COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS

RECORDS:

RECORD NO. 1968/15

CARPENTARIA REGION
UPPER MANTLE PROJECT 1966. RESULTS FROM RECORDINGS MADE IN PAPUA

by

D. DENHAM

5928/65

RECORD NO. 1968/15

CARPENTARIA REGION UPPER MANTLE PROJECT 1966. RESULTS FROM RECORDINGS MADE IN PAPUA

by

D. DENHAM

CONTENTS

ILLUSTRATIONS

SUMMARY

The results of the Carpentaria Region Upper Mantle Project are presented for the readings made in Papua. Five stations were established to record the explosions and one refractor spread was laid out at Daru. Only six reliable points could be plotted as shot 10 was not completely detonated. No estimate of the Upper Mantle velocity could be made.

1. INTRODUCTION

The Carpentaria Region Upper Mantle Project (CRUMP) was carried out during September and October 1966 to investigate the crustal structure of the Cape York Peninsula and its environs (Finlayson, 1968). Four series of charges were detonated off the coast of Australia by the Royal Australian Navy and seismic stations were set up on the Australian mainland to record the explosions.

One group of explosions was located in the Torres Strait and this presented a good opportunity to establish temporary short-period stations in Papua to obtain travel-time data across the Gulf of Papua.

2. LOCATIONS OF STATIONS

Plate 1 shows the location of the explosions and the recording stations and Table 1 lists their co-ordinates.

The Daru, Kerema, and Tapini stations occupied the same locations as used by the long-period seismographs, installed for the determination of crustal thickness by surface wave techniques and controlled from the Port Moresby Observatory (Denham, 1967; Brooks and Ripper, 1966). The Sogeri station and the Daru spread were set up especially for CRUMP. At Port Moresby the World-wide Standard Seismograph was used at its normal magnification of 50,000 at 1 c/s.

Originally it was hoped to lay out the refraction spread near Port Moresby but since it was not possible to arrange for any additional shots to be located nearer to Papua this was not considered worth while. Hence the spread was moved to Daru, which was the only other place where all the shots could be recorded and a spread conveniently laid out.

Daru was not the ideal site since it was really too near the shot-points and the background noise was rather high, but it was logistically possible to operate at this location. Plate 2 shows the layout of the spread at Daru in relation to the airstrip. A native village was situated near stations 15 and 20 and large earth moving equipment was operating on the airstrip at the time of the explosions. However, it was possible to quieten the villagers at the shot instant and Commonwealth Department of Works kindly arranged for the earth moving equipment to be stopped for a short period at the expected arrival times.

3. EQUIPMENT

Tapini and Kerema

At both these stations Willmore Mark I seismometers were coupled to modified UED ER230 pen recorders. The Willmores contained coils for galvanometer usage and consequently were rather underdamped, having a damping factor h = 0.5. The input filters were modified to give a suitable high frequency response and the drum drive mechanism was modified to give an increased paper speed of 180 mm per minute. This

last alteration meant that the records had to be changed every eight hours but the resolution of the records was considerably improved. Power and time marks were provided by the NCD2 units built by the BMR and VNG signals were used for time control.

Daru

The Daru station operated in the same way as the ones at Tapini and Kerema except that a Wilson-Lamison seismometer was used instead of a Willmore. The Wilson-Lamison has a higher coil impedance than the Willmore and had a damping factor of h = 0.7.

The refraction equipment consisted of 6 c/s Century and Midwestern geophones coupled to SIE refraction amplifiers and a 26-trace galvanometer camera. Time control was provided by a Mercer chronometer and VNG time signals, which were put on to the record by a relay output from a Labtronix receiver.

Port Moresby

At this station the World-wide Standard Seismograph system was operated normally, with a magnification of 50,000 at 1 second.

Sogeri

A Willmore geophone was coupled to a D.C. amplifier and pen recorder on loan from the Department of Terrestrial Magnetism. Wide ranges of paper speed were available and the shots were recorded at a speed of 2 cm/s. Time control was provided by VNG and a Mercer chronometer.

Apart from radios to receive VNG time signals all stations were equipped with receivers to monitor transmissions from the firing ship.

