AGSO

Gunnedah Basin and Cobar Basin Seismic Test Survey 1989: Operational Report

by K D Wake-Dyster and D W Johnstone

Record 1993/89

AGSO
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

AGSO

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

AGSO RECORD 1993/89

GUNNEDAH BASIN AND COBAR BASIN SEISMIC TEST SURVEY 1989: OPERATIONAL REPORT

by

K.D. WAKE-DYSTER[1] and D.W. JOHNSTONE[1]

[1]Onshore Sedimentary & Petroleum Geology Program
Australian Geological Survey Organisation, GPO Box 378, Canberra, ACT 2601, Australia.

DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY

Minister for Resources: Hon. Michael Lee, MP
Secretary: Greg Taylor

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

Executive Director: Harvey Jacka

ISSN: 1039-0073

ISBN: 0 642 19925 6

CONTENTS

FIGURES

TABLES

EXECUTIVE SUMMARY

This record describes the field operations of the Gunnedah Basin and Cobar Basin Seismic Test Survey conducted by the Bureau of Mineral Resources, Geology and Geophysics (BMR) (now Australian Geological Survey Organisation (AGSO)) during the early part of 1989. The objective of the survey was to test the suitability of the seismic reflection technique for proposed regional deep reflection seismic lines in the Gunnedah Basin and Cobar Basin. The major emphasis of the test survey was to assess the feasibility of acquiring shallow and deep seismic reflections in order to examine various geological models of bounding faults and basin structure.

The survey acquired data from five sites in the Gunnedah Basin and three sites in the Cobar Basin. The quality of data in the deeper part of the sections, i.e. 6-15 seconds (TWT), varied from very good to excellent. Seismic reflections in the sedimentary part of the succession were, in general, very poor, but some surprisingly good seismic reflection events were obtained below the Pilliga Sandstone in the Gunnedah Basin.

The test survey indicated that the deep seismic reflection technique in the Gunnedah Basin and Cobar Basin would provide data that would be of assistance in developing new geological models, and an understanding of fault geometries and basin structure, and would assist the exploration for mineral and petroleum resources in the future.

INTRODUCTION

The Bureau of Mineral Resources, Geology & Geophysics (BMR) (now Australian Geological Survey Organisation (AGSO)) conducted seismic reflection test lines at five locations within the Gunnedah Basin and three locations within the Cobar Basin during April and May of 1989. The objective of the test seismic survey was to determine recording parameters along segments of proposed regional seismic lines across the Gunnedah Basin and the Cobar Basin, in an effort to acquire shallow and deep seismic reflection data. The proposed deep seismic reflection profiles were positioned to test geological models for major bounding faults and their relationship to formation of sedimentary basins and mineral deposits in the areas.

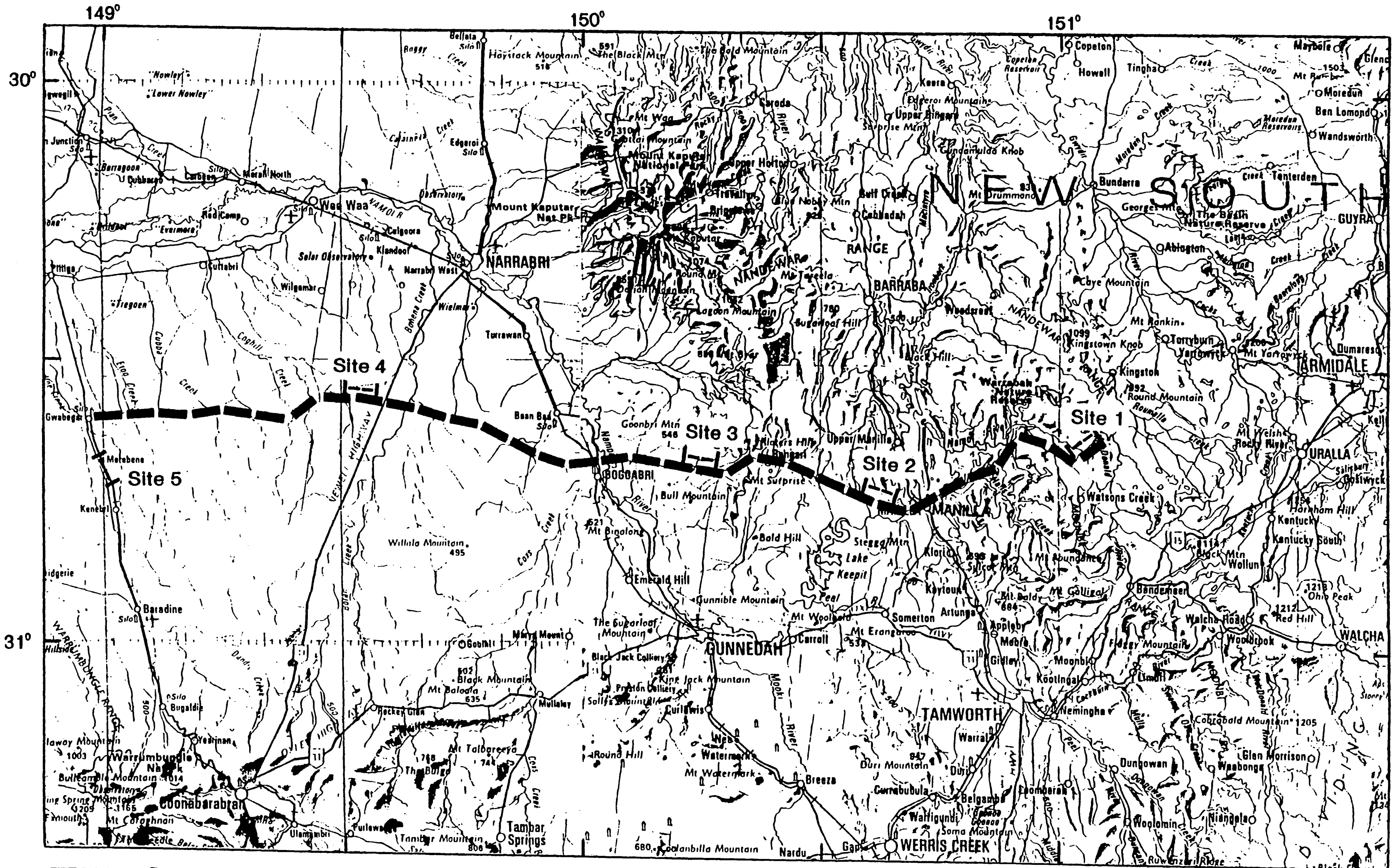
1.1 Background

A proposal for a deep seismic reflection profile over the Gunnedah Basin and New England Orogen of NSW was put forward by E. Scheibner of the NSW Department of Minerals and Energy (now NSW Department of Mineral Resources) as part of the Australian ACORP (Australian Continental Reflection Profiling) program (Scheibner, 1985). The seismic traverse suggested by Scheibner over the northern part of the basin (i.e. Uralla to Boggabri via Manilla) was seen by BMR to be the best alternative from a logistic and scientific point of view. Petroleum industry companies mooted that the line should also attempt to solve the problem of the location of the western margin of the basin. The proposed regional seismic line was therefore extended west of Boggabri to examine the western margin of the basin.

The Cobar Basin seismic survey was also proposed as part of the ACORP program and envisaged as a joint research project between the BMR, the NSW Department of Minerals and Energy and mining industry interests in the Cobar region. The profiles were designed and positioned to determine the three dimensional structure of the Cobar Basin. Emphasis would be placed on mapping the faults that delineate the northern and eastern boundaries, and detachment surfaces of thrust faults at depth.

1.2 Location

Location of the five test lines within the Gunnedah area are shown in Figure 1. Figure 2 is a map of the Cobar region showing the location of the three seismic test lines in that area. The seismic test lines are confined to the following 1:250000 topographic map sheets; SH 56-9 MANILLA, SH 55-12 NARRABRI and SH 55-14 COBAR. In the area east of Boggabri, 1:25000 maps were used to extrapolate AMG coordinates for the test lines and 1:250000 maps were used in other areas.



▬ ▬ ▬ Proposed Seismic Line

I--I Seismic Test Site 1989

0 km 20

Figure 1: Location Map, Gunnedah Basin

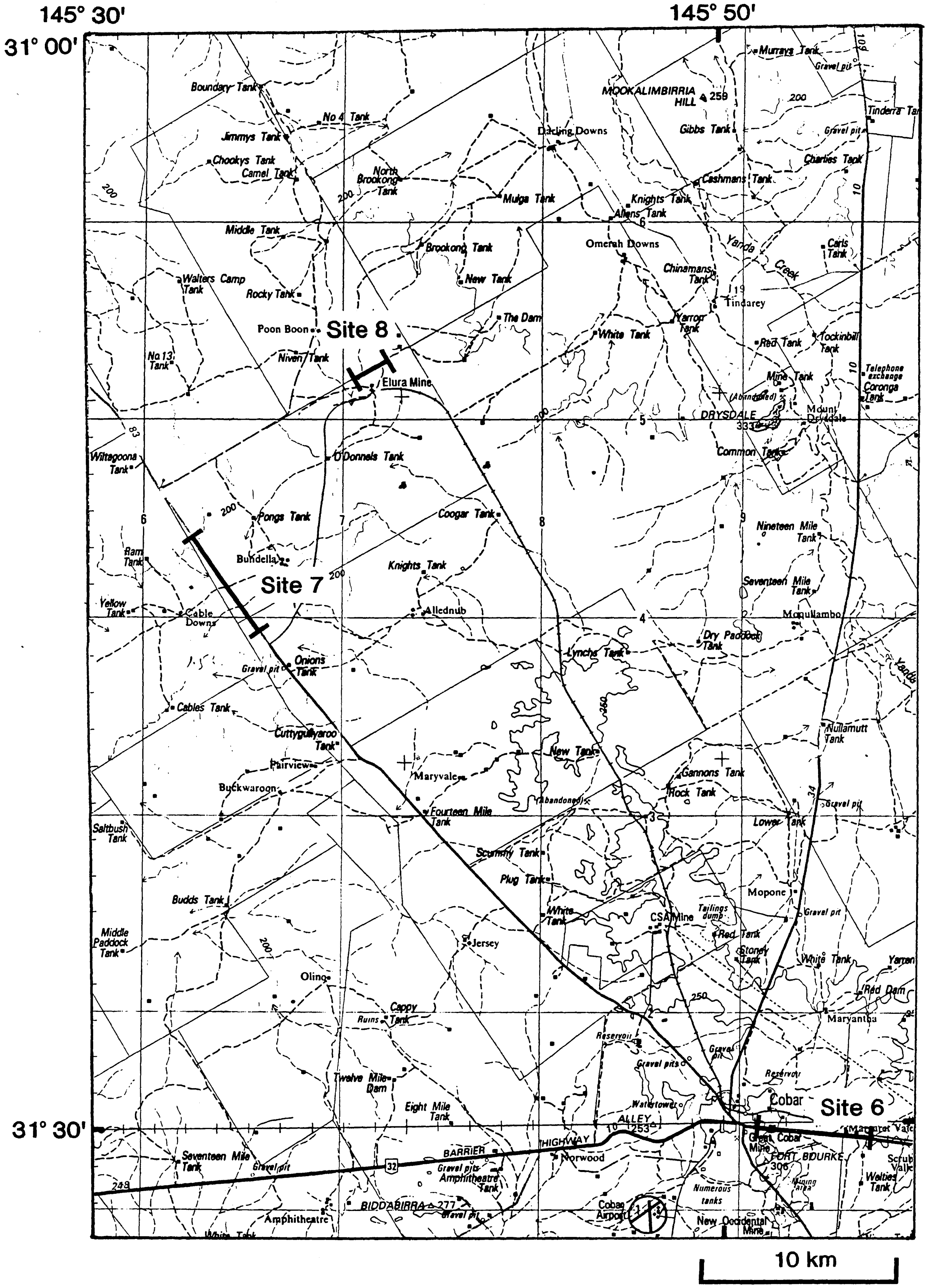


Figure 2. Location map, seismic test lines, Cobar area.

