Bureau of Mineral Resources, Geology & Geophysics

RECORD

Record 1989/52

Central Victoria Seismic Test Survey, 1989

Operational Report

by

T. Barton, M. Sexton, W.R. Lodwick *, D. Johnstone

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* Monash University

R8905201

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SUMMARY

This investigation was a joint project between the Department of Geology, University of Melbourne, the Department of Earth Sciences, Monash University, and the Bureau of Mineral Resources to investigate the suitabiltiy of the seismic reflection technique for determining the crustal structure within central Victoria. The project was initiated as a pilot study for a proposed 400 km deep crustal transect across Victoria in 1991-92. Funding for the project was provided jointly by the Victorian Department of Industry, Technology and Resources (ITR) and the BMR.

Data acquisition was carried out during the university vacation period from the 17th to 24th June 1989 to enable participation of university staff and students. Two traverses were completed, the first 6 km long (line 89-09), and the second 8 km long (line 89-10), each being up to twelve fold common mid-point (CMP). The traverses were located on the downdip side of the Mt. Ida - McIvor fault approximately 40 km north of Heathcote. Traverse orientation was east-west and perpendicular to regional strike, and was constrained by the requirement to use existing roads and tracks in the area.

The seismic data show two major events. The first is a steeply westerly dipping event between 2 and 3 seconds two-way-time (twt). The second is a package of lower crustal reflections between 9 and 10 seconds twt.

The seismic data were processed in the BMR's seismic processing centre.
Students from the universities also carried out gravity and magnetic traverses and some magneto-telluric (MT) soundings.

1 INTRODUCTION

1.1 BACKGROUND

A number of researchers at the three principal Melbourne universities have proposed that a geophysical transect should be carried out across Victoria to provide clear three dimensional constraints on the nature of the crust across the state (Wilson and others). The outcome of such a project should provide information on the crustal structure and genesis of the western edge of the Lachlan Fold Belt. In addition it would aid in solving two geological problems. The first is the position and nature of the suture between the westerly vergent Delamerian Fold Belt of South Australia and the east vergent Lachlan Fold Belt of Victoria. Secondly such a transect would test the mid-crustal detachment model of Central Victoria (Fergusson and others, 1986).

As a precursor to an application for an Australian Research Council (ARC) grant to fund such a study, a small test survey was planned in the Stawell area of Victoria. Due to the geological complexity of the initial site the survey was moved to the Bendigo zone along the Heathcote axis.

1.2 AIMS AND OBJECTIVES

The aims of the seismic recording in this region were to enable an evaluation of the deep seismic reflection technique, logistics and data acquisition methods that may be used in a full study of the Victorian crust. The particular site chosen allowed for the additional objective of imaging the Mt Ida fault and the Heathcote Cambrian greenstone sequence to ascertain its structure at depth. Finally the relatively non-chaotic nature of the surface geology would allow structures throughout the crust to be imaged if they were present.

1.3 LOCATION

The location of the survey traverses was constrained by the availability of accessible roads and tracks with minimal cultural noise problems such as traffic, power lines, stock etc. Fortunately the roads were in an east-west direction thus allowing the lines to be placed cross strike. The two survey lines (89-09 and 89-10) are shown on a portion of the Heathcote (7824) 1:100,000 topographic sheet (fig.1). Two map sheets of the 1:25,000 series covered the area : Toolleen (7824-4-2) and Barnadown (7824-4-3).

1.4 ASSOCIATED SURVEYS

Students from Melbourne and Monash Universities carried out a number of geophysical measurements throughout the general area as a part of their studies. Gravity and magnetic traverses were carried out along line 89-09 and along other roads in the area. MT soundings were also undertaken at various sites. The students also carried out levelling along 89-09, but due to time commitments were unable to level line 89-10.

Because this region is on the boundary of the Murray Basin and subject to salinity problems, the Victorian Department of Conservation, Forests and Land (DCFL) in Bendigo was approached following advice from the Rushworth Shire engineer. It transpired that part of the survey area coincided with a salinity study area. As a result eight shot holes at the eastern end of line 89-09 were cased for water monitoring studies after the seismic operations had been completed.

2 GEOLOGY

The local area geology is shown in fig.2 which is a portion of the 1:250,000 Bendigo geological sheet (SJ55-1). It shows the main features described below and the location of the seismic lines.

The major geologic feature of the area which was investigated is the Heathcote Greenstone belt which maintains a general north-south strike over approximately 150 km of central Victoria. It forms the present boundary between the Cambrian to late Ordovician Bendigo - Ballarat zone to the west and the lower Ordovician to mid-Devonian Melbourne trough to the east. The seismic work was adjacent to the eastern boundary of the belt which is delineated along its entire length by the steep westerly dipping Mt Ida - McIvor - Mt William reverse fault system. Gray (1988) suggests that because the greenstones to the north and south are conformable with the overlying Castlemaine Supergroup, which is to the south-west of the survey area, the greenstones may underlie the Supergroup across the entire zone.

Surface mapping by Green (1972) shows that the near surface dips of the fault range from 60 to 80 degrees and implies that there is a second fault on the western side of the greenstone belt, which would be an extension of the Heathcote fault, as shown in section A-A' on fig.3.

3 FIELD OPERATIONS

3.1 GENERAL

Two traverses were recorded on the western side of the Mt Ida fault axis. The first line (89-09) was 6 km in length and the second (89-10) was 8 km long.

Progress of the seismic recording was as expected and drilling was better than originally anticipated. Weather conditions were cold and windy for the first few days of recording which had an adverse effect on record quality for line 89-09. However conditions improved for the recording of line 89-10. Traverse access was good for most of both lines, although some parts of line 89-09 were unsuitable for vehicle access. In these areas no drilling was possible and the spread was walked in. Some equipment problems caused one day of recording to be lost and prevented the time being available to carry out some test shots on the eastern side of the fault.

In total, one uphole and twenty-four production shots over 14 km of line were recorded over the one week period.

3.2 RECONNAISSANCE

Reconnaissance for the survey was carried out over a two day period in early June. Inspection of the originally proposed lines showed that one line was unsuitable due to the poor condition of the road due to heavy rain. An alternative line was located which provided good all weather access for most of its length. It was hoped that the short sections of the line along fences in paddocks would dry out sufficiently to allow access upon commencement of the survey.

Conducting seismic surveys in moderately populated areas such as this require many logistical considerations to be made. Firstly the large number of roads and farms make it difficult to ensure that traffic or stock do not come onto the spread whilst recording is in progress. The area contained a large number of underground cables, single-wire earth return (SWER) power lines, electric fences and dams which can present difficulties for shot hole location and induce noise on the seismic record. In addition access restrictions due to bridge load limits and clearance heights were checked.

Property owners adjacent to the proposed line were informed of our proposed activity and permission was sought to operate through private land when required. All landowners were very co-operative. However some remarked that they had experienced problems which related to commercial mineral exploration.

