POST-SEISMIC SURVEYS IN THE EPICENTRAL AREA OF THE 1988 TENNANT CREEK, N.T., EARTHQUAKES

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Summary

On 22 January 1988 three earthquakes of M_S 6.3-6.7 struck 30 km southwest of Tennant Creek, N.T., Australia and produced approximately 32 km of surface faulting along two main scarps. An extensive survey program in the epicentral area was conducted in February and March, 1988 by the Australian Surveying and Land Information Group (AUSLIG) on behalf of the Bureau of Mineral Resources in order to quantify the deformation associated with the earthquakes. The survey program consisted of: (1) aerial photography of the fault scarps; (2) 170 km of double run levelling; (3) three detailed levelling profiles of 3 km length; (4) 85 geodimeter traverses across the scarps at intervals of 0.5 km along the scarp; (5) global positioning system (GPS) measurements of the coordinates of temporary benchmarks along the scarp and of portable seismograph stations; and (6) detailed surveying in selected areas. This report describes the survey program and tabulates the data that were collected.

Introduction

Three earthquakes of M_S 6.3-6.7 occurred within a 12 hour period (0036, 0357 and 1205 UTC) on 22 January 1988 southwest of Tennant Creek, N.T. (Figure 1). These earthquakes produced 32 km of surface faulting on two main scarps. The Lake Surprise scarp is the longer of the two and in map view looks like a boomerang that is concave to the south. The Kunayungku scarp is shorter and lies about 6 km northwest of the Lake Surprise scarp. Fortunately, the epicentral area had been part of a gravity and magnetic survey during the early 1970s (Hone, 1973; Bullock, 1977), so elevation data are available from the fault zone for the period preceding the earthquakes. In order to measure the surface deformation associated with the earthquakes, the Bureau of Mineral Resources engaged the Australian Surveying and Land Information Group (AUSLIG) to conduct an extensive survey of the epicentral area during February and March, 1988.

The 1988 fault zone at Tennant Creek was essentially aseismic from the start of local monitoring in 1965 until 1987, but more than 1100 small to moderate earthquakes occurred during 1987 (Bowman, 1988). The activity in 1987 was concentrated in the gap

between the two 1988 scarps (Bouniot et al., 1990; Bowman and Dewey, 1991). Focal mechanisms for the three main shocks were thrust and oblique thrust with compressional axes oriented north to north-northeast (McCaffrey, 1989; Choy and Bowman, 1990; Jones et al., 1992). Because of their remote location, these large earthquakes caused less than $1,000,000 damage (Jones et al., 1992). The spatial distribution of aftershocks (Bowman et al., 1990) and coseismic elevation changes (Bowman, 1991) indicate rupture along three fault planes in conjugate orientation. A portion of the surface rupture from the Tennant Creek earthquakes followed a pre-existing fault (Bowman, 1988) with evidence of previous seismic displacement during the Quaternary (Crone et al., 1992).

The 1988 surveying data presented here are derived from reports of the AUSLIG survey team. "Weather conditions (hot, windy and dusty) were not conducive to accurate levelling; results obtained were adequate for the scientific study of the effects of the earthquake, but not for other more precise work...." (Erickson, 1988). Data are presented as printed tables and as ASCII tables on 3 1/2" floppy disks (MS-DOS and Macintosh formats; Appendix).

Aerial Photography

There were two main purposes for conducting aerial photography. First, it helped AUSLIG to construct an accurate map of the scarp at a scale of 1:25,000 (Plate 1; Peters, 1988). Second, the photographs allow more detailed analysis of the coseismic deformation than possible from only ground observations. On 16 and 17 February 1988 colour aerial photographs with 60% forward overlap were taken along the main fault scarps from an elevation 5039' (1536 m) above mean sea level. A total of 88 photos were taken along six flight runs at a scale of 1:8000. Each 23 cm x 23 cm contact print shows an area of 1.8 km x 1.8 km. The aerial photographs are available for purchase from AUSLIG as the "Tennant Creek Special" (SOC 769).

Over much of its length, the scarp was anastamosing, broken into numerous strands, and displaced *en echelon*. It was difficult to identify the scarp in the aerial photographs at many places, and vehicle tracks that followed the scarp and large white

targets that were deployed at photo control points were the primary indication of the scarp's location. Along the western Lake Surprise segment, the scarp was linear for several kilometres and a fissure several metres behind the scarp face formed a prominent dark line in the aerial photos (Figure 2). Further to the west, a ridge of brecciated quartz that marks an ancient fault shows as a linear, white feature (bottom third of Figure 2). Along the Kunayungku scarp, a band of dried spinifex (*triodia sp.*) that was killed by the surface rupture was visible in the photos.

Large-Scale Levelling

Perhaps the most important aspect of the 1988 survey program was 170 km of double-run levelling in and around the epicentral area (Figure 1). Comparison of the 1988 level data with those collected in 1972/3 gives a measure of vertical displacements caused by the earthquakes.

Star pickets were installed as temporary benchmarks (TBM) at 170 sites with nominal spacing of 1 km. The TBMs outline a large rectangular paddock that is useful for geographic reference (Figure 1). In addition, eight benchmarks from earlier surveys (old galvanized iron pipes: OGIP) and a fence corner were reoccupied. Although the TBMs were labelled with aluminium tags, many tags had already been mutilated or removed by grazing cattle at the time of a field visit in September, 1990. TBM locations were estimated by AUSLIG on 1:100,000 scale maps based partly on mileage from known points; we then measured the coordinates from these maps (Table 1). For convenience we numbered the OGIPs (these are not AUSLIG designations). The large-scale levelling survey was tied into three benchmarks (DCR 77, DCR 78 and DCR 79) along the proposed Alice Springs-Darwin railway route. These benchmarks are 10 km northeast of the easternmost fault scarp and probably were not displaced significantly by the earthquakes. Bowman (1991) reorganised the levelling data to make continuous north-south and east-west profiles and calculated distances along each profile from the south or east end. Following this convention, the 1988 levelling data are compared with those from BMR150 (1972) and BMR164 (1973) in Table 2 and for selected lines in Figure 3.

Table 6 (disk only) lists the data in the sequence reported by AUSLIG, with original chainages. We note that Erickson (1988) considered the accuracy of the BMR 164 levelling to be "doubtful".

Three-km Levelling Lines

Lines of 3-km length were levelled across the scarp at three locations shown in Figure 1 and Plate 1. Survey pegs were driven in at 100 m intervals and elevations were reported from these sites and from the midpoints between pegs. Where the southern part of profile AA' obliquely crosses the road along the eastern fence of the paddock, the pegs were driven flush with the road surface, and by September, 1990, many of these pegs were covered with soil. Elevations along the three 3-km profiles (Erickson, 1988) are shown in Figure 4 and listed in Table 3. Bowman (1991) estimated the scarp height along profiles AA', BB; and CC' as 1.3, 1.8 and 0.8 m, respectively.

Detailed Topographic Profiles Across the Scarps

Eighty-five topographic profiles of 200 m length were made across the scarps at about 500 m intervals using a geodimeter (Fryc, 1988; Figure 5, Table 4). We refer to these 200-m lines as "topographic profiles" to distinguish them from other profiles measured using spirit levels. The locations of the topographic profiles are shown on Plate 1 and listed in Table 4 (Peters, 1988); for reference points of profiles that were occupied by GPS, latitudes and longitudes as well as Australian map grid coordinates are given in Table 7. The profiles were coarsely sampled, typically with eight to twelve data points each, but collectively they provide a useful description of the surface deformation produced by the Tennant Creek earthquakes. The 200-m topographic profiles are a less accurate representation of the co-seismic vertical deformation than the 3-km levelling lines because surficial deformation was often distributed in a zone wider than 200 m (Bowman, 1991). The absolute elevation for each topographic profile is accurate to about half a metre (G. Clarke, written communication, 1988). Some of the topographic profiles missed the primary zone of seismic deformation (e.g., profiles 5500 and 25000).

GPS Locations

Global Positioning System (GPS) receivers were used to determine the coordinates of 73 key sites in and around the epicentral area. These sites include the photo control points (PCP) for the aerial photography, reference points for the topographical profiles across the scarps, and temporary seismograph stations (G. Clarke, written communication, 1988). The GPS coordinates for the profiles and PCPs are given with the corresponding elevation data in Table 4 and are given for the seismograph stations in Table 5. These locations were used by AUSLIG to help construct an accurate map of the epicentral area and to plot the fault scarps in Plate 1. Elevations determined by spirit levelling were systematically about 1 m higher than those measured with GPS receivers (G. Clarke, written communication, 1988).