GEOLOGICAL SETTING

2.1 Gunnedah Basin

The proposed transect of the Gunnedah Basin is a study of a classic orogenic setting. Traversing eastwards from the Lachlan Orogen, the foreland basin (Gunnedah Basin) is separated on the east by a major thrust system (Hunter-Mooki-Goondiwindi Thrust System) from an overthrust belt (Tamworth Belt, New England Orogen); this is in turn separated by a major fault zone (Peel Fault) from the Tablelands Complex, New England Orogen. The transect has economic importance for hydrocarbon accumulations associated with the over-thrusting of the Sydney-Bowen Basin by the New England Orogen (Scheibner, 1985).

2.2 Cobar Basin

The Cobar Basin in central New South Wales is one of several early-middle Palaeozoic basins within the Lachlan Orogen. It is prospective for copper, gold, silver, lead and zinc. The gold and copper mineralisation is concentrated along the faulted eastern margin. The western margin of the basin may also be prospective, but it is covered by younger rocks and is therefore relatively unknown along much of its length. The Elura silver-lead-zinc deposit lies in the northern part of the basin, and its relation to the basin-forming structures is unknown. A recent tectonic model for the Cobar Basin suggests that the basin formed by extension, and that many of the extensional faults were later inverted as thrusts. Many of the known ore deposits lie on younger, short, cut back thrusts and fore thrusts that link to the major bounding faults of the region (Glen, 1988). This model has wide ranging implications for the prospectivity of the Cobar Basin, and also for other similar basins within the Lachlan Orogen.

FIELD OPERATIONS

3.1 Reconnaissance - Gunnedah Basin

Reconnaissance for the Gunnedah Basin test survey was undertaken in February 1989. The proposed transect was inspected and locations for test sites chosen. Local authorities were visited and informed of the planned seismic survey. The towns of Manilla, Narrabri and Coonabarabran were selected for accommodation and supply centres. Shire councils were particularly helpful with regards to vehicle and explosive storage. Permission was given by the NSW Department of Forestry to conduct a seismic test line within the Pilliga State Forest and the NSW National Parks and Wildlife Service were advised of the planned seismic test line locations.

3.2 Reconnaissance - Cobar Basin

The Cobar area was visited also in February of 1989 and test sites selected after consultation with geoscientists from the NSW Department of Minerals and Energy and mining companies. Two sites were chosen on shire roads and one site on a mining lease.

3.3 Surveying

Chaining, line pegging and levelling were performed by various members of the BMR seismic test survey team. Coordinate AMG values were extrapolated from available topographic maps. A list of AMG bendpoint coordinates for the seismic test survey lines appears in Appendix 6. Elevations for geophone stations are included in Appendix 7.

3.4 Drilling

Gunnedah Basin Area:

Drilling was slow on Lines 1, 2 and 3. Granites on Line 1 and hard silicified mudstones on Lines 2 and 3 hampered progress. Due to the hard drilling the majority of shotholes along Lines 1, 2 and 3 were drilled to between 10 and 20 m depths. Conditions improved on Lines 4 and 5 with sandstone and clays the predominant subsurface rocks with the majority of shotholes being drilled to 40 m.

Cobar Basin Area:

Drilling in the Cobar region presented no problems to shothole drilling production. All shotholes were drilled to 40 m depth and an uphole shoot at Elura would have been drilled deeper (than 105m), had more drill rod been available. Rock types drilled included weathered siltstones and shales. An inspection of the Elura underground mine drive, showed weathering of rocks to depths of around 30 m. On average each drilling rig drilled about 8 shotholes each of 40 m depth, in a standard drilling day (ie. 320m/10hr).

3.5 Explosives

A total of 1920 kg of seismic explosives was used for the survey. Shotholes were loaded with 10 kg explosive charges and solid tamped with drill cuttings. Line 7 and 8 were loaded with 23 kg charges in each hole and an extra 16 holes on Line 8 were loaded with 2 kg charges. Explosive charges were supplied in 2 kg plastic sleeves from Dyno-Westfarmers. Charge assemblies were formed at the shothole locations using five 2 kg charges placed into rigid plastic tubes and primed with an electric detonator.

3.6 Recording

The Sercel SN368, 96 channel digital seismic acquisition system was used by BMR to record all the seismic data. Ninety six station units were laid on the ground at 60 m spacing (20 m on Line 8). Connected to these units were strings of sixteen geophones planted in-line over the 60 m geophone station interval. The recorder was parked at least 400 m away from the end of the geophone recording spread in order to reduce the generator noise from the recording truck being detected by the geophone arrays. Shots were fired at each end of the spread and at 360 m intervals along the recording spread. An uphole signal was also recorded for each shot for the purposes of static corrections. Most lines were situated on existing roads or tracks and as such were affected by cultural noise. This was most evident on Line 6 at Cobar where domestic and commercial 50 hz electricity power lines induced noise on many of the geophone recording channels. On Line 8, low frequency noise from the crushers and concentrate mill at the Elura mine severely degraded the seismic data quality. A 96 channel spread could be laid down, recorded, and picked up again, by a 6 person crew in one day.

3.6.1 Line 1

Objective: CMP deep seismic reflection recording to test for the quality of deep seismic events beneath adamellite granites of the Bundarra Plutonic Suite, east of the Peel Fault.

Location: 40 km ENE along the road from Manilla to Uralla, NSW.

Seismic Tests: Due to hard drilling conditions (near surface granites), 15 shotholes were drilled with an average depth of 15 m. Average charge size was 10 kg, with shots recorded by a 96 channel spread, 5.7 km in length, with geophone group interval of 60 m. In addition three shots were recorded by the NSW Department Minerals and Energy using a high resolution seismic acquisition system.

3.6.2 Line 2

Objective: CMP deep seismic reflection recording to test for the quality of deep seismic events beneath the Tamworth Belt, New England Orogen, between the Mooki and Peel Faults .

Location: 15 km west of Manilla, along the Manilla to Boggabri road.

Seismic Tests: Seventeen shotholes were drilled with an average shothole depth of 22 m. Drilling conditions were variable, with very hard siliceous mudstones encountered in the majority of holes which slowed drilling dramatically. Average charge size was 10 kg, with shots recorded by a 96 channel spread, 5.7 km in length, with geophone group interval of 60 m.

3.6.3 Line 3

Objective: CMP deep seismic reflection recording to test for the quality of deep seismic reflection events across the Mooki Fault, a major eastern boundary feature of the Gunnedah Basin.

Location: 25 km east of Boggabri, along the road from Boggabri to Manilla.

Seismic Tests: Seventeen shotholes were drilled with an average depth of 31 m. Drilling was average with some water injection, and some hard drilling due to floaters of basalt in the near surface Quaternary sediments. Average charge size was 10 kg, with shots recorded by a 96 channel spread, 5.7 km in length, with geophone group interval of 60 m.

3.6.4 Line 4

Objective: The seismic test site was located in an area of outcropping Pilliga Sandstone, regarded as being deeply weathered and an area considered to produce very poor quality seismic reflection data. It was considered by BMR that incorrect acquisition parameters by previous seismic surveys had resulted in the poor data quality, and a reappraisal was necessary using a deep uphole shoot, and noise tests. A CMP deep seismic reflection recording spread was also recorded to test for the quality of deep seismic reflection events on the western margin of the Gunnedah Basin.

Location: 31 km SSE of Narrabri, 1 km west of the Newell Highway joining Narrabri and Coonabarabran, along Sparrow Road.

Seismic Tests: A 60 m uphole shoot was recorded at SP 4036, indicating the base of weathering at a depth of 18 m, with a sub-weathering velocity of 1840 ms^{-1}. The uphole shoot was recorded using an off-end array of 12 geophones spaced at 5 m geophone intervals. A noise shoot was also recorded into 96 single geophones spaced 1 m apart. Two offset shots at 95 m and 190 m were also recorded into the noise spread. Twenty shots with an average depth of 40 m and 10 kg charge size were recorded into a 96 channel spread, 5.7 km in length with a geophone group spacing of 60 m. Four high resolution seismic reflection recordings were made also by NSW Department Minerals and Energy.

3.6.5 Line 5

Objective: CMP deep seismic reflection recording to test the quality of deep seismic events in the area west of the Rocky Glen Ridge. The NSW Department Minerals and Energy (Yoo, 1988) had interpreted a possible Permo-Triassic sub-basin in this region based on a gravity low anomaly and a major objective of this line was to test for the presence of the interpreted sub-basin.

Location: 25 km NNW of Baradine, along the Baradine to Pilliga road, NSW.

Seismic Tests: Seventeen shots with an average shothole depth of 39 m and average charge size of 10 kg were recorded into a 96 channel spread, 5.7 km in length with a geophone group interval of 60 m. In addition a charge depth and charge size comparison test was made using 5 additional shots.

3.6.6 Line 6

Objective: CMP deep seismic reflection recording to test the quality of deep seismic events across a type example of mineralisation and structural setting in the Cobar region.

Location: 1 km east of Cobar along the Cobar to Nyngan Road.

Seismic Tests: Seventeen shots with average shothole depths of 40 m with an average charge size of 8 kg were recorded into a 96 channel spread, 5.7 km in length with a geophone group interval of 60 m and shot interval of 360 m. Drilling conditions were very good, requiring only air injection with blade bits.

3.6.7 Line 7

Objective: CMP deep seismic reflection recording to test the quality of deep seismic events within the central portion of the Cobar Basin.

Location: 35 km NW of Cobar along the Cobar to Louth Road, 950 m NW of the turn-off to the Elura Mine.

Seismic Tests: Seventeen shots with average shothole depths of 40 m with an average charge size of 23 kg were recorded into a 96 channel spread, 5.7 km in length with a geophone group interval of 60 m and shot interval of 360 m. Drilling conditions were very good, requiring only air injection with blade bits.

3.6.8 Line 8

Objective: CMP deep seismic reflection recording to test the quality of deep seismic events across a known occurrence of sulphide mineralisation at 400 m depth at the Elura Mine site, Cobar, NSW.

Location: 49 km NW of Cobar, within the boundaries of the Elura Mine. The seismic test line was located across Pod 5 zone of mineralisation.

Seismic Tests: Seventeen shots with average shothole depths of 40 m with an average charge size of 23 kg were recorded into a 96 channel spread, 1.9 km in length with a geophone group interval of 20 m and shot interval of 120 m. Although geophone take-out positions were located at 20 m intervals, geophone sets were spread over 60 m, to attenuate ground roll noise as much as possible. In addition a further 16 shots were positioned mid-way between the 23 kg shots, with an average depth of 40 m and charge size of 2 kg and recorded into a 96 channel spread, 1.9 km in length with geophone group interval of 20 m using single 8 hz geophones. The second spread arrangement was used in an attempt to record higher resolution seismic data at shallow depths across the mineralised zone. An uphole shoot was also performed over Pod 5 at the Elura mine site. Maximum depth of the uphole shoot was 105 m, with shots fired at 5 m intervals up the hole.

DATA PROCESSING

All seismic data from the survey were processed at BMR using DISCO processing software running on a VAX computer. The end product of the processing is a 'Final Stack' section of all test lines. The processed seismic sections are presented in Figures 3 through to Figure 16. Besides producing CMP stacked sections of the seismic data, shot gather displays and near trace gathers displays were also produced to assist in quality control during seismic data processing. The seismic data processing steps taken in the production of the 'Final Stack' are shown in Table 1. The processing sequence differs little from test line to test line except for parameters used in datum corrections.

Although seismic data from test Line 8 were processed, the seismic signal was saturated with 8 hz seismic noise from the Elura mine crushing and processing plant (ie. insufficient dynamic range of the system to resolve smaller seismic reflection signals). All efforts to remove the 8 hz noise proved unsuccessful, hence seismic sections for test Line 8 are not displayed. Future seismic surveys in the vicinity of crushing and processing plants should consider using a seismic acquisition system with programmable selectable notch filters options (eg. I/O System 1), or systems with the new 24-bit delta-sigma analog to digital converter technology having 120 db of dynamic range (Abrams and Brook, 1992).