4. RESULTS

Results from the stations

Table 2 gives the arrival times for the P and S phases. The S 'picks' are probably not completely reliable except at Port Moresby where horizontal instruments were available. Unfortunately the first one-ton charge (shot 10) did not explode properly and the amplitude was not large enough for it to be recorded at any station except Daru. Consequently only shot 11 was recorded at all the stations, since Shot 12 was only a half-ton charge. This was a big disappointment and the travel-time curve shown in Plate 3 contains only 6 reliable points. The Sogeri result is probably not a genuine P phase and is unreliable. Plate 4 shows some of these arrivals.

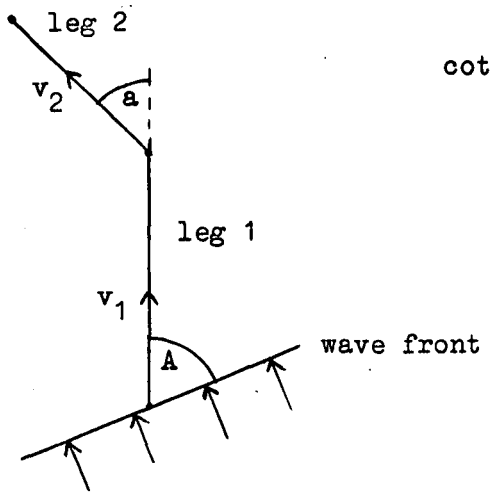
All the P phase 'picks' are considered to be accurate to 0.1 second except the Port Moresby reading which is accurate to 0.2 second.

Compared with the Jefferies-Bullen tables for surface P times the Kerema arrival is about 4 seconds late and the Tapini event about 3.5 seconds early. These departures are rather large but the paucity of points on the travel-time graph and the probable anomalous crustal structure preclude any definite conclusions at this stage.

The S phases are all consistent with the Jefferies-Bullen tables except the Tapini event. This is a very clear arrival as is shown in Plate 4, but it is evidently not a genuine Sn phase.

Results from the spread

It was hoped to be able to obtain estimates of the velocity across the spread at Daru for each shot. No record for shot 10 was available but shot 11 gave clear arrivals at all stations. To calculate the true velocity of the wave-front across the spread (v) and its direction of approach (A) the model and formulas in the following figure were used.



$$\cot A = (v_1/v_2)\operatorname{cosec} a - \cot a$$

$$v = v_1 \sin A \qquad (km/s)$$

In this model leg 1 is that containing stations 9-13 (Plate 2), and leg 2 is that containing stations 1-8; a is the supplement of the angle between the legs and A is the angle between the wave front and leg 1; v_1 and v_2 are the apparent velocities along legs 1 and 2.

For shot 11 the following results were obtained: $v_1 = 13.05 \pm 1.40$; $v_2 = 11.64 \pm 2.90$; $v = 10.60 \pm 1.99$; $A = 54.4^\circ \pm 6.0^\circ$. Both v and A are anomalous (values of about 6.2 and 40° being expected) indicating that either the refractor in the vicinity is very irregular or that surface effects are very large.

For shot 12 the results were: $v_1 = 8.65 \pm 0.82$; $v_2 = 12.02 \pm 2.06$; $v = 8.38 \pm 1.16$; $A = 75.8^\circ \pm 10.2^\circ$. The value of the velocity is reasonable if it corresponds to the velocity in the upper mantle. The expected value for A was 84°.

A disadvantage of the equipment used at Daru was the lack of dynamic range. Once the first arrival had been recorded it was impossible to follow the traces and no secondary arrivals could be picked. Without magnetic tape recording or a much improved camera, it is difficult to see how this could be overcome.

Another problem was the cable length; it is preferable to have large spacings between the detectors so that the time differences on the record are large enough to give accurate velocity determinations. At Daru the time differences between the extreme stations for shot 11 was less than 0.1 second. This was not large enough for a representative velocity determination to be made.

5. CONCLUSIONS

The incomplete detonation of shot 10 reduced the value of the results and only six reliable first arrivals could be plotted on the time/distance graph. Compared with the Jefferies-Bullen tables for surface shocks, the Tapini arrival is about 3.5 seconds early and the Kerema event about 4 seconds late.

6. REFERENCES

BROOKS, J.A. and RIPPER, I.D. 1966 Proposed investigations of crustal structure in New Guinea. Bur.Min.Resour.Aust. Rec. 1966/33.

