BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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PRELIMINARY REPORT ON THE CADOUX EARTHQUAKE, WESTERN AUSTRALIA, 2 JUNE 1979

by

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DEPARTMENT OF NATIONAL DEVELOPMENT

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ABSTRACT

An earthquake occurred on 2 June 1979 near the small town of Cadoux, Western Australia. Only one person was injured, but the cost of damage in the town and surrounding district could exceed $1.5m.

Preliminary results show that the earthquake had a Richter magnitude of 6.2 and occurred at 09h 48m 01s UT at latitude 30.83°S, longitude 117.15°E, and at a depth of 15 km. It is the third earthquake of magnitude 6 or greater to occur in the southwest seismic zone in eleven years. The maximum Modified Mercalli intensity observed was IX.

The surface of the Earth fractured in a zone 14 km long. Three scarps were formed, the largest was 8 km long and ran northerly with overthrusting up to 1.1 m from the west, and vertical uplift up to 0.6 m. Some right-hand strike-slip occurred. The general direction of movement (70°-80°) conformed roughly with the direction of the axis of maximum stress measured in the area in 1976.

The two smaller faults (2 km and 5 km long) ran about southeast; the area between them was raised by up to 0.5 m and left-lateral motion reached 0.6 m.

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* Photograph reproduced by courtesy of West Australian Newspapers Ltd.

INTRODUCTION

A large earthquake occurred on 2 June 1979 near the town of Cadoux (population 36) which is situated in a farming area 180 km northeast of the Western Australian capital, Perth (see Fig. 1). The earthquake caused only one casualty, a broken arm, but resulted in almost total destruction of the town. Roads and water pipes were ruptured and railway lines were distorted by a fracture zone, and farmhouses in the surrounding district were damaged. The earthquake was felt strongly in Perth and many residents were alarmed, but damage there was only minor.

This report is of a preliminary nature and a more comprehensive report will be prepared after further analysis of the data.

The effects of the earthquake were reported in the West Australian newspaper on 4 June 1979. Extracts of the report are quoted below.

"Earthquakes that ranged through the south west of Western Australia in the weekend struck hardest at the little wheatbelt town of Cadoux. Damage at Cadoux, 215 km north-east of Perth, is estimated at $1.5m.

The quake struck the town at 5.50 p.m. on Saturday and almost demolished it. When the quake struck, streets heaved and buckled for more than 30 seconds. The quake struck with a deafening explosion after almost continuous rumblings throughout the day.

The main road on both sides of the little town (population 36) was criss-crossed with deep cracks where the earth moved. In some places the road dipped half a metre.

Halls, pavilions, and houses collapsed and the town was plunged into darkness. Cracks opened in gardens, recreation areas, streets, and footpaths.

Two women and three children were trapped for nearly an hour when a farmhouse collapsed on them. One of the children received a broken arm when a heavy beam fell across him, pinning him to furniture under the rubble.

The Wongan-Ballidu town clerk, Mr. Alan Selkirk estimated damage to public buildings alone at $400,000.

In addition, the school was wrecked, private houses were damaged or destroyed, roads and stretches of railway line were damaged, and a nine-million litre reinforced concrete water tank was probably made useless.

Four major buildings had been destroyed and more were in a dangerous condition.

Mr. Selkirk said that nearly all the 70 buildings in the area had been damaged in some way. The asbestos and timber houses survived better than the brick or cement-block homes".

"Perth escaped serious damage from the weekend earthquakes, though many power services were cut.

People reported cups, glasses, and books falling from the shelves, and lights swinging.

Church bells rang as the quake set them swinging throughout the southwest".

The epicentre, 7 km SSE of Cadoux, is in the southwest seismic zone and is close to a site where high levels of crustal stress were measured in 1976 (Denham & others, 1979); it is in zone 1 on an earthquake risk map prepared by the Bureau of Mineral Resources, Geology & Geophysics (Fig. 2).

OBSERVATIONS AND RESULTS

Instrumental data

Interpretation of data from Western Australian seismographs gave the following provisional results.

Epicentre	:	Latitude 30.83°S
		Longitude 117.15°E
Depth	:	15 km
Origin time	:	09h 48m 01s UT (5 48 01 p.m. WST)
Magnitude	:	6.2 (ML)

The first determination of magnitude quoted to the press was low as the recording traces on the Mundaring seismograms disappeared, resulting in a conservative estimate of the maximum ground amplitudes. Subsequent analysis of seismograms from all Western Australian seismograms gave a Richter magnitude of 6.2.

Strong-motion recorders were triggered at Meckering (distance 90 km) and Mundaring (at the weir wall, distance 150 km). Peak ground accelerations in m/s^2 measured at these places were:

Meckering: Z 2.0×10^{-1} ; N 1.0×10^{-1} ; E 2.0×10^{-1}

Mundaring: Z 1.9×10^{-1} ; N 1.0×10^{-1} ; E 3.9×10^{-1}

Foreshocks and aftershocks

All foreshocks and aftershocks of magnitude (ML) greater than 2.9 up to 14 June are listed in Table 1. Details of the five main earthquakes, all of which were felt in Perth, are given in Table 2.

A large foreshock, magnitude ML = 5.2, occurred on 1 June 1979 at 2154 UT, twelve hours before the main earthquake. Cadoux was severely shaken, but no significant damage was reported. The intensity in Perth was sufficient to awaken many people. Twelve tremors between magnitudes ML = 2 and 3.8 occurred in the next 6 hours, the largest, ML = 3.8, at 0135 UT on 2 June.

By comparison with previous large earthquakes in the southwest seismic zone, this pattern did not indicate that the earthquake at 2154 UT was a foreshock of a larger earthquake; for example the earthquakes at Meckering (1968: ML = 6.8 (Everingham, 1968)), Calingiri (1970 : ML = 6 (Everingham & Parkes, 1971)) and Albany (1977 : ML = 4.5 (Gregson, 1978)) were not preceded by such large foreshocks.

