G101167

STANDARD FORM 26, JULY 1966
GENERAL SERVICES ADMINISTRATION
FED. PROC. REG. (41CFR) 1-16.101

AWARD/CONTRACT

PAGE 1 OF

1. CONTRACT (Proc. Inst. Ident.) NO.	2. EFFECTIVE DATE	3. REQUISITION/PURCHASE REQUEST/PROJECT NO.	4. CERTIFIED FOR NATIONAL DEFENSE UNDER BDSA REG. 2 AND/OR DMS REG. 1. RATING: N/A
EG-77-C-08-1527	9/15/77	RFP EY-R-08-0007	

5. ISSUED BY CODE
U. S. Energy Research & Development Admin.
Nevada Operations Office
P. O. Box 14100
Las Vegas, Nevada 89114

6. ADMINISTERED BY (If other than block 5) CODE

7. DELIVERY
[X] FOB DESTINATION
[ ] OTHER (See below)

8. CONTRACTOR NAME AND ADDRESS CODE FACILITY CODE
(Street, city, county, State, and ZIP code)
Seismic Exploration, Inc.
717 South 300 West
Salt Lake City, Utah 84101

9. DISCOUNT FOR PROMPT PAYMENT

10. SUBMIT INVOICES (4 copies unless otherwise specified) TO ADDRESS SHOWN IN BLOCK 12
In duplicate

11. SHIP TO/MARK FOR CODE
See attached Schedule

12. PAYMENT WILL BE MADE BY CODE
U. S. Energy Research & Development Admin.
Finance Division
P. O. Box 14100
Las Vegas, Nevada 89114

13. THIS PROCUREMENT WAS [ ] ADVERTISED, [X] NEGOTIATED, PURSUANT TO:
[ ] 10 U.S.C. 2304 (a)( )
[X] 41 U.S.C. 252 (c)(10)

14. ACCOUNTING AND APPROPRIATION DATA

15. ITEM NO.	16. SUPPLIES/SERVICES	17. QUANTITY	18. UNIT	19. UNIT PRICE	20. AMOUNT
	This Contract EG-77-C-08-1527 consists of (1) Schedule (2) General Provisions, Standard Form 32 with Alterations and Additions thereto, and (3) Appendix B, Intellectual Property Clauses; all as attached hereto and made a part hereof with Article B-6 "Rights in Technical Data" of Appendix B amended as follows: Paragraphs g and h are deleted and the first three lines of paragraph e "Withholding of Proprietary Data" are revised to read: "Except as provided in the Article entitled 'Deliverables' the Contractor - - -"				

21. TOTAL AMOUNT OF CONTRACT $ 11,740.00

CONTRACTING OFFICER WILL COMPLETE BLOCK 22 OR 26 AS APPLICABLE

22. [X] CONTRACTOR'S NEGOTIATED AGREEMENT (*Contractor is required to sign this document and return* 2 *copies to issuing office.*) Contractor agrees to furnish and deliver all items or perform all the services set forth or otherwise identified above and on any continuation sheets for the consideration stated herein. The rights and obligations of the parties to this contract shall be subject to and governed by the following documents: (a) this award/contract, (b) the solicitation, if any, and (c) such provisions, representations, certifications, and specifications, as are attached or incorporated by reference herein. (*Attachments are listed herein.*)

26. [ ] AWARD (*Contractor is not required to sign this document.*) Your offer on Solicitation Number _____, including the additions or changes made by you which additions or changes are set forth in full above, is hereby accepted as to the items listed above and on any continuation sheets. This award consummates the contract which consists of the following documents: (a) the Government's solicitation and your offer, and (b) this award/contract. No further contractual document is necessary.

23. NAME OF CONTRACTOR Seismic Exploration, Inc.
BY Lewis J. Katz (Signature of person authorized to sign)

27. UNITED STATES OF AMERICA
BY _____ (Signature of Contracting Officer)

24. NAME AND TITLE OF SIGNER (Type or print)	25. DATE SIGNED	28. NAME OF CONTRACTING OFFICER (Type or print)	29. DATE SIGNED
Lewis J. Katz (President)	9/22/77	Robert W. Taft, Assistant Manager for Plans, Engineering & Budgets	9/7/77

