GL2560

MICROSEISMICITY INVESTIGATION of THE RAFT RIVER VALLEY, IDAHO

Final Report

on

Contract No. AT(11-1)-2476

(submitted 1 March 1976)

1978

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EG&G, Idaho report

ABSTRACT

A microseismicity survey of the Raft River Geothermal Prospect was conducted between 26 July and 29 October 1974.

Three seismograph stations were deployed. Two stations were single vertical seismometers linked by radio telementry to a central recording trailer. The third station included a normal three component group of seismometers hard wired to the recording trailer. Displacement magnifications in the range 2×10^5 to 1×10^6 were achieved. Approximately 280 channel-days of data were recovered.

The detection threshold, throughout the prospect area, was below M = 0.0 and close to M = -0.5 near Sheep Mountain south of Malta.

Only seven events with (S-P) times of less than 2.0 seconds, corresponding to epicentral distances of less than about 17 km, were detected during the entire ninety days of field operations. None of these events were detected by more than one station. The Magnitudes of the events are estimated to range from -0.4 to + 0.2. Too little data was present to determine a reliable log N vs M seismicity estimate. A simple event count yields a rate of 0.2 events per day with magnitudes greater than 0.0. According to the criteria of Sanford and Singh, (1968), this estimate has a 95% confidence level of being within a factor of two of the ten year seismicity rate.

The scarcity of events and their extremely low magnitudes suggest that the prospect is in an area whose seismicity

characteristics are more closely related to the aseismicity of the Snake River Plain than to the active Basin and Range. and the Intermountain Seismic Belt. Pennington, et. al., (1974), have noted the absence or extreme low level of seismicity in the Snake River Plain to the north, both at the microseismic level and at the macroseismic level. A search of the historical records reveals no epicenter within 30 km of the prospect area, and the area appears definitely separated from the belt of large scale activity immediately to the east.

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FORWARD

In response to inquiries from Mr. Lowell Miller, Aerojet Nuclear, and Dr. James K. Applegate, Boise State University, Dr. Maurice W. Major, Geophysics Department, Colorado School of Mines, proposed to conduct a small scale microseismic epicenter location program in the Raft River Valley. The program was to be in conjunction with other geophysical investigations carried out by the U.S.G.S. in the Raft River Geothermal Prospect. Upon approval of the proposal, Dr. Major, senior investigator, and L. H. Kumamoto, graduate student, assembled equipment for a tripartite earthquake location survey.

The survey was to be conducted through the months of July and August, but was subsequently extended to include September and October, 1974. The field work was conducted by Mr. Kumamoto with Dr. Major making two trips to the area to supervise the project.

INTRODUCTION

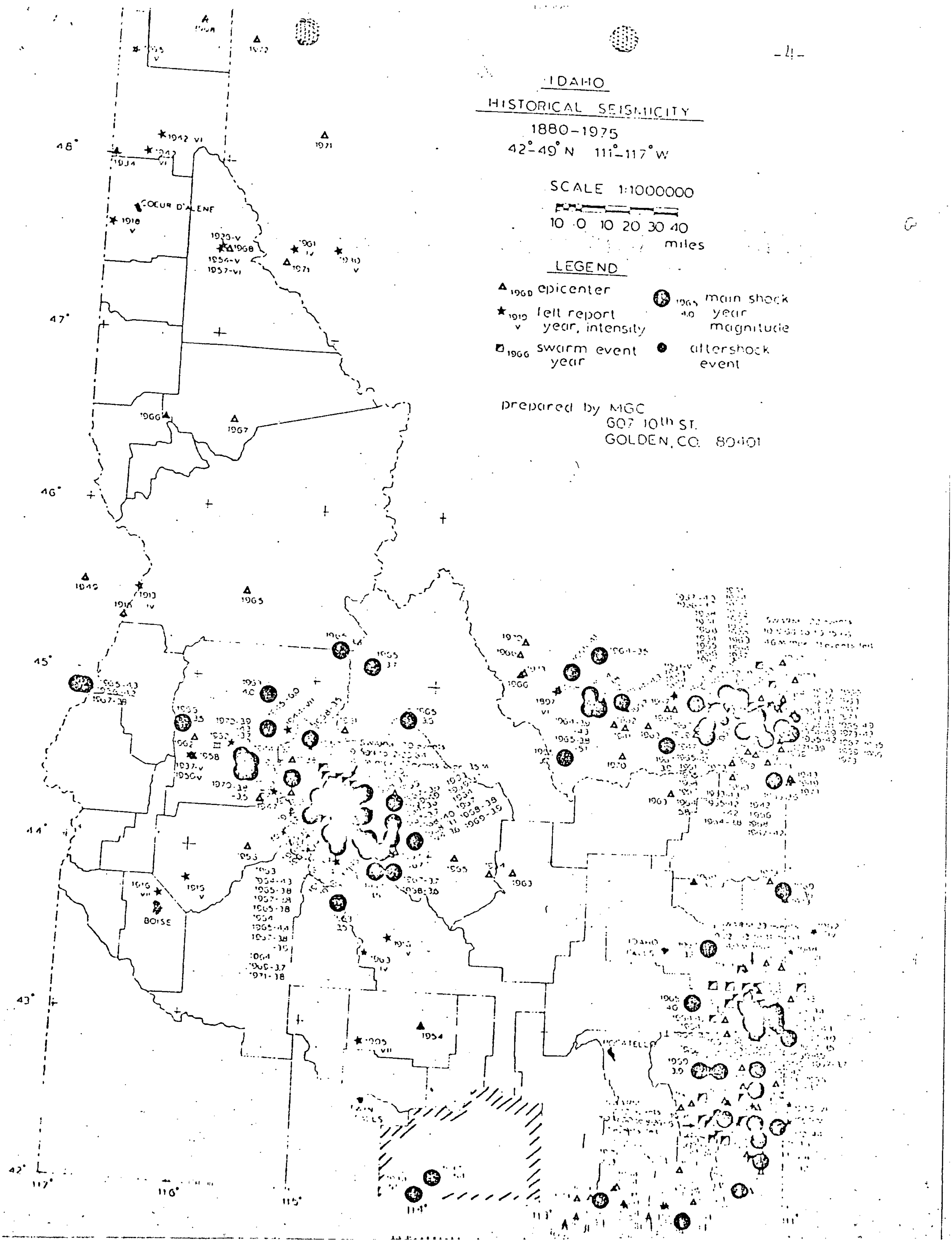
The Raft River Prospect, Eastern Cassia County, is located in a structurally complex zone near the junction of two geologic provinces, the Snake River Plain to the north, and the Basin and Range Province to the south and west. The unstable northern Rocky Mountain Province lies just to the east along the Idaho-Wyoming border. The Snake River Plain a major trough filled with as much as 2 km of Quaternary volcanics, is interpreted by Smith and Sbar (1974) to be a crustal rift forming the "wake" of the Yellowstone "plume". Whatever the interpretation, the Plain represents a broad expanse of recent volcanic activity. The Basin and Range region of block faulting is well known for its manifestations of current tectonic activity.

The north-south trending Raft River Valley is bounded to the west by the Cottrell and Jim Sage Ranges, to the east by the Black Pine and Sublett Ranges and to the south by the east-west trending Raft River Range; the boundary structure is predominately fault determined while to the north the sedimentary basin opens into the Snake River Plain. The prospect is, as inferred from geologic considerations, a region within which it is reasonable to expect seismic activity associated with current geologic activity.

A search of the Earthquake History of the United States, (1970 Edition, through 1970), and the N.O.A.A. Earthquake Data file (through 1973), indicates no historical earthquake epicenter within Cassia County (Figure 1). Smith and Cook (1965) whose catalog covered the interval from 1850 to June 1965, indicate no epicenter in Cassia County although their area of interest for the Seismicity of Utah Map does include southern Idaho. Slemmons, et. al. (1965) however, in their Catalogue of Nevada Earthquakes 1852-1960, list two events which plot in the southwest portion of Cassia County near the borders of Nevada and Utah (Figure 1). Dahl and Johnson (1974) have located one event in December 1973 that falls close to the Slemmons epicenters.

Year	Date	Co-ords	Magnitude	Comments
1934	12 Mar	42.0° N 114.0° W No depth	5.1	Reported by Reno and U.S.G.S. Distance 550 km from Reno. Felt in Elko. Other hard shocks this date in N. Utah (Slemmons)
1937	19 Nov	42.1° N 113.9° W No depth	5.4	Reliability: Poor fit. Reported by U.S.G.S. and B.S.S.A. Near Wells, Nev. Objects swung N-S at Wells and Carlin. Felt as far as Salt Lake City, Ely and Elko. (Slemmons)
1973	?? Dec	42.2° N 113.75° W No depth	1.5 (2.5)	Tripartite array NRTS (Dahl and Johnson)

These epicenters are located to within .1° or approximately ± 10 km at best; even hypothesizing larger error limits, reasonable play in the locations would not permit them to be grouped with the bank of seismic activity crossing the south-eastern corner of Idaho from Utah to Wyoming. They are isolated as well to the North and West in Idaho, the West and South in Nevada and Utah. These events lie thirty to fifty km west of the center of the geothermal prospect (Figure 2).


