THERMAL SURVEILLANCE OF VOLCANOES OF THE CASCADE RANGE AND ICELAND UTILIZING ERTS DCP SYSTEMS AND IMAGERY

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16. Abstract

Significant results of the thermal surveillance of volcanoes experiment during 1972 included the design, construction, emplacement and successful operation at volcanic sites in the Cascade Range, North America and on Surtsey, Iceland, of automated thermistor arrays which transmit ground and fumarole temperatures via the ERTS-1 Data Communication System to Goddard Space Flight Center. Temperature, radiance, and anomalous heat flow variations are being plotted by a U.S. Geological Survey IBM 360/65 computer program (E857) to show daily fluctuations at each of the sites. Results are being compiled in conjunction with NASA and USGS aircraft infrared survey data to provide thermal energy yield estimates during the current repose period of several Cascade Range volcanic systems.

ERTS-1 MSS images have provided new information on the extent of structural elements controlling thermal emission at Lassen Volcanic National Park.

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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.

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

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c. 1. The late date (September 22, 1972) at which this project's (#251) Data Collection Platform (DCP) sets were received from the manufacturer (General Electric) jeopardized installation of integrated thermistor sensor arrays and DCP systems at altitudes above 8,000 feet at the Cascade volcanoes before the onset of 1972 fall and winter snow conditions. U.S. Geological Survey laboratory assembly and checkout of the sets after September 22nd by Duane Preble and staff and the use of helicopter support for field installation in the southern Cascades at Lassen National Park made possible the successful installation of two DCP systems and a related ground recording system, but the onset of stormy conditions in late October at Mount Saint Helens and Mount Baker prevented installation of DCP systems at these two sites. A field team of five, using U.S. Army helicopter support, made an unsuccessful attempt under hazardous conditions to install one system near the summit of Mount Saint Helens.

2. The slow rate of acquisition of MSS images over Iceland's nonvolcanic zone during the late summer and fall, and the hiatus in acquisition of images at high latitudes during the winter period of low sun angles

has prevented acquisition of full and repetitive coverage of the areas of experiment interest. After February 23d, the sun angle during orbital passes over Iceland will again exceed 15°. See recommendation in item g.

d. During the reporting period (July 1 to December 31, 1972) six DCP systems for experiment SR 251 were received by the USGS electronics laboratory at the Mississippi Test Facility (MTF). There, thermistor sensor arrays keyed to temperature ranges at surface thermal anomalies in the Cascade Range were interfaced with the transmitter sets. During the last half of October, DCP No. 6021 was installed at 8,000 feet elevation at the Bumpass Hell thermal area in Lassen National Park, California. DCP No. 6104 was installed at 6,000 feet elevation at the Devil's Kitchen thermal area, also in Lassen National Park. Both systems utilize eight thermistor probes to obtain temperature data at geothermal ground surfaces, at 50 cm depth, and at nongeothermal ground surfaces, as well as to obtain thermal-spring, fumarole, air, and instrument box temperatures. Several sets of data are expected to be suitable for determination of outgoing radiant flux and near-surface convective heat flow. A USGS computer program has been designed for reduction of the above-mentioned data. All probes were reporting consistent data during October, November, and December and both

transmitters were functioning well despite possible snow over the antenna cover. Transmission was received primarily at Goldstone, California.

To place a third DCP set in operation before winter, and within the Cascades and Iceland volcanic areas of interest for thermal monitoring in experiment SR 251, DCP set No. 6056 was installed (in cooperation with Iceland's National Energy Authority, Science Institute, and Museum of Natural History) on Surtsey Island, Iceland, at 63°25'N 18°20'W, following successful long-range test transmissions from Reykjavik to the GSFC via the ERTS-1 satellite relay system. DCP set No. 6056 was installed on the volcanic tephra rim of Surtur II in an area of significant convective heat flow through the tephra. A team of five Icelandic and American scientists and a helicopter pilot made the installation on November 14th during a period of cold, clear weather and strong winds.

Eight temperatures are transmitted twice daily over the ERTS-1 Data Collection System (DCS) and are recorded on paper tape every 32 hours, using a Fischer-Porter paper-punch recorder. The eight variables and their ranges are: air temperature (-25° to 25°C); nongeothermal ground surface (-25° to 25°C); geothermal ground surface (-25° to 25°C); and five channels of geothermal near-surface (1 m.) probes (0° to 100°C). Yellow Springs Instrument Company linear thermistor networks encapsulated in stainless steel fixtures are the basic transducers.

