EARTHQUAKES IN THE GULF OF CALIFORNIA RECORDED USING LAND-BASED RECORDINGS OF MOORED HYDROPHONE ARRAYS

JAMES N. BRUNE*
SERVANDO DE LA CRUZ**
HUGH BRADNER*
CESAR VILLEGAS***
IAN REID*
MIKE REICHLE*
ALEJANDRO NAVA**
MANUEL LOZADA**** AND
PEDRO SILVA*****

ABSTRACT

We report results of the use of telemetering sonobuoy hydrophones to record small local earthquakes in the Gulf of California. The signals were recorded with simple radio receivers

* *Scripps Institution of Oceanography, San Diego, Cal.*
** *Instituto de Geofísica, UNAM.*
*** *Consejo de Recursos Naturales No Renovables, México.*
**** *Becario de la OEA.*
***** *Becario del Instituto de Geofísica, UNAM.*

and visible recorders both on land at Guaymas and on the Scripps Institution of Oceanography ship R/V Melville. In this paper we give preliminary results of the land-based recordings at Guaymas. Results of the recordings on board the Melville will be discussed in a separate paper (Reid et al, 1973, henceforth referred to as Paper I). We also attempted land-based recordings at Topolobampo but were unsuccessful because of radio interference and inability to find a recording site with sufficient altitude.

RESUMEN

En este trabajo se informa acerca de los resultados obtenidos mediante el registro telemétrico de pequeños sismos locales en el Golfo de California, utilizando sonoboyas como hidrófonos. Las señales fueron registradas con radioreceptores comunes y registradores visibles tanto en tierra, en Guaymas, como en el barco de la "Scripps Institution of Oceanography" R/V Melville. Aquí se presentan los resultados preliminares de los registros de la base terrestre de Guaymas. Los resultados de los registros obtenidos a bordo del Melville serán discutidos en una publicación separada.

Los intentos de registros en tierra, desde Topolobampo, resultaron infructuosos debido a la interferencia de la radio y a la imposibilidad de encontrar un sitio de registro suficientemente elevado.

EXPERIMENTAL PROCEDURE

A tripartite hydrophone sonobuoy array was moored near the Guaymas Basin using the Scripps Institution of Oceanography ship R/V Melville. The hydrophones hung beneath the sonobuoys at a depth of 20-100 m. Radio signals transmitted from the sonobuoys were recorded with radio receivers and portable suitcase smoked paper recorders (Prothero and Brune, 1971). The recording site was on a peak overlooking Guaymas and the Gaymas Basin at an altitude of about 1000 m. The radio reception was generally excellent even though the line of site distance to the array was about 100 km. Fig. 1 shows the position of the recording site and moored array. Also shown are the position of some free-floating expendable sonobuoys from which signals were recorded, and the approximate position of a spectacular swarm of earthquakes recorded on the Melville on April 11. This swarm, which consisted of about 1000 events of magnitude less than 2.0 in a period of about six hours is reported in Paper I. Also shown in Fig. 1 are approximate locations of two groups of the earthquakes recorded by the Guaymas land-based sonobuoy recording station.

The hydrophones in the moored array were considerably noisier

than the free-floating hydrophones because of cable noise and because of the swift tidal currents in the Gulf. During the semi-diurnal periods of high tidal currents the moored arrays were essentially useless, the currents reaching about two knots. The moored hydrophones of course had the advantage that they did not drift and did not require the presence of the ship to verify hydrophone positions. In the four weeks of recording at Guaymas about 1122 hours of relatively noise-free recordings were obtained and fifteen earthquakes were recorded, ten from expendable free-floating hydrophones and five from the moored array.

RESULTS

Fig. 2 shows some of the seismograms recorded at Guaymas. Note that the inital arrivals are sharp and the seismograms look quite similar to the microearthquake seismograms on land. In addition to P and S phases a T phase (sonic wave in water) is commonly observed (figs. 2e, 2f). At near distances multiple water reflections, P_1, P_2, etc., are observed (fig. 2b). The magnitude scaling for hydrophone recordings is described in Paper I. All of the events recorded during the experiment were quite small. The magnitude for the event in fig. 2a is about 2 and that for the event in fig. 2d about 1. The magnitude for the event in fig. 2b is approximately about 0 to 0.5. The largest magnitude event recorded on the ship was about 3.0.

