Reviewed research article

Geothermal systems in Iceland

Stefán Arnórsson[1], Gudni Axelsson[2], and Kristján Sæmundsson[2]
[1]*Institute of Earth Sciences, University of Iceland, Sturlugata 7, IS-101 Reykjavík, Iceland*
[2]*Iceland GeoSurvey, Grensásvegur 9, IS-108 Reykjavík, Iceland*
stefanar@raunvis.hi.is

Abstract — *Geothermal systems in Iceland have been classified as high and low-temperature. High-temperature systems are located within the belts of active volcanism and rifting whereas low-temperature systems are in Quaternary and Tertiary formations. The heat source for the high-temperature systems is high-level magma intrusions. Therefore these systems are volcanic by a commonly used classification of geothermal systems. From data on the natural heat output of several high-temperatures areas, it is concluded that the heat conduction layer between melt and the base of fluid convection is very thin, from several tens of meters to a few hundreds at the most. Most high-temperature fields lie astride active fissure swarms where these swarms intersect the lithosphere plate boundary. Central volcanic complexes have formed at some of these points of intersection and calderas have developed in several of them. Most low-temperature activity in Iceland is known to be associated with recent sub-vertical fracturing and faulting of older crust of the North-American plate and the Hreppar microplate. These systems may therefore be classified as tectonic. Their heat sources are hot rocks at depth. Convection in high-temperature areas is density driven. It is also density driven in some low-temperature areas but in others by hydraulic head. Recorded maximum temperature in drilled high-temperature fields is >380°C at ∼2 km depth. The highest temperature recorded in a low-temperature field is 175°C at 2 km depth. Many fossil high and low-temperature systems in Quaternary and Tertiary formations have been exhumed by erosion providing important information on the geological structure of such systems. The energy current from below Iceland has been estimated as ∼30 GW (1 GW = 10^9 W), corresponding to 5-fold the world average heat flux per unit area. At the surface, this energy current is split as follows; 7 GW comes from rising magma, 8 from fluid flow in geothermal areas and 15 GW from heat conduction. The estimated amount of thermal energy stored in the crust down to 10 km depth is ∼1.2 EJ (1 EJ = 10^{24} J). Above 3 km depth, the energy stored in high-temperature fields is estimated as ∼0.1 EJ. Geothermal fluids in Iceland are meteoric, seawater or mixtures thereof in origin. Low deuterium content in some of these fluids is due to the presence of a Pre-Holocene water component. Primary geothermal fluids that do not contain a seawater component are low in Cl and other dissolved solids. The cause is the low Cl content of the host basalt. Geothermal energy constitutes a very important energy resource in Iceland involving both direct uses of geothermal water and power generation by geothermal steam. In 2005 the annual direct use of geothermal heat was ∼6800 GWh (9% of the worldt's total) and the installed capacity 1844 MWt. At present the installed capacity of power plants using geothermal steam is 484 MWe (5% of the world's total). Four countries use more geothermal heat directly than Iceland and six have higher installed capacity of geothermal power plants.*