26-105

U.S. GOVERNMENT PRINTING OFFICE : 1967 O--289-055

SCHEDULE

Article 1 STATEMENT OF WORK

The Contractor shall conduct a Seismic Emissions Study at Roosevelt Hot Springs, Milford, Utah, in accordance with its proposal dated May 26, 1977, submitted in response to RFP EY-77-08-0007. Three arrays will be used to map a 20,000 X 20,000 ft. area in T.26S., R.9W. Secs 13 through 36 and T.27S., R.9W. Secs 1 through 6 and the northern half of section 7 through 12. In addition, a fourth array will be used to map a 30,000 X 30,000 ft. area which will overlap the previous area as well as extend 10,000 ft. to the south. The area to be mapped shall be as shown on Figure No. 1, attached. In addition the Contractor shall perform the computer reduction of all field data and prepare the study which shall include maps showing the seismic emission plots.

Article 2 DELIVERABLES

Within 90 days after the effective date of the Contract, the Contractor shall provide to the ERDA on a non-proprietary basis irrespective of paragraph e, "Withholding of Proprietary Data" of Article B-6, "Rights in Technical Data" of Appendix B of this Contract, the Seismic Emissions Study and all relevant data

resulting from the performance of the program provided for in the Article entitled "Statement of Work." Six copies of the study and other data, one of each of the field tapes and one copy of the computer program on cards to permit viewing of field tapes on the University of Utah's Univac 1108 computer will be forwarded to:

Mr. James B. Cotter, Chief
Energy Research Projects Branch
U. S. Energy Research & Development Admin.
P. O. Box 14100
Las Vegas, Nevada 89114

Article 3 COMPENSATION

Upon delivery to and acceptance by ERDA of the data to be provided in accordance with the article of this Contract entitled "Deliverables," the Contractor shall be paid the lump sum amount of $11,500 plus $240.00 for all field tapes.

SEISMIC
EXPLORATION
INC.

717 SOUTH 300 WEST
SALT LAKE CITY, UTAH 84101

Roosevelt Hot Springs
Milford, Utah

▬▬-outlines 20,000 x 20,000 ft. area to be surveyed using 3 arrays.

■■■■-outlines 30,000 x 30,000 ft. area to be surveyed using one array.