IDAHO
HISTORICAL SEISMICITY
1880–1975
42°–49° N 111°–117° W
SCALE 1:1000000
10 0 10 20 30 40
miles
LEGEND
1960 epicenter
1919 V felt report year, intensity
1966 swarm event year
1965 4.0 main shock year magnitude
aftershock event
prepared by MGC
607 10th ST.
GOLDEN, CO. 80401
COEUR D'ALENE
BOISE
IDAHO FALLS
POCATELLO
48°
47°
46°
45°
44°
43°
42°
117°
116°
115°
114°
113°
111°

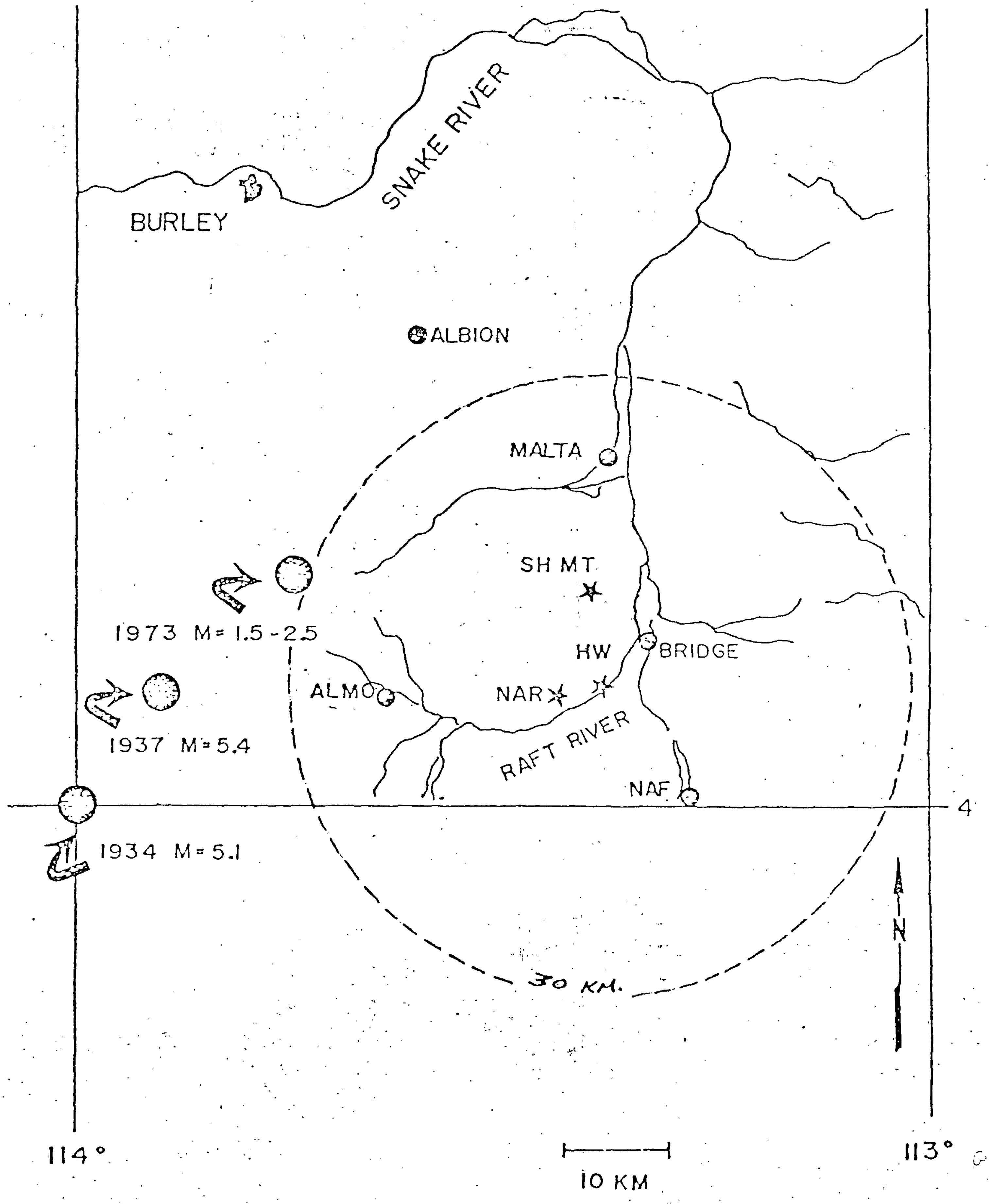

SNAKE RIVER
BURLEY
ALBION
MALTA
SH MT
HW
BRIDGE
ALMO
NAR
RAFT RIVER
NAF
1973 M= 1.5-2.5
1937 M=5.4
1934 M=5.1
30 KM.
4
N
114°
113°
10 KM

FIGURE 2

Within a thirty km radius of the prospect area itself, no historical epicenter has been cataloged.

The Raft River Prospect is situated adjacent to the Intermountain Seismic Belt, a broad swath of intense tectonism and macroseismicity (both current and historical). The immediate vicinity of the prospect is, in contrast, singularly lacking in both instrumental and intensity-inferred epicenters. The prospect itself is similar to the Snake River Plain in being aseismic in the macroseismic or large scale sense. This characteristic does not rule out the possibility of smaller scale activity, however, because of the well known consequences of increasing the density of observatories as well as certain poorly understood curiosities of earthquake recurrence relationships.

Pennington et. al., (1974) have conducted microseismic surveys in the Snake River Plain and demonstrate that that region is marked by a lack of micro-, as well as macro-, earthquakes. It was not clear, however, that the absence of macroearthquakes in the Raft River Valley in historic time could be interpreted to imply a correspondingly low level of microearthquake activity there.

The object of this Raft River survey is to determine the microseismic character of the prospect, both as to location and mechanism of events, and to use seismic data to delimit possible zones of connected fractures. Such fracture zones, if found, would influence design of the geothermal project underway in the area.

INSTRUMENTATION

Field instrumentation consisted of one three component seismograph station and two single component (Z) stations. The three component station included a recording trailer, requiring 120 V 60 hz power, which provided facilities for recording all five seismograms on the same time base at 240 mm/min.

The two single component (portable) stations were linked by radio-telemetry to the recording trailer. Each of the single component stations was composed of a vertical seismometer (Mark Products Model L-4, 1 hz, damped to 0.63 critical, coil resistance 5500 ohms, 270 volts/meter/sec.) connected to an amplifier-VCO (Develco Model 6202, constant bandwidth) which drove a transmitter (Repco Model 810-038) connected to a directional antenna. Power was provided by 12 volt automobile batteries. This type of power supply restricted station deployment to those locations with reasonable vehicle access because of the necessity for battery exchange-charge services. An additional restriction, of more importance, was imposed by the requirement that the telemetry stations be connected to the recording trailer by a line-of-sight path. This restriction arose from the use of Mega hz radio carrier frequencies. Practically, the single-component stations had to be deployed on topographic highs near existing roads.

The recording trailer was the terminus for the telemetered signals. There, two directional antennae were mounted on a single mast about twelve feet high. The radio receivers (Repco FM Receivers Model 810-055) drove discriminators (Develco Model 6203) from which the signal was taken to the recorders.

The three component station involved hard wire from the seismometers to the recording trailer which was less than 100 feet from the instrument pit. The seismometers (Sprengnether Model S-7000, 1 hz, damped to 0.6 critical, coil resistance 3300 ohms, 270 volts/meter/sec) were connected to matched amplifiers (Geotech Model EA-310) from which the signal was taken to the recorders.

Figure No. 3 is a block diagram which shows the relations between the various components of the instrumentation system. Those blocks which indicate that group of components which were mounted in the recording trailer are enclosed by the dotted line.

The time base for recording was provided by a crystal chronometer (Sprengnether TS-100) mounted in a console (Sprengnether PS-1000-5S) which provided pulses at one-minute intervals. Periodic synchronization with the C.U.T. signal from Fort Collins, Colorado, was provided by a radio receiver (Specific Products Model WVTR) and a shop built strob light.

All seismic signals were fed to pen motors (Gulton-Technirite Model 215, 16 hz) writing with ink on recording drums (Sprengnether Autocorder) at 240 mm/minute, and a

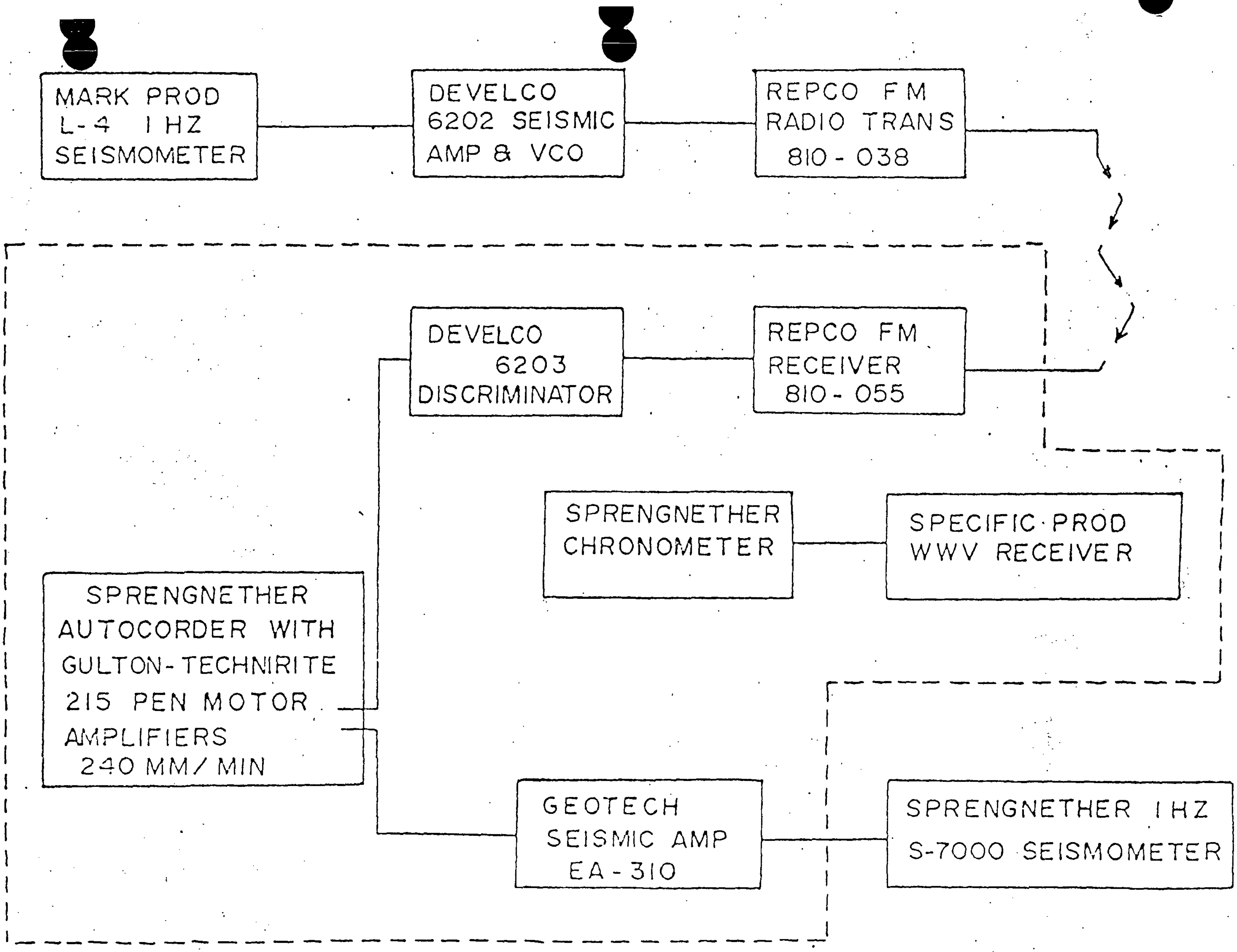

MARK PROD
L-4 1 HZ
SEISMOMETER
DEVELCO
6202 SEISMIC
AMP & VCO
REPCO FM
RADIO TRANS
810-038
DEVELCO
6203
DISCRIMINATOR
REPCO FM
RECEIVER
810-055
SPRENGNETHER
CHRONOMETER
SPECIFIC PROD
WWV RECEIVER
SPRENGNETHER
AUTOCORDER WITH
GULTON-TECHNIRITE
215 PEN MOTOR
AMPLIFIERS
240 MM/MIN
GEOTECH
SEISMIC AMP
EA-310
SPRENGNETHER 1 HZ
S-7000 SEISMOMETER

FIGURE 3

$2\frac{1}{2}$ mm/revolution translation rate. Three pen motors were mounted on each of two recorders. The resulting records are about 12" x 33", show three channels of data, and cover about two hours of time. Figure No. 4 is a sample record, about 42 seconds from left to right, showing P-waves, of period 1.0-1.2 seconds, from an earthquake near Hokkaido, Japan. The drum rotates once every 3.75 minutes. Time increases downward and to the right.