Five earthquakes of magnitudes ML = 3.1 to 3.8 occurred in about the same area on 13, 14, 15 March, and 10 May 1979.

Three main aftershocks of magnitudes ML = 5.3, 5.5, and 4.3 occurred on 3, 7, and 10 June respectively; 123 aftershocks of magnitude greater than 2.4 occurred in the 12 days after the main earthquake. Figure 3 illustrates the rate of decrease of number and magnitude of aftershocks.

All the foreshocks and aftershocks were located within 8 km of the main earthquake.

The fracture zone

The earthquake fractured the Earth's crust in a zone trending roughly north-south for 14 km. A preliminary survey was made and Figure 4 shows the surface trace of the fracture zone and the ground displacements measured at several places. Figures 5 to 10 illustrate the effects along the fracture zone.

The main scarp formed an arc 8 km long, convex to the east. The western side moved relatively upwards and over the eastern side. The maximum overthrust measured was 0.6 m upwards and 1.1 m horizontally in an easterly direction. There was some lateral movement along the strike of the scarp, the west side moving north. These surface effects are consistent with shallow thrust-faulting with a right-handed strike-slip component. The direction of thrust is between 070° and 080°, which is consistent with the direction of the maximum stress axis (065°) measured in the Wongan Hills-Manmanning area in 1976 (Denham & others, 1979).

Two secondary scarps 2 km and 5 km long running roughly southeast were formed to the north of the main scarp. The block between the two scarps was raised relative to the surroundings by up to 0.5 m, and there was left-lateral motion up to 0.6 m but no obvious overthrusting.

Intensities and damage

An isoseismal survey (700 questionnaires) was initiated immediately after the earthquake, and damage in the Cadoux area was inspected. Preliminary results showed that the earthquake was felt as far as Northampton to the north and Esperance to the southeast, i.e. over a radius of 500 km. The maximum Modified Mercalli intensity of MM IX was observed adjacent to the earthquake fracture, and intensities MM VII or greater occurred up to 5 km from the surface fracture.

Intensities in Perth ranged between MM IV and MM V. Variations were probably due to sub-soil conditions, and this aspect will be investigated in the later report.

Damage estimates of $1.5m supplied by the Insurance Council of Australia are made up as follows:

231	country domestic claims	$720 000
59	country commercial claims	$335 000
214	Perth domestic claims	$360 000
23	Perth commercial claims	$ 49 000

The major structure damaged was a nine-million litre concrete water tank (Fig. 11) valued at $250 000. The tank moved 0.45 m off its base in a northerly direction, releasing all the water. At this stage it is not known whether or not the tank can be repaired. Uninsured buildings, and damage to public buildings, will raise the above figures considerably.

Figures 11 to 18 illustrate damage done in the Cadoux area. As happened at Meckering during the 1968 earthquake, older brick and stone houses were damaged the most, and timber-framed houses and iron or timber-framed sheds were damaged much less.

Figure 13 shows a cement-brick house close to the scarp which was completely demolished, and an adjacent iron-framed machinery shed which was only slightly damaged. The owner of the house was outside at the time and was thrown to the ground. The house 'exploded' and collapsed in a heap of rubble burying the rest of the family, but fortunately the only injury was a broken arm.

Figure 14 shows a transportable house with the scarp running underneath. Apart from the house tilting about 0.2 m to the east it was only slightly damaged. The house can be relevelled by jacking it up.

A large reinforced concrete wheat silo two kilometres west of the scarp incurred only very minor damage.

There were several examples of damage which could have been avoided by appropriate design and construction. Figure 15 shows the damage caused by two brick chimneys which fell through the roof of the timber-framed school house. This could have caused serious injury had the school been occupied at the time.

Minor damage resulted from the three earthquakes of magnitude greater than 5.

ACKNOWLEDGEMENTS

Figures 5-9 and 13 are reproduced by permission of West Australian Newspapers Ltd; the estimates of damage costs were given by the Insurance Council of Australia.

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TABLE 1

EARTHQUAKES IN THE CADOUX AREA (ML GREATER THAN 2.9)

(1 March-13 June 1979)

DATE	UT*	ML	DATE	UT*	ML
Mar 13	0730	3.8	Jun 02	1925	3.7
14	2346	3.7		2009	3.2
14	2349	3.2		2101	3.7
15	1735	3.1		2129	3.5
May 10	1933	3.2		2129	3.4
Jun 01	2154	5.2		2135	3.0
	2229	3.1		2210	3.0
	2239	3.4		2227	3.0
	2239	3.2	Jun 03	0422	3.3
Jun 02	0051	3.1		0746	5.3
	0135	3.8		0955	3.5
	0135	3.5		1714	3.5
	0147	3.0		1918	3.3
	0214	3.6		2054	3.6
	0214	3.6	Jun 04	0226	3.2
	0312	3.4		0313	3.5
	0720	3.3		0604	3.4
	0948	6.2		1414	3.0
	1006	3.5		1416	3.1
	1010	3.2		1431	3.4

TABLE 1 (continued)

DATE	UT*	ML	DATE	UT*	ML
	1011	3.0		1627	3.3
	1017	3.3		1940	3.2
	1030	3.5	Jun 05	0023	3.6
	1034	3.0		1026	3.4
	1038	3.7		1134	3.6
	1041	3.4		1335	3.0
	1105	3.6		1858	3.2
	1108	3.2		1926	3.5
	1136	3.3	Jun 06	0505	3.6
	1148	3.6		0618	3.6
	1228	3.6		1737	3.6
	1301	3.2	Jun 07	2233	3.7
	1709	3.7	Jun 10	1825	4.3
	1720	3.5	Jun 11	0224	3.5
	1731	3.6		2215	3.3
	1733	3.3	Jun 13	1139	3.0
	1748	3.0			

* Universal Time. To obtain Western Standard Time add 8 hours to UT.