In addition the Shire Engineer in Rushworth was visited and consulted on the roads which were to be used. Permission was sought and given by Lake Cooper Quarries to store explosives within their magazine, with daily access.

Arrangements for explosives licences were made with the Victorian Department of Labour in Bendigo. Contact with the DCFL was made to ascertain whether shot holes would be of any use to them after shooting was completed. This in fact proved to be a valuable tool for public relations with land owners. The geologist at the ITR in Bendigo, Eric Wilkinson, was also visited and provided comments on the structural nature of the area.

3.3 PARTY PERSONNEL, VEHICLES & ACCOMMODATION

The field party consisted of twelve BMR personnel and twelve vehicles (Appendix 3). In addition, a number of students and staff of the universities assisted in various field tasks over the course of the survey. Commercial accommodation in Heathcote was used which was approximately 40 km south of the survey area. Officers from the Melbourne branch of ITR also visited the survey to observe field operations.

3.4 SURVEYING

Pegging of the lines at 60 m station spacing was carried out using a measuring rope. Both lines were pegged from east to west. Station ranges for line 89-09 were 1000 to 1101 and line 89-10 from 2000 to 2136.

Levelling was carried out by the students along line 89-09. However, only the stations east of 1066 were levelled at peg locations. Levels for the remainder of the line were made at 200 m intervals from this point due to the pegs having been removed prior to the work. It was not possible to obtain levels for 89-10 due to other commitments of both personnel and equipment. The primary objective for elevation data was for gravity traverses carried out during the week. The elevation data are listed in Appendix 4 were used for the seismic data processing and are based upon an integration of acquired levels and interpolations from 1:25,000 maps.

3.5 DRILLING & EXPLOSIVES

Drilling commenced on 17 June and was completed on 23 June. One Mayhew rig and one tanker were used. Drilling conditions were variable with some holes requiring mud pits. A 2 m deep near surface weathering shot at station 1065 on line 89-09 was used to determine that the weathered depth was between 36 m and 40 m. Subsequently all shot holes were drilled to 40 m. Overall the drilling conditions were better than anticipated, which resulted in a total of twenty six holes being drilled over the week. It was noted that the only mud drilling was at the western end of line 89-10 which is located within the Quaternary Shepparton formation.

A total of 400 kg of TOVEX explosive in 1 kg sticks was used for the survey. Charge sizes varied from 10 kg to 27 kg. Initially 10 kg charges were used but were found to produce very little energy due to the type of material at the depth of the shot. The majority of the remaining shots were either 12 kg or 16 kg with some shots being greater than 20 kg. Due to the length of the charges at least two detonators per shot were used. One misfire occurred (the very first shot of the survey) which required a redrill. Overall energy penetration was not very good due to the nature of the near surface geology. Where it was possible shots were water tamped to allow for reloading if required.

3.6 SEISMIC RECORDING

The recording parameters for this survey are detailed in Appendix 2, and were similar to those used in the 1986 Millmerran test survey (Johnstone and others, 1987).

The seismic acquisition system was upgraded prior to the survey with the addition of a 10 kVA silent-running diesel generator to replace the one used in previous surveys. Tests undertaken during this survey indicate that no detectable spread noise is induced on the line as was present in the Canning Basin survey during 1988 (Sexton and others, in prep.).

The Sercel SN368 performance was disappointing considering that it had only just returned from a test survey in northern N.S.W.. One short length record occurred after a Sercel system error. An unusually high number of station units (12) was found to be faulty during the present survey, but the cause was not identified. Trouble was also experienced in the playback of records. Recording was suspended for one day and the problem investigated. The fault was not located and owing to time constraints recording recommenced on the final day of the survey. Fortunately the data, seven shots on line 89-10, were recorded onto tape. The fault was later found to be located in the backplane board of the MCU, an area where several faults have occurred during previous surveys.

Both lines were recorded from east to west. Field operations were similar to those described by Johnstone and others (1987). Station units and cables situated along roadsides were collected at the end of each days recording for security reasons.

4 PRELIMINARY RESULTS

4.1 DATA PROCESSING

Data from this survey were processed at BMR using the DISCO system. Demultiplexing of the SEG-D tapes was performed using a modified version of the SEG-B demux module. All DISCO jobs were run using Version 7 software. The basic data processing stream was similar to that as described by Johnstone and others (1987).

4.2 INTERPRETATION

Figures 4 and 5 show single shot records from each of the lines after application of a coherency filter. Shot 6 (station 1018) from line 89-09 shows deep events around 9 seconds twt (two-way time) and a shallow dipping event around 3 seconds twt. Shot 7 (station 2085) from line 89-10 also shows deep events between 9 and 10 seconds twt and a linear event around 3 seconds twt.

Analysis of first break refractor velocities yields shallow dipping refractors (fig.6) with weathering velocities of 1800 m/s and sub-weathering velocities of 4080 m/s on line 89-10 and 5070 m/s on line 89-09. From these results it may be concluded that the weathering depths are up to the order of 100 m, especially in the areas of Quaternary cover.

Stacked sections are shown in figs. 7 and 8 from which zones of energy at 9 to 10 seconds twt and a shallow dipping event from 1.5 to 4 seconds twt are evident across the comnplete section. From the r.m.s. velocities computed from the CMP gathers of the shallow event (3000 m/s on 89-09 and 5200 m/s on line 89-10) it is evident that these are valid reflections. The surface projection of this event coincides with the Mt Ida fault; steep near surface dips are not imaged but the event appears listric with dips flattening out to the west. This event is likely to be the base of the Bendigo trough and implies that the greenstone belt underlies it.

The events around 9 and 10 seconds twt also appear to be valid reflections associated with the lower crust.

The origin of the westerly dipping events on line 89-10 between 6 and 7 seconds twt is less clear. They may be an indication that the Melbourne Trough also underlies the Bendigo trough. They may also de due to side reflections from the southern or northern trough boundaries. A north - south traverse through the Bendigo trough would be needed to ascertain which of the explanations is valid.

5 ACKNOWLEDGEMENTS

The cooperation and assistance of the property owners, the Rushworth Shire engineer, officers of the Victorian Department of Industry, Technology and Resources, and Roy Webb of Lake Cooper Quarries allowed the survey to be undertaken with a minimum of difficulty. In addition, the authors acknowledge the efforts of the field crew for this survey.