While no problems with data telemetry propagation were encountered except occasional signal dropouts attributable to wind induced motion of the antennae, and battery draw down, serious difficulties did occur with reception of WWV time signals. A twenty foot directional antenna was installed, but resulted in no appreciable improvement of reception. Time adjustments to the internal crystal chronometer were made only about once a week when reception cleared for several tens of minutes. Because of the central recording station technique, however, only relative time between stations was necessary and despite the loss of absolute time, the crystal chronometer provided excellent cross-channel time control. Drum rotation speeds on the recorders varied from 240 mm/min only by ± 2-3 mm/min.

Figure No. 5 shows the system frequency response. Magnification was determined by using the manufacturer's specifications and checking the result by direct comparison of certain records of distant earthquakes with records from well calibrated instruments at Bergen Park, Colorado (WWSS-COL).

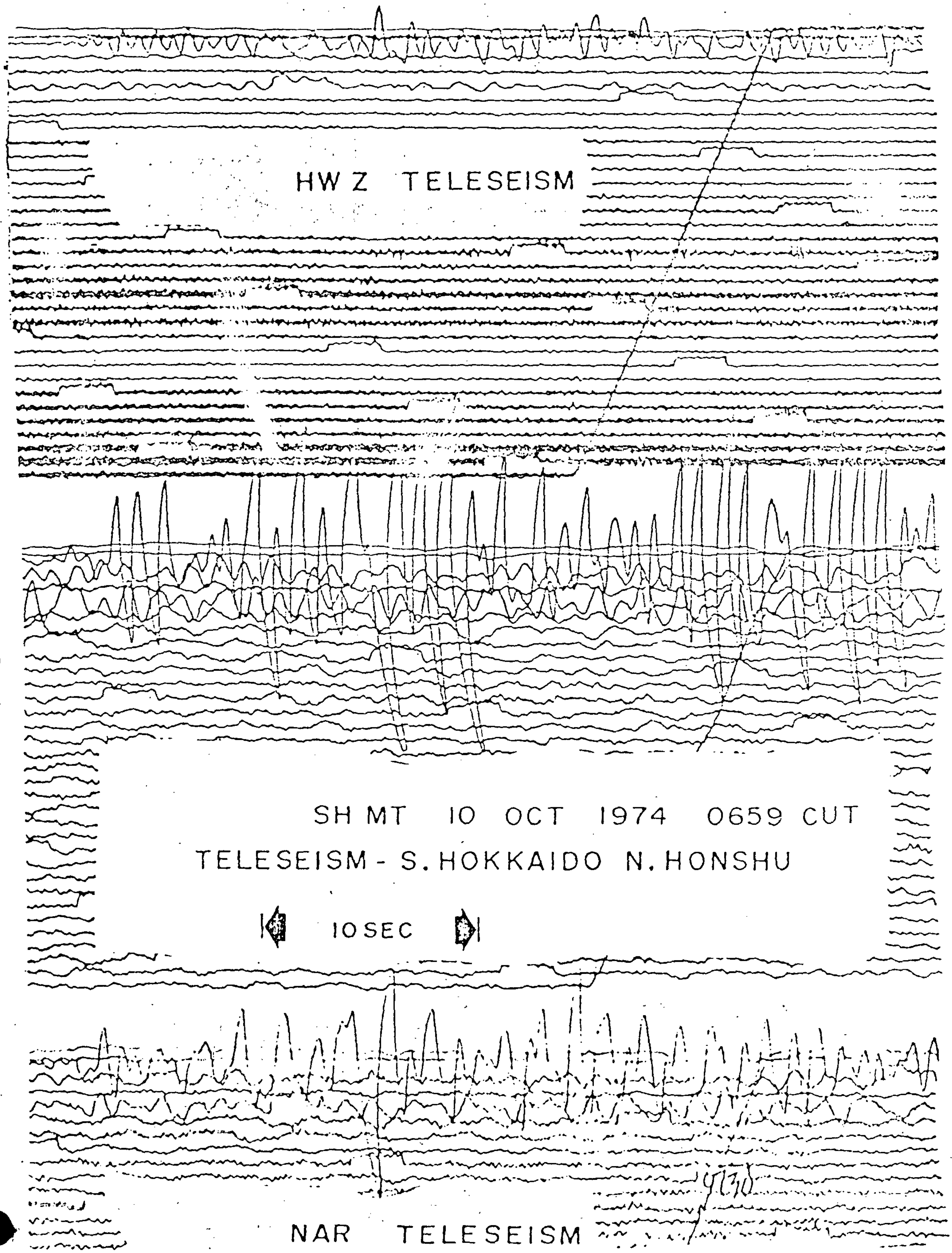

HWZ TELESEISM
SH MT 10 OCT 1974 0659 CUT
TELESEISM - S. HOKKAIDO N. HONSHU
10 SEC
NAR TELESEISM

FIGURE 4

SYSTEM FREQUENCY RESPONSE

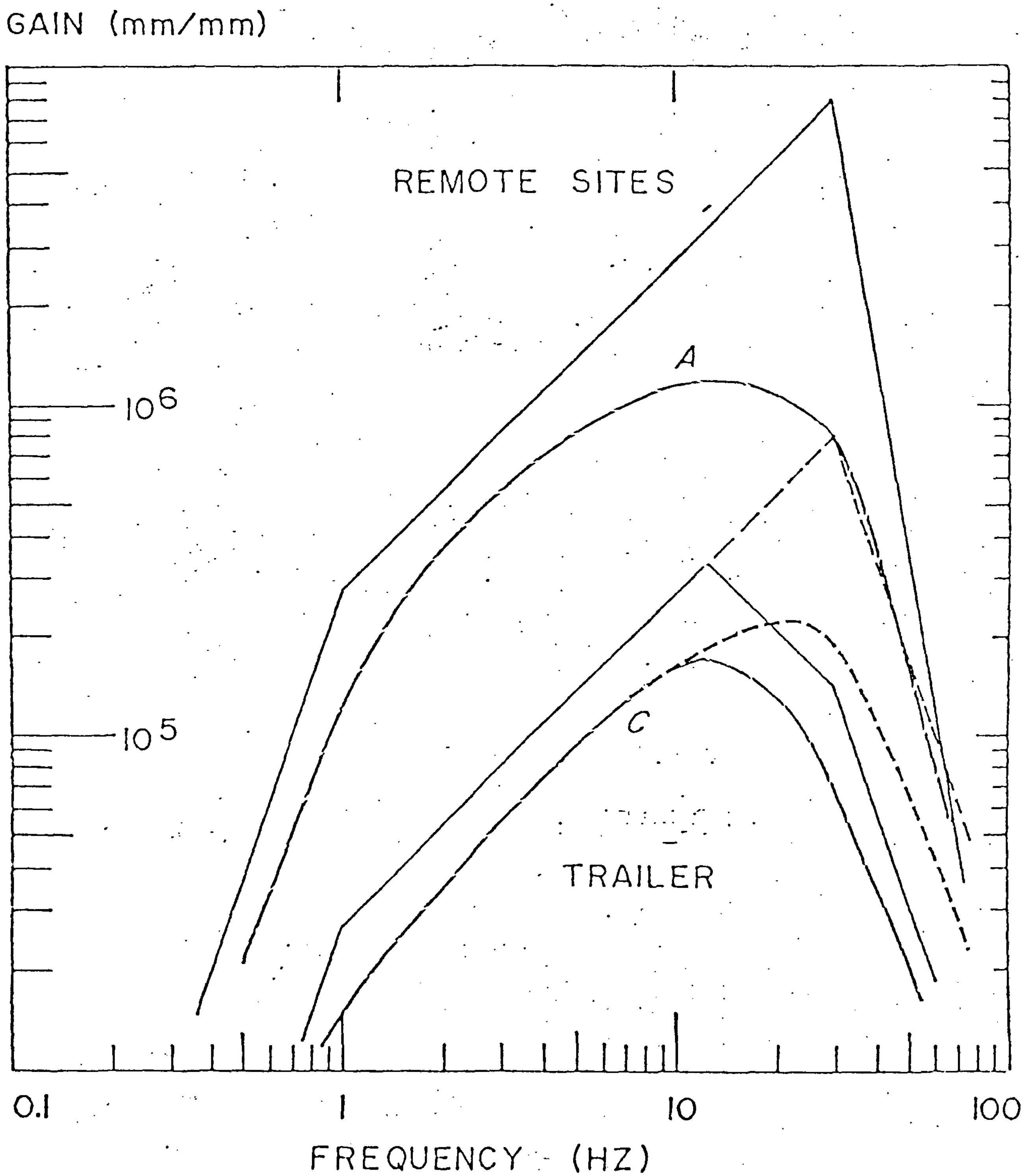
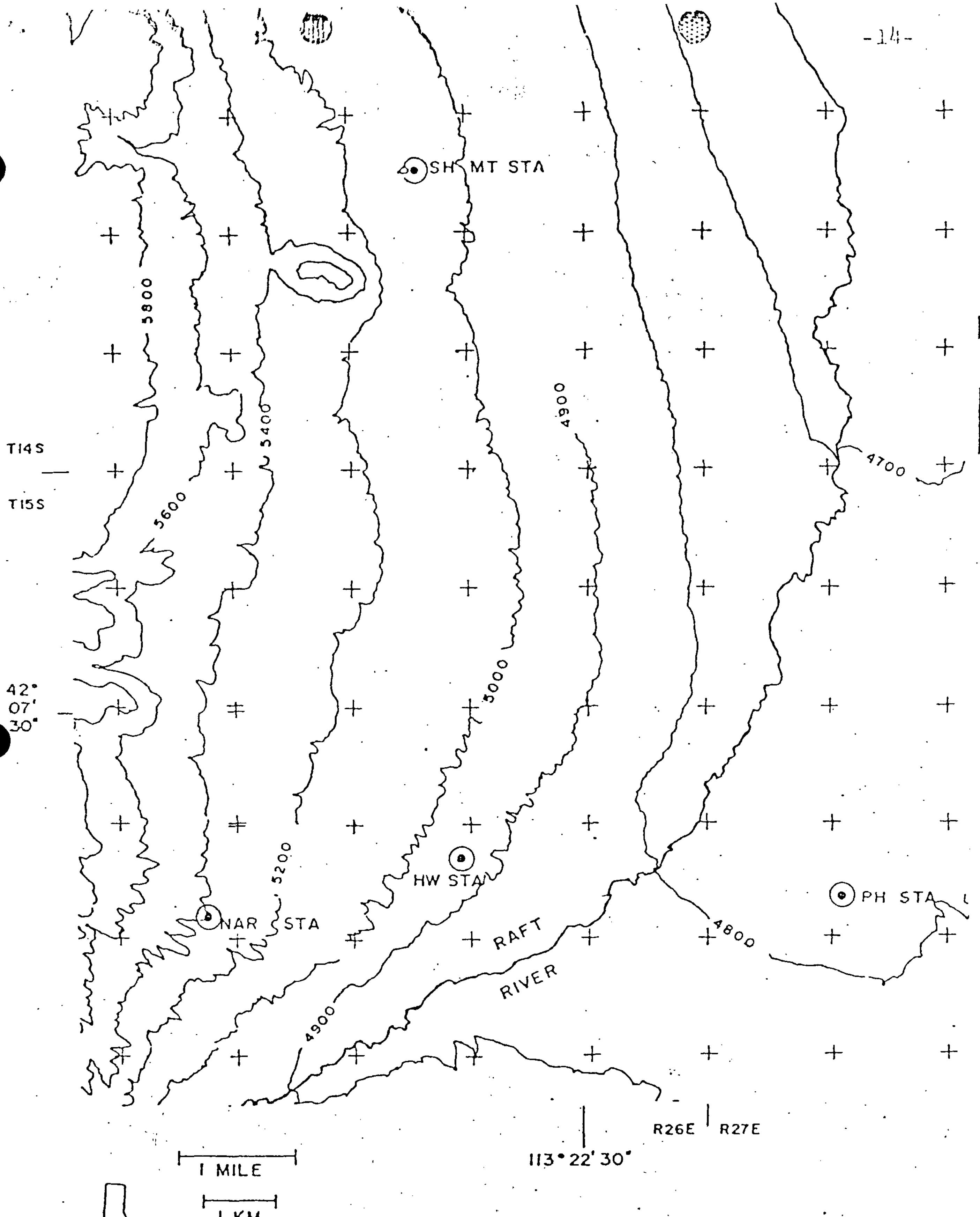