Table 1: Seismic Data Processing sequence

1. Demultiplex SEGD to DISCO internal format
2. Geometry definition
3. Quality control displays and edits
4. Spherical divergence correction
5. Spike removal
6. Statics computation
7. CDP sort
8. Velocity analysis and NMO correction
9. Pre stack NMO mute
10. Time varying equalisation (gate length = 500ms)
11. CDP stack
12. Band pass filter
13. Time varying equalisation (gate length = 1000ms)
14. Coherent signal enhancement (Digistack)
15. Display

RESULTS

CMP final stack seismic sections displays, both to 4 seconds and 20 seconds TWT (Two-Way Travel) time for seismic test Lines 1 through to 7 are shown in Figures 3 to 16. Overall, the seismic reflection data sets from the test sites provide information to reinforce support for major seismic surveys in the Gunnedah Basin and Cobar Basin. The seismic test data also enables acquisition parameters to be defined for a major survey, (ie. optimal shot depths, charge sizes and spread configurations). Acquisition parameters for a major survey in the Gunnedah Basin are discussed further in Korsch & others (1990).

Gunnedah Basin area:

Test Line 1:

Shothole drilling on Line 1 was very slow due to near surface granites of the Bundarra Plutonic Suite. Provided shotholes are drilled to a depth of about 15 m, the shot charges are placed below the weathered layer. The seismic section shown in Figure 3, indicates west dipping features within a non-reflective zone down to 3 seconds TWT time. The strong reflection events at about 3 s TWT time are interpreted to be the base of the granite pluton.

Test Line 2:

The acquisition of test Line 2 showed that shothole drilling was very slow in very hard silicified mudstones. Provided shothole depths are drilled to about 22 m depth the shot charge would be placed below the weathered layer. The seismic section in Figure 4 shows many reflection events with diffraction events occurring at 1.6 s TWT time. The reflection events can be interpreted to be from sedimentary horizons of the sedimentary succession of the Tamworth Belt. Figure 11 shows strong deep reflection events between 9-10 s TWT time, giving strong support that a regional deep seismic reflection profile would record good quality deep reflection events from the lower crust under the Tamworth Belt.

Test Line 3:

Test Line 3 was located across a geologically inferred position of the Mooki Fault. Shothole drilling was difficult in Quaternary sediments consisting of sands, clays and gravels and floaters of basalt. Shothole depths were drilled to 31 m, a depth close to the base of the weathered layer. Figure 5 shows a seismic section with many reflection events down to 2 s TWT time. The reflection events are interpreted to be from sedimentary layers within the Maules Creek Sub-basin. The structure of the Mooki Fault is not apparent on the seismic section, with most reflection events dipping to the east. A regional seismic line would provide an extended dataset imaging sediments of the Maules Creek Sub-basin and possibly highlighting the structure of the Mooki Fault.

Test Line 4:

Shothole drilling in the Pilliga Sandstone was good, requiring only air and water injection drilling techniques. The uphole shoot showed that the depth of weathering was 18 m, highlighting the fact that shothole depths would need to be drilled to at least 20 m or more to enable the shot charges to be placed below the weathered layer. Earlier seismic surveys in the area using explosive seismic sources drilled shotholes to only 6 m depth, which could explain the poor data quality with shot charges placed within the weathered layer. Figure 6 shows a seismic section with strong reflection events down to 2 s TWT time from sedimentary layers within the West Gunnedah Sub-basin. The deep seismic section in Figure 13 shows several deep seismic reflection events at 6 s and 11.5 s TWT time, providing additional encouragement for a regional deep seismic reflection profile.

A graphical representation of the uphole shoot in the Pilliga Sandstone is shown in Figure 17. A Meissner plot of the uphole shoot is shown in Figure 18, illustrating the interpretation of a low velocity layer between 13 to 18 m depth. The higher velocity near the surface could perhaps be explained by water saturation of the Pilliga Sandstone from heavy rainfall in the area prior to the seismic test survey.

Test Line 5:

Shothole drilling along test Line 5 was good, with shotholes drilled on average to 39 m depth. The initial shot record monitors during acquisition showed the existence of a high velocity refractor layer of 5500 ms^{-1} at very shallow depths of 300 m. CMP stack processing confirmed the initial results as shown in Figure 7. Based on the seismic results and the gravity low anomaly, the geological body causing the gravity low is now interpreted to represent a low density granitic pluton, rather than a sedimentary Permo-Triassic sub-basin. Strong reflection events at 2 s TWT time could be interpreted to be the base of the granitic pluton. Deep seismic reflection events were also recorded down to 13 s TWT time, again reinforcing support for the recording of a regional deep seismic reflection profile to assist in developing geological models of the Gunnedah Basin and bounding margins.

Cobar Basin area:

Test Line 6:

Discontinuous seismic reflections events were recorded from 0 to 4 s TWT time on test Line 6 across the Rookery Fault on the eastern margin of the Cobar Basin, as shown in Figure 8. Some deeper seismic reflections were recorded at 8 s TWT time as displayed on Figure 15. Although the near surface reflection events were discontinuous and of poor quality, the deeper seismic data shows some encouragement for a regional seismic survey to record deep seismic reflection events in the Cobar Basin region.

Test Line 7:

The results from test Line 7 were similar to those from test Line 6. Shallow reflection events were discontinuous and weak (Figure 9) with strong deep seismic reflection events recorded between 8 and 12 s TWT time (Figure 16). The deep seismic reflection data across the Buckwaroon Fault further enhanced the viability of a regional deep seismic reflection survey to record good quality deep seismic reflection data across the Cobar Basin and bounding margins.

Test Line 8:

As stated before, no figures are shown for the seismic data recorded over Pod 5, at the Elura Mine, due to the poor quality of the data and saturation of the seismic signal by noise generated from the crushing and processing plants at the Elura Mine. However results of the uphole shoot are shown in Figure 19, with the depth of weathering interpreted to be at 30 m depth. Some of the uphole shoot recordings did show a hint of very shallow, steeply dipping reflection events, but were not conclusive. The uphole shoot recordings into single geophones spaced at 5 m intervals may have however demonstrated that for successful recording of very shallow reflection events in mineral target areas, close geophone group intervals (less than 5 m) are necessary. Wider geophone spacings results in spatial aliasing of the seismic data causing seismic reflection events not to be resolved. Future seismic surveys over shallow depth, small mineral ore-body targets should have geophone group spacings of perhaps 2 m or even 1 m, depending on the size of the target objective.

ACKNOWLEDGEMENTS

Thanks are expressed to Barry Drummond for his notes on the geological setting of the Cobar Basin. Assistance from the NSW Department of Minerals and Energy, Elura Mine, NSW Department of Forestry, Road Traffic Authority, NSW National Parks and Wildlife Services and Manilla, Coonabarabran and Cobar Shires is also acknowledged.

SITE 1

Seismic Test Section

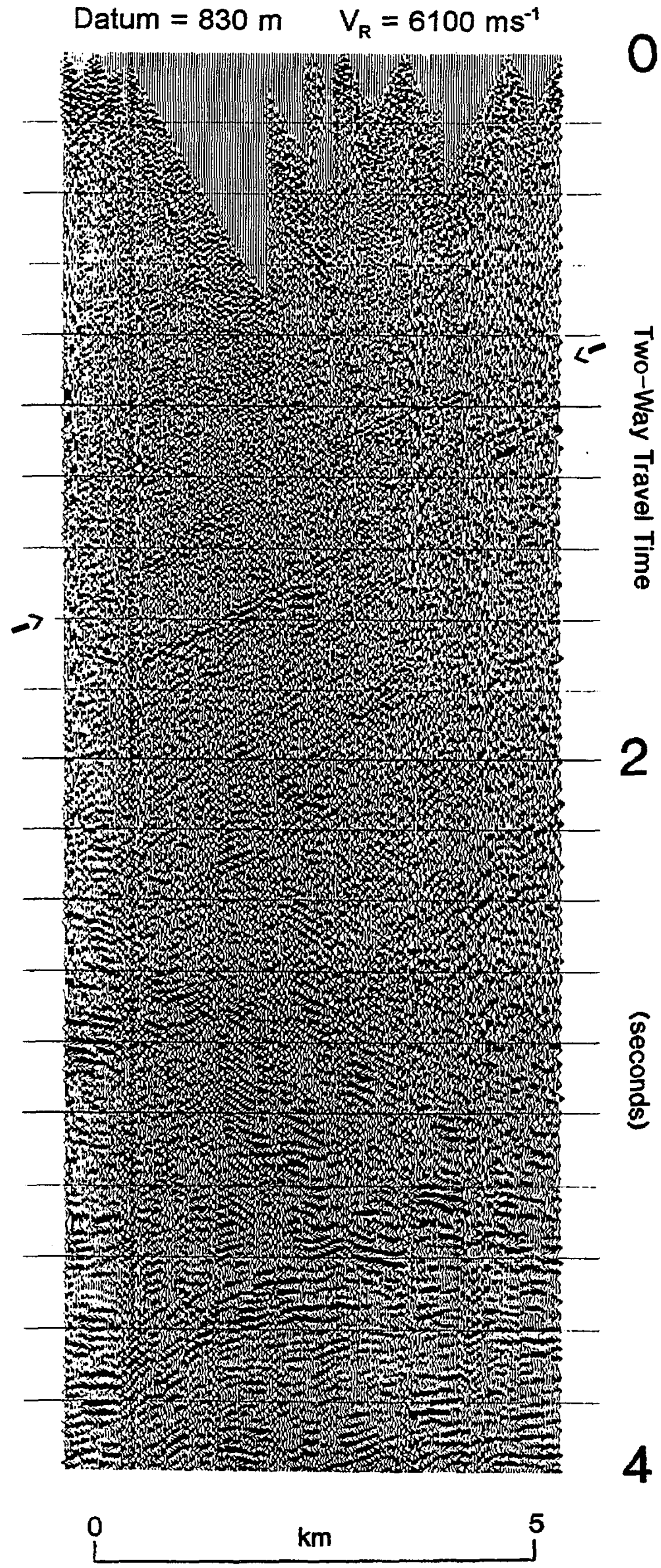


Figure 3: East of the Peel Fault, with surface outcropping Adamellite Granites.

SITE 2

Seismic Test Section

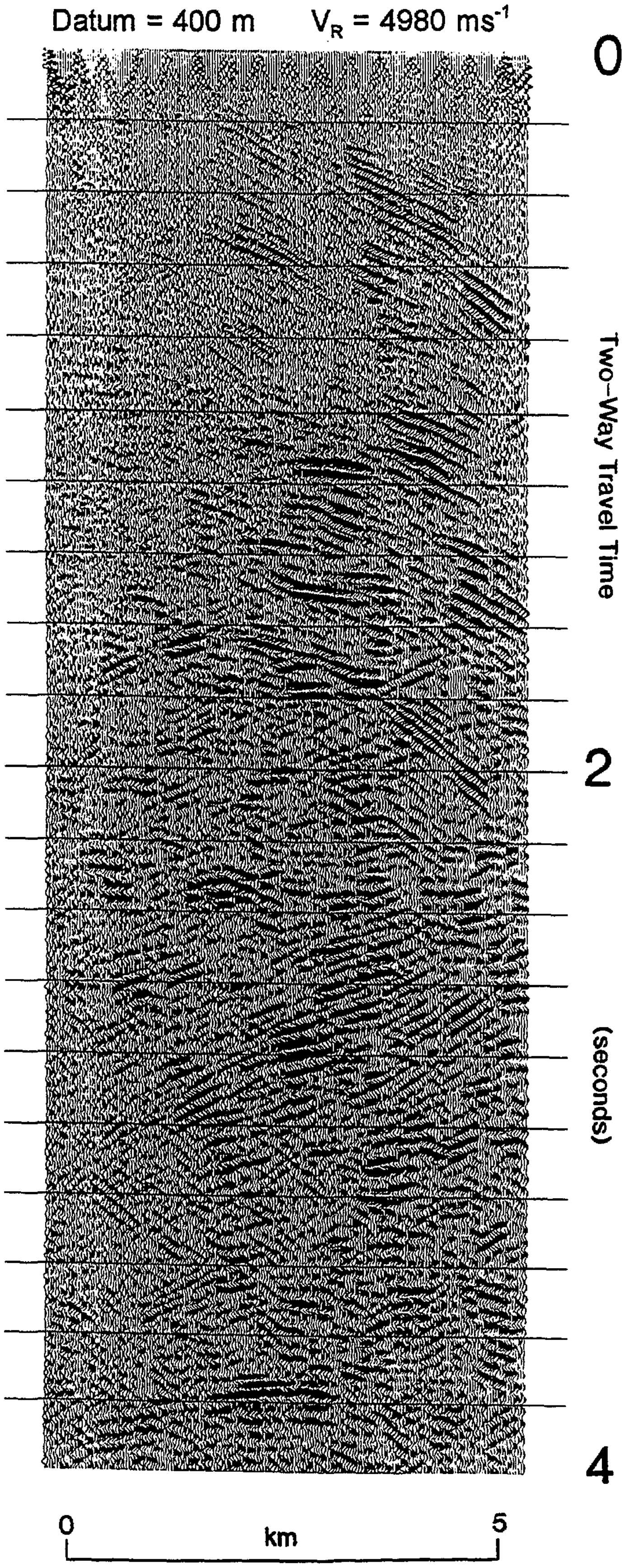


Figure 4: Between the Mooki and Peel Faults.