TABLE 2

MAIN EARTHQUAKES IN THE CADOUX AREA, JUNE 1979

DATE	UT	LAT° S	LONG° E	DEPTH km	MAGNITUDE ML	LOCATION
Jun 01	21 54 02.9	30.83	117.17	17	5.2	7 km SE Cadoux.
02	09 48 01.0	30.83	117.15	15	6.2	7 km SSE Cadoux.
03	07 45 34.5	30.77	117.17	10	5.3	4 km E Cadoux.
07	06 45 16.1	30.81	117.16	12	5.5	5 km SE Cadoux.
10	18 24 52.6	30.78	117.19	12	4.3	6 km E Cadoux.

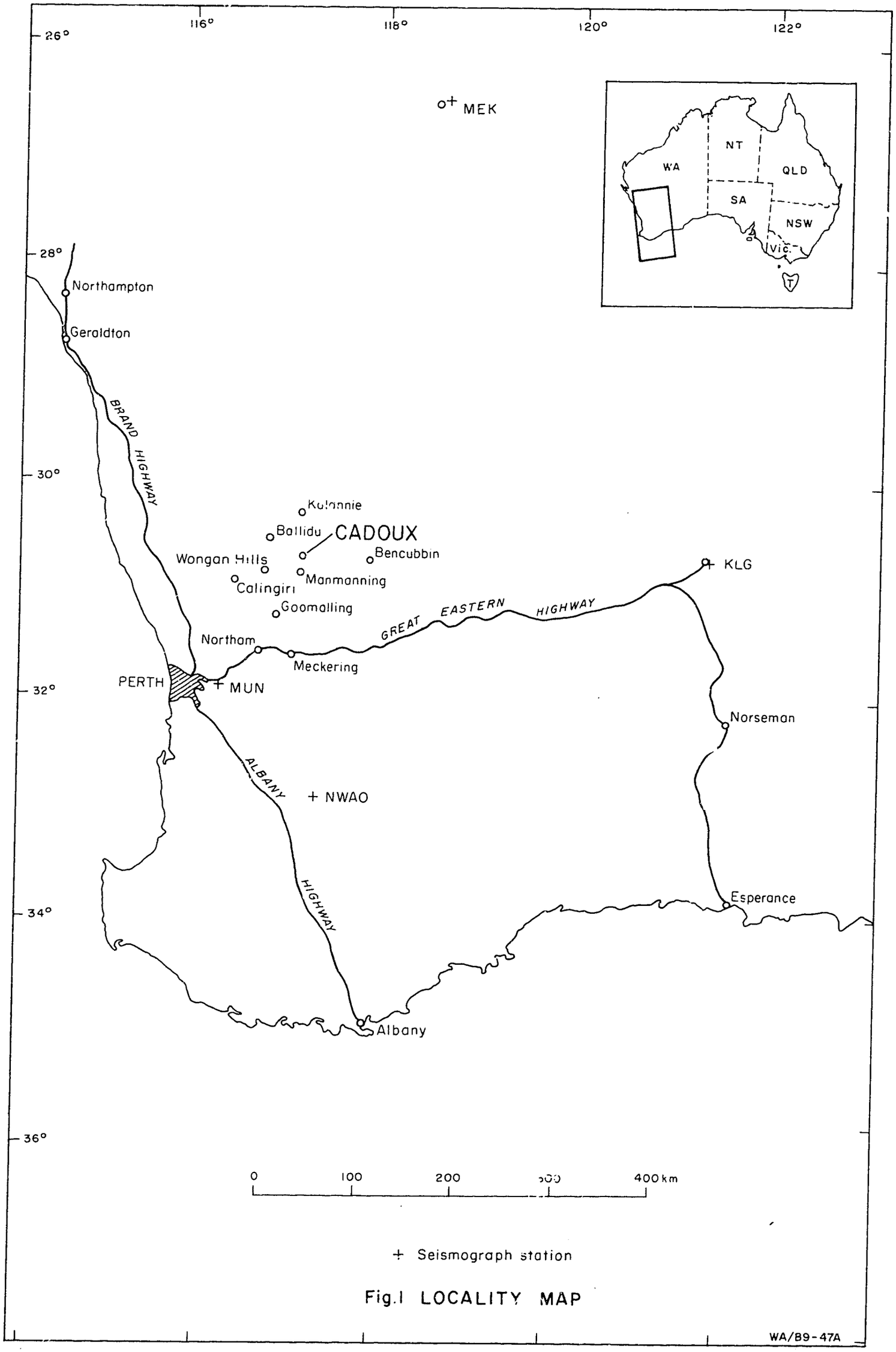


Fig.1 LOCALITY MAP

WA/B9-47A

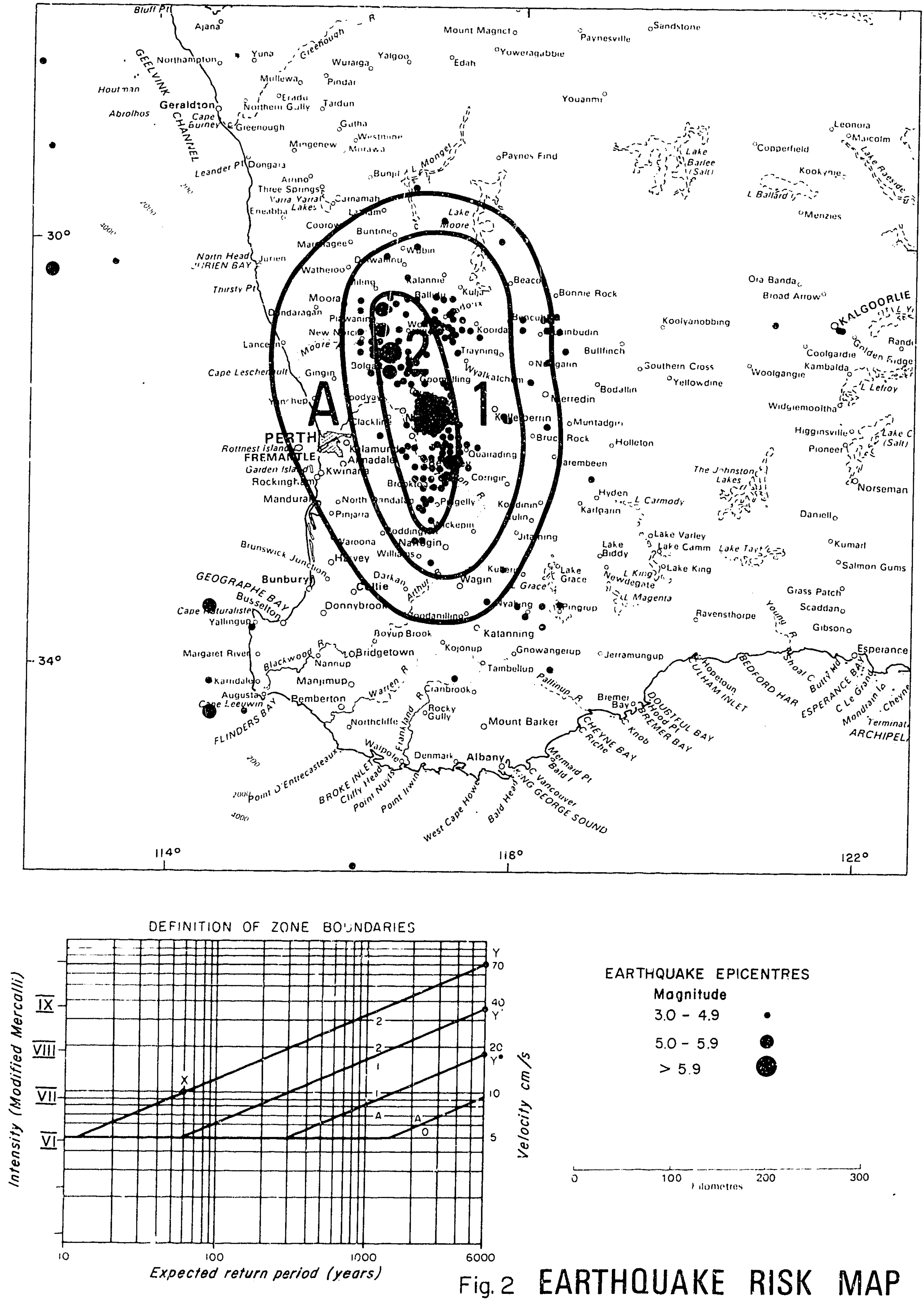


Fig. 2 **EARTHQUAKE RISK MAP**

WA/89-48A

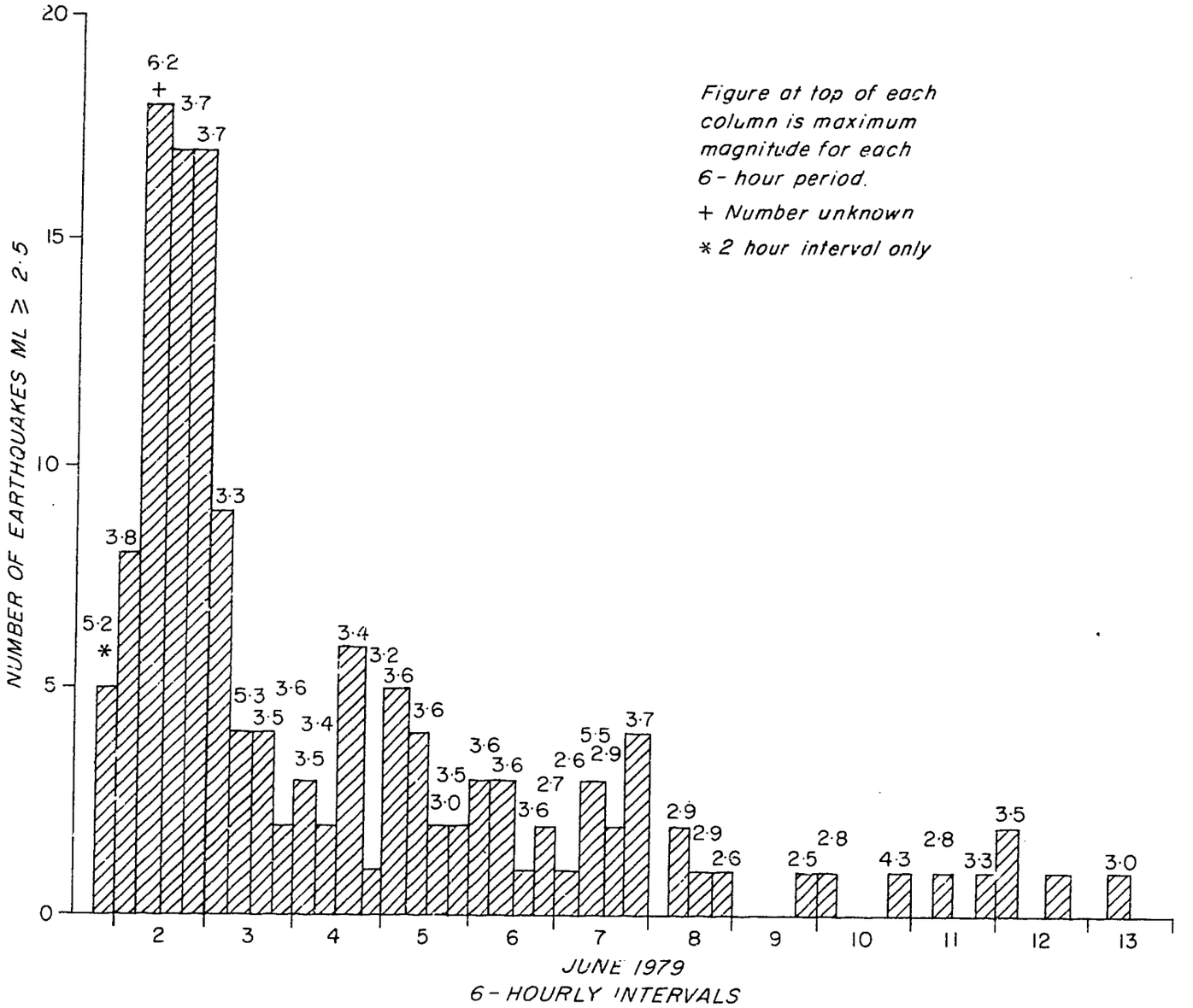


Fig.3 EARTHQUAKE NUMBERS (ML ≥ 2·5)