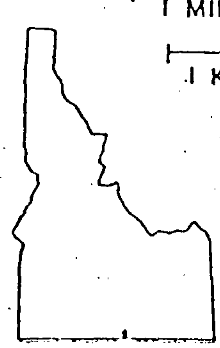
FIGURE 5

OPERATIONS

At the onset of the survey, geometric considerations and the reconnaissance nature of the program suggested a large aperture triangular array which would include as much of the prospect as possible. In consequence, stations SH MT, located on the eastern flank of Sheep Mountain, an igneous intrusive forming a dome shaped prominence, and NAR, located at the 5400 foot contour on the northern side of Chokecherry Canyon, were established as remote telemetry sites to encompass the north-south extent of the prospect. Power requirements of the recording trailer (three component) station necessitated a site with 60 hz, 120 V power and PH, Pig House, was occupied in Sec. 20-27E-15S as one of the few sites offering both power and east-west depth to the network. It was intended that the aperture be narrowed and the array resituated in the vicinity of any subregions of the initial net that manifested seismic activity after the initial setup (Figure 6).

At SH MT, only a thin veneer (about 6-12 inches) of weathered detritus and float covered the highly jointed but competent hardrock base upon which the seismometer was set. NAR offered a somewhat deeper thickness of loose weathering (12-20 inches), enough to support numerous dwarf Juniper pines, but presented no difficulties for seismometer emplacement. The noise at both of these remote sites was wind induced rather than cultural. During the numerous wind storms endemic to the area, significant portions of the





SURVEY AREA AND SEISMIC

STATION LOCATIONS

FIGURE 6

recordings were rendered useless. The initial placement of seismometers at PH was on the concrete foundation of a sheet metal grain enclosure, but high levels of wind noise forced the construction of a buried, timber reinforced instrument vault; noise from agricultural processes and swine contributed to the substantial background level at this site.

This array was operated from 26 July to 22 August, 1974. Figures 7 and 8 show the operations schedule. The solid horizontal lines indicate hours during which usefull records were recovered from the indicated channel. The numbers to the immediate right of the operational plots indicate the temporary magnification in terms of the number of DB down from the gain curves of Figure 5. In this operations schedule channel numbers, rather than station names, indicate the existing seismograms. A key to the channel number-station designations is printed to the right whenever there is any change from the original arrangement.

Temperature variations at the telemetry sites caused small variations in the Voltage Controlled Oscillators' center frequencies. Prior to 10 August this problem had caused up to one half of the records from the remote stations to be off-scale, the zero positions of the traces wandering back and forth in a daily cycle. The problem was solved by installing simple high pass RC filters after the discriminator stages. The filter has a 6 db/octave corner at 0.5 hz which removed the low frequency wandering, but did not affect the

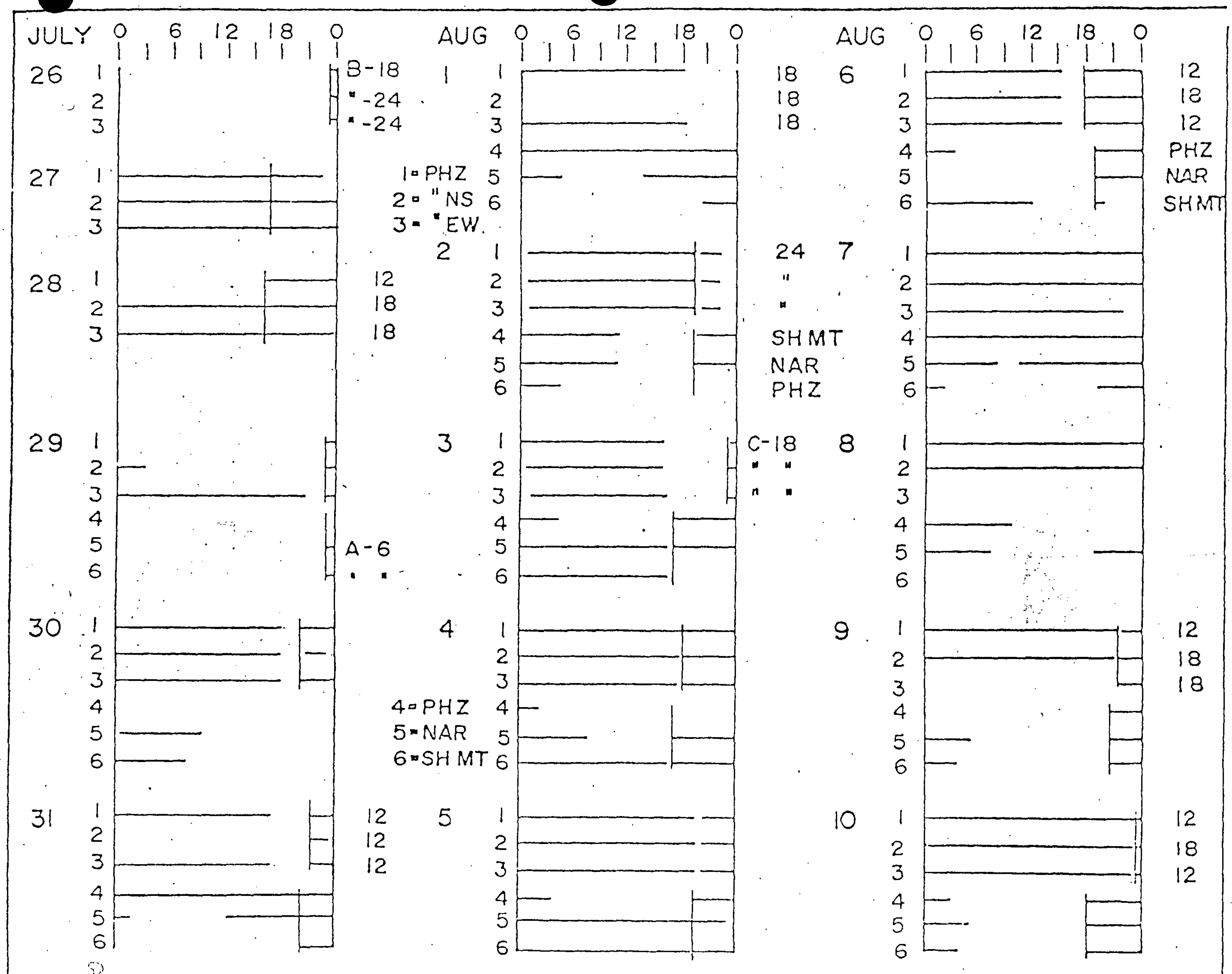

JULY 0 6 12 18 0
AUG 0 6 12 18 0
AUG 0 6 12 18 0
26
27
28
29
30
31
1
2
3
4
5
6
7
8
9
10
B-18
" -24
" -24
1 = PHZ
2 = " NS
3 = " EW
4 = PHZ
5 = NAR
6 = SH MT
A-6
C-18
SH MT
NAR
PHZ
SHMT
24

