U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

JORDAN SEISMIC SYSTEM

FINAL PROJECT REPORT

by

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PROLOGUE

SELECTED PHOTOGRAPHS ON THE EFFECTS

OF EARTHQUAKES IN THE MIDDLE EAST

PREFACE

Formal activities with the Natural Resources Authority (NRA) of the Hashemite Kingdom of Jordan were initiated with a Project Implementation Order/Technical Services PIO/T No. 278-0258-2-20001 signed by USAID/Jordan on August 2, 1982. This document was a request to negotiate a PASA with the U.S. Geological Survey (USGS) to provide technical assistance, equipment and training to the NRA, through the National Planning Council (NPC), to establish a Jordan Seismic System (JSS). The initial PASA IJO-0258-P-IC-2198-00 was agreed to on September 27, 1982. The concept of the JSS was a cooperative effort between the NRA and the USGS, centered around a report entitled "A Proposal for the Development and Installation of the Jordan Seismic System (JSS) with Emphasis on Earthquake Risks, Crustal Structure and Geothermal Energy". This report forms Appendix B of this document.

A subsequent Memorandum of Understanding was signed between the NRA and the USGS on April 25, 1985, and a Project Implementation Plan between the USGS and the NRA was agreed to by both parties on June 12, 1986. There have been several time-continuing amendments to the original PASA together with the additional request under Jordan CIP Grant 278-K-643 to provide field equipment to facilitate the work of the NRA. These procurements involved a strong-motion seismic system; additional stations for the Jordan microseismic network and geophysical, laboratory and peripheral equipment. However, this report only summarizes the activities of the earthquake monitoring in Jordan.

Many people have contributed to the success of this project. Acknowledgment is given to the previous Minister of Energy and Mineral Resources, Dr. Hisham Khatib. From the NRA, particular thanks go to Engrs. Y. Nimry and K. Jreisat, Director Generals, for their patience and wisdom, Deputy Director General M. Abu-Ajamieh for his vision, Kays El-Kaysi who saw this project to fruition and M. Jaradat, Head of the Seismology Division. Gordon Andreasen, USGS (retired), was instrumental in the success of this project. His tact and diplomacy can never be replaced and we wish him well.

We also want to acknowledge the following USGS personnel who participated in many facets of the project. John Van Schaack, John Coakley and Robert McClearn were responsible for the seismic instrumentation, telemetry and parts of the field installation. Willie Lee and Will Kohler made invaluable contributions to the software for seismic analyses. Mark Gettings assisted in much of the early day to day observatory operations in Jordan. Frederick Simon, Chief, Middle Eastern and African Geology, was an invaluable interface between the USGS, and the NRA and USAID/Jordan.

Acknowledgment is also given to Project Officers Zachary Hahn, Stan Stalla, Thomas Pearson, Lyle Weiss and Aylette Villemain of USAID/Jordan and Lewes Reade, AID Mission Chief, Amman, who oversaw various stages of the project.

THE JORDAN SEISMIC SYSTEM

EXECUTIVE SUMMARY

The Jordan Seismic System can trace their beginnings back to 1981 with an Interagency Agreement between the U.S. Geological Survey, Department of Interior and the Graduate School, U.S. Department of Agriculture to provide services aimed at ultimately establishing a microseismological network in Jordan. Professor Robert L. Kovach of Stanford University visited Jordan in August 1981 culminating in a proposal for the Development and installation of the Jordan Seismic System with emphasis on Earthquake Risks, Crustal Structure and Geothermal Energy. This proposal subsequently led, through funding from USAID and the NRA, for the purchase and installation of a 32-station microseismic network in Jordan.

This report summarizes the technical and scientific results attained to date beginning with a description of the seismic network and some recommendations for future work. The Jordan Seismic System provides an unusual avenue for the future training of Jordanian scientists and technicians and allows for fruitful international scientific dialogue and exchange of seismological data in a global format.

List of Abbreviations and Acronyms

A	Peak Ground Acceleration, cm/sec^2
A/D	Analog to Digital
B.S.	Bachelor of Science Degree
CIP	Commodity Import Program
FM	Frequency Modulation
FY	Fiscal Year
g	Earth's Gravitational Acceleration, 980 cm/sec^2
GOJ	Government of Jordan
I_{MM}	Mercalli Intensity
ISC	International Seismological Centre
JD	Jordanian Dinars
JSO	Jordan Seismological Observatory
JSS	Jordan Seismic System
M_L	Local Earthquake Magnitude
M.S.	Master of Science Degree
NRA	Natural Resources Authority, Jordan
PASA	Participating Agency Support Agreement
PC	Personal Computer
Ph.D.	Doctor of Philosophy Degree
R & D	Research and Development
USAID	United States Agency for International Development
USGS	United States Geological Survey
UT	Universal Time
VCO	Voltage Controlled Oscillator

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Damage in Kahk from Dasht-E Bayaz, Iran Earthquke, August 31, 1968. M=7.3, 12,100 Casualties

Damage to Central Tea House, Kakhk, Iran
August 31, 1968

Damage to Palace Hotel in Jericho

Jordan Valley Earthquake, July 11, 1927. M=6.2

Damage in Jericho, Jordan Valley Earthquake
July 11, 1927

Damage in Jericho, Jordan Valley Earthquake
July 11, 1927

1. Introduction

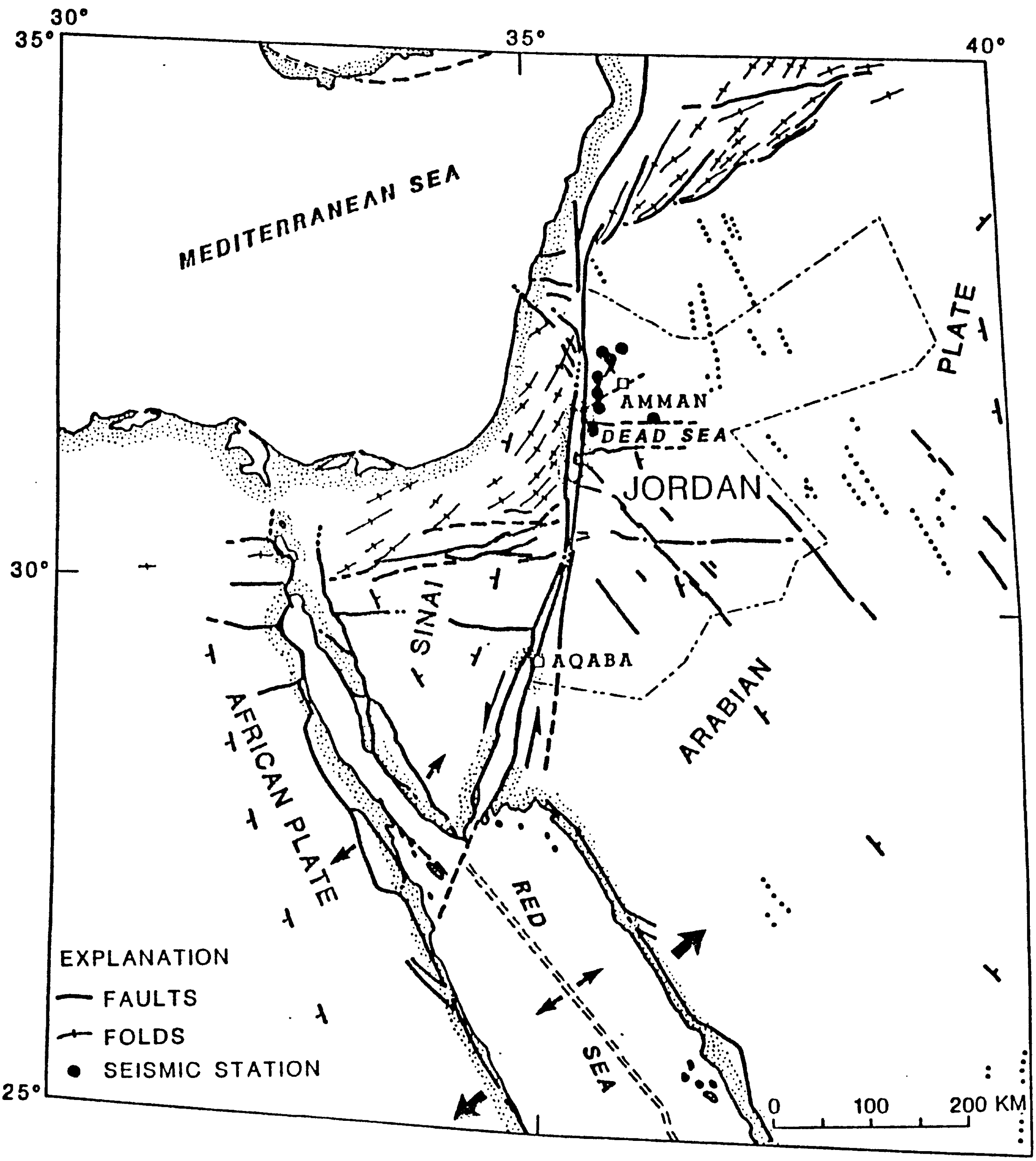
A. Background

The Dead Sea Rift zone extends northward from the northern end of the Red Sea for a distance in excess of 800 km. Several linear topographic fault controlled depressions are present along a great portion of this fault zone. Within the purview of plate tectonics, the Dead Sea Rift is a transform plate boundary connecting the Red Sea, where crustal spreading is occurring, northward to a zone of plate convergence. The Arabian plate lies to the east of the rift whereas on the west several smaller plates, the largest of which is the Sinai microplate, form a part of the larger African plate (Figure 1).

Although the geology of Jordan is mapped and quite well known (e.g. Bender, 1974), the pattern of earthquake activity, in particular, its temporal and spatial characteristics and its relationship to the geologic and tectonic framework of Jordan have not been well documented; this is primarily due to the absence of a seismograph network in Jordan. Previous studies of the seismicity of this region have shown that much of the measured earthquake activity correlates well with the dominant tectonic feature of the area, the Dead Sea Rift (Arieh, 1967; Wu et al., 1973; Ben-Menahem et al., 1976).

Studies of the seismicity, however, suggest results which are not compatible with the inferred rate of slip that is occurring along the Dead Sea Rift plate boundary (Freund et al., 1968). On the other hand, geological and magnetic evidence point to a relative rate of plate movement of 4-6 mm/yr along the rift boundary (Girdler and Styles, 1974; Hatcher et al., 1981), and a total strike-slip movement of approximately 107 km has been indicated by matching magnetic anomalies across the rift. However, the rate of slip calculated from seismic data as a function of time yields an average slip rate of only 1-3 mm/yr (Kovach, 1979; Ben-Menahem, 1981 ab). One is therefore forced to conclude that the region is probably accumulating strain energy for a future large earthquake. Other explanations, that the opening of the Red Sea has slowed significantly in historic time or that strain is being released as aseismic slip (North, 1974) or distributed slip is taking place (Kovach et al., 1985), are considered less likely.

Figure 1: Geographic location of the Dead Sea Rift Zone. The Rift Zone is the major N-S fault zone shown on the western border of Jordan. The locations of the initial seismic stations in Jordan are shown by the larger solid circles. The smaller solid circles are volcanic domes. Compare the figure with Figure 3 showing the currently operating stations in Jordan.



Clues to the pattern of seismicity can be gleaned from the historical record, and a large amount of literature is available for careful scrutiny. Three main sources of data include: (1) earthquake listings or catalogs; (2) descriptions of specific events, and (3) inferences from archaeological excavations.

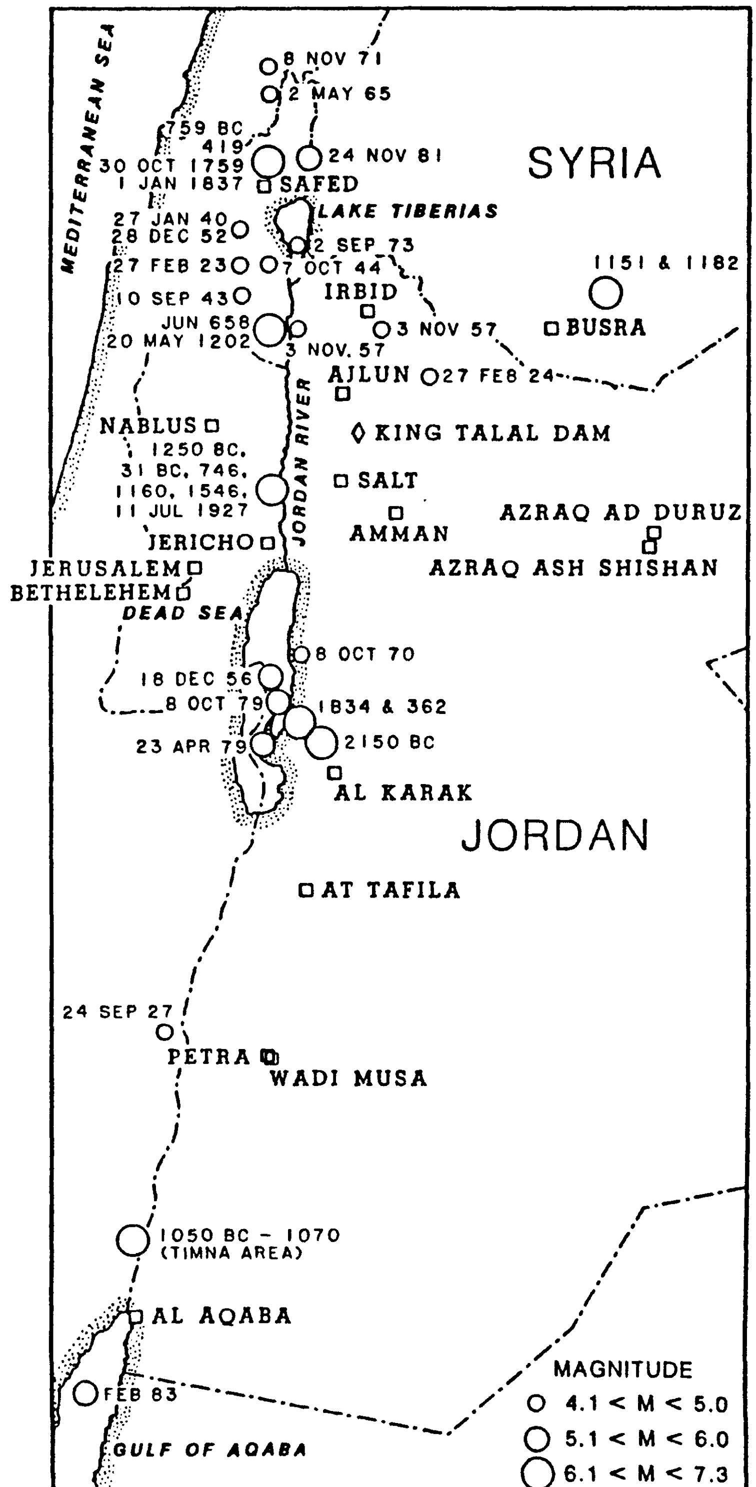
Earthquake listings have been presented by Alsinawi and Ghalib (1975), Ambrayseys (1961, 1962), Ambrayseys and Melville (1982), Amiran (1950, 1951), Arieh (1967, 1985), Ben-Menahem (1979), Perrey (1849), Poirer and Taher (1980), Poirer et al., (1980), Sieberg (1932a), Sprenger (1843) and Willis (1928).

Specific seismic events have been analyzed or their effects described by Arieh et al., (1977, 1982), Ben-Menahem et al, (1977), Blanckenhorn (1905, 1925, 1927), El-Isa et al., (1984), El-Isa and Mustafa (1986), Sieberg (1932b), Tristram (1865, 1874), Vered and Striem (1977) and Watson (1895). Archaeological evidence for earthquake events in the period from 1050 B.C. to 1070 A.D. (Timna area and at Ram, 40 km east of Aqaba, Figure 2) can be found in Avi-Yonah (1975-1976).

Figure 2 is a compilation of earthquake epicenters for western Jordan and nearby areas from 2150 B.C. to 1981 for events of magnitude 4.1 to 7.3. The first major earthquake to be recorded instrumentally was the July 11, 1927, $M_L = 6.25$ event near Jericho (32.0°N, 35.5°E). Magnitudes of the earlier events have been inferred from empirical seismic intensity-magnitude relations which have been calibrated for Middle East earthquakes (Ben-Menahem, 1979). Certainly for the very ancient events (before the beginning of the Christian era) the epicentral locations can only be inferred from archaeological findings or religious accounts (Ben-Menahem pp. 261-266, 1979).

Most of the seismic events are located along the axis of the Dead Sea Rift. These events, together with recent microearthquake data, point to a recurrence interval of about 250 years for a $M_L = 6.4$ earthquake along the rift (Ben-Menahem, Aboodi, Vered and Kovach, 1977; Ben-Menahem and Aboodi, 1981). Vered (1978) has utilized the geologic record of total fault displacement and the rate of seismic activity to estimate that the maximum expected earthquake along the rift zone would be in the range $M_L = 7.5$-8.

Figure 2: Historical Seismicity of Jordan and Vicinity Compiled from Various Sources



B. *Importance of A Seismic Network in Jordan*

In 1983 the Government of Jordan with support from the USGS with funding from USAID established an 8-station seismic network in northwestern Jordan to monitor earthquake events and assess the overall pattern of earthquake activity and collect information pertinent to seismic risk. The network was subsequently expanded in 1989 to a 32-station network, including ten 3-component stations. This network now provides continuous monitoring of all areas in Jordan.

The seismic data which are now being acquired by the 32-station network can be applied to the special needs of Jordan for studies of seismic activity induced by new reservoirs, in the problem of estimating and reducing potential earthquake hazards in Jordan, in analyses of earthquake data to provide clues to the distribution of geothermal and other natural energy resources, and finally, to provide data for the scientific study of earthquakes as part of the worldwide effort to unravel and understand their tectonic significance leading to the eventual prediction of earthquakes.

Perhaps a more important factor is that the Jordan Seismic System (JSS) provides a venue for the training of Jordanian scientists and technicians in the global community of seismology and provides a focal point for international scientific exchange.

C. Observatory Management and Staff

The sucess for the installation and operation of the Jordan Seismic System can be attributed to many individuals, affiliated with the NRA, whose contributions cannot be overlooked nor overstated. Engineers Y. Nimry and K. Jreisat, Director Generals of the NRA, provided administrative interfacing through many facets of the government Mohammed Abu-Ajamieh had the vision to realize the importance of a seismic network in Jordan. Mohammed Jaradat contributed to the technical evaluations for the establishment of the Jordan strong ground motion network. Abdel-Qader Amrat has assisted in many details of preparing this report. Kays El-Kaysi saw this project to fruition with a blend of humor and realism.

As the project developed many NRA staff members have contributed to the day-to-day operation, data processing, and maintenance of the seismic network. Certainly the following individuals deserve particular recognition:

Mohammed Jaradat	Head of Seismology Division
Abdel-Qader Amrat	Seismologist
Najwa Abu Maizar	Seismologist
Abdel-Razzaq Jbour	Seismologist
Eman Al-Momany	Seismologist
Tawfig Al-Yazjeen	Seismologist
Eid El-Taraze	Seismologist
Bassam Al-Biss	Computer Technician
Ghanem Abed Rabbo	Chief Technician
Towfik Atmeh	Assistant Technician
Walid Abdel-Hafes	Assistant Technician
Mohammed Hijazy	Assistant Technician
Ahmad Masoud	Assistant Technician
Khamees Rizq	Assistant Technician

2. Description of Seismic Network

The operating stations of the Jordan seismic network are shown in Figure 3. Geographic coordinates and elevations of the seismic stations are given in Table 1. The coordinates and elevations were taken from 1:50,000 topographic maps of Jordan prepared for the Ministry of Economy and the United States Agency for International Development in Jordan. Latitudes and longitudes are believed to be accurate to within ± 0.01 degrees and elevations to ± 5 meters. Each recording site is enclosed by concrete walls 3 meters in height topped with barbed wire with a length and width dimension of 10 meters and 2 meters, respectively. One-Hertz vertical and horizontal component seismometers are buried outside the enclosure to minimize the effects of wind-induced seismic noise. The antennas and solar panels are mounted on a mast on or within the enclosure. Voltage-controlled oscillators (VCO's) for each seismometer are separated to minimize interference. The stations are regularly inspected for any obvious damage and repaired as required.

Line-of-sight radio transmision of the seismic data employs FM radio frequency transmitters operating in the band from 168.800 to 172.700 MHz. Power is supplied to both receivers and transmitters by solar panels and batteries. The antennas are specially designed Yagi-type which are highly directional with a gain of 9dB. The subcarrier oscillator frequencies are within the audible band and range from 680 to 3060 Hz. Typical details of the radio frequency distribution scheme for the network are given in Table 2.

Because of the rugged topography along the eastern margin of the Dead Sea Rift, line-of-sight transmission to the Observatory in Amman from each remote seismic station was not possible. It was therefore necessary to transmit many signals to repeater stations for multiplexing and subsequent transmission to the NRA (Figure 4).

At the Observatory, the data are continuously recorded on visual film Develocorders. Gain settings are nominally set at 60-66 db for all stations. Universal Time (UT), transmitted from Radio Moscow (14996 KHz), is used to synchronize a crystal clock at the Observatory.

The visual records are examined daily and the first arrivals (P-wave), second arrivals (S-wave), and duration are measured to ± 0.1 second and

Table 1: Station List of Jordan Seismological System

No	Station Name	Abbr	Latitude			Longitude			Elevation(m)
1	Saham	SHM	32°	43'	36"	35°	45'	51"	363
2	Ruweishid	RUW	32°	28'	30"	38°	24'	6"	751
3	Shahba	SHB	32°	18'	9"	37°	34'	30"	960
4	El-Aritein	ART	32°	14'	48"	36°	49'	42"	1058
5	Jarash	JAR	32°	14'	9"	35°	56'	51"	840
6	Burma	BUR	32°	12'	45"	35°	45'	30"	520
7	Rumman	RUM	32°	10'	51"	35°	49'	39"	445
8	Hallabat	HLB	32°	04'	39"	36°	18'	9"	827
9	Casr Tuba	CST	31°	07'	12"	36°	40'	19"	760
10	El-Salt	SAL	32°	00	30"	35°	41'	15"	780
11	Kafrein	KFN	31°	51'	42"	35°	40'	15"	-90
12	Maslubiya	MAS	31°	43'	48"	35°	43'	6"	823
13	Mudeisisat	MDS	31°	38'	00"	36°	14'	45"	970
14	Makawir	MKR	31°	32'	51"	35°	37'	48"	815
15	Sirfa	SRF	31°	20'	9"	35°	38'	42"	979
16	Qatrana	QTR	31°	17'	55"	36°	00'	36"	876
17	Lisan	LIS	31°	14'	24"	35°	28'	36"	-327
18	Karak	KAR	31°	07'	9"	35°	39'	09"	1240
19	Sultana	SUL	31°	05'	12"	36°	04'	36"	951
20	Dahal	DHL	30°	49'	00"	35°	24'	6"	-80
21	Daraweish	JRD	30°	43'	41"	35°	45'	58"	1365
22	Ghuzeima	GHZ	30°	34'	45"	36°	19'	30"	1048
23	Al-Shawbak	SHW	30°	23'	00"	35°	30'	00"	1734
24	Khashabia	KSH	30°	16'	27"	36°	57'	57"	1005
25	J. Risha	JRH	30°	15'	28"	35°	14'	00"	357
26	Ras En-Nab	NAQ	29°	59'	51"	35°	30'	18"	1640
27	Hittiya	HIT	29°	44'	33"	35°	50'	27"	1235
28	Aqaba	AQB	29°	43'	39"	35°	03'	00"	170
29	Quwayrah	QRH	29°	41'	06"	35°	19'	18"	810
30	Muduarah	MUD	29°	26'	30"	35°	49'	6"	900
31	Hashim	HSH	29°	25'	14"	35°	23'	24"	1100
32	Qatafi	QTF	31°	49'	21"	37°	29'	00"	648

Figure 3: Operating stations of the Jordan Seismic Network

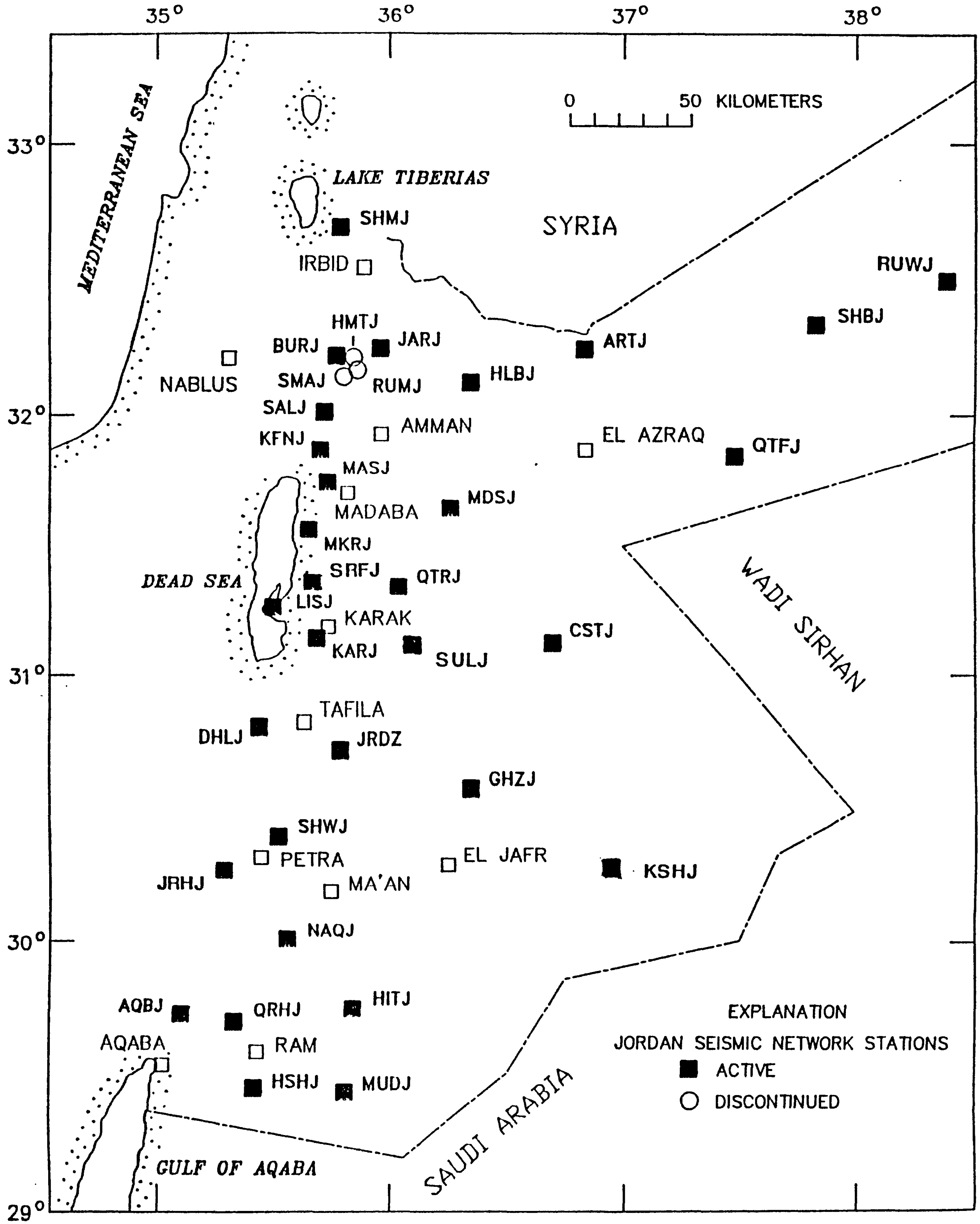


Figure 4: Diagram of the Radio Transmission Scheme of Several of the Remote Seismic Stations to the Jordan Seismological Observatory

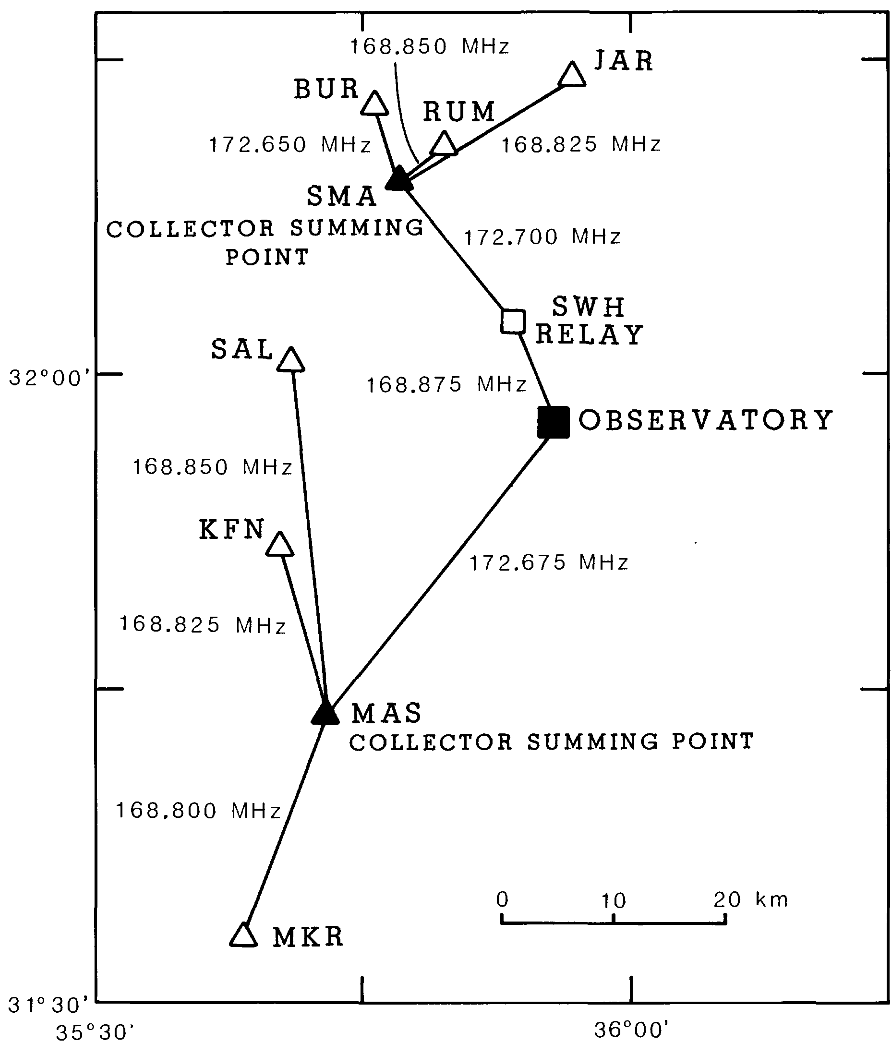


Table 2: Radio Transmitter and Receiver Frequencies Assigned to Seismic Stations and Relays, Jordan Seismological Observatory

STATION CODE (Hz)	RADIO UNIT	TYPE	FREQUENCY (MHz)	MODULATED CARRIER
BURJ	9T	TRANSMITTER	172.650	1020
JARJ	3T	TRANSMITTER	168.825	1360
RUMJ	5T	TRANSMITTER	168.850	1700
SMAJ	--	LINE	---	680
	9R	RECEIVER	172.650	1020
	3R	RECEIVER	168.825	1360
	5R	RECEIVER	168.850	1700
	11T	TRANSMITTER	172.700	SUMMED
	7T	TRANSMITTER	168.875	SUMMED
SUWEILIH	11R	RECEIVER	172.700	SUMMED
NRA-	7R	RECEIVER	168.875	SUMMED
AMMAN	10R	RECEIVER	172.675	SUMMED
MKRJ	2T	TRANSMITTER	168.800	2380
KFNJ	4T	TRANSMITTER	168.825	2720
SALJ	6T	TRANSMITTER	168.850	3060
MASJ	--	LINE	---	2040
	2R	RECEIVER	168.800	2380
	4R	RECEIVER	168.825	2720
	6R	RECEIVER	168.850	3060
	10T	TRANSMITTER	172.675	SUMMED

recorded on standard forms. The data are subsequently entered into a disk file on a microcomputer as input to a hypocenter location program. Events are identified on the basis of waveform shape and their occurrence on at least four records within a time window of five to ten seconds. Accuracy of measured arrival times ranges from 0.1 to 0.3 second, depending upon background noise (e.g., vehicular traffic, wind, sonic booms, livestock, and other cultural sources). The original seismograms and film copies are archived for future reference at the Observatory. In addition, quarterly seismological bulletins have been issued from 1984 to 1987. Biannual bulletins have been issued since 1988. Station readings are also routinely reported to the International Seismological Centre (ISC) in Newbury, United Kingdom and are available to the scientific community.