SITE 3

Seismic Test Section

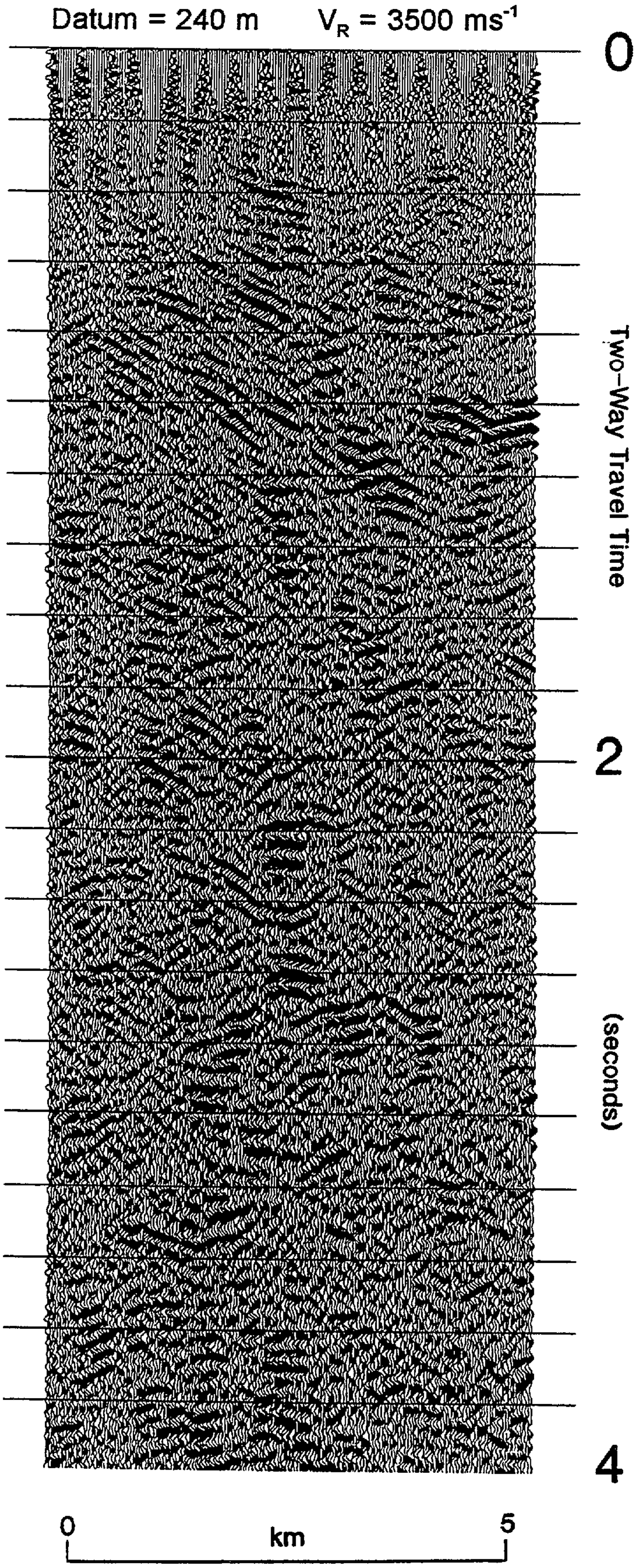


Figure 5: Across the Mooki Fault.

SITE 4

Seismic Test Section

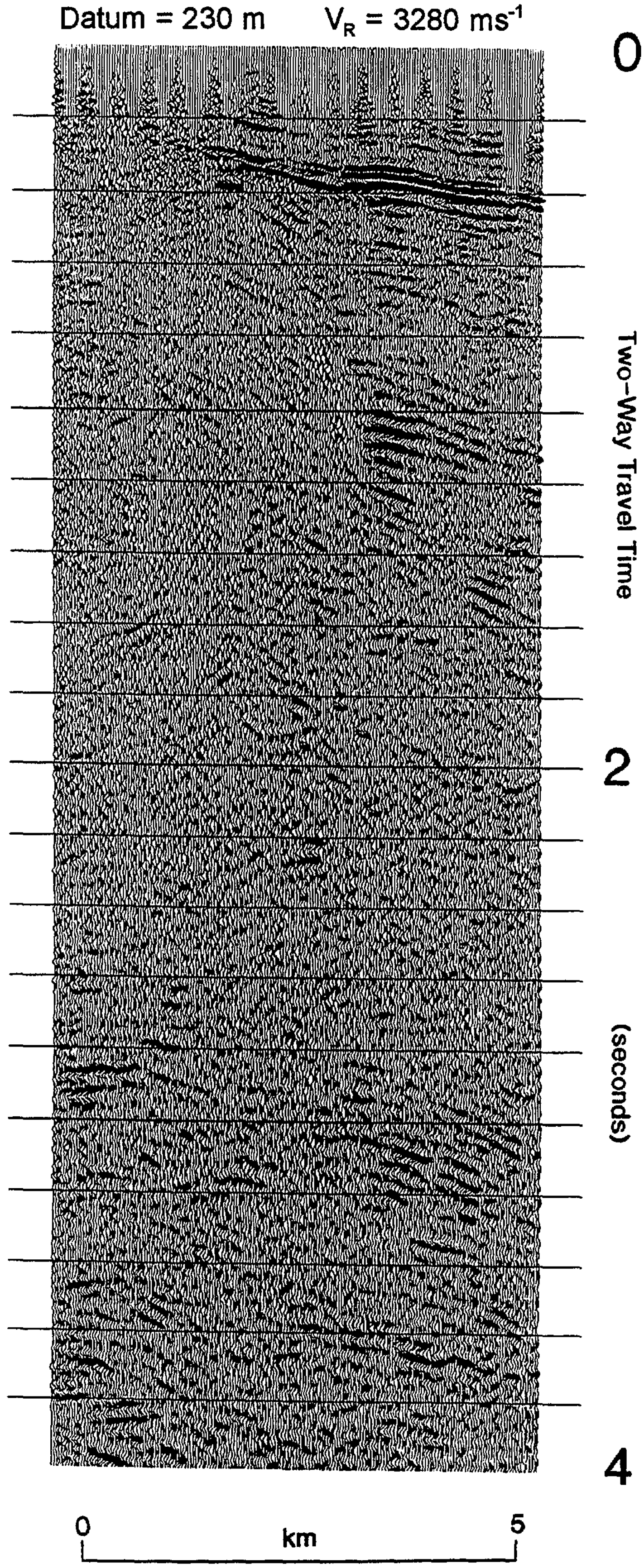


Figure 6: Area of outcropping Pilliga Sandstone, western margin of the Gunnedah Basin.

SITE 5

Seismic Test Section

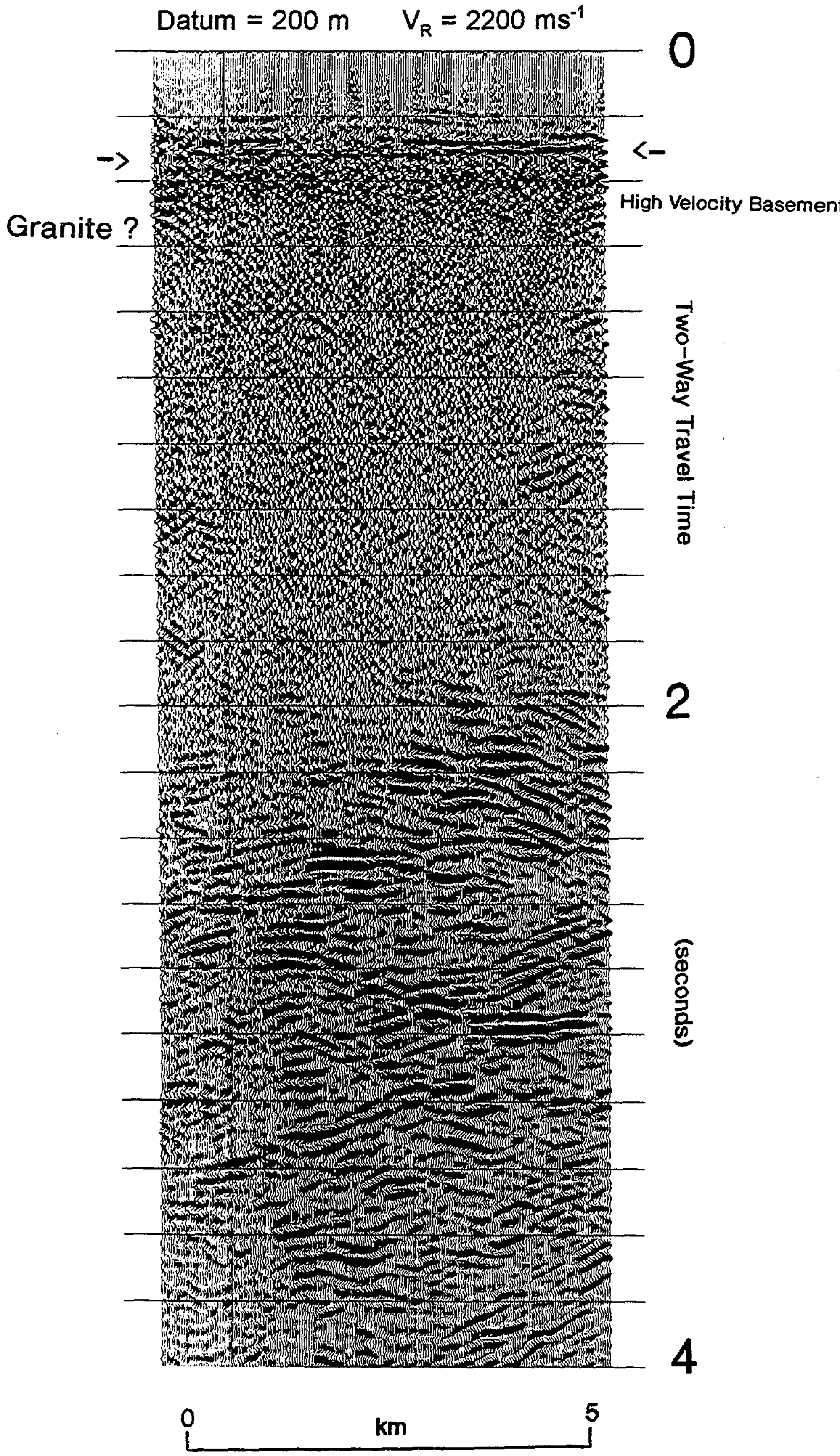


Figure 7: West of the Rocky Glen Ridge, across a postulated Permo–Triassic sub-basin.