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APPENDIX 1 OPERATIONAL STATISTICS

Drilling commenced	17.6.89
Drilling completed	23.6.89
Rig days	6
Metres drilled	1060
Recording commenced	17.6.89
Recording completed	24.6.89
Recording days	6
Total number of shots	24
Uphole shots (1 hole)	8
Explosives (Tovex)	400 kg
Detonators	58
Charge size	10 kg to 27 kg

APPENDIX 2 SURVEY SUMMARY

PROJECT : ACORP VICTORIAN TRANSECT TEST SURVEY			
BMR SURVEY NO. : 128			
MAP SHEETS	: 1:250000		
	: SJ/55-1		
	: BENDIGO		
	: 1:100000		
	: 7824		
	: HEATHCOTE		
	: 1:25000		
	: 7824-4-2, 7824-4-3		
	: TOOLEEN, BARNADOWN		
LOCATION	: W. LONGITUDE 144.55		
	: E. LONGITUDE 144.73		
	: N. LATTITUDE 36.75		
	: S. LATTITUDE 36.80		
TRAVERSES	: LINE	: STATIONS	: LENGTH (km)
	: 89-09	: 1000 to 1101	: 6.1
	: 89-10	: 2000 to 2136	: 8.2
EQUIPMENT	: AMPLIFIERS SN368, 96 CHANNEL		
	: GEOPHONES GSC20D 8 Hz		
FORMAT	: 6250 BPI GCR, SEG-D		
PARAMETERS	: SAMPLING RATE 2 ms		
	: FILTERS 8 - 178 Hz		
	: CHARGE SIZE 10 - 27 kg		
	: SHOT HOLE DEPTH 40 metres		
GEOMETRY	: SPREAD 96 CHANNELS		
	: GEOPHONE SPACING 60 metres		
	: GEOPHONE PATTERN 16 IN LINE, 4 metres apart		
	: CDP FOLD VARIED UP TO 4 FOLD		
DATA	: FIELD TAPE NUMBERS		
	: UPHOLE SP 1065 89-09 89013		
	: LINE 89-09 89014 to 89015		
	: LINE 89-10 89016 to 89017		

APPENDIX 3

Personnel

T.Barton	Party leader
C.Cannon	
R.Cherry	
A.Crawford	
B.Dickinson	
G.Jennings	
N.Lodwick	
G.Price	
L.Rickardson	
J.Somerville	
A.Takken	
J.Whatman	

Vehicles

Recording truck	Mercedes Benz 911, 4X4
Driling Rig	Mayhew 1000/ Mack 6X8 truck
Drill water tanker	Mack R875, 6X6 1900 gallon
Shooting truck	Toyota tray top, 4X4
Pre-loading truck	Toyota tray top, 4X4
Explosives	International Acco 1800
Maintenance truck	International Acco 1800
Personnel carriers	2 X Toyota Troop carriers, 4X4
Geophone carriers	4 X Toyota tray tops, 4X4

APPENDIX 4 ELEVATIONS

TABLE 1 ELEVATIONS LINE 89-09

(Elevations in metres above sea level)

STAT	ELEV	STAT	ELEV	STAT	ELEV
1000	160	1040	176	1080	198
1001	160	1041	177	1081	199
1002	160	1042	178	1082	202
1003	160	1043	179	1083	204
1004	160	1044	180	1084	210
1005	161	1045	181	1085	218
1006	162	1046	182	1086	218
1007	164	1047	183	1087	211
1008	165	1048	184	1088	211
1009	166	1049	185	1089	209
1010	167	1050	187	1090	206
1011	168	1051	189	1091	206
1012	169	1052	190	1092	205
1013	169	1053	190	1093	205
1014	170	1054	189	1094	206
1015	171	1055	188	1095	206
1016	172	1056	188	1096	207
1017	173	1057	190	1097	207
1018	173	1058	191	1098	208
1019	173	1059	192	1099	209
1020	173	1060	194	1100	209
1021	173	1061	196	1101	210
1022	173	1062	197		
1023	173	1063	197		
1024	172	1064	197		
1025	172	1065	197		
1026	172	1066	198		
1027	172	1067	197		
1028	172	1068	198		
1029	173	1069	199		
1030	173	1070	201		
1031	173	1071	201		
1032	173	1072	199		
1033	173	1073	197		
1034	173	1074	195		
1035	173	1075	195		
1036	173	1076	192		
1037	174	1077	196		
1038	174	1079	196		
1039	175	1079	197		

TABLE 2 ELEVATIONS LINE 89-10

(Elevations in metres above sea level)

STAT	ELEV	STAT	ELEV	STAT	ELEV	STAT	ELEV
2000	140	2040	148	2080	159	2120	177
2001	141	2041	148	2081	159	2121	176
2002	141	2042	148	2082	159	2122	175
2003	141	2043	147	2083	160	2123	175
2004	141	2044	149	2084	160	2124	174
2005	142	2045	149	2085	161	2125	173
2006	142	2046	149	2086	162	2126	173
2007	142	2047	149	2087	163	2127	172
2008	142	2048	149	2088	163	2128	172
2009	142	2049	150	2089	164	2129	171
2010	142	2050	150	2090	164	2130	171
2011	143	2051	150	2091	165	2131	170
2012	143	2052	150	2092	166	2132	170
2013	143	2053	150	2093	167	2133	170
2014	143	2054	151	2094	168	2134	169
2015	143	2055	151	2095	168	2135	169
2016	143	2056	151	2096	169	2136	169
2017	144	2057	151	2097	169		
2018	144	2058	152	2098	170		
2019	144	2059	152	2099	171		
2020	144	2060	152	2100	172		
2021	144	2061	153	2101	173		
2022	145	2062	153	2102	173		
2023	145	2063	153	2103	173		
2024	145	2064	154	2104	174		
2025	145	2065	154	2105	175		
2026	145	2066	154	2106	175		
2027	145	2067	154	2107	176		
2028	146	2068	155	2108	177		
2029	146	2069	155	2109	178		
2030	146	2070	155	2110	179		
2031	146	2071	156	2111	180		
2032	146	2072	156	2112	180		
2033	147	2073	156	2113	181		
2034	147	2074	157	2114	181		
2035	147	2075	157	2115	180		
2036	147	2076	157	2116	179		
2037	147	2077	158	2117	179		
2038	148	2079	158	2118	178		
2039	148	2079	158	2119	178		