DENHAM, D. 1967 Port Moresby geophysical observatory annual report 1965 Bur.Min.Resour.Aust.Rec. 1967/118.

FINLAYSON, D. 1968 Carpentaria Region Upper Mantle Project, 1966. Operational Report. Bur.Min.Resour.Aust.Rec. 1968/14.

TABLE 1

Coordinates of shot-points and recording stations

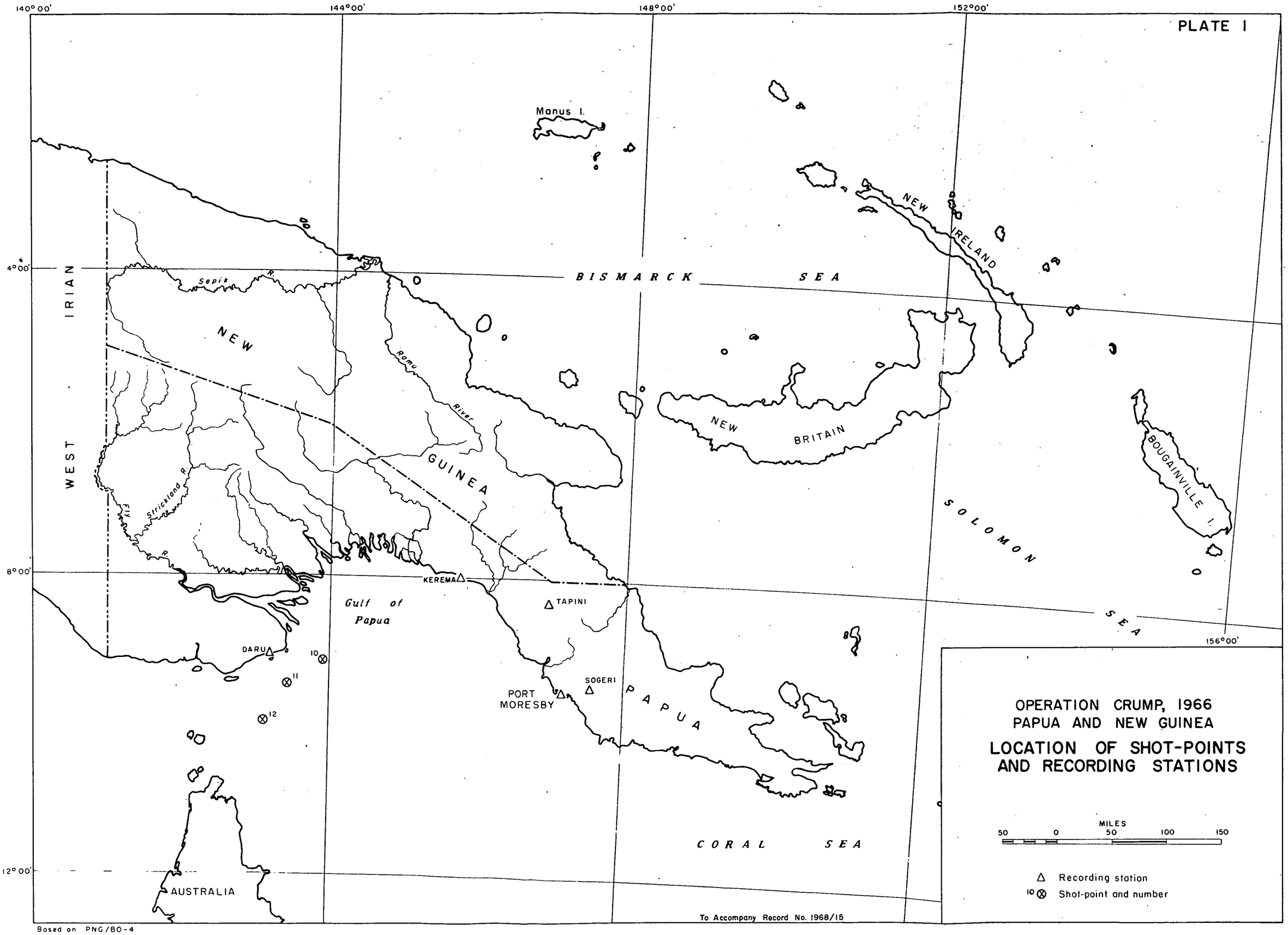
Location	Latitude (S)		Longitude (E)		Elevation (metres)
Shot 10	09°	10.0'	143°	54.0'	-
Shot 11	09°	30.6'	143°	28.3'	-
Shot 12	10°	00.0'	143°	04.0'	-
Daru Station	09°	05' 19"	143°	12' 20"	03
Daru Spread	09°	05' 26"	143°	12' 18"	03
Kerema	07°	57' 35"	145°	46' 08"	14
Port Moresby	09°	24' 33"	147°	09' 14"	67
Tapini	08°	21' 24.7"	146°	59' 01.4"	988.5
Sogeri	09°	25.4'	147°	24.5'	480