FIGURE 7

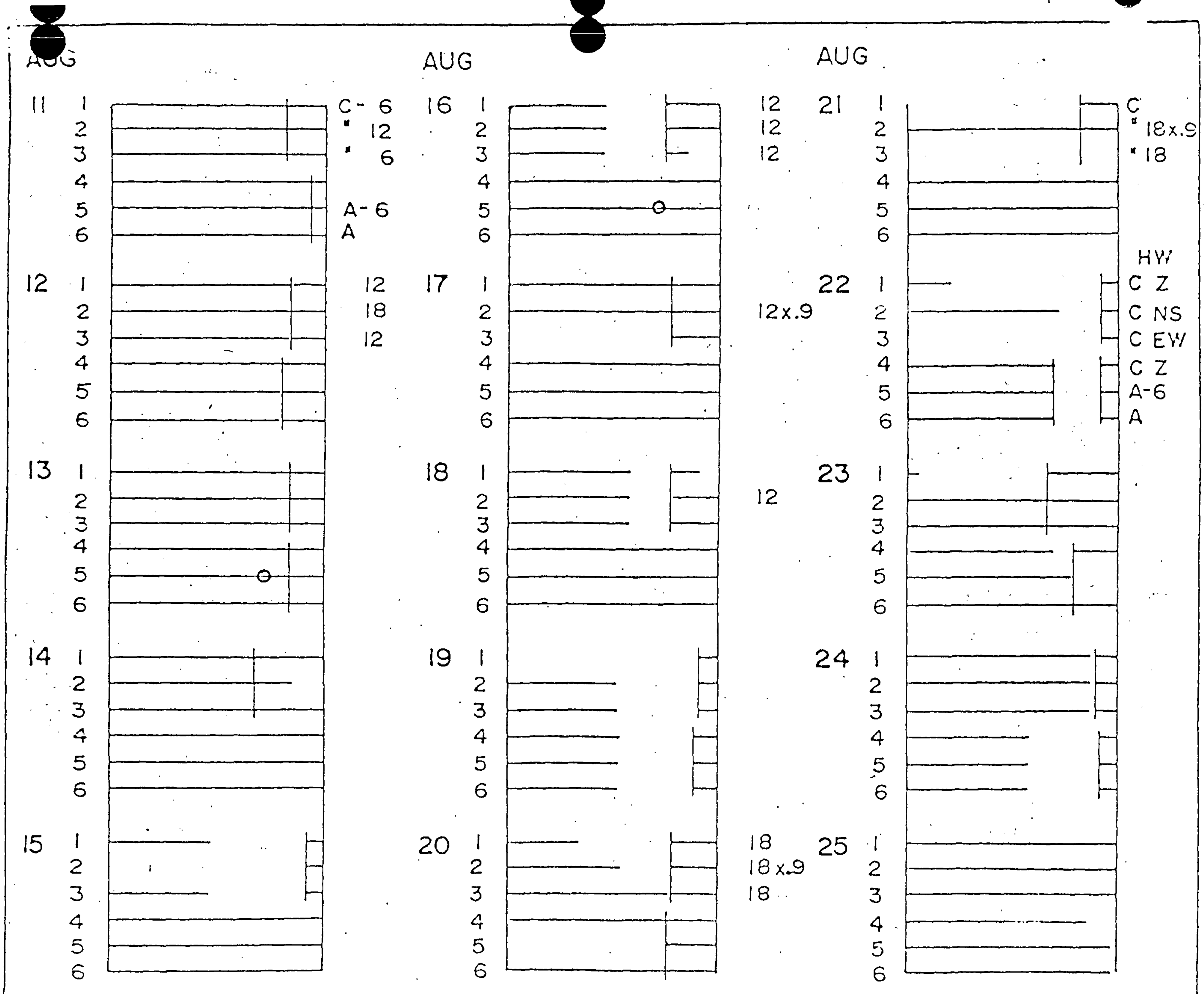

AUG
AUG
AUG
11
16
21
12
17
22
13
18
23
14
19
24
15
20
25
1 2 3 4 5 6
C - 6
" 12
" 6
A - 6
A
12
18
12
12
12
12
12x.9
12
18
18x.9
18
C
" 18x.9
" 18
HW
C Z
C NS
C EW
C Z
A-6
A

FIGURE 8

bandpass of the instrumentation.

Noise problems associated with cultivated tracts immediately adjacent to the seismometers, and both livestock and people wandering on and about the trailer and instrument vault, caused the abandoment of the PH site. The loss of two recording days in the period 6-9 August was occasioned by an airborne dispersion of methyl-parathione in and on the trailer and its environs.

On 22 August, after Mr. E. Schlender of the Raft River Electrical Co-op installed a transformer and drop, the recording trailer and station were transferred to the HW site, SE NE Sec. 22-26E-15S. Background noise levels were considerably lower at HW than at the PH site although traffic on a nearby gravel road caused noise bursts several minutes long.

At this time, the internal amplifier high cut filters of the trailer station system, which had been set at 30 hz, were replaced by 12 hz high cut filters. The high frequency noise problem that occasioned the change was not improved and on 31 August, the two horizontal components of the trailer station were shut down. The problem is believed to have been in the electrical power system.

The system operated with only three vertical components from 31 August to 29 October. The signals were switched from channels 4, 5, and 6 to channels 3, 4, and 5 on 15 October because of a failure in one of the two recorders. Vehicle problems caused the loss of several days records in late October. Figures 9, 10, and 11 detail the operational conditions through the end of the project on 29 October 1974.

The entire seismogram library totals the equivalent of 210 - 285 complete channel-days.

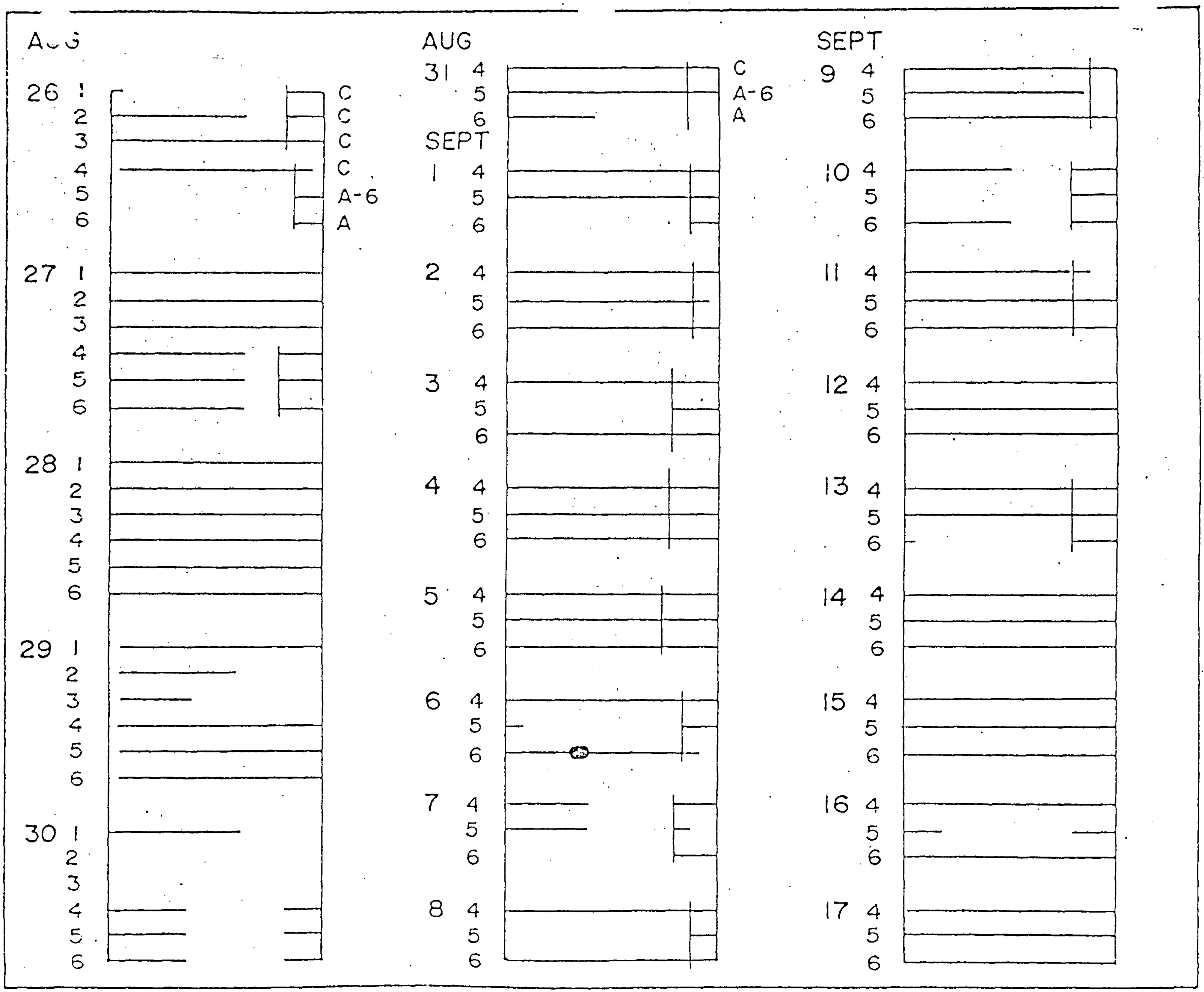

AUG
26 1 2 3 4 5 6
C
C
C
C
A-6
A
27 1 2 3 4 5 6
28 1 2 3 4 5 6
29 1 2 3 4 5 6
30 1 2 3 4 5 6
AUG
31 4 5 6
C
A-6
A
SEPT
1 4 5 6
2 4 5 6
3 4 5 6
4 4 5 6
5 4 5 6
6 4 5 6
7 4 5 6
8 4 5 6
SEPT
9 4 5 6
10 4 5 6
11 4 5 6
12 4 5 6
13 4 5 6
14 4 5 6
15 4 5 6
16 4 5 6
17 4 5 6