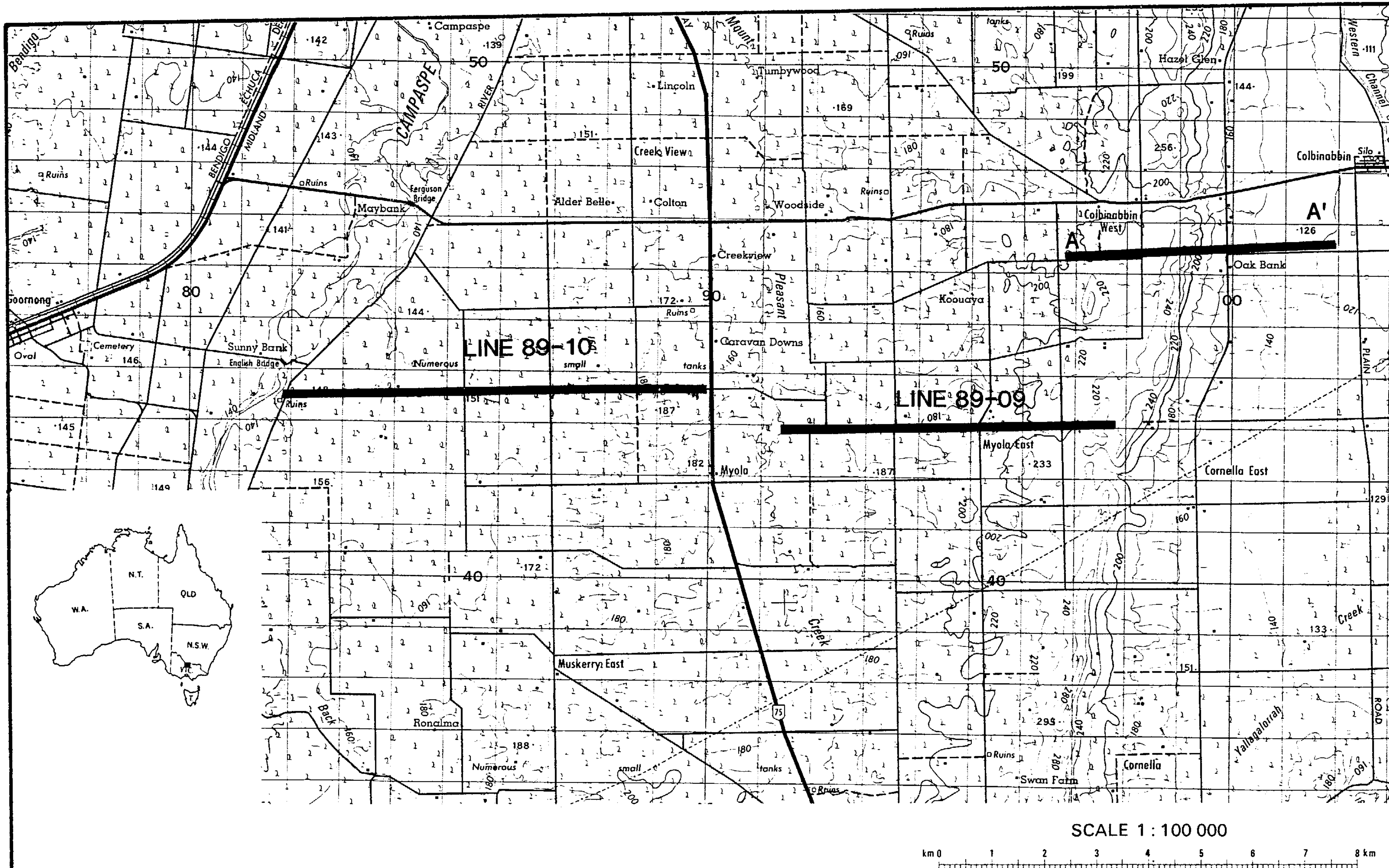
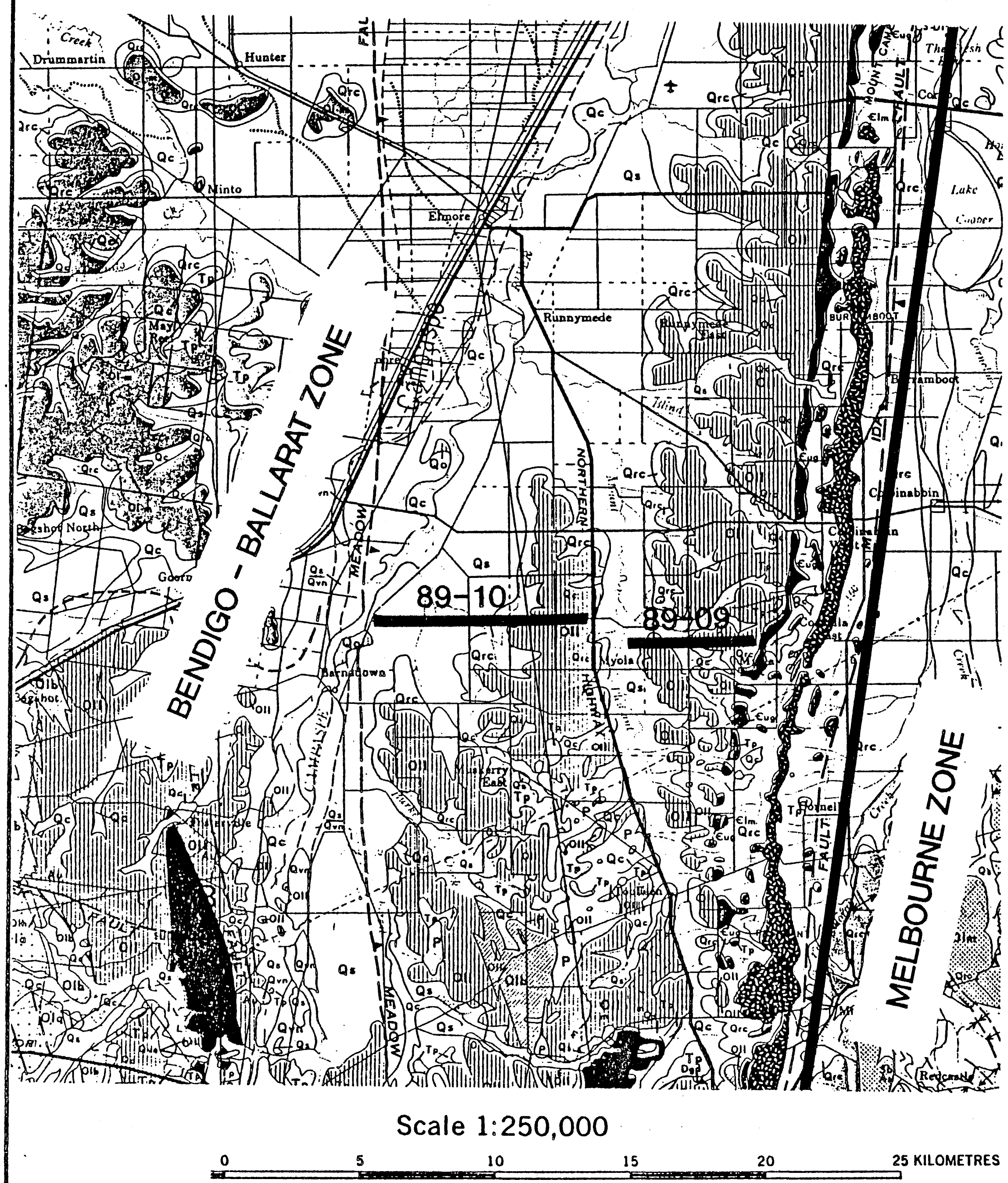


