G E O P H Y S I C S

Some Geophysical Observations at Surtsey in 1964.

by

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A. Observations of atmospheric electric disturbances at the volcano cloud.

In the beginning of the submarine Surtsey eruption, there were frequent lightning discharges in the volcano cloud and this lightning activity continued with varying intensity until April 4th 1964, when the formation of a wall of scoria prevented the ready access of sea water into the crater and it filled with molten lava.

First attempts to investigate these electric disturbances were undertaken by Prof. Thorbjörn Sigurgeirsson, University of Iceland, in November-December of 1963 and January of 1964. These investigations were greatly advanced when U.S. scientists began their observations of the electrical phenomena in February of 1964.

On February 5th Bernard Vonnegut, Arthur D. Little, Inc., Barrie McLean, American Meteorological Society and the writer went on M.V. Haraldur to Surtsey and made observations of the potential gradient of the electric field with a portable electrometer. Motion pictures of the volcano cloud were taken from the boat. Time lapse motion pictures were also taken from the airport on Vestmannaeyjar 23 km distant from the volcano.

On February 16th Charles B. Moore, Arthur D. Little, Inc., Duncan C. Blanchard, Woods Hole Oceanographic Institution and James Hughes, Office of Naval Research, sailed to Surtsey on M.V. Haraldur and recorded the potential gradient and point discharge near the volcano cloud.

On February 11th, 12th, 15th and 16th Robert Anderson and Stuart Gathman, Naval Research Laboratory and Henry I. Survilas, Arthur D. Little, Inc., made flights near the volcano in a

Constellation airplane equipped by the Naval Research Laboratory with electric field meters in the wing tips.

These observations have been continued by the writer. On March 22nd further potential gradient observations were made near the volcano and under the volcano cloud aboard an Icelandic Coast Guard ship.

A report on all these observations and the obtained results has been written and is being published in "Science" under the title "Atmospheric Electric Disturbances Produced by the Volcano Surtsey, Iceland".

B. Observations of charge separation at the contact of molten lava with sea water.

As lava flowed into the sea, dense, white steam clouds evolved. It was soon suspected that these clouds might be electrically charged. D.C. Blanchard (Nature, 201, 1164, (1964)) found in his laboratory experiments that if drops of salt water fell on molten lava, positively charged clouds of sea salt particles evolved. The charge concentration in these laboratory-created clouds was estimated to be as high as 10^8 elementary charges per cubic centimeter. This is about two million times as great as the positive space charge that is normally found in the atmosphere.

In order to verify, if this kind of charge separation was working in Surtsey, the writer went on July 24th aboard an Iceland Coast Guard vessel to Surtsey and waited for a flow of lava into the sea. It was not possible to go ashore because of surf, but when the ship sailed under the steam plume, evolving from the contact of lava and sea, a strong increase in the potential gradient was observed. From the recorded observations it may be deduced that the charge concentration in the cloud at its source must have been about 10^6 elementary charges per cubic centimeter.

On August 19th an U.S. Navy helicopter brought a group of scientists to Surtsey. This was the first opportunity to observe the charge separation directly at its source, where the lava flowed into the sea. The lava flow was covered with a thin black crust and its contact with the sea was relatively quiet. Dense, white steam clouds evolved there. By means of potential gradient measurements the charge concentration in these clouds was estimated to be of the order of 10^6 elementary positive charges per cubic centimeter.

At some places the thin crust broke and molten lava was squeezed out. Explosions occurred as this very hot lava came into contact with the sea. Fragments of lava were thrown up to several meters height along with fountains of waterdrops. These waterdrops evaporated and formed clouds of steam. The charge concentration in these clouds was estimated to be $10^7 - 3\cdot 10^8$ elementary positive charges per cubic centimeter.

Further observations of the charge separation were made on January 18th. This time the space charge was measured directly with a Faraday cage. Steam clouds evolving from the quiet contact of lava and sea contained positive charge up to 1.1×10^6 elementary charges per cubic centimeter. No negative space charge was observed.

According to the potential gradient measurements made near the volcanic crater in February and March 1964, the volcano cloud carried a net positive charge as it was ejected from the crater. It is tempting to attribute the positive electricity in the volcano cloud to the contact of sea water with magma in the crater. However, caution must be used here, for the conditions during the eruption are exceedingly complex, and other charge separation mechanisms undoubtedly play a rôle. It would be of great interest to investigate the similar intense lightning activity, which accompanies the frequent subglacial eruptions in Iceland. In these eruptions the water plays the rôle of the sea at Surtsey.

C. Measurements of the radon content of magmatic gas.

Radon is the decay product of radium. If the radium concentration in magma is determined, the radon concentration in the magmatic reservoir can be calculated. As the magma ascends and pressure is released, the magmatic gases escape.

A determination of the ratio of the radon concentration in the magmatic gases and the radon concentration in the magmatic reservoir would give an estimate of the content of volatile gases in the reservoir.

One attempt has been made to determine the radon content in the magmatic gases. A value of 100 pC per liter of magmatic gas was obtained. Further measurements are necessary. Measurements of the radium content of the lava are in preparation.