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PIRIE TORRENS BASIN

1956 WILKATANA AREA SHALLOW REFLECTION SEISMIC SURVEY FINAL REPORT

Submitted by

Santos Ltd.
1957

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DEPARTMENT OF MINES

SOUTH AUSTRALIA

GEOLOGICAL SURVEY

GEOPHYSICAL SECTION

SHALLOW SEISMIC REFRACTION SURVEY

WILKATANA

by J.L. HARRIS, Geophysicist

D.L. MILTON, Geophysicist

G.S. Report No. Refer 712

H.O. Report No. Cofer 44/96

Geophysical Report No. 9/57

4th June, 1957.

INDUSTRIAL CONFIDENTIAL

TO THE DEPUTY DIRECTOR:

SHALLOW SEISMIC REFLECTION SURVEY - WILKATANA.

Forwarded herewith is a report of the above title by J.L. Harris and B.E. Milton.

The Wilkatana area has proved a most difficult one for the seismic technique, and has involved the officers concerned in months of computation in an endeavour to obtain all possible information from the records. Besides our own resources, we have called upon officers of the Bureau of Mineral Resourcesand Geophysical Services International to assist in the task.

The results are possibly disappointing, but are in no way lacking because of either equipment or personnel, and I feel quite justified in stating that there is little to be gained by the use of the seismic method in this area.

14.6.57

SENIOR GEOPHYSICIST.

CONTENTS

ABSTRACT

Both a time and dip cross section plot have been attempted over a distance of 14,400 feet along a line passing through the No. 1 Bore Site. The dip cross section is an attempt to outline the Tertiary-Cambrian unconformity only whereas the time cross section shows some reflections below the base of the Tertiary. The quality of reflections obtained was very poor.

1. INTRODUCTION

As a result of representations made to the Department of Mines early in 1956 by Geosurveys of Australia Ltd., a shallow reflection survey was carried out in the Wilkatana area, 27 miles north of Port Augusta on an oil lease held by Santos Ltd., (Oil Exploration License No. 7). The survey was made along a west-east line, 19,000 feet in length which passed through No. 1 Bore Site.

In December 1955, the company encountered "slight showings of a heavy greenish black crude oil" in this bore at a depth of 574 feet, the showings being in limestones of Cambrian age. Consequently further holes were drilled at distances which were multiples of 400 feet on two lines running North - South and East-West centred on the No. 1 Bore. More oil slicks were detected in these holes and it was further determined that the various members of the Cambrian dip gently to the east at an angle of approximately 3 degrees. Since this was the first occasion that a shallow reflection survey had been attempted in South Australia, the technique being a very recent development in seismic prospecting, it was decided to conduct an experimental traverse along the west-east line to determine whether the trend indicated by the borehole information would be confirmed by the reflection survey.

Field work was commenced on the 20th September 1956 with J.B. Webb as party leader for a period of four weeks. J. Morris then acted as party leader until the completion of the survey on 30th November, 1956.

2. PREVIOUS GEOPHYSICAL WORK

During February 1955 gravity and magnetic observations were made in portions of the Pirie-Torrens basin by Geosurveys Ltd., geophysicists D.M. Pegum and P. Neyman (Santos Quarterly Report for period ended 30th April 1955). In the region of interest an area of low magnetic intensity was revealed with a negative west-east gradient. The gravity results also showed a similar negative gradient. These results are consistent with a thickening of sediments to the east as indicated by the dip of the Cambrian beds. A detailed gravity and magnetic survey was also completed by Pegum and Hayman over an area 4000 feet x 4000 feet surrounding No. 1 Bore. (Quarterly Report for period ended 31st March 1956). The area is one of low magnetic intensity with a strong west-east gravity gradient of 0.5 gravity units per 100 feet.

In September and October 1955, two short seismic refraction surveys were made by Mines Department geophysicists J. Harris and R. Parker using 6 channel ABEM equipment borrowed from the Bureau of Mineral Resources. (Report No. G.S. 400, Geophysical Report No. 15/55). A very high speed layer with a velocity of 19,000 - 20,000 feet/second was interpreted as being basement with a dip of 5 degrees in a direction 036M at a depth of approximately 800 feet. This depth figure was determined indirectly as follows. Knowing the depth at which the drill entered the limestone; the velocities of the Tertiary sediments and the inferred basement; and assuming a velocity for the limestone, it was possible to calculate a minimum thickness for the limestone in order to obtain a refraction from that bed. Later drilling results showed that this interpretation was incorrect in that the high speed layer was not basement but the dense Cambrian limestone. A revised calculation of depth based on the fact that Tertiary sediments lie unconformably on the Cambrian limestone, gave a depth to the high speed layer of 500-550 feet at No. 1 Bore Site.

3. GEOLOGY

The geology has been mapped by GeoSurveys Ltd. and details are contained in the Quarterly Reports issued to the Department by Santos Ltd. The following descriptions have been drawn from these quarterly reports.