3. Description of Automated Data Processing

The automatic processing system for the Jordan Seismic Observatory (JSO) was designed to achieve several objectives:

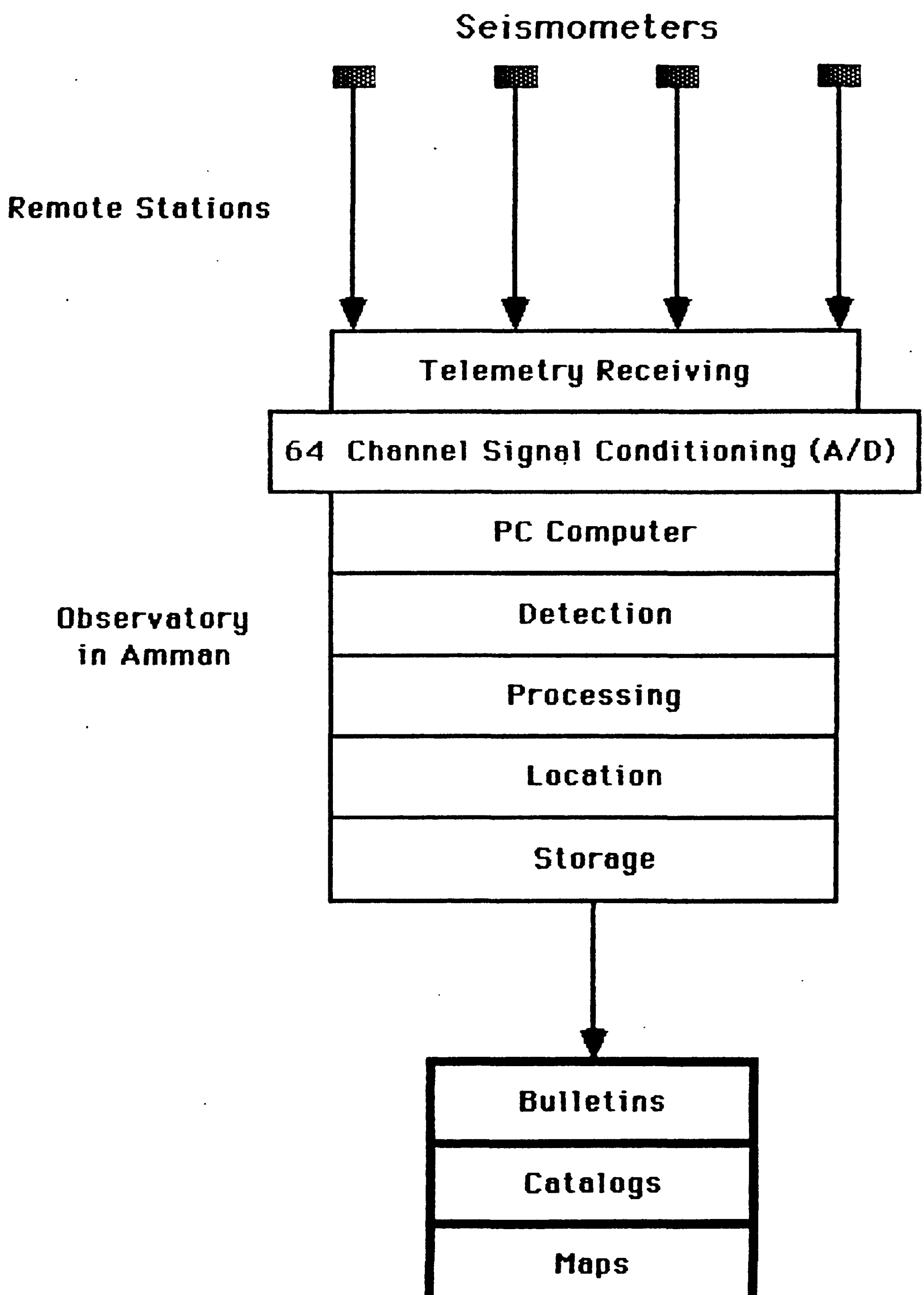
1. To detect and locate earthquakes immediately.
2. To save digital records of the seismogram for further analysis offline.
3. To operate at a remote location where telemetry to a central observatory might not be feasible.

At the onset of this project a number of automatic processing systems were operating on USGS networks in California, Hawaii, and Washington, but none of these systems achieved all the objectives listed above. Futhermore, the most successful systems required expensive and complicated computer facilities backed by an experienced staff of seismologists, programmers, and engineers. With the rapid development of powerful small computer systems, we anticipated that it would be possible to utilize a simpler system that would achieve the desired objectives.

We ultimately settled on a seismic data acquisition system based on IBM PC-AT technology. 64 channels of seismic data can be displayed in real time from the Jordan network. The data are transmitted by FM telemetry to Amman where they are converted to digital format at 100 samples per second using an internal A/D board and displayed on one or more monitors in real time. A 5-second time window is displayed which advances every 5 seconds. An event triggering algorithm compares the ratio of a short time signal average (1 second) to a long-term signal average (10 seconds). When this ratio exceeds a pre-set value on a specified number of channels simultaneously an event is declared detected. If an event is detected the digitized waveform data are saved on a hard disk and the event can be subsequently located and displayed (Lee, Tottingham and Ellis, 1988). A flow chart is shown in Figure 5.

The unique aspect of the IBM PC-based system is that ample software are available for the acquisition, processing, and analysis of local seismic network data. The existing software contains a variety of programs for both realtime operation of the seismic network and offline data processing, and analysis. The heart of the system is a commercially available A/D board capable of digitizing and processing up to 64 channels

Figure 5: Block Diagram of the PC-Based Jordan Seismic Acquisition System



of seismic data. In the event triggered mode, the computer software automatically picks first P-arrival times, locates the earthquake, and saves the digitized waveform data on the hard disk. The off line software provides options for: 1) rapid playback of the digitized data; 2) interactive picking of seismic phases; 3) earthquake location; and 4) user selected interactive signal processing such as filtering, Fourier spectra, corner frequencies, and coda Q analyses.

One unique feature of the PC-based system is that seismic data are displayed in real time in collaboration with the existing analog Develocorder film system. It is very important to see all of the seismic signals in real time, to identify if any seismic equipment is not functioning properly, and to visually check if the system is correctly detecting seismic events.

A decided advantage of the PC-based system is that many systems are now operating worldwide: 1) Yakutat, Alaska (USGS); 2) Spokane, Washington (U.S. Bureau of Mines); 3) Moscow, Idaho (Univ. of Idaho); 4) Vancouver Washington; 5) Menlo Park, California (USGS); 6) Mexico City, Mexico (National University of Mexico); 7) Scott Base, Antarctica (Victoria University); 8) Stanford University (Stanford, California); and 9) Lima, Peru (National University).

4. Crustal Structure of Western Jordan

A number of seismic refraction profiles were obtained in 1977 and 1984 in the vicinity of the Dead Sea Rift zone (Ginzburg et al, 1979; El-Isa et al., 1986). The location of these profiles are shown on the index map (Figure 6).

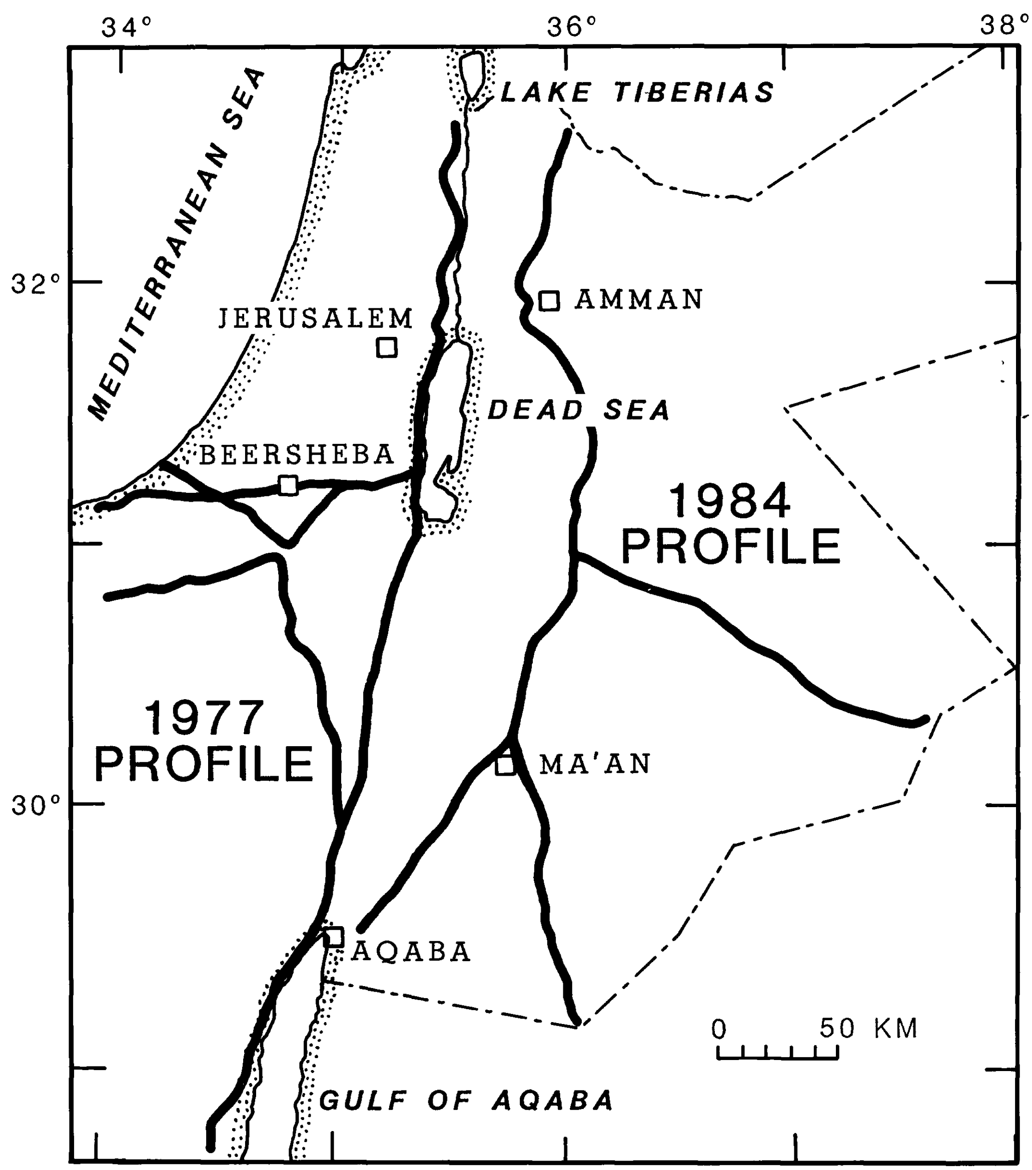
The north-south profile from Lake Tiberias to the Gulf of Aqaba roughly parallels the axis of the Dead Sea Rift zone. The upper crust, as deduced from an analysis of the seismic refraction and wide angle reflection data, consists of low velocity material (2.5 km/sec) overlying a 4.0 km/sec layer representing the Paleozoic-Mesozoic sequence of sandstones and limestones. Below the 4.0 km/sec material the crust has a velocity of 6 km/sec at its upper boundary increasing to 6.7 km/sec at its base. The total thickness of the crust is 29-30 km and the measured upper mantle velocity is 7.8 km/sec.

The east-west profile through Be'er Sheva' reveals a somewhat similar crustal section with the exception of the upper mantle velocity. The sedimentary cover varies in thickness from 4 km in the east to 6 km in the west and consists of a low velocity (2.5 km/sec) layer, corresponding to Tertiary chalks and marls, which overlies 4.2 km/sec material again representing the Paleozoic-Mesozoic section.. The crust has a velocity of 6.0 km/sec in the upper part increasing to 6.7 km/sec at the crust-mantle boundary. An upper mantle velocity of 8.0 km/sec was observed.

In 1984 a number of seismic refraction profiles were obtained in Jordan with observations being made out to distances of approximately 200 km along four lines (Figure 6). The derived crustal section of the north-south profile, which passes slightly west of Amman, is shown in Figure 7. For orientation shot-point 2 is located very close to Amman.

The upper sedimentary layer ranges in velocity from 2.9 to 4.1 km/sec and overlies an upper crustal layer to a depth of 18 km in which the velocity ranges from about 5.8 km/sec to 6.35 km/sec. An intracrustal zone between 18 and 20 km depth is present with a velocity increasing from 6.35 to 6.65 km/sec. The lower crust has a constant velocity of 6.65 km/sec overlying a 4.5 km thick transition zone in which the velocity increases from 6.65 to 8.0 km/sec. A northward dipping crust-mantle boundary is present varying from a depth of about 32 km beneath shot-

Figure 6: Index Map Showing Location of Seismic Refraction Profiles in the Vicinity of the Dead Sea Rift Zone



point 3 to 35 km beneath shot-point 1. The upper mantle velocity is 8.1 km/sec.

For purposes of earthquake hypocenter locations in Jordan and vicinity we adopted a step-wise approximation to the model shown in Figure 7. This velocity model is shown by the dashed line in Figure 8.

Figure 7: Interpreted Crustal Velocity Section for North-South Profile in Jordan. Shot-Point 2 is Near Amman (El-Isa et al., 1986)

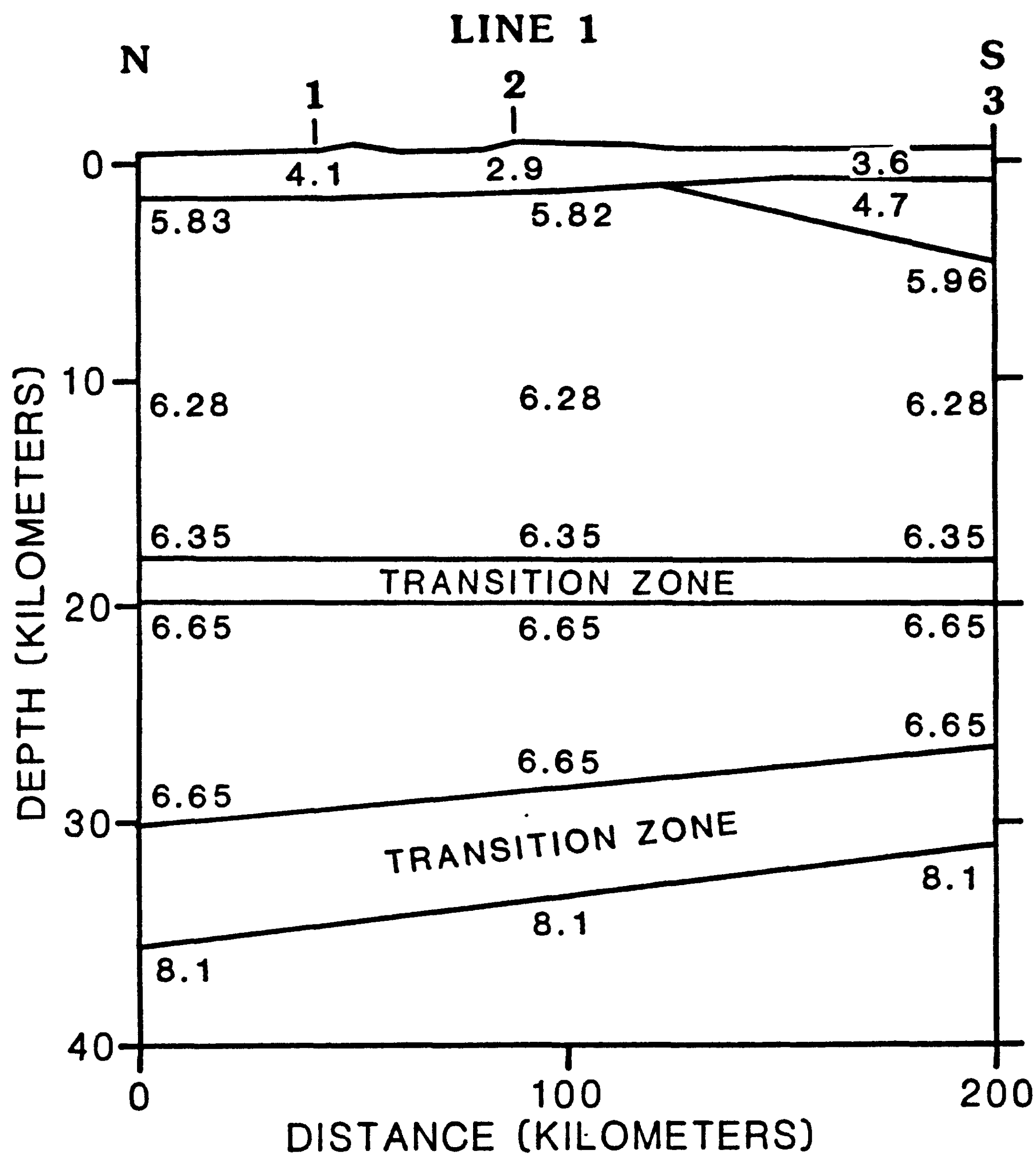
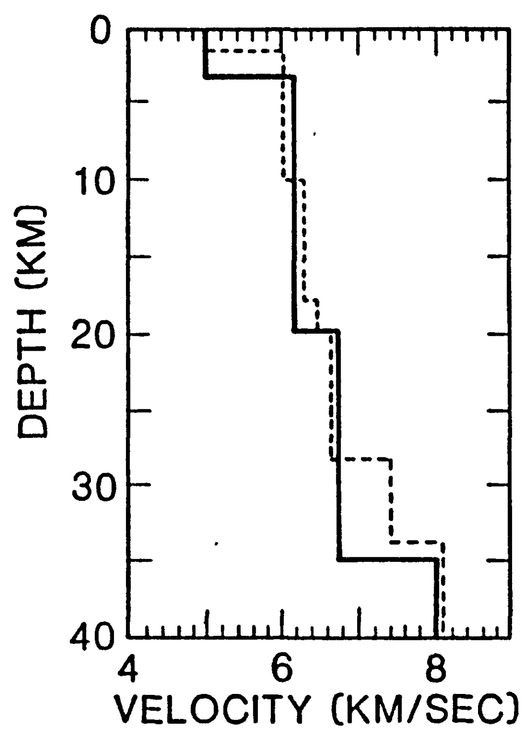


Figure 8: Adopted Crustal Velocity Model for Western Jordan Compared with Velocity Model Previously Used (Kovach et al., 1986). The adopted velocity model is shown by the dashed line.



5. Epicentral Locations and Overall Seismicity Pattern

Our experience in Jordan and elsewhere indicates that accurately locating local earthquakes requires considerable effort. Accurate station coordinates (± 0.1 km if possible) are needed together with an adequate station distribution. A reasonable crustal model, based on controlled explosions is necessary and reliable P and S wave arrival times are essential. It needs to be emphasized that no computer program will give correct answers if the input data contain errors. It should also be pointed out that small travel time residuals and small standard errors do not necessarily guarantee accurate hypocenter solutions.

The program HYPO71 is now in routine use for the determination of hypocenters and earthquake magnitudes in Jordan. HYPO71 has been the main computer program used by the U.S. Geological Survey for locating local earthquakes and has been adapted for use on portable personal computers (Lee and Valdes, 1985) making it possible for field or office use in the rapid analysis of earthquake observations. Initially, a modification of the hypocentral location program LME83 described by Shapira (1983) was utilized in Jordan.

To test the dependence of the hypocentral locations on the adopted crustal model seven events were located with HYPO71 using two crustal velocity models (Figure 8). In addition, published arrival time data (P and S-wave) (Regional Catalog of Earthquakes, ISC, 1984) from additional seismic stations located on the western side of the Dead Sea Rift were used to improve the station azimuthal coverage. The results are presented in Table 3. It can be seen that the latitude location differences range from 0.2 to 2.0 km implying that an adequate azimuthal distribution of stations is of paramount importance.

Work is now continuing on the development of station corrections to improve the location accuracy of events which occur within the Jordan seismic network. The development of station corrections (station delay times to be applied to the observed arrival times) is an evolving trial and error procedure and the corrections shown in Table 4 are meant to be illustrative.

Table 5 compares two events located within the Jordan network with and without the above station corrections being applied. It can be seen

Table 3: Comparison of Hypocenter Locations Using Old and New Crustal Velocity Models

Model	Date	Origin Time hr	min	sec	Latitude Deg	Min	Longitude Deg	Min	Focal Depth	RMS* sec
Old	84-04-05	23	47	44.2	32	9.93	35	29.76	5.0	0.48
New		23	47	44.5	32	10.27	35	29.98	7.6	0.62
Old	84-04-26	15	02	47.0	32	47.50	35	22.58	5.0	0.51
New		15	02	47.7	32	47.34	35	22.06	3.6	0.39
Old	84-05-30	10	16	44.6	32	17.39	35	21.44	7.6	0.36
New		10	16	45.3	32	17.07	35	21.54	5.0	0.28
Old	84-08-02	11	04	6.7	31	44.28	35	30.68	13.5	0.47
New		11	04	7.2	31	45.34	35	30.84	12.0	0.43
Old	84-08-02	14	01	27.0	31	45.58	35	30.57	10.6	0.30
New		14	01	27.5	31	45.08	35	31.42	5.0	0.24
Old	84-08-10	02	50	46.6	32	4.86	36	13.25	11.7	0.26
New		02	50	46.8	32	5.40	36	14.35	12.7	0.26
Old	84-08-24	06	02	26.1	32	39.35	35	14.94	9.8	0.84
New		06	02	26.6	32	39.32	35	13.88	11.4	0.97

*See Table 5

Table 4: Trial Station Delays for Some Jordan Seismic Stations

Station	Delay (sec)
BURJ	-0.10
JARJ	-0.10
MDSJ	0.14
SALJ	0.10
MASJ	0.14
MKRJ	0.16

Table 5: Comparison of Hypocenter Locations Using HYPO71 with and without Station Corrections

Model	Date	Origin Time			Latitude		Longitude		Depth	RMS*
		hr	min	sec	Deg	Min	Deg	Min	km	sec
A	84-05-05	10	30	49.30	31	43.84	35	39.83	2.0	0.16
B		10	30	49.55	31	44.83	35	43.20	5.0	0.30
A	86-05-26	15	12	13.90	31	53.96	35	44.40	12.6	0.05
B		15	12	14.17	31	54.41	35	46.11	8.6	0.18

A = HYPO71 with station corrections.

B = HYPO71 without station corrections.

RMS* is here defined as the root-mean-square error of the time residuals except N, the number of observations, has been replaced by N-4 in accordance with recent modifications made to the program HYPO71 (Lee and Valdes, 1985).

$$RMS = \left[\sum_i R_1^{\,2} / (N - 4) \right]^{\frac{1}{2}}$$

where R_i is the time residual

that the application of station corrections significantly reduces the RMS error of the time residuals.

The local magnitudes M_L of the seismic events detected by the Jordan seismic network have been estimated from the time duration of the seismic signal utilizing the relation

$$M_L = -0.87 + 2 \log (T) + 0.0035D$$

where T is the signal duration in seconds, measured from signal onset to the point where the signal amplitude is twice the ambient background noise and D is the epicentral distance in kilometers. Further work needs to be done on the determination of local magnitudes inasmuch as many of the estimates appear to be too large, probably due to the excessive ringing and lengthy durations of the observed wave codas.

Figure 9a shows the location of seismic events for the Dead Sea transform for the time period of January 1985 to June 1986 as located from station readings in the Middle East reported to the ISC. The azimuthal coverage is quite good, except in the northeast (Syria) and to the east in the Jordan panhandle. Local magnitudes as small as 2.5 are believed to be detectable, but individual station residuals can be large emphasizing the need for individual station corrections and possibly an improvement in the regional crustal model for epicentral locations.

Much of the current seismic activity is clustered along the axis of the Dead Sea rift. North of the Dead Sea a northwesterly trend to Haifa (near 33°N, 35°E) can be seen, and the distribution of seismicity becomes more diffuse north of the Dead Sea. The northeasterly trend of seismic activity from the northern end of the Dead Sea into southern Syria is worthy of mention. A branching ENE pattern in the seismicity at about a latitude of 30.5°N may represent an extension of the present seismic activity in the central Sinai/Negev shear zone. North of the Gulf of Aqaba there is a notable gap in the current seismic activity and this portion of the rift zone--the Wadi Araba, has been known to possess a much lower level of activity than the northern Dead Sea section. Speculations have been made that the Wadi Araba region possesses relatively high aseismic slip (low seismic activity) due to the absence of a significant resistance to plate motion produced by lower rigidity coupled with a thinner crust.

