MASTER

INTERIM PROGRESS REPORT
AND PROPOSAL FOR NO FUND EXTENSION

TO

CONTRACT NO. AT(45-1)-2229

TASK AGREEMENT NO. 8

TO U.S. ENERGY RESEARCH AND
DEVELOPMENT ADMINISTRATION

SEARCH FOR SHALLOW MAGMA ACCUMULATIONS AT AUGUSTINE VOLCANO

Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

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TASK AGREEMENT NO. 8

U. S. Energy Research and
Development Administration

INSTITUTION:

Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

TITLE:

Search for Shallow Magma
Accumulations at Augustine Volcano

PRINCIPAL INVESTIGATOR:

Juergen Kienle
Associate Professor of Geophysics
574-20-0499

DURATION OF EXTENSION:

6 months

STARTING DATE:

January 1, 1976

SUM REQUESTED FROM ERDA:

None

ABSTRACT

A large amount of geological and geophysical data, including thermal, geochemical, geodetic, magnetic and seismic measurements and a shallow drill hole, has been acquired during the 1975 field season. Data reduction and analysis have not progressed sufficiently to justify a meaningful renewal proposal at this time. Part of this delay is due to the late granting of the contract modification in June, 1975, which pushed the completion of the field operations back to late September. We are therefore requesting a six-month no fund extension of the contract.

INTRODUCTION-BACKGROUND

Extrusion of several lava plug domes at Augustine Volcano between 1902 and 1964, abundant rhyolite deposits and high heat flow values of several 1000 HFU's suggest that a magma reservoir may be present at shallow depth beneath the volcano, which could prove valuable as a target for magma-tap related research.

On February 19, 1975, ERDA funded our proposal to systematically prospect for such a magma body, effective January, 1975, at a level of \$50,000 for one year. This funding was to cover two studies: (1) a thermal investigation of the recent lava domes and (2) a fan shooting experiment with logistic support from Sandia Laboratories, both designed to estimate the size, shape and viscosity of the suspected magma body. From this data we were hoping to gain enough insight into the internal plumbing of Augustine Volcano to be able to assess the usefulness of this particular volcano as a natural laboratory to test hot rock and magma tap heat extraction technology. On June 19, 1975, a contract modification was granted for an amount of \$40,000 to conduct three additional experiments: (1) to drill a shallow thermal hole in the summit area of the volcano, (2) to re-fly an existing aeromagnetic survey at different elevations, allowing the determination of vertical magnetic gradients and thus three-dimensional magnetic modelling and (3) expansion of the existing earthquake seismic array on the Island to a larger aperture network of stations which would allow a study of the deeper seismicity of the volcano and thus the source of magma generation and magma transport.

WORK ACCOMPLISHED

Between July 23 and August 15, 1975, we conducted the fan shooting experiment, completed a drill hole on the summit of Augustine Volcano and collected thermal data. During this time, we also extensively sampled all available rock outcrops for magnetic susceptibility determinations needed for the magnetic modelling. The same samples will be used for geobarometric and geothermometric studies which will hopefully

allow us to estimate at what depth the plug-forming lavas originated.

Previously established geodetic and gravimetric bench marks were reoccupied in order to monitor morphologic changes of the volcano. An aeromagnetic resurvey was flown on August 28, 1975. Between September 15 and 22, 1975, we installed the large aperture seismic array surrounding Augustine Volcano with funding from this contract and the University of Alaska Environmental Assessment Program on the Outer Continental Shelf of the Gulf of Alaska.

1. Thermal Studies

Evaluation of the near-surface thermal structure of Augustine Volcano was continued during the 1975 field season. It included a ground based infrared radiometer survey of the 1964 lava dome, a repeat from the previous year to test the long-term stability of the then identified thermal anomalies, a fumarole temperature, shallow temperature and pit temperature survey of a fumarole field at the western base of the 1964 dome, which we also chose as the drill site, a resistivity survey in the fumarole field. We also performed a shallow temperature survey on top of the 1964 dome. Soil samples are now being analyzed for thermal conductivity to determine heat flow.