A regional cross section through No. 1 Bore shows an assymmetrical synclinal basin with rather shallow easterly dips on the western limb and very steep dips on the eastern limb where this latter abuts against the Flinders Ranges. Eight bores have been drilled along the reflection line, and are numbered from West to East No's. 10A, 20, 8, 1, 7, 4, 13 Plan ( ).

The area has a slight gradient to the east with occasional undulating sand dunes which rise to about 20 - 30 feet. The dunes are usually covered with pines and mulgas whilst the flatter portions are thickly covered with saltbush and spinifex.

Quaternary-Recent

Sand dunes and alluvial flats.

Tertiary

Red brown clayey sands and gravels

Grey sandy mudstones

Lignitic and marcasitic sands and mudstones.

Unconformity.

Cambrian

White dolomite with Archaeocyathinae.

Mottled grey and white beds containing Archaeocyathinae

Slumped or Algal member

Girvanella horizon

Breccias, calcarenites, calcilutites, oolites, and orthoquartzites.

Transition zone above red shales.

Upper Proterozoic

Marinoan Group.

The deepest bore drilled at [illegible] is No. 1 which extends to a depth of 2200 feet and has been stopped in the Adelaide System Marinoan shales. Above the Marinoan is a transition zone containing sandstone-limestone phases with quartzites, sandy limestones, siliceous sandstones and calcareous shales.

Immediately overlying these are the Cambrian limestones which have a maximum thickness of about 1300 feet. Sprigg, in a quarterly report for period ended 30th June 1956, referring to No. 2 Bore mentions the occurrence of porous zones. "Below 950 feet porous zones wherein water circulation was sometimes "lost" reflected extensive mechanical brecciation as observed in the core and also interpreted from the electric log". Sprigg also mentions a white porous dolomitic zone with a thickness of 80 - 100 feet occurring immediately below the Cambro-Tertiary unconformity. Density determinations for the limestone are shown in Table I and indicate some variation below 700 feet.

TABLE I

Depth in feet	No. 2	No. 4	No. 8
460			2.81
473	2.75		
500	2.72		2.82
550	2.74	2.78	2.85
600	2.75	2.80	2.85
650	2.80	2.81	2.80
700	2.85	2.81	2.82
800	2.66	2.65	2.59
900	2.66	2.64	2.54
2000	2.63	2.62	2.57

Unconformably overlying these limestones are approximately 500 feet of Tertiary terrestrial sediments consisting of clays, sands, gravels, mudstones, lignites, and marcasitic sands. A mantle of superficial deposits comprising sand dunes and alluvial sands covers the area. Oil traces have been found in nearly all holes drilled with an occasional minor gas show reported. Although these traces have been found in both the Tertiary and Cambrian beds, the latter are considered both the source and reservoir rocks. The not so frequent occurrences in the Tertiary appear to be the result of some migratory process not yet fully explained.

Between bores No. 6 and 10A on the western margin of the syncline the limestone beds pinch out, with the Tertiary sediments immediately overlying the Marinoan Shales.

4. EQUIPMENT

The equipment used for the survey comprised a R.T.L. 7000 B seismograph shock mounted in a Land Rover station wagon and a Conrad SH II portable drilling rig mounted on a Dodge Power Wagon.

Explosives were carried in special boxes in a Land Rover which also pulled a trailer containing 2 - 44 gallon drums of water for tamping shot holes. Other vehicles used included an Austin truck provided by Santos to supply water for the drill, a Land Rover for use by the cable layers, and another Land Rover for use by the party chief. Magazines for the storing of explosives and detonators were built by Santos personnel.

5. PERSONNEL

The party consisted of two geophysicists, one electronic technician, one explosive technician, two cable layers, one driller and one driller's assistant. The two cable layers were employed by Geosurveys Ltd., who in addition provided a surveyor to locate shot holes and geophone stations. The remainder of the crew were supplied by the Mines Department. Both operating and drilling crews worked a six day week of nine hours a day. The progress of the survey was frequently slowed down due to mechanical breakdowns of the drill and also because of lack of progress made by the drilling crew operating one shift per day. Minor delays only were caused by instrumental failure and weather conditions.

One geophysicist supervised field operations and was responsible for the general organisation of the survey, whilst the other was engaged full time in reducing results. The reduction of results lagged considerably behind the recording of results even though both geophysicists were employed on reductions at night.

6. METHOD USED

In the reflection method of prospecting a shot hole is drilled and an explosive charge electrically fired at the bottom of the hole. A shock wave is set up which is transmitted through the various subsurface strata and is reflected from those horizons (not necessarily geological horizons) where an elastic discontinuity exists. Elastic discontinuities are due to variations in density, volume and rigidity and are associated with changes in wave velocity.

Generally these elastic discontinuities coincide with geological interfaces. The echoes from these reflecting horizons are picked up at the surface by electromagnetic detectors and converted into electrical impulses which are recorded photographically. In addition the instant of firing and timing lines are also photographed on this record. Knowing the time for any wave to be reflected back to the surface and also the average velocity to the reflector, depths may be calculated. Subsurface velocities may be determined from surface profiling information and very often this is the only data available. Whenever it is possible to lower a geophone down a deep well and record the time for waves to reach this geophone then this technique is used as velocities so determined have a greater degree of accuracy.