Figure 9a: Seismicity Map of the Dead Sea Transform for the Time Period of January 1985-June 1986

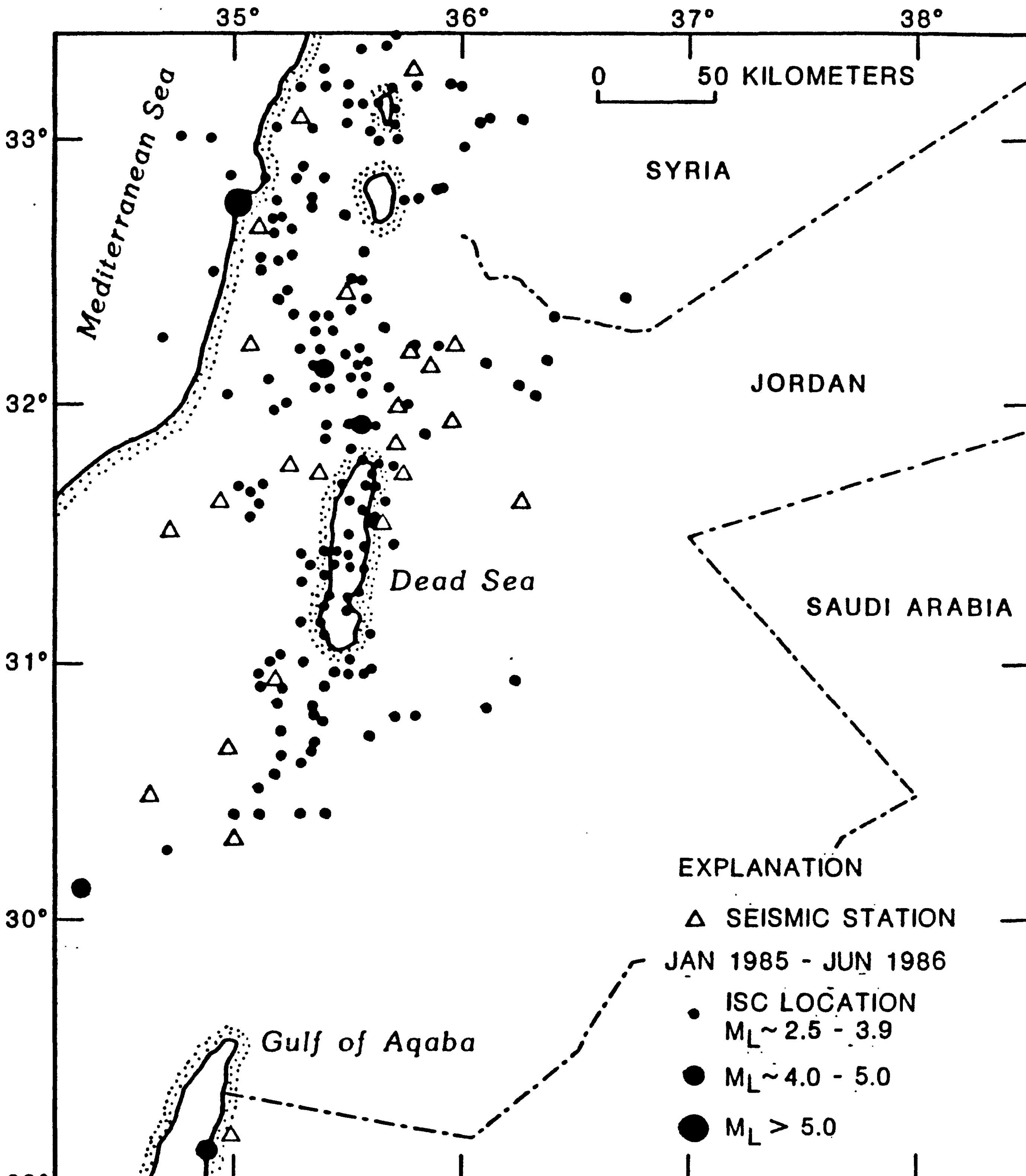


Figure 9b: Seismicity Map of the Dead Sea Transform for the Time Period of July 1986-June 1987

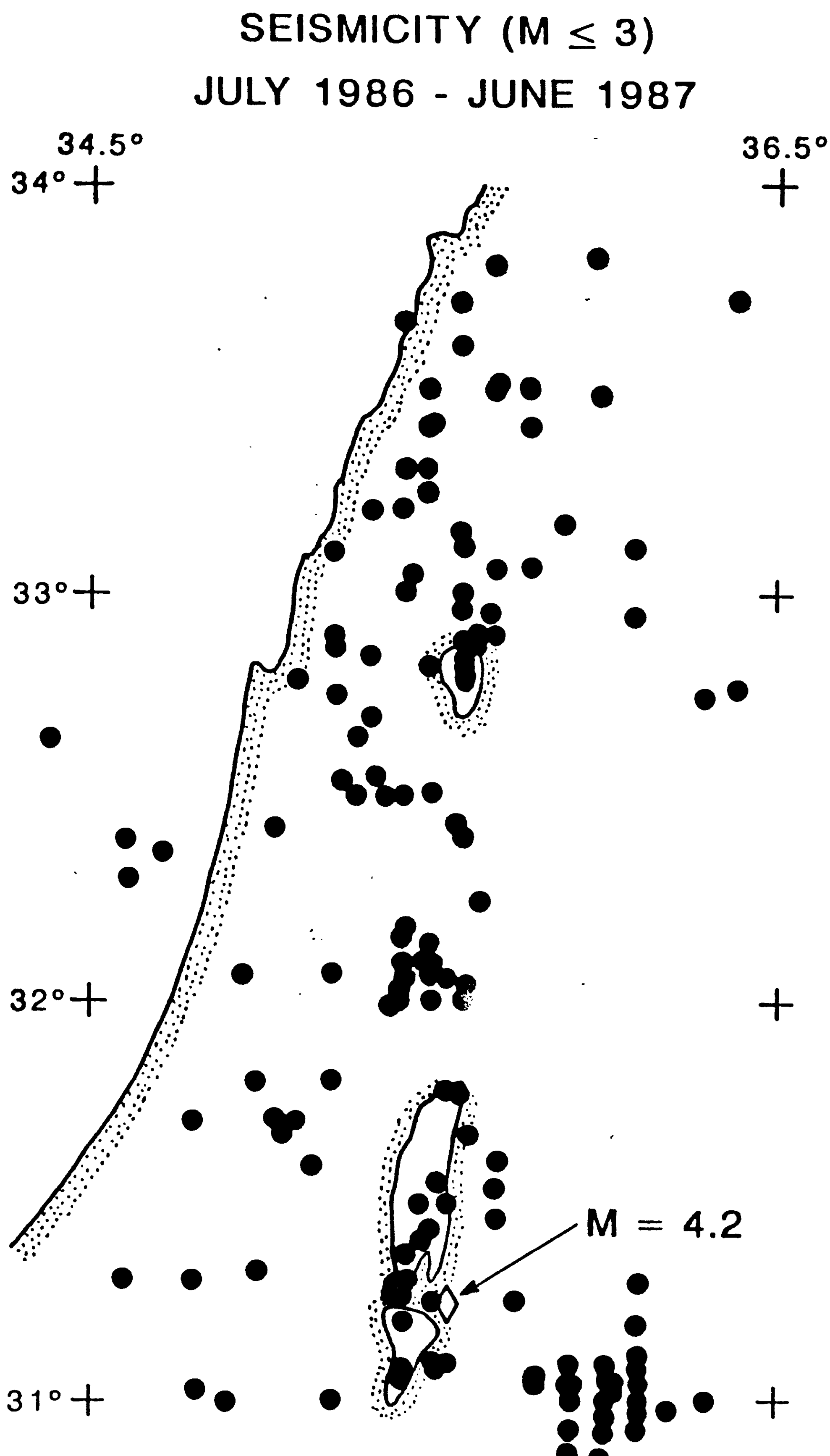


Figure 9b shows the seismicity from July 1986 to June 1987. As for the previous time frame, the data emphasize the activity of the rift zone, but some interesting clusters of seismicity can be observed. Many of these current clusters have been the loci of large damaging earthquakes in the historical past.

6. Tectonic Framework and Focal Plane Solutions

Before discussing a few seismic focal mechanisms it is useful to review some aspects of the tectonic evolution and setting of the Dead Sea Rift. The structure of the Dead Sea is primarily the result of left lateral strike-slip motion mixed with uplifting along its sides. The net result is to produce rift faulting which traverses a topographically and structurally uplifted region. In a plan view the rift zone changes direction so that blocks along its two sides cannot fit together once strike-slip motion has occurred. As a result along some sections of the rift zone gaps are opened producing structural and topographic depressions, the so-called rift valleys. Along other segments local compression arises (Figure 10). Topographically, the boundaries of the gaps or depressions produced along the rift are controlled by dip-slip faulting. However, much of the present strike-slip motion takes place on en-echelon faults which strike at an angle to the main overall trend of the rift. As a consequence rhomb shaped grabens or pull apart basins are produced together with intervening segments of structural and topographic saddles (Figure 11).

The slip along the Dead Sea Rift Zone is believed to have taken place in several stages because in the southern part of the rift the pull-apart basins are only about 40-50 km in length whereas a total strike-slip movement of about 105 km has occurred. The slip which produced these basins cannot be greater than their length so the additional movement necessary to produce the 100 km or so of total left-lateral offset must have occurred at an earlier time, probably in a direction more aligned with the overall trend of the rift (Figure 12).

Focal mechanisms for several earthquakes in the vicinity of the Dead Sea Rift Zone were determined using the grid searching program FPFIT (Reasenberg and Oppenheimer, 1985). First motion polarities from stations on the west side of the rift were provided by Shapira (personal communication). A few observations can be made concerning the focal plane solutions shown in Figure13.

The two events of August 2, 1984, located in the northern end of the Dead Sea exhibit normal faulting with the axis of tension (the axis of minimum compressive stress) oriented SW-NE. A normal faulting mechanism is compatible with the concept of a rhomb graben or pull-apart

Figure 10: A Model for the Overall Structure of the Dead Sea Rift
(Freund, 1965)

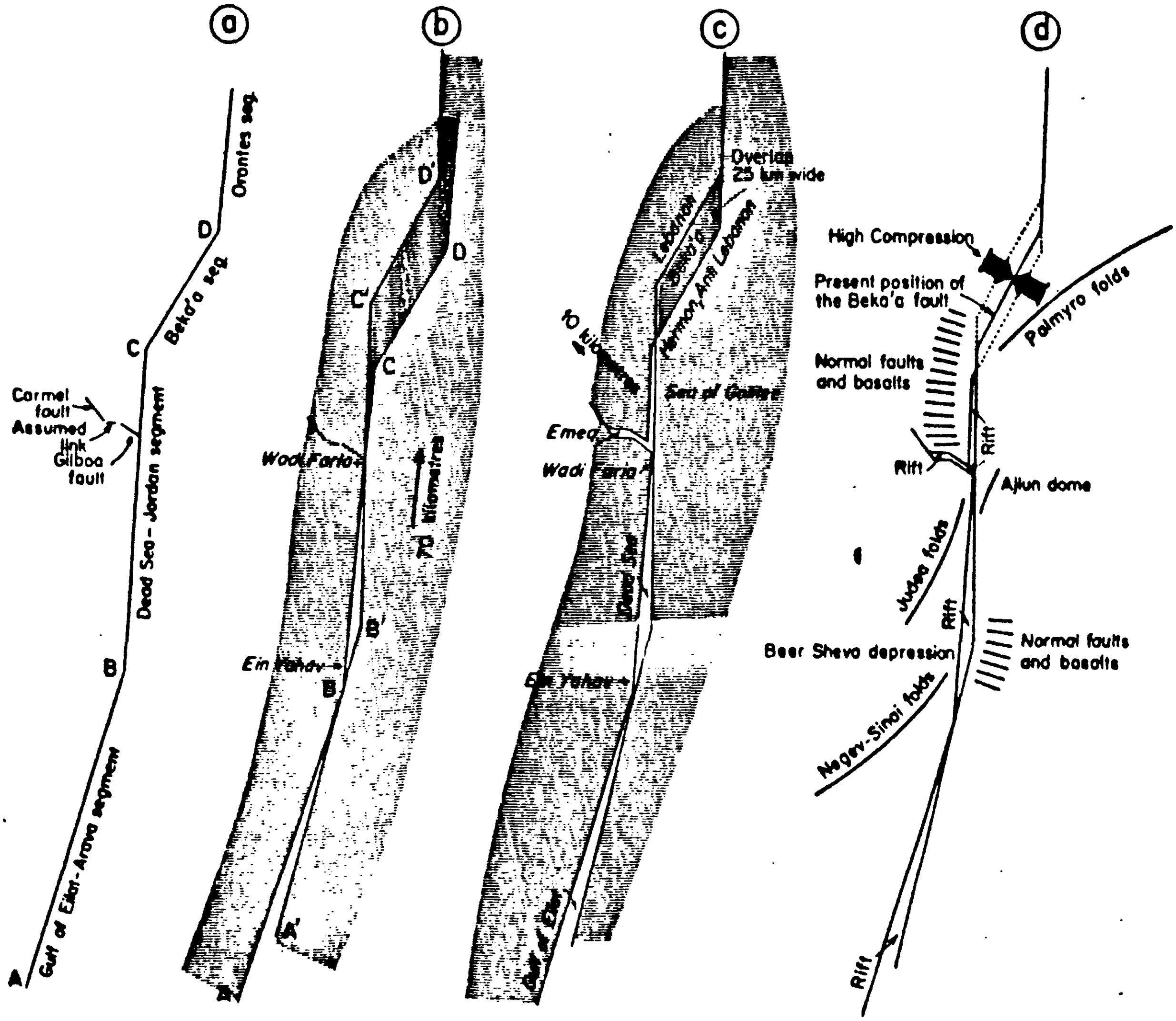


Figure 11: Model for the Formation of Rhomb Grabens or Pull-Apart Basins Along the Northern Segment of the Dead Sea Rift (Freund and Garfunkel, 1976)

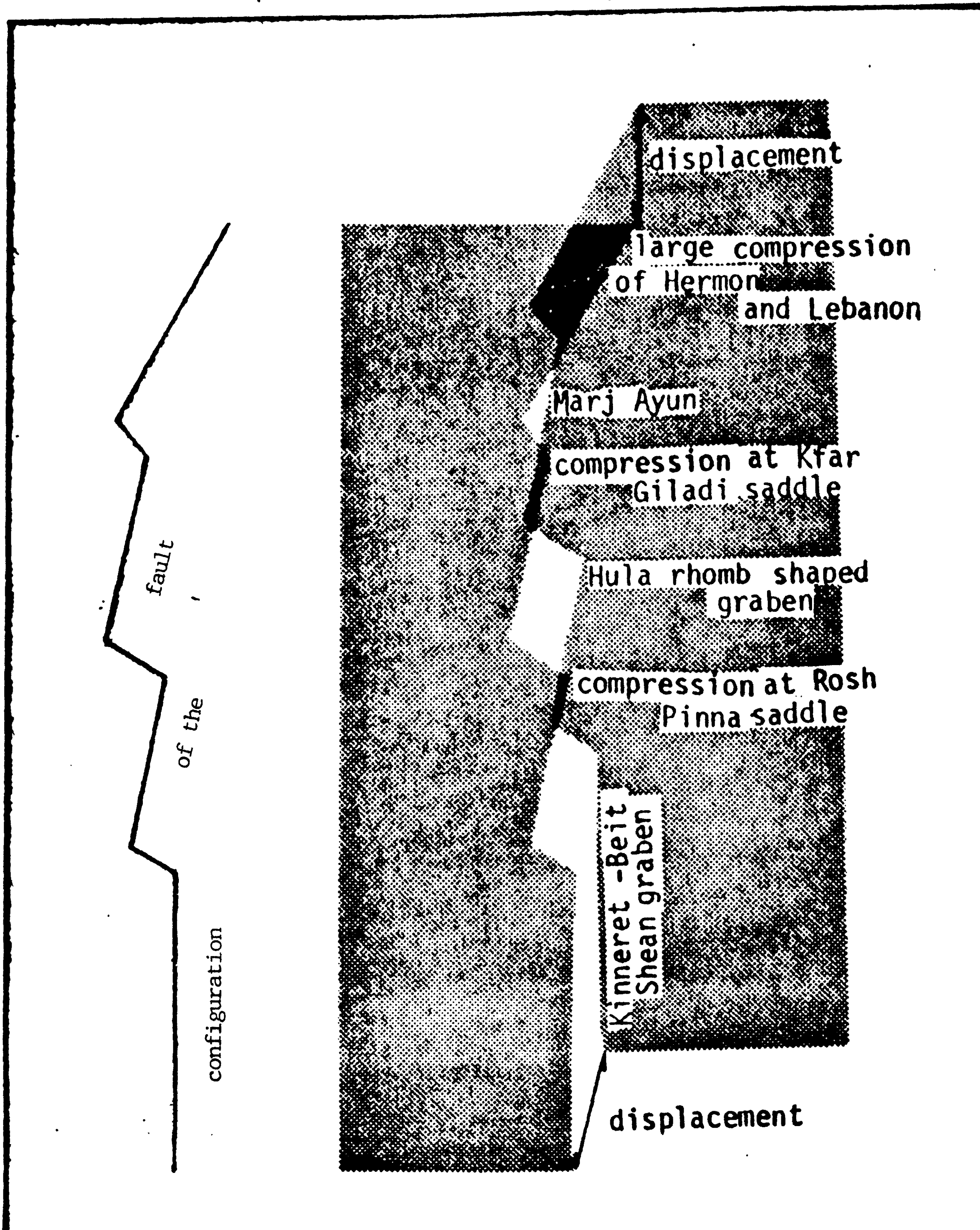


Figure 12: Cartoon Showing the Presumed Development of the Dead Sea Basin (Freund and Garfunkel, 1976)

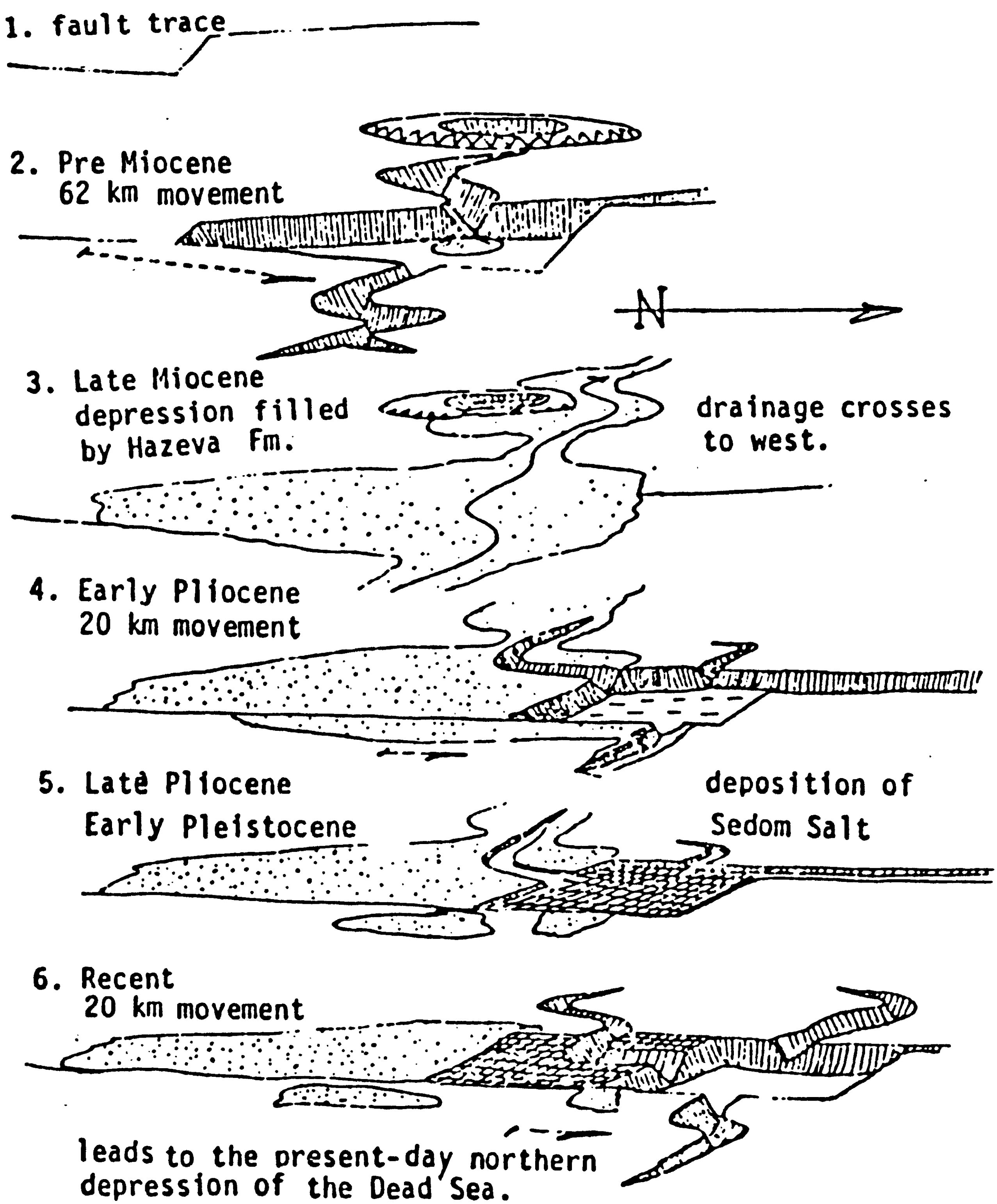
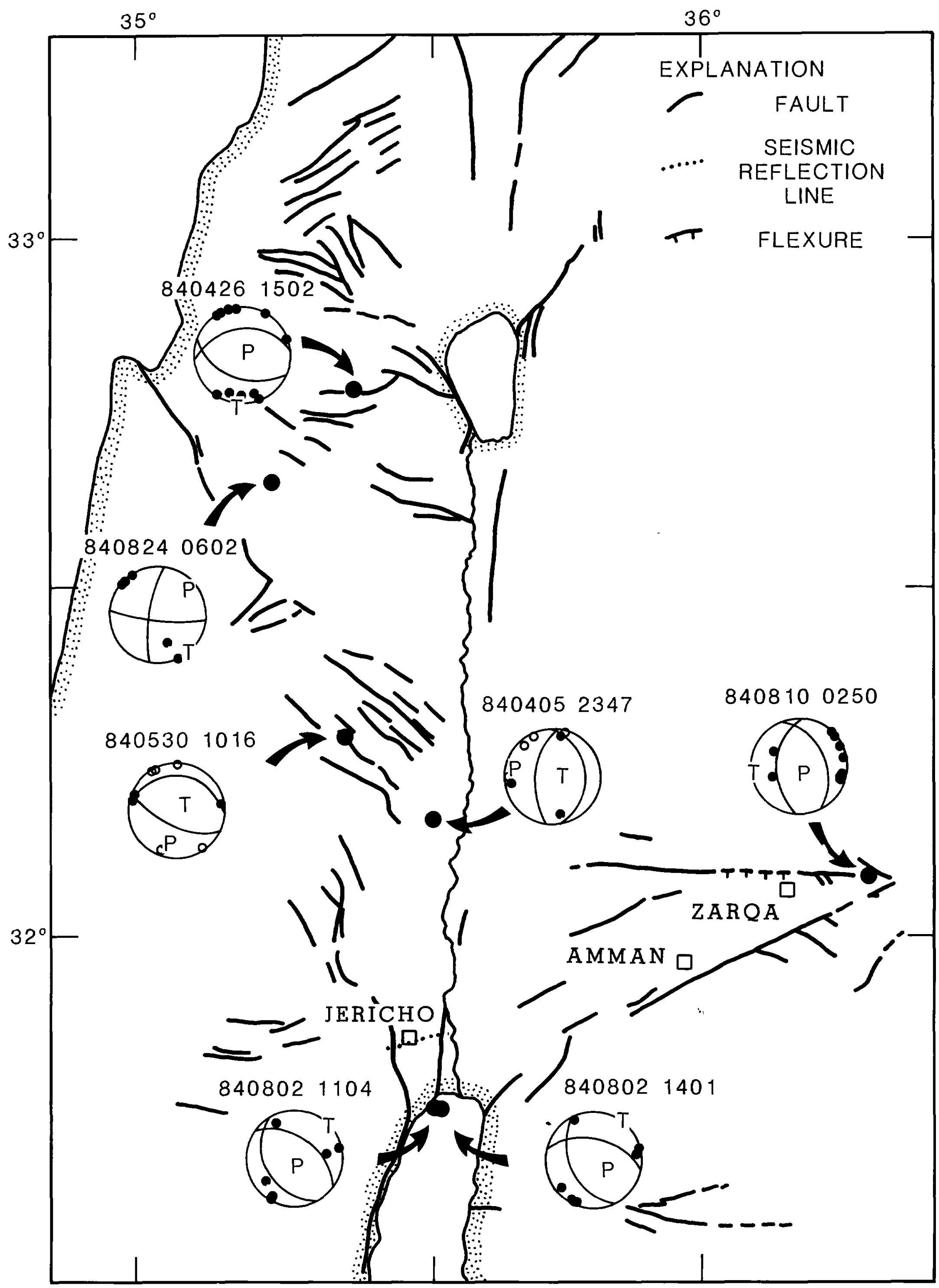


Figure 13: Focal Plane Solutions for Some Earthquakes Near the Dead Sea Rift Zone



structure for the Dead Sea basin in which the northern part of the basin is bounded by a northwesterly trending normal fault.

Further north, the events of April 5 and May 30, 1984, possess thrust fault mechanisms. As mentioned earlier local compression is to be expected along certain segments of the rift zone, particularly in the regions between the northerly trending pull-apart basins.

Viewed collectively, the focal plane solutions exhibit a diversity of faulting mechanisms which provide some insight into the tectonic framework of the Dead Sea Rift Zone. However, it should be borne in mind that individual earthquake mechanism solutions do not necessarily always reflect the actual tectonic stress field because of local perturbations to the regional stress distribution.

7. Seismic Hazard in Jordan

Seismic hazard is routinely expressed as the probability that a certain value of seismic intensity, earthquake magnitude, or a specific ground motion parameter such as peak ground acceleration, velocity, or displacement will not be exceeded at a specific location within a specific interval of time.

It is clear that ground accelerations, for example, are best determined from records obtained by strong motion instruments or accelerographs during earthquakes. However, in Jordan such records are not yet available, particularly for large earthquakes, and one must rely on estimated values of ground acceleration inferred from seismic intensities or magnitudes of historical events. There are shortcomings in the approach of using macroseismic intensity as the quantity characterizing earthquake effects, and one is further constrained, in the case of Jordan, in that the number of observations is small and the return periods of severe damaging shocks are large.

Correlations are often made between horizontal peak ground acceleration A(cm/s^2) with the maximum Mercalli intensity I_{MM} observed for an earthquake. Seismic intensity, by definition is directly linked to damage (Evernden and Thomson, 1986), yet peak ground acceleration is desired by engineers for the development of building codes. Any correlations, therefore, should be taken as guidelines, a necessary constraint when utilizing historical earthquake data in the absence of instrumental observations.

Trifunac and Brady (1975) in a correlation study of the modified Mercalli intensities observed for 57 western United States earthquakes in the range of $IV \leq I_{MM} \leq X$ and 187 strong-motion accelerograms determined a useful regression model for horizontal peak accelerations A:

$$\log_{10}A \ (cm/s^2) = 0.01 + 0.30 \ I_{MM}$$

Such a model would suggest for I_{MM} = IX peak horizontal ground accelerations of ~ 0.5 g. However, as Trifunac and Brady (1975) point out, the spread of the measured peak values of strong ground motion is quite large.

In an analytical-empirical study of Middle Eastern seismicity Ben-Menahem, Vered and Brooke (1982) derived the following empirical relation, which relates the local horizontal bedrock acceleration to the modified Mercalli intensity.

$$1n\ A = 0.5 + 0.60\ I_{MM}$$

This relation, believed to be appropriate for events along the Dead Sea Rift Zone, would suggest, for a maximal intensity of IX, a peak horizontal ground acceleration of ~ 0.37 g, slightly less than that inferred from the western U.S. data set.

It is likely therefore, that peak horizontal accelerations in the range of 0.4 to 0.5 g could be expected in Jordan, based on an assessment of the historical seismic record. However, it needs to be emphasized that this estimate is based on the maximum intensity reported. Accelerations greater than 0.5 g are likely at close distances to the epicenter.

The primary earthquake source region in terms of historical damaging activity is that portion of the Dead Sea Rift which extends from 30.8°N to 33.3°N latitude. A plot of the earthquake recurrence data from 2150 B.C. to 1979 taken from the catalog of Ben-Menahem (1979), correlated with recent network data is shown in Figure 14. The data covering the Dead Sea fault system from 30.8°N to 33.°N support the relation

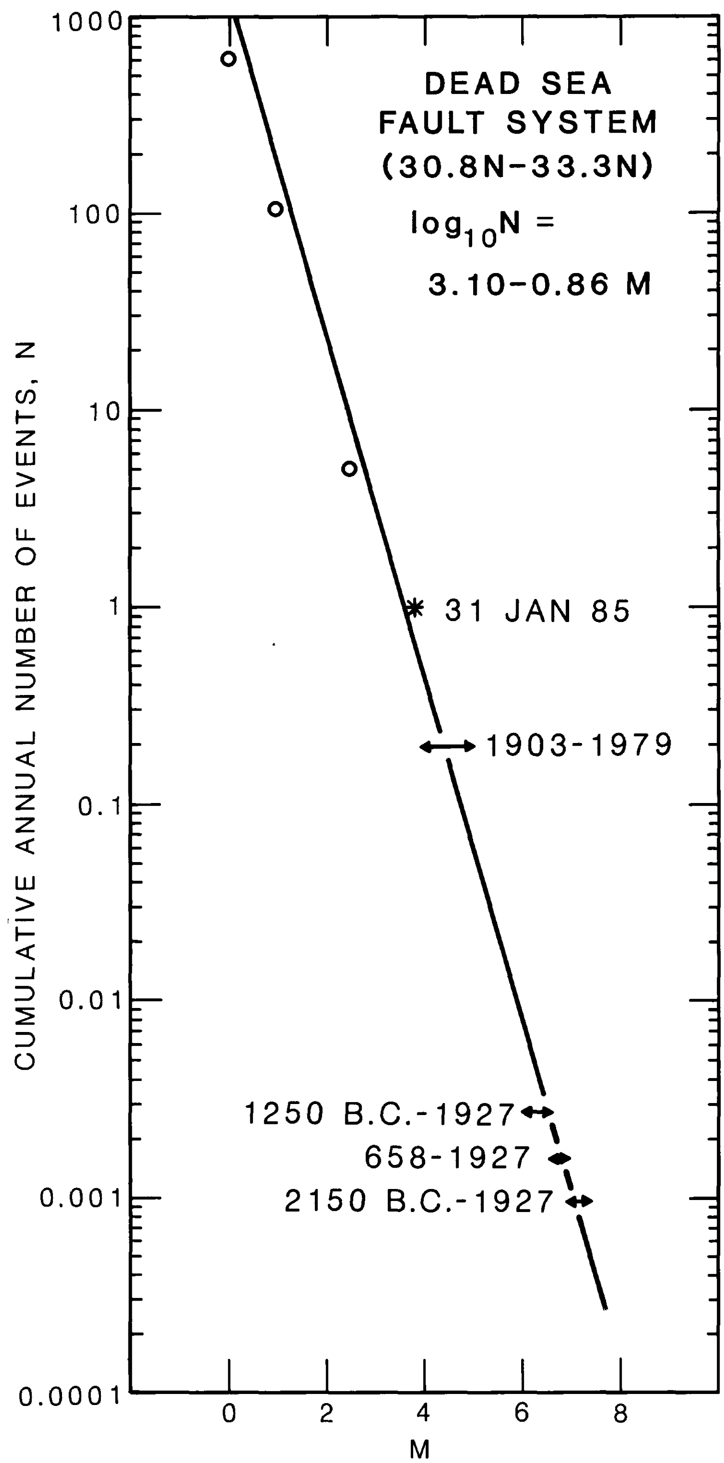
$$\log_{10}N = 3.10 - 0.86M$$

where N is the number of earthquakes per year with magnitudes greater or equal to M. This relation can be used to determine a mean return period, T, of

$$T = 10^{0.86M - 3.10}\ \text{years.}$$

For example a return period of 115 years is expected for a M = 6.0 event, and a return period of 2 years is expected for a M = 4.0 earthquake. A repeat time of 2 years for a M = 4 event is in agreement with recent instrumental observations.

Figure 14: Recurrence Relation for the Northern Dead Sea Rift Zone



Yucemen (1989) utilized a recurrence relation for the Dead Sea fault

$$\log N = 2.64-0.75M$$

which he considered to be valid in the magnitude range of 4 to 7.5. This relation would suggest a return time for a magnitude 6 earthquake of aout 72 years.

Under the assumption of a Poisson process the probability of the occurrence of an earthquake with a magnitude greater or equal to M within a period of ΔT years (taken to be the earthquake risk) is given by the relation

Under the assumption of a Poisson process the probability of the occurrence of an earthquake with a magnitude greater or equal to M within a period of DT years (taken to be the earthquake risk) is given by the relation

$$P(DT^{\cdot}M) = 1 - \exp(-DT/T(M))$$

where T(M) is given by the frequency - magnitude recurrence relation

$$T(M) = 10^{bM-a}$$

and a and b are derived from

$$\log10^{N} = a - bM.$$

Thus, along the northern section of the Dead Sea Rift there is an <u>expected</u> probability of 0.96 that an earthquake of magnitude 5.0 will occur within 50 years and a probability of 0.35 that a magnitude 6.0 event will take place in this same time frame. The odds are even (50-50) that a magnitude 6.0 event will take place within 80 years. Yucemen's 1989 relation there is a 50-50 chance that a magnitude 6 event should occur within a 50 year time window, or in layman's terms, a magnitude 6 event is imminent.

