COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1962/51

TIMBURY HILLS No. 2 BORE SEISMIC VELOCITY SURVEY, QUEENSLAND 1960

by

E.R. Smith and K.B. Lodwick

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ILLUSTRATIONS

NOTE: Plates 4 to 7 have been copied from a report on this survey by Walls and Hightower (1960).

SUMMARY

On 30th March 1960, a seismic velocity survey was made in the A.A.O. Timbury Hills No. 2 bore, jointly by the Bureau of Mineral Resources and Associated Australian Oilfields N.L. The bore had been drilled to a depth of 4400 ft and was surveyed to a depth of 4304 ft below the rotary table.

There remains a doubt whether the breaks recorded on the well geophone were, in fact, cable breaks, particularly between 2300 and 3305 ft below the rotary table. The interpretation has been made with the belief that true breaks were recorded.

Average and interval velocities were computed and are acceptable geologically. Sandstones, particularly cemented ones, have generally higher velocities than shale. The average velocity of the Mesozoic sequence is about 9800 ft/sec. A velocity of 17,980 ft/sec was measured at the bottom of the bore and corresponds to the Timbury Hills Formation of unknown age. The Moolayember Shale has a low velocity calculated as 8360 ft/sec.

1. INTRODUCTION

On 30th March 1960, a seismic velocity survey of the A.A.O. Timbury Hills No. 2 bore near Roma, Queensland, was made as a joint investigation by the Bureau of Mineral Resources and Associated Australian Oilfields N.L.

The bore is located about two miles north-east of Roma (Plate 1) and had been drilled to a depth of 4400 ft. The formations drilled were mainly sandstone and shale of Mesozoic Age to a depth of 3845 ft, where a much harder and denser formation was encountered. This formation is called (by A.A.O.) the Timbury Hills Formation and marks the base of the Mesozoic sediments at this location in the Great Artesian Basin. No age has yet been assigned to the Timbury Hills Formation. Detailed lithological and electric logs of the bore were made available by A.A.O. to aid in the interpretation of the velocity survey. The major changes in lithology and the boundaries of the stratigraphic units interpreted by S.S. Derrington of A.A.O. (personal communication) are shown on Plate 3.

2. FIELD WORK

The following table shows the personnel participating in the velocity survey, and the equipment used.

Cooperating organisation	Personnel	Equipment
Bureau of Mineral Resources	E.R. Smith A. Turpie (geophysicists)	T.I.C. 3-component well geophone
Associated Australian Oilfields N.L.	S.S. Derrington (geologist)	
Schlumberger (contractor to A.A.O.)	Logging operator	Winch and cable with 5 available conductors
Austral Geo Prospectors Inc. (contractor to A.A.O.)	Seismic observer	Century seismic reflection system.

As there were only five available conductors in the cable used by Schlumberger, the two horizontal components of the T.I.C. well geophone were connected in parallel to one pair of conductors and the vertical component was connected to another pair of conductors.

The layout of geophones for recording reflections, and the positions of the shot holes in relation to the bore, are shown on Plate 2. Shot-points 1, 2, or 3 were shot for all selected depths of the well geophone and Shot-points 4 or 5 were used to check the times at depths of 1370, 2300, and 3305 ft (Plate 2).

The depths of the well geophone at which shots were fired were selected by A.A.O. after studying the lithological and electric logs, and were in general at depths of changes in formation (Plate 3).

3. RESULTS

On Plate 2 results are tabulated, and symbols and expressions used in the following discussion are illustrated and defined.

Satisfactory first break times (tv) were obtained using charges of 10 lb with a shot depth of between 70 and 100 ft. The corrected slant time and the vertical time are shown plotted against depth on Plate 3.

Photographs of the records used in the computations are shown on Plates 4, 5, 6, and 7 by courtesy of A.A.O. The following traces on each record had the following functions:

Trace	Function
1 to 3	Horizontal components of well geophone, connected in parallel.
4 to 6	Vertical component of well geophone.
7	Time break
8	Up-hole time
9 to 14	Reflection spread (Plate 2 for arrangement of geophones).

Good first breaks were recorded on the well geophone at depths of 690 to 1890 ft and 3597 to 4194 ft. On these records the horizontal and vertical components of the geophone broke simultaneously, which suggests that the energy reaching the geophone was travelling obliquely. For this reason, it is considered that the breaks recorded are true formation breaks and not cable breaks, although their times are generally close to the theoretical cable break time.

At well geophone depths of 2190, 2590, and 3195 ft there is some doubt that the vertical component breaks are true formation breaks. In these three cases the vertical component breaks from 5 to 8 milliseconds earlier than the horizontal component and also the times are again close to the theoretical times for arrival of cable breaks. This may indicate that energy travelling vertically down the geophone cable has caused the vertical component to break, but has not disturbed the horizontal component. However, as far as can be seen on the traces, the vertical component does not show a second break coincident with the horizontal component break as one would expect. It is likely that because the two horizontal components were connected in parallel, their signals were sometimes out of phase, and consequently the first breaks were cancelled out. The horizontal component traces may not be a reliable guide to the first arrival of the energy.

In the absence of shots from a greater distance from the hole than that used (600 ft), it is not possible to resolve with certainty the nature of the breaks at the three depths of 2190, 2590, and 3195 ft. Charges were reduced to see whether there was any evidence of secondary breaks, but none was apparent. A decrease in the average velocity curve, such as occurs between 3195 ft and 3597 ft, sometimes indicates that cable breaks are present, but in this case the interval velocity measured are acceptable geologically (see 'INTERPRETATION'). All calculations have been made from the first arrival at the vertical component of the well geophone, and it is considered that from the information available, these give the most probable interpretation.

