The Grímsvötn Geothermal Area, Vatnajökull, Iceland

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ABSTRACT
Melting of ice at the Grímsvötn geothermal area has created a depression in the surface of the ice cap Vatnajökull and produced a subglacial lake from which jökulhlaups drain to Skeidararsandur. The geothermal activity is also expressed by small cauldrons on the surface of the ice as well as by fumaroles on two nunataks that rise 300 m above the lake level. Vapour from the fumaroles yields little information about the deep reservoir fluid. The vapour seeps upwards from the water table and repeatedly condenses and evaporates on the way to the surface. The chemistry of the water in jökulhlaups, however, provides information about the fluid in the geothermal system. This information is not easy to interpret because of water-rock interaction in the lake. Silica solubility data and assumptions about the likely reservoir temperature, however, indicate that about 15% of the total mass in the lake is fluid discharged from the geothermal reservoir. This information about the geothermal mass fraction together with mass and energy balances for the lake enables one to calculate the masses of water and steam discharged from the geothermal reservoir as well as the mass of ice melted in the lake. The steam mass fraction is estimated to be 20-35% when the fluid enters the lake. From this, new estimates of the thermal power of the geothermal system are obtained. The total thermal power of the system is 4700–4900 MW, of which 2100-3000 MW are transported by steam and the rest by water.

Grímsvötn is one of few geothermal areas where active volcanism is observed and where there is a direct interaction between magma and geothermal water. Evidence of volcanic activity was found in the water chemistry of the jökulhlaup in December 1983. The high content of sulphate and the presence of iron indicated eruption of magma into the geothermal fluid.

Since the nineteen-fifties jökulhlaups have occurred regularly at 4-6 year intervals when the lake level has risen up to a critical level required for draining water from the bottom of the lake. However, jökulhlaups may occur at lower water levels. In 1983 a jökulhlaup was triggered at a water level 20-30 m lower than the critical level. This jökulhlaup may have been triggered by the opening of waterways into the lake along the slopes of Grímsfjall, where increased geothermal or volcanic activity has melted ice in places. An odour of hydrogen sulphide was detected for two months on Skeidararsandur before the jökulhlaup commenced. Sulphurous odour for long periods may warrant a forecast of such premature jökulhlaups.

INTRODUCTION
The Grímsvötn geothermal area is located in the interior of the Vatnajökull ice cap at the most active caldera volcano in Iceland. The volcano, the thermal area and the caldera lake Grímsvötn are almost completely covered with ice. Periodic bursts of water (jökulhlaups) drain the lake subglacially down to the rivers on the Skeidararsandur outwash plain: Skeiðará, Sandgígjukvisl and Súla. (Fig.1). The volcanological and geothermal activity in the area has been studied by many authors. This includes the history of eruptions and jökulhlaups, the mass balance of the lake,