FIGURE 5

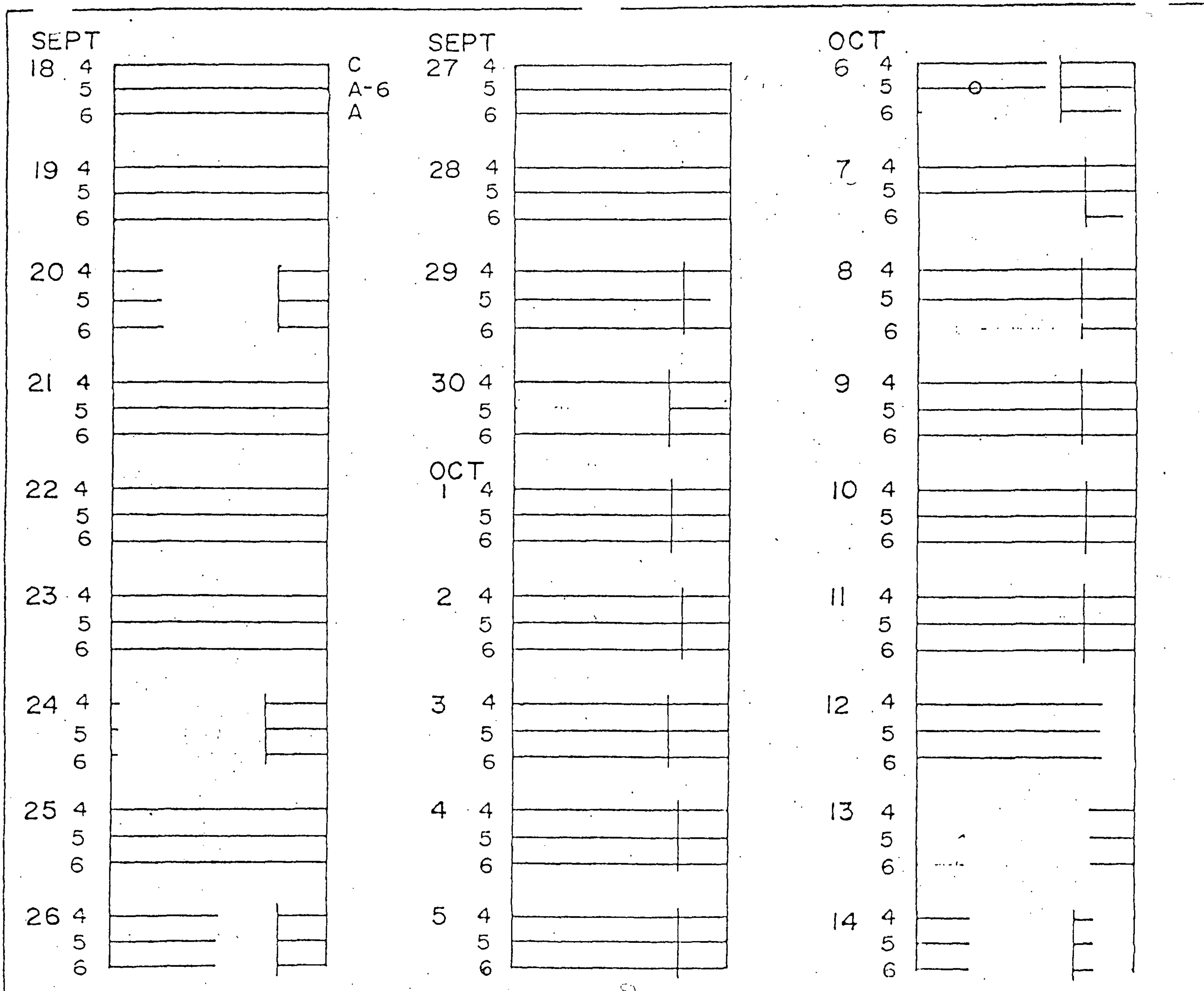

SEPT
18 4 5 6
19 4 5 6
20 4 5 6
21 4 5 6
22 4 5 6
23 4 5 6
24 4 5 6
25 4 5 6
26 4 5 6
C
A-6
A
SEPT
27 4 5 6
28 4 5 6
29 4 5 6
30 4 5 6
OCT
1 4 5 6
2 4 5 6
3 4 5 6
4 4 5 6
5 4 5 6
OCT
6 4 5 6
7 4 5 6
8 4 5 6
9 4 5 6
10 4 5 6
11 4 5 6
12 4 5 6
13 4 5 6
14 4 5 6

FIGURE 10

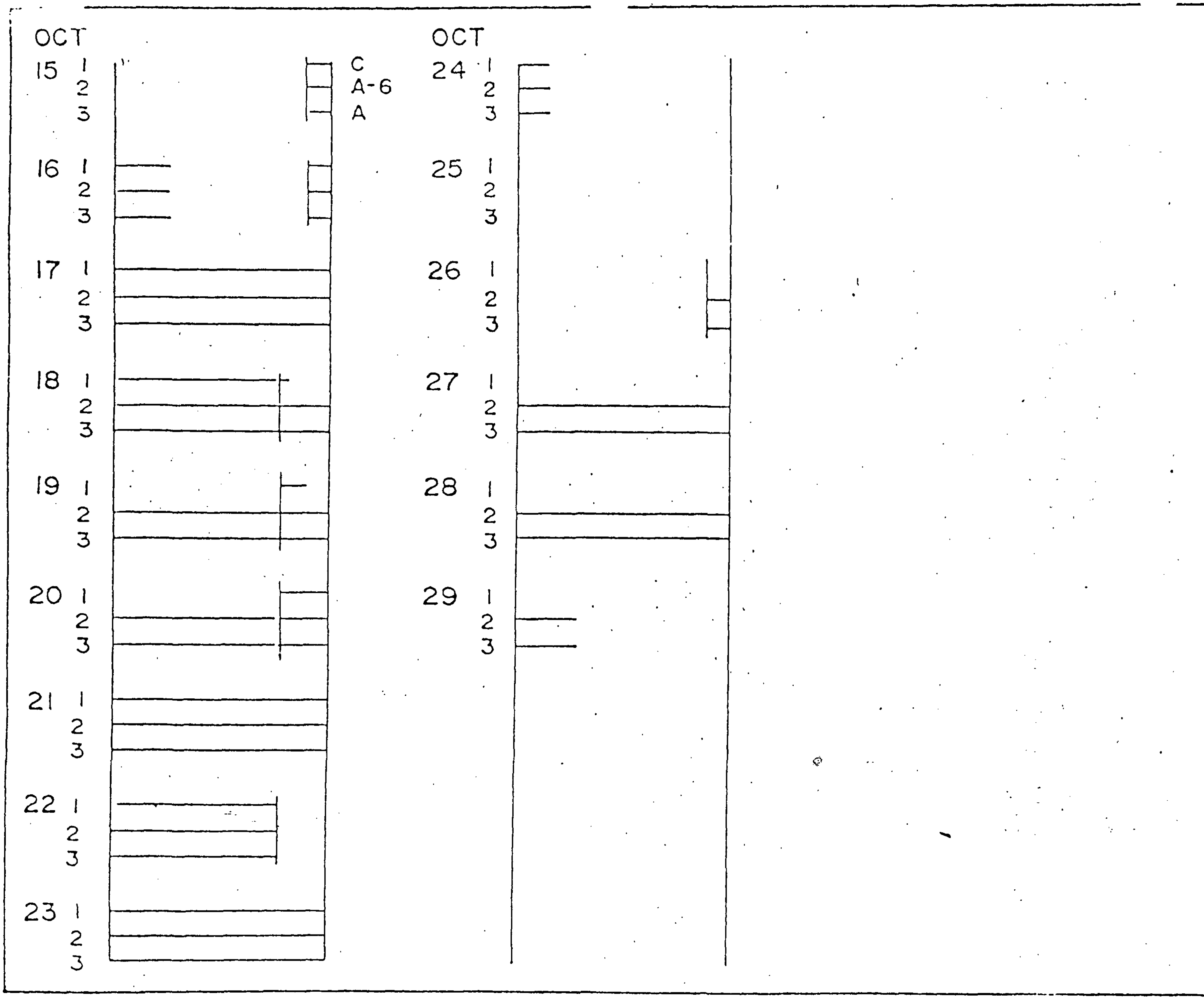

OCT
15 1 2 3
C
A-6
A
16 1 2 3
17 1 2 3
18 1 2 3
19 1 2 3
20 1 2 3
21 1 2 3
22 1 2 3
23 1 2 3
OCT
24 1 2 3
25 1 2 3
26 1 2 3
27 1 2 3
28 1 2 3
29 1 2 3

FIGURE 11

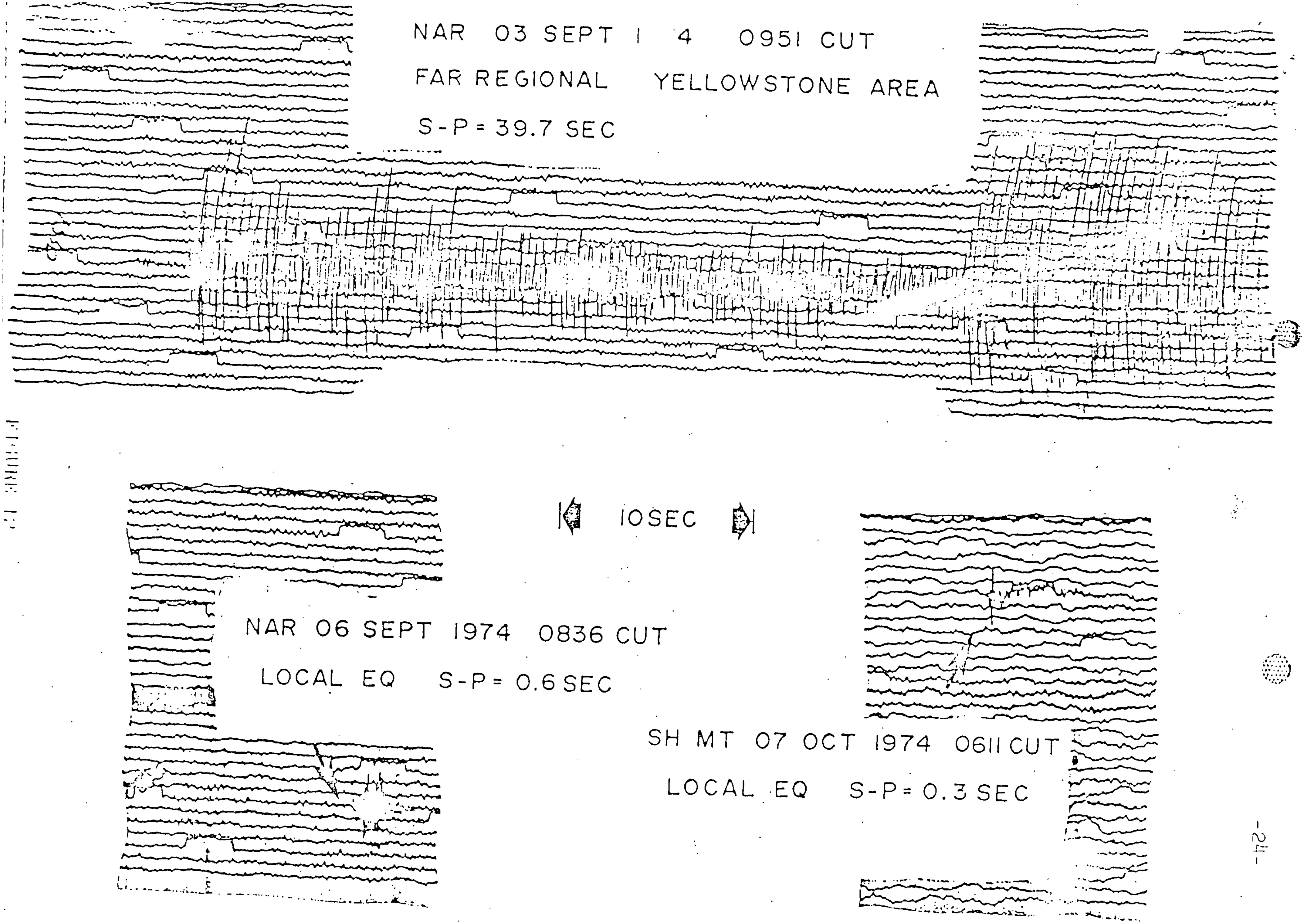
OBSERVATIONS AND INTERPRETATION

It was intended that events be located by the standard three station method, for which as least one (S-P) time is also necessary, and the standard Jeffreys-Bullen (1958) travel time curves for near earthquakes.