In column (t_{cab}) of Table 2, the theoretical times at which cable breaks (assuming a cable velocity of 11,500 ft/sec) could be recorded for each depth of the well geophone are listed. It will be noticed that the corrected slant times are very close to these theoretical times. It seems that in the Roma area, and possibly the whole of the Great Artesian Basin, at least two different distances between shothole and bore should be used to check whether cable breaks are present.

4. INTERPRETATION

The reduction and interpretation of the data are illustrated on Plates 2 and 3.

Following the method of interpretation suggested by Pilcher (1953) the results obtained from one side of the bore only (shot holes 1, 2, and 3) have been used in the present interpretation. The results from the other side (shot holes 4 and 5) have been used for checking. This interpretation departs from that presented by Walls and Hightower (1960) in which the results from all shot holes have been used, and the first-break times averaged where two values, one from each side of the bore, were obtained.

A comparison of the interval velocities, shown on Plate 3, with the lithological logs indicates that sandstone facies have in general a higher velocity than shale. The cementation of the sandstone raises the velocity considerably. The velocities recorded for the friable sandstones of the Blythesdale Group range from 8000 to 10,000 ft/sec whereas the velocities of cemented sandstone and sandy shale in the Walloon Coal Measures and Bundamba Group range from 10,000 to over 13,000 ft/sec. The predominantly shaly member at the top of the Walloon Coal Measures and the soft Moolayember Shale have velocities of 8000 to 9000 ft/sec. The low velocity shown for the Moolyember Shale suggests cable-break misinterpretation, but the description of its lithology by Derrington (soft mudstone and siltstone) indicates that the velocity is reasonable. The velocity survey shows that the velocity of the sandy facies of the base of the Moolayember Shale, which includes the gas-bearing Hospital Hill Sandstone, is 11,380 ft/sec. The velocity measured in the Timbury Hills Formation, to which no age has yet been assigned, is nearly 18,000 ft/sec, and this is compatible with the description of the lithology.

Reflection times for the tops of the main stratigraphic units have been calculated from the well geophone times and are shown on Plate 7.

5. CONCLUSIONS

The following conclusions may be drawn from the results of the survey:

(a) It has not been possible to resolve with certainty whether the breaks recorded on the well geophone and used in the computations are true breaks (energy transmitted via the rock strata) or cable breaks (energy transmitted via the geophone cable). In future well velocity surveys in the Roma area, two different distances of shot-point from the well may be helpful in resolving the problem of cable breaks. The interpretation of the well survey has been made on the assumption that the well geophone breaks recorded are true breaks.

(b) The results presented are geologically acceptable and indicate that velocities are generally higher in sandstone, particularly cemented sandstone, than in shale. The average velocity of the Mesozoic sequence is 9800 ft/sec. Two characteristic velocities measured were an unusually low value of 8360 ft/sec for the Moolayember Shale and a high value of 17,980 ft/sec for the Timbury Hills Formation below the Mesozoic.

6. BIBLIOGRAPHY

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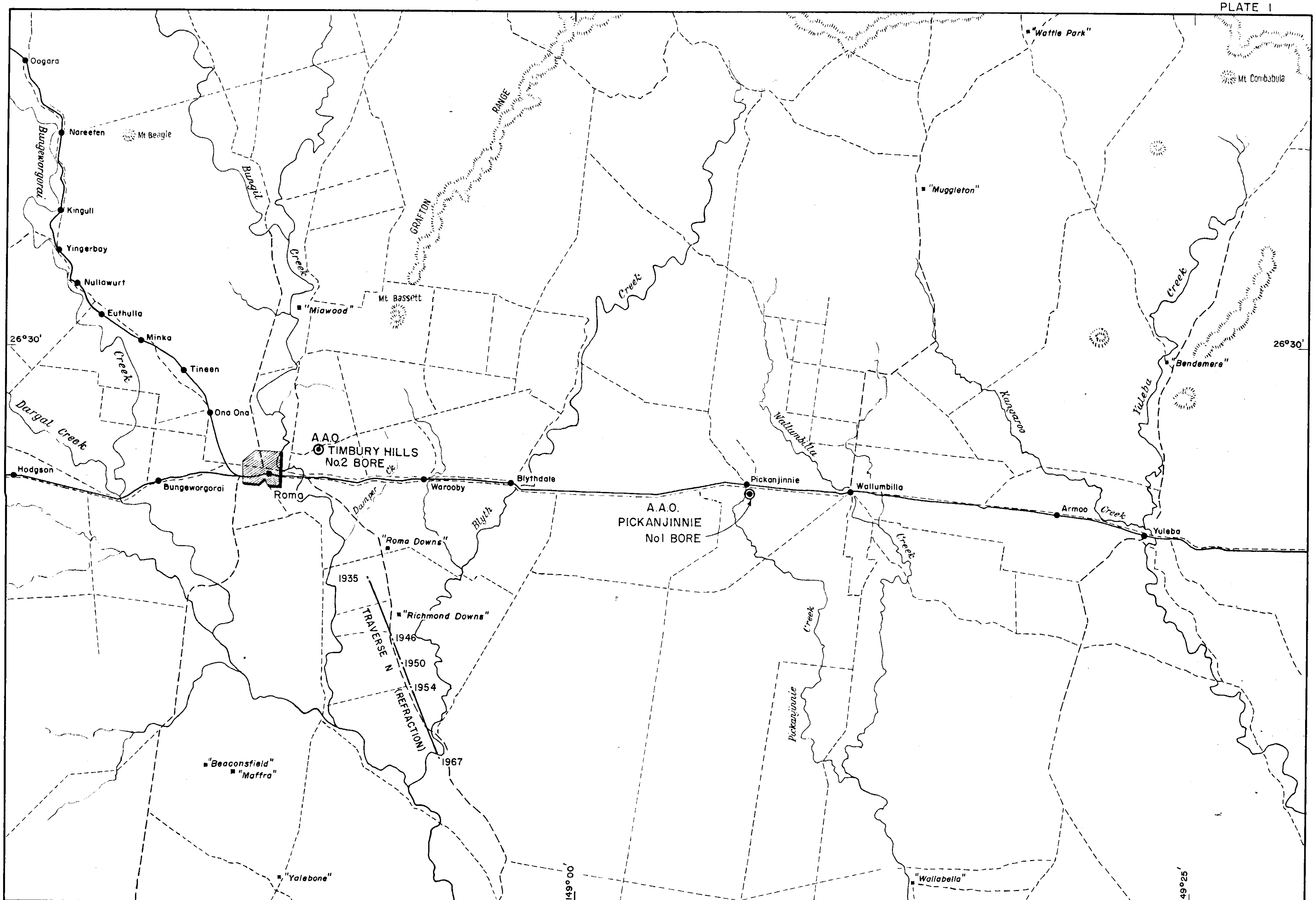
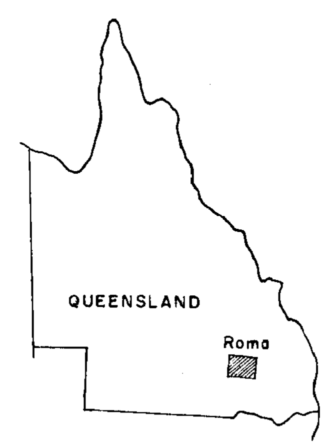
*LODWICK, K.B. and SMITH, E.R.	1961	Pickanjinnie No. 1 bore velocity survey, Queensland 1960. Bur. Min. Resour. Aust. Rec. 1962/52.
PILCHER, Ted	1953	Velocity Survey Data - unpublished pamphlet by courtesy of West Australian Petroleum Ltd.
WALLS, J.A. and HIGHTOWER, W.E.	1960	Report on velocity survey conducted in Timbury Hills No. 2 well. Company Report (A.A.O.).
*WHITEHOUSE, F.W.	1954	Artesian water supplies in Queensland; Appendix G - The geology of the Queensland portion of the Great Australian Artesian Basin. Govt Printer, Brisbane.

