on using of magnetotelluric and transient electromagnetic data and calibrated by the available temperature logs is applied to determine three-dimensional temperature model of the Hengill geothermal area up to 20 km depth. The analysis of the temperature model shows that the background temperature consists of two layers. The upper layer extending from the surface to 5 km has lower temperature (below 200°) while the deeper one, which spans in depth from 5 km to at least 20 km is characterized by temperature ranging from 200 to 400°. The two-layered background temperature distribution is overlapped by a circulation system of high-temperature low resistive channels, which braid through the studied area mainly at a level of 10-15 km and root to a depth deeper than 20 km. Accordingly, the probable heat sources feeding the geothermal system are supposed to be the intrusions of the hot partially molten magma upwelling from the mantle through the faults and fractures.

The comparison between the vertical temperature cross-sections and the projections of the earthquake hypocenters showed that they all are located in the areas where temperature does not exceed 400°, which is a gabbro solidus in a silica rich Icelandic crust. Joint analysis of the 3D resistivity and temperature models provided taking into account the residual Bourger gravity anomalies enabled to explain the distribution of the earthquakes hypocenters by different geothermal regimes in adjacent parts of the area and by cooling of large massifs of the partially molten solidified magma beneath seismically active areas. Migration of the partially molten material or the formed supercritical fluids along the fractures from deep layers to the surface may increase the pore pressure at shallow depths up to the lithostatic value and thus enhance instability of the faults, which, in turn, leads to activation of seismic processes.

The obtained results allowed us to construct a self-consistent conceptual model of the Icelandic crust which agrees with the most of previous geophysical results and provides an explanation for the facts, which the existing models fail to explain.