VIII. CONCLUSIONS AND RECOMMENDATIONS

Earthquakes are a threat to many countries. In the Middle East earthquakes at El Asnam, Algeria (1954, 1980), Agadir, Morocco (1960) and Yemen (1982) destroyed many homes with great loss of human life. The recent great earthquake in Iran (1990) is one of a series of great earthquakes that are a threat to the people of that region. Most earthquakes occur in seismic zones that are boundaries between great crustal plates which are moving with respect to one another. These seismic zones are connected to one another on a global scale so that movement of one of the great crustal plates effects the movement of all the other plates. The recognition that earthquakes are a global problem has led to an unusual degree of international cooperation between scientists who are trying to mitigate the damage and loss of life caused by great earthquakes. With the successful installation and operation of a large modern seismic network, Jordan has become an important contributor to this international research effort.

The data that will be provided by this network will lead to a better understanding of the plate boundary which passes through Jordan, the Dead Sea Rift, and the relationship of this seismic zone to other great fault zones that threaten Middle Eastern countries. Two conclusions emerge from the data already in hand. The current level of seismic activity and the earthquakes that have occurred in the recent history of the region are not consistent with the size of this fault zone. Based on the displacement of the zone determined from geologic observations we would expect larger and more frequent earthquakes than are actually observed. One possible explanation for this discrepancy is that the fault zone is storing strain energy that will be released in a future great earthquake.

A second conclusion relates to the distribution of the earthquakes in Jordan. Not all the earthquakes are concentrated in the rift zone. Many small earthquakes are occurring on other, previously unrecognized faults, located at a considerable distance from the rift zone. Further work will be required to explain these two observations and make a scientific estimate of the earthquake hazard in Jordan.

Earthquake prediction has been a central goal of earthquake research for the last twenty years. Large research programs on earthquake prediction are carried out in the United States, Japan, the Soviet Union, and China. Many other countries recognize the importance of this research and contribute to it as their resources permit. We have not yet achieved the ability to reliably predict the exact time of a future earthquake but we have made considerable progress in predicting the location and magnitude of earthquakes. With a combination of geologic observations, surveying data, and a seismological record, we can estimate the probability that an earthquake will occur in a given period of time. In the last few years scientists in the Soviet Union have developed mathematical algorithms that identify "Times of Increased Probability" (TIPS) that identify areas that are most likely to have great earthquakes in the near future.

The progress already achieved, the scale and diversity of the research, and the current rate of progress are grounds for optimism that much further progress will be made toward earthquake prediction in the next five to ten years. Great benefit can accrue to Jordan by association with this vigorous international research program. The benefits will come from the scientific assessment of the earthquake risk, the design of appropriate steps to reduce that risk, and from the stimulation of science and technology in Jordan that association with this research program will provide. Our suggestions for the future are based on our judgment that Jordanian scientists can and will become important players in this international research.

Any program in the next five years should emphasize training. Modest funding is required for equipment and supplies to maintain the network. Some new computer hardware and software is needed to provide the capability to detect and locate regional earthquakes so that the Jordanian seismologists can study the seismicity of the surrounding region. These expenditures are modest because the Jordanians now have all the equipment needed to carry on the research.

- Training can be achieved in several ways:
    - Use of outside contractors for intensive short courses and refresher courses as needed.
    - In-house training by previously trained scientific staff.
    - Short-term technical visits by U.S. experts of no less than 2-3 months in duration.

- Long-term technical support and in-country residence by U.S. personnel for periods of up to several years.
- Enrollment in specialized courses at selected universities for a 1-year minimum period in a non-matriculated degree program.
- Pursuit of a professional degree at the B.S., M.S. and Ph.D. levels.
- Post-doctoral work in various universities.
- Development of a collaborative research project with a U.S. university investigator.
- Use of a computer module training curriculum.

- **It is believed that a <u>computer module training</u> program possesses the highest probability of success for Jordan, and it is strongly recommended that a long-term training program centered around computer modules be established, which will take into account present and future NRA roles. To develop such a program will require a substantial effort but will result in a first-class, to be emulated, seismic facility. We elaborate on this suggested future work below.**

With the completion of the Jordan seismic network and the purchase of strong motion seismographs the need for training competent seismologists is the next important step for the continued development of seismology in Jordan. University education by itself is not adequate to meet a nations needs in a rapidly changing technological world. There is a need for continually updating technological skills at all levels of a modern society. We suggest a program that will help to prepare scientists for successful pursuit of advanced degrees at major universities and that will also provide for a continuing technology transfer as the science advances.

The portable personal computer is changing the nature of the educational process. These computers can be used to solve problems that only a few years ago required large main-frame computers and as a result can be used extensively in scientific applications. Course modules can be developed for these computers to provide a program of continuing education in all countries, but particularly in countries like Jordan, that do not have easy access to the main centers of technological development.

In our experience a key factor that stimulates the learning process is to give each person their own personal computer which is theirs forever. The reason is obvious. Any computer system requires a major effort to master the machine-related facts needed for its successful operation. Most people are not enthusiastic about working with a computer system if they feel that their access to the tool will not be continuous. After spending a month of work developing methods to meet an individuals needs, ideas about "sharing" computer systems or otherwise limiting the individuals use of the system tends to break the spell that is needed for the effective use of these tools. The idea of **one student-one computer** is the key to success, and we discuss a proposed implementation in the next section.

Our experience with technical training is mostly in Jordan and we propose a program that we are sure will work in Jordan. From our many discussions with USGS scientists who have had experience in other countries, we believe that training programs that are successful in Jordan will also meet the needs of many other countries that have similar problems. When the people of a country perceive the possibility of an earthquake, they expect their government to respond intelligently with steps to insure their safety. Sometimes, governments are pushed into expensive and unnecessary measures that are inappropriate for their situation. It is important for all countries where earthquake disasters are possible to have the in-country expertise to understand the issues and make the difficult choices between safety from a possible future event and the immediate economic cost of hazard reduction. The goal is to begin to develop that expertise in Jordan.

THE COMPUTER SYSTEM

The every day situation of the students is the prime factor that determines the choice of the computer. Most of the people that we want to reach are already engaged with full time responsibilities in their professional careers. Their time and opportunity to learn difficult new material will be at home after working hours and on weekends and holidays. Their own efforts will be supported by periodic group training sessions that will often be in other countries. These considerations require that any system be easily portable.

The only computer systems, presently available, with any sufficient power and portability to meet these requirements are in the family of IBM PC Compatible computers. New computer tools appear frequently and the choice of a computer system should be reviewed at the time they are purchased, but at the present time we would select the new Compaq 386 portable computer.

The choice of peripherals and software is as important as the choice of the computer. All the components and software must be assembled into an integrated system that minimizes the complexities of operation. At present we would select system components as follows:

HARDWARE

Compaq 386 Portable Computer
Expansion Chassis
Compaq EGA Monitor
HP Ink Jet Portable Printer
HP Laser Jet Office Printer
HP Plotter
HP Color Printer
Digitizing Table
Laser Disk System

SOFTWARE

Typing Tutor
Wordstar Professional 5.0
Lotus 123
Harvard Graphics
Mathematica
Auto CAD

TRAINING MODULES

The materials that should be covered in a modular format will require extensive use of mathematics and physics, and solid preparation in these subjects is essential. Students who do not have adequate preparation in these subjects will have to take courses at local universities to supplement the material that we will present. Any course module will test and improve the students facility to use mathematics and physics in the solution of problems, with examples drawn from seismology.

Seismology is an earth science that uses seismic waves generated by earthquakes, explosions, or other artificial sources to infer the composition and structure of the interior of the earth and to study geologic processes at depths that are not accessible to direct observation. Seismologists need a background in chemistry, mineralogy, petrology, and structural geology to apply seismology to real problems. We would try to include some review material on these subjects, but some students will require additional preparation beyond the material we can cover in our modules.

TEACHING STRATEGY

The student's interest and motivation will be essential to the success of any program. This interest can be developed by choosing problem exercises that have immediate application in the student's work.

In all scientific work the task of writing proposals and reports is critical to the success of a project. The ability to write clear, understandable descriptions of the work that needs to be done and the results of work completed often determines the success or failure of a project. Clear writing is related to clear thinking. A report that is overly complex and hard to understand often indicates that the author doesn't understand his own material. In scientific research we deal with very difficult concepts and observations, but it is the business of science to try to model these complexities and describe them in elementary terms that can be understood by most educated people. Therefore, it is important to emphasize writing and clear presentation of results at the beginning and continuously throughout any modular course. The word processor and the spreadsheet program are the most widely used computer programs in business and professional work and develop the student's facility.

The program Typing Tutor provides exercises and tests to improve the students ability to type material into the computer. Typing by scientific professionals is a very different activity than that performed by the traditional "typist". The very best typists we have known could transcribe material from one document to another at rates between 60 and 100 words per minute, rarely making a mistake in spelling or punctuation, but they achieve this speed by suppressing the meaning of the words and the intellectual content of the document from their minds. Training a traditional typist requires concentration on speed and accuracy. The training professionals need requires the development of a sufficient facility so that the mechanics of the keyboard and the word processor does not interrupt their thought as they enter their ideas into the computer. Speed and accuracy are not very important, but learning the proper fingering techniques of the keyboard and the ability to type the letters without looking at the keyboard are important. The "hunt and peck" typist will always be limited in the use of these powerful tools. Spending one hour a day for a month to develop a minimal facility with the keyboard will pay dividends for the rest of the student's life. For the student who has not used computers before the use of the regular use of the Typing Tutor program will help to overcome the "computer fright" that many people experience when they start to use computers for the first time.

After the basic introduction to the keyboard and the computer, the word processor and the spread sheet programs can be utilized. Tutorials supplied with these programs, together with exercises in the course permit the student to master these programs as the course proceeds. Many elementary problems can be solved using the spreadsheet program and the critical parts of large special purpose programs can be duplicated and checked on a spread sheet. The graphing capabilities of the spreadsheet program permit a display of mathematical results that help the student visualize the result and explore the effect of varying input parameters.

COST ESTIMATE

We would estimate that the average cost for a university to develop a new course and teach that course for one year is at least $100,000. There is not much experience in developing computer assisted instruction but these costs can be substantial. We would recommend containing these costs by placing heavy reliance on standard programs with tutorials and a new program Mathematica which has been developed specifically as an aid for teaching mathematics. We would estimate the cost to develop and test a course in this program at $100,000. A rough estimate of costs is as follows. These costs are only for planning purposes and should not be construed as a formal proposal.

Hardware and Software

Systems for three students in Jordan	**$30,000**
NRA Hardware shared by the students	**12,000**
Two Systems for USGS scientists	**20,000**
Total Hardware and Software	**$62,000**
Expenses related to developing course modules and travel to Jordan for training	**100,000**
Total	**$162,000**

The cost for a program such as this, involving more institutions and additional students over a period of years can be estimated on this basis. The cost per student decreases as the number of students and number of years increases. In future years it will be possible to link the computer systems by satellite so that students with problems can query their colleagues in other institutions. In this suggested program we outline a modest test of this new concept as a continuation of training already started in connection with the Jordan Seismic Observatory. If these methods of training are successful in Jordan, we believe that a much larger program involving more countries is feasible.

The suggested program in this proposal is not a substitute for advanced degrees in seismology from qualified universities. Our hope is to reach many qualified people who will never have the opportunity for graduate study at major universities and to provide them with the tools necessary to deal with earthquake problems in their countries. Modern graduate education tends to be highly specialized, producing experts in rather narrow areas of specialization. Our recommended program aims at providing a broader perspective, based on a solid foundation of mathematics and physics. We hope that over a period of years one could develop people whose facility with applied mathematics and physics exceeds that of most people with Ph.D.'s in the earth sciences.

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APPENDIX B

STATEMENT OF WORK

A PROPOSAL FOR THE DEVELOPMENT AND INSTALLATION OF THE JORDAN SEISMIC SYSTEM WITH EMPHASIS ON EARTHQUAKE RISKS, CRUSTAL STRUCTURE AND GEOTHERMAL ENERGY

IJO-0258-P-1C-2198

1. Initial Starting Date (Mo., Day, Yr.) o/a September 1, 1982	**PASA**	6. [X] PASA ORIGINAL [ ] PASA AMENDMENT
2. Projected Completion Date (Mo., Day, Yr.) o/a September 30, 1983	**PARTICIPATING AGENCY SERVICE AGREEMENT**	7. PASA Number IJO-0258-P-1C-2198-
3. Category [X] TDY [ ] ASSIGNED	BETWEEN THE AGENCY FOR INTERNATIONAL DEVELOPMENT AND The Department of the Interior U.S. Geological Survey	8. Country/AID/W Office Jordan
4. Duration of Funding [X] CURRENT YEAR [X] FORWARD FUNDING	5. Project Number and Title Technical Services and Feasibility Studies III Grant No. 278-0258	9. Type [X] GRANT [ ] LOAN [ ] COUNTRY FINANCED — 10. Year FY 19

11. FUNDING

A. CITATIONS	(1) Appropriation Number 72— 1121037	(2) Allotment Number NESA-82-23278-KG13		(3) PIO/T/Obligation Number 20001
B. FOR PARTICIPATING AGENCY	(1) Initial or Current $380,000	(2) Change (+ or —)		(3) New Total $380,000
C. RETAINED FOR AID DIRECT DISBURSEMENT	(1) Initial or Current	(2) Change (+ or —)		(3) New Total
D. TOTAL AMOUNT OBLIGATED (Blocks B + C)	(1) Initial or Current $380,000	(2) Change (+ or —)		(3) New Total $380,000
E. PRINCIPAL COST COMPONENTS OF (Block B)	(1) Salaries, Differential and Benefits $154,000	(2) Transportation Including Per Diem $30,000	(3) Miscellaneous $88,000	(4) Overhead $108,000

12. Statement of Purpose

I. <u>Summary</u>

This agreement between AID and the U.S. Geological Survey is to obtain Technical Assistance from the USGS to respond to the Jordanian Natural Resources Authority's (NRA) request for assistance in financing the establishment of a Jordanian Seismic System (JSS), the design for which was a cooperative effort between the NRA and the USGS which culminated in the project report entitled <u>A Proposal for the Development and Installation of the Jordan Seismic System, With Emphasis on Earthquake Risks, Crustal Structure and Geothermal Energy</u>. A proposal serves as the basis of the work to be performed under this Agreement, a copy of which is attached to this document.

13. GOVERNING PROVISIONS: Pursuant to the General Agreement dated April 5, 1967 between AID and Department of the Interior, the Agency named above agrees to provide the services outlined in Block amplified as needed by Appendix A, unless otherwise authorized by AID, all services shall be of U.S. origin. Any appendices attached hereto are considered part of this PASA.

14. Signatures

NAME Hillary A. Oden (signed)
TITLE/OFFICE Assistant Director for Programs
DATE 9/27/82

NAME Joseph C. Watkins (signed for)
TITLE/OFFICE CHIEF, SERVICES OPERATION DIVISION CONTRACT MANAGEMENT, AID
DATE August 23,1982

Appendices
[X] APPENDIX A - SCOPE OF WORK
[X] APPENDIX B - BUDGET PLAN
[X] APPENDIX C - USE OF AID PERSONNEL/FACILITIES
[X] APPENDIX D - SUBCONTRACTING
[X] OTHER/REFERENCE Appendix E - Billings
Proposal for JSS

16. Negotiating Officers
AID: CM/SOD/IIA — J. Auer
AGENCY: INT/USGS L. Benton

PARTICIPATING AGENCY SERVICE AGREEMENT
BETWEEN
THE AGENCY FOR INTERNATIONAL DEVELOPMENT AND
The Department of the Interior
U.S. Geological Survey

☒ ORIGINAL ☐ AMEND NO.
PASA NO. IJO-0258-P-1C-2198-
FISCAL YEAR 1982

II. Statement of Work

A. Objectives

The project objectives, which are described in greater detail in Attachment No. 3, are as follows:

1. To set up a (temporary) conventional seismic system of eight remote seismic stations to telemeter information to portacorder drum recorders until the automatic cluster seismic system is fully installed and operational;

2. To design, procure and field test (in California) the automatic cluster seismic system, and then to ship and install it in Jordan to replace the conventional seismic system;

3. To train Jordanian technicians for three (3) months during field testing of the automatic cluster seismic system in California, and to continue "on-the-job" training of these technicians until they are capable of operating and maintaining the JSS with minimal outside assistance.

B. Implementation

1. Technical Assistance. The USGS will provide technical assistance in the form of specialists and staff to work in Jordan and the U.S. in the acquisition and installation of the JSS, as described in Attachment No. 3. For all positions in Jordan, the USGS will nominate qualified persons and submit their curriculum vitae to the NRA for approval. The NRA and/or USAID reserve the right to reject any proposed candidate judged unsuitable to work under the project. All personnel selected to work under the project in Jordan will work directly with, and be responsible to, the NRA project manager. The USGS field manager will provide monthly status reports to the designated NRA and USAID officials, as well as a final project report, in triplicate to the NRA and USAID, upon termination of the PASA. This final report will be a summary report of the establishment of the JSS.

2. Equipment. The USGS will undertake the procurement, testing, shipping and installation of all equipment and software itemized in Attachment No. 3. Prior to shipment (the costs of which will be borne by the NRA), the USGS will coordinate all shipping arrangements, including consignee designation and import procedures, with the NRA.

3. Training. During field testing of the automatic cluster seismic system in California, USGS personnel will train Jordanian technicians in system testing, operation and maintenance procedures. As part of their responsibilities in Jordan, USGS specialists will provide "on-the-job" training to designated NRA technicians. They will also identify any additional training requirements of qualified NRA personnel.

4. Construction, Sites and Facilities. The NRA will be responsible for providing all labor and materials, as well as any required sites and facilities, to ensure the successful implementation of the project. In particular, the NRA will 1) obtain access to all sites selected for the automatic cluster systems, 2) prepare such sites, as required, for the installation and operation of the systems, 3) construct, as required, a protective shelter over the collection terminals, and 4) provide a satisfactory facility for the central observatory.

5. Project Schedule. Figure 2 of Attachment No. 3 presents a schedule (by month) of the implementation of the JSS. USGS and NRA agree to provide the required personnel on a timely basis in order to help ensure that the project is implemented on schedule.

6. Project Financing. A.I.D. is contributing $380,000 to the financing of this activity. All remaining funds required for project implementation will be provided by the NRA.

III. Background Information

The proposed JSS results from a request from the NRA to develop a work plan for the establishment of such a system. The NRA has accepted the recommendations for such a system (including technical assistance, training, and equipment procurement) made by Messrs. Gordon E. Andreasen and John H. Healy of the USGS, and Dr. Robert L. Kovach of Stanford University in their report A Proposal for the Development and Installation of the Jordan Seismic System (JSS) with Emphasis on Earthquake Risks, Crustal Structure and Geothermal Energy, dated 1981. This report is hereby incorporated in the PASA agreement, and is attached hereto.

IV. Relationships

A. The USGS specialists will be responsible to the NRA Project Manager, Mr. Mohammad Abu Ajamieh, or his designee, for all services performed and all equipment delivered and installed in Jordan. They will also submit two copies of any required reports to the USAID/Amman Liaison official. Services performed in the United States will be coordinated through the AID/W Liaison Official.

B. Cooperating Country Liaison Official

Mr. Mohammad Abu Ajamieh, Director
Geological Survey and Bureau of Mines
Natural Resources Authority (NRA)

C. AID Liaison Officials

AID/W: Mr. Davy McCall, NE/PD
USAID/Amman: Mr. Thomas A. Pearson, PO, U.S. Embassy, Amman, Jordan

V. <u>Logistics</u>

The GOJ will provide office space, and equipment, in-country transportation, interpreter/secretarial services, provide qualified personnel for training, international transportation to be paid in local currency, local funds for shipment of equipment to Jordan and the training of three (3) months of Jordanian technicians in the U.S., the construction and maintenance of the station sites.

USGS will provide services to design, procure and test equipment, make arrangements to ship equipment to Jordan, participate in the training of Jordanian technicians in the U.S.

Embassy Health Room will be available to PASA personnel.
Check Cashing/Exchange privileges of Embassy cashier.
Exemption from Jordanian Customs and Taxes.

Commissary privileges available to those who are bearers of official diplomatic U.S. passports.

Duty Stations:

(1) Amman, Jordan

(2) USGS facilities within the U.S.A.

VI. All international travel should be cleared with NE/Tech and the timing approved by USAID/Jordan prior to departure.

BILLINGS

A. Billings should be submitted for payment to A.I.D. on Standard Form 1080 or 1081, together with dates of services rendered and a breakdown of accrued expenses. Submissions should be made on a monthly or quarterly basis with the following identifying data shown on the facesheet: (1) PASA No., (2) Project Name and No., and (3) PIO/T Obligation No. Disbursements will not be made without this identifyi information.

B. Billings for services rendered under this agreement should be addresse to:

Controller
USAID Amman
Agency for International Development
Washington, D. C. 20523

APPENDIX D

"Subcontracting

a. As used herein, the term "subcontracting" includes purchase orders.

b. Subcontracting by the participating agency with AID funds must be specifical authorized in the PASA or RSSA involved or, separately requested in writing and approved by the AID Agreements officer prior to negotiations. According participating agencies are required to clearly indicate in their budget submission to AID for a particular PASA or RSSA the extent of anticipated subcontracting. Where such subcontracting arises during performance an amended budget and amendment to the PASA or RSSA to cover subcontracting may be neces prior to entering into a subcontract. All subcontracting under PASA and RSSA agreements using AID funds is subject to the provisions on contracting as sta in AID Handbook 12, 1C7. a. through f. pages 1-21 and 1-21a.

c. AID authorized subcontracting shall be undertaken using the participating agency's own contracting authority and its own contracting regulations. Such authority shall be cited in the subcontract. When subcontracts are negotiate the circumstances permitting negotiation shall also be cited. AID may, when it in the best interest of the Government, authorize a participating agency to subcontract with an individual for personal services abroad under a subcontrac in which the participating agency may, absent its own authority to contract fo personal services, cite Section 636(a) (3) of the Foreign Assistance Act of 19 as amended (FAA). In such event, the circumstance permitting negotiation is 41 U.S.C. 252(c)(15). Where the FAA is used as authority, the participating agency shall also use applicable AID contracting regulations."

"Use of AID Facilities and/or Personnel

a. Participating agencies, their employees, and consultants are prohibited from using AID facilities (such as office space or equipment) and AID clerical/technical personnel in the performance of services specified in a Resources Support Service Agreement (RSSA), unless the use of such personnel and/or facilities is/are specifically authorized in the RSSA.

b. If at any time it is determined that the participating agency has used AID facilities or personnel without authorization in the RSSA, then the amount payable under the RSSA agreement shall be reduced by an amount equal to the value of the AID facilities or personnel used by the participating agency as determined by the agreement officer."

BUDGET PLAN APPENDIX B

PAGE ___ OF ___

PARTICIPATING AGENCY SERVICE AGREEMENT BETWEEN THE AGENCY FOR INTERNATIONAL DEVELOPMENT AND

U.S. Geological Survey

1. PASA NO.	2. AMENDMENT NO.	3. FISCAL YEAR
IJO-0258-P-IC-2198-00		1982

4. APPROPRIATION	5. ALLOTMENT	6. AMOUNT CURRENTLY FUNDED
72-1121057	NESA-82-23278-KG-13	

7. FUNDED BY	PIO/T-OBLIG. NO.	AMOUNT	PIO/T-OBLIG. NO.	AMOUNT	PIO/T-OBLIG. NO.	AMOUNT
	20001					

8. PASA BUDGET PLAN – FUNDING

DESCRIPTION	AMOUNT
SALARIES	140,000
BENEFITS (10 % OF SALARIES)	14,000
DIFFERENTIAL (____ % OF SALARIES)	–
LEAVE FACTOR (TDYs ONLY) (____ % OF SALARIES & BENEFITS)	–
TRAVEL (EXPLAIN BELOW) 1/	25,000
PER DIEM (EXPLAIN BELOW) 3/	5,000
MOVEMENT EFFECTS (INTERNATIONAL) (NORMALLY ONLY MOVEMENT TO POST)	–
MOVEMENTS/STORAGE OF EFFECTS (DOMESTIC)	–
OTHER: (SPECIFY BELOW) ow cost 18,770	16,300 ~~88,000~~ ~~103,300~~
OVERHEAD 18% 40 % [ ] SALARIES & BENEFITS [ ] PERSONNEL COSTS [X] ALL COSTS 73600	~~108,000~~ 92,370
TOTAL (INCLUDES ____ TO BE FUNDED BY FUTURE PASA AMENDMENTS)	380,000

9. STAFFING

NAME AND TITLE	GRADE	PERIOD (PEOPLE-DAYS/MONTHS)	AMOUNT
Geophysicist	14/5	12	45,000
Geophysicist	15/5	12	46,000
Seismologist	15/5	6	25,000
Electronic Tech	11/5	6	13,000
Field Technicians	9/5	6	11,000

140,000
14,000
25,000
5,000
184,000
73,600 (40%)

85,000
40%
35,200

88,000
18%
15,840

88,000
18%
15,840

19000
- 3100

EXPLANATORY COMMENTS

1/ 10 round trips - San Francisco/Amman Jordan.
2/ International per diem plus misc. travel expenses
3/ Equipment for remote stations 34,000
Data collection terminals 31,000
Ancillary seismic supplies & materials 23,000
misc computer mat. 88,000
16,300
104300

345,600

18% 18770
40% 73600
92370

Note: All in-country per diem and in-country travel costs to be paid directly to traveler or provided in kind by USAID or GOJ/NRA.

Kovach JO-13

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PROJECT REPORT
Jordan Investigations
(IR)JO-13

A PROPOSAL FOR THE DEVELOPMENT AND INSTALLATION OF THE JORDAN SEISMIC SYSTEM (JSS) WITH EMPHASIS ON EARTHQUAKE RISKS, CRUSTAL STRUCTURE AND GEOTHERMAL ENERGY

Prepared in cooperation with Jordan Natural Resources Authority, under the auspices of the Agency for International Development.

1981

A PROPOSAL FOR THE DEVELOPMENT AND INSTALLATION OF THE JORDAN SEISMIC SYSTEM (JSS) WITH EMPHASIS ON EARTHQUAKE RISKS, CRUSTAL STRUCTURE AND GEOTHERMAL ENERGY

BY

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The project report series presents information resulting from various kinds of scientific, technical, or administrative studies. Reports may be preliminary in scope, provide interim results in advance of publication, or may be final documents.

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A PROPOSAL FOR THE DEVELOPMENT AND INSTALLATION OF THE JORDAN SEISMIC SYSTEM (JSS) WITH EMPHASIS ON EARTHQUAKE RISKS, CRUSTAL STRUCTURE AND GEOTHERMAL ENERGY

by

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EXECUTIVE SUMMARY

This is a proposal to develop and deploy a specially designed seismic network to meet the needs for information on the distribution of earthquakes in the Kingdom of Jordan. The design is based on a new system concept that integrates seismic systems, telemetry, computer hardware and software, and technical man power in a way that will minimize the cost of long-term monitoring. The system is not experimental as it is made up of components that have been thoroughly tested in extensive earthquake research by the U.S. Geological Survey. However, it is new in the sense that these existing elements are combined in a new way in order to meet the special needs of the Kingdom of Jordan, and we have named this system "JSS" (Jordan Seismic System) to identify its unique qualities.

The system is made up of clusters involving as many as eight seismic stations from which data are telemetered by radio to a central collection point where all routine data are analyzed automatically by a data processor. The results of the automatic analysis are saved, together with selective portions of seismograph data, for later transmission to the Central Observatory where the data from the individual clusters are collated and displayed in bulletins and maps. The system can be expanded almost without limit by the addition of new clusters. The seismometer, electronic amplifier, and telemetry instruments to be employed in the system are identical to those in the systems now in use in the U.S. Geological Survey networks in California. The computer systems employed at the cluster centers and at the Observatory are all manufactured by the Digital Equipment Corporation (DEC), and we have taken care to use interchangeable components between clusters and the Observatory so that maintenance can be accomplished by interchanging components and by periodic visits by the maintenance people who will be maintaining other DEC computer soon to be operating at the NRA. The system can be easily modified to meet future needs of the Kingdom of Jordan, involving both an increase in the number of instruments and the application of different types of instruments without interfering with the basic structure of the initial installation.