* Consulted but not specifically referred to in text.

PLATE 1





LOCATION
Reference to Australian 4-Mile Military Map Series

LEGEND

- Bore
- Railway and Railway Station
- Metal or Gravel Road
- Track
- House

A.A.O. TIMBURY HILLS No.2 BORE VELOCITY SURVEY,

QUEENSLAND, 1960

LOCALITY MAP

MILES

4 0 4 8 12

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TIMBURY HILLS QLD

WELL VELOCITY SURVEY DATA SHEET

WELL NAME *TIMBURY HILLS NO 2* | OWNER *ASSOCIATED AUST. OILFIELDS* | WELL LOGGING CONTRACTOR *SCHLUMBERGER LTD. (AUST)*

LOCALITY *ROMA AREA* | ADDRESS | ADDRESS

COORDINATES *26°33'38"S, 148°49'38"* | DRILLING CONTRACTOR *MINES ADMINISTRATION PTY LTD* | TYPE AND NUMBER OF LOGGING UNIT

DATE OF SURVEY *30TH MARCH, 1960* | ADDRESS | LOGGING UNIT OPERATOR

ORGANIZATION SUPERVISING VELOCITY SURVEY *AUSTRAL GEO. PROSPECTORS INC.*

ADDRESS

SURVEY SUPERVISOR

SEISMIC INSTRUMENTS — MAKE *CENTURY* — TYPE

WELL GEOPHONE — MAKE *TIC.* — TYPE *3 COMPONENT* — No

B.M.R. REPRESENTATIVE *E.R. SMITH*

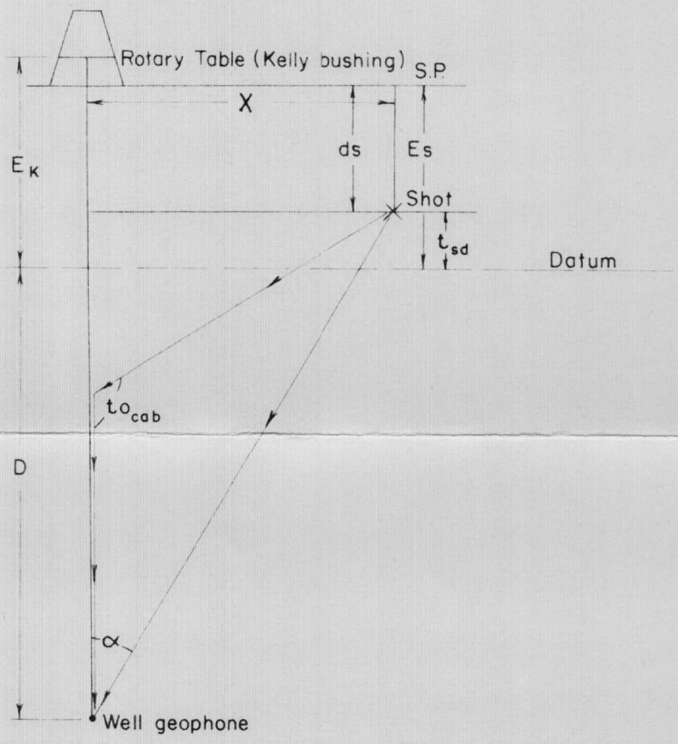
DATA CALCULATION *K.B. LODWICK*

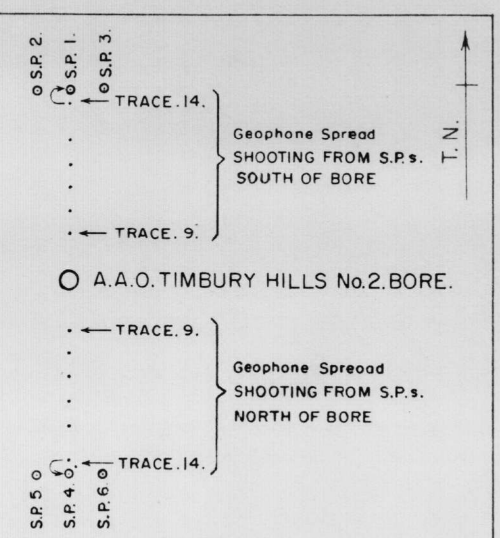
E_K = *110 ft* Vo = Ve = *8000 ft/sec* Do = *1000 ft* ρm = B.H.T. or Tm = Vcab (Manufacturer) = (Test) = *11000 ft/sec* Cable Depth Accuracy = *±1 ft*

SHOT No.	E_K+D	D	S.P.	X	chge	Es	ds	t_{sd}	α	tv_1. Gr.	tv_2. Gr.	tha_1. Gr.	tha_2. Gr	thb_1. Gr.	thb_2. Gr.	t_{RG} or to_R Gr.	Δt_{RG} or Δto_R	t_{cab}	to_{cab} Gr.	t_o or $t_o - \frac{t_{sd}}{\cos\alpha}$	Cos α	tc	Va
18I	800	690	3	600	1	99	73	0	39°49'	116 G		116				558	-3	116		113	0·768	86·0	7970
3A	1000	890	3	600	10	99	100	0	34°06'	131 G		131				555	0	131		131	0·828	109	8160
17H	1370	1260	3	600	1	99	85	0	25°18'	167 G		167				560	-5	165		162	0·904	146	8630
16A	1370	1260	5	600	10	80	100	+2	25°18'	161 G		161				552	0	162		163	0·904	147	
15G	1800	1690	3	600	2½	99	91	0	19°26'	208 F		208				557	-2	201		206	0·943	194	8710
14F	2000	1890	3	600	10	99	100	0	17°39'	222 G		222				558	-3	218		219	0·953	209	9040
13D	2300	2190	1	600	37½	95	100	+1	15°11'	246 G		250				556	-1	243		246	0·965	237	9250
12B	2300	2190	4	600	10	81	100	+2	15°11'	242 F		247				552	0	242		244	0·965	235	
11E	2700	2590	3	600	10	99	91	0	13°05'	278 F		286				558	-3	280		275	0·974	268	9660
10D	3305	3195	3	600	10	99	97	0	10°34'	328 F		336				558	-3	334		325	0·983	320	
9A	3305	3195	4	600	10	81	100	+2	10°34'	323 P		330				552	0	330		325	0·983	320	9660
7B	3707	3597	2	600	5	92	99	+1	9°35'	374 G		374				557	-2	366		373	0·986	368	9760
6B	3855	3745	3	600	10	99	97	0	9°15'	387 F		387				556	-1	380		386	0·987	381	9840
5C	4304	4194	1	600	30	95	100	+1	8°06'	411 G		411				557	-2	418		410	0·990	406	10330
1A	4280	4170	1	600	10	95	100	+1		410 NG						555	0						
2A	4304	4194	2	600	10	92	100	+1		411 NG						555	0						

ΔD	Δtc	Vi
200	22·5	8700
370	37	10000
430	48	8950
200	15	13330
300	28	10710
400	31	12900
605	52	11880
402	48	8360
148	13	11380
449	25	17980

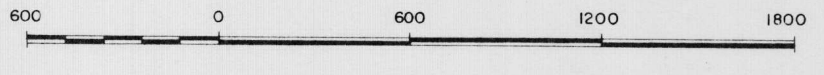
REMARKS: *REFLECTION TIME (to_R) FOR THE FIRST SHOT IN EACH SHOT-HOLE IS TAKEN AS REFERENCE. e.g. ALL SHOTS FIRED IN SHOT-HOLE 3 ARE REFERRED TO THE REFLECTION TIME OF ·555 SECONDS FROM SHOT 3A*





LAYOUT OF WELL SHOT-POINTS AND GEOPHONE SPREAD

SCALE IN FEET



DEFINITIONS OF SYMBOLS AND COLUMN HEADINGS:

- E_K+D — Depth of well geophone below rotary table Kelly bushing
- Do — Elevation of Datum above sea level
- E_K — Elevation of rotary table Kelly bushing referred to datum plane
- D — Depth of well geophone below datum plane
- ΔD — Difference between depths of well geophone for two shots
- S.P. — Shot-point
- X — Distance of shot-point from centre of well
- chge — Pounds weight of explosive fired
- Es — Elevation of shot-point referred to datum plane
- ds — Depth of shot below surface
- Vo — Weathering velocity
- Ve — Subweathering velocity
- t_{sd} — Vertical time from shot to datum plane. Normally $= \frac{Es-ds}{Ve}$
- α — Vertical angle subtended by straight line from shot to well geophone $= \tan^{-1}\frac{X}{D+Es-ds}$
- tv_1 — Vertical component first break time for well geophone
- tv_2 — Vertical component first trough time for well geophone
- tha_1 — Horizontal component A first break time for well geophone
- tha_2 — Horizontal component A first trough time for well geophone
- thb_1 — Horizontal component B first break time for well geophone
- thb_2 — Horizontal component B first trough time for well geophone
- RG — Reference geophone
- t_{RG} — Reference geophone time
- Δt_{RG} — Reference geophone correction time. In general practice $tv_1 - \Delta t_{RG}$ is best estimate of t_o
- to_R — Reference reflection time
- Δto_R — Reference reflection correction time. In general practice $tv_1 - \Delta to_R$ is best estimate of $t_o - \frac{t_{sd}}{\cos\alpha}$
- t_{cab} — Calculated cable break time
- to_{cab} — Observed vertical component cable break time
- Δto_{cab} — Difference between to_{cab} corresponding to well geophone depth difference ΔD
- t_o — Accepted time for straight line ray from shot to well geophone. In idealized case t_o would equal tv_1, tha_1 and thb_1
- tc — Vertical time from datum plane to well geophone $= t_o\cos\alpha - t_{sd}$
- Va — Average vertical velocity between datum plane and well geophone $= \frac{D}{tc}$
- Δtc — Difference between tc corresponding to well geophone depth difference ΔD
- Vi — Interval velocity over depth difference ΔD $\left(=\frac{\Delta D}{\Delta tc}\right)$
- Vcab — Logging cable velocity $= \frac{\Delta D}{\Delta to_{cab}}$
- T.D. — Total depth of well referred to rotary table Kelly bushing
- ρm — Density of mud in well
- Tm — Temperature of mud returns when circulating in hole
- B.H.T. — Bottom hole temperature i.e. temperature at T.D.
- Gr. — Grading of certainty and accuracy of time:
  - 1st grade: G means: Certain that true formation break selected; P " : Some doubt " " " "
  - 2nd grade: G " : Accuracy less than ± ·001 seconds; F " : " " " ± ·003 "; P " : " " " ± ·005 "
  - ? grade means very doubtful certainty or time

FIELD INSTRUCTIONS:

1. Do not use outer sheath of cable or other neutral lead as geophone lead.
2. Before running geophone in well, shoot buried detonator under well geophone or do tap test to check all connexions and polarity.
3. While running geophone into well fasten small geophone and a clamp to cable and strike a vertical blow on the clamp to check manufacturer's figure for cable velocity.
4. As soon as cable and shallow formation velocities are sufficiently well known, and before survey proceeds, construct calculated cable break curves for all shot-point offsets.
5. Do complete calculation as survey progresses and watch for cable breaks.
6. Where possible obtain copies of C.V.L., electric and lithologic logs and fill in all information required on this sheet.

AFTER G 85 - 113

PLATE 2

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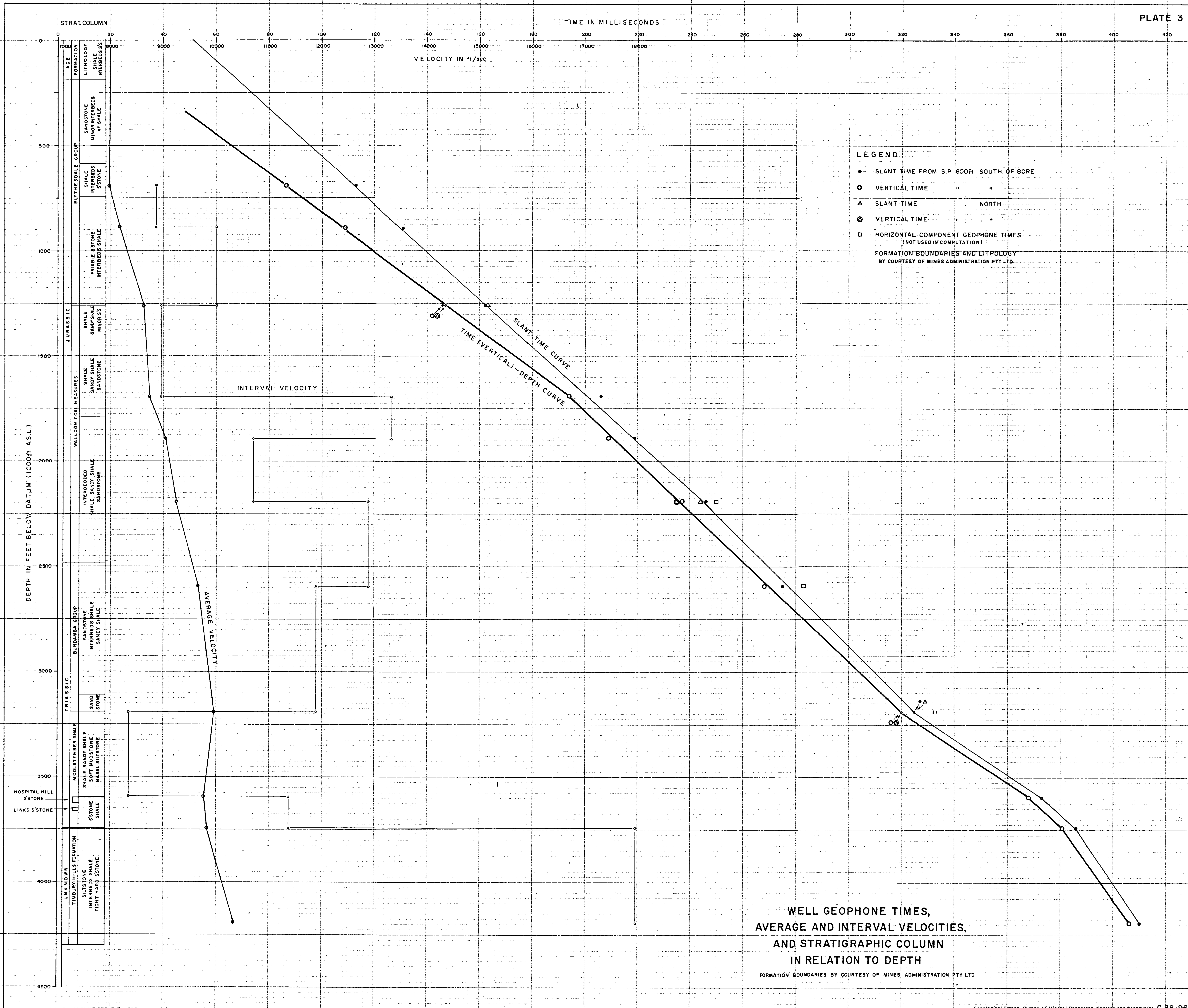
PLATE 3