SITE 6

Seismic Test Section

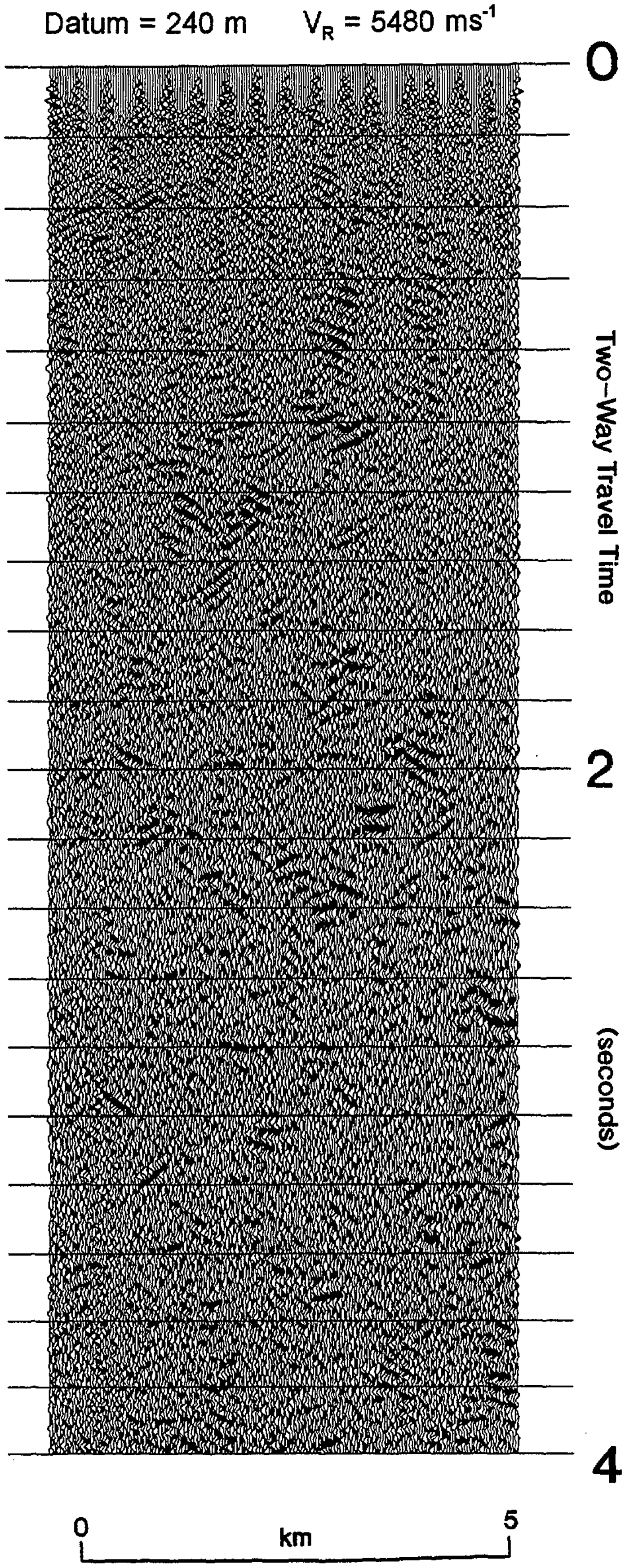


Figure 8. Across Rookery Fault, Cobar area.

SITE 7

Seismic Test Section

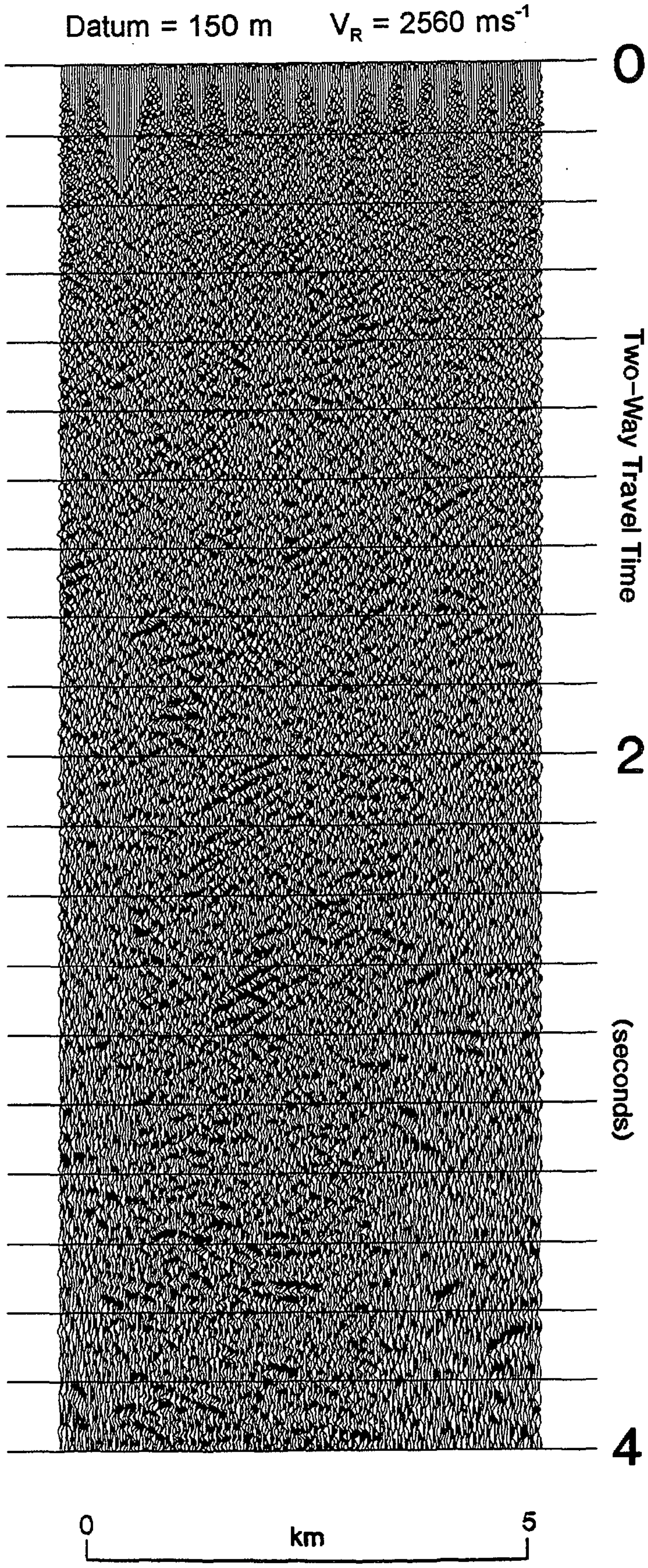


Figure 9. Across Buckwaroon Fault, Cobar area.