Not only can depths be determined but also the direction and amount of dip can also be ascertained. Certain corrections such as weathering, elevation, compensation for the distance of each geophone from the shot (spread correction) must be made before a final interpretation can be made.

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During the preliminary testing stages numerous different geophone spacings, filter settings, shot hole depths, and shot sizes were used to determine the optimum operating conditions for the survey. Some shots were fired using an air shooting technique, the charges being supported on stakes about four feet above the ground. Although both single and multiple pattern shots were used the quality of the results was not as good as that obtained from conventional shooting in shot holes. Eventually a continuous profiling technique with end to end shooting was employed. This method is particularly applicable to areas of gentle dip and gives a complete subsurface coverage. Shot holes were drilled at intervals of 300 feet to a depth initially of 40 to 50 feet. Later the depth was increased to 70 - 80 feet in an endeavour to improve record quality. Frequently it was necessary to fire as many as seven or eight shots in the one hole. The majority of holes remained open, only about six being redrilled during the entire survey. Single geophones were used on each station. The twelve geophone stations were equally spaced at intervals of 25 feet between the shot points. Small charges varying in size from

½ lb. to 2½ lb. were used. Insufficient geophones were available to permit the use of multiple detectors by means of which the quality of the reflections could possibly have been improved. Multiple pattern shooting was used in one test area when nine shot holes each 20 feet apart were arranged in a diamond pattern. This method was discontinued because of the time factor and expense involved in additional drilling since there did not appear to be any significant improvement in the few records shot. Usually it was not necessary to tamp the shot holes as the water level was within a few feet of the surface. The smaller ½ lb. charges had a tendency to float free from the spike on the end of the loading pole and to remedy this, the charges were packed in a cardboard tube which was then filled with sand and lowered to the bottom of the hole. Due to the short time intervals required for reflections to return from the shallow horizons and the necessity for the Automatic Gain Control to act as quickly as possible, the High Resolution Range was used. Conventional reflection filter settings (in the range 30 - 80 cycles) were not actually used when shooting the line but were tried when testing and found to be less satisfactory than the higher frequencies. Filter settings in the range 70 - 160 cycles were used during the survey.

7. REDUCTION OF RESULTS

The results are presented as

1. a time cross section.

and 2. a cross section based on dip calculations which attempts to trace the unconformity only and which shows two possibilities.

Phantom horizons have been drawn for those profiles where no reflections are apparent.

For the time cross section, surface corrections have been made and times below each shot point have been plotted wherever possible. All corrected times have been tied from record to record by correlating (a) corrected times at the shot points where shots were fired at one shot hole (b) corrected end times when shots were fired at adjacent shot points.

Because of the very poor quality of the records a limit of five milliseconds for the two way travel times was used as a basis for correlation.

Between co-ordinates 6300 W and 900 W only those records shot with filter settings of (90 - 160) cycles have been used and between 900 W and 8100 W only those with filter settings of (70 - 120) cycles.

On the cross section based on dip determinations, corrections for surface conditions were made similar to those on the time cross section. In addition a correction for normal move out was necessary.

Frequently in trying to improve record quality several shots using different filter settings were fired at each shot hole. The same reflection did not necessarily record at exactly the same time on each record but there should be no significant variation in dip calculated from reflection recorded with the different filter settings.

Use has been made of as many as possible of these records in plotting the two possibilities on the dip cross section.

1. One possibility has been plotted by averaging the dips of these reflections, recorded from the one reflector using different filter settings, over intervals of 300 feet. Often several reflections have been averaged over the one interval, whilst in other instances there has only been one value for a given interval, either because a reflection was recorded on one filter setting only or because only one filter arrangement was used.

The plot has been migrated from 6000 W 00 W in an easterly direction.

II. The second possibility has been plotted by averaging a certain number of dip values, if numerous, over 300 foot intervals, or if few in number over longer intervals. In no case was a distance of greater than 1200 feet used for the averaging process. This plot was migrated from 6400 W 00 N to the east in a similar manner to the first possibility.

Surface Corrections

Reflection times have been corrected to a level reference plane, 20 feet above M.S.L. The thickness of the weathered layer at each shot point was determined from uphole time calculations and subweathered velocities at each shot point obtained from plotting first arrival breaks for each record.

Normal Correction

The correction for normal move out is a function of the observed time of the reflection and of the average velocity of the seismic waves between surface and reflector. Initially this correction was made using well velocity survey data but it was found that the values obtained were too great. The Bureau of Mineral Resources were contacted in connection with this problem and the possibility of multiple reflections raised by one of their officers.

In determining dips three different methods were used to calculate the normal move out.

(i) Depth points were plotted under each shot point and a non-migrated plot made using the subweathered velocity. It was inferred on the basis of earlier refraction work, that the first rather strong but erratic reflection was coming from the Tertiary-Cambrian unconformity.

(ii) The formula $L_s \Delta t_s = \frac{10(n+1)\Delta x^2}{2\bar{V}^2 t_o}$

was used with V_e being substituted for $\bar{V}$.

n is number of geophones.