WELL GEOPHONE TIMES, AVERAGE AND INTERVAL VELOCITIES, AND STRATIGRAPHIC COLUMN IN RELATION TO DEPTH

FORMATION BOUNDARIES BY COURTESY OF MINES ADMINISTRATION PTY LTD

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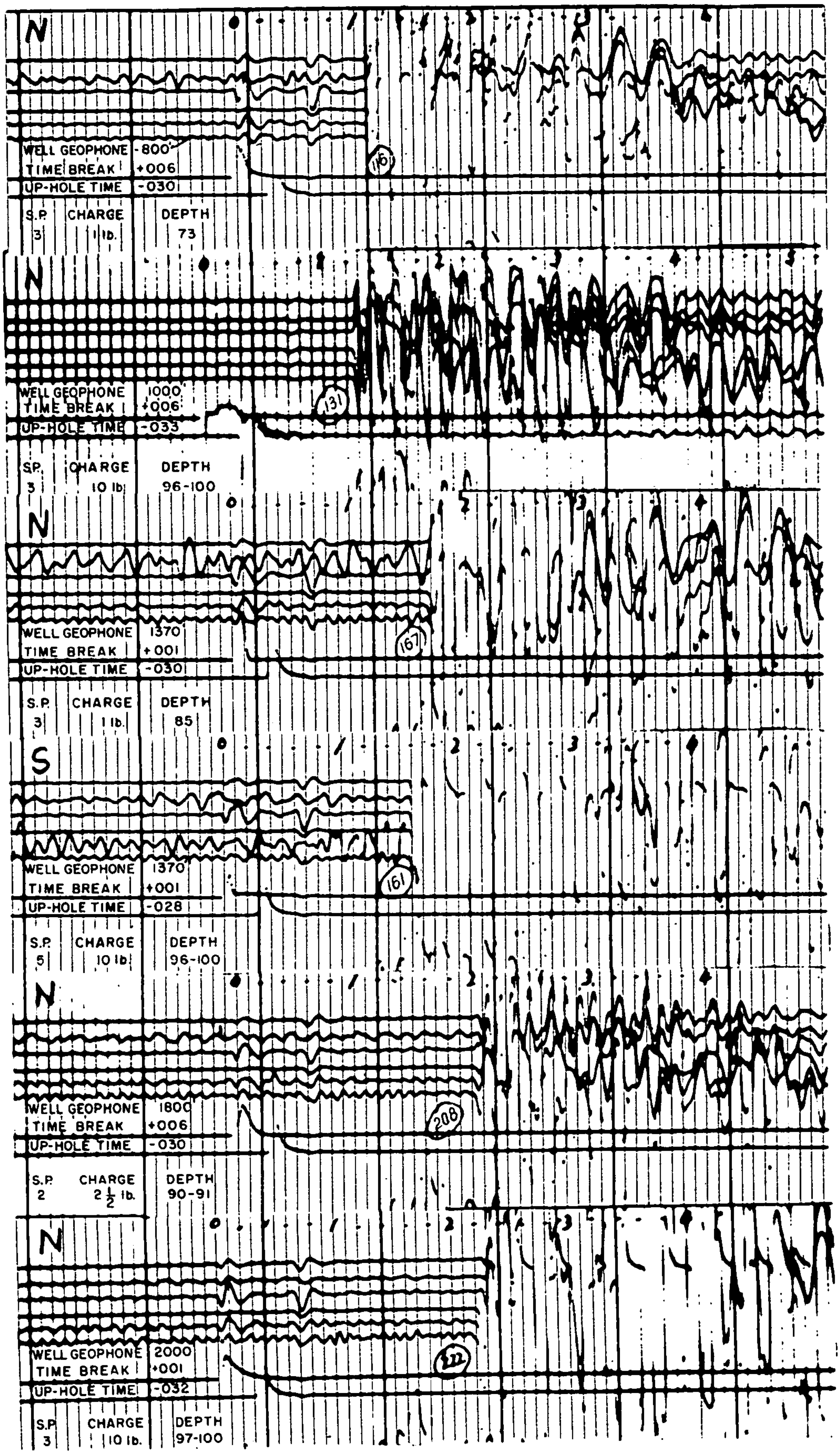
TO ACCOMPANY RECORD No. 1962/51