Other Surveying

There were several other minor elements of the 1988 surveying program that we describe here for sake of completeness. However, these were relatively insignificant in the overall program, and so data are not presented. In the first of these studies, two trenches of 3 m depth were excavated across the eastern Lake Surprise scarp near the gas pipeline. The trench walls were surveyed to determine that the fault plane dipped to the south at 20-30° (Bowman et al., 1990; Jones et al., 1992). Second, sections of wire paddock fences that had been disrupted by the surface faulting were surveyed in an attempt to measure fault offsets (Figure 1). In the final study, levelling was conducted along 200 m of the dry bed of a creek which crossed the fault scarp and which formerly drained north into Lake Surprise (Plate 1). The levelling confirmed the sense of thrust faulting and uplift associated with the western Lake Surprise fault; following the earthquake the northern block was uplifted and the direction of the flow of this stream had reversed (Bowman, 1991).

Discussion

The scarp morphology (Figures 4 and 5) and excavations across the scarp (Bowman et al., 1990; Crone et al., 1992; Jones et al., 1992) indicate primarily thrust faulting during the 1988 Tennant Creek earthquakes. The orientation of the scarps (Plate 1) and the opposed sense of thrusting, from south-over-north along the eastern Lake Surprise and Kunayungku scarps to north-over-south along the western Lake Surprise scarp (Bowman, 1988, 1991; Jones et al., 1992), requires a complex geometry of faulting at depth.

Comparison of the 1988 levelling data with data collected in 1972 and 1973 can be used for modelling the distribution of faulting with depth. Bowman (1991) assumed uniform slip on rectangular, dip-slip faults to derive a fault model consisting of three faults in conjugate orientation. It is likely that a more detailed model that allows for variable slip on the faults will provide a better fit of calculated and observed elevation changes, but lack of data in the eastern portion of the fault zone may make it difficult to constrain such a model.

In addition to the surveying data in the earthquake epicentral area, a range of other geophysical data exist. These include the gravity and magnetic data collected in surveys in 1972 and 1973 (Hone, 1974; Bullock, 1977), a set of hundreds of foreshocks and aftershocks recorded by field instruments in 1987 and 1988 (Bowman et al., 1990; Bouniot et al., 1990; Jones et al., 1992), and a history of seismic monitoring in the area extending back to 1965 when the Warramunga Seismic Array some 30 km east of the surface faulting, was established (Bowman, 1988). This comprehensive data set makes the Tennant Creek earthquake sequence an outstanding example, suitable for intensive study, of earthquake occurrence in a stable continental interior.

Acknowledgements

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Figure Captions

Figure 1. Location of the levelling survey conducted in the fault zone of the 1988 Tennant Creek earthquakes. Heavy black lines show the fault scarps from AUSLIG mapping, and teeth are on the upthrown blocks. Filled circles show sites for which pre-seismic elevation could be estimated accurately, and open circles show other TBMs. Three levelling profiles of 3 km length are shown as grey lines. Letters show the end points of the profiles shown in subsequent figures, and the inset shows the location of the main map within Australia. Profile PP' lies along a natural gas pipeline that was deformed by the earthquakes. Open square shows location of photograph in Figure 2.

Figure 2. Example of aerial photograph of the fault scarp from the "Tennant Creek Special" at a scale of 1:8000 (SOC 679, Run 4, 065). Arrow at top of photograph shows north, and Figure 1 shows the location of the photo. Dark line in top of photo is a fissure several metres behind the scarp face, and linear white feature in bottom of photo is a quartz ridge that is colinear with the 1988 scarp.

Figure 3. Change in elevation between surveys in 1972/73 and 1988 along five profiles in the fault zone. Letters to the right of each profile refer to locations in Figure 1. Diamonds and circles show 1988 elevations relative to 1972 and 1973, respectively; large symbols represent reoccupied benchmarks, whereas small symbols rely on elevations interpolated from earlier surveys. Outlying values that were rejected by Bowman (1991) on the basis of interpolation errors are shown in grey. Stippled vertical lines show the locations of the scarp and the dashed horizontal lines show zero change of elevation.

Figure 4. Detailed levelling profiles crossing the 1988 fault scarps at three locations shown in Figure 1. Elevations are relative to mean sea level and were measured at 50 m intervals with extra points near the scarps.

Figure 5. Short topographic profiles crossing the 1988 scarps at 85 locations shown on Plate 1 and plotted from the data in Table 4. Profiles are about 200 m long and 1 m elevation is shown by the vertical bar in the upper left. The abrupt change in topographic gradient represents the fault scarp. (The last two zeros are dropped from station names.)

Plate 1. Map of the fault zone prepared by AUSLIG (Plate E88/17-sheet 4 of 4).

Table Captions

Table 1. Coordinates of benchmarks (OGIP) and temporary benchmarks (TBM).

Table 2. Data from large-scale levelling survey reorganised to make continuous profiles by Bowman (1991). Elevations that were interpolated from the BMR 150 and 164 surveys by AUSLIG without recovery of a benchmark are shown as negative. Points considered to be spurious by Bowman (1991) are labelled as "outliers".

2a. Cabbage Gum profile (GG')
2b. Lake Surprise profile (DD')
2c. West fenceline of paddock (WW')
2d. North fence line (NN')
2e. South fence line (SS')
2f. East fence line (EE')
2g. Natural gas pipeline (PP')
2h. Bore P10 road profile (B'D')

Table 3. Levelling data for 3-km profiles:

3a. AA'
3b. BB'
3c. CC'

Table 4. Short topographic profiles across the scarps at locations shown on Plate 1 and listed in Table 7. Only the first page of this table is shown; the entire table is included on the accompanying floppy disk.

Table 5. Coordinates of temporary seismograph stations.

Table 6. Details of levelling from large-scale survey as in Table 2, but in the original order given by AUSLIG. This table is only given on the accompanying floppy disk.

6a. Traverse from railway BM DCR78 to TBM 20
6b. Cabbage Gum West
6c. Cabbage Gum North
6d. Cabbage Gum South
6e. Large rectangular fenced paddock
6f. Fence lines to west of large rectangular fenced paddock
6g. NT Gas pipeline

Table 7. Coordinates of reference points for the topographic profiles (Table 4) in Australian Map Grid and geographical coordinates. Those points for which locations were determined with GPS receivers are included; other coordinates can be estimated from Plate 1. This table is only included on the floppy disk.

Table 1. Coordinates of benchmarks (OGIP) and temporary benchmarks (TBM)

Station	Latitude °S	Longitude °E
TBM1	-19.7825	134.1749
TBM2	-19.7888	134.1668
TBM3	-19.7940	134.1589
TBM4	-19.7989	134.1508
TBM5	-19.8051	134.1429
TBM6	-19.8104	134.1343
TBM7	-19.8147	134.1247
TBM8	-19.8165	134.1139
TBM9	-19.8196	134.1054
TBM10	-19.8260	134.0959
TBM11	-19.8203	134.0925
TBM12	-19.8127	134.0855
TBM13	-19.8111	134.0776
TBM14	-19.8096	134.0706
TBM15	-19.8102	134.0629
TBM16	-19.8110	134.0549
TBM17	-19.8108	134.0489
TBM18	-19.8088	134.0425
TBM19	-19.8097	134.0352
TBM20	-19.8151	134.0249
TBM21	-19.8036	134.0244
TBM22	-19.7958	134.0205
TBM23	-19.7877	134.0158
TBM24	-19.7800	134.0118
TBM25	-19.7758	134.0095
TBM26	-19.7682	134.0062
TBM27	-19.7604	133.9959
TBM28	-19.7604	133.9866
TBM29	-19.7604	133.9790
TBM30	-19.7603	133.9696
TBM31	-19.7603	133.9601
TBM32	-19.7603	133.9503
TBM33	-19.7602	133.9388
TBM34	-19.7602	133.9314
TBM35	-19.7601	133.9209
TBM36	-19.7601	133.9117
TBM37	-19.7602	133.9020
TBM38	-19.7606	133.8928
TBM50	-19.8203	134.0856
TBM51	-19.8295	134.0856
TBM52	-19.8755	134.0860
TBM53	-19.8757	134.0768
TBM54	-19.8757	134.0676
TBM55	-19.8759	134.0581
TBM56	-19.8760	134.0485
TBM57	-19.8761	134.0395
TBM58	-19.8762	134.0290
TBM59	-19.8763	134.0210
TBM60	-19.8764	134.0121
TBM61	-19.8765	134.0031
TBM62	-19.8767	133.9931
TBM63	-19.8768	133.9832
TBM64	-19.8769	133.9750
TBM65	-19.8769	133.9718
TBM66	-19.8770	133.9633