DIFFICULTIES

The major difficulties encountered in the land-based recording included:

1. Radio interference. Local radio transmitters at times operated in the same frequency bands as the sonobuoys. This was one of the reasons for failture of the experiment at Topolobampo.

2. Lack of recording sites with high enough elevation. At Topolobampo our recording site was only about 100 m in elevation and this

was inadequate. Although there were higher peaks nearby they were unacessible because of dense cactus and lack of roads.

3. Cable and current noise. Even when the tidal currents were low the moored sonobuoys had considerably greater noise than the free-floating sonobuoys, and when the tidal currents were high the noise was so great as to make recording impossible.

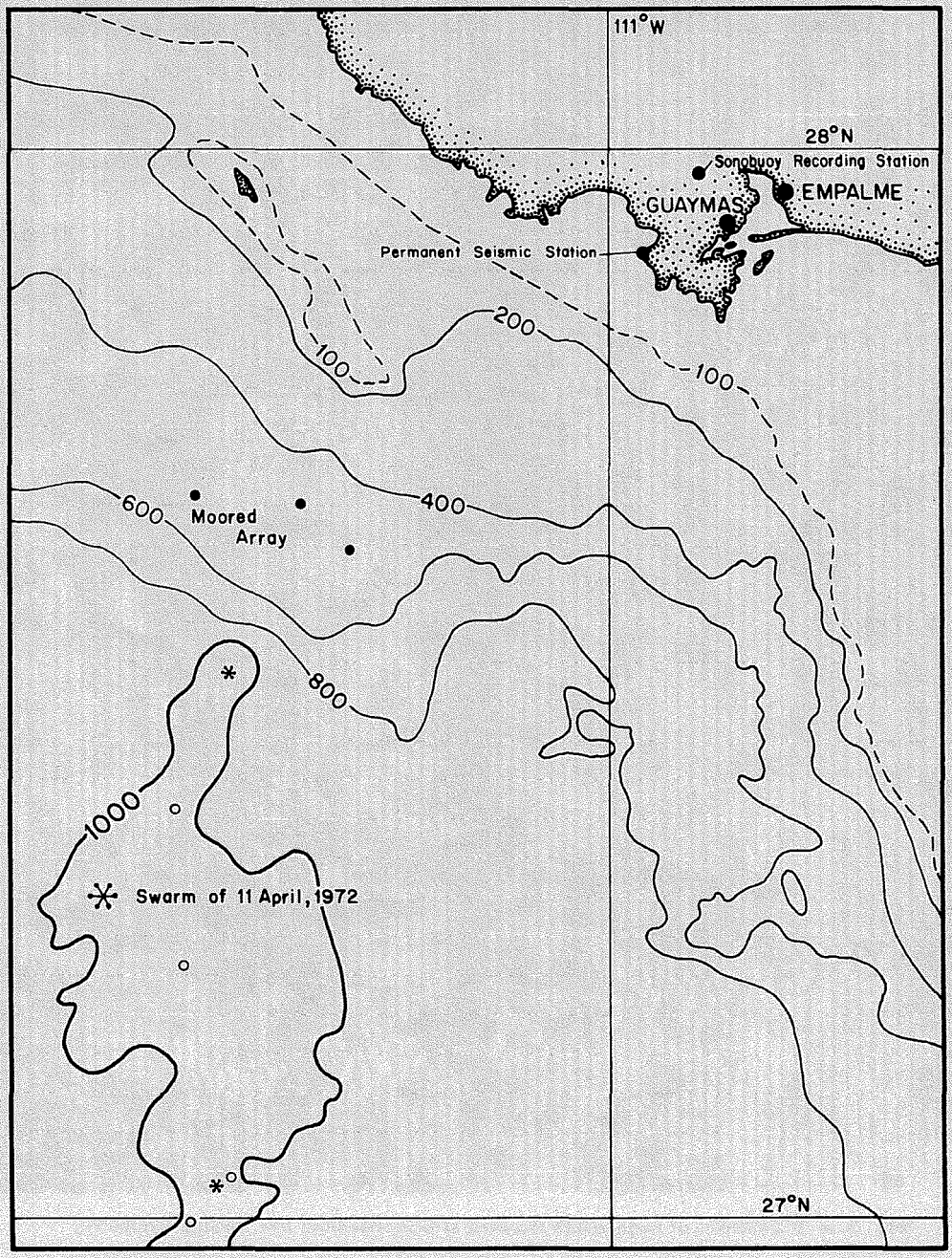
4. Unexplained cessation of operation. Independent moored sonobuoys lasted from a few days to a few weeks. In some instances the sonobuoys ceased operation after a great increase in noise level and a series of peculiar noises. We suspect that in many cases the cables were broken by shrimp trawlers which are quite common in the Gulf. One of the moored sonobuoys in the Farallon Basin near Topolobampo was found 36 days after mooring at a distance of 137 km from the original site with the anchor broken off. Although our original plan was to change batteries every ten days as the ship passed, the first Guaymas array could not be located and hence a new array was set out. No attempt was made to recover or resupply batteries on the second array.