Although little natural seismic activity was observed from within the network, one to two distant teleseismic events were registered daily as well as one to two events from 75 km to 150 km to the east and southeast and occasional earthquakes from the Yellowstone area of Montana (Figure 12).

For several weeks USGS refraction shots in the alluvium at the southern end of the network were observed as full scale clipped signals (Figure 13). Although P breaks were readily observable and pickable (S was not pickable) on the shot records, apparent velocity vectors deviated considerably from the actual shot points (Ackermann, USGS, personal communication). So great were the errors that it became evident that neither the uniform half space nor the Jeffreys-Bullen model would have been sufficient for three station locations with uncertainties less than several miles. The location problem for local earthquakes did not arise.

Figure 14 is a map showing our estimated detection threshold for local events. We estimated that any event producing a trace deflection of more than 4 mm would be identified as an earthquake. Corresponding magnitudes were calculated according to Richter as described in the next



NAR 03 SEPT 1 4 0951 CUT
FAR REGIONAL YELLOWSTONE AREA
S-P = 39.7 SEC
10 SEC
NAR 06 SEPT 1974 0836 CUT
LOCAL EQ S-P = 0.6 SEC
SH MT 07 OCT 1974 0611 CUT
LOCAL EQ S-P = 0.3 SEC

FIGURE 12

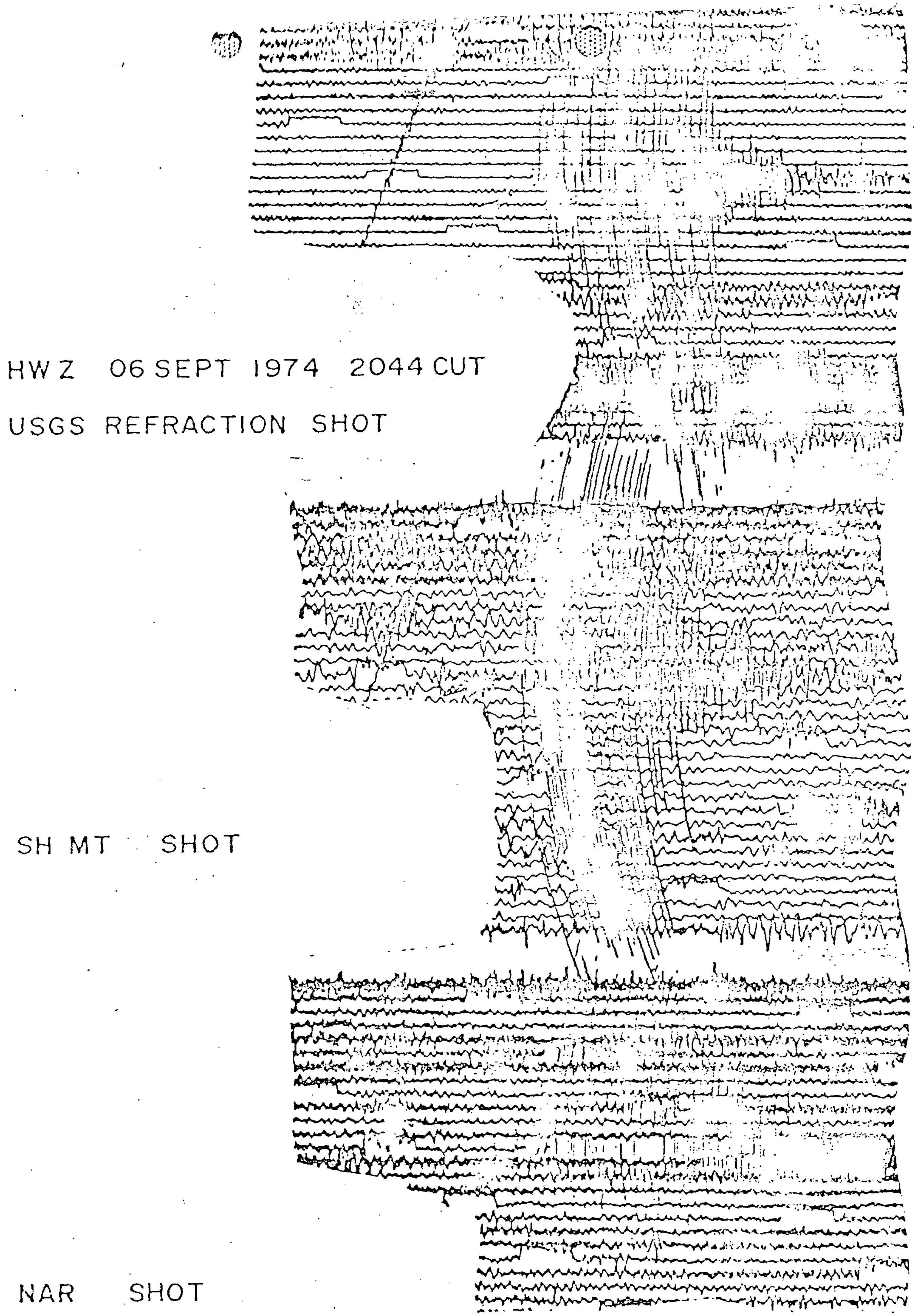

HWZ 06 SEPT 1974 2044 CUT
USGS REFRACTION SHOT
SH MT SHOT
NAR SHOT

FIGURE 13

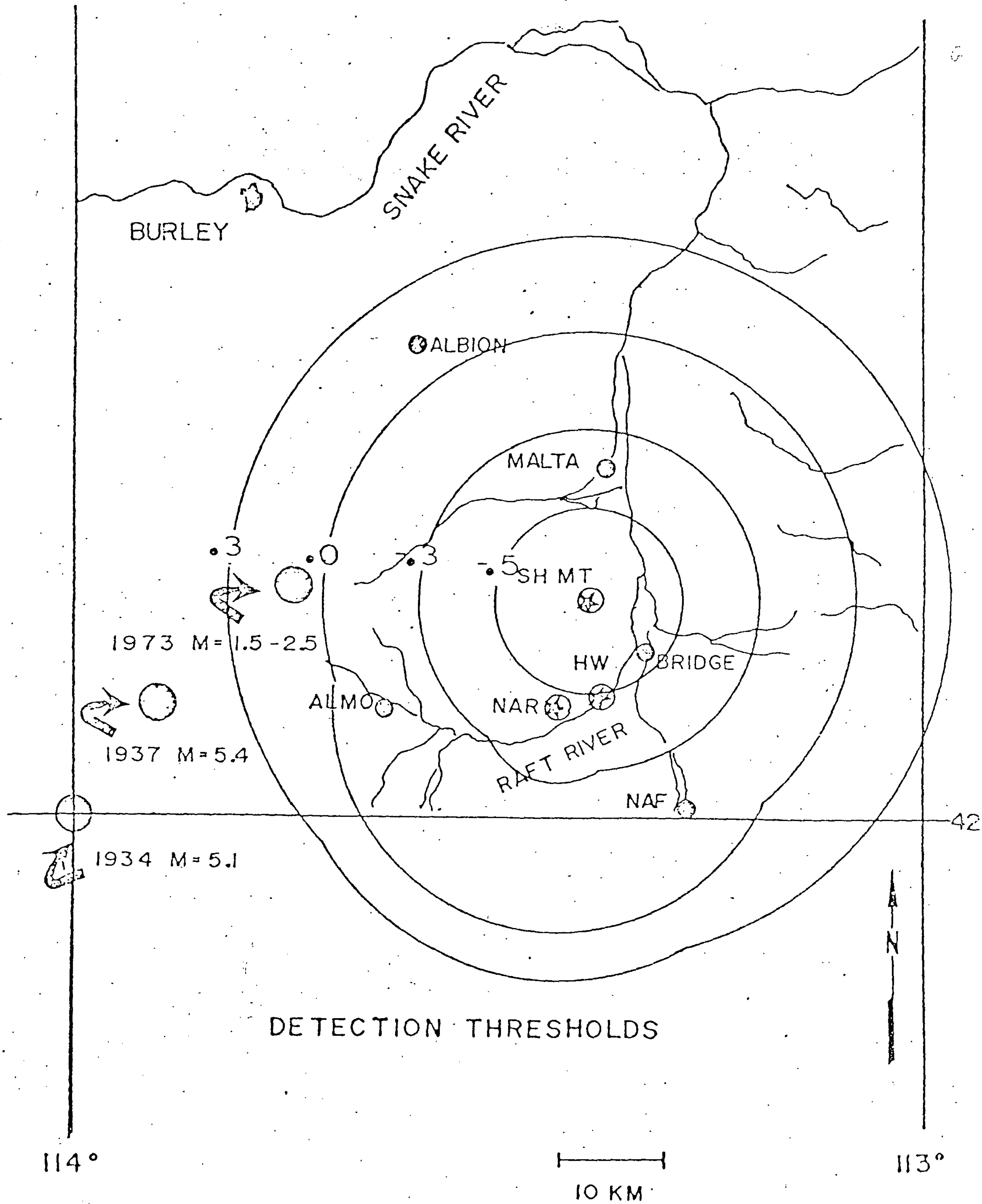

SNAKE RIVER
BURLEY
ALBION
MALTA
.3
.0
-.3
-.5
SH MT
1973 M= 1.5-2.5
HW
BRIDGE
ALMO
NAR
RAFT RIVER
1937 M=5.4
NAF
42
1934 M=5.1
N
DETECTION THRESHOLDS
114°
113°
10 KM

FIGURE 14

section. Three stations, NAR, SH MT, and HW are shown. The contours enclose that area in which an earthquake of magnitude greater than or equal to that indicated by the contour value would be detected. Note that this diagram is only a surface view. The volume within which the event would be detected is a hemisphere, for the half space model with constant attenuation. The relative insensitivity of HW is evident in this display. The noise level of agricultural work and road traffic was associated with every site where 60 hz power was available; therefore the recording trailer site was always relatively low gain.