In order to obtain some data from critical problem areas at the earliest possible date, we propose a plan to install eight chart recorders at the Central Observatory to record data from the first cluster in a visual, traditional format. The remote seismometer stations are positioned to monitor events in the area of the waterpipeline from the Jordan Valley to Amman and the area surrounding the King Talal dam, which is scheduled for substantial raising of its water level in the near future (see figure 1). In addition to obtaining

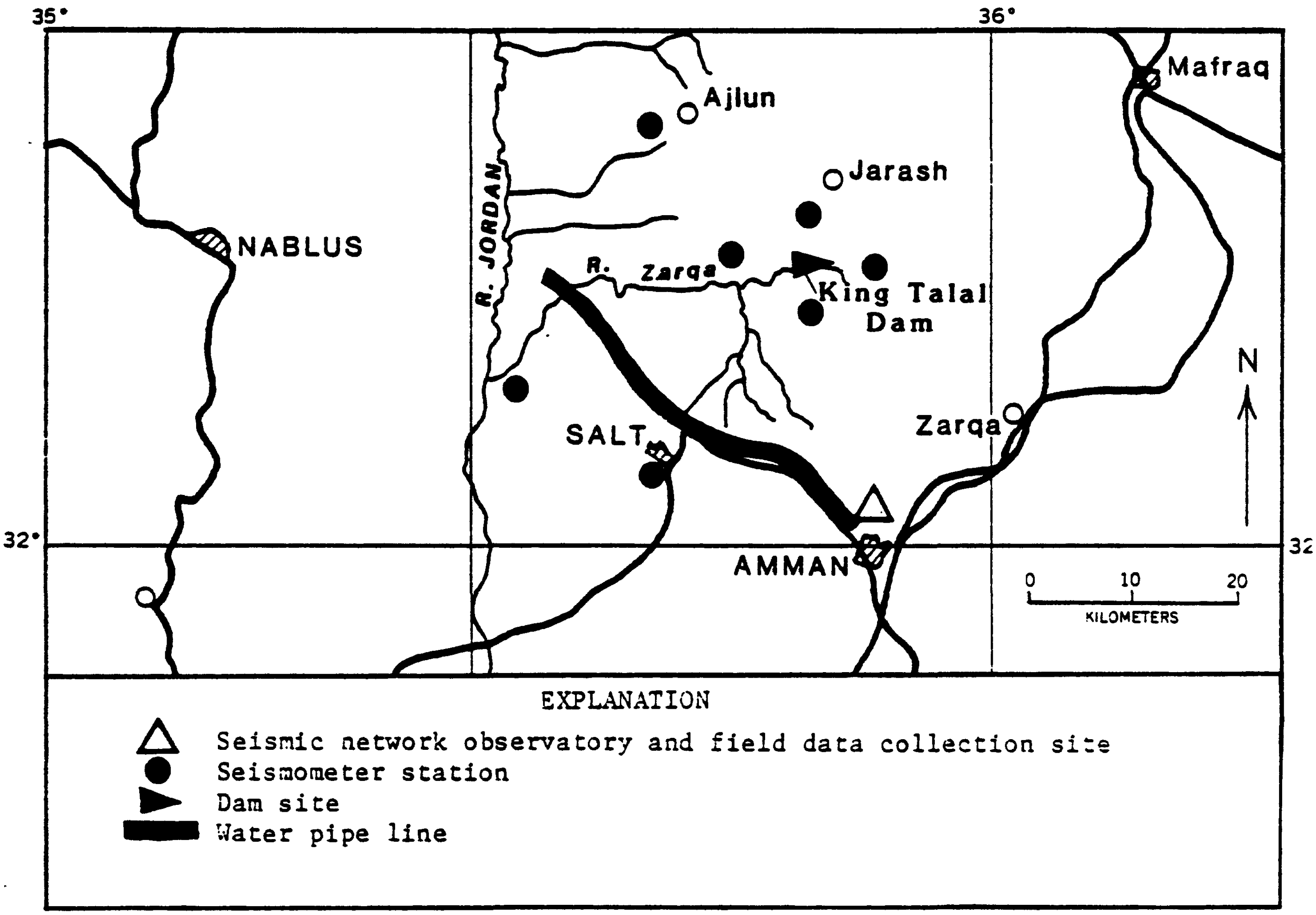


Figure 1 : Proposed locations of seismometers for the first cluster of the Jordan Seismic System (JSS)

data at an early date, these systems will provide trainees with valuable experience in the traditional ways of analyzing seismic data. As the automatic system becomes fully operational, the recorders can be deployed as individual stations for short-term special studies.

The system is designed so that it can be operated by Jordanian technicians with minimal outside assistance after an initial training period. In this regard, it is important to recognize that the system itself is not a research tool. The goal of the system is to provide usable and reliable seismic data for any desirable objective. Thus, the personnel required for the successful, long-term operation of this system are primarily competent technicians having natural aptitudes but perhaps minimal training in science and engineering. The part-time efforts of a nonscientist manager will be needed for long-term supervision of this facility.

The seismic data may be applied to the special needs of Jordan in studies of seismic activity induced by new reservoirs, in the problem of estimating and reducing earthquake hazards in Jordan, in analysis of earthquake data to provide possible clues to the distribution of geothermal resources, and in the scientific study of earthquakes as part of the worldwide effort to better understand their tectonic significance for eventual prediction of earthquakes. Each of these goals will require competent seismologists capable of analyzing the data and drawing useful inferences. We believe that it will be best to separate these activities from the day-to-day management and operation of the JSS.

The expandable system can be implemented in three phases; the first and second phases must be concurrent and the third phase may be implemented and at any later time as required to meet the objectives of the Government of Jordan. A schedule of events for the phases is shown in figure 2, and a summary of estimated costs is shown in table 1.

Table 1.—Summary of costs for phases 1 and 2.

	Estimated cost in US dollars
Equipment	185,225
Software	30,000
Salaries, per diem, travel and overhead	256,500
	$471,725

The above estimates reflect present-day (1981) costs and do not include rising costs due to inflation or administrative overhead. The figures cited above are believed to represent maximum costs; the actual costs may be somewhat less.

INTRODUCTION

Under the sponsorship of the Government of Jordan (GOJ) and the U.S. Agency for International Development (AID), the U.S. Geological Survey (USGS) is providing geological and geophysical assistance for Jordan's Natural Resources Authority (NRA). Included under this program is a feasability study for installing a seismological network in the Kingdom of Jordan, with particular emphasis on addressing questions pertaining to seismic risk, crustal structure, and geothermal energy. This work is partly accomplished under a work agreement between the U.S. Geological Survey and the U.S. Department of Agriculture Graduate School with the Government of Jordan.

The Hashemite Kingdom of Jordan covers an area of approximately 95,000 km^2 in the northwestern part of the Arabian Peninsula. It is bordered by the countries of Syria, Iraq, and Saudi Arabia, and the seismically active Wadi Al Arabah

JSS (JORDAN SEISMIC SYSTEM)
PROPOSED SCHEDULE (by Month)

8 PORTACORDER CLUSTER

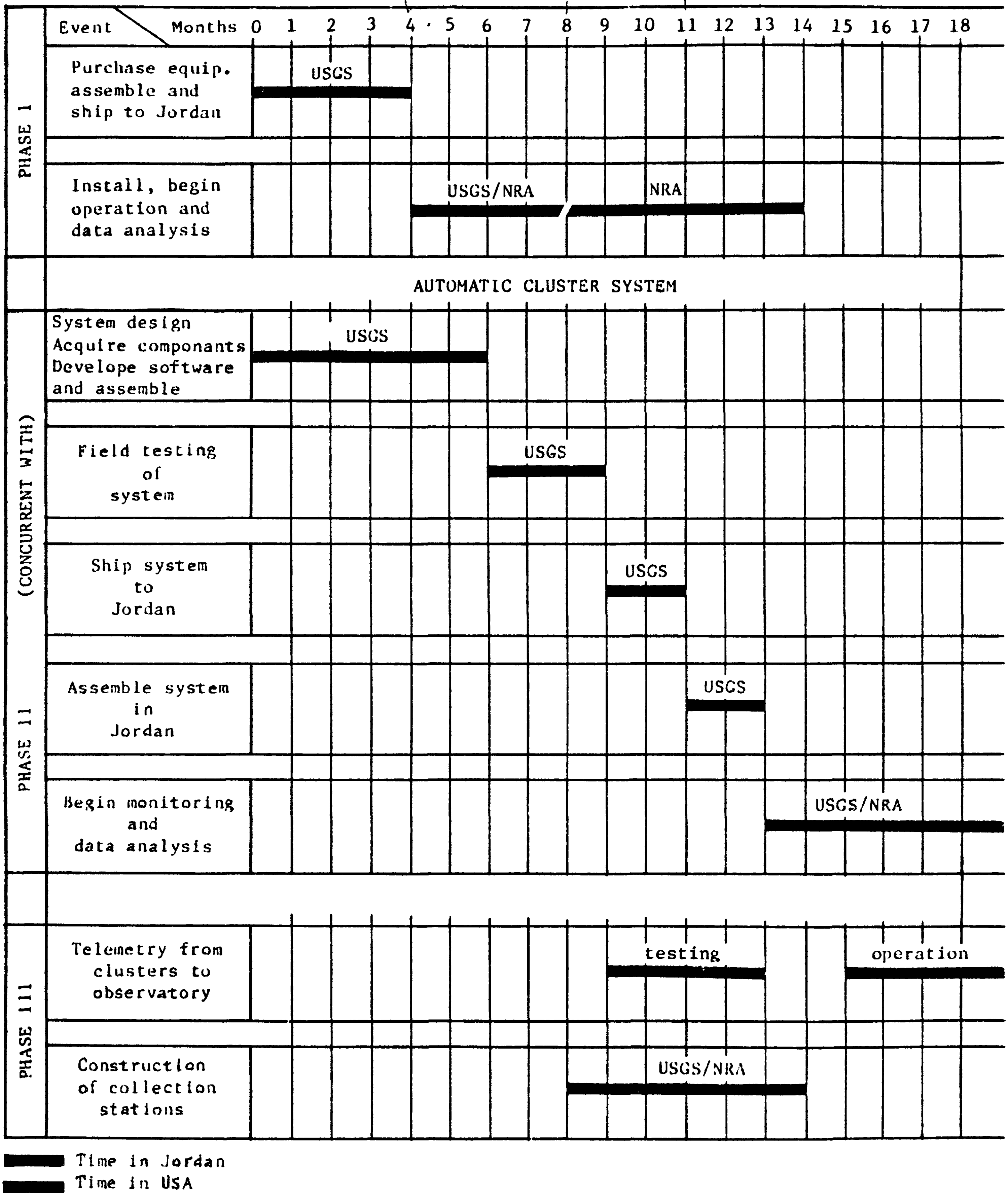


Figure 2. Schedule of events in the establishment of the Jordan Seismic System (JSS)

(alternatively known as the Jordan Rift or the Dead Sea Rift and referred to in this report as the Dead Sea Rift) which forms the western margin of the Arabian Plate. The physiographical and geological provinces of Jordan are shown in figure 3, taken from the comprehensive work on the geology of Jordan by Bender (1974). Though the geology is quite well known, the pattern of earthquake activity, its temporal and spatial characteristics, and their relation to the geologic and tectonic framework of Jordan are not well understood.

Very pertinent questions can be posed concerning the Dead Sea, the crustal structure of Jordan, the assessment of seismic risk, and induced seismicity. Adequate seismic data would provide valuable information relative to these questions. In addition, seismic data together with existing airborne electromagnetic data can be used in the assessment of geothermal and hydrothermal areas. The final important consideration involves the training of young Jordanian scientists and technicians in seismology. Recently, a limited 3-station seismic system using modern equipment supplied by the Government of West Germany has been installed in the local environs of the University of Jordan. The work is being carried out performed under the direction of Dr. Zuhair El-Isa, Assistant Professor of Geophysics. Essential details of the system are shown in Appendix B of this report.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the enthusiastic support of the many officials and staff of the Natural Resources Authority (NRA), the National Planning Council (NPC), the Jordan Valley Authority (JVA), the University of Jordan, the Royal Scientific Society (RSS), and the U.S. Agency for International Development (AID). We particularly thank Vice President A. Dokhgan, Director General Y. Nimry, Director of the Geological Survey M. Abu-Ajamieh,

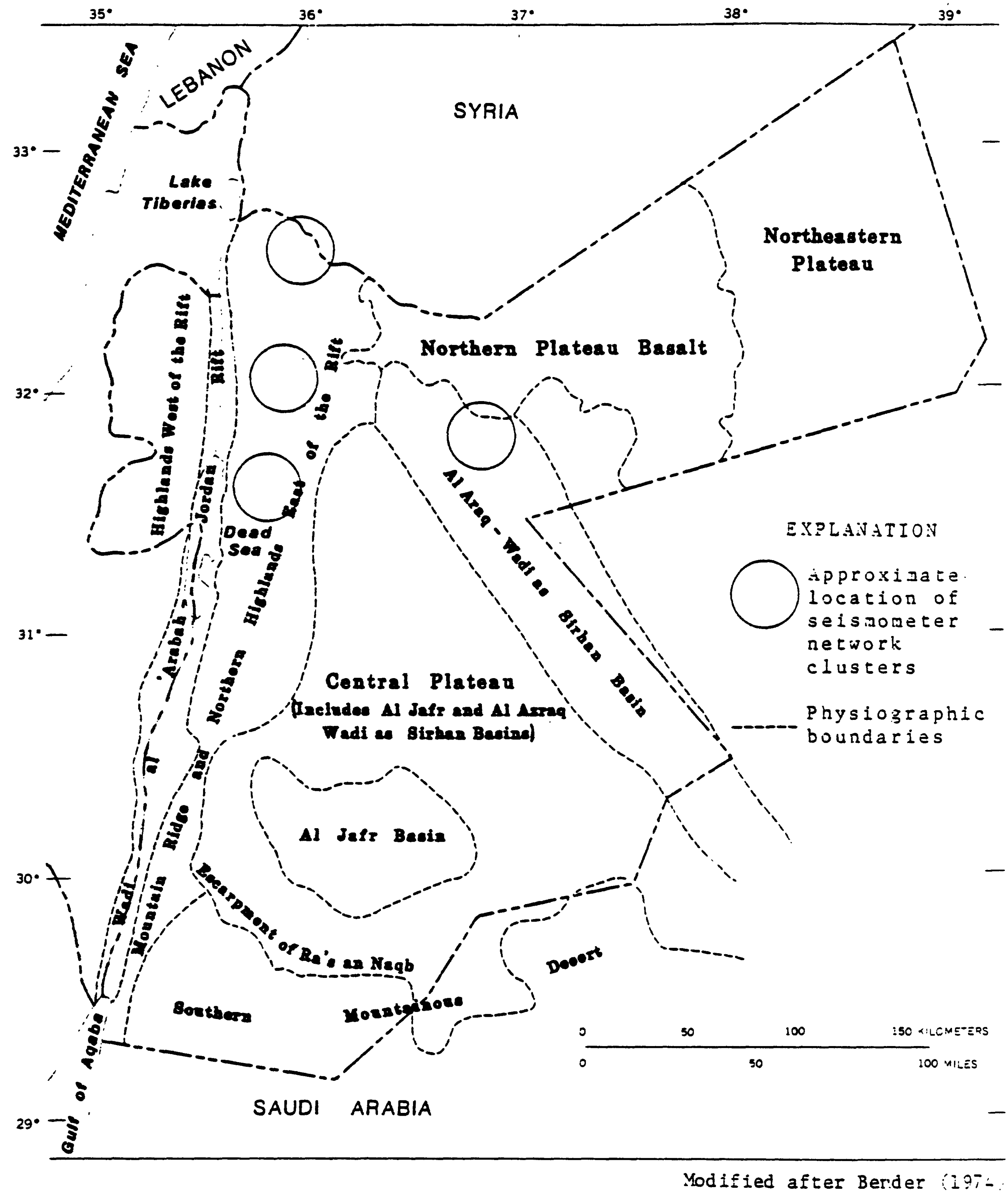


Figure 3. Index map showing physiographic-geologic provinces of Jordan and approximate locations of proposed seismometer clusters.

and Chief Geophysicist, K. Kaysi, of the NRA; Dr. I. Khubeis, Head of Science and Technology, NPC; Dr. Zafer Alem, Director of Dams' staff member Ibrahim Barjawi of the JVA, and Dr. Zuhair El-Isa of the University of Jordan, for many technical discussions. We also thank Mr. Stan Stalla, AID, for his kind support. We acknowledge the assistance of Dr. Arthur F. Byrnes, Head, International Programs, U.S. Department of Agriculture Graduate School, for making the participation of the first author possible.

SEISMICITY OF JORDAN

Crustal structure

The crustal structure of Jordan and its relation to geologic features is not known. Knowledge of the crustal structure to depths of the Moho-discontinuity is important because it sets the basic framework for understanding the geologic evolution of the region. It is not difficult to pose a series of provocative, but pertinent, questions concerning the crustal structure in the Kingdom of Jordan: a) what are the variations in crustal structure approaching the rift zone from the east? b) What is the crustal structure in northeastern Jordan in the vicinity of extensive basalt flows and the interesting alignment of small basalt domes, such as those found north of Al Azraq? One is intriqued by the possibility of a comparison of the crustal structure in this region with the anomalous crust found in the eastern Snake River Plain, Idaho, which is believed to be due to the passage of a mantle hot spot. c) What are the crustal characteristics of the Al Karak-Wadi al Fayha zones—a major structural feature that obliquely intersects the Dead Sea Rift zone but has a trend parallel to the Gulf of Suez and the Red Sea, which are known spreading centers?

Perhaps the most important objective of crustal structure studies is to provide information pertinent to understanding the geologic framework and its relation to possible energy resources. Routine observations of S minus P arrival times will contribute much to the development of a crustal model appropriate for the Kingdom of Jordan.

The Dead Sea Rift

Previous, but very limited, observations have demonstrated the continuing seismic activity of the Dead Sea Rift zone (Ben-Menahem and others, 1977, and Arieh, 1967). In fact, one does not have to look very far back into the historical record to recall the magnitude (M) 6.5 earthquake which severely damaged Jericho in 1927.

Extrapolation of microseismological data suggests that one might anticipate along the Dead Sea Rift a magnitude (M) 5.0 earthquake every 40 years, an earthquake of magnitude greater than 6.1 every 500 years, and that, in a seismological-enginering context, the Dead Sea Rift is a fault capable of producing a magnitude (M) 7.0 earthquake. The earthquakes that occurred in 1976 in Tabas, Iran, and 1980 in El-Asnam, Algeria, were approximately magnitude 7.0 earthquakes and produced great loss in human life and property damage.

However, the limited seismological data results are not compatible with the inferred rate of slip that is occuring along the Dead Sea Rift plate boundary (Ben-Menahen and others, 1977). That is, geological and paleomagnetic considerations convincingly point to a relative rate of plate movement of 4-6 mm/yr along the Rift boundary (see for example, Freund and others, 1968; Girdler and Styles, 1974). The total strike-slip movement of approximately 107 km has also recently been demonstrated by matching magnetic anomalies across the rift (Phoenix Corporation, 1980, p. 57-60). On the other hand, the seismic data (which can be used via magnitude-moment considerations[1/] to infer a rate of slip) only

---

1/ A common measure of earthquake size is magnitude M which is empirically related to energy, and is computed from the logarithm of the amplitude of seismic waves. Seismic moment is a more accurate measure of earthquake size and is proportional to the amount of fault area offset and the average amount of offset.

yield an average slip rate of 1 mm/yr (Kovach, 1979). One is therefore forced to conclude that either deformation along the Dead Sea Rift is taking place as seismic slip or that the region is accumulating strain energy for a future, large earthquake.

OBJECTIVES OF A SEISMOLOGICAL NETWORK

Improvement of the data base for assessing seismic risk

Although the earthquake recurrence in Jordan is not known, and the location of zones of seismic activities have not been studied in detail, earthquakes are known to occur along the Dead Sea Rift. However, their epicentered locations are poor. An example of such a damaging earthquake is the 1927 M = 6.5 earthquake in the vicinity of Jericho. Examination of Arabic documents from the 7th to the 18th Century A.D. has also revealed that damaging earthquakes have taken place in the Middle East. Before seismic risk can be accurately forecast, the pattern of seismic activity needs to be delineated.

Knowledge of the seismicity patterns is important for future development in establishing criteria for building codes for housing, hospitals, commercial buildings, power plants, dams, pipelines, and other facilities. Seismicity patterns are also of use in mapping regional geologic structures that may have controlled the concentration of economically important minerals.

Natural and induced seismicity in the vicinity of proposed dam sites

Man-made earthquakes have occurred as a result of the filling of large dams. Following the filling of Lake Mead behind the Hoover Dam in the United States in 1935, more than 600 local tremors occurred over a 10-year period. Since that time there have been other notable examples, with deadly results, for example, in Kremasta, Greece, a major earthquake was associated with the filling of a large artificial lake behind a dam. The most devastating example, however, occurred in India--the Koyna earthquake of December 10, 1967, caused 200 people to lose their lives, in addition to widespread destruction. This example is of particular interest because the dam was built in an area believed to be aseismic: the Deccan shield of India. There was no recorded seismic activity prior to the impounding of the reservoir in 1962. However, a very high water level was maintained from August to December 1967 and that appears to have been responsible for an increased level of seismic activity followed by the damaging earthquake.

It will be important to monitor the microseismicity activity prior to and subsequent to the filling of dams such as the Maqarin Dam (Seismic Monitoring at the Maqarin Project, 1979) to properly assess the seismic hazards in the vicinity of the dam site.

Our knowledge of the level of overall seismic activity in Jordan, away from the Dead Sea Rift, is at best speculative, and prudence would dictate that a microearthquake monitoring program be implemented so that an evaluation can be made of any possible seismic hazards.

Geothermal considerations

An exploitable geothermal area has been inferred in the Zerqa Ma'in and Zara areas (Abu Ajamieh, 1980). Other possible areas for consideration are the Hamme Hot Springs near El Mukheiba and the Azraq region. Microearthquake activity has been observed in many geothermal areas, and even though there is a lack of understanding of the detailed mechanism causing such earthquakes, there is no question that monitoring of microearthquake activity appears to be useful in evaluating the depth of water circulation and the location of faults and fractures which allow hot water to channel to the surface. Monitoring of the microearthquake activity from a tripartite array operated on the West Bank from August 26-November 6, 1976, detected 10 events associated with the Zerqa Ma'in area, and one event possibly associated with the Zara region (fig. 4 and table 2). These regions are seismically active, and it is important to precisely locate the seismic activity in this part of the Dead Sea Rift. Microearthquake monitoring of the Zerqa Ma'in and Zara areas has also been recommended by other investigators (Mabey, 1980, unpublished data; McEuen, 1981).

Total intensity magnetics of the Zerqa Ma'in and Zara area

During 1979-80 an electromagnetic survey of the western part of Jordan was made as a part of a Kingdom-wide minerals program sponsored by the NRA and the USAID. In addition to the recording of electromagnetic data, absolute total-intensity magnetic data were also recorded by use of a proton-procession magnetometer recording at one second intervals with an accuracy of one gamma. The survey was flown along east-west flightlines spaced 0.25 km apart at a nominal ground clearance of 75 meters. Figure 5 shows a part of the resulting magnetic anomaly map covering an area of approximately 120 sq km. The International Geomagnetic Reference Field (1975 Epoch 1980.1) has been removed and a 10,000-gamma constant added to the data.

To provide a visual impression of magnetic highs and lows, the map has been contoured with areas of highs of 10,000 gammas and greater colored red, and lows of 9800 gammas and less colored blue. The impressive east-west trend of the anomaly pattern is characterized by steep gradients and short-wave-length anomalies commonly observed over volcanic rocks. The magnitude of the anomalies observed at this low level (75 m) is approximately 3500 gammas. The anomalies are produced by rocks magnetized in the earth's present field and by a certain amount of remnant magnetization.

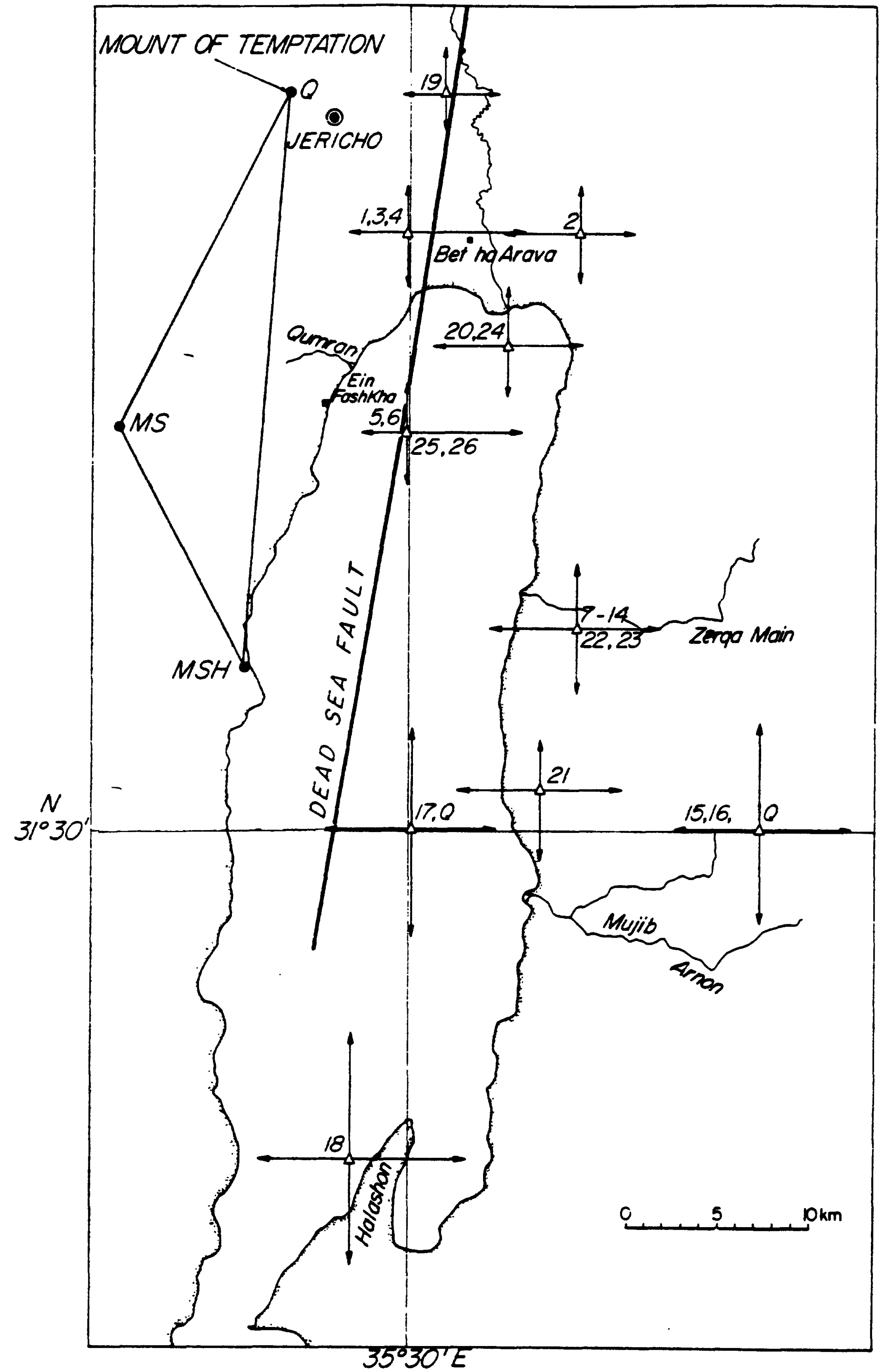


Figure 4. Stations (solid circles) and epicenters rounded to the tenth of a degree (open triangles) during Aug.1976-Jan.1977 in the vicinity of the Dead Sea fault (solid line).

Note: Numbers relate to entities in Table 1. Uncertainties in epicenter locations are indicated by horizontal and vertical arrows. Epicenters observed at Quarantal alone (Table 1) are indicated by the letter Q. For additional data concerning the Dead Sea fault see Ben-Menahem and others, 1977.

TABLE 2

Summary of located events in area of interest

No.	Date	Origin time GMT (h m s)	Epicenter (°N)	Epicenter (°E)	M_L	Location
19	Sep. 13, 1976	16 44 04	31 52	35 32	1.90	E of Jericho
20	Sep. 22, 1976	13 23 40	31 45	35 35	1.50	northern Dead Sea
1	Oct. 27, 1976	01 43 39	31 45	35 29	2.10	Bet Ha'arava-Qumran
2	Sep. 2, 1976	10 36 18	31 45	35 40	1.16	Bet Ha'arava-Qumran
3	Sep. 11, 1976	21 59 50	31 45	35 29	2.00	Bet Ha'arava-Qumran
4	Sep. 22, 1976	02 41 29	31 45	35 28	1.10	Bet Ha'arava-Qumran
5	Sep. 3, 1976	01 55 00	31 43	35 33	1.08	Ein Fashkha
6	Oct. 27, 1976	06 30 11	31 43	35 27	1.80	Ein Fashkha
7	Sep. 2, 1976	14 42 28	31 36	35 38	2.00	Zarqa Main
8	Sep. 2, 1976	15 53 19	31 36	35 38	0.86	Zarqa Main
9	Sep. 3, 1976	02 07 47	31 36	35 38	1.02	Zarqa Main
10	Sep. 5, 1976	10 41 02	31 36	35 39	1.24	Zarqa Main
11	Sep. 8, 1976	19 27 50	31 37	35 39	0.86	Zarqa Main
12	Sep. 10, 1976	20 45 22	31 36	35 36	0.96	Zarqa Main
13	Sep. 14, 1976	17 54 48	31 37	35 40	1.30	Zarqa Main
14	Sep. 17, 1976	14 42 36	31 36	35 33	0.86	Zarqa Main
15	Oct. 9, 1976	07 47 55	31 32	35 46	1.32	Arnon-Zarqa Main
16	Oct. 9, 1976	07 55 56	31 33	35 35	1.18	Arnon-Zarqa Main
21	Oct. 31, 1976	06 59 01	31 28	35 34	1.40	S of Zarqa Main
17	Sep. 16, 1976	20 03 16	31 27	35 36	1.86	N of Halashon
18	Sep. 4, 1976	09 23 28	31 18	35 25	1.60	N of Halashon

No.	Date	Arrival time GMT (h m s)	Epicenter (°N)	Epicenter (°E)	M_L	Recorded at
	Additional events (recorded at Elat and one/two network stations):					
22	Oct. 6, 1976	20 40 20 (*Q*)	31.6	35.6	2.50	*MS, Q, E*
23	Sep. 25, 1976	05 31 32 (*Q*)	Zarqa Main		1.90	*Q, E*
24	Sep. 25, 1976	01 33 17 (*Q*)	northern Dead Sea		2.00	*Q, E*
25	Oct. 3, 1976	16 42 47 (*MSH*)	31.7	35.5	1.90	*MSH, F*
26	Oct. 3, 1976	18 43 24 (*MSH*)	31.7	35.5	2.00	*MSH, E*
	ARAVA fault system:					
1-A	Aug. 31, 1976	11 27 49 (*E*)	30.5	35.25	1.90	*E, MSH, Q, MS*
2-A	Oct. 11, 1976	01 26 18 (*E*)	30	35	2.50	*E, MSH, Q, MS*
3-A	Oct. 22, 1976	19 28 06 (*E*)	30.5	35.25	2.25	*E, MSH, Q, MS*
4-A	Oct. 23, 1976	14 08 42 (*E*)	29.5	35	2.10	*E, MSH, MS*
5-A	Oct. 24, 1976	14 55 01 (*E*)	30.5	35.25	1.70	*E, MSH, Q, MS*
6-A	Oct. 24, 1976	18 04 20 (*E*)	30	35	2.00	*E, MSH, Q, MS*

Recording stations: *F* = Elat; *MS* = Mar Saba; *MSH* = Mitspe-Shalem; and *Q* = Quarantal.