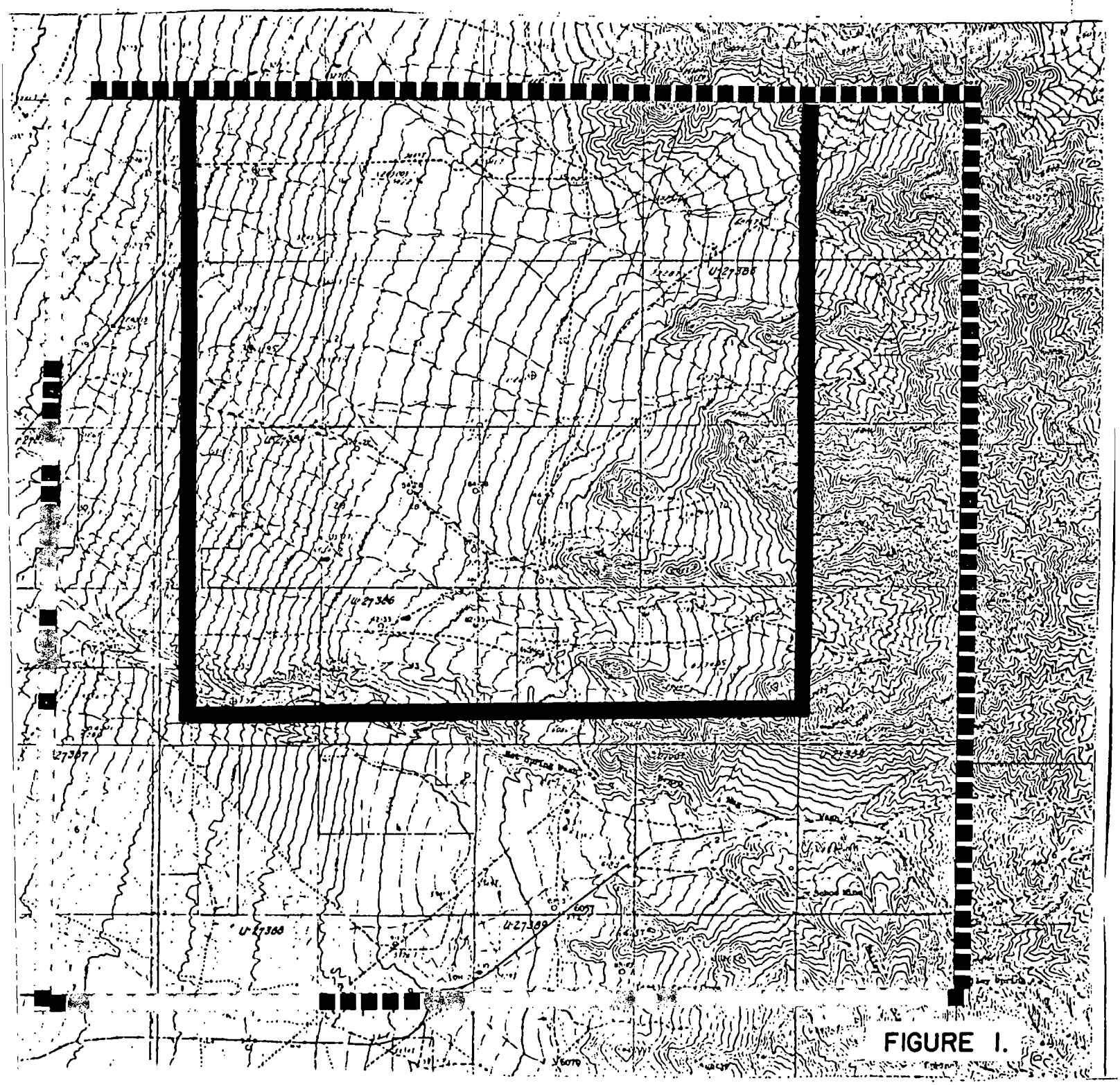


FIGURE 1.

5/E

SEISMIC
EXPLORATION
INC.

717 SOUTH 300 WEST • SALT LAKE CITY, UTAH 84101 • (801) 364-2082

May 26, 1977

Mr. James Cotter
Chairman, Source Evaluation Panel
U.S. Energy and Development Administration,
Nevada Operations Office
P.O. Box 14100
Las Vegas, Nevada 89114

Re: RFP EY-R-08-0007

Dear Mr. Cotter:

Enclosed please find 10 copies of our proposal for a "Seismic Emissions Study at Roosevelt Hot Springs, Milford, Utah." This proposal was prepared by us on behalf of Union Oil of California. Because of the lack of time between the due date of this proposal and the decision to submit it, it was felt that Seismic Exploration Inc. would be more likely to meet the proposal deadline than Union Oil Co. All correspondence and inquiries regarding this proposal should be directed to the undersigned. Confirmation of Union Oil Company's participation in this proposal can be obtained by contacting Mr. Neil Stefanides, Union Oil Co. of California, P.O. Box 7600, Los Angeles, Calif. 90054 or calling him at (213)486-7740.

Very truly yours,

Lewis Katz

SEISMIC EXPLORATION INC.
Lewis Katz
President

LK:ec

PROPOSAL FOR A SEISMIC EMISSIONS STUDY AT ROOSEVELT HOT SPRINGS MILFORD, UTAH

Submitted in Response to:

RFP EY-R-08-0007
U.S. Energy Research and
Development Administration
Nevada Operations Office
Las Vegas, Nevada 89114

Submitted by:

SEISMIC EXPLORATION INC.
717 South 300 West
Salt Lake City, Utah 84101

On Behalf Of:

UNION OIL COMPANY OF CALIFORNIA
P.O. Box 7600
Los Angeles, California 90054

May 1977

Lewis J. Katz
President
(801)364-2082

Introduction:

Seismic Exploration Inc. (SEI) proposes to conduct a Seismic Emissions Study at Roosevelt Hot Springs, Milford, Utah. The area of study is shown on the enclosed map and includes T.26 S., R. 9W., Secs. 13 through 36 and T. 27 S., R. 9W., Secs. 1 through 6 and the northern half of sections 7 through 12.

The region outlined in blue on the map will be subjected to a more detailed investigation. The orange area was included so that the survey could be tied into known productive wells in the southern portion. Union Oil Company holds leases on T. 26 S., R. 9W., Secs. 15, 21, 22, E 1/2 17 and E 1/2 20.

Significance of Proposal:

A Seismic Emissions Study is used to delineate zones of faulting and fractures. These fractures are necessary for permeability and production. For example, Phillips Petroleum drilled several wells at Roosevelt Hot Springs. Well 13-10 (see enclosed map) was productive encountering a fracture zone, whereas, Well 9-1 1/2 mile to the east was non-productive, not having permeability, even though it had a sufficient source of heat. Thus, in this geological region, for well site locations and reservoir assessment, zones of fractured granite must be delineated.