AAO TIMBURY HILLS N°2 QLD



WELL GEOPHONE DEPTHS 800' TO 2000' BELOW ROTARY TABLE

VELOCITY SURVEY RECORDS

TIMBURY HILLS QLD

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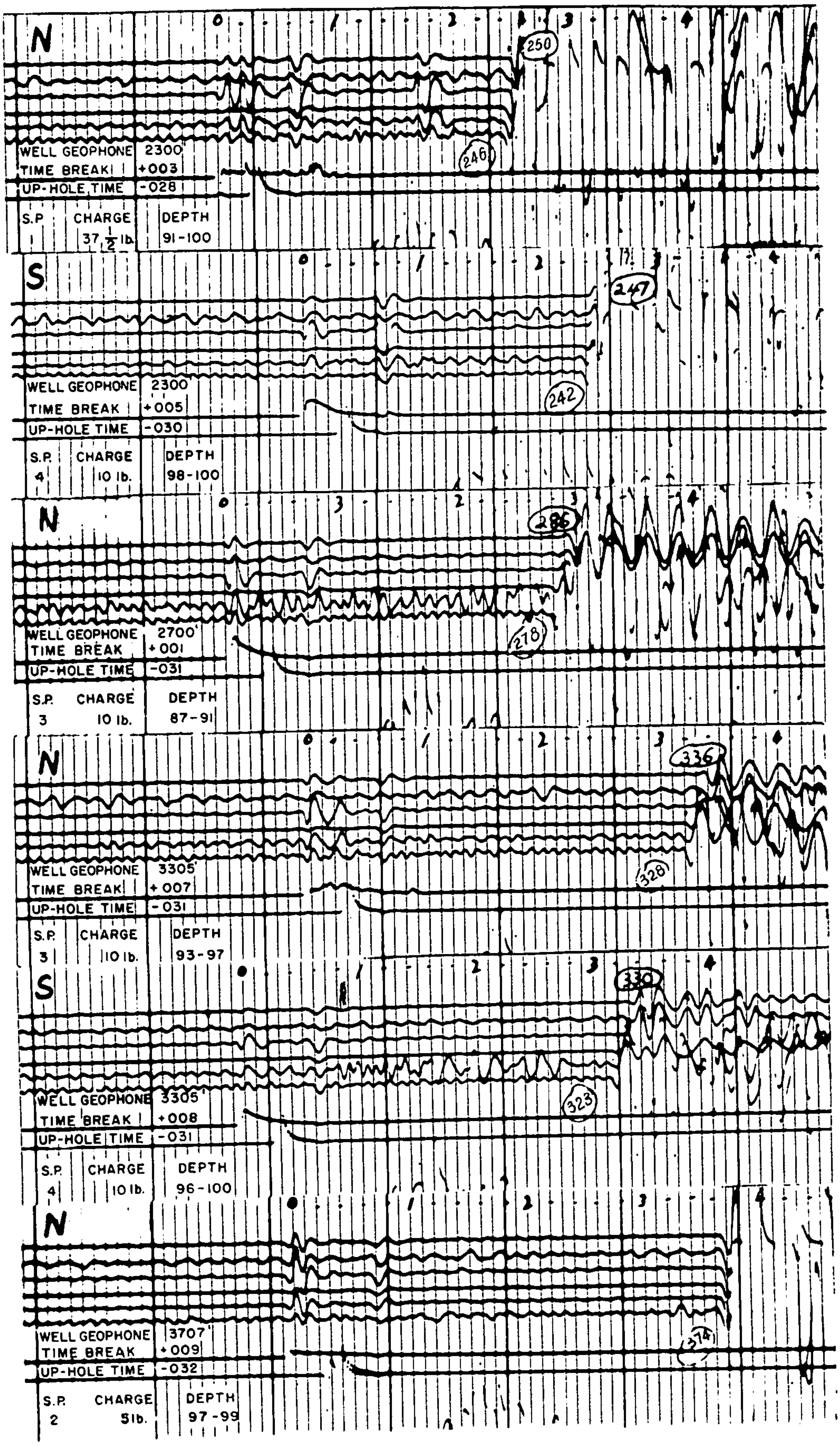

