Gas chemistry of the Krísuvík geothermal field, Iceland, with special reference to evaluation of steam condensation in upflow zones

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Abstract

Subsurface temperatures in the Krísuvík geothermal field, SW-Iceland, have been estimated from fumarole data using gas geothermometry. In the eastern part of the field, the Sveifluháls area, temperatures of 280°C are indicated, but in the western part of the field, the Vesturháls area, they seem to be around 260°C. Evidence exists for an upflow of undegassed water in the northeastern part of the Sveifluháls area around the southern shore of Lake Kleifarvatn. A method has been developed to estimate the degree of steam condensation in the upflow of geothermal systems using CO_2 and N_2 chemistry. Condensation is envisaged to occur by either or both of two processes: 1) Conductive heat loss and 2) mixing of the rising steam with colder water. In the Krísuvík field steam condensation is seen to be relatively limited, 0–30%. Evaluation of steam condensation in the upflow helps interpret those geothermometers that use gas concentrations in the steam. The N_2 concentrations in the fumarole steam, together with the gas geothermometry results, are taken to indicate extensive boiling in the upflow, i.e. boiling over a large temperature interval (>50°C) without the water separating from the steam.

INTRODUCTION

The Krísuvík geothermal field is one of five high-temperature fields on the Reykjanes Peninsula in southwest Iceland. Distribution of thermal manifestations and resistivity surveys indicate an areal extent of some 40 km^2 (*Arnórsson et al.*, 1975a). During 1970–72 exploration surveys and exploratory drillings were carried out in the area to assess the characteristics of the geothermal reservoir (*Arnórsson*, 1971; *Arnórsson et al.*, 1975a, 1975b). Four exploration wells were drilled during this period ranging in depth from 800 to 1000 m. Another two wells, 1200–1300 m deep, had been drilled around 1960. Temperature reversals were observed in all these wells and the maximum temperature in each well was fairly close to the boiling point curve for depth, the highest recorded temperature being 262°C in a well by Trölladyngja (Fig. 1). The data from the drillings and the exploration surveys were not sufficiently diagnostic to explain these reversals and to locate upflow zones.

A part of the exploration work in 1970–72 involved the study of the chemistry of gas from hot pools and fumaroles. In interpreting the data it was attempted to establish how the gas composition might reflect subsurface temperatures (*Arnórsson*, 1971, *Arnórsson et al.*, 1975a). Since that time extensive research has been carried out on gas chemistry in geothermal systems involving assessment of equilibrium between gases and minerals and geothermometry (*Arnórsson et al.*, 1983a; *Arnórsson and Gunnlaugsson*, 1983, 1985; D'Amore and Celati 1983; D'Amore and Nuti, 1977; *D'Amore and Panichi*, 1980; D'Amore and Truesdell, 1979, 1980, 1985; D'Amore et al., 1983a, 1983b; *Giggenbach*, 1980; *Nehring and D'Amore*, 1984).

In 1981–1985 a total of 58 samples of gas from fumaroles and hot pools were collected in the Krísuvík field. These data, together with older data (Tables 1 and 2), have been used to evaluate boiling processes, to predict subsurface temperatures and to assess gas reactions in the upflow. A new method, using CO_2 and N_2 chemistry, has also been developed to estimate the amount of steam condensation in the upflow, thus improving geothermometry interpretation. Together with geological and hydrological information the gas data have been used to delineate a conceptual model for the Krísuvík reservoir.

GEOLOGICAL FEATURES AND GEOTHERMAL MANIFESTATIONS

The geothermal manifestations in the Krísuvík field consist mostly of fumaroles, hot altered ground and steam heated pools of acid water. The activity, present