FIGURE 1. SURVEY LOCATION MAP

BASED ON HEATHCOTE SHEET 7824

26/J55-1/1

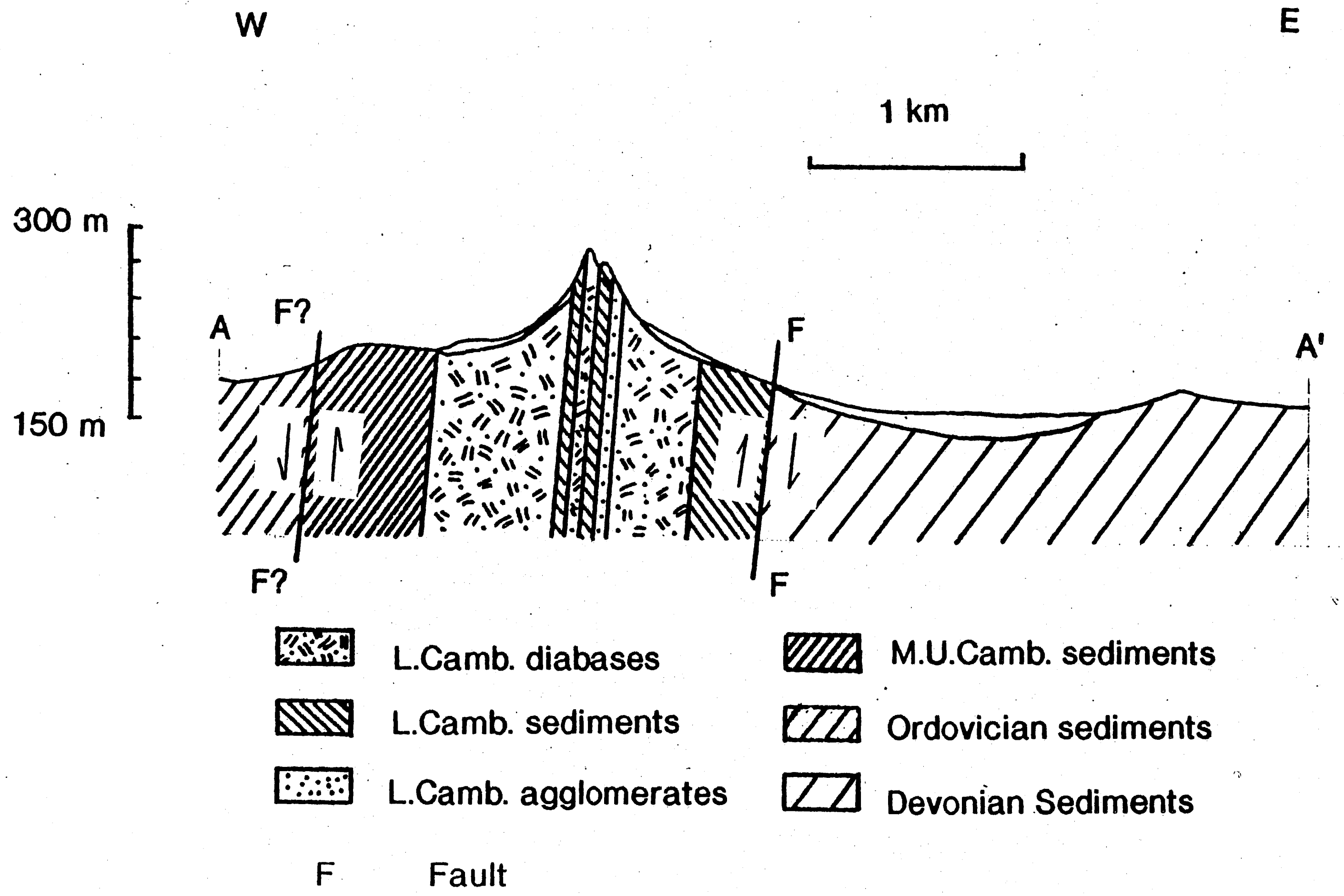


Coonambidgal Formation	Qc	Clay, sand, sandy, clay, often grey, slight soil development. Also lake deposits, often grey clay, in the form of terraces with scroll pattern, or plains with a network of channels. equivalent to Qra on adjoining sheets
	Qrm	Swamp and lake deposits; clay, silt and mud;
	Qe	Source bordering dunes, quartzose sand, yellow to red
	Qu	Lunette deposits; clay, silt, sand, gypseous clay, gypsum
	Qrc	Fan deposits, hill wash, scree
Shepparton Formation	Qs	Clay, silt, sand, gravel; surface with numerous levee traces, soil often red-brown
Newer Volcanics	Qvn	Basalt, olivine basalt, limburgite
	Tp	Gravel, sand, clay in old stream courses; (includes White Hills Gravel and Mongolore Gravels) Quartzose gravel, sand; lateritized (Non marine equivalent of Parilla Sand)
Calivil Sand	Tms	Gravel, sand, conglomerate, predominantly quartz, some kaolinitic cement. mainly subsurface, including the deep lead system
	Tm	Gravel, grit, silt and clay. Lateritic remnants underlying Tp especially in granite areas, possibly equivalent to Tor
Renmark Group	Ter	Siltstone, carbonaceous and dolomitic; lignite and sand, often pyritic and carbonaceous. (Subsurface only)
	P	Glacial and fluvio-glacial tillite; conglomerate, sandstone
	Dgd	Granodiorite with metamorphic aureole
	Dgr	Granite, coarse porphyritic with metamorphic aureole. Finer grained granite at Avenel
Baringhup Granodiorite	Dg3	Granodiorite, fine to medium grained, intrudes Dg1 and Dg2
Harcourt Batholith	Dg2	Granodiorite, coarse, porphyritic
Harcourt Granodiorite	Dg1	Granodiorite, coarse, slightly porphyritic
Puckapunyal Formation	Dlp	Siltstone and interbedded sandstone, with numerous greywacke-conglomerate intervals
Broadford Formation	Dlb	Sandstone and interbedded siltstone, with minor greywacke-conglomerate intervals
Mt Ida Formation	Dli	Siltstone and interbedded sandstone, heavy greywacke-conglomerate interval near top
Humevale Formation	Dlh	Siltstone, with interbedded thin sandstone
McIvor Formation	Dlm	Sandstone, with minor interbedded siltstone and conglomerate
	S-Dl	Sandstone, siltstone, undifferentiated
Dargile Formation	Sud	Sandstone, laminated and current bedded, with interbedded mudstone and siltstone prominent
Wapentake Formation	Smw	Sandstone, predominantly in upper beds, lower beds mainly mudstone. (Includes Illaenus band). Thin pebbly siltstone near base
Costerfield Formation	Slc	Mudstone with thin interbedded sandstone
Terrick Terrick Granite / Pyramid Hill Granite	Oug	Granite
Subdivision biostratigraphic (graptolites)	Ou, Omd, Oly, Ole, Olh, Olb, Oll, Ol-m	Shale, slate and sandstone, thinly bedded. Metamorphism in aureoles around granitic rocks. Omd includes characteristic soft shales east of Bendigo. Oll includes coarse rudites at Derrinal, Ou as extremely small infaulted slices within the Heathcote Axis
	Oll	Sandstone, greywacke of Sugarloaf Range
Goldie Shale / Knowsley East Beds	€yg	Silicified shale-quartzite, chert, with tuff bands in lower portion
Heathcote Greenstone	€lm	Agglomerate, ferro-gabbroic differentiate, basalt and andesite, ash, tuff. Greenstone, diabase, dolerite, quartz-talc-magnesite, altered serpentenite, fault rock Silicified shale, argillite, quartzite, chert, jasper, jasperite