WA/B9-49A

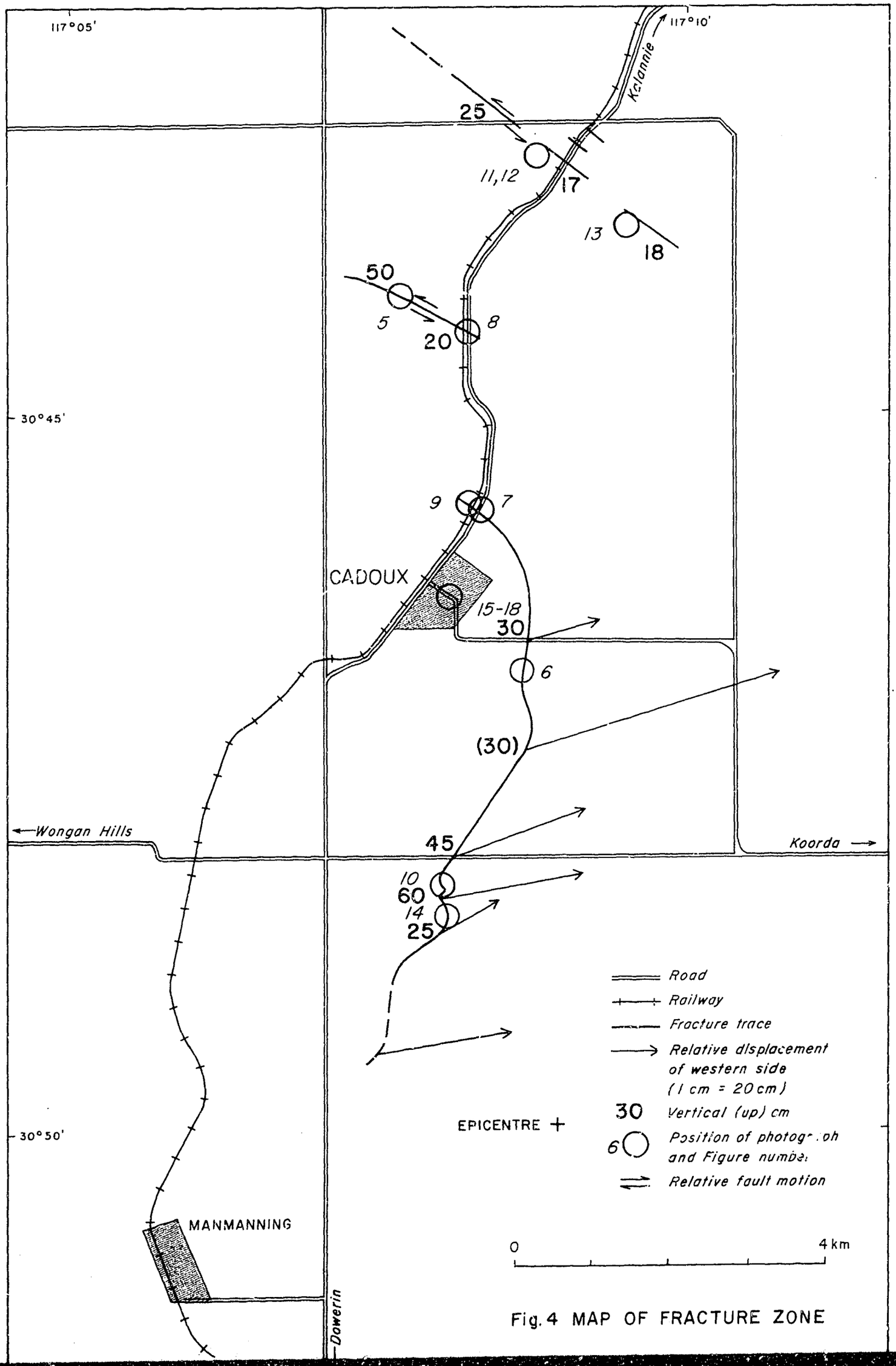