Program Description:

The program is described in Exhibit A (letter to Union Oil Co.) and Exhibit B (Seismic Emisssions Study) which are attached.

Schedule:

Data acquisition, processing and interpretation will take approximately 10 weeks to complete. Depending on availability of field crew, field work will start about one month after contract is awarded.

Cost Proposal:

Seismic Exploration proposes to perform this survey at a fixed price of $23,000.00. This price is based on our published price of $21,000.00 for mapping a 20,000 x 20,000 ft. area plus an additional $2,000.00 charge for one array being 30,000 x 30,000 ft.

Union Oil Co. of California has verbally agreed to pay 50% of the above cost providing ERDA pays the remaining 50%. Thus, the cost to ERDA would be $11,500.00. This price will remain fixed for 90 days. If ERDA wishes to purchase field tapes, an additional charge of $12.00/tape will be incurred.

Cost Proposal: (Continued)

A letter confirming Union Oil Company's participation in this proposal can be obtained by contacting Mr. Neil Stefanides, Union Oil Co., P.O. Box 7600, Los Angeles, Calif. 90054 or calling him at (213)486-7740.

SECTION 3 - CORPORATE DESCRIPTION

3.1 SEISMIC EXPLORATION INC.

Seismic Exploration Inc. (SEI), a subsidiary of ENSCO, Inc. of Springfield, Virginia, provides passive seismic services to major oil and mining companies, as well as government agencies such as The U.S. Geological Survey and Nuclear Regulatory Commission. Members of SEI's technical staff have considerable experience in instrumentation, seismology, geothermal exploration, and computer processing. They have performed over three dozen passive seismic surveys involving the analysis of more than 2,000 groundnoise spectra and the locations of several hundred microearthquakes.

SEI has developed unique technology in geothermal and mining exploration in which it presently holds several contracts from private industry. Currently, SEI has a contract from the Nuclear Regulatory Commission for groundmotion investigations and is doing seismic monitoring under a U.S. Geological Survey Contract.

3.2 ENSCO, INC.

ENSCO, Inc. is a research and engineering firm located in suburban Washington, D.C. Founded in 1969, it is a privately owned firm which conducts business with Federal and State governments as well as with industry. Currently, ENSCO has 200 employees and has experienced continued growth from its initial staff of four employees. In general, members of the professional staff have backgrounds in engineering,

mathematics, and the physical sciences. The average senior staff member has over fifteen years of professional experience. ENSCO maintains a Top Secret facility clearance.

ENSCO's experience in the field of seismology includes studies of seismometers, development of seismic data processing techniques, analysis of received seismic signals, and the development of computer based systems. Many of ENSCO's personnel are thoroughly experiences in seismic array data analysis and processing techniques.

SEI maintains a close technical liaison with ENSCO's Information and System Sciences Division (ISS). The primary interest of ISS is geophysical research, data processing, and system development. Their research emphasis is on developing and implementing improved ways of processing seismic, magnetic, acoustic, and infrared data. They are currently applying new signal processing methods to magnetotelluric data and seismic noise data related to identifying and evaluating geothermal systems.

EXHIBIT A

Letter to Union Oil Company

SEISMIC
EXPLORATION
INC.

717 SOUTH 300 WEST • SALT LAKE CITY, UTAH 84101 • (801) 364-2082

May 20, 1977

Mr. Neil Stefanides
Union Oil Company of California
P.O. Box 7600
Los Angeles, California 90054

Dear Neil:

This letter will confirm our telephone conversation of this date. Seismic Exploration Inc. proposes to perform a Seismic Emissions Study at Roosevelt Hot Springs, Utah for a total cost of $23,000.00. The area to be surveyed is outlined on the enclosed map in blue. Three arrays will be used to map this 20,000 x 20,000 ft. area. In addition, a fourth array will be used to map a 30,000 x 30,000 ft. area which will overlap the previous area as well as extend 10,000 ft. to the south. This overlapping region is outlined in orange on the enclosed map and will include several productive wells.

If you should have any questions please feel free to call me. We look forward to the possibility of working for you on this project.