FIGURE 2 GEOLOGY OF THE SURVEY REGION

BASED ON BENDIGO GEOLOGICAL SHEET SJ55-1

26/J55-1/2



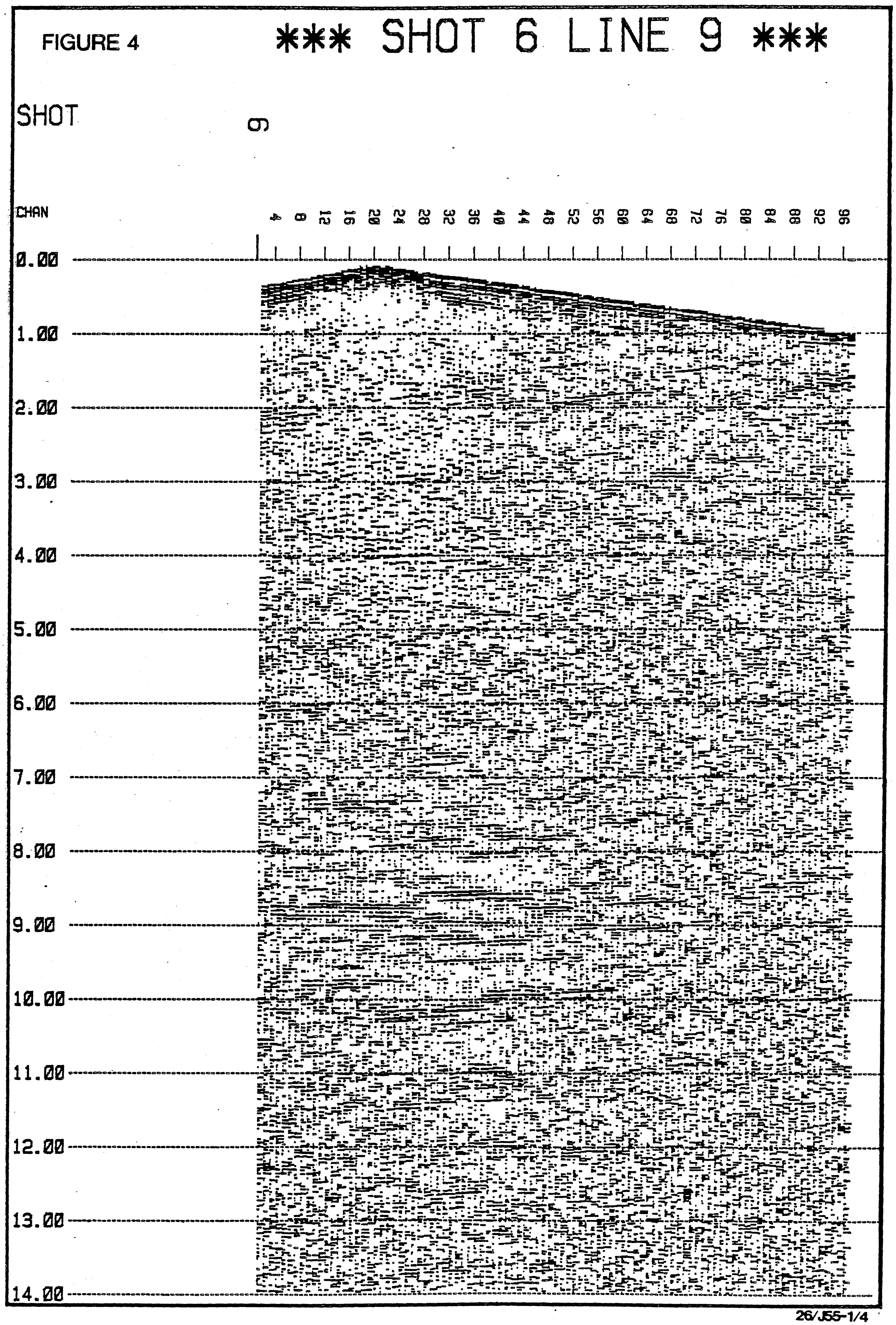
MOUNT CAMEL RANGE

GEOLOGICAL CROSS SECTION A – A'