In this reconnaissance configuration, there is good detection coverage over the entire prospect; for good location coverage the array aperture was to have been narrowed and moved to the vicinity of any detected activity. No activity was detected.

Magnitudes were determined according to Richter (1958) with amplitudes corrected to the response of the standard Wood-Anderson torsion seismometer, gain 2800, free period 0.8 sec, and damping 0.8 critical:

$$M = \log A_{wa} - \log A_o$$

where A_{wa} is the amplitude in millimeters of the largest zero to peak trace deviation and A_o is the amplitude in millimeters of the zero magnitude reference earthquake at the specified epicentral distance (Table 22-1 Richter). Since

$$A_{wa} = \frac{G_{wa}}{G} A$$

where G indicated gain and the nonsubscripted quantities are those of the field system, then

$$M = \log A - \log A_o + \log G_{wa} - \log G.$$

Certain problems are inherent in Richter's definition of local magnitude; azimuth with respect to the source mechanism, variations of elastic parameters along the travel path, coupling of the geophone to the ground, and the fact that his attenuation is based on southern California data. In addition the instrumentation and the targets of microseismic investigations introduce two further sources of uncertainty: (A) vertical rather than horizontal motion is recorded, and (B) the frequencies observed with 0-20 hz high gain recording of very near microearthquakes are much higher than those Richter observed. Brune and Allen (1967) give a 20 hz wave attenuation factor to be added to the Richter equation, but given the uncertainties involved with one station magnitude estimates, this refinement is needless.

During the 90 days of the survey, only seven events with S-P times of less than two seconds (17 km epicentral distance) were detected (Table 1). All of these events were detected on one station only, either SH MT or NAR. Locations cannot be determined from one station events, although epicentral distances can be inferred from S-P times. In combination with trace amplitudes these distances will then yield the event magnitudes shown in the Table. No relation between local working hours and time of occurrence is evident. (Table 1, local time = CUT-6)

Table 1

LOCAL EVENTS DETECTED (S-P LESS THAN 2.0 SEC)

DATE	TIME CUT	S-P	DISTANCE	STATION	MAGNITUDE
13 Aug	1755	0.2s	2.0 km	SH MT	0.17
17 Aug	1733	1.1s	9.0 km	SH MT	0.00
6 Sept	0806	0.6s	5.0 km	NAR	0.05
6 Sept	0806	0.8s	7.5 km	NAR	-0.10
6 Sept	0836	0.6s	5.0 km	NAR	0.03
6 Sept	0840	0.5s	4.5 km	NAR	-0.37
7 Oct	0611	0.3s	1.5 km	SH MT	-0.45

The conventional measures of seismicity are the log N vs M plot, called the cumulative recurrence plot, and the simple event rate. Figure 15 is the cumulative recurrence plot for the seven local events, where N is the number of events greater than or equal to M. Although event magnitudes, based on single observations, are not accurate to ± 0.5, it is assumed that their relative precision is more tightly constrained. Interpretation of the relationship $\log N = A - bM$ where $-b$ is the slope, results in an astonishing and unrealistic value of $b = -6.7$ (the worldwide average 0.92 is plotted on the figure for comparison). Smith and Sbar (1974) have determined a slope of -1.06 for the Intermountain Seismic Belt.

The low magnitude end of the data, although seeming to agree with the worldwide average, must from purely instrumental arguments represent too low a slope. Failure to detect very small shocks should reduce the slope in this range of magnitudes. Very steep portions of the log N vs M curve are often attributed to inclusion of man made events (e.g., shots of about the same charge weight), but the problem in this case is more fundamental. Sanford and Singh (1968) working with ten years of data, conclude that regardless of the time window, at least 150 events are necessary to derive a reliable b slope from such a diagram. While this estimate may be high, it certainly does not change the obvious conclusion that not enough data points are available. It is

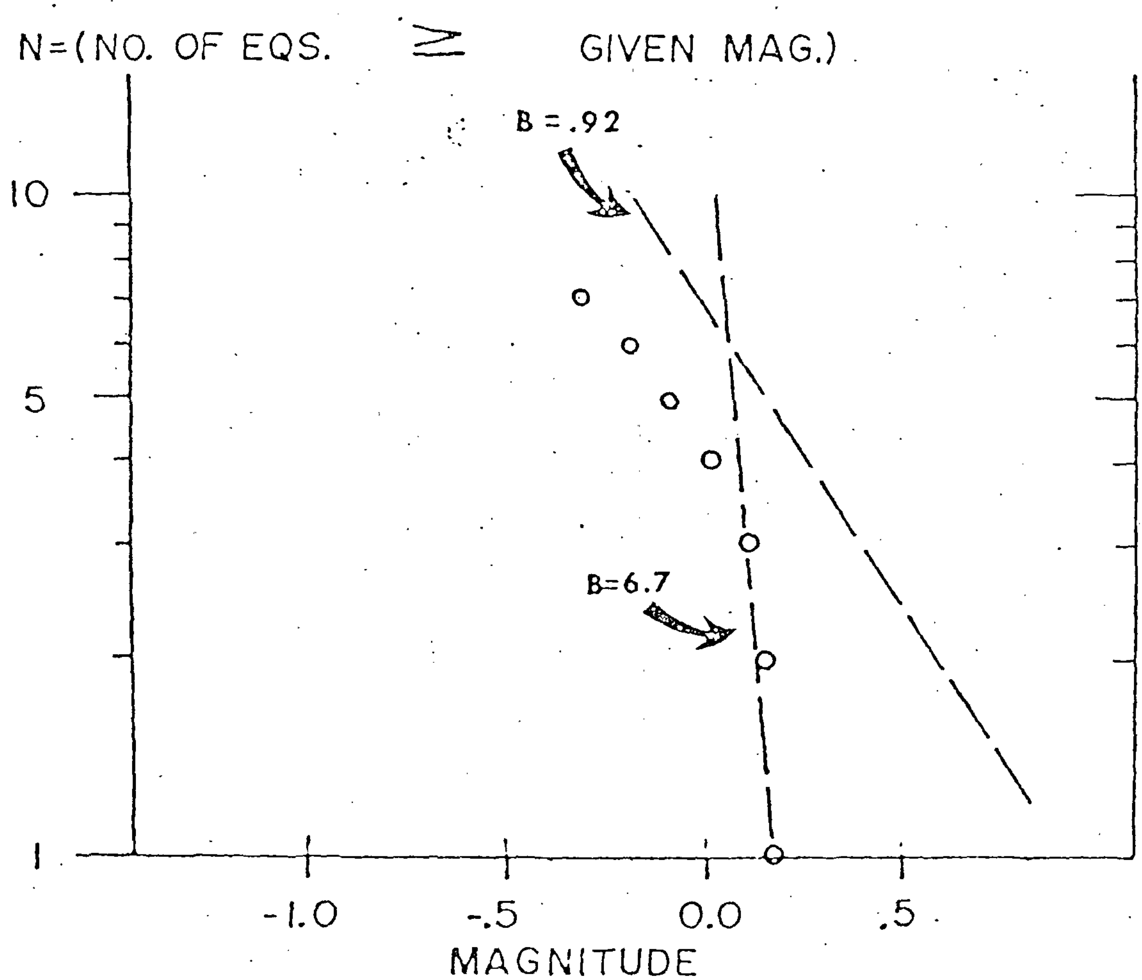


FIGURE 15

evident that the reliability of recurrence estimates are dependent upon the level of seismicity, i.e., the higher the rate or the total number of events, the more well determined the estimate of seismicity, at the lower end of the scale little can be said other than the seismicity is low. This being the case, we must resort to the simpler but less informative event count method of seismicity estimation.

The event rate is determined as follows:

(1) a threshold magnitude is chosen, high enough to insure uniform detection capability throughout the area whose seismicity is to be characterized.

(2) the possibility of the estimated event rate being depressed by the masking of true events during abnormal periods of high cultural or wind noise is taken into account by introducing multiplicative factors, of greater or lesser subjectivity, to adjust the observed count.

(3) the event-per-day seismicity rate is determined.

If we take M = 0.0 as that magnitude above which we believe all events, within twenty km of the prospect center, to have been detected (Figure 14), and we estimate that half of these events were masked by high wind noise, then the resulting rate is approximately 0.1 event of Magnitude $\geq$ 0.0 per day.

This is a very low rate. Lange and Westphal (1969) observed 19 earthquakes in 120 hrs., or about four per day at the Geysers, California. Westphal and Lange (1966) report from 0 to 10 events per day with an average of about 1.5 per day over 19 days of intermittent recording in the Sunbeam-Stanley area of Central Idaho. Pennington, et. al. (1974) however note, "no natural events near any of the arrays in the Snake River Plain . . . ," in a total of 21 days at various sites.

Sanford and Singh (1968) working with ten years of New Mexico seismic data, have determined that one week of recording is necessary to determine an event rate seismicity with a 95% confidence level of being within a factor of ten of the ten year rate, four weeks for a factor of three and three months for a factor of two.

With 90 days of records in this survey, it may be said with confidence that the Raft River Prospect exhibits less than 0.2 events per day and resembles the Snake River Plain rather than the Basin and Range or the Intermountain Seismic Belt as far a seismicity is concerned.

The first two or three weeks of the survey were sufficient to determine this seismicity; the Senior Investigator and the Field Observer suggested verbally that further investigation was not likely to demonstrate any appreciable change. The seismic array was never contracted to narrow aperture because no localized activity was detected in its reconnaissance configuration. Although background noise exhibited some interesting peculiarities, and noise studies were suggested, logistical problems precluded further investigation into that problem.

CONCLUSIONS

1. The seismicity rate of the Raft River Prospect, less than 0.2 events per day (M greater than 0.0) is extremely low and categorizes the area as being seismically more akin to the Snake River Plain than to the Intermountain Seismic Belt.

2. The difficulties encountered in locating USGS refraction shots indicate that for location of events in such an area, at least four stations and a velocity model more complex than a half space or the Jeffreys-Bullen tables are in order.

RECOMMENDATIONS

If further microseismic investigations are contemplated for areas on and about the Snake River Plain, which exhibit little historical activity, serious cost effectiveness considerations should be applied as regards the necessary time window.

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