Δx is geophone station interval.

$\bar{V} = V_e$ where V_e is subweathered velocity.

t_o is two way travel time.

(iii) By selecting the same reflection on records which were shot from either end of a 300 foot spread, applying surface corrections to each and then averaging the two results, it is assumed that dip effects cancel, and that the resultant average value represents the normal move out.

9. DISCUSSION OF RESULTS

Due to the very poor quality of the reflections it has not been possible to plot a cross section with any degree of certainty. Values have been plotted between co-ordinates 6300 W and 8100 E, the reflections from 8100 E to 12800 W being too poor. The depth to the unconformity has been converted to time and marked on the cross section. Only those reflections with two way travel times less than 250 milliseconds and which lie within the previously mentioned limits have been plotted as any deeper reflections must either originate from within the Adelaide System or be multiple echoes. The reflections have been shown on the time cross section as fair, poor and partial or doubtful. Partial and doubtful reflections have been plotted where there is some evidence on either side of them to justify their use. Many isolated reflections are shown which apparently have originated from some purely local irregularity. Selective scattering due to reflections from irregularities is much greater when using high frequencies such as used in this survey.

The shortcomings of the cross section based on dip information are obvious. This cross section has been included only as an additional piece of evidence to support the time cross section, which has been constructed with mainly very poor reflections. There is some indication on the time cross section in the area bounded by co-ordinates 3600 E and 8100 E of easterly dipping beds below those reflections which have been interpreted as the unconformity. This trend is not very distinctive, and it is very doubtful whether the correlation with the geological cross section would be possible if the subsurface geology were not known.

The lack of reliable velocity information prevents any attempt to name these beds if in fact they do represent formation boundaries. It is worthy of comment that even though they are of very poor quality these deeper reflections appear between those limits where the inferred unconformity reflections are weakest. Whilst the plotted position of the unconformity does not match exactly the position as shown from the known geology it would appear that the majority of the reflections have originated from the Tertiary - Cambrian unconformity. In the discussion which follows relating to the possibility of multiple echoes, a very high reflection coefficient was shown to exist between the Tertiary and Cambrian, i.e. there is a very high reflection of incident energy from the unconformity surface.

A separate report (G.S. No. 710) deals with the Well velocity survey at No. 1 Bore Site. It was decided not to use velocity information obtained from the well shoot because of some doubt as to the accuracy of the results. Velocity determinations by means of reflection profiles were attempted but this technique has serious limitations, particularly when detector spreads are short and also when the quality of reflections is poor.

Normally the subweathered layer velocity remains reasonably constant over considerable horizontal distances. Such was the lateral variation in this area that it was necessary to use four different subweathered velocities over a distance of 19,000 feet ranging from 6,500 feet/second to 8,900 feet per second. (See Plan S 1458). This variation could be caused by lithological changes or variations in porosity. As mentioned earlier Sprigg has made reference to variations in porosity which have been confirmed in the interpretation of electric logs. Table I revealed variations in density in a vertical direction below about 700 feet and although there are some lateral variations in density these are not nearly so pronounced.

Although every care was taken and small charges weighted to ensure that they reached the bottom of the shot hole, there was an occasional discrepancy in uphole times which could not be explained in terms of hole fatigue. The most obvious explanation for these anomalous uphole times is that an occasional charge has floated higher up the hole.

The following evidence is presented to support the theory that multiple echoes were present at least over sections of the line.

1. A Tot analysis using both end-to-end and split spread arrangements (Plans S 1456 and S 1457) gave a constant velocity value in each instance of about 5000'/second which approximates to the average subsurface weathered velocity found from first breaks. In these analyses only those reflections which could be correlated from end to end of each profile or at the shot point in the case of the split spreads were used.

2. Impulses were repeated at intervals of time about equal to the arrival time of the primary reflection. Arrivals at twice primary reflection time were very common and arrivals were also noted at approximately

three and four times the primary time.

3. A previous refraction survey indicated a very high speed layer of approximately 20,000 feet/second at a shallow depth.

4. It was not possible to make density determinations of the unconsolidated Tertiary sediments, but the limestone was found to have a density range 2.6 to 2.9 and thus it can be inferred that a rather strong density contrast does exist in the region of the unconformity. Assuming a comparatively low velocity of 15,000'/second for the limestone; a velocity of 6,500 feet per second for the Tertiary sediments and densities of 2.8 and 2.4 respectively, the reflection coefficient is nearly 50%. The real value would probably be higher since (a) a lower velocity has been assumed for the limestone and (b) a rather high density value of 2.4 given to the unconsolidated sediments.

9. CONCLUSIONS

(i) The area appears to be a difficult one in which to obtain good reflections and the quality of the records generally is very poor. The results have been plotted on the cross sections between co-ordinates 6300 W and 8100 E. Record quality from 8100 E to 12,800 E deteriorated to such an extent that it was not possible to pick any reflections in this area.