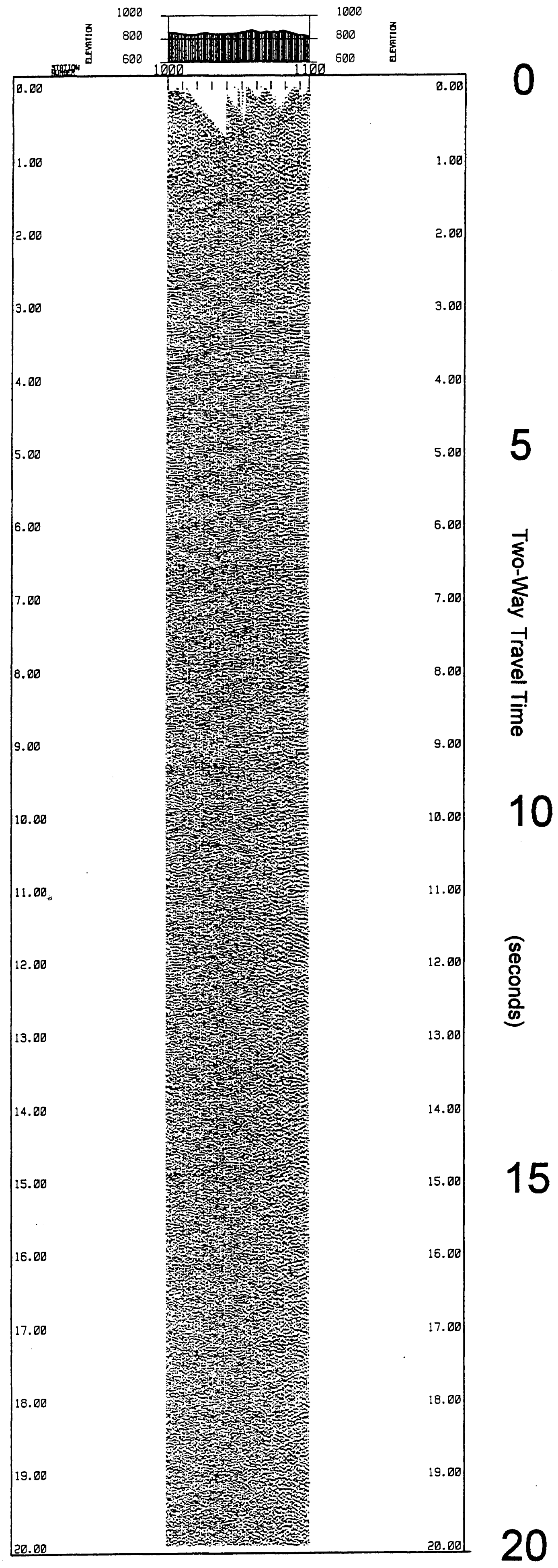


Figure 10. Seismic Test Line 1, 20 sec TWT seismic section

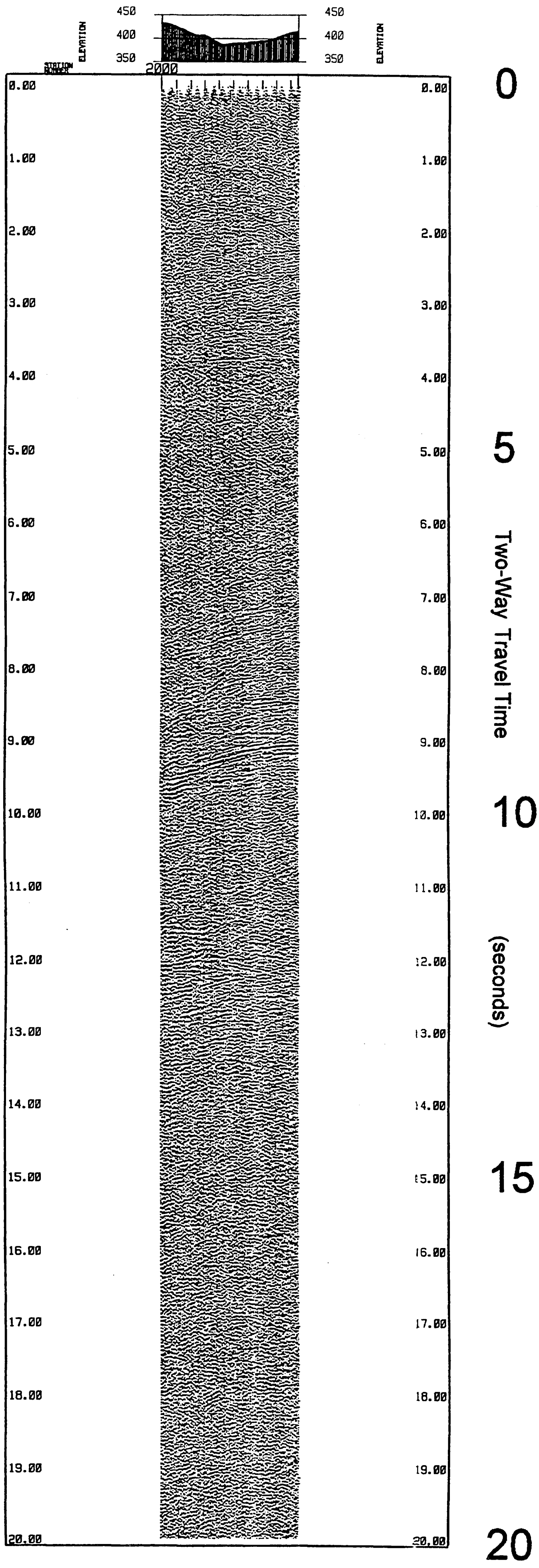


Figure 11. Seismic Test Line 2, 20 sec TWT seismic section

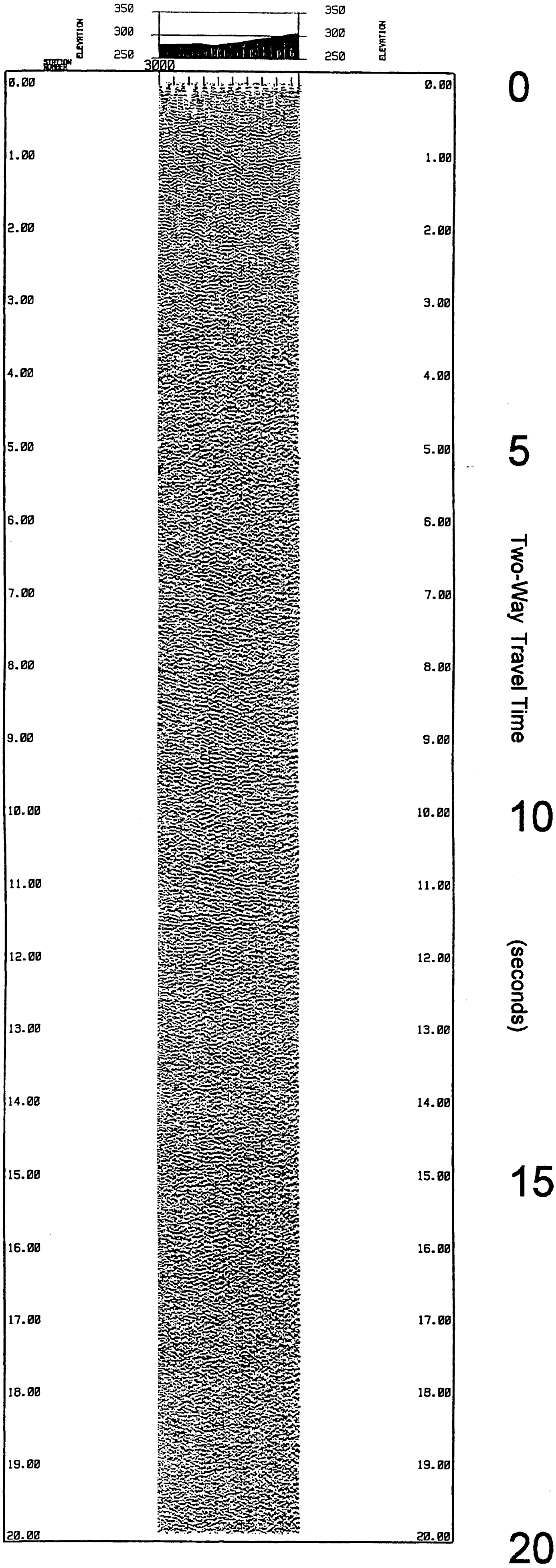


Figure 12. Seismic Test Line 3, 20 sec TWT seismic section

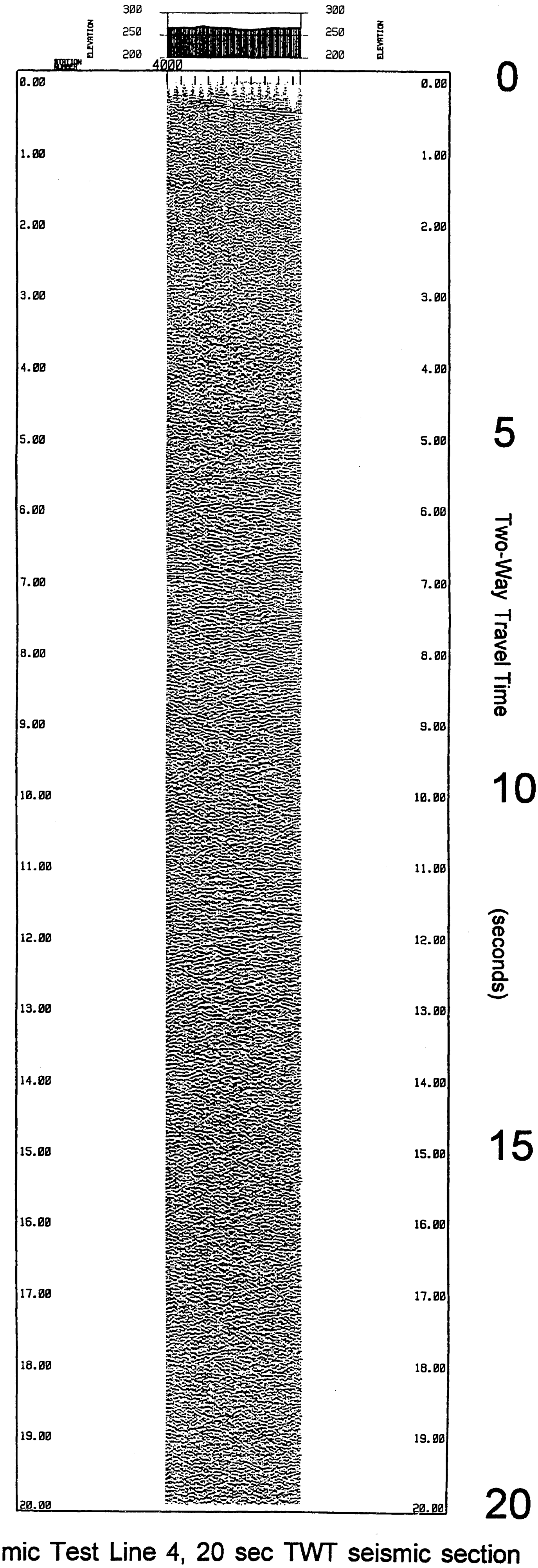


Figure 13. Seismic Test Line 4, 20 sec TWT seismic section

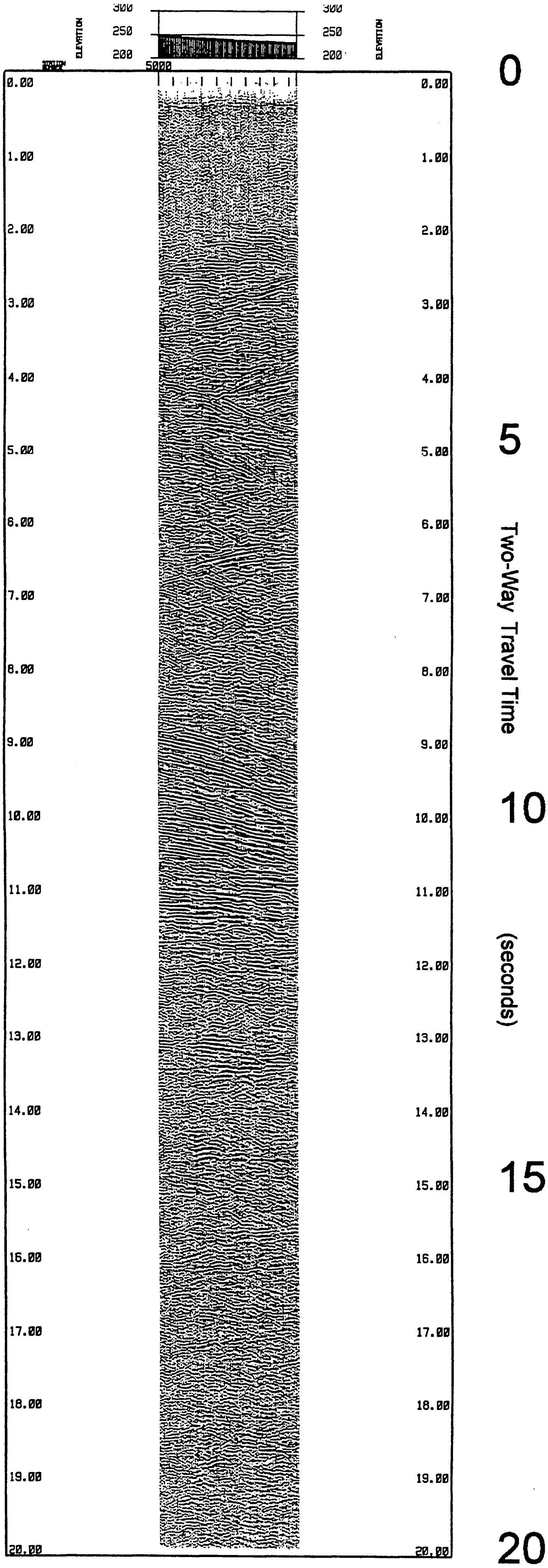


Figure 14. Seismic Test Line 5, 20 sec TWT seismic section

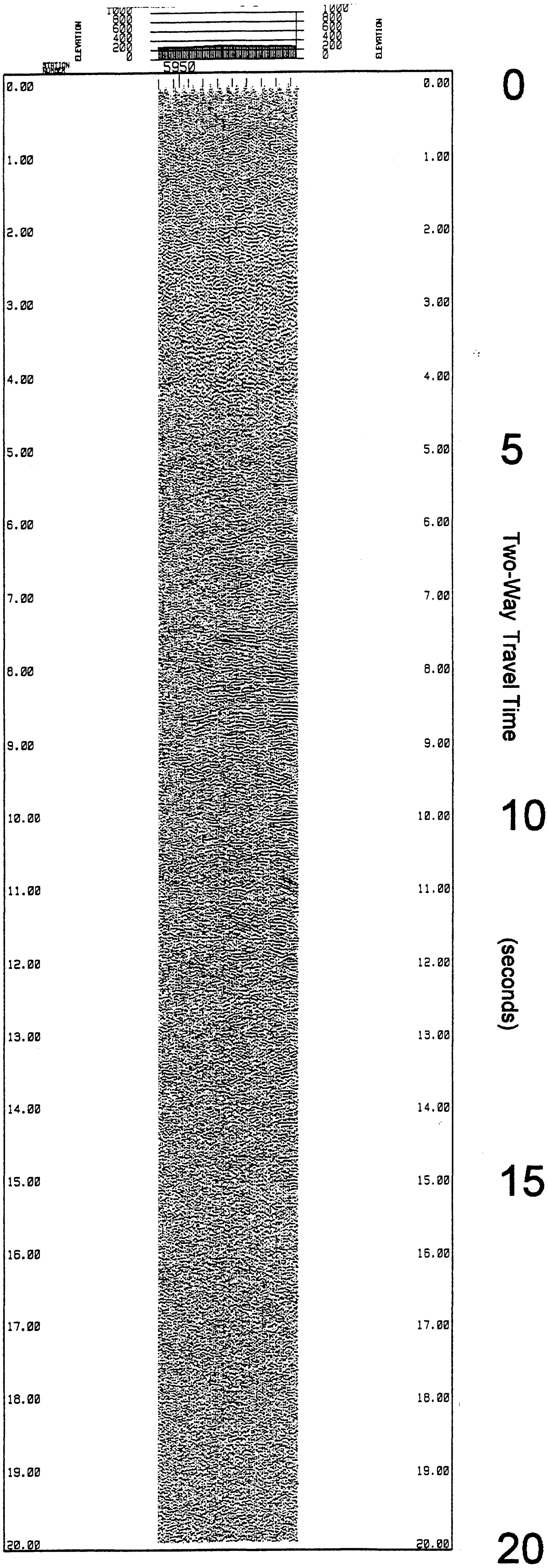


Figure 15. Seismic Test Line 6, 20 sec TWT seismic section

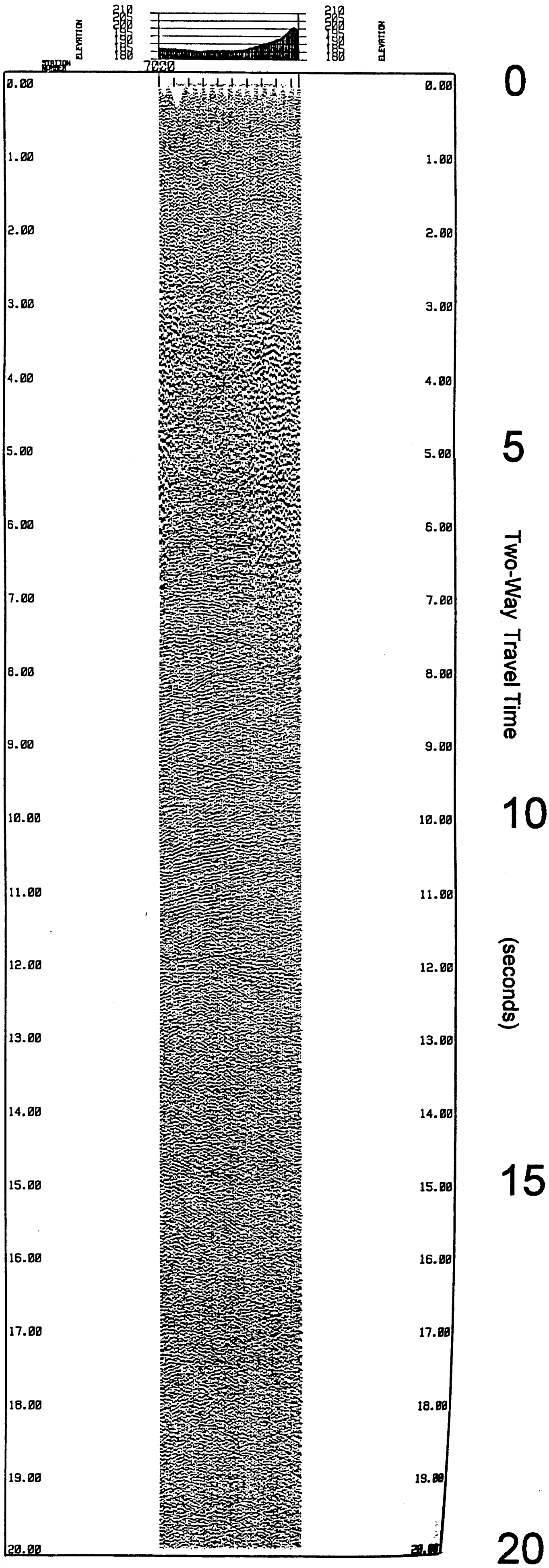


Figure 16. Seismic Test Line 7, 20 sec TWT seismic section

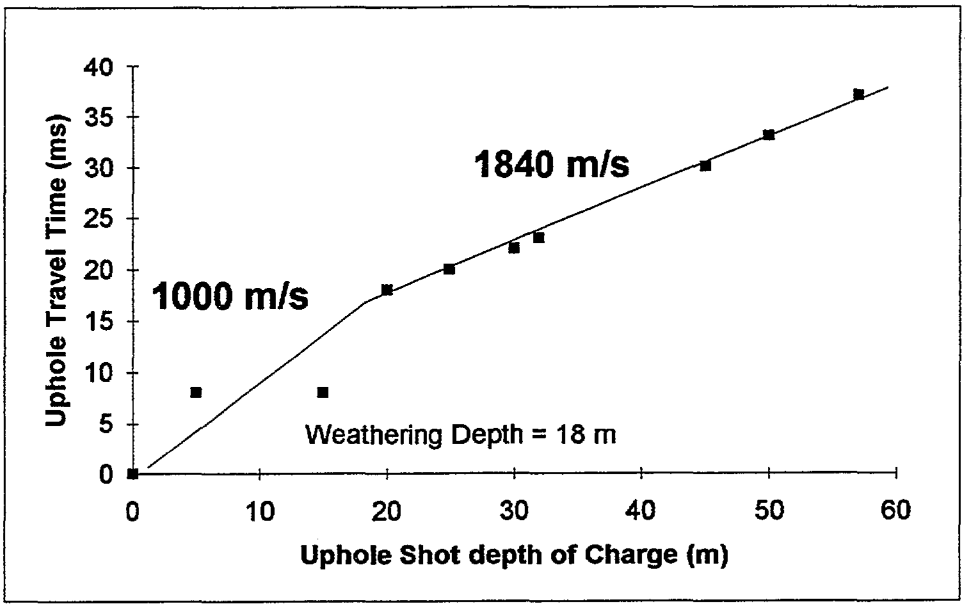


Figure 17. Uphole Shoot, Test Line 4, SP4036

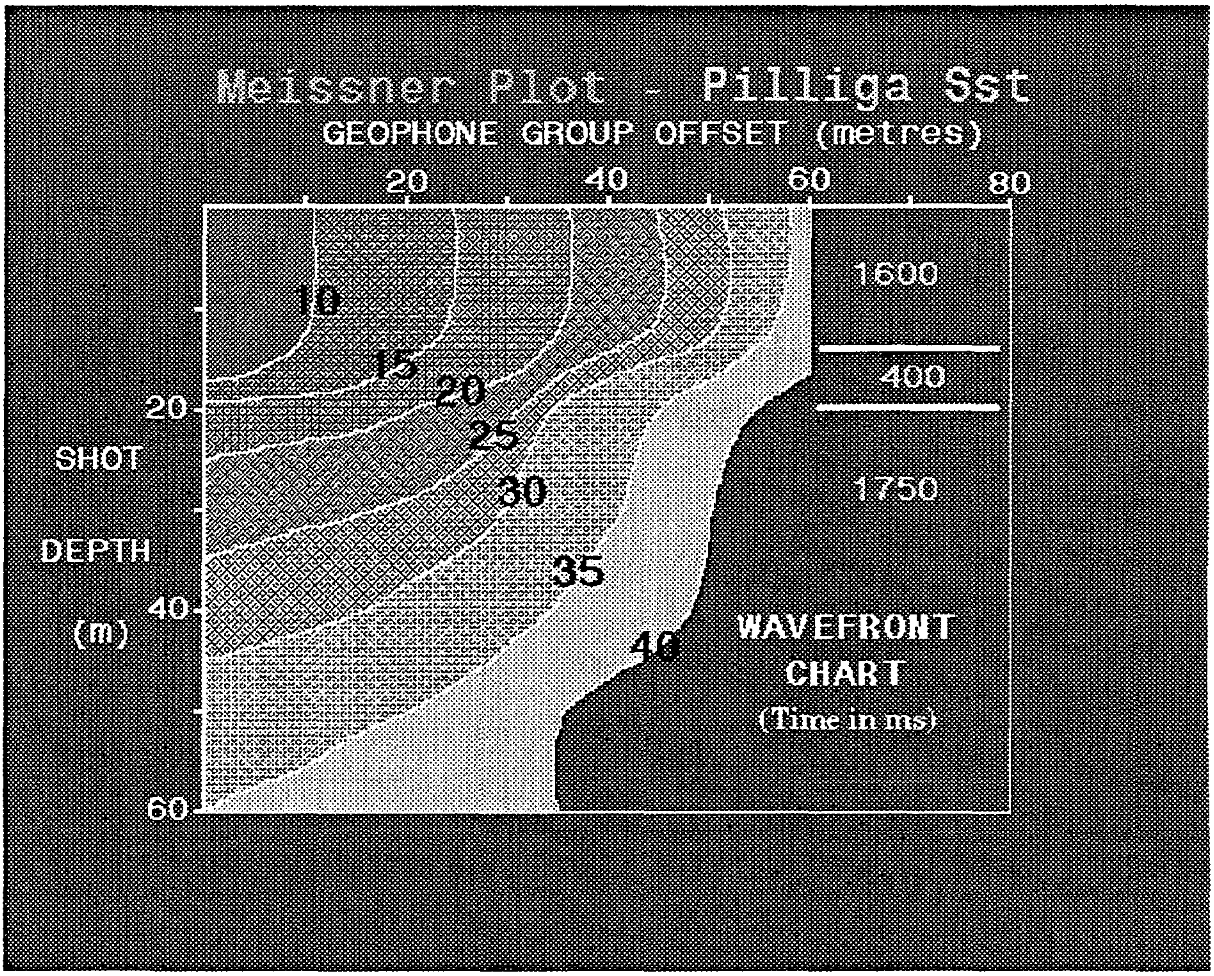


Figure 18. Meissner plot of uphole shoot, Line 4, SP 4036.

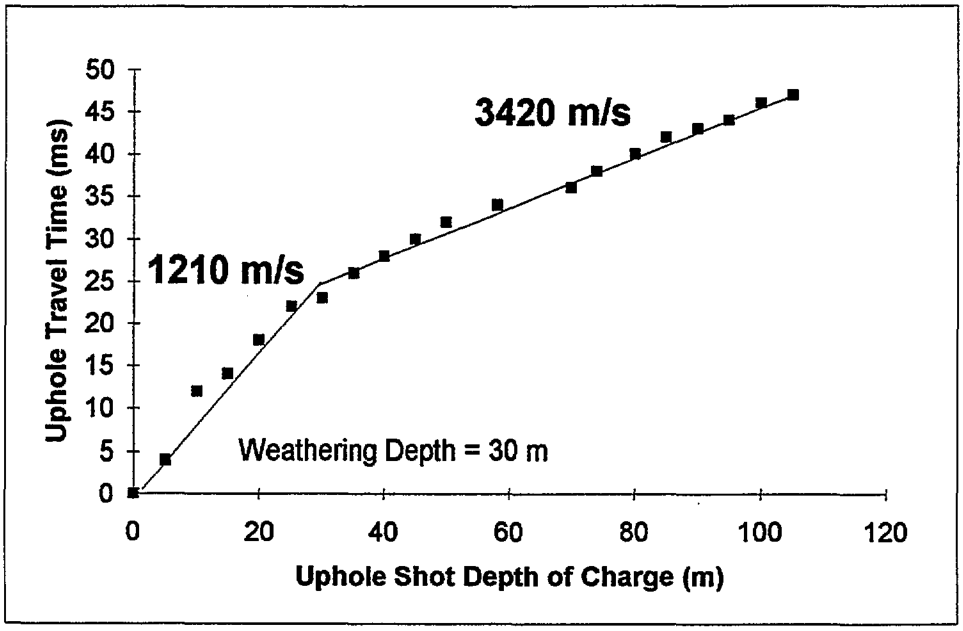


Figure 19. Uphole Shoot, Test Line 8, SP 150

REFERENCES

Abrams, L.A. and Brook, R.A., 1992. Increased Precision in Seismic Acquisition. *Handbook / Abstracts Volume, ASEG 9th Geophysical Conference and Exhibition, p 21.*

Glen, R.A., 1988 - Basin Inversion, Thrusts and Ore Deposits at Cobar, New South Wales: A Preliminary Report. *Geological Survey of New South Wales, Quarterly Notes, 73, 21-26, 1988.*

Korsch, R.J., Wake-Dyster, K.D. and Johnstone, D.W., 1990. Land seismic data acquisition proposal: Gunnedah Basin, New South Wales. *Bureau of Mineral Resources, Australia, Record, 1990/93.*