TABLE 2

Arrival times for P and S

Recording Station	G M T									Distance (km)
	Shot time			P time			S time			
Daru										
Shot 10	07	50	19.1	07	50	33.3	07	50	(45)	76.8
Shot 11	12	50	17.9	12	50	28.7	12	50	(37)	55.1
Shot 12	23	50	05.6	23	50	23.3_5				101.7
Kerema										
Shot 11	12	50	17.9	12	51	07.9	12	51	(33)	305.4
Port Moresby										
Shot 11	12	50	17.9	12	51	15.3	12	52	08	404.5
Tapini										
Shot 11	12	50	17.9	12	51	13.7	12	51	(43.3)	406.8
Sogeri										
Shot 11	12	50	17.9	12	51	(18.4)	12	52	09.6	432.4

PLATE 1

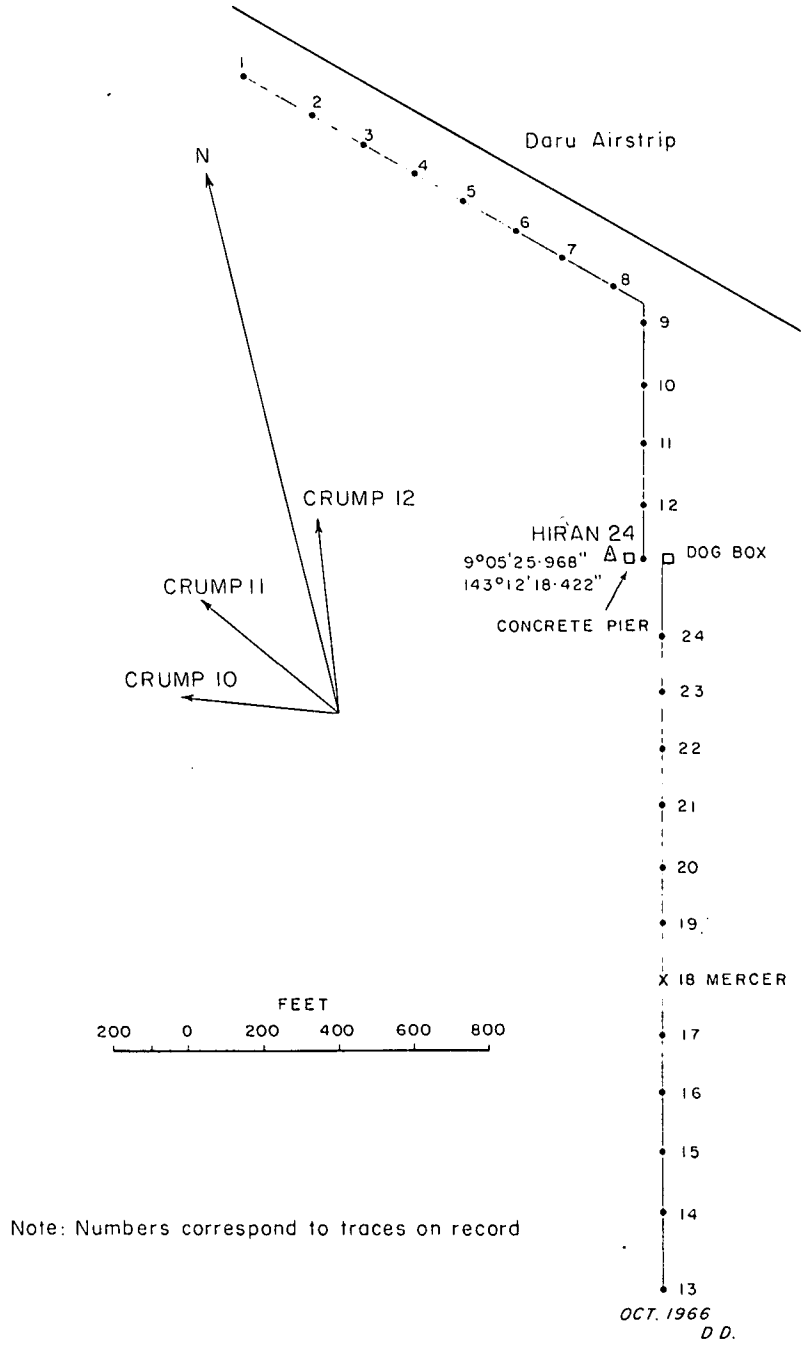


To Accompany Record No. 1968/15

Based on PNG/80-4
Base map: Geological Map of the World - Australia and Oceania - sheet 7

G443-16

PLATE 2



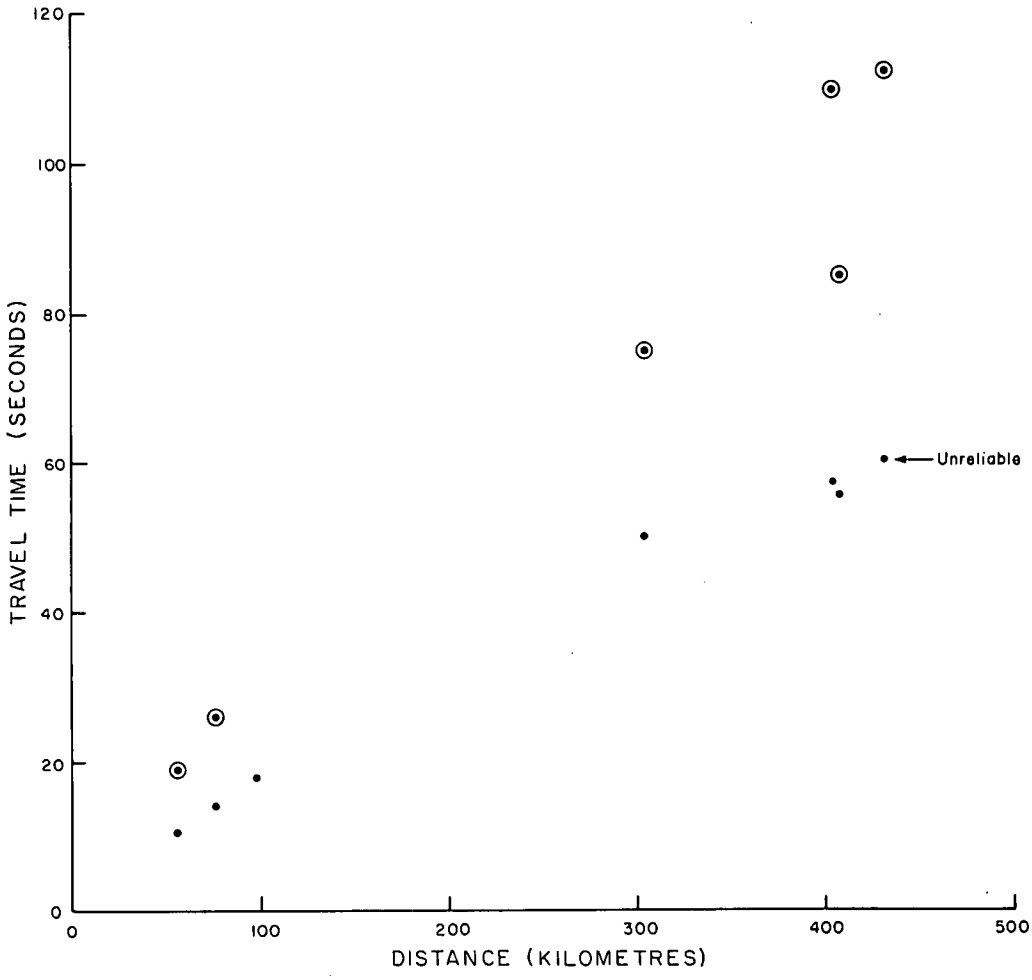
Note: Numbers correspond to traces on record