2. Summit Drill Hole

The successful completion of a drill hole at the 4000 foot level of Augustine Volcano demonstrated that the somewhat difficult logistics involved in such a venture can be solved. A Longyear helicopter-portable drill, air compressor, drill pipe and miscellaneous other equipment were transferred from Anchorage to Homer by truck and then by barge to Augustine Island. The barge was met at Augustine by a Bell 205

Helicopter, which slung the drilling gear to the summit of the volcano. The heaviest single sling load was the compressor weighing 2,800 pounds. The drill site is located in a fumarole field surrounded by the 1902, 1935 and 1964 lava plug domes (Figure 1). The depth of the hole was determined by the lifetime of the drill bit and mainly by the weight of the drill. It bottomed at 82 feet. Because of the small size of the drill rig, it had no provision to allow pulling of the drill stem to change bits. We, therefore, ended up using the drill stem as a permanent casing of the hole. The first ten feet were drilled with N-rod and a 3 1/2 inch tri-cone bit; the remaining 72 feet were drilled with A-rod (1 1/2 inch o.d.) and a 2 15/16 inch tri-cone bit.

Figure 2 shows two temperature logs of the drill hole taken one month apart, the August 6 log being taken three days after completion of the hole. Both curves show very similar temperature structures. The September 26, 1975, log, however, has a 3°C higher temperature maximum tentatively attributed to equilibration of the steam layer discussed below. The temperature logs can be interpreted by dividing them into three regions. The rapid temperature rise from 0 to 3 meters can be attributed to the combined effects of upwelling vapor and radiative and convective cooling near the end of the pipe. Due to the small diameter of the drill stem, pipe effects were negligible at depths greater than 3 meters. The region from 3 to 9.5 meters is identified with a confined convecting hot vapor region, which was also encountered in some of the shallow pits. The pit studies show the fumarole field to consist of a capping clay layer of highly variable thickness which confines the vapor in a layer of cavernous rubble breccia. The fumarole temperatures increase dramatically at a rate of 85°C per 100 meters(!) as one approaches

Figure 1. Summit region of Augustine Volcano seen from the south, showing the location of the drill hole relative to the 1902, 1935 and 1964 lava plug domes.

Figure 2. Temperature logs of the Augustine summit drill hole taken on August 6, 1975, three days after completion of the hole, and September 26, 1975.

the 1964 lava dome, suggesting that this dome is still the main heat source on the summit of Augustine. The temperature maximum of the September 26 log fits the vapor temperature predicted from the horizontal fumarole temperature gradient for the position of the drill hole. The region between 9.5 and 24 meters is dominated by downhole conductive cooling with the vapor layer as the heat source. A winter logging of the hole is planned for January or February, 1976, and we are now synthesizing the thermal data into a thermal structure model of the fumarole field.

3. Fan Shooting

During the fan shooting on August 4, 5 and 6, 1975, we operated the 5 permanent short-period seismic stations on Augustine Island plus 13 portable stations provided by Sandia Laboratories. The permanent array was recorded in Homer on 16 mm film and on magnetic tape; the signals from the portable array were recorded on magnetic tape in a Turbo-Beaver airplane overflying the Island. The two arrays were synchronized by placing two portable stations next to two permanent ones. The shot time break was transmitted to the airplane and recorded on the data channels. We fired a total of 10 shots, which were recorded successfully over the majority of seismic stations resulting in about 150 usable ray paths through the volcano and which we are analyzing for changes of body wave velocities and attenuation effects expected to be associated with a magma body. In order to avoid costly drill holes to place the charges, we designed surface shape charges which used 100 to 200 pounds of explosives. Coupling of the explosion energy to the ground was quite satisfactory, i. e. the arrivals of elastic waves could be seen island-wide even though some of the more distant first arrivals may have to

be picked using some enhancement technique such as maximum entropy.