Surface exposure of the volcanic rocks, approximately delineated by a dashed line (fig. 5), was taken from an unpublished detailed geologic map (scale 1:10,000) prepared by the NRA. No outcrops were mapped in the Zara area. Areal extent of the anomaly-producing rocks, generally shown by the colored areas, is delineated by the dotted line which has been interpreted from the magnetic data. Two volcanic necks and one plug have been mapped in the Zerqa Ma'in area (not shown in fig. 5). The magnetic data show seven or eight anomalies that may have been produced by similar features.

Although further analysis of the magnetic data is necessary (requiring a computer), the present compilation is useful in delineating the extent of the volcanic rocks on the surface and the subsurface. The information is also helpful in determining locations for shallow drill holes for heat-flow measurements. Only one proposed seismometer site is shown on the aeromagnetic map. Two more sites are located just off the map area, a few kilometers to the north at Mt. Nebo and Ma'in. The location of seismometer sites is discussed in a later section.

Much of the acquired aeromagnetic and electromagnetic data for other geothermal regions of interest have not yet been analyzed in detail. Work should proceed on detailed analyses of anomaly patterns, relation to tectonic features, depths to basement, depths to the Curie point isotherm, etc.

Educational benefits

The operation of a high-quality seismic network in Jordan would offer many educational benefits. The objectives can be succintly stated: 1) to provide training so that maintenance and data analysis would be carried out by Jordanians; 2) to strengthen geophysical sciences in Jordan by the creation of a focal point for scientific discussions and an avenue for educational contacts to the international community; 3) to create the opportunity for training of selected Jordanian scientists and technicians.

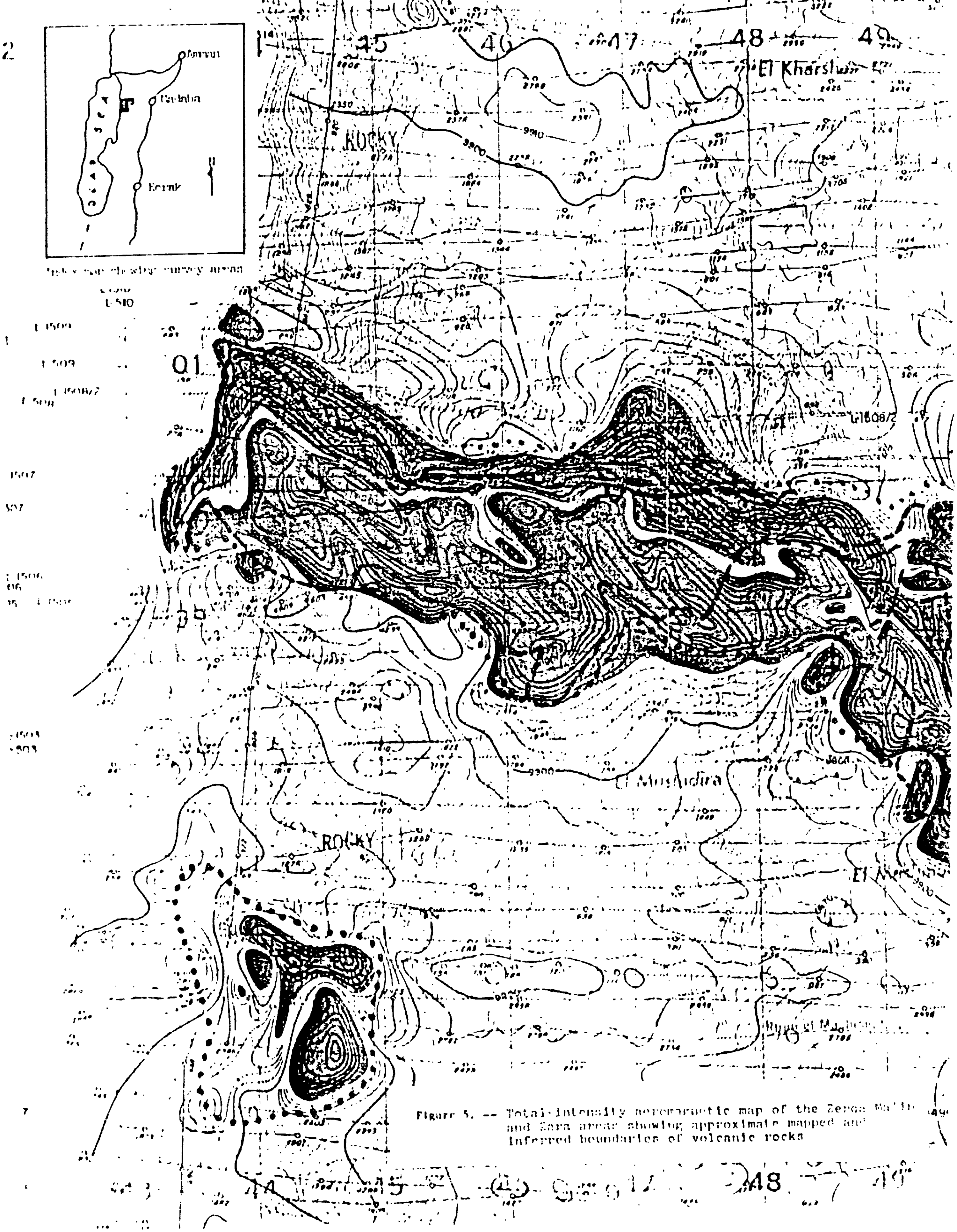
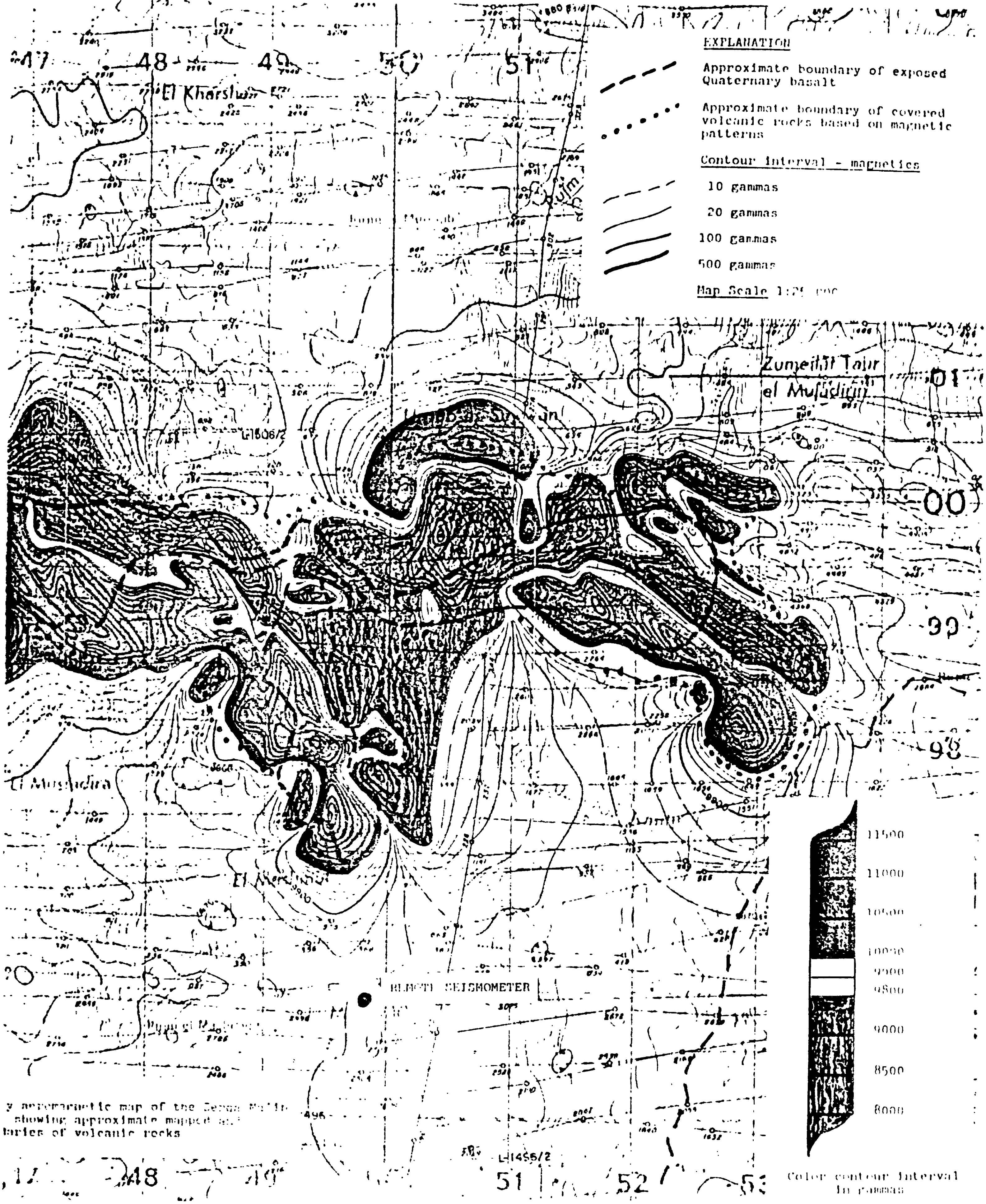


Figure 5. -- Total-intensity aeromagnetic map of the Zerqa Ma'in and Zara areas showing approximate mapped and inferred boundaries of volcanic rocks



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THE JORDAN SEISMIC SYSTEM (JSS)

System design concepts

The proposed design of the Jordan Seismic System (JSS) is based on a new system concept that integrates seismic systems, telemetry, specialized computer hardware and software, and technical personnel to produce high quality results with minimal cost of long-term monitoring. The system is named "JSS" (Jordan Seismic System) to identify its unique qualities. The system is not experimental as it is made up of components that have been thoroughly tested by the U.S. Geological Survey in extensive on-going earthquake monitoring networks in California.

The JSS is made up of "clusters" of as many as eight remote seismic stations from which data are telemetered by radio to a central field collection station where all routine data analyses are performed automatically by a data processor (computer). The results of the analyses are saved, together with certain portions of the seismograph data, for later transmission to the Central Observatory. Here the data are collated and displayed as bulletins and maps.

The JSS can be expanded almost without limit by the addition of new clusters. The computer components to be employed in the JSS are produced by the Digital Equipment Corporation (DEC). All components are interchangeable between clusters and the Central Observatory. In this way, maintenance can be accomplished by component interchange and periodic routine servicing by DEC engineers who will also be maintaining the new DEC 11/44 computer system soon to be installed at the NRA.

Construction and installation of clusters

A typical cluster installation is shown in figure 6. At the central collection terminal for the remote stations a small structure should be available, with electric power and thermostatic control to maintain the temperature sta-

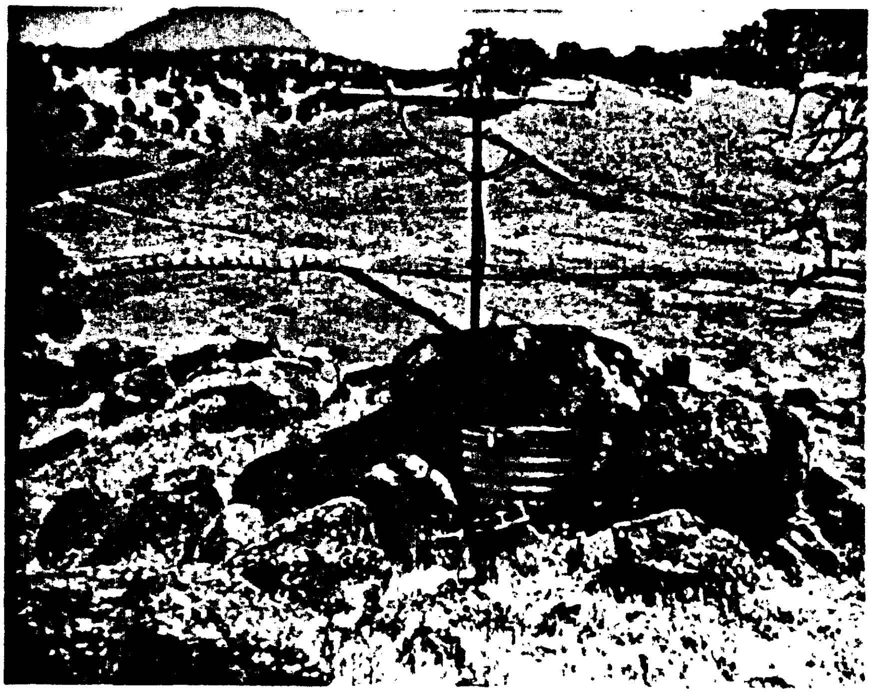

Figure 6. Typical USGS solar-powered remote seismometer site. Separation of seismometer and electronics, about 50 feet. Height of antenna approximately 6 feet. Telemetry range - 50 kilometers.

bility for the data-processing computer. This unmanned terminal will house the following electronic instruments designed to receive data from the remote seismometers:

- signal conditioner
- signal detector
- data processing (via a special computer)
- data storage and data telemetry to observatory in Amman.

A schematic diagram is shown in figure 7.

Tentative site selection for clusters

During the visit to Jordan several key areas of interest for seismological monitoring were identified. These are:

- the northern Dead Sea Rift.
- the Zerqa Ma'in and the Zara geothermal regions.
- the selected dam sites and pipe lines in the northeast of Jordan.
- the Azraq area in central Jordan.

These areas are shown on the index map (fig. 8) together with other proposed dam sites, pipelines, and possible geothermal prospects.

Because of the need to eliminate the tedious daily routine of changing analog records at remote sites, it is recommended that radiotelemetry be used at these sites for transmission to a collection point in the vicinity. This requirement in turn dictates that for the site selection of the array elements (remote seismometers, line-of-sight characteristics be maintained so that low-power telemetry can be used. Another criteria used in the site-selection process is the need to avoid positioning stations in the Jordan Valley underlain by Quaternary alluvium or the Lisan Formation (marl, shale, gypsum, oolitic limestone and

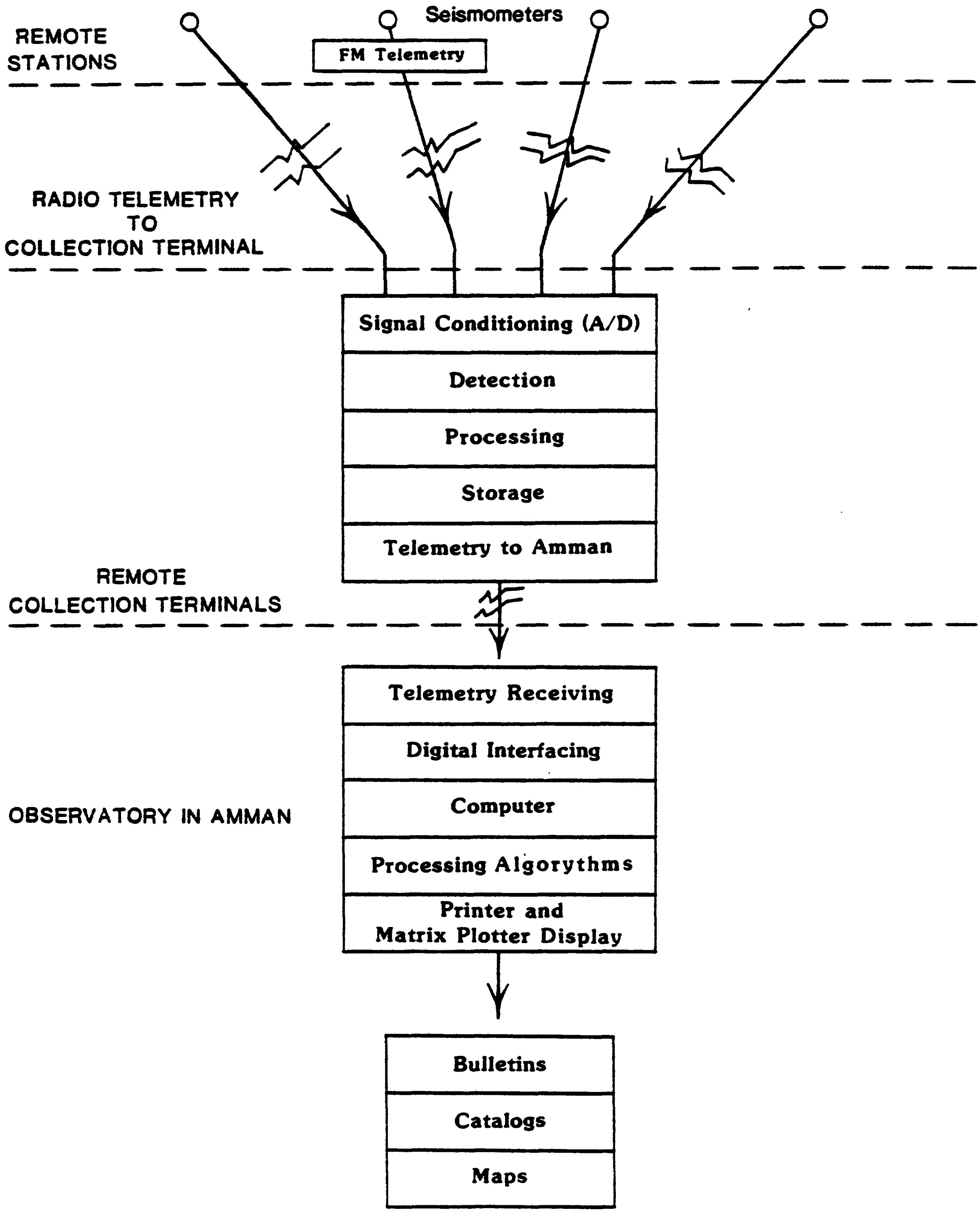

Figure 7. Schematic diagram of a modular, expandable seismic network system and observatory.

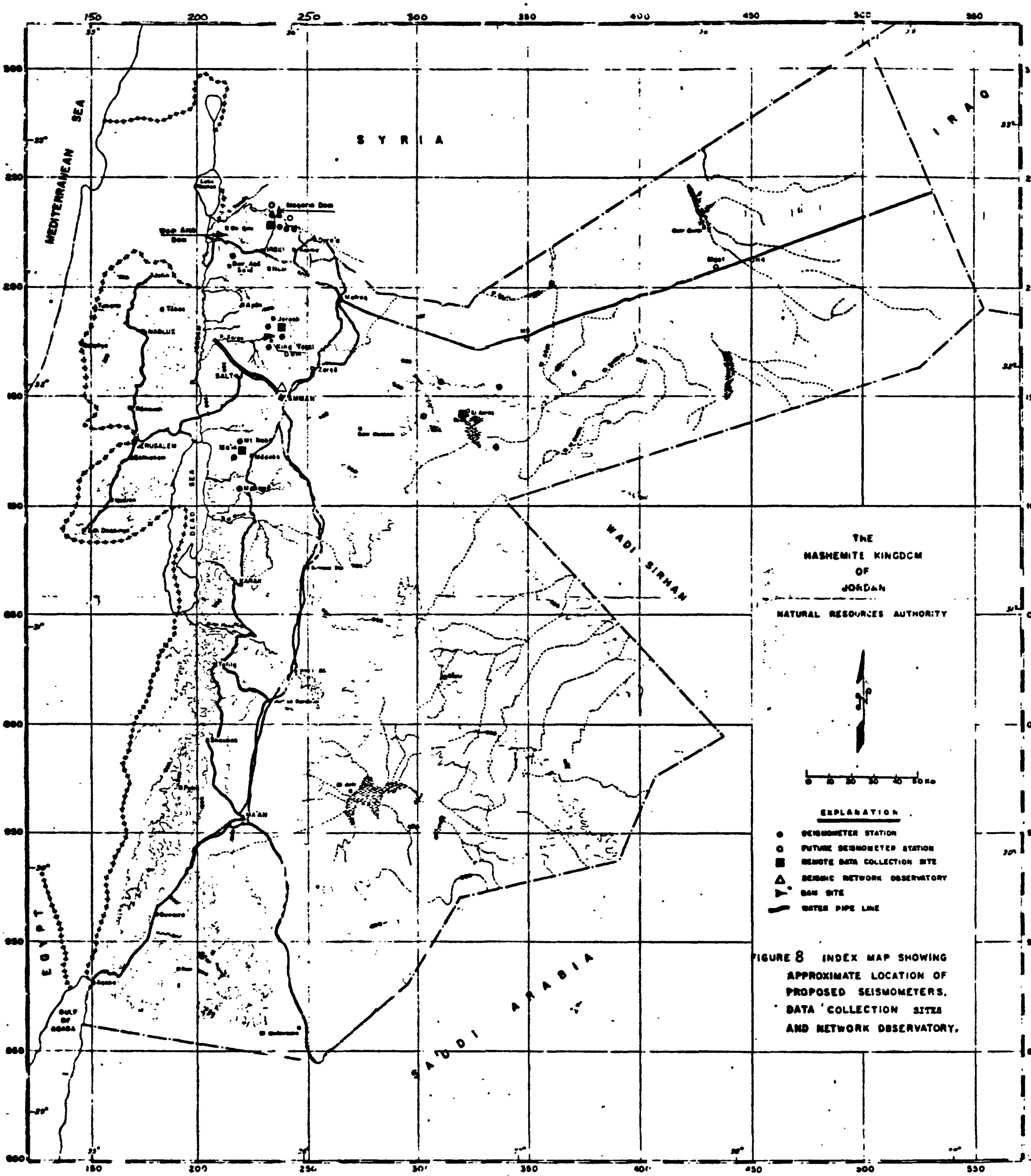

FIGURE 8 INDEX MAP SHOWING APPROXIMATE LOCATION OF PROPOSED SEISMOMETERS, DATA COLLECTION SITES AND NETWORK OBSERVATORY.

clastic intercalations), as previous observations (Ben-Menahem, and others, 1977) have demonstrated that seismometers cannot be operated at a sufficiently high magnification because of high background noise level. Therefore, stations must be located on rock outcrops. Accessibility and remoteness from cultural noise were also taken into consideration during site selection.

To meet the objectives of monitoring the seismic activities of the Dead Sea Rift and the Zerqa Ma'in areas, three sites were examined and selected on the eastern escarpment. These sites are remote, but are within line-of-sight of each other. The selected sites (shown in fig. 9) are at Makawir, Ma'in and Mt. Nebo. In addition to the seismic station to be placed at Ma'in, this location should also be used as the collection terminal for the remote sites. Topographic profiles showing line-of-sight are depicted in figures 10 and 11. As electric power is not yet available at Ma'in, a diesel generator will be required.

Eventually it is planned to build a dam across the Yarmouk River at the Syrian border—the proposed Maqarin site. Because of the possibility of induced seismicity during and after the filling of the dam, it is important that pre-monitoring of any local seismicity be started prior to the construction of the dam. A visit to the site of the dam, and an examination of the monitoring sites proposed by Western Geophysical Engineers International, Inc., for the Harza Overseas Engineering Co., showed their sites to be suitably located. It is recommended that seismic monitoring begin at the sites shown in figure 12. Diesel power is required at the suggested data collection site.

A site visit was also made to the King Talal reservoir which is scheduled for a substantial raising of its water level in the near future. Although the site selected was not investigated in detail, because of time constraints, the

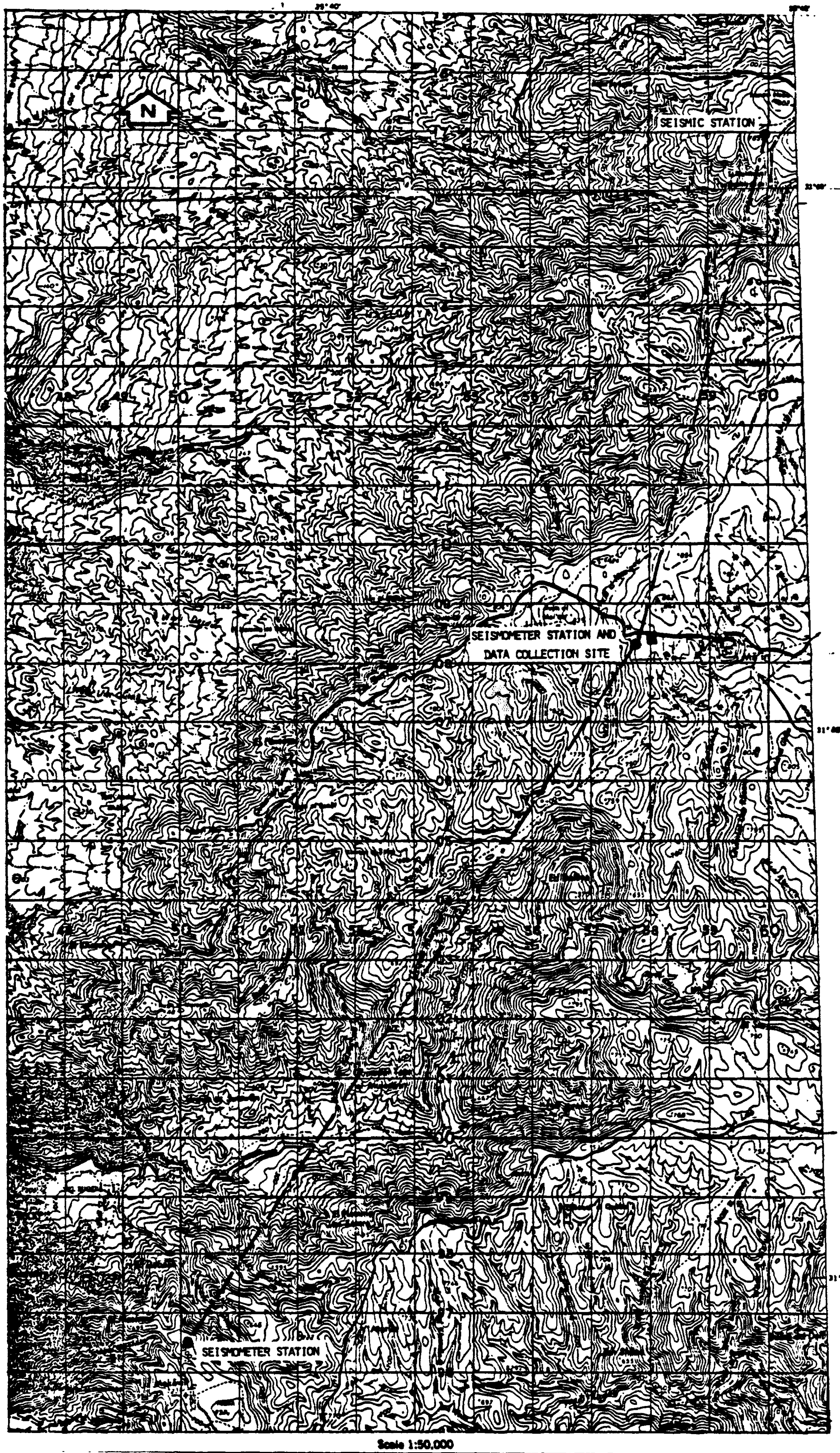

Figure 9. Detailed map showing proposed locations of remote seismic stations, and possible collection sites, Zerqa-Ma'in area, Jordan.

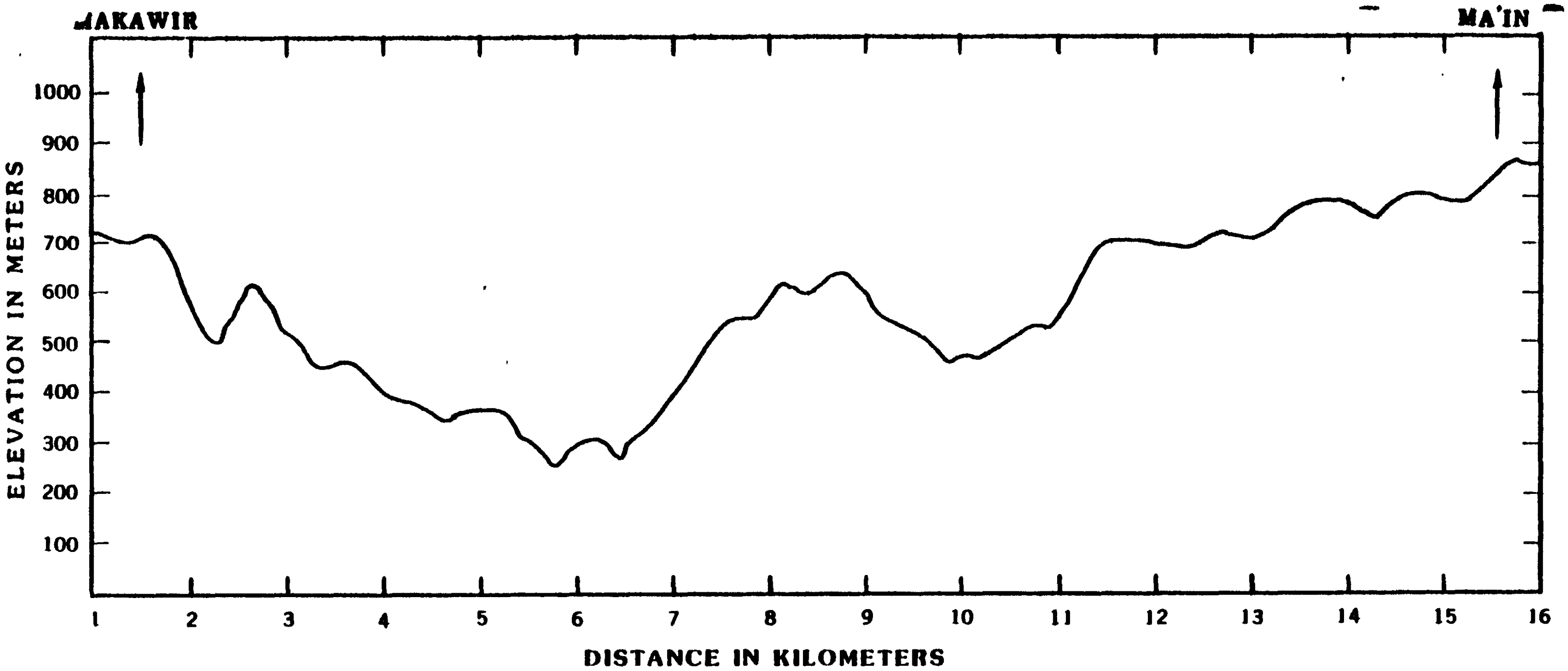

Figure 10. Generalized topographic profile from Makawir to Ma'in, Jordan.

