GL02567

SEISMIC MONITORING AT RAFT RIVER, IDAHO

## 1.0 INTRODUCTION

In recent years, a sizeable body of literature has accumulated on the subject of induced seismicity which are earthquakes induced, or triggered, by human activity. Induced seismicity has been observed in association with surface reservoir filling activities, mining, underground nuclear testing, fluid withdrawal from the earth, and fluid injection into the earth. None of the above activities is thought to have produced earthquakes directly. Rather, it is thought that these activities have altered a previously existing stress field within the earth sufficiently to allow stress energy to be released in the form of earthquakes.

Most geothermal prospects in the United States are in areas of active faulting. Many geothermal prospects exhibit microearthquake activity as well as large-scale faulting with effects observable at the surface, both of which imply the existence of an active stress field at depth. Fluid withdrawal and (usually) reinjection are necessary for the production of electricity from geothermal fluids. Thus the development of geothermal energy carries with it a high probability of inducing earthquakes. This is a matter of concern from environmental and operational viewpoints.

This proposal addresses a program of seismic monitoring at the Raft River geothermal prospect in southern Idaho. Some testing of the Raft River reservoir has already been done; more production tests are planned. It is important that a baseline of seismological data be obtained prior to continued production. Therefore, it is important for seismic monitoring at Raft River to be resumed rapidly.

## 2.0 PRESENT MONITORING SYSTEM

A three-station seismic array was operated by EG&G personnel at Raft River from 1976 through 1978. Operation was halted in 1978 due to equipment problems, principally with the recording apparatus. On March 21, 1979, Sky Schaff and Alan Fidler of ESL/UURI visited the Raft River site to assess the quality of the seismograms and the state of the equipment.

The seismograms were found to be sufficient to give a qualitative evaluation of earthquake activity, but are not suitable for detailed analysis. The recording equipment appeared functional; its failure was probably due to environmental causes. The electronics at two of the field stations were not available for inspection because they were buried in concrete vaults. Of the electronics that could be inspected, all appeared functional except the seismometers, which had been corroded as a result of burial without protection or maintenance, and the telemetry radios, which had never been licensed and which had interference problems with the site communications radios.

## 3.0 SCOPE OF WORK

The system proposed here to locate and define seismic activity in the Raft River area is hybrid system. Four simgle component stations of the conventional telemetry type, and two digital event recorders each recording three components from a downhole geophone are recommended.

The telemetered stations would record the data from one seismometer, on or very near the ground surface. The analog seismic signal would then be conditioned and transmitted by radio to a collection point, where all four signals would be mixed and re-transmitted. At the next receiving site, the mixed signals would be received and put onto telephone lines for transmission to the University of Utah. The mixed signal would then be recorded onto magnetic tape at the University. The tape would be played back for analysis.

The digital event recorders would contain a microcomputer chip with an algorithm which would constantly search the incoming seismometer signal for earthquakes. When an event passes the algorithm's test, it would be written onto a cassette tape. Tapes would be changed periodically, and transmitted by non-dedicated telephone line to the University of Utah, where they would be recorded and then fed into a computer for analysis. The digital event recorders would record three components of motion, allowing better discrimination of the nature of the seismic waves. The digital format would preserve the higher frequencies in the seismic spectrum and would have a greater dynamic range to permit recording a larger range of magnitudes of earthquakes. Geophones would be placed downhole if possible to minimizes the problem of high-frequency attenuation and to increase the signal-to-noise ratio by about 32dB. Most seismic noise travels in the near-surface layers.

An description of tasks to be performed is as follows:

Task 1: Detailed Equipment Scoping

The present buried equipment will be exhumed tested and repaired or replaced

Task 2: Siting and Installation

Sites for the telemetered stations will be chosen and the stations installed; boreholes for the digital stations will be selected and the stations will be installed. Note that the cost and time to obtain of new boreholes, if no those existing holes at Raft River are satisfactory, is not addressed in this proposa.

Task 3: Data Transmission

Radio links will be designed, permitted (by DOE), and installed to telemeter the analog data to the University of Utah campus. Telephone-interfacing equipment will be installed at the Raft River site and at the University of Utah campus, and arrangements will be made for the site operator to change tapes and transmit them to Salt Lake City. The cost of an on-site operator is not included in this proposal. It is assumed that this operator will be furnished by DOE.

Task 4: Recording

The analog data will be recorded on an existing DOE-supported analog FM tape recording system and onto 24-hour helicorder records at the University of Utah; the digital data will be recorded on cassettes on site and telephoned to Salt Lake City.