TBM67	-19.8771	133.9541
TBM68	-19.8772	133.9447
TBM69	-19.8774	133.9356
TBM70	-19.8775	133.9261
TBM71	-19.8776	133.9158
TBM72	-19.8777	133.9079
TBM73	-19.8777	133.9035
TBM74	-19.8685	133.9029
TBM75	-19.8600	133.9023
TBM76	-19.8510	133.9017
TBM77	-19.8424	133.9017
TBM78	-19.8338	133.9004
TBM79	-19.8248	133.8998
TBM80	-19.8158	133.8992
TBM81	-19.8066	133.8985
TBM82	-19.7982	133.8980
TBM83	-19.7894	133.8973
TBM84	-19.7806	133.8967
TBM85	-19.7716	133.8962
TBM86	-19.7628	133.8955
TBM87	-19.7605	134.0022
TBM88	-19.7605	134.0106
TBM89	-19.7606	134.0198
TBM90	-19.7606	134.0287
TBM91	-19.7607	134.0383
TBM92	-19.7607	134.0475
TBM93	-19.7608	134.0578
TBM94	-19.7608	134.0671
TBM95	-19.7609	134.0766
TBM96	-19.7609	134.0850
TBM97	-19.7668	134.0851
TBM98	-19.7761	134.0852
TBM99	-19.7848	134.0856
TBM100	-19.7947	134.0853
TBM101	-19.8038	134.0854
TBM102	-19.8459	134.0291
TBM103	-19.8548	134.0291
TBM104	-19.8638	134.0291
TBM105	-19.8726	134.0288
TBM106	-19.7898	134.0050
TBM107	-19.7924	133.9962
TBM108	-19.7947	133.9871
TBM109	-19.7980	133.9782
TBM110	-19.8036	133.9692
TBM111	-19.7859	134.0419
TBM112	-19.7858	134.0514
TBM113	-19.7865	134.0614
TBM114	-19.7875	134.0709
TBM115	-19.7892	134.0808
TBM116	-19.7917	134.0956
TBM117	-19.7928	134.1034
TBM118	-19.7926	134.1113
TBM119	-19.7940	134.1217
TBM120	-19.7948	134.1331
TBM121	-19.7918	134.1449
TBM122	-19.7881	134.1528
TBM123	-19.7877	134.1604
TBM125	-19.7890	134.1758
TBM126	-19.7895	134.1916
TBM127	-19.8160	133.9584
TBM128	-19.8250	133.9579
TBM129	-19.8331	133.9622
TBM130	-19.8421	133.9589

TBM131	-19.8498	133.9599	
TBM132	-19.8583	133.9637	
TBM133	-19.8668	133.9680	
TBM134	-19.8839	133.9646	ambiguous location
TBM135	-19.8884	133.9594	
TBM136	-19.8995	133.9608	
TBM137	-19.9073	133.9632	
TBM138	-19.9163	133.9642	
TBM139	-19.9252	133.9640	
TBM140	-19.9352	133.9646	
TBM141	-19.9420	133.9689	
TBM142	-19.9514	133.9748	
TBM143	-19.9586	133.9775	
TBM144	-19.9667	133.9795	
TBM145	-19.9757	133.9823	
TBM146	-19.8001	133.9455	
TBM147	-19.7910	133.9412	
TBM148	-19.7832	133.9367	
TBM149	-19.7751	133.9321	
TBM150	-19.7681	133.9285	
TBM151	-19.7515	133.9188	
TBM152	-19.7442	133.9145	
TBM153	-19.7372	133.9106	
TBM154	-19.7295	133.9059	
TBM155	-19.7103	133.8997	
TBM156	-19.7027	133.8958	
TBM157	-19.7004	133.8860	
TBM158	-19.6962	133.8772	
TBM159	-19.6930	133.8703	
TBM160	-19.6826	133.8702	
TBM161	-19.6752	133.8676	
TBM162	-19.6667	133.8652	
TBM167	-19.7603	133.8418	
TBM168	-19.7605	133.8514	
TBM169	-19.7607	133.8611	
TBM170	-19.7607	133.8719	
PEG00	-19.8366	134.0295	
PEG17	-19.7602	133.8840	
PEG38	-19.7610	133.8927	
PEG00A	-19.8682	134.0856	
PEG30A	-19.8390	134.0856	
OGIP0	-19.9813	133.9828	
OGIP1	-19.8892	133.9591	
OGIP2	-19.8430	133.9570	
OGIP3	-19.8075	133.9498	
OGIP4	-19.8068	133.9618	
OGIP5	-19.7601	133.9235	
OGIP6	-19.7870	134.0301	
OGIP7	-19.7198	133.9030	
OGIP8	-19.7890	134.1959	
OGIP/D	-19.7895	134.0852	
PCP115	-19.7350	133.8416	
PCP120	-19.7475	133.8418	
DCR77	-19.7893	134.1852	

Table 2a. Levelling data for Cabbage Gum (north-south) profile (GG')

Station name 1988	Chainage (1988) (km)	Reduced elevation top of peg	Reduced elevation ground	Chainage 150 (km)	Elevation 150 (m)	Station name 164	Elevation 164 (m)	Remarks
OGIP0	0.00	323.484		21.0	323.347			
TBM145	0.6	325.100	325.01		-324.7			
TBM144	1.55	332.834	332.75		-332.7			
TBM143	2.53	330.215	330.01		-330.0			
TBM142	3.53	323.813	323.63		-323.4			
TBM141	4.51	320.761	320.64		-320.0			
TBM140	5.50	321.030	320.91		-321.1			
TBM139	6.49	319.712	319.63		-319.4			
TBM138	7.46	315.673	315.58		-315.4			
TBM137	8.45	313.961	313.88		-313.8			
TBM136	9.95	314.069	313.96		-314.0			
TBM135	10.44	317.017	316.92		-316.8			
OGIP1	10.60	317.281		10.055	-316.8			
TBM134	11.41	312.577	312.50		-310.9			outlier
TBM65	12.45	308.225	308.11		-307.7			
TBM133	13.50	306.841	306.73		-305.9			
TBM132	14.46	306.118	306.01		-305.4			
TBM131	15.45	304.861	304.75		-304.0			
-	15.6		304.4					
-	15.8		304.1					
-	16.0		303.6					
OGIP2	16.2	303.582	303.55	4.32	-302.5			
TBM130	16.46	302.919	302.83					
-	16.6		302.5					
-	16.8		302.1					
-	17.0		301.7					
-	17.2		301.3					
TBM129	17.44	301.192	301.07		-300.2			
-	17.6		300.9					
-	17.8		300.9					
-	18.0		301.0					
-	18.2		301.0					
TBM128	18.41	301.441	301.31		-300.3			
-	18.6		301.0					
-	18.8		300.4					
-	19.0		300.1					
-	19.2		300.0					
TBM127	19.40	300.288	300.19		-299.3			
-	19.6		300.5					
-	19.8		300.7					
-	20.0		300.6					
-	20.2		300.4					
OGIP4	20.40	299.903	299.82	25.43	299.303			
-	20.6		298.8					
-	20.8		298.5					
-	21.0		297.4					
-	21.2		297.5					
-	21.4		297.3					
-	21.6		297.5					
OGIP3	21.64	298.654		26.705	297.982			
-	21.84		297.85					
-	22.04		297.8					
-	22.24		298.7					
-	22.44		298.6					
TBM146	22.66	298.510	298.38		-298.0			
-	22.84		298.2					
-	23.04		298.4					