(ii) The only indication of reflections below the Tertiary Cambrian contact occurs between co-ordinates 3600 E and 8100 E. In this area the unconformity reflections are weak and a very sharp velocity contrast has been shown to exist between the unconsolidated sediments and the limestone. This would seem to suggest that little energy has been transmitted through this contact.

(iii) Both outside organisations consulted, the Bureau of Mineral Resources, Melbourne and Geophysical Services International, Perth, agreed with departmental officers that multiple echoes do occur, although opinions expressed by officers of these organisations were necessarily based on somewhat limited data.

(iv) There are known to be variations in density and porosity of the limestones but the writers are unable to indicate whether these variations are such as to effect the results.

(v) The well velocity surveying technique employed will require to be modified for future work and it has been decided to carry out the next well survey in accordance with standards and specifications laid down by the Southern Seismic Well Shooting Association U.S.A. This does not necessarily imply that the problem of shooting a shallow well at short vertical intervals will be automatically overcome. The examination of actual results will eventually determine whether the method is applicable to short vertical depth intervals.

(vi) Because of the short spreads used in shallow work the relationship between the depth of shot and base of weathering is very critical and assumptions made when reducing results from longer conventional spreads are not applicable. If it is not possible in future to fire at the base of the weathering for these short spreads it may be necessary to make a trace analysis if a dip cross section is required.

(vii) More frequent uphole surveys are indicated in the reductions to obtain more accurate weathered layer velocities and depths. Some uphole times recorded are obviously in error, probably due to the rather small charges floating. A closer examination of uphole times immediately after each record has been developed should result in the elimination of these discrepancies.

(viii) It is essential for purposes of planning re-shoots and obtaining best results that the results should be computed immediately after the actual records have been shot in the field.

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Geophysicist

B.E. Milton
B.E. MILTON
Geophysicist

JLH:AGK
4/6/57

ACKNOWLEDGEMENTS

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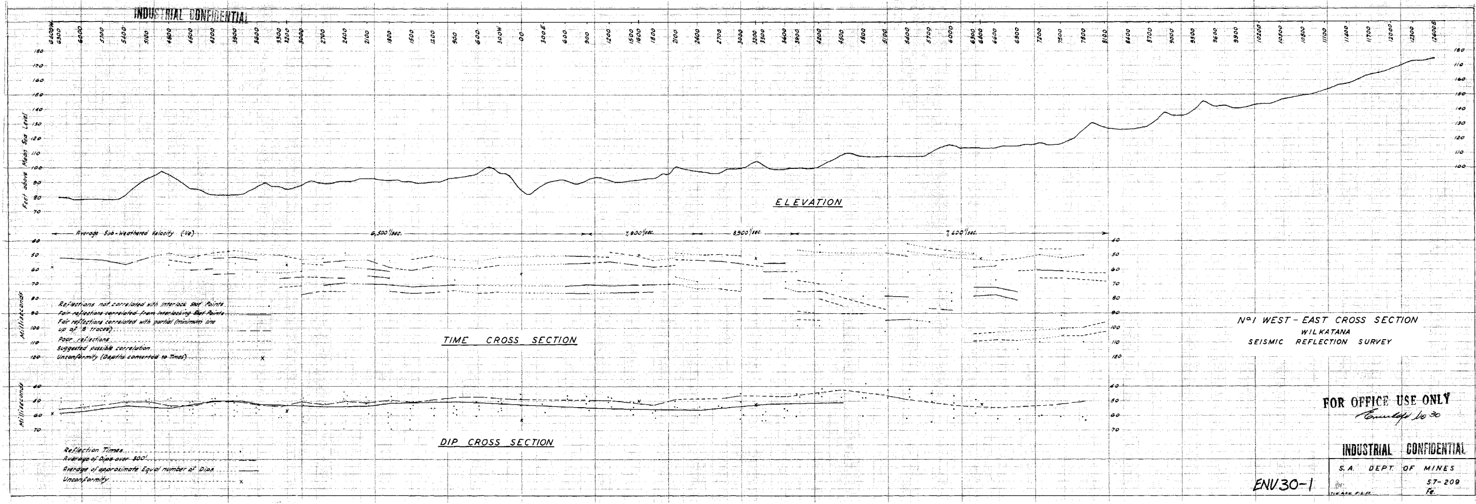
They also express their indebtedness to Geophysical Services International supervisors G. Howard and E. Kimbler, whose advice on this particular survey and on seismic reflection prospecting generally resulted in the clarification of many problems.