Very truly yours,

Lewis Katz

SEISMIC EXPLORATION INC.
Lewis Katz

LK:ec

EXHIBIT B

SEISMIC EMISSIONS STUDY

SEISMIC
EXPLORATION
INC.

717 SOUTH 300 WEST • SALT LAKE CITY, UTAH 84101 • (801) 364-2082

SEISMIC EMISSION STUDIES

Seismic Exploration Inc. (SEI) is presently offering its customers a new geothermal exploration tool. This new passive seismic method developed through the research efforts of ENSCO Inc. is designed to accurately delineate the source location of Seismic emissions. These emissions are believed to be associated with zones of finite fractures or movement within the conduits of the geothermal system. A survey of this type is intended as a tool for well site positioning. Results of this method to date have been quite impressive indicating a powerful new tool for geothermal exploration.

Some advantages of these surveys include:

- Three dimensional location of seismic noise sources in geothermal regions.
- Spatial distribution allows discrimination of geothermally produced seismic emissions from those produced by cultural sources.
- Elimination of ground amplification problems which plague conventional noise surveys.
- Identification of the more prevalent but lower magnitude seismic events through sensitive multi-station array processing.

A formal description of these surveys is attached.

SEISMIC EMISSIONS STUDY

Background

Recently, the successful use of high amplitude groundnoise surveys in delineating geothermal reservoirs has come to light. Phillips Petroleum Company has reported at several meetings (AAPG, 1976; 1976 Rock Mechanics Meeting-Snowbird, Utah) that a groundnoise survey at Roosevelt Hot Springs, Utah was instrumental in delineating faults and fracture zones needed for production. Beyer et al. (1976) documents the use of this technique at Leach Hot Springs, Nevada and Combs and Hadley (1977) show a good correlation with high heat flow zones and groundnoise anomalies at East Mesa, Imperial Valley, California.

Combs and Hadley (1977) report recording small magnitude (<0) nanoearthquakes at the East Mesa geothermal anomaly. They also report "a coincidence between areas of high seismic noise and areas of microearthquake activity . . . . Enhanced seismic groundnoise probably caused by surface wave phenomena associated with the continuous occurring nanoearthquakes." It is our belief that seismic emissions (groundnoise) in the vicinity of geothermal anomalies are not surface waves but a continuous stream of seismic events smaller than the discrete nanoearthquakes of Combs and Hadley. This hypothesis is based on the findings of Iyer and Hitchcock (1976) at Long Valley, California and Katz (1976) at Neels, Utah who found that groundnoise near geothermal anomalies indicate a predominance of P-wave motion rather than surface wave motion. In addition, recurrence curves (Figure 1) indicate statistically that the number of seismic events increase as the magnitude of events decrease. Theoretically, therefore, extremely low magnitude events would occur in the thousands