-	23.24		298.5		
-	23.44		298.6		
TBM147	23.66	298.512	298.39		-298.2
-	23.84		298.2		
-	24.04		298.1		
-	24.24		298.0		
-	24.44		298.0		
TBM148	24.64	298.036	297.93		-297.7
-	24.84		297.7		
-	25.04		297.6		
-	25.24		297.4		
-	25.44		297.3		
TBM149	25.65	297.592	297.49		-297.1
-	25.84		297.5		
-	26.04		297.5		
-	26.24		297.8		
-	26.44		297.1		
PCP25	26.50	297.229			
TBM150	26.64	297.234	297.11		-297.0
OGIP5	27.41	296.417		6.0	296.352
PCP20	27.59	296.550			
TBM151	28.55	295.798	295.61		-295.6
TBM152	29.48	295.043	294.95		-295.0
TBM153	30.38	294.701	294.56		-294.5
TBM154	31.34	294.169	294.07		-294.0
OGIP7	32.34	293.589	293.59	11.03	293.550
TBM155	33.48	293.539	293.42		-293.3
TBM156	34.40	293.671	293.58		-293.5
TBM157	35.34	291.989	291.90		-292.3
TBM158	36.39	290.899	290.80		-290.6
TBM159	37.26	290.229	290.08		-290.1
TBM160	38.27	290.785	290.60		-290.9
TBM161	39.30	285.733	285.61		-285.6
TBM162	40.26	286.942	286.82		-286.3
TBM163	41.30	290.248	290.14		
TBM164	42.30	294.028	293.92		
TBM165	43.29	298.520	298.42		
TBM166	43.89	301.913	301.81		

Table 2b. Levelling data for Lake Surprise profile (DD')

Station name 1988	Chainage (1988) (km)	Reduced elevation top of peg	Reduced elevation ground	Chainage 150 (km)	Elevation 150 (m)	Station name 164	Elevation 164 (m)	Remarks
OGIP3	0.0	298.654		26.705	297.982			
	-	0.04			297.5			
	-	0.24			297.3			
	-	0.44			297.5			
	-	0.64			297.4			
	-	0.84			298.5			
	-	1.04			298.8			
OGIP4	1.24	299.903	299.82	25.43	299.303			
TBM110	2.29	303.570	303.43					
TBM109	3.21	304.099	303.96					
TBM108	4.24	304.035	303.92					
TBM107	5.27	305.243	305.06					
TBM106	6.26	306.090	305.96					
TBM23	7.27	306.984						
OGIP6	8.81	308.654		17.7	308.648			

TBM111	10.01	310.348	310.19		
TBM112	11.03	311.996	311.84		
TBM113	12.01	313.044	312.93		
TBM114	12.99	314.074	313.94		
TBM115	13.96	314.774	314.65		
OGIP/D	14.50	315.210		11.875	315.180
TBM116	15.51	316.249	316.16		
TBM117	16.50	316.983	316.86		
TBM118	17.51	318.219	318.13		
TBM119	18.47	318.817	318.69		
TBM120	19.44	320.227	320.09		
TBM121	20.44	321.579	321.42		
TBM122	21.43	322.943	322.80		
TBM123	22.39	324.885	324.75		
TBM2	22.88	325.079	324.92		
TBM125	23.95	326.270	326.14		
DCR77	24.53	326.892			
TBM126	25.52	329.377	329.22		
OGIP8	26.04	331.285	331.25	00.	331.225

Table 2c. Levelling data for west fence line profile (WW')

Station name 1988	Chainage (1988) (km)	Reduced elevation top of peg	Reduced elevation ground	Chainage 150 (km)	Elevation 150 (m)	Station name 164	Elevation 164 (m)	Remarks
TBM73	0.0	293.649	293.52			FL17	293.5	
TBM74	0.96	292.035	291.92				-291.7	
TBM75	1.89	289.375	289.25				-289.3	
TBM76	2.83	288.867	288.75				-289.0	
TBM77	3.80	290.836	290.75				-291.0	
TBM78	4.75	295.773	295.67				-294.7	
TBM79	5.69	298.902	298.70				-297.7	
TBM80	6.66	298.580	298.49				-297.7	
TBM81	7.60	301.870	301.78				-301.8	
TBM82	8.55	305.945	305.84				-303.7	outlier
TBM83	9.49	298.670	298.57				-297.0	outlier
TBM84	10.43	294.962	294.88				-294.4	
TBM85	11.41	293.869	293.78				-293.1	
TBM86	12.33	293.641	293.48				-293.0	

Table 2d. Levelling data for north fence line profile (NN')

Station name 1988	Chainage (1988) (km)	Reduced elevation top of peg	Reduced elevation ground	Chainage 150 (km)	Elevation 150 (m)	Station name 164	Elevation 164 (m)	Remarks
TBM167	0.0	287.430	287.30					
TBM168	1.08	288.244	288.17				-287.7	
TBM169	2.05	289.822	289.73				-288.0	outlier
TBM170	3.07	291.402	291.30				-290.4	
PEG17	4.32	292.598	292.31				-291.7	
TBM38	5.22	293.805						
F/Intn	5.79					1.2704W	-293.2	
TBM37	6.2	293.809	293.66					
TBM36	7.17	295.094					-295.9	outlier
TBM35	7.88	296.320					-296.2	
OGIP5	8.35	296.417				FL1	-296.3	

TBM34	9.12	297.183	
TBM33	9.90	298.205	
TBM32	11.05	299.880	
TBM31	12.03	300.164	
TBM30	13.01	300.772	
TBM29	13.97	301.904	
TBM28	14.94	303.103	
TBM27	15.90	304.014	303.84
TBM87	16.37	304.513	304.36
TBM88	17.33	305.790	305.67
TBM89	18.28	307.141	307.07
TBM90	19.19	307.891	307.80
TBM91	20.19	309.027	308.93
TBM92	21.11	312.018	311.91
TBM93	22.10	312.131	312.03
TBM94	23.05	312.796	312.67
TBM95	24.02	313.609	313.49

Table 2e. Levelling data for south fence line profile (SS')

Station name 1988	Chainage (1988) (km)	Reduced elevation top of peg	Reduced elevation ground	Chainage 150 (km)	Elevation 150 (m)	Station name 164	Elevation 164 (m)	Remarks
TBM73	0.0	293.649	293.52			FL17	293.5	
TBM72	0.44	294.757	294.66				-294.3	
TBM71	1.35	297.051	296.93				-296.3	
TBM70	2.28	300.089	299.98				-299.4	
TBM69	3.25	305.353	305.25				-304.0	outlier
TBM68	4.19	309.853	309.71				-309.3	
TBM67	5.12	313.074	312.93				-312.6	
TBM66	6.07	310.794	310.63				-308.7	outlier
TBM65	7.19	308.225	308.12			FL25	-307.9	
TBM64	7.49	308.332	308.20					
TBM63	8.40	310.872	310.76					
TBM62	9.34	316.995	316.91					
TBM61	10.32	323.373	323.28					
TBM60	11.24	328.797	328.63					
TBM59	12.18	333.154	333.02					
TBM58	13.04	335.027	334.91					
TBM57	14.07	335.490	335.34					
TBM56	15.00	337.163	337.07					
TBM55	15.96	345.352	345.22					
TBM54	16.91	345.576	345.41					
TBM53	17.86	340.211	340.07					
TBM52	18.79	335.672	335.55					

Table 2f. Levelling data for east fenceline profile (EE')

Station name 1988	Chainage (1988) (km)	Reduced elevation top of peg	Reduced elevation ground	Chainage 150 (km)	Elevation 150 (m)	Station name 164	Elevation 164 (m)	Remarks
TBM52	0.00	335.672	335.55					
TBM51	4.79	318.694	318.56					
TBM50	5.94	316.876	316.76					
TBM12	6.66	315.880	315.73					
TBM101	7.46	315.446	315.30					

TBM100	8.46	315.461	315.33
OGIP/D	9.20	315.210	
TBM99	9.42	315.203	315.06
TBM98	10.38	314.512	314.35
TBM97	11.37	317.025	316.95
TBM96	12.32	314.603	314.52

Table 2g. Levelling data for gas pipeline profile (PP')