REFERENCES

Seismic Prospecting for Oil	-	C. Hewitt Dix
Geophysical Exploration	-	C.A. Heiland
Geophysical Prospecting for Oil	-	L.L. Nettleton
Exploration Geophysics	-	J.J. Jakosky
Geophysics Vol. XIII No. 1. January 1948	-	Authors of all articles on Multiple Reflections.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Feet above Mean Sea Level
ELEVATION
Average Sub-Weathered Velocity (Vo)
6,500'/sec.
7,800'/sec.
8,900'/sec.
7,400'/sec.
Milliseconds
Reflections not correlated with Interlock Shot Points
Fair reflections correlated from Interlocking Shot Points
Fair reflections correlated with partial (minimum line up of 8 traces)
Poor reflections
Suggested possible correlation
Unconformity (Depths converted to Times)
TIME CROSS SECTION
Reflection Times
Average of Dips over 300'
Average of approximate Equal number of Dips
Unconformity
DIP CROSS SECTION
N°1 WEST - EAST CROSS SECTION
WILKATANA
SEISMIC REFLECTION SURVEY
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S.A. DEPARTMENT OF MINES

Nº1 BORE WILKATANA
SEISMIC REFLECTION SURVEY
GEOLOGICAL WEST EAST CROSS SECTION

Scale	1000' to 1"
Dr.	R.L.S.
Exd.	R.R.
Date	7-6-57

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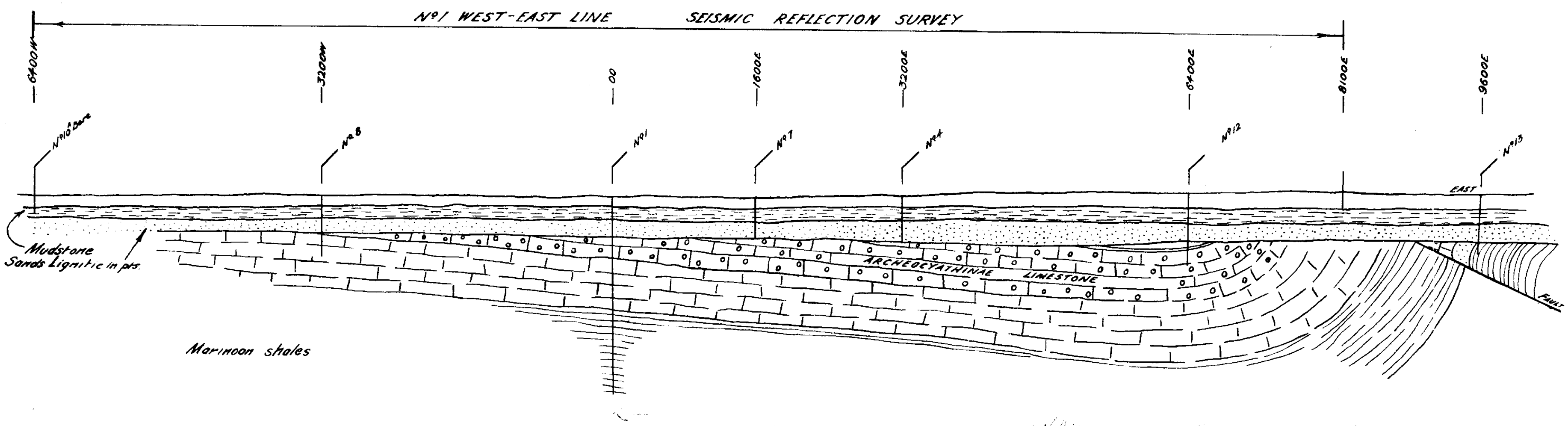

Nº1 BORE WILKATANA
SEISMIC REFLECTION SURVEY
GEOLOGICAL WEST EAST CROSS SECTION

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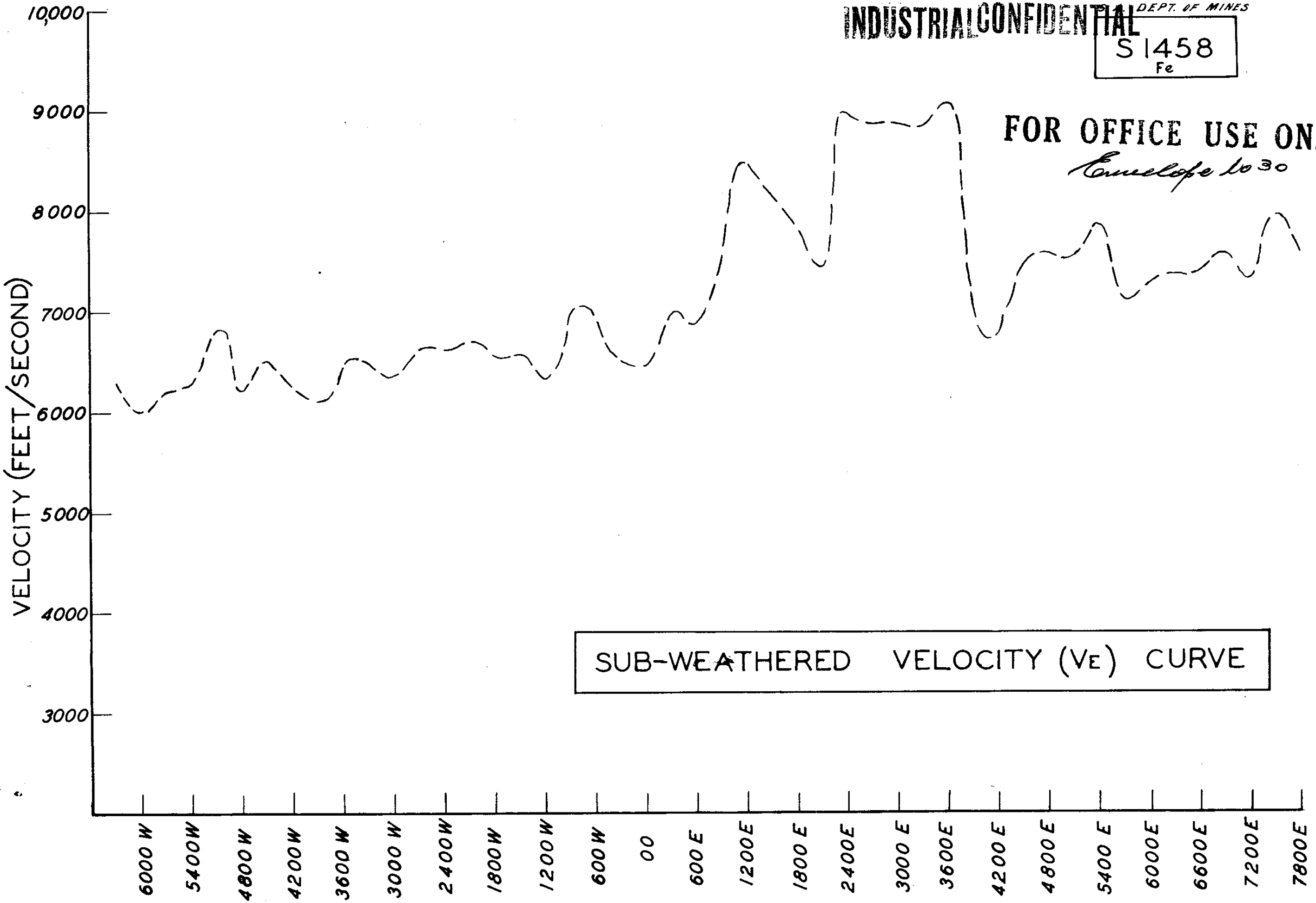