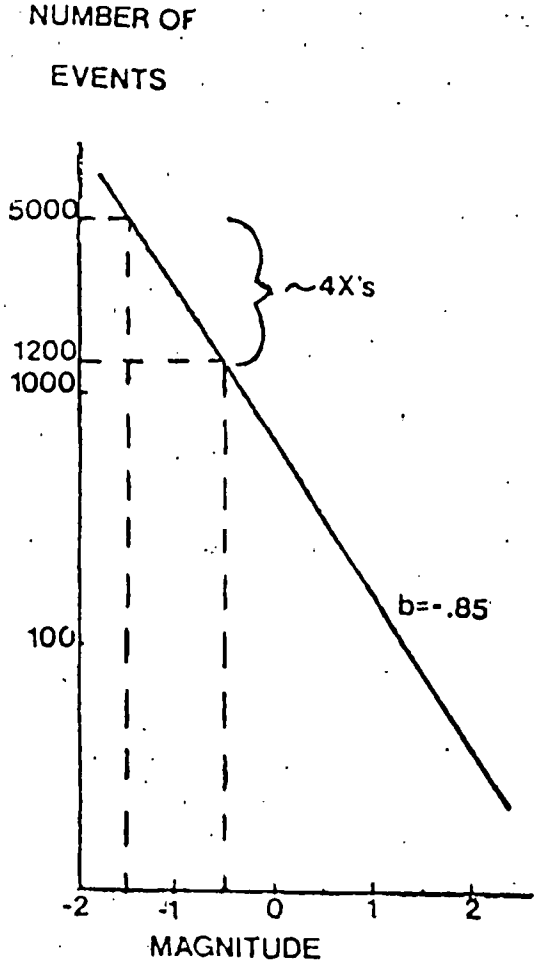
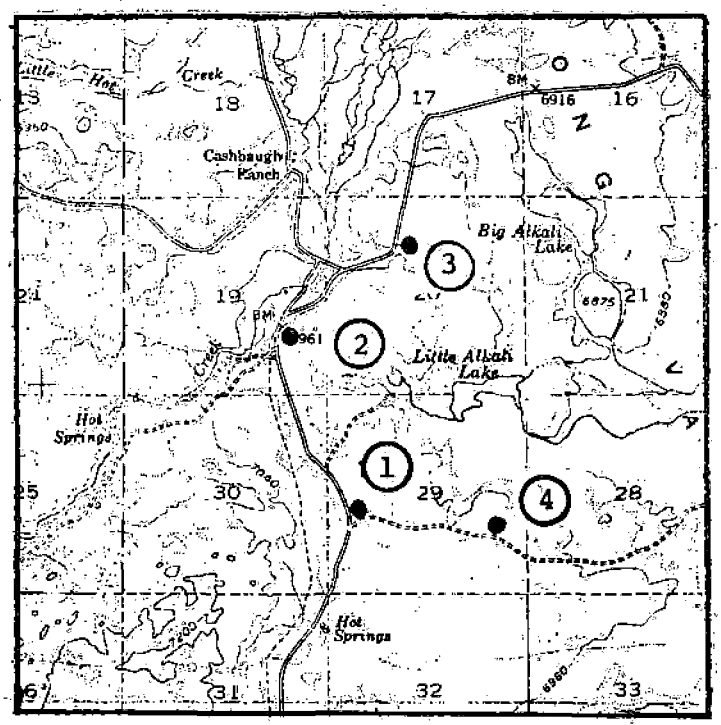


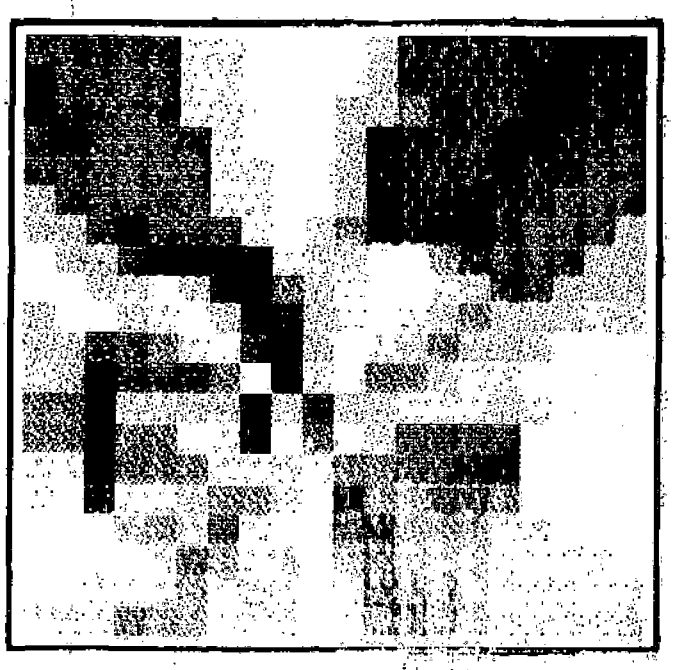
Fig. 1. Recurrence curve, Calif.

perhaps continuously in the form of microtremors (groundnoise). The following paragraphs describe an improved seismic emission (groundnoise) mapping technique offered exclusively by Seismic Exploration Inc.

