1979/31. Use of the DHR1632 seismic system for deep crustal targets.

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Abstract

The DHR1632 digital seismic recorder, although possessing some storage-record length restrictions, can, given a preliminary indication of arrival times, be set to record a portion of large events and thus may be used for certain limited aspects of earthquake analysis or deep crustal sounding. Low frequency geophones and moderate charge sizes (up to 100 kg) may be necessary. Tests on a traverse south of St Helens have confirmed its viability and indicate a crustal thickness of about 25 km.

INTRODUCTION

A general description of the DHR1632 equipment and its uses is given by Leaman (1978). The bulk of that report deals with means of optimising response from certain types of shallow reflectors (less than 1 km). Consequently, emphasis is placed on field procedures, array geometry and charge style and size. However Figure 7 (p.17) of that report offers an example of crustal usage. The four second record is reproduced here as Figure 1. The first 600 ms reflects Tertiary cover and the remainder represents events in Permian rocks, dolerite sheet and basement. The four seconds in Figure 1 probably converts to about 7-8 km of penetration. In other circumstances (outcropping basement or similar materials), four seconds could be expected to equate with 10-12 km or nearly half the crust.

As an adjunct to a large scale crustal programme in Northern Tasmania (from Savage River to St Helens) using conventional seismograph and cassette recording facilities, each shot fired at Binalong Bay was monitored by a DHR1632 station on a line perpendicular to the principal traverse. The object was four-fold; it was necessary firstly to establish whether the DHR1632 could record sufficient information to be useful in crustal work due to possible restrictive time scan and detail; secondly to ascertain if the system contained adequate sensitivity; thirdly if standard geophones were adequate (4.5, 14, 20, 28, 40Hz); and finally to gain additional crustal data for future reference if the system was adequate. The latter reason, seismograph commitments elsewhere and the different character of the recording systems meant that the DHR system was not used for comparative duplication on-line, although one site (Piccaninny Point) was concomitantly occupied by a conventional recording system.

A subsequent report by R. Richardson (project leader) will deal with the two records from Piccaninny Point after processing of the two magnetic tapes has been arranged and will also provide a brief summary of the entire project with comments on future applications.

PROCEDURE

A radio or telephone check was made with the shot firer on each possible day of the programme, to ensure that all was to proceed. The DHR system was then installed at a pre-selected site intended, over the series of tests, to yield a data set over 150 km. At each site, eight geophones or sets of geophones were installed along an east-west line about 25 m long. Geophones were buried at regular intervals. Recorder gains were set to 96dB and with input filters off, the system was tested. It was desirable that noise levels be confirmed at 8-10 bits under these conditions.

The time scan for the recorder was set to allow ample coverage of the most likely arrival times for both first arrivals (P) and Moho reflections (M), based on a prediction chart. In each case, 8 seconds were recorded at 250 samples per second.

Since the DHR1632 system does not contain an absolute time monitor, a radio receiver was connected to the start impulse circuit. The shot was fired at either 11.46 or 12.46 EST, according to the standard time signal from Lindhurst, 7.5 MHz AM and the recorder started by the onset of the long minute pip, having been armed during the silent 59th second. Thus time standards were set. Where the time scan start time exceeded 10 seconds (the maximum controlled delay on the recorder) the arming took place in the silence between the appropriate second pips and recording commenced with the onset of the next pip.

Records were played back in confirmation of firing pending communications by USB 3.716 MHz and taped. Unfortunately, due to communication problems, procedural and operator errors, only two records were actually taped for future processing.

OBSERVATIONS

Records from the various sites are reproduced in Figure 2. Details of the sites are given in Table 1.