CONCLUSION

Earthquakes have been successfully recorded using land-based recording of moored hydrophone-sonobuoy arrays.

Although in this experiment there were numerous difficulties, we feel that the experiment demonstrated that the technique can be fruitfully used in the future, especially in cases where there are nearby land sites available for recording, such as in the Gulf of California.

Fig. 1 Bathymetry map of the Guaymas Basin area, showing the location of the moored array (closed circles), and the positions of free floating sonobuoys (open circles). Also shown are the Permanent seismic station at Guaymas, the position of our land recording site, and the location of the 11 April 1972 earthquake swarm recorded on the R/V Melville. Small asterisks show two approximate locations from which several events were recorded at Guaymas.


111°W
28°N
Sonobuoy Recording Station
EMPALME
GUAYMAS
Permanent Seismic Station
100
200
100
600
400
Moored
Array
800
1000
Swarm of 11 April, 1972
27°N

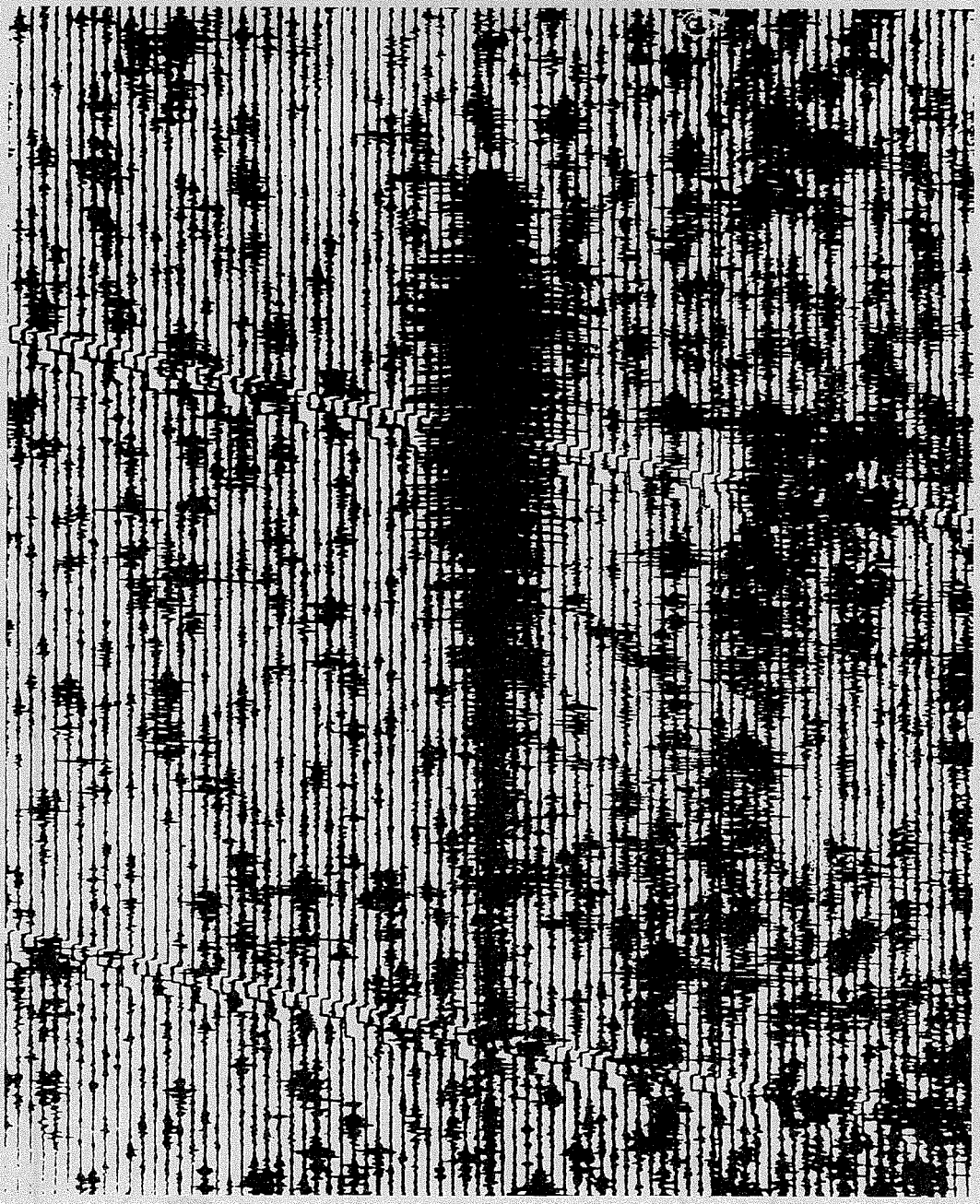


Fig. 2a to 2f Examples of earthquakes recorded at Guaymas from free floating sonobuoys.

