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THERMAL SURVEILLANCE OF VOLCANOES

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16. Abstract

Successful installation of DCP sets #6251 at Mr. Baker volcano, Washington, and #6166 at Mt. St. Helens volcano, Washington, during the winter and spring of 1973 completed the installation phase of experiment SR 251. DCP punched data cards are currently being processed by USGS IBM 360/65 computer program #G278, designed for experiment SR-251, followed by a plotting package which gives the minimum, maximum range and standard deviation for each temperature, radiance value and anomalous heat flow function as transmitted from each thermistor array-DCP station. Aerial IR scanner missions over the Cascade volcanoes were completed with a mission April 29th which provided thermographic IR images of Glacier Peak, Mt. Baker, Mt. St. Helens, Mt. Rainier and Mt. Adams. Earlier repetitive coverage had obtained IR images depicting thermal anomalies of Lassen Volcanic National Park, Shasta, Crater Lake and the northern Cascades. The April 29th mission and subsequent ground reconnaissance yielded new information on 48 heretofore unreported pinpoint radiation anomalies, of possible fumarolic origin, on the flanks of Mt. Rainier and several new thermal points on Mt. Baker. Cartographic plots of these anomalies, in conjunction with surface temperature and other data obtained as a result of experiment SR 251 will permit estimation of radiation heat loss during the repose periods of the host volcanoes.

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a. Title: Thermal Surveillance of Volcanoes of the Cascade Range Utilizing ERTS DCP Systems and Imagery

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c. The main problems which impeded the progress of the investigation in its earlier stages were the result of unduly late receipt from the manufacturer (GE) of DCP sets (fall, 1972). Subsequently, late fall and winter conditions at high altitudes in the Cascade Range slowed completion of installations. The last set was installed in April 1973 at Mt. St. Helens, Washington. During the winter of 1972-73 the principal shortcoming of the DCP sets was found to be the inability of the large disc-shaped antenna to resist breakage under the confining pressure of heavy snow cover or under high winds (100km/hr).

d. The following discussion of the accomplishments during the reporting period summarizes and amplifies Section d of two Type I Progress Reports, dated April 1973 and June 1973.

On February 8, 1973 DCP #6251 was installed in an area of fumaroles and anomalously warm ground at 8,000 feet elevation on the north slope of Mt. Baker, Washington, and has been operating and transmitting thermistor-derived temperature data satisfactorily since then. On May 17, 1973 DCP set #6166 was finally installed successfully in a thermal area at about 9,000 feet elevation, 1,000 feet southwest of and below the summit of Mt. St. Helens, and has been transmitting temperature data successfully since then. The installation required a helicopter sling maneuver from a hovering position on Mt. St. Helen's steep southwest side slope.

On April 29, 1973, between 0400 and 0552 PDT, aerial infrared

thermographic imagery was obtained over six northern Cascade Range volcanoes, using an RS-7 scan system, by a U.S. Forest Service Aerial Fire Depot aircraft, Missoula, Montana, flying for the U.S. Geological Survey, expressly for experiment NASA ERTS-1 SR 251. No large radiation anomalies were found for Glacier Peak and Mt. Adams. The southwest slope anomaly of Mt. St. Helens in the Crums Hot Rocks area yielded a much better thermal infrared registration than previous flights as a result of carefully selected flight altitudes and V/H settings. However, the Boot Ridge thermal area does not appear on the images due to snow cover. Several small, previously unknown, point-source radiation anomalies were detected in the extensive stream fields on Mt. Hood and Mt. Baker; otherwise, the configuration and intensity of the stream fields appears to be similar to that recorded on earlier thermographic infrared images.