Table 1. SITE DETAILS, DHR1632 CRUSTAL TESTS

Site No.	Date	Charge size (Kg)	AMG Reference	Distance from shot (km)	Geophones used	Comments
1	27 June (Beaumaris)	75	FQ067146	19	1 =4.5Hz single 2-3=14Hz single 3-4=22Hz sets of 6 5-6=28Hz sets of 6 7-8=40Hz sets of 6	No record. Shot fired at 11.45 by error, hence no possibility of sampling events.
2	28 June (Friendly Beaches)	150	FP054492	83	1-5=14Hz single 6 =4.5Hz single 7-8=28Hz sets of 6	12.46 firing
3	3 July (Rheban)	200	EN758830	153	1-7=14Hz single 8 =4.5Hz single	Heavy rain, spikes on record (to 11 bits). Signal contrast thus low.
4	4 July (Akaroa)	75	FQ106266	6	1 =4.5Hz single 2-8=14Hz single	Taped.
5	5 July (Piccaninny Point)	50	FP065857	48	1 =4.5Hz single 2-8=14Hz single	Taped.

Co-ordinates of shot point: about FQ112327 (Skeleton Bay)

In general, the 14Hz geophones proved adequate, although significant phase changes may be noted at sites 2 and 3, when contrasted with the 4.5 Hz geophone. Lower frequency geophones are to be preferred at greater distances, but only one was available for these tests, all others being used on the principal traverse.

With the exception of the Rheban recording, where heavy rain interposed reverse signal-noise problems, all records were good. Those from sites 4 and 5 being excellent. Note that the records reproduced in Figure 2 from these sites are the result of some output filtering which was not applied to the other records.

Notes on observations

In each case where the shot was recorded, the seismic transmission was captured within the time frame of the recording as preset on the basis of model calculations presuming

V_{PG} = 5.95 km/s V_{PN} = 8.00 km/s

V_{SG} = 3.48 km/s V_{SN} = 4.44 km/s

Layer thickness (to Moho) = 25 kms (Source of prediction data: R. Richardson).

Table 2 presents the model prediction and the observed arrival times for the principal events. Note that there may be some subjectivity in relation to V_{PN}, M arrivals due to the wide separation of soundings and the many arrivals and reflections observed. In addition, the length of records precludes full hyperbolic comparison and checking by multiples.

Table 2. PREDICTED AND OBSERVED ARRIVAL TIMES

Site No.	Prediction (secs)				Observed			
	P_G	S_G	P_N	M	P_G	S_G	P_N	M
2	13.9	23.9	16.0	16.3	14.4	-	16.1? 16.3	16.8 (train); record 14-22 secs.
3	25.7	44.0	24.7	27.1	26.5	-	-	26.9 (train); record 22-30 secs.
4	1.0	1.7	-	8.5	2.2	3.0	-	8.6-8.8 (train); record 2-10 secs.
5	8.1	13.8	-	11.6	8.9	14.1	-	11.4 (train); record 7-15 secs.

V_{PG} (calculated) (not including site 4 where arrivals were very slow) ≃ 5.7 km/s.

V_{SG} (calculated) ≃ 3.78 km/s. This is a maximum value since it includes the effect of a probable delayed arrival.

With the possible exception of significant train arrivals (interpreted as Moho reflections) at sites 3 and 5, all events were later than predicted. Most of the delay can be ascribed to the value of V_{PG} chosen in the model. However site 4 is significant in that it implies a very much slower direct wave velocity and a lower crustal velocity than assumed, even though both shot point and observation point were sited on the same granite pluton which could be expected to support velocities of the scale envisaged.

It has also been suggested that the deviation from predicted to observed results may be due to false triggering of the DHR record due to interference induced static on the radio reception causing record initiation prior to a time pip. In view of the lower value of V_{PG} observed, and which is largely independent of start times which, if due to static, could be expected to be randomised, it seems unlikely that false triggering is the solution. However some effort must be made in future usage to minimise the effect of radio interference due to the high power demands of the DHR system.

COMMENTS

The model proposed for the Tasmanian crust does not appear to be greatly in error on the basis of the highly qualitative interpretation offered here. The results of processing the records from sites 4 and 5 will be reported separately when the means and money permits such processing. The principal deviations from the model lie in a reduced V_{PG} velocity and a slightly thinner 2 layer crust. Values of 5.7 km/s and 24.5 km respectively might be more appropriate for the east coast region.