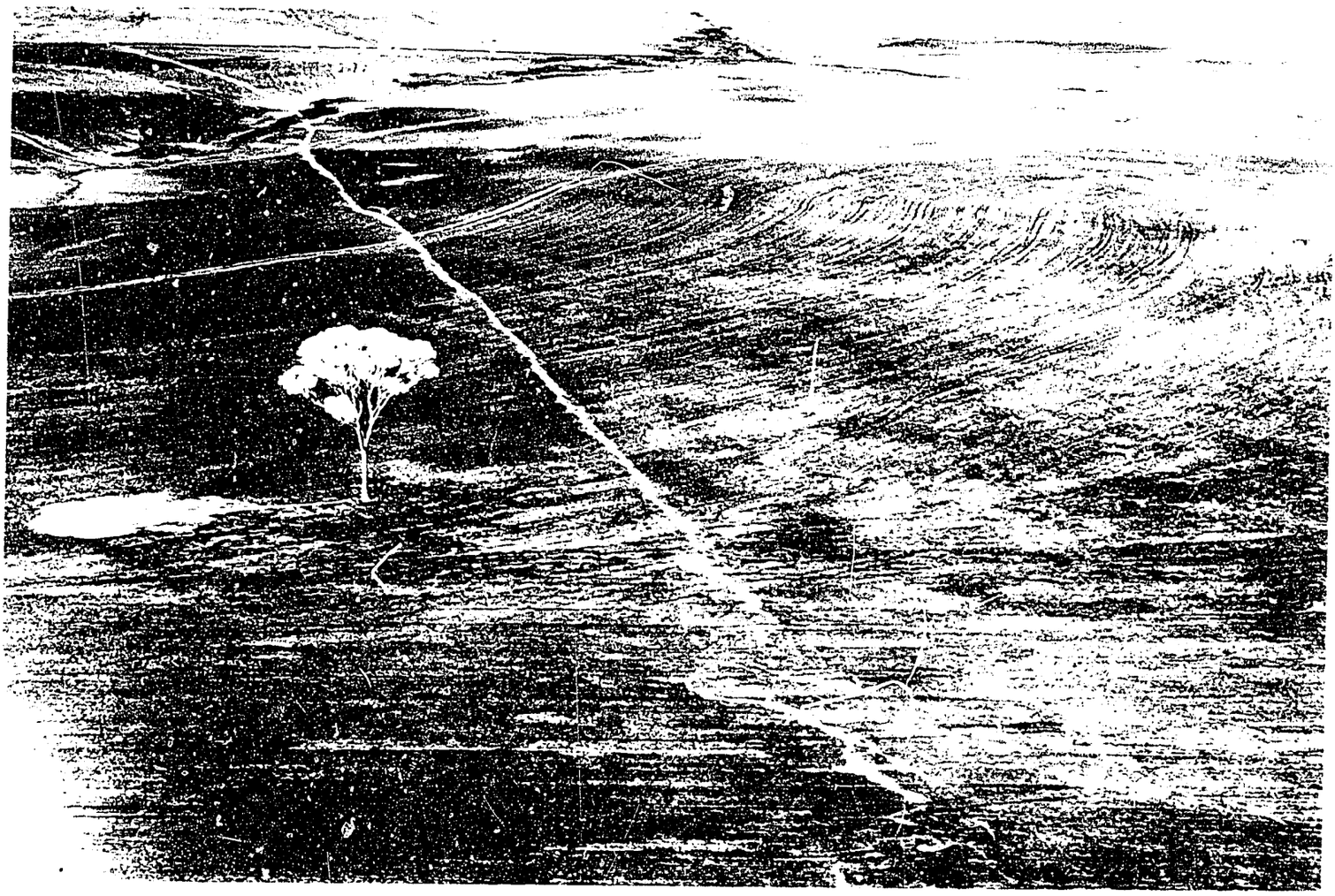
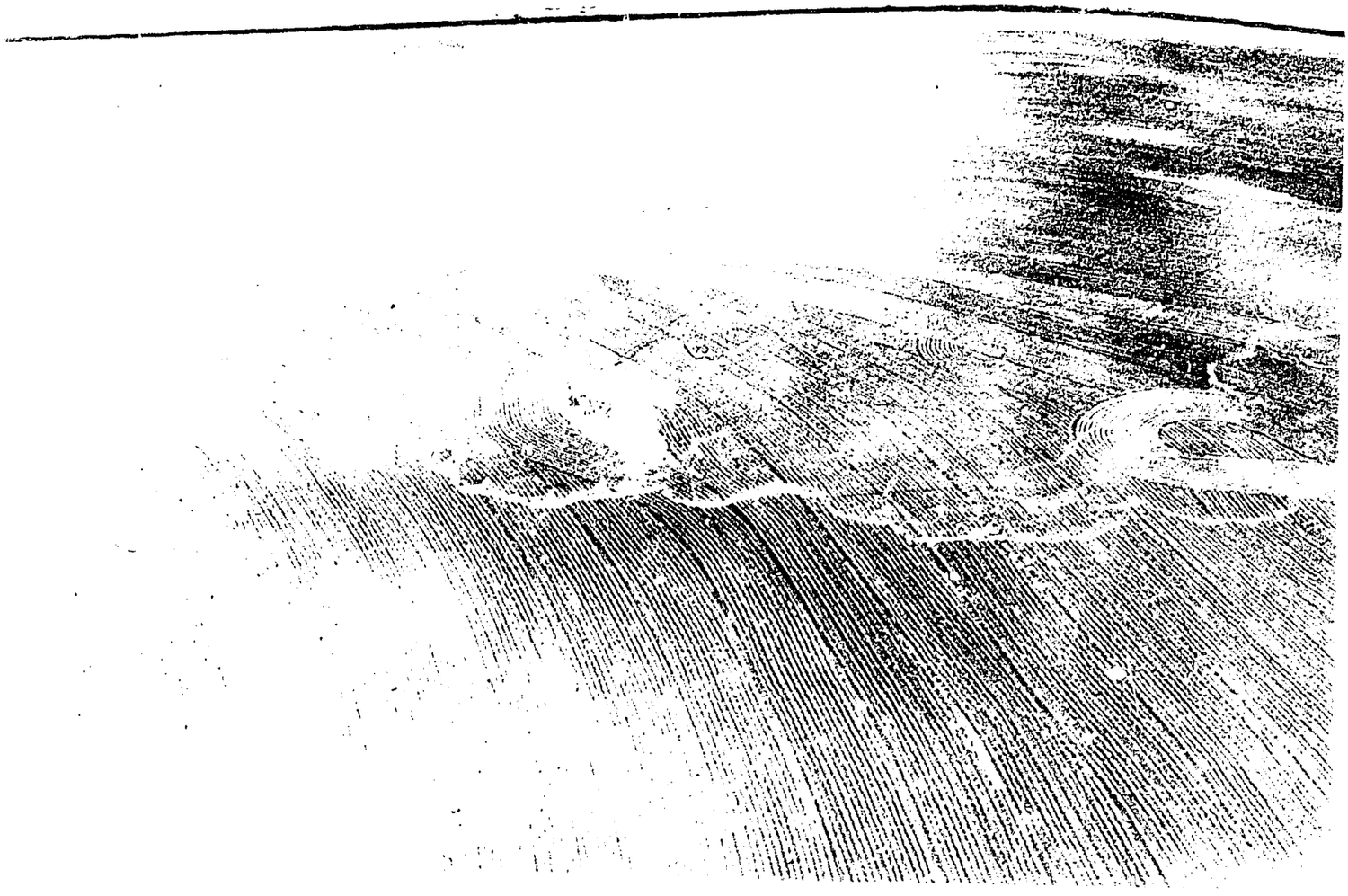