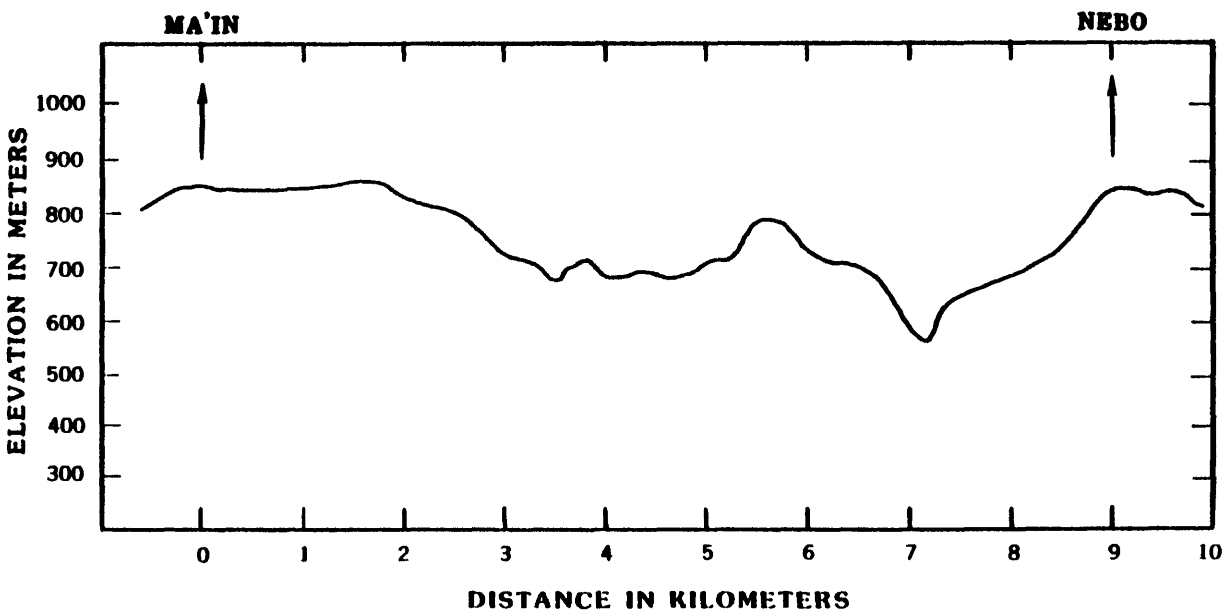

Figure 11. Generalized topographic profile from Ma'in to Mt. Nebo, Jordan.

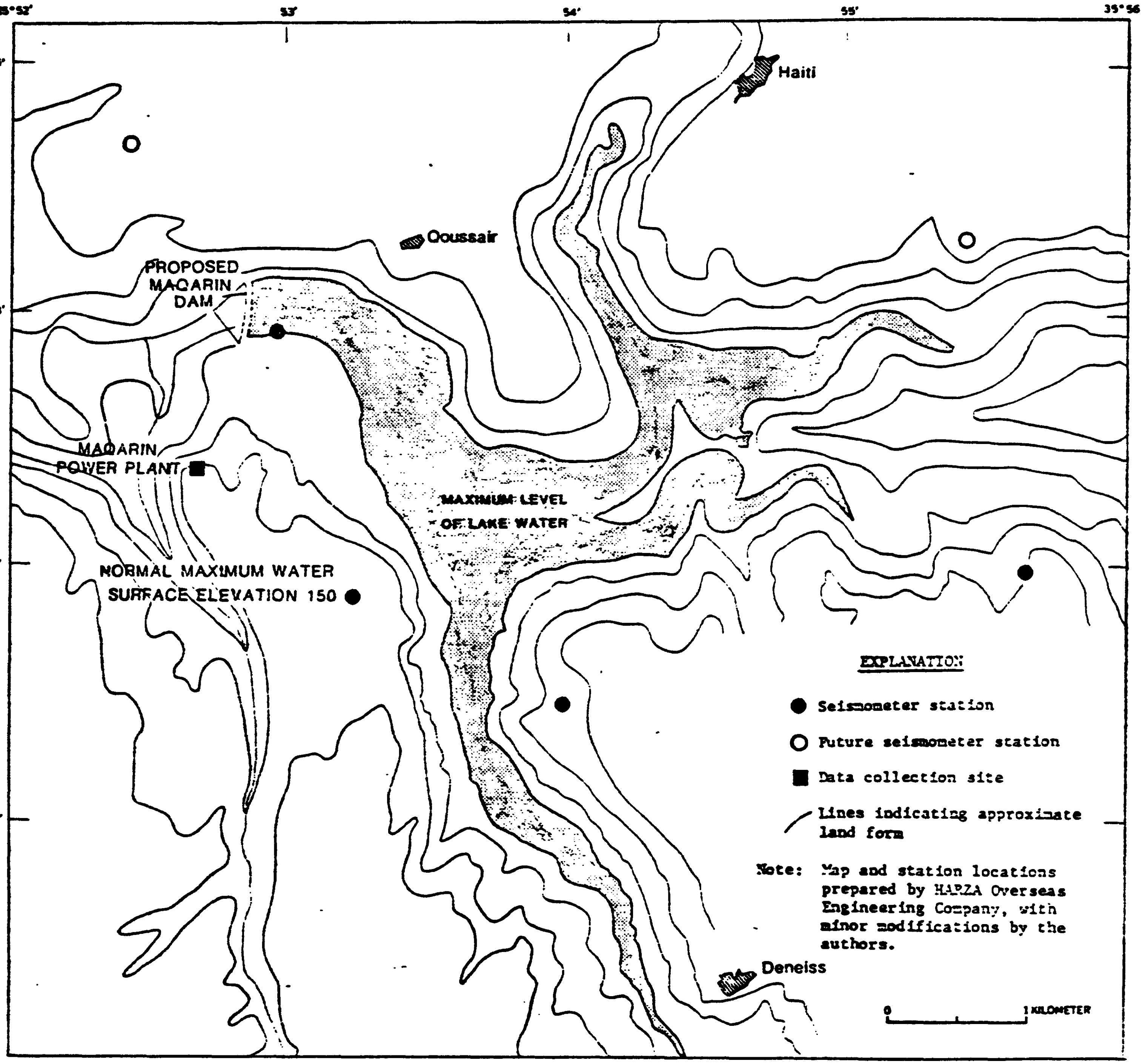

Figure 12. Sketch map of the proposed Maqarin dam site showing locations of seismometers and data collection site.

topography was noted to be ideal for the positioning of seismic stations which can be tied by line-of-sight around the dam. It is therefore recommended that a three-station array be operated at the King Talal reservoir site. No detailed map of this area was immediately available.

The Azraq area should also be considered for the installation of seismic stations. The proposed array roughly shaped in an X-array centered at Azraq, would be useful in monitoring any activity in the eastern 'panhandle' of Jordan and any activity associated with a possible geothermal area in the Azraq region. Tentative site locations are shown in figure 13. Electric power is available at Azraq; there should be no difficulty in installing a data-collection terminal in that region. The Azraq installation could follow after the installation of the arrays in western Jordan.

Because of the modular design approach of the individual seismic clusters, it will be possible to install clusters at a later date in these areas of interest, and other areas such as along the southern Dead Sea Rift and the Aqaba area.

Central Observatory

Basically the central observatory facility in Amman will be a computer-based seismic-data-acquisition system that will receive data from the remote collection points. The central observatory is envisioned to consist of telemetry-receiving equipment, a small digital computer, a line printer, a graphics CRT terminal, and a matrix plotter. The purpose of the central facility is for further analyses and refinement of the data collected at the remote collection points, such as the possible improvement of automatic phase picks, computation of hypocenters and magnitudes and the determination of focal mechanisms. A principal objective of the central facility is that seismological analyses can be performed on all previous data collected at the remote sites, without interruption of the remote recordings.

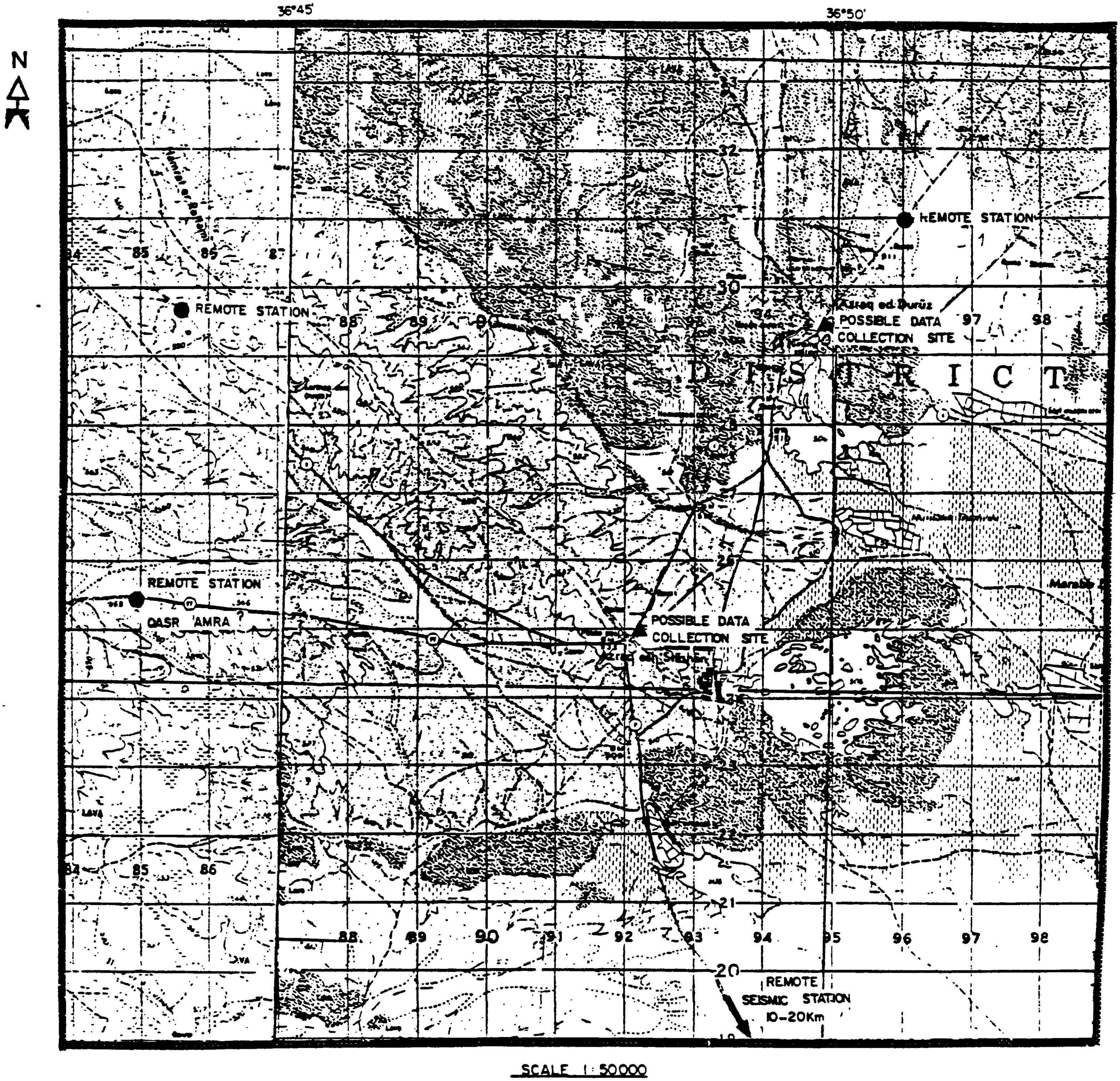

Figure 13. Detailed map showing proposed locations of remote seismic stations and possible data collection sites, Azraq area, Jordan.

In particular, it will be possible to construct and update catalogs and maps and carry out further sophisticated data processing.

Radio frequencies

Eight radio frequencies are intially required. The JVA has already been assigned six frequencies for the Maqarin dam site and these are: 166.525, 166.550, 166.575, 166.600, 166.625, and 166.650 in the Megahertz range. A standard radio frequency request form is included as Appendix A.

PROPOSED DEVELOPMENT OF THE JORDAN SEISMIC SYSTEM

In order to obtain the goals of the JSS, it is recommended that the systems be developed in three phases, phases 1 and 2 proceeding concurrently.

Phase 1

In order to obtain data for certain critical areas at the earliest date possible, it is proposed to start with eight remote seismic stations that will telemeter seismic information by radio to the eight portacorder drum recorders located in the central observatory, presumably at the NRA. In this way, data can be available for analysis within approximately 4-5 months from project start-up. This lead time is required for equipment procurement and arrangements for telemetry. This conventional system would continue to operate for about 12 months until the automatic system commences operation. This period of conventional monitoring and data analysis will provide Jordanian seismologists and technicians with valuable experience in traditional methods of seismology. When the automatic system becomes operational, the portacorder system can serve useful purposes in special studies of other areas in Jordan as the need arises.

Phase 2

It is essential that phase 2 run concurrently with phase 1 in order to meet the overall objectives of the JSS. During this phase, approximately the first 6 months will be devoted to acquisition of components, engineering design, and system prefabrication. This period would be followed by field testing in California for approximately 3 months. During this time, Jordanian technicians would come to the U.S. to participate fully in the system testing, operation, and maintenance procedures. The initial one-cluster automatic system would then be shipped to Jordan and installed. Approximately 3 months would be required for this activity. In this first JSS installation, the Field Collection Station would be installed in the central observatory's main computer. Subsequent Field Collection Stations would be installed in the areas of the remote clusters in phase 3.

Operation of the automatic system would begin approximately 12 months after project start-up. A sequence of events chart for the development of the JSS for phases 1-3 is shown in figure 2.

Phase 3

During this phase additional clusters and field data collection centers may be added for more complete coverage and would ultimately provide the long-term network goals of the JSS.

DETAILED COST ESTIMATES

Detailed cost estimates for the initial JSS pertain only to the concurrent phases 1 and 2, and approximate costs for phase 3 add-on clusters.

The cost estimates for phases 1 and 2 are believed to be representative of present-day costs, and do not include rising costs due to inflation.

1. Remote station equipment costs*

Model No.	Instrument	Cost (US dollars)
Geotech S13	Seismometer	575.
" A2.50	Amplifier	345.
- -	Signal discriminator system	180.
Monitor T1527	Radio transmitter	510.
- -	Radio antenna	310.
- -	Solar-powered battery systems	250.
	Cost for 16 units	$34,720.

*Includes spare units and special purpose 3-component instruments in addition to the 8-station cluster.

2. Field-data collection-terminal equipment costs

Model No.	Instrument	Cost (US dollars)
DEC ADV 11-A	Degitizer	1600.
DEC 11/23	Detection computer (128 words)	7,000.
DEC 11/23	Data-processing computer (128 words)	7,000.
DEC RL 02	10 Megabyte hard disk	5,000.
DEC LA 120	Printer device	2,800.
- -	Miscellaneous supplies	3,000.
- -	Power supply	5,000.
		$31,400.

3. Central observatory equipment costs

Model No.	Instrument	Cost (US dollars)
DEC 11/23	Central processor	
DEC RL 02	10 Megabyte hard disks (2)	27,100.
DEC UT 100	Terminal with display	
DEC LA 120	Printer device	2,800.
DEC —	64-word add-on memory	2,400.
Dec ADV IIA	Digitizer	1,600.
Dec DRV IIJ	Parallel interface port	450.
Comeplot -	X-Y plotter	5,500.
Tectronix -	CRT Terminal and hard copy device	16,000.
- -	Work station equipment	10,000.
		$65,850.

4. Additional equipment costs

Instrument	Cost (US dollars)
Clocks for precise timing	10,000.
Satellite telemetry prototype	15,000.
	$25,000.

5. Total equipment costs

	Cost (US dollars)
Remote stations	34,720.
Field data collection terminals	31,400.

Central observatory	65,850.
Additional equipment	25,000
	$156,970
Overhead 18%	28,255
	$185,225
	$ 30,000

6. Software

Specialized system software

7. Staffing (USGS)

It is estimated that 42 man-months (mm) effort will be required to accomplish phases 1 and 2. A representation break-down of key personnel follows:

	Time in mm
Principal Seismologist (research program and data analysis)	6
Development Manager and staff (System engineering, programming, computer and software design, observatory layout)	12
Field Manager and staff (portacorder installation, telemetry, equipment maintenance and repair, analysis of portacorder and auto system data)	12
Technical support staff (equipment electronics, prefabrication, system integration, packaging)	12
	42 mm

	Cost in US dollars
Salaries for 42 mm	140,000.
overhead	56,000.
Travel	30,000.
Per diem (1-man year)	30,500.
TOTAL	$256,000.

Summary of costs for Phase 1 and 2

	Cost in US dollars
Equipment	185,225
Software	30,000
Salaries, travel, per diem, overhead	256,500
TOTAL	$ 471,725

Estimate of continuing operation costs (Phase 3)

	Cost in U.S. dollars
Installation of additional Cluster (USGS)	60,000
Seismic research supervision and program development (USGS)	40,000
Seismologist (NRA)	-
Technician (NRA)	-
System Manager (NRA)	-

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عمان

APPLICATION FOR RADIO FREQUENCIES IN JORDAN

نموذج طلب إنشاء محطـة لاسلكية

(يقدم من سبعة نسخ)

١ – إسم صاحب الطلب : ....

٢ – عنوان صاحب الطلب : ....

٣ – جنسية صاحب الطلب : ....

٤ – أسماء العاملين على الاجهزة : ....

(يرفق قائمة مبين بها أسماء العاملين على الاجهزة من أربعة مقاطع والمعلومات التالية عن كل منهم)

١ – العشيرة ....

٢ – رقم جواز السفر / أو الهوية ....

٣ – الجنسية ....

٤ – مكان وتاريخ الولادة ....

٥ – مكان الإقامة ....

٦ – المهنة والثقافة ....

٧ – إسم الأم ....

٥ – الجهة الحكومية المتعاقد معها صاحب الطلب (إن وجدت) ....

٦ – الغرض من استخدام المحطة اللاسلكية ....

٧ – الاحداثيات والمواقع للمحطات اللاسلكية المطلوبة :

أ – مواقع المحطات الثابتة بدقة (والاحداثيات إن أمكن) ....

....

ب – منطقة عمل المحطات المتحركة / أو المحمولة باليد ....

....

....

جـ – المسافة الهوائية بالكيلومترات ....

د – مخطط شبكة الإتصال (يرفق مع الطلب)

هـ – تاريخ ابتداء استخدام التردد/الترددات / / ١٩ تاريخ الانتهاء المتوقع / / ١٩

٨ – هل هناك إمكانية تأمين الإتصال بواسطة مؤسسة المواصلات السلكية واللاسلكية ؟

أ – نعم ، لا

ب – ما هي أسباب عدم استخدام الامكانية في حالة توفرها ....

٩ – هل توجد لديكم محطات لاسلكية داخل الاردن ؟ نعم لا

أ – ما هي الترددات المستخدمة في هذه المحطات : ....

....

ب – مواقع هذه المحطات بدقة : ....

....

جـ – النداء المستخدم : ....

١٠– عدد وحدات الإتصال المطلوب :

a — (Fixed Station(s))	أ – محطات ثابتة
b — (Mobile Station(s))	ب – محطات متحركة
c — (Portable Station(s))	جـ – محطات محمولة باليد
d — (Repeater Station(s))	د – معيدات بث

١١– ساعات العمل على الاجهزة (يراعى أقل عدد ممكن من الساعات) :

نهاراً : من .... إلى ....

ليلاً : من .... إلى ....

١٢– عدد الترددات المطلوبة :

Technical Informations :

1. Name and address of manufacturer

....

....

2. Name and Address of Manufacturers agent in Jordan (if available)..................

....

....

المواصفات الفنيـــة للأجهزة :

١ – إسم وعنوان الشركة الصانعة ....

....

....

٢ – إســم وعنوان وكيل الشركة في الاردن (إن أمكن) ....

....

....

٣ – عدد الاجهزة التي ستستخدم في الشبكة :

النـــوع	رقم الطراز	الرقم المتسلسل	العــدد

3. Number of radios to be used :

Type	Model No.	Serial No.	Qty.

4. Frequency Range	٤ – مجال ترددات الجهاز ....
....	....
5. Type of modulation (AM, FM, PM)	٥ – نوع التشكيل (AM, FM, PM)
....	....
6. Type of mission, A1, A3, F3, F1 .... etc.	٦ – نوع الارسال برقي هاتفي .... الـخ
....	....
7. Frequency stability (in ± %)	٧ – مدى ثبات ترددات الجهاز (±النسبة المئوية)
....	....
8. Transmitter(s) O / P Power :	٨ – أقصى قدرة لمرسلة الجهاز / الاجهزة :
a — Fixed stations	أ – المحطات الثابتة ....
b — Mobile stations	ب – المحطات المتحركة ....
c — Portable stations	جـ – المحطات المحمولة باليد
d — Repeater stations	د – معيدات البث ....
9. State what standars applys ?	٩ – لأي مواصفات يخضع الجهاز ؟ ....
....	....
10. For SSBSC application :	١٠– في حال ارسال الحزمة الجانبية المفردة بدون ناقل :
a - What is the min carrier suppression ....(dB)	أ – ما هو أقل اخماد على تردد ناقل (dB) ....
b - What is the opposit side band supprenion ....(dB)	ب – ما هو أقل اخماد على الحزمة الجانبية الاخرى (dB) ....
c - What is the harmanic suppression .... (dB)	جـ – ما هو أقل اخماد على مضاعفات التردد (dB) ....
11 What is the transmitted bandwidth Required ______________ KHZ.	١١– عرض الحزمة المطلوبة للإرسال .... كيلو هيرتز ....
12. What is the receiver selectivity	١٢– انتخابية المستقبله ....
....	....
13. What is the receiver sensitivity in terms of :	١٣– ما هي حساسية المستقبله بالنسبة إلى :
a — Noise figure	أ – رقم الضجيج ....
b — Signal to noise ratio	ب – نسبة الإشارة إلى الضجيج ....
14. Will aditional filters be used in the antenna feedline ? Yes , No	١٤– هـل يستخدم فلتر إضافي ما بين الجهـاز والهوائي ؟ نعم ، لا

15. Antenna informations :

١٥– معلومات عن الهوائي :

a — Type of Antennas

أ – اسم الهوائي المنوي استخدامه

....

b — Directivity : directional or ND

ب – توجيه الهوائي موجه أم غير موجه

....

c — Antenna gain ....dB

جـ – كسب الهوائي .... (dB)

d — Direction of main labe with respect to true North for each station. ....

د – زاوية الاشعاع الرئيسي بالنسبة للشمال لكل محطة ....

....

....

e – Attach diagram of antenna puttern

هـ – يرفق مخطط الإشعاع الهوائي مع الطلب

f – Antenna(s) hight(s) and building hight(s)

و – ارتفاع الهوائي / الهوائيات والبنـــاء

....

....

ملاحظات هامة :

١ – التقيد بتعبئة النماذج بدقة أمر في غاية الأهمية .

٢ – تعتبر الرخصة الممنوحة بخصوص هذا الطلب منتهية بعد عام من تاريخ منحها ما لم تجدد الرخصة قبل شهر من تاريخ انتهاء الإستخدام ويعتبر تجاوز ذلك مخالفة .

٣ – يرفق كتالوج عن الأجهزة وتفرعاتها المستخدمة في المحطة اللاسلكية في هذا الطلب .

٤ – تعتـبر الرخصة الممنوحة بخصوص الطلب منتهية بتاريخ انتهاء الاستخدام المتوقع للتردد مـــا لم يرد إشعار بتأجيل هذه المدة .

٥ – يشترط في استخدام الـ (H. F.) أن يكون الإرسال على حزمه جانبية مفردة (S. S. B.)

٦ – في حالة تجاوز أي بند من المتعهد أو الشروط وفي حالة ارتكاب أية مخالفة تسحب الرخصة الممنوحة وتتخذ الإجراءات القانونية بحق المخالف .

٧ – يمكن استعمال ورقة اضافية عند الضرورة .

APPENDIX B

SEISMOLOGICAL SYSTEM, UNIVERSITY OF JORDAN

Equipment

Seismometers: Mark Products L-4 (1 Hz)

- one 3-component seismometer located in the basement of the geology building, Hardwired.
- two vertical-component seismometers located on University grounds. Data telemetered to laboratory via radio.

Associated electronics include:

- three channel demodulator, amplifier and modulator.
- signal distributor (one channel analog display)
- A/D convertor plus two trigger channels memory loop, ratio of signal to background noise.
- four channel plus time channel for playback facility.
- time code generator.

Radio time signal:

- Moscow 14.996 Megahertz

Assigned radio telemetry frequencies:

- 11 frequencies assigned from 454.10 Megahertz in increments of 0.05.

Range - 20-25 km

Note: Operation began about mid-June 1981 under the direction of seismologist Dr. Zuhair El-Isa, Assistant Professor of Geophysics.

APPENDIX C

ACTIVITY LOG

The following activity log pertains to the visit of R. L. Kovach and G. E. Andreasen in Jordan.

August 8, 1981

Arrival Amman 6:30 p.m.

August 9, 1981

Met with Stan Stalla of AID office in the American Embassy. Met with Dr. Isa Khubeis of the National Planning Council to discuss plans for a seismological network in Jordan. Met with M. Abu Ajamieh (Director of the Geological Survey, Bureau of Mines and Natural Resources Authority) and Kays El-Kaysi (Head of Geophysics Division, NRA). Planned itinerary for Jordan site visits. Acquired topographic maps. Discussed geothermal areas.

August 10, 1981

Reviewed aeromagnetic and gravity data at NRA. Met with Zafar Alem (Director, Jordan Valley Authority, Directorate of Dams) to discuss needs for seismic monitoring at proposed Maqarin Dam. Six telemetry frequencies have been assigned for 1981 to JVA for the Maqarin site monitoring: 166.525, 166.550, 166.575, 166.600, 166.625, and 166.650 Megahertz. JVA plans to continue reserving these frequencies.

August 11, 1981

Inspected field areas near Makawir. Selected Makawir for location of seismic station to monitor seismic activity at Zerqa Ma'in and Zara. Due to heavy schedules, Dr. Isa Khubeis of the NPC kindly invited us to his home in the evening to discuss the possibility of 10-day extensive workshop in January 1982 for training Jordanians in basic seismology to understand objectives and analyze data from network.

August 12, 1981

Meeting with Akef G. Nasser (Transmission Manager, Telecommunications Corporation, Tel: 37030) to discuss availability of radio frequency asignments in Jordan. 150-170 Megahertz band is very congested and much interference. 135-150 Megahertz band not as congested. 135-150 KHz bands are more readily available. Request for assignments needs supporting letter from NRA, and application forms (see Appendix A) to be filled in describing equipment and power outputs. Examined feasibility of possible field sites at Ma'in and Mt. Nebo in the afternoon.

Both sites are good locations for telemetered seismic installations.

August 13, 1981

Field investigation of Azraq pumping station in eastern Jordan. Selected four station locations in an X-configuration through Azraq at distances of about 20 km from Azraq. Azraq has power and can be used for remote collection point.

August 14, 1981

Report writing and preparation of visual aids for lecture. Examined aeromagnetic data and plotted topographic profiles along the eastern side of the Dead Sea Rift. Afternoon meeting with Dr. Zuhair El-Isa of the University of Jordan to discuss objectives.

August 15, 1981

Visited the Maqarin Dam site under the expect guidance of Ibrahim Barjawi of the Jordan Valley Authority. Seismological sites suggested by Western Geophysical Engineers International, Inc. for local seismic monitoring of pre- and post filling at Maqarin appear to be suitably located. On return journey visited King Talal Dam which is scheduled for raising of its reservoir level in 1982. Should be no major difficulties for positioning of a network of seismic stations in the vicinity. Kovach gave evening lecture to Jordanian officials and professionals regarding objectives and proposed implementation of a Jordan seismic observatory network. Dinner with NRA officials, kindly hosted by Mr. and Mrs. Kays Kaysi followed the lecture, providing opportunity for further informal discussion of the project.

August 16, 1981

Collecting maps at Jordan Valley Authority; illustration preparation; report writing, etc.

August 17, 1981

Examined seismic installation at University of Jordan run by Dr. Zuhair El-Isa. Briefing given to Walter Bollinger, AID Mission Director. Meetings with M. Abu Ajamieh of NRA and Dr. Isa Khubeis of NPC. Afternoon visit to Royal Scientific Society by kind invitation of Daud Jabaji and Faisal Suyagh of the Building Materials Research Center.

August 18, 1981

Kovach departed Amman 12:00 noon.

August 19-26, 1981

Report preparation by Andreasen. Discussion with Mr. Ahmad Dokhgan on M.O.U. Work on Project Evaluation Summary report with Stan Stalla.

August 27, 1981

Meeting with Dr. Isa Khubeis and Dr. Zuhair El-Isa.
Briefing with Tom Pearson.

August 29, 1981

Andreasen depart for Jeddah.

APPENDIX C

Project Implementation Plan between the Geological Survey of the Department of the Interior of the United States of America and the Natural Resources Authority Ministry of Energy and Mineral Resources of the Hashemite Kingdom of Jordan for Phase III of the Development and Installation of the Jordan Seismological Observatory with Emphasis on Earthquake Risks and Crustal Structure.

JO 1-1
June 12, 1986

PROJECT IMPLEMENTATION PLAN
BETWEEN
THE GEOLOGICAL SURVEY
OF THE
DEPARTMENT OF THE INTERIOR
OF THE UNITED STATES OF AMERICA
AND
THE NATURAL RESOURCES AUTHORITY
MINISTRY OF ENERGY AND MINERAL RESOURCES
OF THE
HASHEMITE KINGDOM OF JORDAN
FOR PHASE III OF
THE DEVELOPMENT AND INSTALLATION OF THE
JORDAN SEISMOLOGICAL OBSERVATORY WITH EMPHASIS ON
EARTHQUAKE RISKS AND CRUSTAL STRUCTURE

The Geological Survey of the Department of the Interior of the United States of America (hereinafter referred to as "USGS") and the Natural Resources Authority, Hashemite Kingdom of Jordan (hereinafter referred to as "NRA") agree to cooperate in activities set forth in this Project Implementation Plan (hereinafter usually referred to as "PIP") JO-1-1 pursuant to and subject to the provisions of Memorandum of Understanding JO-1 signed by USGS and NRA (hereinafter sometimes referred to as the "parties") on 25 April 1985.