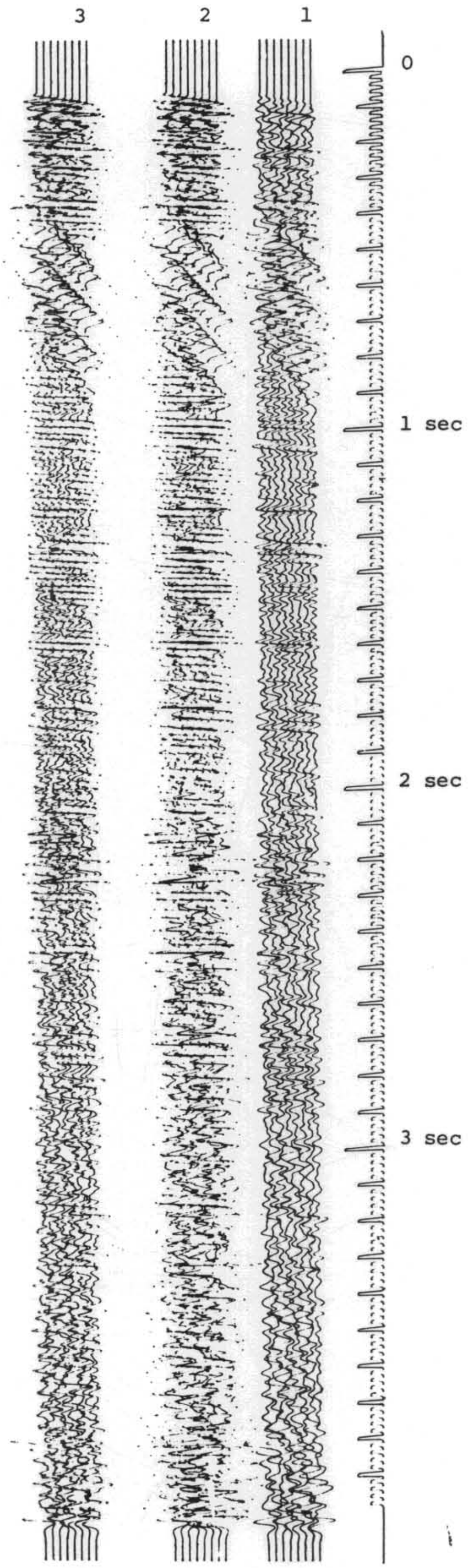
The equipment was certainly adequate in terms of sensitivity, although no future records should be attempted during heavy rain as this is liable to produce record degradation. At distances over 50 km, 4.5 Hz geophones are recommended.

Future surveys based on the DHR system should experiment with a lower sample rate and consequent longer record, since the current record length is somewhat restrictive. Timing must be guaranteed so that shots are not missed (site 1), since an 8 second scan cannot compete with continuous taping equipment and communications must be by independent radio channels carrying minimal interference. An attempt must also be made to reduce interference from the DHR recorder. Earthing is of minor assistance.

REFERENCE

LEAMAN, D.E. 1978. DHR1632 seismic system. Use of reflection method in Tasmania. Part 1: Equipment, techniques and problems. *Geophys.Spec. Rep.Dep.Mines Tasm.* 7.

[6 August 1979]

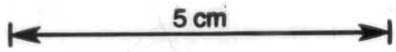


a = 5, S = 70, IF = 0, SR = 500

2 kg gelignite

1. PBF = LH + HM + AGC + PGC (=6dB)
2. PBF = LH + HH + AGC + 12dB
3. PBF = LH + HH + AGC + 6dB

Figure 1. *DHR test record, Clifton (centre)*



Sample rate 250/second
Geophone 1 to right of record
Geophone 8 to left of record

Site	2	3	4	5
	Friendly Beaches	Rheban	Akaroa	Piccaninny Point
Basetime	14 seconds	22 seconds	2 seconds	7 seconds