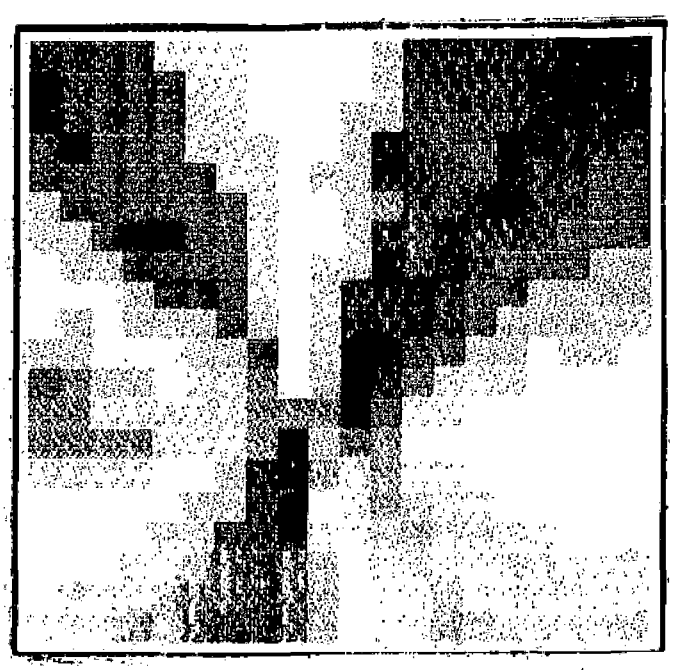
Iyer and Hitchcock (1976) observed that microtremor (groundnoise) data recorded at Long Valley, California were coherent. This meant that array processing techniques could be developed to locate or track the source location (hypocenter) of these events. A U.S.G.S. contract was let to ENSCO, Inc. to develop an array processing algorithm for this purpose. ENSCO worked on the software while its subsidiary, Seismic Exploration Inc. (SEI), developed a sophisticated digital field acquisition system needed to properly acquire microtremor data. Data were then collected at Long Valley, California by SEI and processed by ENSCO. Results are shown in the seismic emissions plot of Figure 2. The darker squares represent higher seismic activity and delineate active faults and hot springs in the area. The group of four dark squares in the southwest portion of the map coincide with the major hot spring (Gorge) in this region and is detected over a mile from the array. Note evidence of the hot spring is diminished in the map computed at 4000'. The line of darkened squares trending northwest agrees in general with the Cashbaugh low resisitivity anomaly (Stanley et al., 1976) and several hot springs indicating a possible zone of fracture permeability. The northeast trending squares agree with a series of hot springs located north of Little and Big Alkali Lake (Sorey and Lewis, 1976), Figure 3. At 4000', a feature in the lower center of the map emerges and is in the vicinity of another known fault (Hilton Creek) and hot spring.