Figure 3 shows the distribution of shot points and seismic stations. We are presently in the midst of station calibration and data playback.

4. Magnetics

On August 28, 1975, Mr. Jerry Hook and the principal investigator flew about 250 line miles of aeromagnetic data over the volcano at the 5000, 4000 and 2000 foot levels. Mr. Hook's Cessna 180 was equipped with a video tape recorder and radar altimeter for navigation and a wing tip mounted proton precession magnetometer and chart recorder. The data has been reduced and data analysis is in progress. A computer program in Fortran IV language to calculate the magnetic field over a three-dimensional structure has been written, and various models of Augustine have been tried assuming a uniformly magnetized volcano. This model cannot account for the observed field, so we are now trying a model consisting of a highly magnetized core and the flanks made up of moderately magnetized but random oriented debris underlain by marine sediments. The next step will be to decide whether or not the central parts of the volcano are above or below the Curie point.

5. Seismicity

Two new short-period seismic stations were installed between September 15 and 22, 1975, on the western shore of Cook Inlet at Oil Point, 35 km NNE of Augustine and Bruin Bay, 32 km W of the volcano (see Figure 4, OPT and BNB), which compliment stations SW, S, SE and E of Augustine. Three of the stations are still troubled by interference from new local bush phone VHF transmitters, but we hope to be able to start locating earthquakes below Augustine shortly.

SEISMIC FAN SHOOTING

August, 1975

Figure 3. Location map of shots and seismic stations for the Augustine fan shooting experiments.

Figure 4. Location map of large aperture seismic array surrounding Augustine Volcano.

EXTENSION

Because the second half of the contract was only granted in June, 1975, and thus field work extended into the latter part of September, we had very little time so far to analyze and digest the great amount of geophysical data accumulated. The earthquake seismic data for example is just beginning to flow. Data analysis of the thermal, magnetic and fan shooting data is in progress, but we feel that much could be gained if additional analysis time could be granted before we formulate the renewal proposal. We, therefore, request a no fund extension to the current contract by 6 months. The progress report and renewal proposal would be submitted in due time to begin the new contract on July 1, 1976.

BUDGET

No additional funding is requested at this time.

PERSONAL DATA

NAME: Jorgen Kienle
DATE OF BIRTH: December 7, 1938
PLACE OF BIRTH: Reutlingen, Germany

EDUCATION:

Diploma Earth Sciences, Swiss Federal Institute of Technology (ETH), Zurich, Switzerland, 1964.
Ph.D. Geophysics, University of Alaska, 1969

POSITIONS HELD AND EXPERIENCE:

Air-Photo Interpreter, German Air Force, 1959-1960
Research Assistant in Glaciology, Swiss Federal Institute of Technology (ETH), Zurich, Switzerland, 1961-1964 (during summer months).
Teaching Assistant in Physics, University of Alaska, 1965.
Research Assistant in Geophysics, University of Alaska, 1965-1966.
Senior Research Assistant in Geophysics, University of Alaska, 1966-1968.
Post-Doctoral Research Scientist, Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York, 1968-1970.
Post-Doctoral Fellow in Geophysics, Geophysical Institute, University of Alaska, 1970-1971.
Assistant Professor of Geophysics, Geophysical Institute, University of Alaska, 1971-1974.
Associate Professor of Geophysics, Geophysical Institute, University of Alaska, 1974-present.

PROFESSIONAL ORGANIZATIONS:

American Geophysical Union
American Geological Institute
Alaska Geologic Society

PRESENT RESEARCH INTERESTS:

Geophysical research on active volcanoes in Alaska (seismicity, gravity, geothermics,); marine geophysics (gravity, magnetics, seismic reflection profiling) and crustal structures of island arcs, small ocean basins and continental shelves: Aleutians, Bering Sea, Alaskan continental shelves.

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