Task 5: Analysis

Using the helicorder records as a guide, a analyst will play out all events from analog magnetic tape onto a chart recorder, producing the seismograms. These seismograms will then be analyzed to provide accurate hypocenters, focal mechanisms, and occurence statistics for seismic events. Hypocenters will be calculated using linear regression of P and S times, and using linear inversion when sufficient data becomes available. Hypocentral location provides data on fault-plane location; and focal mechanism studies provide information on fault plane orientation and the regional stress field; occurrence statistics are useful for estimating arthquake recurrence intervals. All the above will be used in an attempt to develop discrimination criteria to distinguish between natural and induced earthquakes.

Task 6: Reporting

An annual summary of activity and report will be prepared; periodic reports of unusual or otherwise interesting activity will be issued.

## 3.0 PROPOSED BUDGET FOR FY79

| | | |
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| A. Salaries | | $16,400 |
| 1. Seismologist 3 mo → 1 | | |
| 2. Analyst 4 mo → 1 | | |
| 3. Technician 4 mo → 4 | | |
| B. Employee Benefits | | $ 3,930 |
| 1. 24% of Wages and Salaries | | |
| C. Total Salaries, wages, and benefits | | $20,330 |
| D. Permanent Equipment | | $37,075 |
| 1. Field, Telemetered | | |
| a. 4 Transmitters (Monitor T16F, 0.100W) @ $410 | $ 1,640 | |
| b. 4 Receivers (Monitron R16F) @ $585 | 2,560 | |
| c. 1 VCO-Preamp (Geotech 42.50-1 amplifier, 46.22 VCO) @ $540 | 540 | |
| d. 4 Sesimometers (Geotech S-500) @ $420 | 1,680 | |
| e. 3 Antenna-pairs (Scala Radio 2CA5-150) | | |

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| @ $310/pair | 930 | |
| 2. Field, Digital | | |
| a. 2 Recorders (Geotech MCR-600) @ $5995 | $11,990 | |
| b. 2 Geophones (Geo-Space HS1, 3 component High-temp) @ $850 | 1,700 | |
| c. 1 Time Cude (Geotech TE-120) @ $480 | 480 | |
| d. 6 Preamplifiers (Geotech 42.50) @ $275 | 1,650 | |
| 3. Transmission, Telemetry | | |
| a. 1 Transmitter (Monitron T16F-27-37; 10.0W) @ $575 | $ 575 | |
| b. 1 Receiver (Monitron R16F) @ $585 | 585 | |
| c. 1 Antenna-pair (Cala Radio 2CA5-150) @ $310 | 310 | |
| d. 1 Power supply and enclosure @ $165 | 165 | |
| 4. Transmission, Digital | | |
| a. 2 Recorders (Geotech MCR-600) @ $5,995 | $11,990 | |
| b. 1-Interface cable, MCR-600 to PRIME 400 @ $280 | 280 | |
| E. Expendable Supplies and Equipment | | $12,471 |
| 1. Materials for Field/Recording Installations | | |
| a. 4 Seismometer vaults w/hardware @ $75 | $ 300 | |
| b. 15 Reels magnetic tape @ $97 | 1,455 | |
| c. 40 Air Cell batteries @ $65 | 2,600 | |
| d. 40 Rolls chart paper @ $23 | 920 | |
| e. 700 Sheets helicorder paper, @ $28/hundred | 196 | |
| f. 200 Cassettes @ $10 | 2,000 | |
| g. 1000' High-temp cable @ $1.10/ft | 1,100 | |
| h. 2 Geophone calmps @ $450 | 900 | |
| 2. Spare parts and electronic supplies | 1,200 | |
| 3. Equipment repair and maintenance | 1,200 | |
| 4. Office supplies, communications, misc. supplies | 600 | |
| F. Travel (incident to site selection and installation, network maintenance and calibration, and field research) | | $ 7,086 |
| 1. Field Vehicle | | |
| a. 4 mo lease @ $247/mo | $ 996 | |
| b. 18,000 mi @ $0.18 | 3,240 | |
| 2. Per Diem (70 man-days @ $35) → cut by zero | 2,450 | |
| 3. Scientific Meetings (1) | 400 | |
| E. Report and Publication Costs | | $ 700 |
| H. Computer Costs | | $ 1,800 |
| I. Other Costs | | $ 1,200 |

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| | 1. Telephone line from Ogden to Salt Lake City | $ 1,200 | |
| J. | Indirect Costs | | $12,198 |
| | 1. 60% of Salaries, Wages and Employee Benefits | $12,198 | |
| K. | Total Direct and Indirect Costs | | $92,860 |
| L. | Management Allowance @ 7% | | $ 6,500 |
| M. | Total Project Costs | | $99,360 |