Section I. Introduction and Background

The Project, entitled The Development and Installation of the Jordan Seismic Observatory (JSO) with Emphasis on Earthquake Risks and Crustal Structure provides for the design, installation, and operation of a National seismological observatory, herein called the Jordan Seismic Observatory.

Phases I and II of the JSO have now been completed and have produced a prototype eight-station seismic network operating in northwestern Jordan. The Observatory began routine operation in September of 1983 and publishes quarterly earthquake bulletins which are distributed to concerned agencies within Jordan and interested organizations outside of Jordan. Phase III of the JSO will be completed under this Project Implementation Plan between the Parties. This PIP includes the work plan, staffing requirements, cost estimates, and funding sources.

Section II.Purpose

The agencies concerned with this project, NRA, USAID, and USGS have all independently reviewed the progress of this project. The essence of these reviews can be summarized as follows:

1. The NRA has made outstanding progress in developing a Seismological Observatory which is now operating with a Jordanian staff. NRA has made this project one of their priority objectives and the progress that has been made in developing and installing the JSO is largely a result of NRA efforts and support.

2. The project can make important contributions to the understanding of earthquakes and tectonics in the Middle East which will help to assess and mitigate the earthquake hazard. The data will also have indirect application to exploration for mineral resources through the improved understanding of geologic structure which the data will provide.

3. Given the progress that has been made, all three agencies agree that this project should be continued at as expanded level of effort so as to complete the full network in the near future as envisioned in the original proposal. The successful

completion of this project will provide a model seismic observatory. To achieve this objective, increased effort is needed in the training of Jordanian technicians necessary to install, operate, and maintain the network. Although it is not explicitly part of the original project proposal, an important part of the overall development of the JSO is the NRA plans for the formal professional training of Jordanians in the seismological sciences.

Section III. Work Plan

The target completion time for the installation of all seismic stations is two years from the availability of funds. All equipment except for minor items will be purchased in one procurement cycle to save money and time, and ensure uniformity in instrumentation. For station installation, two phases of work are planned. In the first phase, to be completed within one year after funding, the completion of 16 stations including 4 three-component stations, will be undertaken. This will involve adding horizontal seismometers at two of the eight existing stations and adding eight new stations including two three-component stations. In the second phase, the network will be expanded to about 32 stations, including about 10 three-component stations. Two cycles are necessary in order to allow time to evaluate initial results of the 16-stations network and implement changes which may be required such as site relocation, number of stations, changes in data transmission methods, and other refinements to the network. This should yield a network that will provide continuous monitoring of all of Jordan and adjacent areas. The duties of the Chief Scientist will be to advise and assist the training of the Jordanian staff in modern methods of analysis of seismological data. It is hoped that these efforts will lead to one or more formal scientific publications on the results of this project.

Section IV. Staffing Requirements

The estimated level of activity required to complete the network on the schedule is approximately eight man years/year. Gordon Andreasen (USAID) or his replacement will provide one man year. NRA will provide 5 to 6 man years. The training of qualified Jordanians to carry on the work must be of high priority task.

USGS Staff Requirements

Name	Title	Pay Periods (26 per year)	Estimated Salary Cost
Healy	Project Manager	11	$32,000
Kovach	Chief Scientist	09	24,000
Gettings	Research Geophysicist	13	26,000
Kohler	Geophysicist	13	17,000
Van Schaack	Software Development Engineering Supervisor	08	18,000
Coakley	Seismic Technician	13	14,000
Other	Physical Science Technician	11	11,000
			142,000
Air travel costs - 14 RT from US to Amman @ $2,500			35,000
USGS travel in US (10 trips DC to Menlo Park)			10,000
Sub total - salary and travel			187,000
USGS Administrative cost - 40%			74,000
			261,000

In-country per diem will be paid by the AID mission direct to USGS staff.

Gordon Andreasen is currently working under contract to USAID. He is assisting the USGS and NRA in many critical tasks and if he should leave his present position, the USGS might have to consider stationing a full time USGS geophysicist in Jordan. This would increase salary and support costs to a considerable degree.

Section V. NRA Procurement of Seismic Equipment

Equipment costs to expand the network to 32 stations with 10 three-component stations are detailed below. Some additional units are included for spare parts. Three-component stations are needed to locate earthquakes outside of the network, in the Dead Sea Rift or the Gulf of Aqaba, and to provide more accurate locations in regions of sparse coverage. Cost are in US Dollars:

	Est.Unit Cost	Quantity	Est.Total Cost
Seismometers, Vertical	650	34 ea	22,100
Seismometers, Horizontal	650	24 ea	15,600
VCO Preamp	250	60 ea	15,000
Solar Panels	200	40 ea	8,000
Antennas VHF	165	40 ea	6,600
Radio pairs	750	50 ea	37,500
Discriminator Rack	500	03 ea	1,500
Discriminators	180	52 ea	9,400
Develocorders (rebuilt)	10,000	03 ea	30,000
Station clocks	4,000	02 ea	8,000
Film Viewer	5,000	01 ea	5,000

Misc. small equipment and spare parts	---	--	5,000
Misc. Expendable supplies for one year	---	--	10,000
Sub total			173,700
Overhead @ 18%			31,300
Total seismic equipment			205,000

This equipment to be procured in accordance with procurement procedures acceptable to the Arab Fund.

Section VI. <u>USGS Procurement of Computer Components for the Network (USAID funds)</u>

In the design for the network, the use of at least one DEC 11/23 PLUS computer for each eight stations or "cluster" in the network was planned, with each cluster linked to a central computer to collate, store, and process the data. It was envisioned that some of the cluster computers might be located away from the observatory at remote locations where reliable telemetry could not be established. At these locations more than one DEC 11/23 PLUS processor might be required. Three of these computer processors and associated components have been purchased which should handle two clusters communicating to a central computer

At the time of the original proposal, Digital Equipment Corporation supplied the best data acquisition systems and associated software. Despite many advances in computer technology, this system is still one of the best available for the purposes of the JSO real time earthquake detection system.

Recently, the IBM PC-type systems have had important applications to seismology. The IBM PC architecture has a very large base of powerful software that makes their systems extremely versatile and efficient. Most of this software was written for applications in business and management but in the last year there has been a rapid increase of scientific and data acquisition software available for these systems. USGS seismologists have developed Earthquake Analysis software for the IBM PC architecture and all of this software will be available to the JSO if the IBM PC systems are used at least a part at the JSO. The IBM portable PC can be purchased in the USA for about the same price as a standard computer terminal and it is an ideal smart terminal for the DEC VAX series of computers.

Based on these considerations, the following computer purchases must be made as soon as possible: one additional DEC 11/23 PLUS processor upgraded with the new 11/73 CPU board; two IBM PC portable systems, and one IBM XT (PC-type) system. This procurement will yield the project a total of four DEC 11 series computers to be used in the data acquisition (real time) system and three IBM PC systems for training seismic data analyses used in conjunction with the NRA VAX 11/750 computer. It is likely that some additional computer components may be required to automate the integrated completed network but this decision will be deferred until the present systems are installed and operating.

LEM

The Controller System (DEC PDP 11/73):

		Approximate Cost		
1. 173QAA-B2(B3) Processor		$7,600		
2. RD52 31 Mb Winchester and TK25 cartridge tape		4,600		
3. Rack mount kit		200		
IBM PC portable systems:				
1. IBM PC portable	2 ea		4,700	
2. AST SIX PAK with full memory	2 ea		1,200	
3. Okidata 92 printer	2 ea		700	
4. AST REACG! MODEM	3 ea		1,700	
IBM XT Off Line Data Processing System:				
1. IBM XT with 640 k memory			5,000	
Houston Instrument plotter			5,000	
Computer hardware - subtotal				30,700
Supplies/software				1,500
		Subtotal		32,200
		Overhead 18%		5,800
	Total acquisition and analysis costs			$38,000

Section VII. Possible USGS Procurement of Other Hardware (USAID funds)

There are some hardware components that cannot be more than an estimate at this time. these components relate primarily to long range telemetry(LRT). It may be necessary to obtain permission to use the Kingdom microwave network for some of the JSO telemetry needs. The LRT concept would require some additional hardware and engineering time to interface with the current system. Other costs which will be covered in this category include miscellaneous repair and replacement of components within the JSO. Costs associated with these considerations cannot be precisely defined but they are estimated to be no more than $30,000.

Other Hardware		30,000
	Overhead 18%	5,400
	Total	$35,400

Section VIII. Financial Arrangements

A. Summary of Estimated costs.

Seismic equipment and supplies (NRA)		205,000
Acquisition and analysis system (USAID)		38,000
Other hardware (USAID)		35,400
Miscellaneous expenses associated with training (USAID)		7,000
USGS salary and travel (USAID)		261,800
	Total	$547,200

B. Funding Sources

All funds required to carry out this PIP will come from NRA and USAID. Most of the equipment to be procured will be funded by NRA. Funding for construction of the station sites and certain categories of Observatory maintenance and operation is to be provided by the NRA independent of this agreement and is not included in the table. Salaries, travel, and related expenses for NRA personnel are not included in this document.

FUNDING SOURCE	CATAGORY	AMOUNT	TOTALS
NRA	Equipment	$205,000	$205,000
USAID	Salaries, travel, misc. expenses	268,800	
	Equipment	73,400	344,200
	Grand Total		$547,200

1. As noted in the above table, NRA is the Funding Source for the seismic equipment listed within this document (pp.5-6). The total amount is $205,000.

2. USAID will provide the remaining funds needed to complete this planned program. Approximately $224,000 will be required in new funding from USAID in addition to the approximately $120,00 remaining in the existing PASA.

3. The amounts cited in the Budget Estimate are based upon the current cost of equipment and supplies and on current estimates of salary, and other expenses of USGS personnel assigned to this Project Implementation Plan. If the estimates do not cover the actual cost, the Parties will negotiate for any additional funds.

Section IX. General Provisions

A. The terms of the Memorandum of Understanding (JO-1) shall be applicable to this Project Implementation Plan except as amended herein. No changes in or modifications to this PIP shall be made except by mutual concurrence, in writing, between the Parties. When approved by the Parties, this PIP shall become an annex to JO-1. Any notice of amendment given by either of the Parties hereunder shall be sufficient only if in writing and delivered in person or sent by mail addressed as follows:

To: Office of International Geology
U.S. Department of the Interior
917 National Center
Reston, Virginia 22092 USA

To: Geological Survey and Bureau of Mines
Natural Resources Authority
Ministry of Energy and Mineral Resources
P.O. Box 7
Amman, Jordan

or to such address as either Party shall designate by sufficient notice. Such notice hereunder shall be effective upon receipt.

B. Upon request of either Party, regarding and matter relating to this PIP, the Parties will endeavor to resolve any problems or misunderstandings by joint consultation in a spirit of cooperation and mutual trust.

C. The Parties hereby designate Program Coordinators as follows:

The USGS Program Coordinator will be:

John H. Healy
U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

The NRA Program Coordinator will be:

M. Abu Ajamieh, Director
Geological Survey
Natural Resources Authority
Amman, Jordan

The Program Coordinators will work in concert and will be responsible for the respective Parties' participation, including planning, coordination, and scheduling of elements of the project outlined herein, and will be responsible for evaluation of program, and for reporting accomplishments for each Project activity stated in this PIP.

D. Duration of the Project

This agreement will become effective upon signature by both Parties and will remain in force for two years from the date of the last signature. It may be extended by mutual agreement. This project depends on the herein proposed funds from USAID and the NRA being made available before any work on this Project Implementation Plan can begin.

E. Force Majeure

If either the USGS or the NRA is rendered unable, because of force majeure, to perform its responsibilities under Section III of this Agreement, these responsibilities will be suspended during the period of continuance of such inability. The term "Force Majeure" means war, civil disturbance, natural disasters, strikes, and other similar events not caused by nor within the control of the United States Government (or any of its agencies or the Jordanian Government (or any of its agencies). In the event of suspension of duties because of force majeure, the USGS and NRA will consult and endeavor jointly to resolve any attendant difficulties, including the possibility of either completing or terminating the project.

F. Termination

The USGS or the NRA may terminate this Agreement in whole or in part at any time upon ninety (90) days' written notice of termination to the other Party. In the event of such termination by either Party, each Party shall use its best efforts to ensure that any work and/or reports in progress are completed. The termination date for projects in progress shall be the date the work and/or reports are completed or the termination date specified in this PIP, whichever occurs first. However, scientific reports in preparation, resulting from work conducted under this PIP, can be concluded for publication after the termination date of this PIP, if mutually agreeable to the Parties.

Done at Reston, Virginia, U.S.A. and Amman, Jordan.

Geological Survey
U.S. Department of the Interior
of the United States of America

By: ____________________

Name: Dallas L. Peck

Title: Director

Date: JUN 12 1986

Natural Resources Authority
Ministry of Energy and Mineral Resources
Hashemite Kingdom of Jordan

By: ____________________

Name: Engr. Y. Nimry

Title: Director General

Date: ____________________

APPENDIX D

EQUIPMENT SUPPLIED UNDER PHASE III,

JORDAN SEISMIC SYSTEM

Box	Weight	Contents
1	54 lbs.	VCO's, 12 ea. 680Hz., 9 ea. 1020Hz., 4 ea. s/n's 1098,1147,1148, 1127,1171,1189,1194, 1267,1099,1118,1181, 1132.
2	54 lbs	VCO's, 12 ea. 1020Hz., 4 ea. 1360Hz., 9 ea. s/n's 1133,1137,1240, 1319,1139,1149,1157, 1175,1094,1173,1212, 1224.
3	86 lbs	VCO's, 12 ea. 1700Hz., 9 ea. 2040Hz., 4 ea. s/n's 1117,1204,1201, 1100,1134,1130,1120, 1125,1150,1103,1155, 1170.
4	96 lbs.	VCO's, 14 ea. 2040Hz., 3 ea. 2380Hz., 8 ea 2720Hz., 3 ea. s/n's 1210,1143,1293, 1118,1164,1124,1174, 1172,1232,1306,1192, 1123,1163,1169.
5	63 lbs.	VCO's, 10 ea. 2720Hz., 4 ea. 3060Hz., 6 ea. s/n's 1190,1095,1219, 1178,1186,1135,1180, 1109,1152,1151. Radio Power Cables,100 ea.
6	23 lbs.	Discriminators, 53 ea. 680Hz., 7 ea. 1020Hz., 7 ea. 1360Hz., 7 ea. 1700Hz., 7 ea. 2040Hz., 7 ea. 2380Hz., 7 ea. 2720Hz., 7 ea. 3060Hz., 4 ea.
7	29 lbs.	Solar Panel Regulators, 42 ea. Solar Panels, 2 ea.
8	25 lbs.	Solar Panels, 5 ea.
9	25 lbs.	Solar Panels, 5 ea.
10	25 lbs.	Solar Panels, 5 ea.
11	25 lbs.	Solar Panels, 5 ea.
12	25 lbs.	Solar Panels, 5 ea.
13	25 lbs.	Solar Panels, 5 ea.
14	25 lbs.	Solar Panels, 5 ea.
15	25 lbs.	Solar Panels, 5 ea.
16	80 lbs.	Seismometers, 12ea. Vertical s/n's, 7726,7717, 7703, 7725,7704,7716, 7899,7696,7704,7714, 7736,7737.
17	80 lbs.	Seismometers, 12ea. Vertical s/n's, 7727,7695, 7724,7722,7715,7700, 7711,7706,7709, 7731,7694,7721.
18	80 lbs.	Seismometers, 12 ea. Vertical s/n's, 7702,7698, 7734,7705,7729,7728, 7719,7691,7713,7718, Horizontal s/n's,6212, 6211.
19	80 lbs.	Seismometers, 12 ea. Horizontal s/n's, 7757, 7756,7743,7749,7746, 6210,6208,7753,7754, 7748,7744,7745.
20	80 lbs.	Seismometers, 9 ea. Horizontal s/n's, 7755, 6209,7752,7741,6207, 7758,7740,7750,7747.
21	58 lbs.	Seismometer Caps, 58 ea. Seismometer Cables, 58 ea. Seismometer, 1 ea. Horizontal s/n, 7739.
22 thru 81	10 lbs. ea.	Radio Antenna, 1 ea. per box.
82	72 lbs.	Solar Panel Bracket, 22 ea. Solar Panel Hardware.
83	70 lbs.	Solar Panel Bracket, 20 ea. Solar Panel Hardware.
84	65 lbs.	Radios, 18 prs. 168.925,168.725,172.400,172.375,168.850,168.900,172.675,168.775, 168.725,172.200,168.800,168.725,168.775,168.850,168.825,168.775,168.775,172.325.
85	65 lbs.	Radios, 18 prs.172.375,168.825,168.850,172.625,172.100,172.650,168.725,172.100, 168.800,168.725,172.100,168.925,172.650,168.925,172.375,172.150,172.875,168.925.
86	50 lbs.	Radios, 14 prs. 168.900,168.725,172.150,168.725,168.775,172.325,172.325,172.200, 168.775,168.900,172.400,172.150,168.800,172.200.
87	27 lbs.	Discriminator Rack, 2 ea.
88 thru 97	30 lbs. ea.	Coax Cables, 98 total.
98	79 lbs.	Seismometer Bracket, Horizontal, 24 ea.
99	32 lbs.	VCO Tester Box, 2 ea. Sum Amp, 15 ea. Terminal Strip, 48 ea. RF Adapters, 50 ea.
100	15 lbs.	Discriminator Rack, 1 ea.
101	35 lbs.	Time Code Generator, 2 ea.
102	145 lbs.	Reel, 4 Conductor Cable
103	145 lbs.	Reel, 4 Conductor Cable
104	145 lbs.	Reel, 4 Conductor Cable
105	145 lbs.	Reel, 4 Conductor Cable
*106	50 lbs.	Batteries, 12 v Gelled, 60 ea.

* This may be on more than one pallet. Total weight approx. 3000 lbs.

PHASE III EQUIPMENT LIST

(CONTINUED)

3 TELEDYNE DEVELOCORDERS (REFURBISHED)

1 TELEDYNE FILM VIEWER

3 BASES & STANDS FOR DEVELOCORDERS

CABLING AND MISCELLANEOUS PARTS

2 COMPAQ PERSONAL COMPUTERS DESKPRO 286/12 MHZ FOR AUTOMATED DATA PROCESSING

1.640 Mb
40 Mb HARD DISK
1.2 Mb FLOPPY DRIVE
80287 MATH COPROCESSOR

2 VIDEO MONITORS

2 16-CHANNEL DATA TRANSLATION BOARDS

1 M/DETECT SOFTWARE FOR 16-CHANNELS

(TO BE SHIPPED)

2 COMPAQ PERSONAL COMPUTERS AS ABOVE

2 VIDEO MONITORS

2 128-CHANNEL MULTIPLEXERS DEVELOPED BY USGS

2 16-CHANNEL DATA TRANSLATION BOARDS

1 LOCAL AREA NETWORK SET FOR 2 MACHINES

APPENDIX E

FUNDING CONTRIBUTIONS FOR PHASE III TASKS,

JORDAN SEISMIC SYSTEM

TASKS

- Assist in Procurement/Deployment of 32 Seismic Network Stations

- Assist in Preparation of NRA Seismic Bulletins

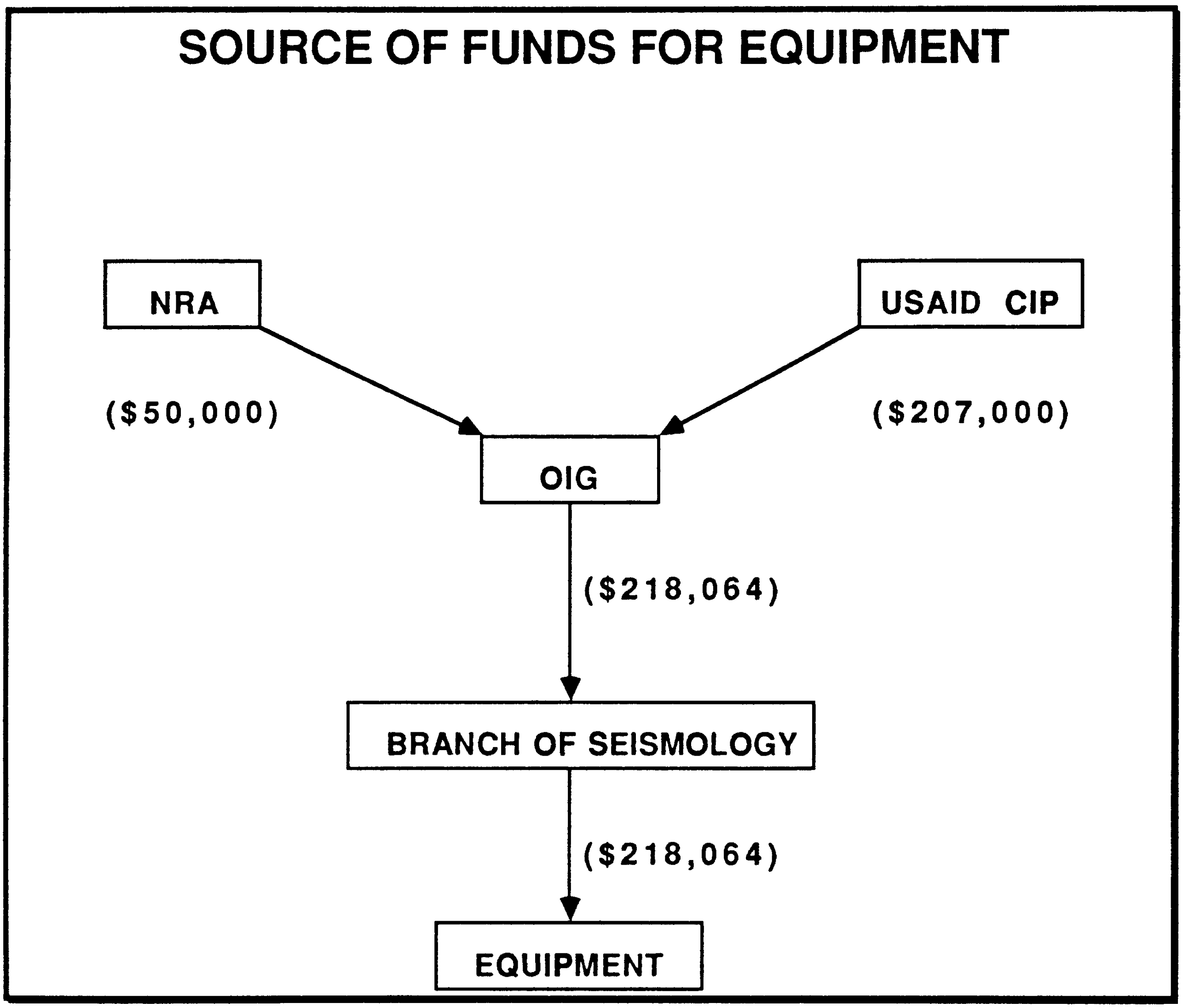
- Assistance in Procurement/Establishment of Strong Motion Network

- Training of NRA Staff to Manage JSS upon completion of Phase III

PHASE III

FUNDING CONTRIBUTIONS

AID	NRA	USGS
USGS SALARIES (PARTIAL)	EQUIPMENT & SUPPLIES	SALARIES (UNREIMBURSED)
EQUIPMENT & SUPPLIES	REMOTE SITE PREPARATION/ CONSTRUCTION/MAINTENANCE	PC HARDWARE DEVELOPMENT
INTERNATIONAL TRAVEL	LOCAL OFFICE SPACE	PC SOFTWARE DEVELOPMENT
LOCAL PER DIEM	LOCAL TRANSPORTATION	MISCELLANEOUS SUPPLIES
	SECRETARIAL/COMPUTER SERVICES	ELECTRONIC TEST EQUIPMENT
	EQUIPMENT SHIPPING COSTS	USE OF LACOSTE--ROMBERG GRAVIMETER 102 - 4 MOS.
	PRINTING/DISTRIBUTION OF SEISMIC BULLETINS	


SOURCE OF FUNDS FOR EQUIPMENT
NRA
USAID CIP
($50,000)
($207,000)
OIG
($218,064)
BRANCH OF SEISMOLOGY
($218,064)
EQUIPMENT

FUNDS RECEIVED AND EXPENDED FOR THE PURCHASE OF EQUIPMENT

Money Received by the Branch of Seismology (after USGS overhead charge) for purchase of equipment.

From NRA	$42,563.56
From USAID (CIP)	$175,500.00
TOTAL	$218,063.56

Funds for Equipment	$218,063.56
Cost of Equipment	$218,063.56
Funds Remaining	$0.00

Funds Expended for Equipment:

ITEM	NUMBER	COST/EA	COST
Seismometers, vertical	34	$656	$22,304
Seismometers, horizontal	24	$666	$15,984
VCO preamps	60	$250	$15,000
Solar panels	42	$150	$6,300
Antennas VHF	60	$165	$9,900
Radio pairs	50	$750	$37,500
Discriminator rack	3	$500	$1,500
Discriminators	52	$180	$9,360
Develocorders	3	$10,000	$30,000
Film viewer	1	$5,000	$5,000
Station clock	2	$3,100	$6,200
VCO tester boxes	2	$400	$800
Summing amplifiers	15	$50	$750
Training W. Mustafa (radios)			$900
Shipping charges			$6,200
Shipping (Develocorders)			$1,500
Crystal filters			$2,900
Modify time code generator			$1,200
Spare parts and supplies (see list)			$19,919
Compaq IBM compatible PC Deskpro 286	4	$3,335	$13,340
Data translation A to D	4	$1,646	$6,584
Multiplexer boxes	2	$1,000	$2,000
40 MB Conner hard disk	2	$820	$1,640
Hard disk installation			$75
Shipping (computers)	(estimated)		$500
Printing final report	(estimated)		$208
Miscellaneous supplies	(estimated)		$500
TOTAL			$218,063.56

SPARE PARTS AND SUPPLIES

ITEM	NUMBER	COST/EA	COST
Battery tester	1	$59.43	$59.43
Battery strap	2	$1.25	$2.50
Battery strap	1	$1.25	$1.25
Battery corrosion spray	2	$4.40	$8.80
Electrical tape	4	$4.98	$19.92
Hot glue	1	$29.95	$29.95
Screw driver set	1	$4.89	$4.89
Thermogrip glue	2	$5.69	$11.38
Thermogrip glue	2	$5.69	$11.38
Screw driver	1	$3.39	$3.39
Screw driver	1	$3.49	$3.49
Soldering iron	1	$62.31	$62.31
Compact tool set	1	$16.55	$16.55
Palm grip pliers	1	$7.95	$7.95
Palm grip pliers	1	$7.95	$7.95
Screwdriver	1	$4.73	$4.73
Screwdriver	1	$5.31	$5.31
Solder roll	1	$13.13	$13.13
Mercury battery	20	$2.71	$54.20
Connectors	2	$2.29	$4.58
Connectors	2	$2.29	$4.58
VCO crystal	2	$10.65	$21.30
Seismometer cable			$50.00
Discriminator test box			$20.00
Banana plugs	10	$0.25	$2.50
Switches			$3.00
VHF transceiver	2	$556.30	$1,112.60
Battery charger	2	$42.00	$84.00
Battery charger	2	$136.50	$273.00
Large leather case	2	$31.50	$63.00
Cloning cable	2	$16.80	$33.60
Rechargeable battery	2	$45.50	$91.00
Connectors	2	$5.00	$10.00
Connectors	2	$5.00	$10.00
VHF transceiver	2	$421.00	$842.00
Battery charger	2	$30.00	$60.00
Battery charger	2	$14.00	$28.00
Leather holster	2	$30.00	$60.00
Antenna cable	2	$20.00	$40.00
Seismic preamplifier	4	$270.00	$1,080.00
Trim pot	10	$1.00	$10.00
Connectors	4	$5.00	$20.00

ITEM	NUMBER	COST/EA	COST
Film	400	$12.00	$4,800.00
Film	100	$12.00	$1,200.00
Batteries	60	$84.00	$5,040.00
Seismomemter brackets	24	$10.00	$240.00
Spiral four cable	4	$100.00	$400.00
Repair o'scope & parts			$375.00
Batteries for radios			$750.00
Power signal connectors	100	$5.50	$550.00
TOTAL			$19,918.67

APPENDIX F

COMPUTER EQUIPMENT NEEDED FOR IMPLEMENTATION OF A DEDICATED SYSTEM IN JORDAN FOR TELESEISMIC DETECTION AND LOCATION

The following list contains all the necessary hardware and software parts of a dual PC system for a small to medium size seismic network. Each item is described and followed by the quantity needed and the approximate cost.

	Equipment	Quantity	Cost
1.	Compaq DeskPro 386's PC (16 MHz) with 2 MB RAM, 40 MB hard disk, 1.2 MB floppy drive, serial/parallel port, clock and calendar, and enhanced keyboard.	2	$6,000
2.	Intel 80387sx math coprocessor (16 MHz)	2	$600
3.	Compaq VGA color monitor (14").	2	$1,000
4.	Compaq PC-DOS version 4.01	2	$200
5.	Data Translation DT2824-PGH analog-to-digital board	2	$2,600
6.	Data Translation DT707 screw terminal panel	2	$400
7.	LANtastic hardware & software by Artsoft	1	$500
8.	Microsoft serial mouse & mouse pad	1	$100
9.	High-quality power surge protector	2	$100
10.	IBM ProPrinter and printer cable	1	$400
11.	IBM 3363 Optical WORM drive	1	$2,500
12.	Miscellaneous supplies	1	$500
13.	IASPEI Software Library Volume 1	1	$250
14.	PCTOOLS by Central Point	1	$100
15.	KEDIT by Mansfield Software	1	$150
16.	XTREE by Executive Systems	1	$50
17.	PCKWIK Power Pak by Multisoft	1	$100
18.	Ellis' multiplexer for 128 channels	2	$3,000
19.	System integration, testing and training	1	$1,000
20.	DSP Board, TMS320C25	2	$800
	TOTAL		$20,350