WELL GEOPHONE DEPTHS 2300' TO 3707' BELOW ROTARY TABLE

VELOCITY SURVEY RECORDS

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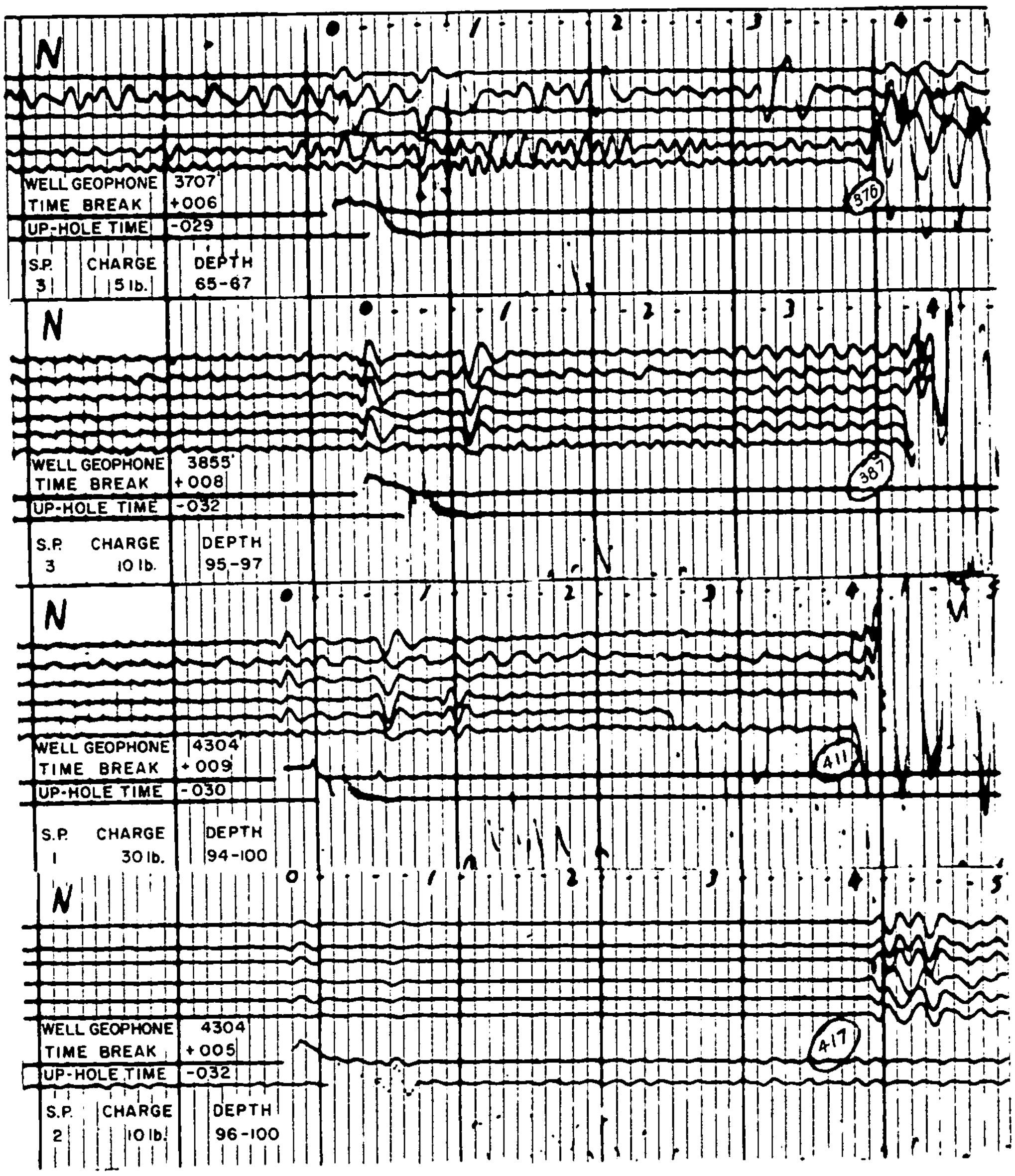
Plate 6