Fig. 2b

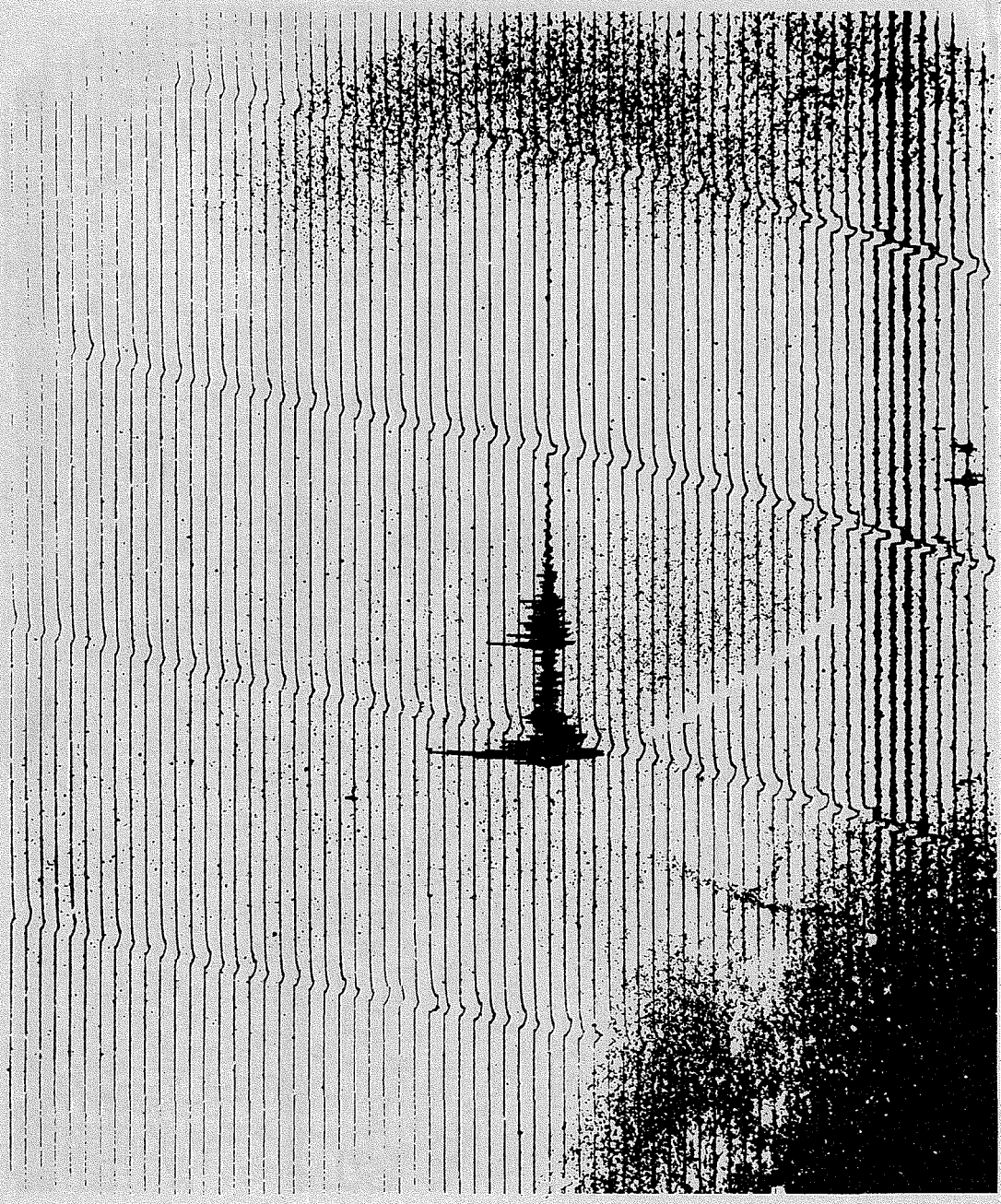


Fig. 2c

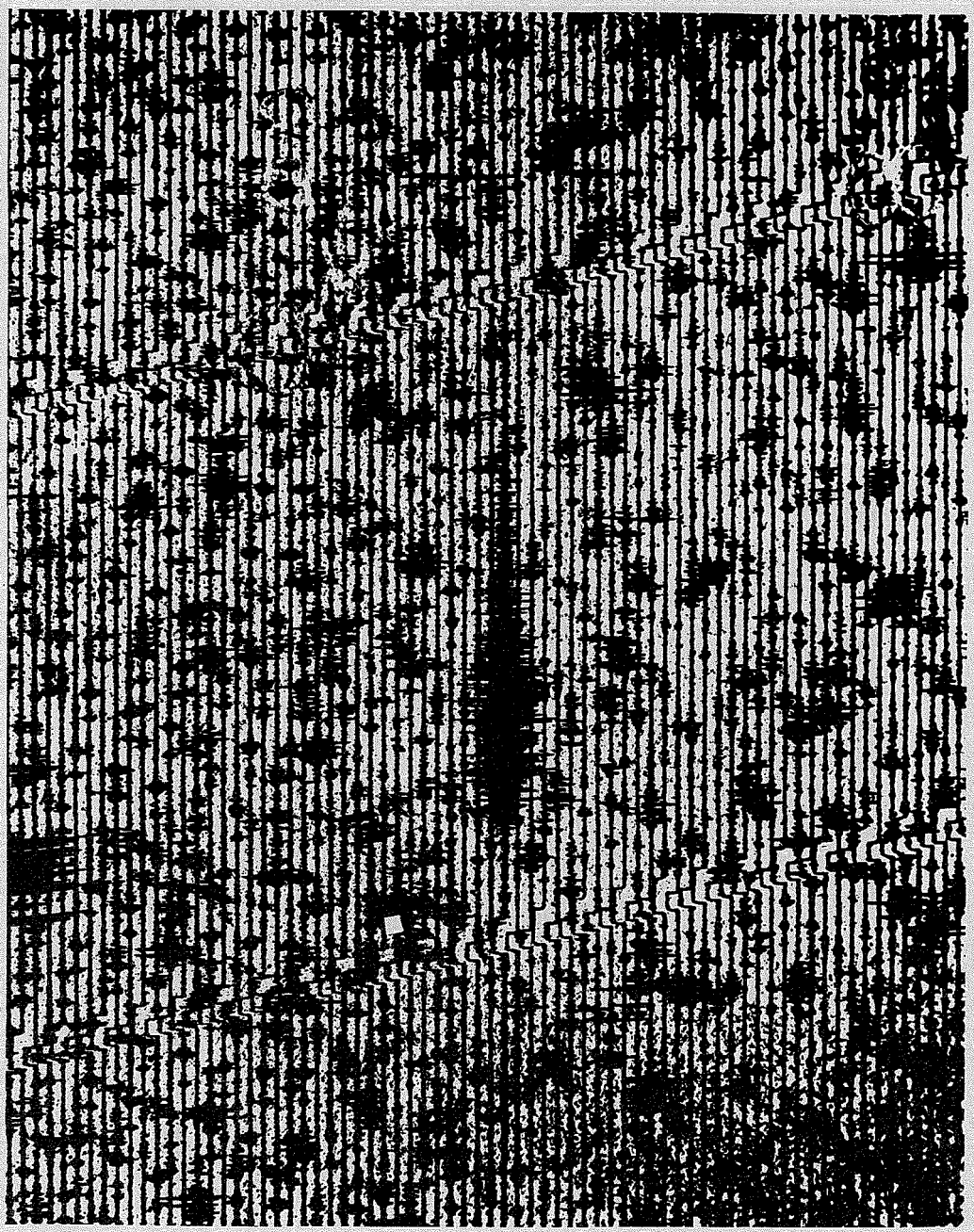


Fig. 2d

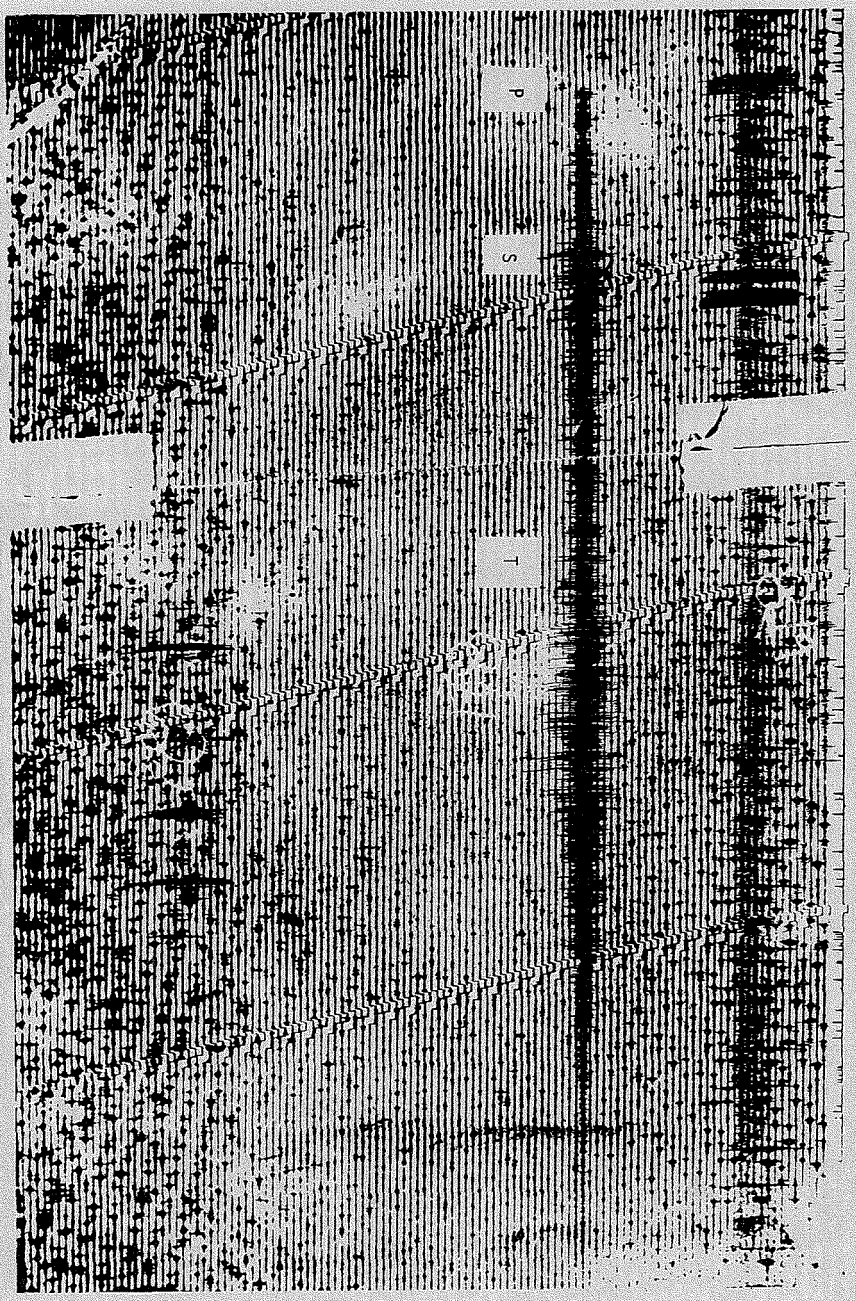


Fig. 2e

Fig. 2f

BIBLIOGRAPHY

PROTHERO, W. and BRUNE, J. 1971. A Suitcase Seismic Recording System, *Bull. Seismol. Soc. Amer.*, 61:6, 1849-1852.

REID, I., REICHLE, M., BRUNE, J. and BRADNER, H. Microearthquake Studies Using Sonobuoys: Preliminary Results from the Gulf of California, submitted to *The Geophysical Journal.*