Station name 1988	Chainage (1988) (km)	Reduced elevation top of peg	Reduced elevation ground	Chainage 150 (km)	Elevation 150 (m)	Station name 164	Elevation 164 (m)	Remarks
TBM58	00	335.027	334.90					
TBM105	0.24	333.656	333.56					
ST401-6		331.107	331.03					Star Iron
TBM104	1.25	327.976	327.83					
ST401-5		326.922	326.83					Star Iron
TBM103	2.21	326.810	326.68					
ST401-4		329.415	329.36					Star Iron
TBM102	3.18	328.513	328.37					
ST401-3		327.480	327.38					Star Iron
TBM21	7.70	308.916						
TBM22	8.76	308.493						
TBM23	9.96	306.979						
TBM24	11.	306.369						
TBM25	12.	305.711						
TBM26	13.	305.043						
TBM27	14.	304.014						

Table 2h. Levelling data for bore P10 road profile (B'D')

Station name 1988	Chainage (1988) (km)	Reduced elevation top of peg	Reduced elevation ground	Chainage 150 (km)	Elevation 150 (m)	Station name 164	Elevation 164 (m)	Remarks
DCR78	00.	327.527						
TBM1	1.	326.104						
TBM2	2.	325.079						
TBM3	3.	323.907						
TBM4	4.	322.841						
TBM5	5.	321.969						
TBM6	6.	320.796						
TBM7	7.	319.986						
TBM8	8.	320.242						
TBM9	9.	319.919						
TBM10	10.	318.943						
TBM11	11.	317.450						
TBM12	12.	315.880						
TBM13	13.	315.039						
TBM14	14.	313.976						
TBM15	15.	312.883						
TBM16	16.	311.633						
TBM17	17.	310.942						
TBM18	18.	310.426						
TBM19	19.	310.753						
TBM20	20.	310.958						

Table 3a. Levelling data for profile AA'

Station	Chainage	Reduced level		Remarks
		top of peg	ground	
	(km)	(m)	(m)	
PEG00	0.000	333.668	333.67	
—	0.050		333.59	
PEG1	0.100	333.429	333.43	
—	0.150		333.28	
PEG2	0.200	333.191	333.19	
—	0.250		333.05	
PEG3	0.300	332.968	332.97	
—	0.350		332.87	
PEG4	0.400	332.782	332.78	
—	0.450		332.65	
PEG5	0.500	332.576	332.58	
—	0.550		332.43	
PEG6	0.600	332.361	332.36	
—	0.650		332.25	
PEG7	0.700	332.178	332.18	
—	0.750		332.06	
PEG8	0.800	331.958	331.96	
—	0.850		331.83	
PEG9	0.900	331.693	331.69	
—	0.950		331.58	
PEG10	1.000	331.438	331.44	
—	1.050		331.29	
PEG11	1.100	331.191	331.19	
—	1.150		331.09	
PEG12	1.200	330.944	330.94	
—	1.250		330.80	
PEG13	1.300	330.906	330.70	
—	1.350		330.58	
PEG14	1.400	330.629	330.44	
—	1.450		330.36	
PEG15	1.500	330.465	330.25	
—	1.550		330.17	
PEG16	1.600	330.201	330.00	
—	1.650		329.81	
PEG17	1.700	329.805	329.57	
—	1.750		329.40	
PEG18	1.800	329.382	329.20	
—	1.850		328.98	
PEG19	1.900	328.983	328.78	
—	1.950		328.61	
PEG20	2.000	328.636	328.50	Change in grade
—	2.017		328.29	Top of scarp
—	2.038		327.73	Top of scarp
—	2.043		327.34	Bottom of scarp
—	2.050		327.28	
PEG21	2.100	327.246	327.06	
—	2.150		326.85	
PEG22	2.200	326.725	326.50	
—	2.250		326.26	
PEG23	2.300	326.267	326.06	
—	2.350		325.75	
PEG24	2.400	325.721	325.50	
—	2.450		325.27	
PEG25	2.500	325.322	325.10	
—	2.550		324.74	
PEG26	2.600	324.783	324.58	
—	2.650		324.24	

PEG27	2.700	324.318	324.06
—	2.750		323.74
PEG28	2.800	323.686	323.49
—	2.850		323.18
PEG29	2.900	323.176	322.89
—	2.950		322.54
PEG30	3.000	322.624	322.33

Table 3b. Levelling data for profile BB'

Station	Chainage	Reduced level		Remarks
		top of peg	ground	
	(km)	(m)	(m)	
PEG00	0.000	323.846	323.58	
—	0.050		323.29	
PEG1	0.100	323.059	322.84	
—	0.150		322.48	
PEG2	0.200	322.326	322.11	
—	0.250		321.88	
PEG3	0.300	321.799	321.60	
—	0.350		321.28	
PEG4	0.400	321.249	321.06	
—	0.450		320.80	
PEG5	0.500	320.700	320.49	
—	0.550		320.30	
PEG6	0.600	320.261	320.01	
—	0.650		319.81	
PEG7	0.700	319.753	319.53	
—	0.750		319.36	
PEG8	0.800	319.428	319.09	
—	0.850		318.92	
PEG9	0.900	318.898	318.68	
—	0.950		318.49	
PEG10	1.000	318.423	318.24	
—	1.050		318.06	
PEG11	1.100	317.995	317.82	
—	1.150		317.57	
PEG12	1.200	317.588	317.38	
—	1.250		317.20	
PEG13	1.300	317.300	317.01	
—	1.350		316.82	
PEG14	1.400	316.829	316.58	
—	1.450		316.37	
PEG15	1.500	316.364	316.11	
—	1.550		315.94	
PEG16	1.600	315.984	315.78	
—	1.650		315.52	
PEG17	1.700	315.472	315.25	
—	1.750		315.03	
PEG18	1.800	314.992	314.77	
—	1.850		314.58	
PEG19	1.900	314.673	314.44	
—	1.950		314.32	
PEG20	2.000	314.392	314.23	Change of grade
—	2.050		313.26	Change or grade
—	2.060		313.06	Top of scarp
—	2.062		312.67	Bottom of scarp
PEG21	2.100	312.644	312.43	
—	2.150		312.14	
PEG22	2.200	312.149	311.81	

—	2.250		311.58	
PEG23	2.300	311.572	311.33	
—	2.350		311.17	
PEG24	2.400	311.283	311.05	
—	2.450		310.84	
PEG25	2.500	310.958	310.74	Also TBM 20
—	2.550		310.61	
PEG26	2.600	310.719	310.48	
—	2.650		310.39	
PEG27	2.700	310.513	310.27	
—	2.750		310.13	
PEG28	2.800	310.289	310.03	
—	2.850		309.89	
PEG29	2.900	310.011	309.77	
—	2.950		309.67	
PEG30	3.000	309.866	309.61	

Table 3c. Levelling data for profile CC'

Station	Chainage	Reduced level		Remarks
		top of peg	ground	
	(km)	(m)	(m)	
—	0.000		290.79	2 km south of Kunayungku scarp
—	0.050		290.83	(no station names assigned)
—	0.100		290.89	
—	0.150		290.95	
—	0.200		291.01	
—	0.250		291.06	
—	0.300		291.10	
—	0.350		291.12	
—	0.400		291.18	
—	0.450		291.21	
—	0.500		291.24	
—	0.550		291.26	
—	0.600		291.28	
—	0.650		291.31	
—	0.700		291.34	
—	0.750		291.37	
—	0.800		291.44	
—	0.850		291.47	
—	0.900		291.52	
—	0.950		291.55	
—	1.000		291.62	
—	1.050		291.65	
—	1.100		291.73	
—	1.150		291.78	
—	1.200		291.79	
—	1.250		291.87	
—	1.300		291.86	
—	1.350		291.91	
—	1.400		291.96	
—	1.450		291.98	
—	1.500		292.05	
—	1.550		292.09	
—	1.600		292.17	
—	1.650		292.23	
—	1.700		292.31	
—	1.750		292.37	
—	1.800		292.45	
—	1.850		292.53	

—	1.900	292.59	
—	1.950	292.67	
—	1.986	293.08	)Main
—	1.996	293.62	)cracking
—	2.000	293.54	)
—	2.007	293.44	)of
—	2.014	293.00	)Kunayungku
—	2.025	292.10	)scarp
—	2.050	291.96	
—	2.100	292.00	
—	2.150	292.04	
—	2.200	292.09	
—	2.250	292.14	
—	2.300	292.23	
—	2.350	292.27	
—	2.400	292.27	
—	2.450	292.27	
—	2.500	292.33	
—	2.550	292.36	
—	2.600	292.40	
—	2.650	292.46	
—	2.700	292.58	
—	2.750	292.60	
—	2.800	292.68	
—	2.850	292.73	
—	2.900	292.84	
—	2.950	292.96	
----	3.000	293.05	1 km north of KS

