3D thermal structure of the Hengill volcanic complex (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 volcanic complex 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 degrees (C)) while the deeper one, which spans in depth to at least 20 km, is characterized by temperature ranging from 200 to 400 degrees (C).

The two-layered background temperature distribution is overlapped by a circulation system of high temperature low resistive channels, which braid through the studied area 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.

Application of the new approach enabled us to build a new self-consistent conceptual model of the Icelandic crust in the Hengill geothermal area. It agrees with the most of previous geophysical results and provides an explanation for the facts the previous models failed to explain. In particular, joint analysis of the temperature and resistivity models indicates that highly conductive layers recognized by MT sounding at shallow and large depths are most probably the parts of the hot melted magma network overlapping generally cold Icelandic crust supposedly composed from the silica rich gabbro. This could explain why has the drilling in the Krafla geothermal field penetrated rhyolitic magmas with a temperature of 1100 degrees (C) at a shallow depth.

Joint analysis of the temperature and resistivity models together with the gravity data enabled to reveal the heat sources and discriminate the locations of relict and active parts of the volcanic geothermal complex. This, in turn, explains the observed seismicity pattern by different geothermal regimes in four adjacent parts of the area.