Scheibner, E., 1985 - Proposal for an ACORP profile through the Gunnedah Basin and New England Fold Belt. *Bureau of Mineral Resources, Australia, Record, 1985/7, 27-29.*

Yoo, E.K., 1988. The Rocky Glen Ridge and Gilgandra Trough, beneath the Surat Basin. *Quarterly Notes of the Geological Survey of New South Wales, 72, 17-27.*

APPENDIX 1

Operational Statistics

Drilling commenced	12/4/89
Surveying commenced	12/4/89
Recording commenced	14/4/89
Drilling completed	01/5/89
Surveying completed	03/5/89
Recording completed	03/5/89

Test Line	Number of shotholes	Metres drilled	Average shothole depth (m)	CMP coverage (km)	Average charge size (kg)	Number of detonators used
Line 1	15	227	15	5.7	10	18
Line 2	17	375	22	5.7	10	17
Line 3	17	533	31	5.7	10	17
Line 4	21	848	40	5.7	10	36
Line 5	22	796	39	5.7	10	22
Line 6	17	680	40	5.7	8	18
Line 7	17	680	40	5.7	23	17
Line 8	34	1425	40	1.9	13	52
TOTAL	160	5564	33	41.8	12	197

APPENDIX 2

Personnel

Party leader	Kevin Wake-Dyster
Geophysicist	David Johnstone
Technical Officer (Sc)	Geoff Price
Technical Officers (Eng)	Glen Jennings
	Jim Whatman
Drillers	Ned Lodwick
	Des Eaton
Drillers Assistants	Tim Johnson
	Barry Dickinson
Pre-loaders	Ron Cherry
	Alan Crawford
Field Assistant	Alex Takken

APPENDIX 3

Vehicles

Drilling rigs	2 x Mayhew 1000/Mack 6 x 8 trucks
Water tankers	2 x Mack 6 x 6 trucks
Mobile magazine	1 x International ACCO 1830C
Pre-loader	1 x Toyota 4 x 4 tray top
Recorder	1 x Mercedes Benz 4 x 4
Jug buggies	2 x Toyota 4 x 4 tray tops
Shooting truck	1 x Toyota 4 x 4 tray top
Office, spares truck	1 x International ACCO 1830C
Personnel carrier	1 x Toyota 4 x 4 troopcarrier