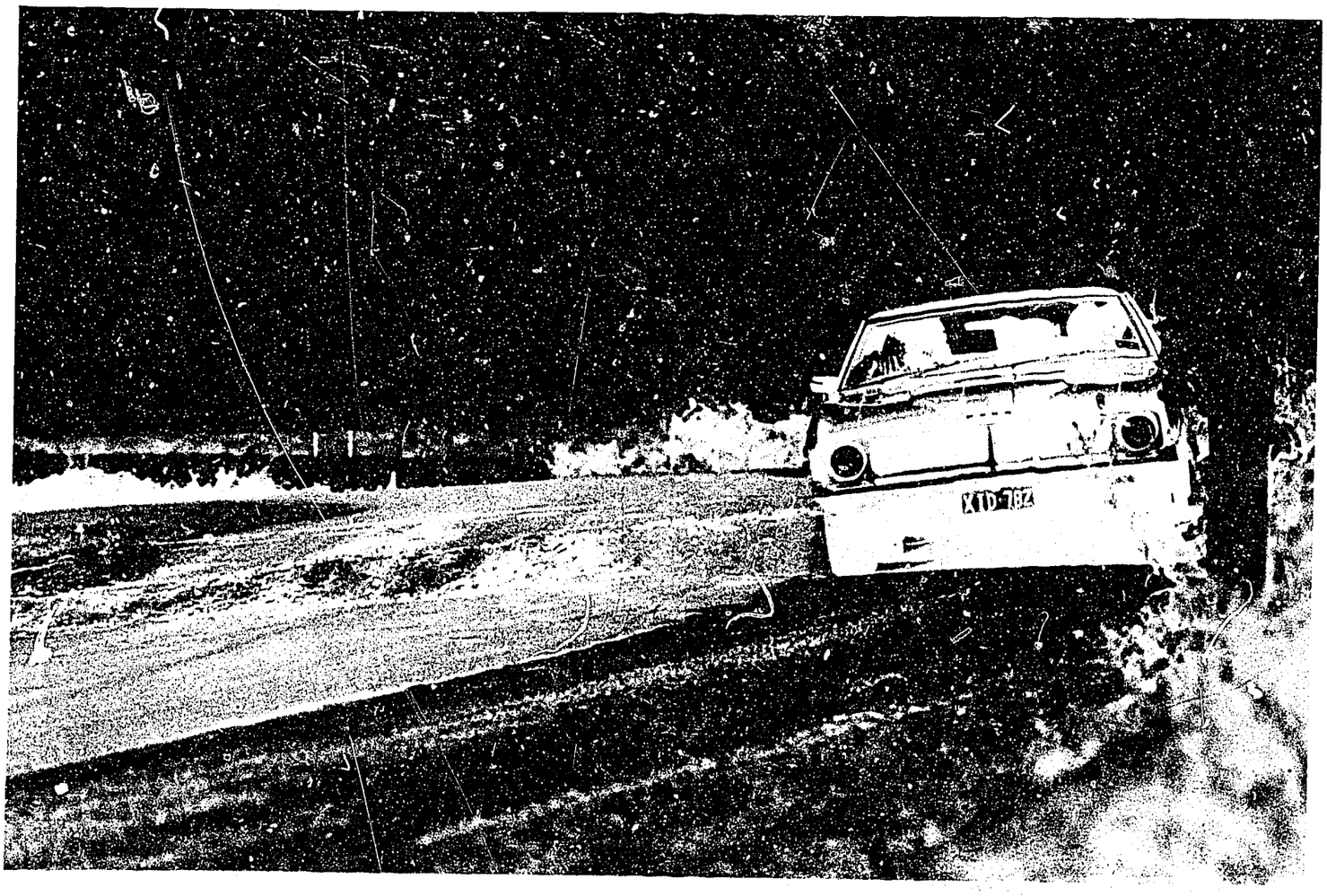
Fig. 4 MAP OF FRACTURE ZONE



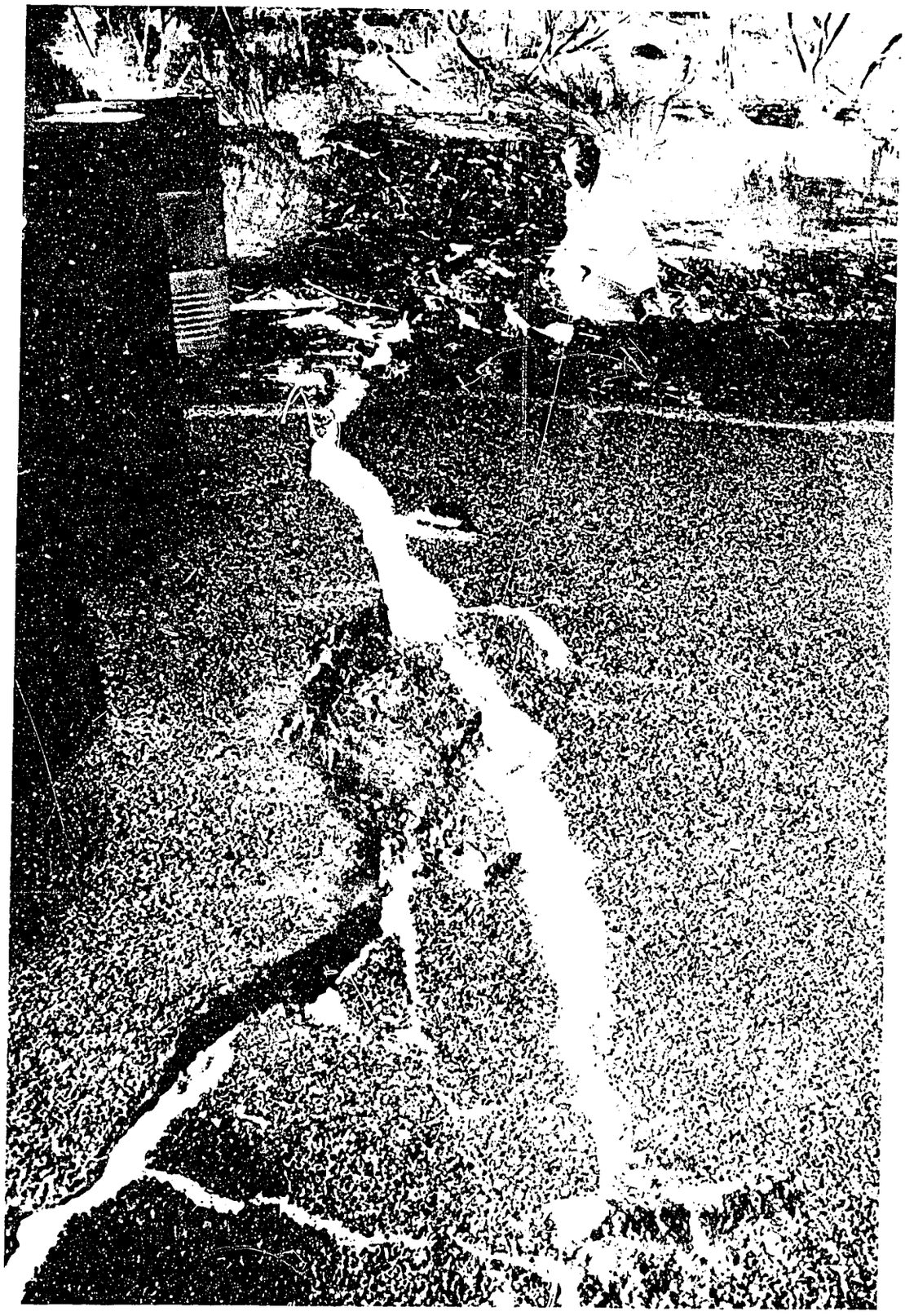
5 Central fracture zone, looking