Table 4. Detailed topographic profiles

Profile name	Australian grid east	Australian grid north	Elev. (m)	Photo control point or ref. from Plate 1
STN_00000	405101.18	7804447.40	325.90	PCP5
Distance (m)	Azimuth (deg)	Azimuth (min)	Rod reading (m)	
96.36	13	21	9.03	
73.42	12	46	9.14	
50.73	12	46	9.28	
27.37	12	42	9.48	
25.74	180	31	9.91	
49.09	180	12	10.01	
73.32	180	23	10.16	
96.65	180	37	10.85	
STN_00500	404759.82	7804584.54	327.15	(4705)
102.32	30	46	8.75	
78.19	30	51	8.91	
53.49	31	03	9.04	
36.28	30	46	9.16	
35.55	30	44	9.28	
23.34	31	28	9.44	
6.56	31	01	9.66	
8.52	210	55	10.13	
26.17	210	41	10.25	
49.50	209	18	10.40	
73.10	209	31	10.54	
94.80	209	26	10.63	
STN_01000	404456.03	7804815.18	327.44	(4710)
101.99	40	04	8.96	
78.54	39	58	9.09	
55.06	40	15	9.19	
31.45	40	51	9.19	
8.71	39	39	9.53	
7.29	39	50	9.84	
7.15	220	04	10.26	
25.43	220	08	10.49	
50.25	220	08	10.65	
74.09	220	01	10.80	
97.69	220	05	10.96	
STN_01500	404049.34	7804961.10	329.12	(4715)
92.26	21	17	8.60	
69.47	21	21	8.79	
47.05	16	45	8.92	
24.62	21	39	9.07	
8.76	20	51	9.32	
6.81	20	51	9.70	
6.37	202	23	10.09	
28.98	203	31	10.18	
55.33	204	51	10.37	
81.26	203	02	10.53	
105.39	202	54	10.73	
STN_02000	403631.13	7804888.03	330.69	(4720)
94.82	06	42	8.79	
70.66	06	22	8.89	
49.73	06	12	9.01	
31.34	04	55	9.16	

Table 5. Coordinates of temporary seismograph stations

Station	Latitude °S	Longitude °E	Elevation (m)
C2	19.7997	133.9222	303.6
C3	19.8505	134.0015	320.9
C4	19.8745	134.0637	347.2
N1	19.7247	133.8158	283.0
N2	19.7378	133.9128	294.6
N3	19.7963	134.0190	307.5
N4	19.8245	134.0842	316.7
N5	19.8830	134.1380	331.6
S1	19.8192	133.8717	287.3
S2	19.8755	133.9023	293.1
S3	19.9318	134.0282	344.1
TCBY	19.8492	133.8998	288.8
TCCY	19.8745	133.9712	307.7
TCEY	19.8743	134.0852	335.3
TCMY	19.8063	133.9582	299.0
TCNY	19.7242	133.7620	279.3
TCPY	19.8372	134.0282	323.2
TCSY	19.9538	133.9725	323.3
TCVY	19.7695	134.0853	318.2
TCXY	19.7858	133.8397	285.3
SAMUEL	19.6896	134.1535	433.0

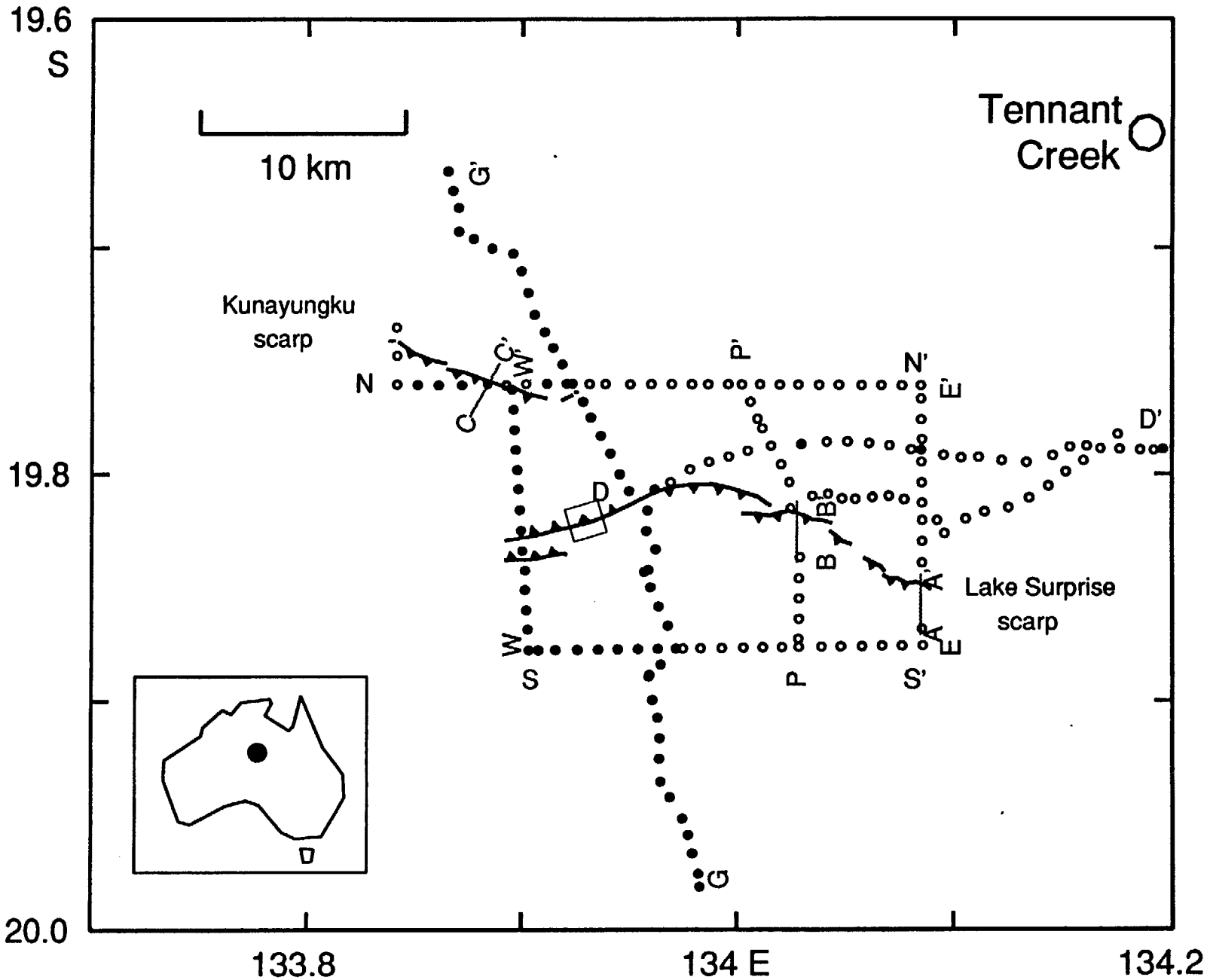
19.6
S
19.8
20.0
133.8
134 E
134.2
10 km
Tennant
Creek
Kunayungku
scarp
Lake Surprise
scarp
N
N'
W
E
S
S'
A
A'
B
B'
C
C'
D
D'

Figure 1


TENNANT CREEK
SPECIAL
RUN 4
059-076
UT
Australian
Survey Office
Canberra
5039' ASL
17/2/88
2769
065