FIGURE 3 after Green, 1972

26/J55-1/3

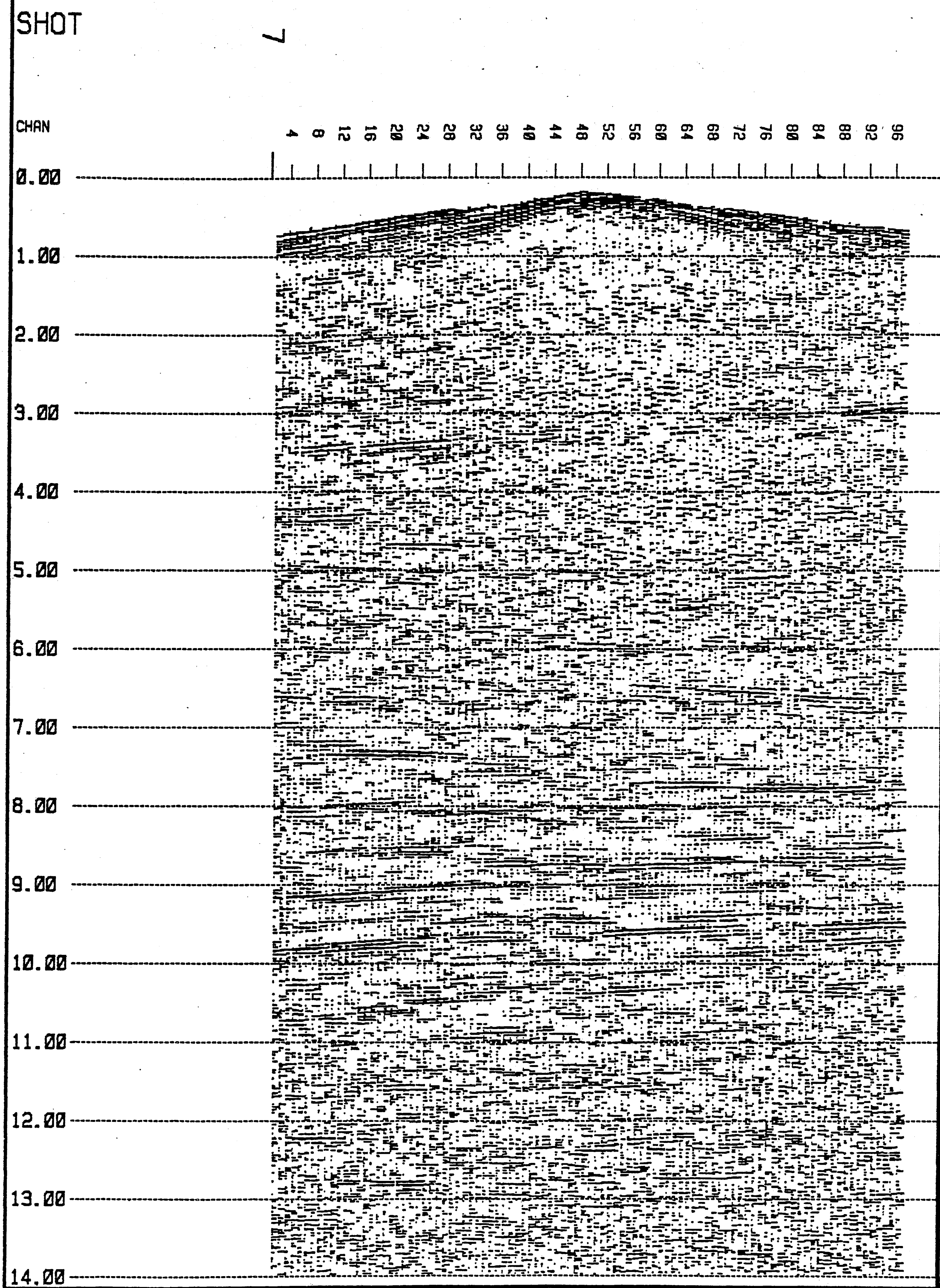
FIGURE 4



26/J55-1/4

FIGURE 5

*** SHOT 7 LINE 10 ***



26/J55-1/5

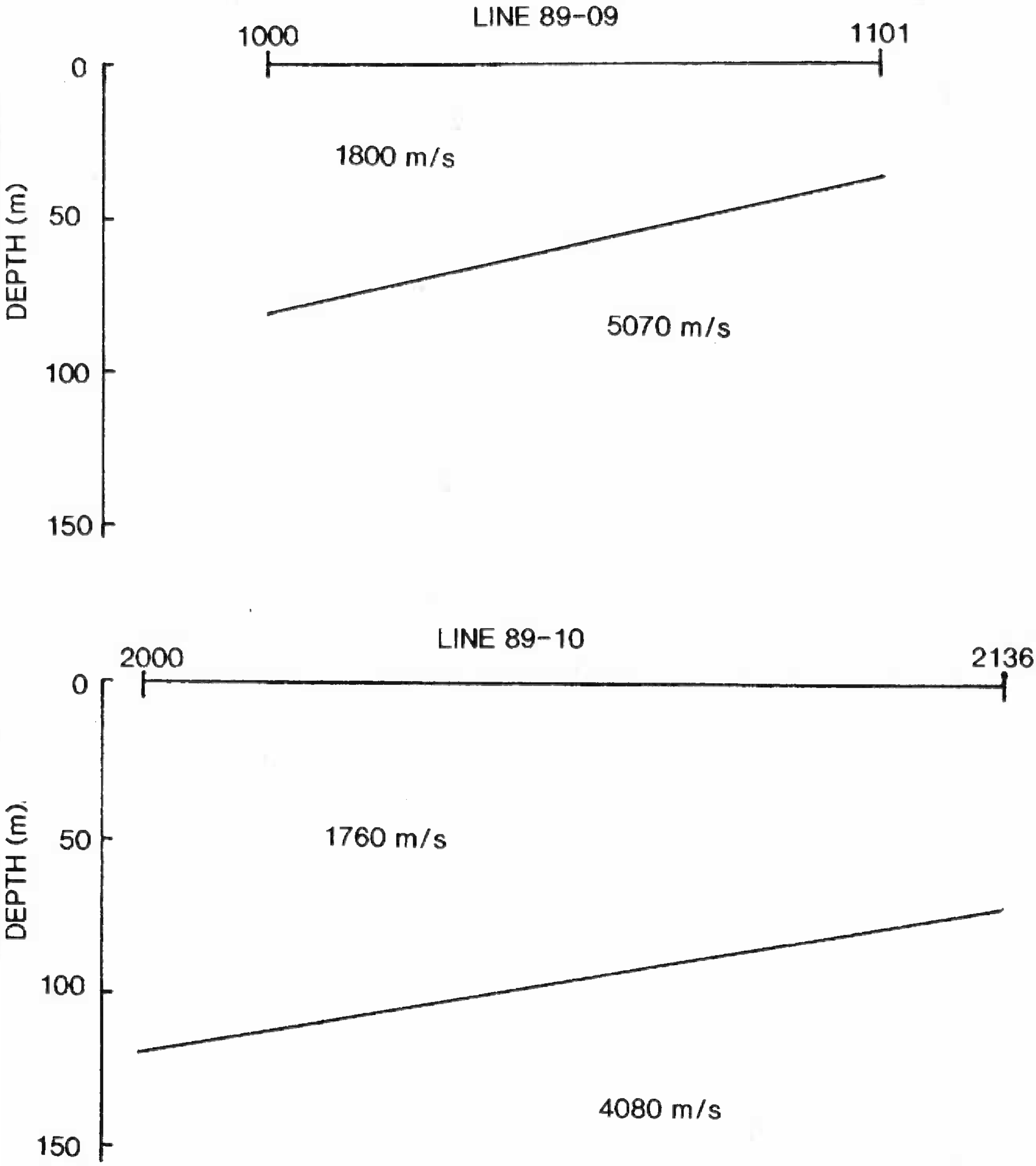
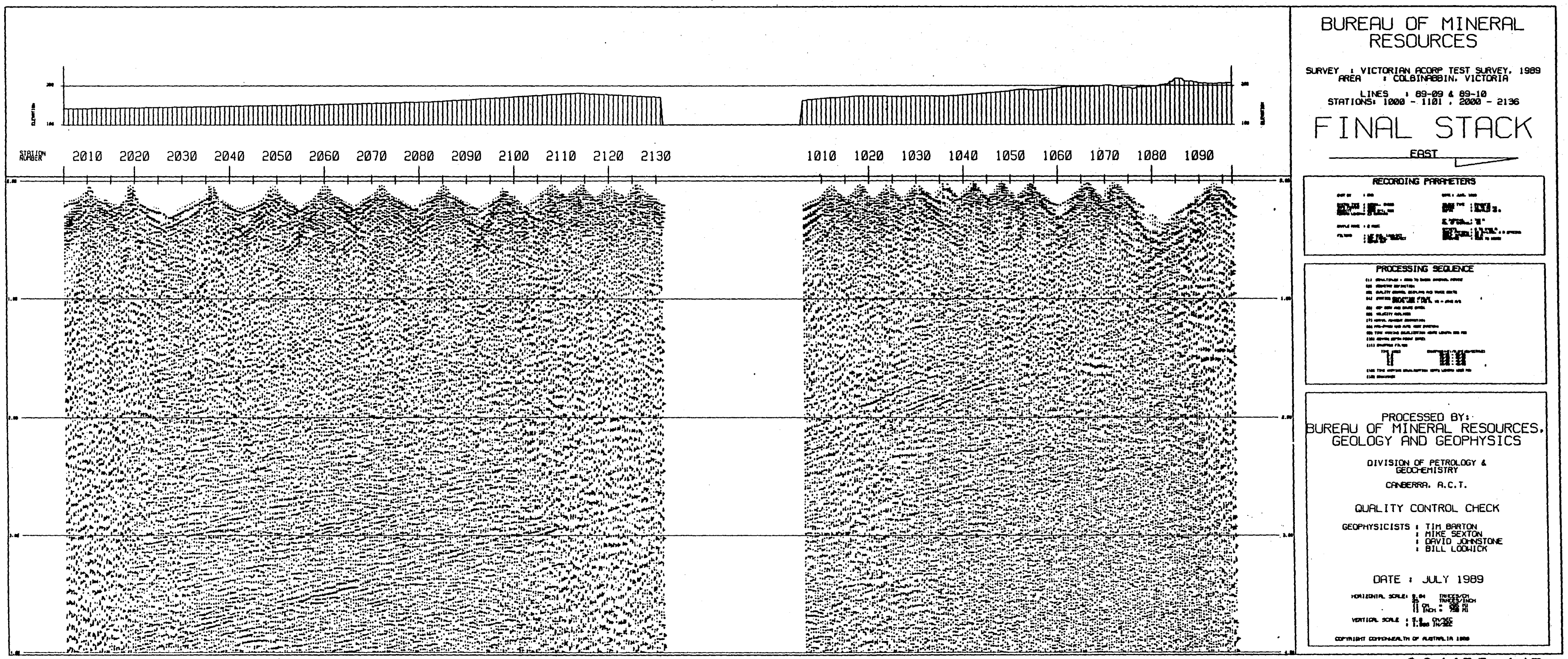