Region of Long Valley Surveyed



Seismic Emission Plot at 2000' Depth



Seismic Emission Plot at 4000' Depth

Figure 2

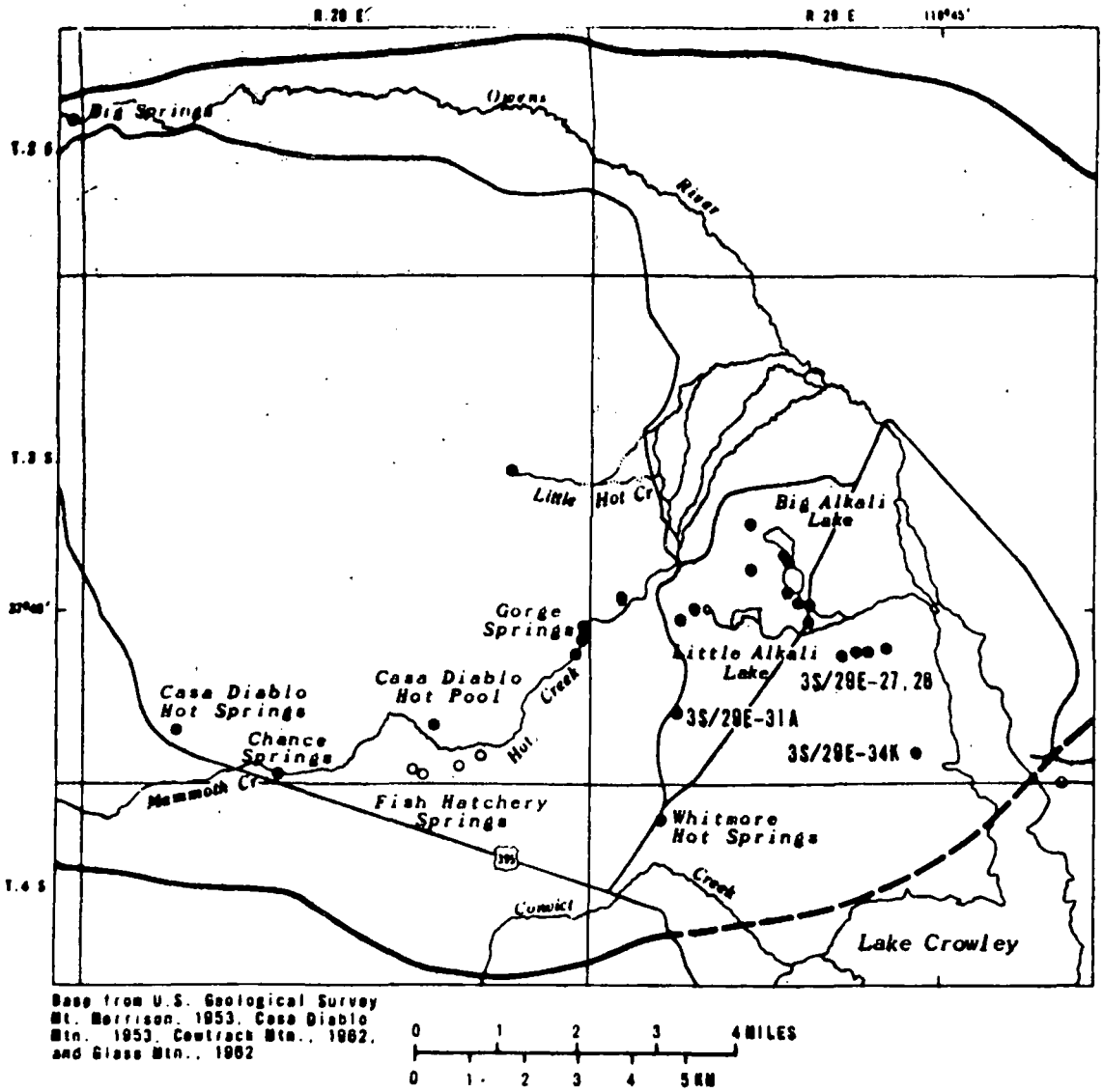


Fig. 1. Map of thermal springs in Long Valley caldera. Solid circles show hot springs or groups of hot springs, and open circles show cold or slightly thermal springs or groups of springs. The thick solid line is the caldera boundary, and it is dashed where the boundary is approximately located.

Fig. 3. Sorey and Lewis: Long Valley Symposium.

Data Acquisition

Six instrument arrays are deployed by SEI to gather field data. Each array consists of 5 Sprengnether MEQ-800 microearthquake recording systems, together with Datamagnetics digital tape recorders. Individual recording systems are synchronized with a radio telemetry system so that absolute relative timing can be obtained by broadcasting time marks every hour. Stations are occupied until satisfactory data quality is observed on smoked paper records used for field monitoring.

Data Processing

Field data are first edited by picking quiet sections from the smoked paper records. These sections are stripped out and re-edited. Data from five arrays are chosen for processing.

Data processing and analysis incorporates multi-station array focusing techniques and stochastic averaging. Seismic array analysis involves the focusing of an array of geophones to a volume element centered at $\bar{r}$, through use of differential time information. Power emitted from this volume is computed and a source power map is obtained.

Typically, three 30 x 30 arrays of possible source locations (hypocenters) are chosen. Horizontal resolution is 1000 feet and vertical 2000 feet. That is, three 30,000 x 30,000 foot horizontal maps will be generated at depths of 2000, 4000 and 6000 feet. Each array is focused on 2700 possible source locations points by using a ray-tracing algorithm to calculate P-wave travel times from each point to each geophone position used in the correlation procedure. Recorded traces are then shifted by the appropriate delay times and multi-station correlations performed

for each array (13,500 correlations for five arrays). A listing of individual delay times, correlation values, and graphic plots are produced.

References

Bailey, R. A., Dalrymple, G. B., and M. A. Lanphere (1976). Volcanism, structure, and geochronology of Long Valley Caldera, Mono County, California, J. Geophys. Res., V. 81.

Combs, J. and D. Hadley (1977). Microearthquake investigation of the Mesa geothermal anomaly, Imperial Valley, California, Geophysics, V. 42.

Iyer, H. M., and T. Hitchcock (1976). Seismic noise survey in Long Valley, California, J. Geophys. Res., V. 81.

Katz, L. J. (1976). Microtremor analysis of local geological conditions, Bull. Seis. Soc. Am., V. 66.

Stanley, W. D., Jackson, D. B., and Z. Zohdy (1976). Deep electrical investigations in the Long Valley geothermal area, California, J. Geophys. Res., V. 81.

Sorey, M. L. and R. E. Lewis (1976). Convective heat flow from hot springs in the Long Valley Caldera, Mono County, California, J. Geophys. Res., V. 81.