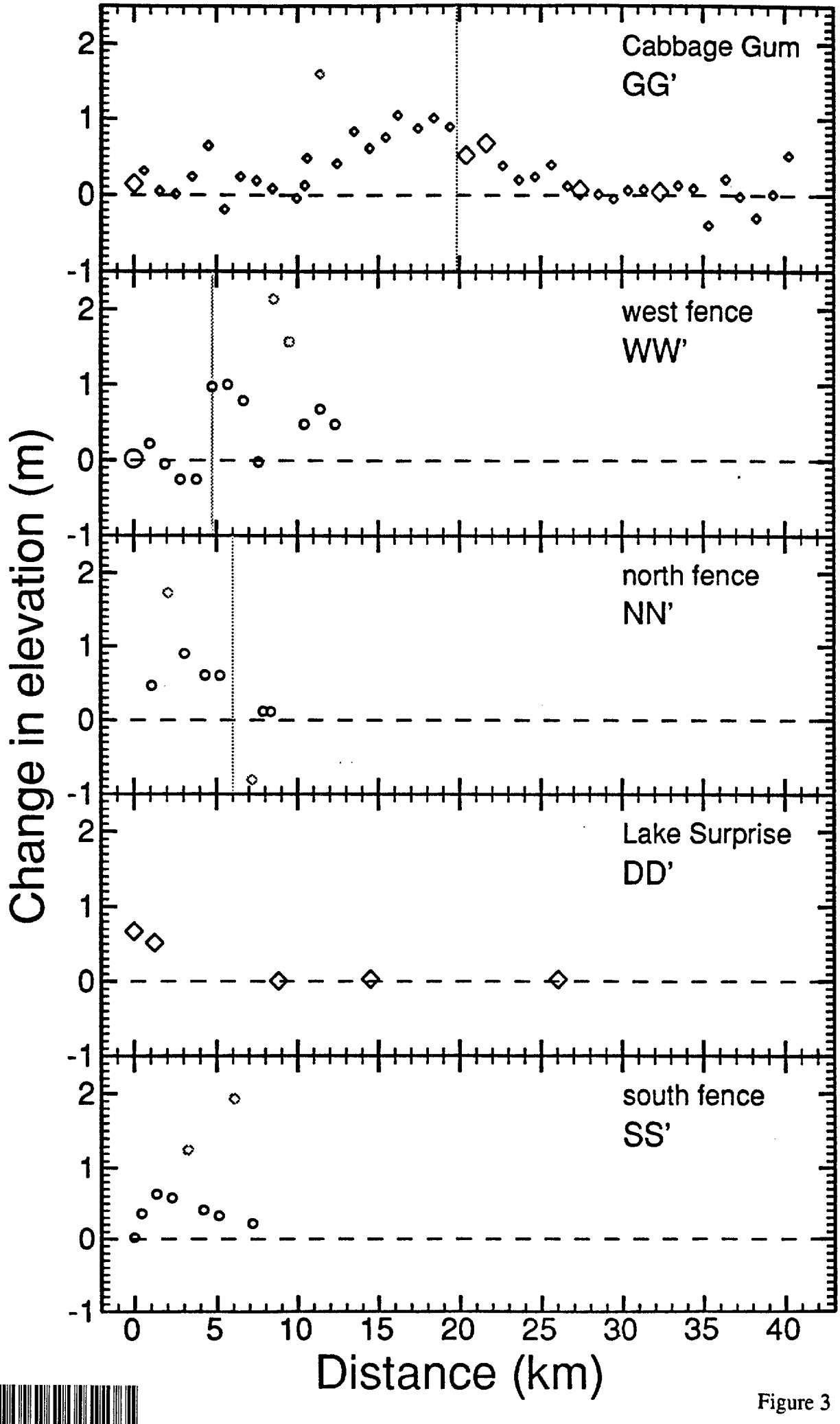

Figure 3

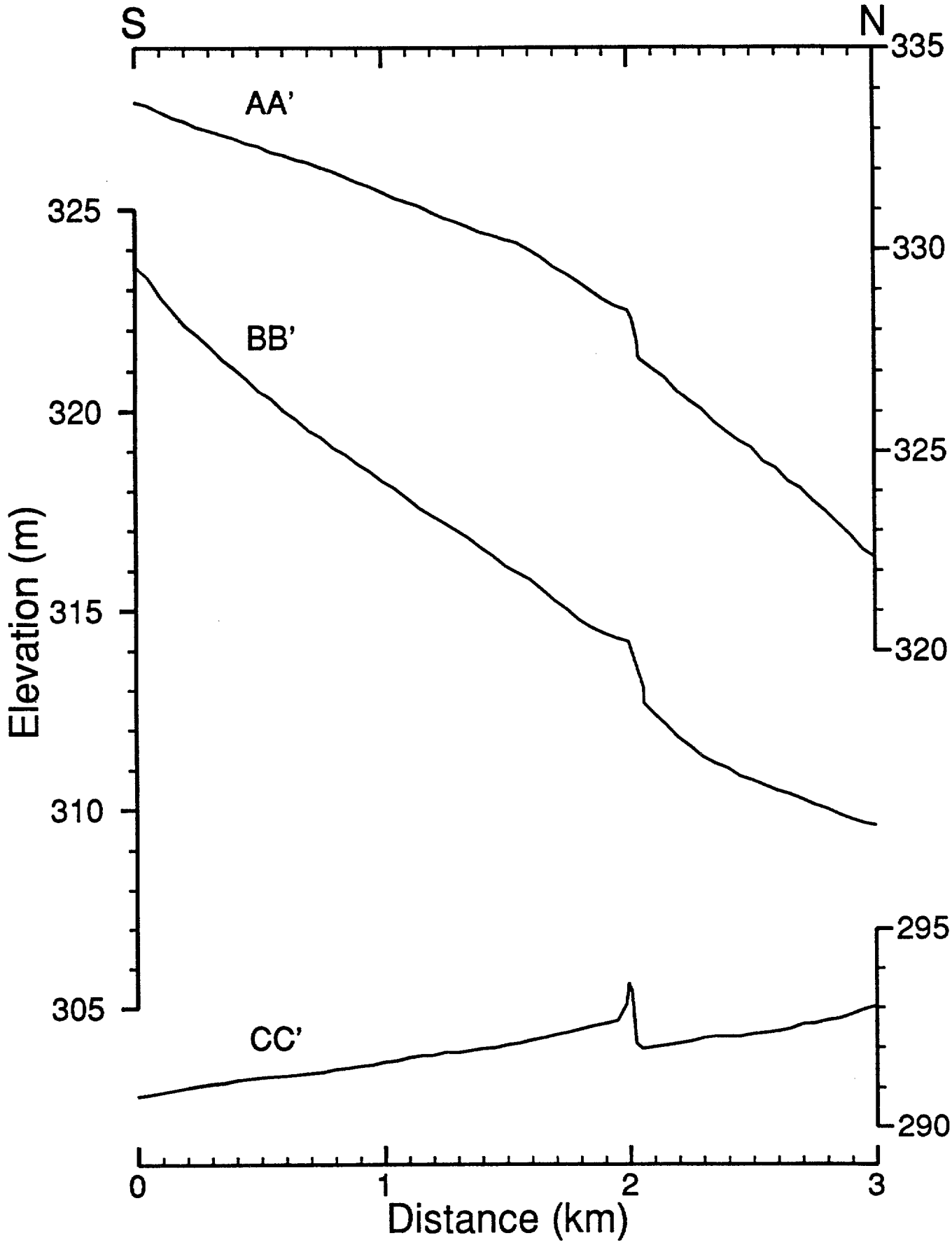
S
N
335
AA'
325
330
BB'
320
325
Elevation (m)
315
320
310
295
305
CC'
290
0
1
2
3
Distance (km)

