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SUB-GLACIAL VOLCANIC ERUPTIONS*

By

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The literature on sub-glacial volcanic eruptions and the related flood phenomena has been reviewed as a minor part of the larger problem of convective and conductive heat transfer from intrusive magma. (See Lovering, 1955, for a review of the extensive literature on this subject.) This summary of data on sub-glacial eruptions is part of a program that the U. S. Geological Survey is conducting in connection with its Investigations of Geologic Processes project on behalf of the Division of Research, U. S. Atomic Energy Commission.

Sub-glacial volcanic eruptions and associated floods of melt-water have been studied in Iceland, almost to the exclusion of other areas. The volcano Grimsvötn is under the large ice cap Vatnajökull and the volcano Katla is under Mýrdalsjökull ice cap. The two volcanoes are among the most active of Iceland; Grimsvötn erupts approximately every ten years and Katla every 30 to 40 years.

Each eruption is accompanied by a major flood from the margin of the glacier. The maximum discharge from Grimsvötn has been estimated at 50,000 cu. m. per sec. (Barth, 1950, pl. 2; Thorarinsson, 1953, p. 271) and that from Katla, 200,000 cu. m. per sec. (Barth, 1950, p. 10). For comparison, the discharge of the Amazon, the largest river in the world, is only 10,000 cu. m. per sec.

According to Nielson (1937, p. 6-23) the crater depression of the volcano becomes filled with ice between eruptions and the ice is melted by molten matter during a maximum period of 20 days. Thorarinsson (1953, p. 270-274), however, has convincingly shown that the characteristics,

timing, and heat demands for the flood waters are not satisfied by Nielson's explanation. Water gradually accumulates between eruptions in the crater depression of Grimsvötn. Ice is melted by a continuous flow of heat from the volcano by conduction and in steam. The sub-glacial lake is contained at least in part within ice walls. When the depth of melt-water at the low point of the bedrock rim of the crater depression attains more than 90 percent of the height of the barrier ice at this point, the water lifts the ice. Sub-glacial escape of ponded water gradually attains flood proportions over a period of a few days and, according to Thorarinsson, is followed rather than preceded by the visible eruption of the volcano. This has led Thorarinsson to suggest that the eruptions are initiated by the sudden decrease in external pressure resulting from draining of the sub-glacial lake.

According to Gunnar Bodvarsson of the Iceland Electricity Authority (oral communication) the surface of the glacier has been observed to rise during the early flood stages. This is consistent with the explanation that sub-glacial water lifts the ice.

No specific evidence has been found to suggest that the flood waters have bored or otherwise penetrated massive ice. Thorarinsson's explanation of gradual accumulation and sub-glacial escape of melt-water satisfies the available data, but the actual mechanism triggering the volcanic eruptions is not yet clear.

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