SUB-WEATHERED VELOCITY (VE) CURVE

TΔT CURVE
No.1 W–E TRAVERSE—WILKATANA (END–TO–END)

S 1456
Fe
S.A. DEPT. OF MINES

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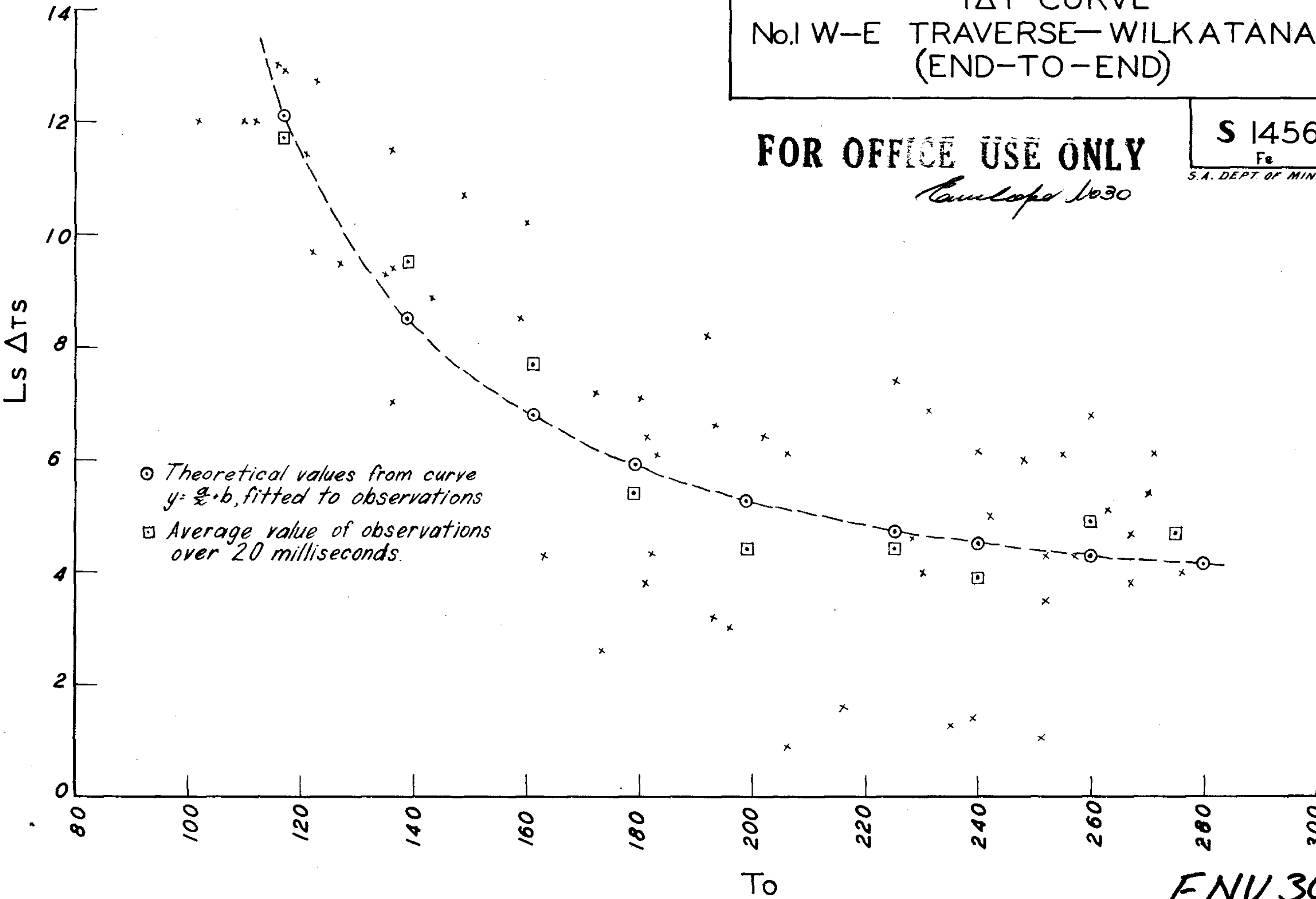