Figure 4

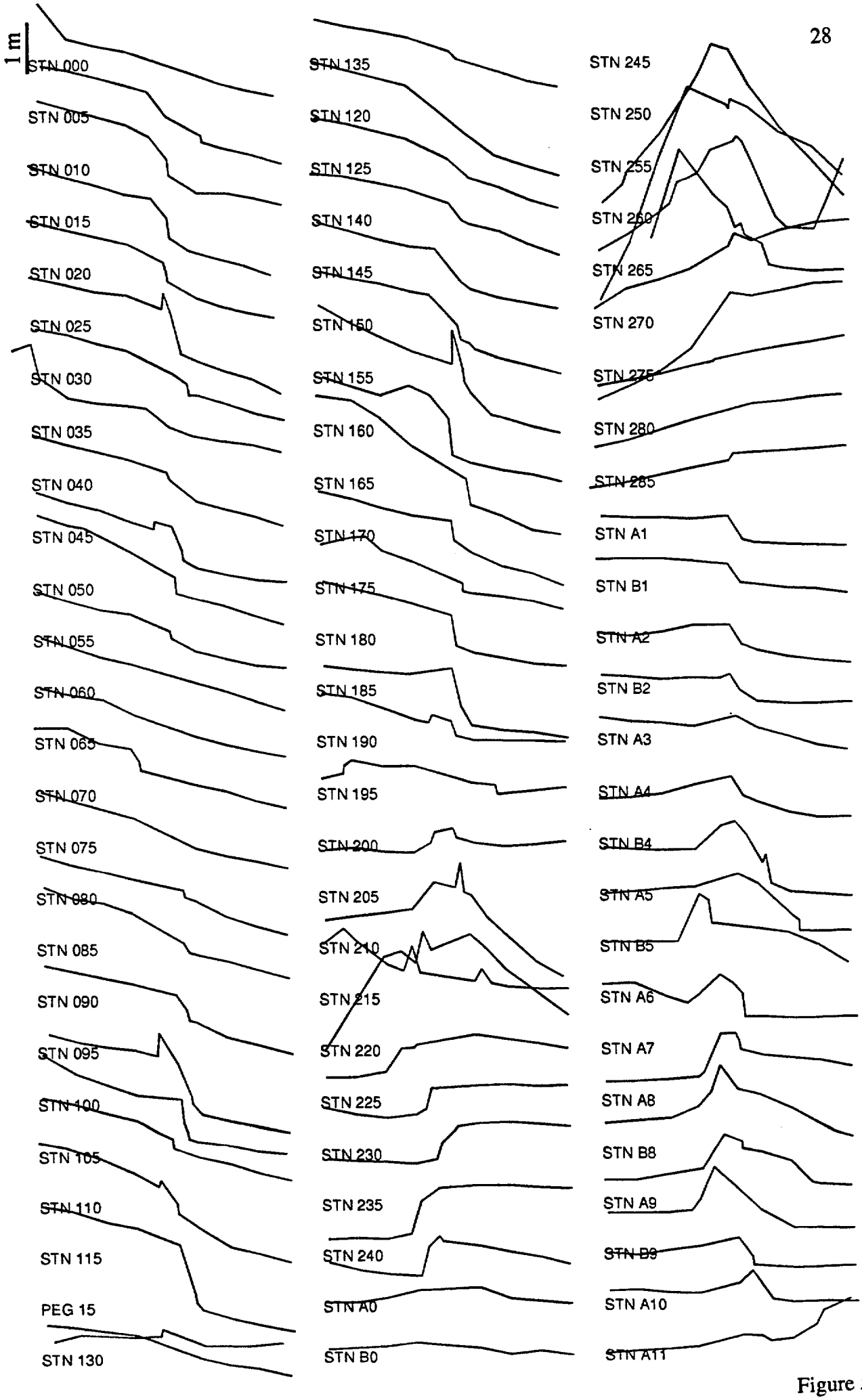
1 m
STN 000
STN 005
STN 010
STN 015
STN 020
STN 025
STN 030
STN 035
STN 040
STN 045
STN 050
STN 055
STN 060
STN 065
STN 070
STN 075
STN 080
STN 085
STN 090
STN 095
STN 100
STN 105
STN 110
STN 115
PEG 15
STN 130
STN 135
STN 120
STN 125
STN 140
STN 145
STN 150
STN 155
STN 160
STN 165
STN 170
STN 175
STN 180
STN 185
STN 190
STN 195
STN 200
STN 205
STN 210
STN 215
STN 220
STN 225
STN 230
STN 235
STN 240
STN A0
STN B0
STN 245
STN 250
STN 255
STN 260
STN 265
STN 270
STN 275
STN 280
STN 285
STN A1
STN B1
STN A2
STN B2
STN A3
STN A4
STN B4
STN A5
STN B5
STN A6
STN A7
STN A8
STN B8
STN A9
STN B9
STN A10
STN A11

Figure 5

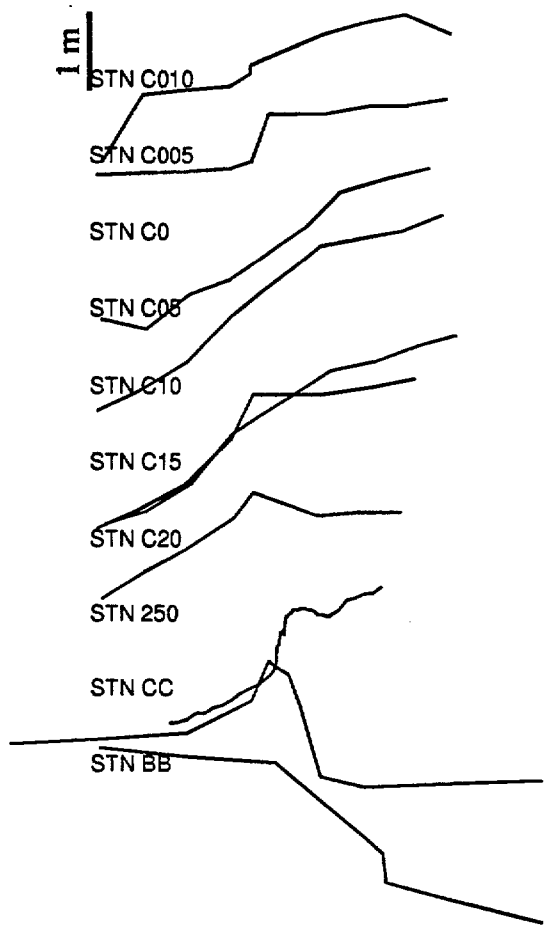

Figure 5 (cont.)

Appendix

Disk 1. Apple Macintosh format

Contents

BMR Record 1992/2	text and all tables in Microsoft Word 4.0 format
Table 1	text only
Table 2	text only
Table 3	text only
Table 4	text only
Table 5	text only
Table 6	text only
Table 7	text only

Disk 2. MS-DOS format

Contents

RECORD.DOC	text and all tables in Microsoft Word for Windows format
TABLE1.DAT	text only
TABLE2.DAT	text only
TABLE3.DAT	text only
TABLE4.DAT	text only
TABLE5.DAT	text only
TABLE6.DAT	text only
TABLE7.DAT	text only

POINT	EASTING	NORTHING	R.L.	MARK
PCP 5	405 101 · 18	7 804 447 · 40	325 · 90	PHOTO CONTROL
PCP 10			325 · 10	PHOTO CONTROL
PCP 15			330 · 25	PHOTO CONTROL
PCP 20			296 · 45	PHOTO CONTROL
PCP 25			297 · 13	PHOTO CONTROL
PCP 40	402 757 · 12	7 895 384 · 12	326 · 63	PHOTO CONTROL
PCP 50	386 052 · 18	7 813 930 · 48	295 · 16	PHOTO CONTROL
PCP 60	384 094 · 05	7 814 475 · 56	293 · 96	PHOTO CONTROL
PCP 70	381 123 · 07	7 815 379 · 49	291 · 23	PHOTO CONTROL
PCP 80	378 785 · 94	7 816 728 · 43	287 · 50	" "
PCP 95			318 · 68	" "
PCP 100	398 316 · 85	7 807 736 · 65	316 · 11	" "
PCP 105			310 · 74	" "
PCP 115			286 · 24	" "
PCP 120			287 · 37	" "
PCP 130			293 · 25	" "
PCP 160	394 967 · 67	7 809 550 · 75	311 · 09	" "
PCP 170			305 · 25	" "
PCP 180	393 379 · 67	7 809 731 · 75	307 · 27	" "
PCP 220			300 · 30	" "
PCP 225			301 · 74	" "
PCP 230	389 100 · 50	7 808 252 · 67	303 · 09	" "
PCP 270			295 · 71	" "
PCP 275			298 · 50	" "
PCP 280	384 465 · 27	7 807 058 · 30	296 · 03	" "

COMPILED BY THE AUSTRALIAN SURVEY OFFICE
FROM AERIAL PHOTOGRAPHY DATED 17-2-88

FILM NO	SCALE	RUN	FRAME NOS
500769	1:8000	3	31-50
		4	59-76
		5	82-94
		6	96-101

DATE OF COMPILATION AUG, 1988

SCALE 1:25000.
HORIZONTAL DATUM: AGD
VERTICAL DATUM: AHD
PROJECTION: AMG ZONE 53

AUSLIG
Australian Surveying & Land Information Group
DEPARTMENT OF ADMINISTRATIVE SERVICES

E. 88/17

TENNANT CK EARTHQUAKE SURVEY

SHEET 4 of 4

R9200204