WELL GEOPHONE DEPTHS 3707' TO 4304' BELOW ROTARY TABLE

VELOCITY SURVEY RECORDS

TIMBURY HILLS QLD

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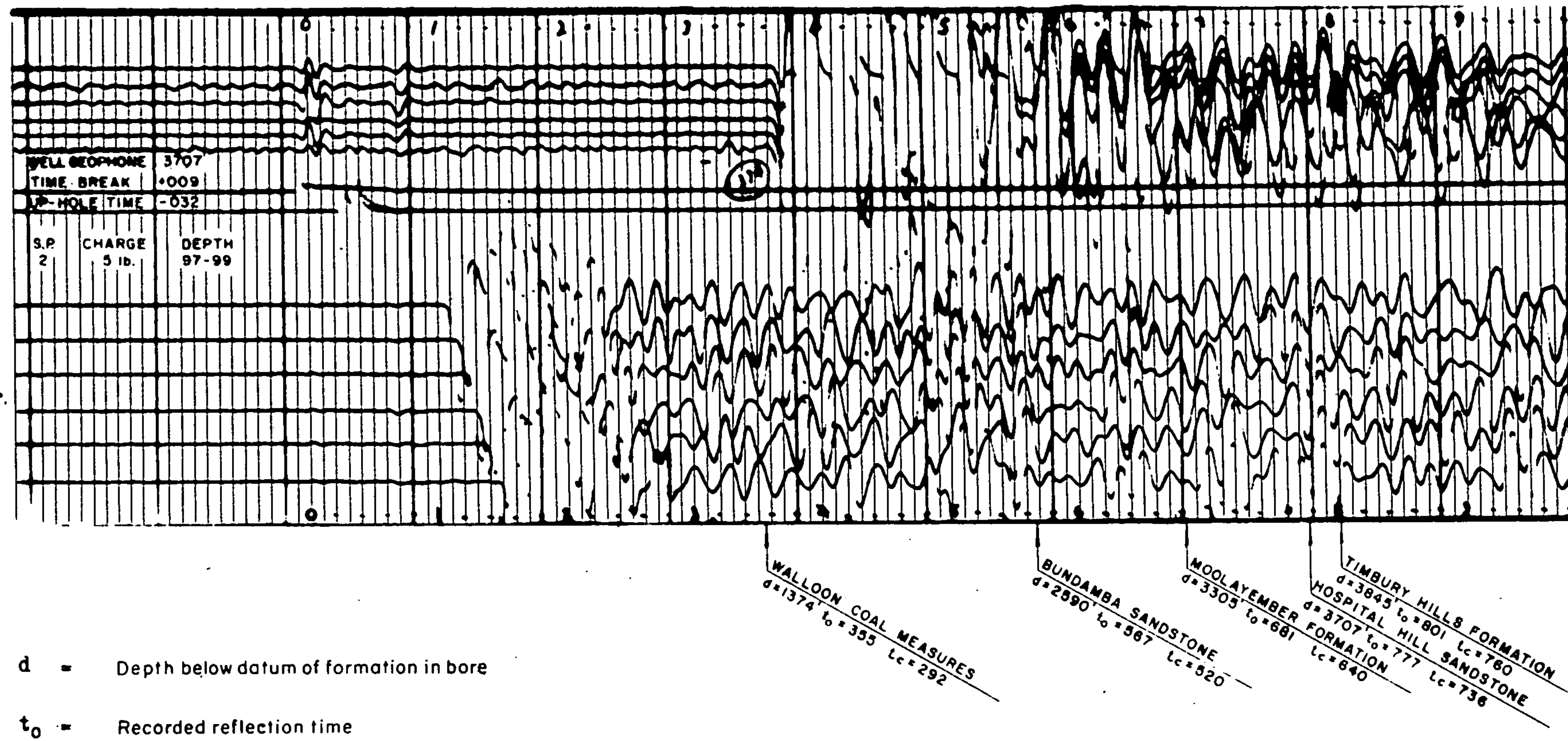

d = Depth below datum of formation in bore

t_0 = Recorded reflection time

tc = Reflection time corrected to datum (1000ft a.s.l.)

= t_0 - (weathering and elevation correction) – (spread correction)

POSITION OF STRATIGRAPHIC BOUNDARIES

IN RELATION TO REFLECTIONS

Plate 7

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