APPENDIX 4

Spread and recording parameters

Spread length (Lines 1 to 7)	5.70 km
Spread length (Line 8)	1.92 km
Number of channels	96
Geophone station interval (Lines 1 to 7)	60 m
Shotpoint interval (Lines 1 to 7)	360 m
Geophone station interval (Line 8)	20 m
Shotpoint interval (Line8)	120 m
Number of geophones/trace	16
Geophone pattern	In-line
Geophone spacing	4 m
Recording mode	GCR 6250 bpi
Format	SEG D
Sample rate	2 ms
Record length	20 secs
Notch filter	out
Low cut filter	8 hz
High cut filter	178 hz

APPENDIX 5

Timetable of operations

10-4-89 Depart Canberra for field, overnight at Dubbo.
11-4-89 Depart Dubbo for Manilla. At Manilla to 18-4-89.
12-4-89 Survey & drill shotholes Site 1.
13-4-89 Drill shotholes Site 1, survey Site 2.
14-4-89 Record Site 1. Drill Site 2.
15-4-89 Drill Site 2, survey Site 3.
16-4-89 No work. Manilla.
17-4-89 Record Site 2, drill Site 3.
18-4-89 Drill Site 3, survey Site 4.
19-4-89 Drill Site 4, Record Site 3, to Narrabri.
20-4-89 Drill Site 4, survey Site 5.
21-4-89 Record Site 4, drill Site 5, Coonabarabran.
22-4-89 Drill & Record Site 5.
23-4-89 No work. Coonabarabran.
24-4-89 Coonabarabran to Cobar. At Cobar to 3-5-89.
25-4-89 No work. Anzac Day holiday.
26-4-89 Survey Site 8, drill Site 8.
27-4-89 Drill Site 8, survey Site 7.
28-4-89 Drill Site 7, Record Site 8.
29-4-89 Drill Site 7, survey Site 6.
30-4-89 No work. Cobar.
01-5-89 Record Site 7, drill Site 6.
02-5-89 Drill Site 6, Record Site 6.
03-5-89 Drill Site 6, Record Site 6.
04-5-89 Return to Canberra. Overnight Parkes.
05-5-89 Parkes to Canberra.

APPENDIX 6

AMG co-ordinates of line bendpoints

Line 1 (Zone 56)

STATION	EASTING	NORTHING
*******	*******	********
1000	312180	6606040
1005	312345	6606292
1010	312525	6606535
1015	312680	6606800
1018	312735	6606975
1019	312775	6607020
1020	312830	6607045
1025	313092	6607185
1030	313320	6607385
1035	313555	6607540
1040	313825	6607640
1045	314075	6607785
1050	314270	6608015
1052	314345	6608110
1055	314500	6608175
1057	314615	6608180
1060	314760	6608280
1065	314925	6608500
1070	315065	6608765
1075	315115	6609040
1080	315280	6609260
1082	315310	6609365
1085	315425	6609500
1088	315550	6609610
1090	315600	6609720
1092	315605	6609845
1095	315700	6610005
1096	315725	6610060

Line 2 (Zone 56)

STATION	EASTING	NORTHING
*******	*******	********
2000	267220	6597600
2004	267430	6597480
2012	267900	6597400
2028	268850	6597300
2036	269305	6597160
2088	272360	6596700
2095	272775	6596700

Line 3 (Zone 56)

STATION	EASTING	NORTHING
*******	*******	********
3000	233800	6602360
3007	234215	6602420
3016	234750	6602350
3059	237300	6601990
3083	238740	6601800
3085	238860	6601830
3095	239465	6601820

Line 4 (Zone 55)

STATION	EASTING	NORTHING
*******	*******	********
4000	741780	6615280
4095	747410	6614360

Line 5 (Zone 55)

STATION	EASTING	NORTHING
*******	*******	********
5000	692920	6598700
5095	690780	6604010

Line 6 (Zone 55)

STATION	EASTING	NORTHING
*******	*******	********
5935	390830	6514180
6000	394690	6513760
6017	395710	6513720
6030	396490	6513640

Line 7 (Zone 55)

STATION	EASTING	NORTHING
*******	*******	********
7000	365820	6539310
7095	362550	6543920

Line 8 (Zone 55)

STATION	EASTING	NORTHING
*******	*******	********
0050	371033	6551844
0145	372670	6552788

APPENDIX 7

Geophone Station Elevations (metres AHD)

Line 1 - Stations 1000 to 1096

856.00	852.93	851.90	854.15	852.36	849.88	847.31	844.70
842.54	839.78	838.63	837.19	836.36	834.99	834.47	834.31
834.30	833.49	832.84	831.95	833.84	836.79	839.76	843.84
848.22	849.99	848.49	845.82	843.07	842.03	841.28	840.83
841.17	840.23	838.75	839.41	839.99	840.71	840.67	840.78
841.88	842.01	841.96	842.00	843.80	845.30	847.20	849.20
851.20	853.70	856.00	858.20	861.70	864.10	866.80	869.00
873.00	869.50	866.00	862.00	857.00	854.00	851.00	849.50
853.00	857.00	860.50	860.50	856.00	855.00	854.00	856.00
858.50	856.50	858.00	859.50	863.50	868.00	869.00	865.00
862.00	859.00	857.00	853.50	848.00	845.00	842.00	838.00
834.00	833.00	833.00	832.00	830.00	827.00	822.00	817.00
813.00							

Line 2 - Stations 2000 to 2095

432.0	431.6	431.2	430.7	430.2	429.4	428.3	427.0
425.9	424.6	423.0	421.9	420.1	419.8	418.8	417.3
415.8	414.3	412.9	411.5	410.1	408.8	407.6	406.9
406.3	406.1	406.2	406.4	406.7	406.4	405.4	403.9
402.2	400.5	398.7	397.1	395.3	393.7	391.3	389.9
388.1	386.4	385.7	385.6	385.9	386.3	386.8	387.3
387.5	388.2	388.4	388.6	388.6	388.9	389.1	389.2
389.4	389.6	390.1	390.4	390.8	391.1	391.5	392.0
392.5	392.6	393.1	393.5	393.9	394.3	394.1	394.5
394.8	395.4	395.9	396.4	397.0	397.9	399.0	400.1
401.2	402.3	403.4	404.4	405.6	406.7	407.8	408.9
410.0	411.0	411.8	412.1	412.8	413.4	414.2	414.8

Line 3 - Stations 3000 to 3095

277.7	277.9	278.0	278.2	278.3	278.3	278.3	278.3
278.4	278.5	278.5	278.6	279.0	278.9	279.0	279.1
279.3	279.3	279.4	279.2	279.2	279.1	279.3	279.7
279.9	279.8	279.7	279.6	279.6	279.4	279.3	279.0
278.7	278.2	277.7	277.4	276.9	276.7	276.7	276.5
277.1	278.3	279.0	279.4	280.0	280.3	280.4	280.5
280.8	281.2	281.2	281.4	281.7	282.0	282.3	283.0
283.6	284.1	284.7	285.3	285.9	286.6	287.3	287.9
288.5	288.8	289.3	289.8	290.4	290.9	291.3	291.8
292.3	292.8	293.4	293.9	294.3	294.8	295.6	296.1
296.8	297.4	297.9	298.2	298.7	299.0	299.4	300.1
300.6	301.3	301.8	302.3	302.7	303.2	303.7	304.4

Line 4 - Stations 4000 to 4095

266.00	266.01	266.09	266.02	266.10	265.96	265.89	265.71
265.80	265.94	266.20	266.28	265.99	265.85	265.75	265.88
265.98	265.96	266.00	266.14	266.61	267.31	268.02	268.71
269.24	269.38	269.18	268.91	268.53	268.22	267.91	267.48
267.16	266.94	266.69	266.44	266.24	266.14	265.99	265.79
265.59	265.48	265.44	265.26	265.08	264.72	264.35	263.80
263.48	263.22	262.88	262.61	262.24	261.98	261.78	261.85
261.80	261.76	261.72	261.82	261.89	262.09	262.38	262.72
263.00	263.21	263.31	263.42	263.76	263.98	264.30	264.66
265.08	265.40	265.52	265.69	265.69	265.56	265.56	265.44
265.20	264.95	264.85	264.79	264.79	264.96	265.30	265.60
265.86	265.95	266.08	265.92	265.89	265.73	265.59	265.36

Line 5 - Stations 5000 to 5095

246.3	246.3	246.3	246.3	246.3	246.1	246.0	246.0
245.8	245.6	245.2	245.1	244.9	245.0	244.9	244.6
244.4	244.1	243.8	243.6	243.2	242.7	242.4	242.3
242.1	241.9	241.7	241.5	241.2	241.1	240.9	240.7
240.6	240.4	240.1	240.0	239.9	239.7	239.7	239.6
239.5	239.3	239.2	238.9	238.9	238.9	238.8	238.6
238.5	238.4	238.2	238.1	237.9	237.9	237.7	237.5
237.4	237.1	237.1	236.9	236.7	236.5	236.4	236.2
235.9	235.7	235.5	235.3	235.2	234.9	234.8	234.6
234.6	234.6	234.7	234.6	234.4	234.2	233.9	234.2
234.0	233.6	233.4	233.2	233.0	233.0	233.0	232.8
232.8	232.8	232.7	232.5	232.5	232.4	232.2	232.1

Line 6 - Stations 5935 to 6030

249.9	251.5	253.0	252.9	253.3	254.9	255.0	256.6
257.4	257.2	256.4	255.0	254.4	254.9	255.7	256.8
257.6	257.5	257.7	257.9	258.2	258.8	260.0	261.1
262.1	263.1	264.3	265.6	267.2	269.9	270.8	270.7
272.0	274.2	275.1	274.3	274.2	275.9	277.3	279.5
281.8	285.0	285.6	285.2	284.5	282.3	286.5	284.4
282.4	281.6	280.3	279.3	278.1	277.4	276.4	275.7
275.1	274.7	274.0	273.6	273.3	272.9	273.0	272.8
272.4	272.2	271.7	272.0	271.8	271.5	271.4	271.0
270.5	270.4	270.6	270.6	270.7	271.0	271.6	271.7
271.5	271.1	270.6	270.4	269.3	268.3	267.4	266.2
265.1	264.2	263.3	262.8	262.3	261.4	260.7	260.0

Line 7 - Stations 7000 to 7095

186.66	186.79	186.72	186.58	186.42	186.28	186.25	186.27
186.30	186.32	186.28	186.13	185.96	185.86	185.80	185.80
185.84	185.80	185.64	185.58	185.57	185.65	185.20	185.04
185.00	185.03	184.74	184.68	184.69	184.80	184.98	185.12
185.12	185.15	185.10	185.12	185.19	185.19	185.25	185.28
185.27	185.15	185.18	185.21	185.78	185.31	185.29	185.23
185.29	185.21	185.32	185.35	185.49	185.56	185.60	185.66
185.65	185.82	185.92	186.10	186.32	186.56	186.99	187.16
187.10	187.46	188.19	188.10	188.31	188.68	189.13	189.49
189.71	189.87	190.06	190.29	190.75	191.09	191.28	191.66
192.15	192.46	192.74	193.12	193.66	194.46	195.35	196.32
197.12	197.89	199.00	200.00	200.42	199.63	199.41	199.28

Line 8 - Stations 50 to 145

208.027	208.12	208.226	208.32	208.422	208.56	208.708	208.81
208.934	209.0	209.148	209.27	209.413	209.51	209.613	209.69
209.779	209.82	209.887	210.00	210.145	210.259	210.37	210.49
210.53	210.59	210.621	210.70	210.780	210.93	211.078	211.24
211.420	211.64	211.862	212.04	212.254	212.899	213.18	213.48
213.79	214.099	214.47	214.852	215.04	215.237	215.36	215.49
215.70	215.911	216.00	216.108	216.30	216.510	216.85	217.19
217.61	218.034	218.56	219.086	219.33	219.585	219.65	219.72
219.70	219.695	219.65	219.618	219.63	219.661	219.71	219.77
219.81	219.853	219.92	220.002	220.11	220.214	220.27	220.34
220.45	220.568	220.57	220.571	220.55	220.530	220.38	220.24
220.05	219.877	219.72	219.576	219.42	219.288	219.22	219.16