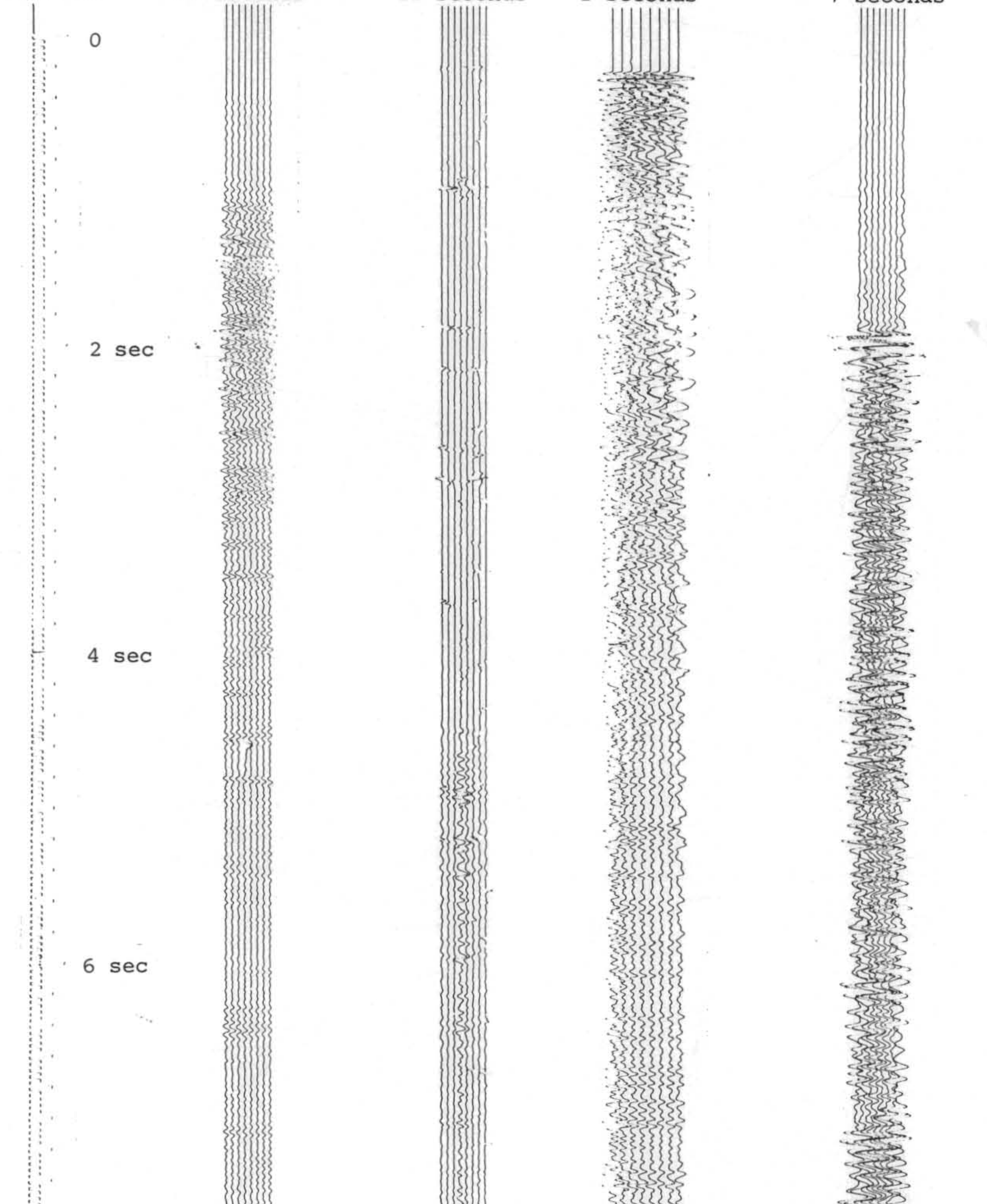


Figure 2. *DHR records, East Coast crustal survey.*

5 cm