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January 1, 1974

Thermal Surveillance of Active Volcanoes

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Type II Progress Report for Period 1 July 1973 - 1 January 1974

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Figure 2A. Technical Report Standard Title Page. This page provides the data elements required by DoD Form DD-1473, HEW Form OE-6000 (ERIC), and similar forms.

Abstract

By the end of 1973, aerial infrared scanner traverses for thermal anomaly recordings of all Cascade Range volcanoes were essentially completed. Amplitude level slices of the Mount Baker anomalies were completed and compiled at a scale of 1:24,000, thus producing, for the first time, an accurate map of the distribution and intensity of thermal activity on Mount Baker. The major thermal activity is concentrated within the crater south of the main summit and although it is characterized by intensive solfataric activity and warm ground, it is largely subglacial -- causing the development of sizable glacier perforation features. The outgoing radiative flux from the east breach anomalies is estimated at $7,780\mu \text{ cal cm}^{-2} \text{ sec}^{-1}$, sufficient to account for the volume of ice melted to form the glacier perforations. DCP station 6251 has been monitoring a thermally anomalous area on the north slope of Mount Baker. The present thermal activity of Mount Baker accounts for continuing hydrothermal alteration in the crater south of the main summit and recurrent debris avalanches from Sherman Peak on its south rim. Such an avalanche, involving $35,000 \text{ m}^3$ of snow, ice and debris, descended 2.6 km down the Boulder Glacier from Sherman Peak (crater rim) on August 20-21, 1973. The infrared anomalies mapped as part of experiment SR 251 and described above are considered the basic evidence of the subglacial heating which was the probable triggering mechanism of this avalanche.

Key Words -- Thermal anomalies; Mount Baker volcano; aerial infrared scanning; subglacial heat emission; glacier perforation features; geothermally induced debris avalanches.

- a. Title: Thermal Surveillance of Volcances of the Cascade Range Utilizing ERTS DCP Systems and Imagery
ERTS-A Proposal No: SR 251
- b. GSFC ID No. of P.I.: IN 023
- c. Problems which impeded progress during earlier stages of the experiment (i.e., late receipt of DCP sets from the manufacturer, delayed launch of ERTS-1, and the subsequent onset of winter conditions at the high-altitude DCP sites in the Cascades) have been overcome. No overriding problems remain which affect completion of the experiment during 1974.
- d. Accomplishments during the reporting period: DCP stations at Mount Baker and Mount St. Helens continued to transmit useful temperature data for computer processing. Temperature, radiance and near-surface heat flow data have been compiled and plotted for the period through July 1, 1973. The computer program is being converted from the IBM 360/65 computer to the DEC 1070 system at the USGS Denver facilities in preparation for a readout for DCP data through January 1, 1974 for experiment SR 251.

By the end of 1973, aerial infrared thermographic surveys were essentially completed over all Cascade Range volcanoes. Scanning-microscope amplitude level slices were made for the aerial IR images which recorded thermal anomalies of Mount Baker, and 1:24,000 maps of these anomalies were compiled on a new topographic base. Thus, by the end of 1973, aerial infrared thermographic surveys completely mapped the distribution and relative intensity of thermal activity on Mount Baker, heretofore never done in detail on suitable base maps.

e. Significant scientific results during the reporting period:

The thermal anomaly maps of Mount Baker, compiled as part of experiment 251, and referred to above, show that the present thermal emission, characterized by solfataric activity and warm ground, is concentrated within the crater south of the main summit. Clusters of strong infrared anomalies coincide with glacier perforation features near the east and west breaches of this crater and suggest that much of the thermal activity is subglacial. The outgoing radiative flux from the east breach anomalies is estimated at $7,780\mu \text{ cal}^{-2} \text{ sec}^{-1}$, and is sufficient to account for the volume of ice melted to form the glacier perforations. Infrared anomalies were also recorded near the head of Mazama Glacier midway down the north slope of the volcano. This latter site has been monitored for surface and near-surface temperature variations by thermistor array and the ERTS-1 Data Communications System. Radiative and other heat loss from all the anomalous areas, as estimated from the thermistor array on the north slope, gives a minimum rate of energy yield of Mount Baker during its present period of repose. The distribution of thermal and solfataric activity confirms historical observations that the Sherman crater was a major site of eruptive activity in the 19th century. Moreover, the present thermal activity accounts for continuing hydrothermal alteration in this crater and recurrent debris avalanches from Sherman Peak on its south rim.

An avalanche of $35,000 \text{ m}^3$ of snow, ice and rock debris descended 2.6 km down the Boulder Glacier on the eastern flank of Mount Baker volcano between 0700 PDT, August 20, and 1000 PDT August 21, 1973. Aerial photographic observations and debris within Boulder Glacier

disclose that similar avalanches have occurred from this same location at intervals of a few years during the current period of repose of Mount Baker. The infrared anomalies recorded and mapped in this ERTS experiment (251), and described above, are considered the basic evidence as to the cause of these mass movement phenomena on Mount Baker. Largely subglacial heating on Sherman Peak (south rim of the crater), which caused water saturation at the ground-firm interface as well as hydrothermal alteration of crater rock material to clay-red soil, is considered to be the principal triggering mechanism of the August 1973 avalanche.

- f. Friedman, J. D., and D. G. Frank, 1974, Thermal Activity at Mount Baker, Washington (abs.): Amer. Geophys. Union Volcanology Section, meeting, Washington, D. C., April 1974.