Stainless steel rods one meter long were used for the near-surface geothermal probes, stainless steel prisms 2.5 x 2.5 x 12 cm were used for the ground surface sensing, and a 1-cm x 8-cm stainless tube, sheltered from the wind and sun, was used as the air temperature thermistor mount. Each probe has a mating signal conditioner which, when power is applied, converts a full-scale probe temperature change to a full-scale voltage range of 0 to 5.0 volts.

The ERTS DCP transmits eight analog channels every 90 seconds. During each transmission and 40 milliseconds (msec) prior to each transmission, the preamplifiers are turned on by command from the DCP. Total "on" time for the system is about 80 msec per transmission period. The low duty cycle allows a five- to eight-month battery life with about 16 kg of alkaline batteries. Transmissions are now being regularly received at GSFC on a twice daily basis. The station now represents the greatest range over which the ERTS-DCS has successfully communicated. Three steps were taken to ensure maximum possibility for transmission to the satellite: (1) maximum system voltage of 27 volts was used to give maximum rf output power, (2) maximum transmission repetition rate of 90 seconds was used, and (3) antenna clearance to the southwest down to a 10° angle was taken into account during site selection.

A backup 16-channel paper tape recording system is operated in parallel with the DCP transmitter. Once every 32 hours the eight temperature parameters are recorded. A 32-hour cycle gives three different daily recording times spaced eight hours apart which recur on a three-day cycle. On command from the crystal-controlled timer the preamplifiers are turned on and the parameters sequentially punched on the paper tape. After the last parameter, which is a reference voltage level used for a system check, the recording system and preamplifiers are shut off. Standby power consumption is about two milliwatts (70 microamps @ $\pm$ 13.5 volts).

On November 14 and 15, Manned Spacecraft Center NP3A aircraft Mission 221 was carried out to obtain infrared images in support of experiment SR 251 over the following Cascade Range volcanoes: Lassen National Park, Crater Lake, Mount Saint Helens, Mount Rainier and Mount Baker. Project geologist David Frank represented the USGS on these night flights. The earlier Mission 212 over Lassen was also reviewed at this time.

As a result of these MSC missions and earlier Forest Service infrared survey flights flown for USGS experiment SR 251, infrared emission data have been analyzed in terms of existing thermal anomalies at the volcanic areas under study.

ERTS MSS images for the Cascade area have been received by the Principal Investigator, particularly

during the latter half of the reporting period. These images have been analyzed in conjunction with the above-mentioned aerial infrared data.

e. Significant scientific results of experiment SR 251 during the reporting period include the following:

1. The successful design and construction of thermistor arrays and interfacing with Data Communication Platforms. The arrays are designed to obtain both surface and near-surface temperature data at surface manifestations of thermal activity in volcanic and geothermal areas.
2. Installation of two DCP sets and successful transmission from the Lassen area of the southern Cascades.
3. Installation of our DCP set at Surtsey, Iceland and successful, high quality message transmission over the longest range yet attempted in any DCP experiment (2,900 miles as measured on the earth's surface from GSFC to Surtsey Island), demonstrating that ground sensor (thermistor) data may be gathered reliably with a DCP system in difficult environments and in remote locations. Also, the steps taken to insure optimum transmission over this distance may be of value for other investigators:
    (a) maximum transmission repetition rate of 90 seconds was used,

(b) maximum system voltage of 27 volts was used to give maximum rf output power, and

(c) site selection was made to give antenna clearance down to a 10° angle toward the southwest horizon.

4. MSS image interpretation in conjunction with aerial infrared thermographic images has revealed in the Lassen area a possible major curvilinear tectonic element, convex to the north around Red Mountain, associated with the alignment of surface thermal anomalies as depicted on the aerial infrared images. The diameter of the inferred tectonic feature is 11-12 miles, and includes the Warner Valley fault.

5. Bathymetric probing (using a weighted line and helicopter in October 1972) of Boiling Springs Lake, has provided sufficient data to estimate the volume of the lake. Boiling Springs Lake is a structurally controlled thermal manifestation situated on a NNW striking fault which intersects the Warner Valley tectonic line. A thermistor array and Fischer-Porter paper-punch temperature recording system were installed at Boiling Springs Lake in October 1972. In combination with aerial infrared images and the above-mentioned volumetric estimate, the thermal measurements provide the necessary data for a thermal regime study of this important thermal manifestation.

f. None.

g. After February 23d, the sun angle during ERTS-1 orbital passes over Iceland will again exceed 15°. It is recommended that MSS image acquisition be programmed for reiterative coverage during this post-February 23d period.

h. Change in ERTS-1 Standing Order Form - December 14, 1972.

i. ERTS Image Descriptor forms to be submitted as a supplement.

j. Changes in the Data Request Form - September 1, 1972 and November 7, 1972.