At Mt. Rainier the summit crater anomalies appear as recorded on earlier images, but with better spatial resolution. The warmest areas appear to be the inside northwest rim of the East Crater, the outside northwest rim of the West Crater, and the outside southwest slope of the West Crater. The most outstanding result of the April 29 flights, however, was the detection of approximately 48 previously unrecorded pinpoint radiation anomalies around the main cone and on the flanks of Mt. Rainier between 10,000 and 13,000 feet elevation, in outcrop areas of andesite of Mt. Rainier volcano (Fiske and others, 1963, USGS Prof. Paper 444, Plate 1). These anomalies are nearly all point sources, appearing warmer than surrounding bedrock, but not as warm as the summit anomalies. They were registered on more than one overpass. They cannot be attributed to geothermal emission without a field check, though they are located on slopes and rock walls

difficult of access. On May 13th, David Frank was able to reach the ground location of one of these anomalies (A_1, on our map compilation) at Disappointment Cleaver and found 27 m^2 of warm ground at that location. There, he measured vapor temperatures of 58°C at two vent openings using PRT-10 radiometer and thermometer. Ground surface temperatures ranged from 18° to 30°C; temperature of 50 cm depth was 54°C.

A U.S. Geological Survey computer program, #G278, has been designed for experiment SR 251, utilizing the USGS IBM 360/65 computer and a plotting program from the Biomedical Computer Programs package. These programs record and plot temperatures, radiance and anomalous heat flow values transmitted to GSFC and Goldstone receiving stations via ERTS-1 by the ground-based Data Communication Platforms emplaced in areas of relatively inaccessible volcanic thermal anomalies. Arrays of thermistor probes provide time-dependent values of ground surface temperature (T), air temperature (T_o), and temperatures at 15, 50 or 100 cm depth. Radiance values are plotted as a function of time using the Stefan-Boltzmann function, where radiance, $W = \varepsilon\ 1.356 \times 10^{-12}\ T^4$. Anomalous near-surface heat flow is analyzed by an empirical relationship in which temperatures at shallow depth are related to surface temperatures.

The USGS Computer Center is supplied with GSFC punched cards containing the voltages reported by the satellite from the thermistor arrays. Temperature values for each probe are calculated from the voltages supplied and from formulas relating resistance of individual thermistor probes to temperature. Two sets of cards are punched by the computer. The first contains a station number, and time and eight temperatures corresponding to the eight probes. The second card contains the same station number, the same time, one to four radiance values and an anomalous heat flow as

required. The radiance value are calculated in μ cal cm^{-2} - sec^{-1}.

The punched cards are processed by program 01D, a program from the Biomedical Computer Programs Package, which gives the minimum, maximum range and standard deviation for each temperature, radiance value and anomalous heat flow function. These values are plotted using the Biomedical plot facility, 05D.

e. Significant scientific results during the reporting period: 1 January - 1 July, 1973.

1) At Devil's Kitchen, Lassen Volcanic National Park, preliminary DCP data processing suggests that during the early winter period, temperatures at 15 cm depth in this active geothermal area showed a 68% correlation with fluctuations of anomalous surface temperatures; and temperatures at 50 cm depth showed an 8% correlation with surface temperature fluctuations.

A preliminary estimate of the anomalous heat flow at the Devil's Kitchen infrared (thermal) anomaly, also in Lassen Volcanic National Park, is 0.75×10^6 cal·sec^{-1} over an area of 41,600 m^2. At the Boiling Springs Lake anomaly, controlled by the same fault system, thermal radiation from the lake surface alone (not considering evaporative heat loss) was calculated to be 0.71×10^6 cal·sec^{-1}.

2) The significance of the discovery of the above-mentioned (Section d) 48 pinpoint radiation anomalies on the upper flanks of Mt. Rainier is that many of these points, definitely including point A_1 at Dissappointment Cleaver, may represent previously unreported or unplotted locations of fumarolic vapor emission or warm ground considerably below the summit crater, in the outcrop area of andesite of Mt. Rainier between 10,000 and 13,000 feet elevation.

3) Aerial IR scanner missions during the reporting period completed coverage of surface thermal anomalies in the Cascade Range volcanoes. Cartographic plots of these anomalous areas, in conjunction with surface temperature and other data compiled as a result of experiment SR 251 will permit making estimates of radiation heat loss from these areas during the repose periods of the host volcanoes.

f. Friedman, J. D., Frank, D. G., Preble, Duane, and Painter, J. E., 1973, Thermal Surveillance of Cascade Range Volcanoes Using ERTS-1 Multispectral Scanner, Aircraft Imaging Systems, and Ground-Based Data Communications Platforms, in Symp. on Significant Results Obtained from the Earth Resources Technology Satellite-1: NASA SP-327, v. 1, p. 1549-1560.

h. None

i. See earlier report

j. None