RESISTIVITY METHODS IN GEOTHERMAL PROSPECTING IN ICELAND

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Abstract. Resistivity techniques have been used successfully to identify and delineate geothermal resources in Iceland. The most frequently used techniques include Schlumberger, central loop TEM and head-on profiling. Geothermal systems in Iceland are located both within and outsite the active volcanic regions. Outside the active volcanic regions the temperature in the upper most kilometer of the geothermal systems is below 150°C whereas the temperature in the geothermal fields within the active volcanic regions exceeds 200°C. The resistivity of the rock in geothermal fields located outside the active volcanic regions ranges from about 10 Ωm to some hundreds of Ωm, and are characterized by considerably lower resistivity than of the surrounding rocks. Most of the geothermal systems within the active volcanic regions, show common resistivity structure with low resistivity of 1–5 Ωm surrounding an inner core of higher resistivity. This increasing resistivity with depth is associated with a change in the conduction mechanism, from interface conduction to electrolyte conduction due to a change in alteration minerals at about 240°C. Examples of resistivity surveys of geothermal fields from both outside and within the active volcanic regions are discussed.

Introduction

Among the physical parameters characterizing the porous crust, resistivity is among the most easily measurable from the surface. As resistivity is highly dependent on temperature, resistivity methods are very useful in finding and delineating geothermal systems. Since the first resistivity sounding in Iceland in 1947, several thousand resistivity soundings have been performed. The most frequently used methods for shallow depth exploration (<1 km) are Schlumberger and TEM soundings. Head-on resistivity profiling is used to locate vertical resistivity boundaries, such as narrow vertical aquifers and sharp resistivity boundaries. AMT and MT are used for deep crustal studies.

The purpose of this paper is to give an overview of how resistivity methods are used in exploring geothermal systems in Iceland. This is done by discussing results of resistivity surveys from geothermal fields both within and outside the active volcanic regions, but first we briefly discuss the relation of the geothermal activity to the main geology and the general resistivity structure of Iceland.

Main geology

Figure 1 shows the main features of the Icelandic geology. The Mid-Atlantic ridge transects Iceland from southwest to northeast along the active zones of rifting and volcanism. These zones are characterized by many active central volcanos with
fissure swarms, each 5–10 km in width and several tens of kilometers in length (Saemundsson 1978, 1979). The geothermal systems within the active volcanic zones are found within volcanic centers or associated fissure swarms. The heat sources are cooling intrusions or magmatic bodies and temperatures up to 400°C have been found. They are called high-temperature systems in contrast to the low-temperature systems found outside the active volcanic zones, which have temperatures lower than 150°C at 1 km depth. Most of the low-temperature geothermal areas are located on the flanks of the active volcanic zones (Figure 1). Their heat sources are either cooling rocks of old volcanic centers which have drifted out from the active volcanic axis or high heat flow in young volcanic crust.

**General resistivity structure**

The general resistivity structure of the uppermost 1 km of the Icelandic crust has been described by Bjornsson (1976), and Flóvenz et al. (1985). Within the active volcanic zones it is characterized by high resistivity (10⁴–10⁵ Ωm) in dry highly porous and fractured basalt lavas, decreasing to about 1000 Ωm below the groundwater level. At 600–800 m depth the resistivity decreases to 30–40 Ωm, compared to 1–10 Ωm within geothermal fields. Outside the active volcanic zones the resistivity is typically 100–500 Ωm down to a depth of some hundreds of meters. Below that the resistivity generally decreases to as low as 30–200 Ωm. The