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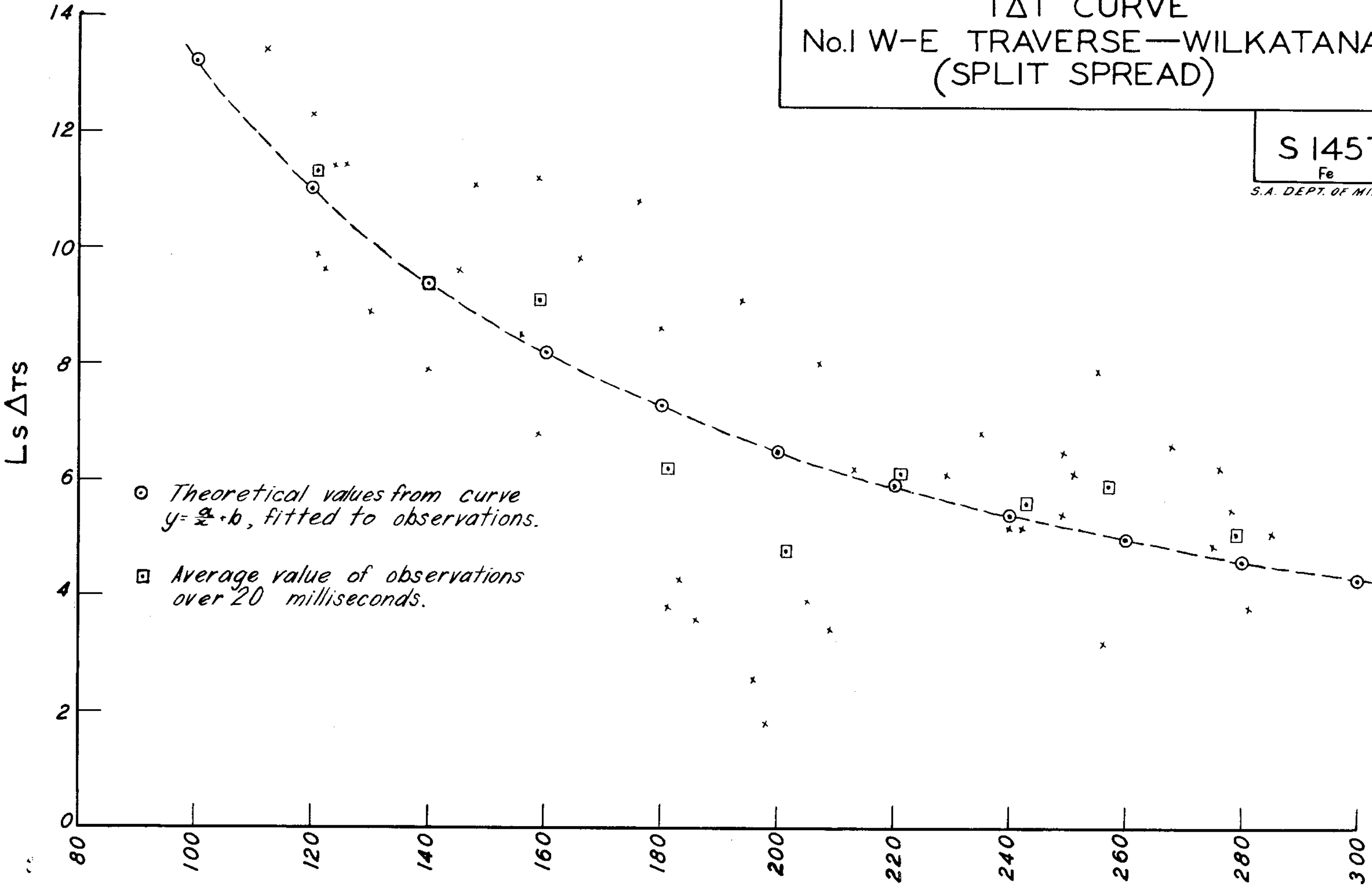
(SPLIT SPREAD)

S 1457
Fe
S.A. DEPT. OF MINES



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ENV 30 - 6

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