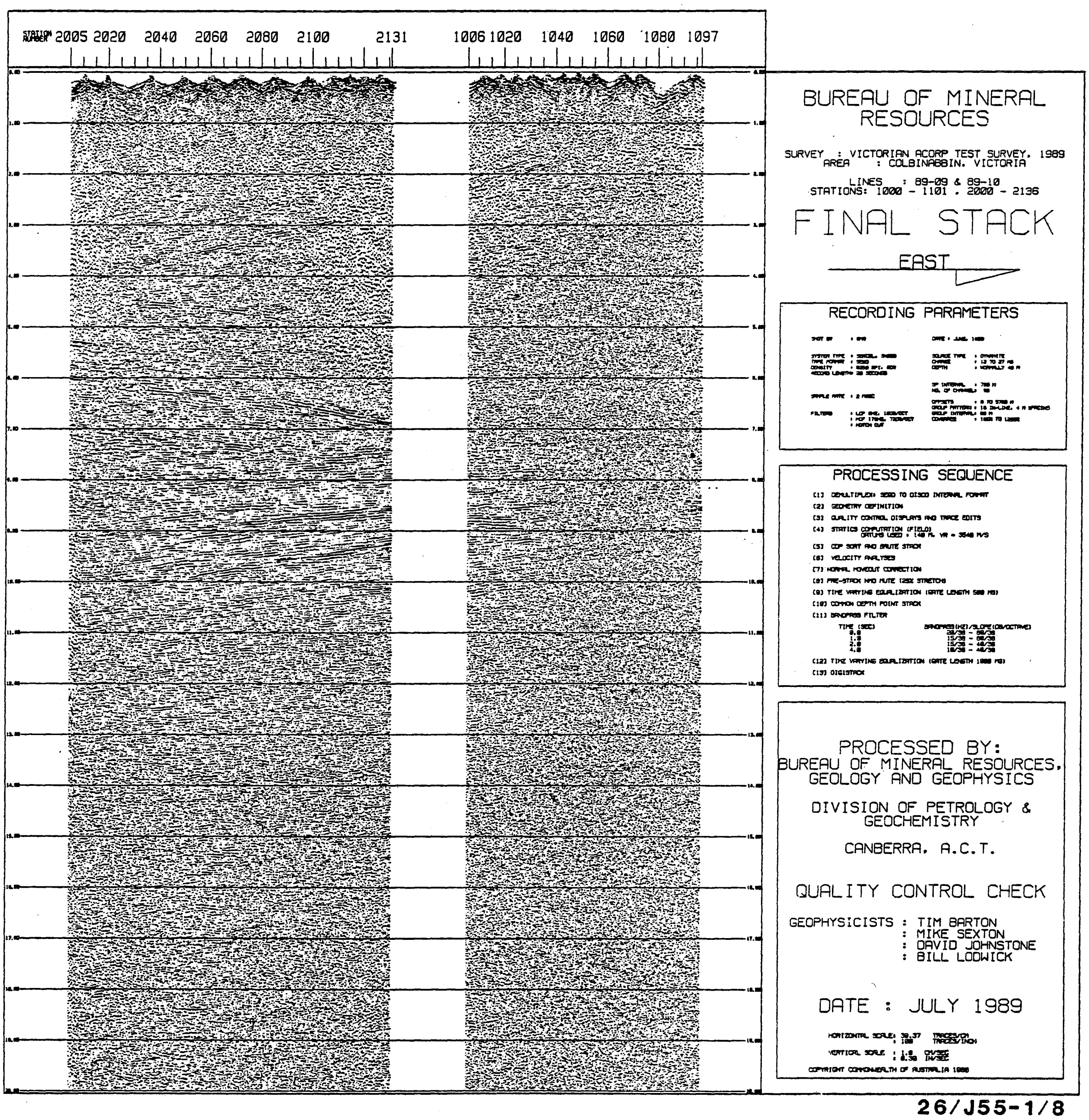
FIGURE 6 NEAR SURFACE REFRACTOR PROFILE

26/J55-1/6



26/J55-1/7

FIGURE 7 LINES 89-09 & 89-10 4 SECOND STACK



26/J55-1/8

FIGURE 8 LINES 89-09 & 89-10 20 SECOND STACK