LAYOUT OF SPREAD AT DARU FOR SHOTS 10, 11 AND 12

To Accompany Record No 1968/15

G443-18

PLATE 3



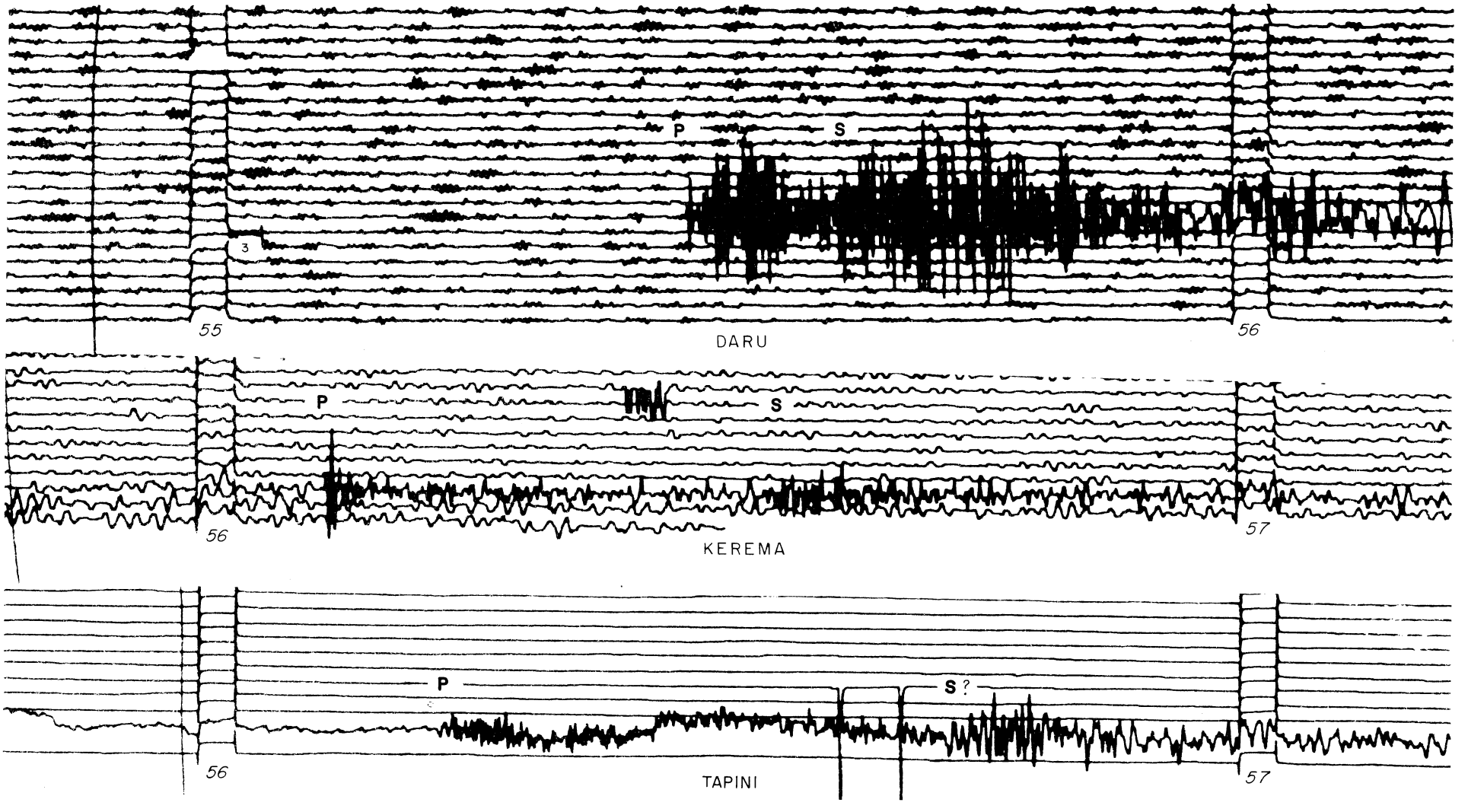
• 1st arrivals

⊙ Other arrivals (probably S)

TIME/DISTANCE PLOT OF ARRIVALS

To Accompany Record No. 1968/15

G443-17



SEISMOGRAMS FOR SHOT 11

PLATE 4

To Accompany Record No. 1968/15

G443-15