northwest. North side up approximately 50 cm.



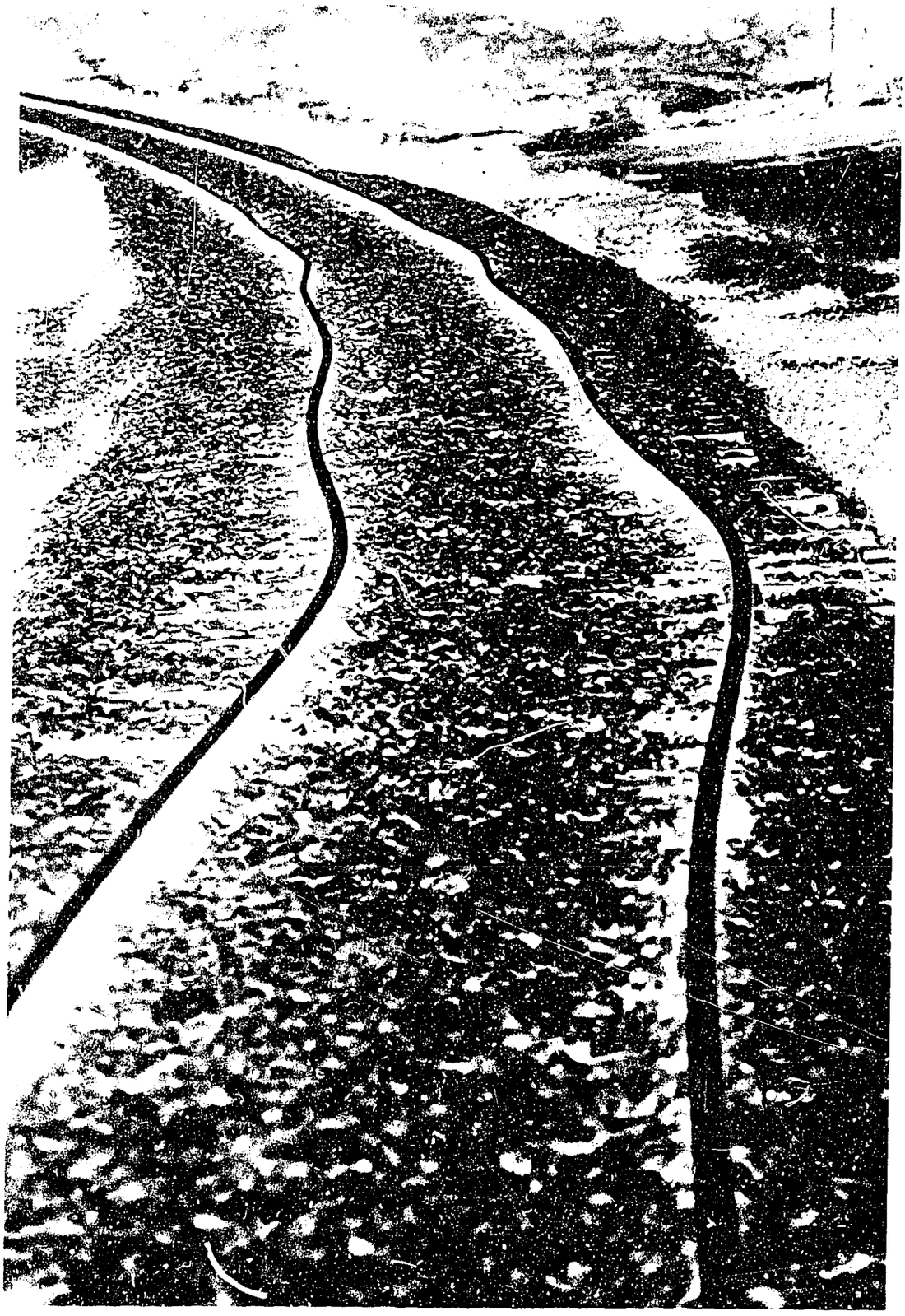
6 Southern fracture zone, looking west. West side up near area



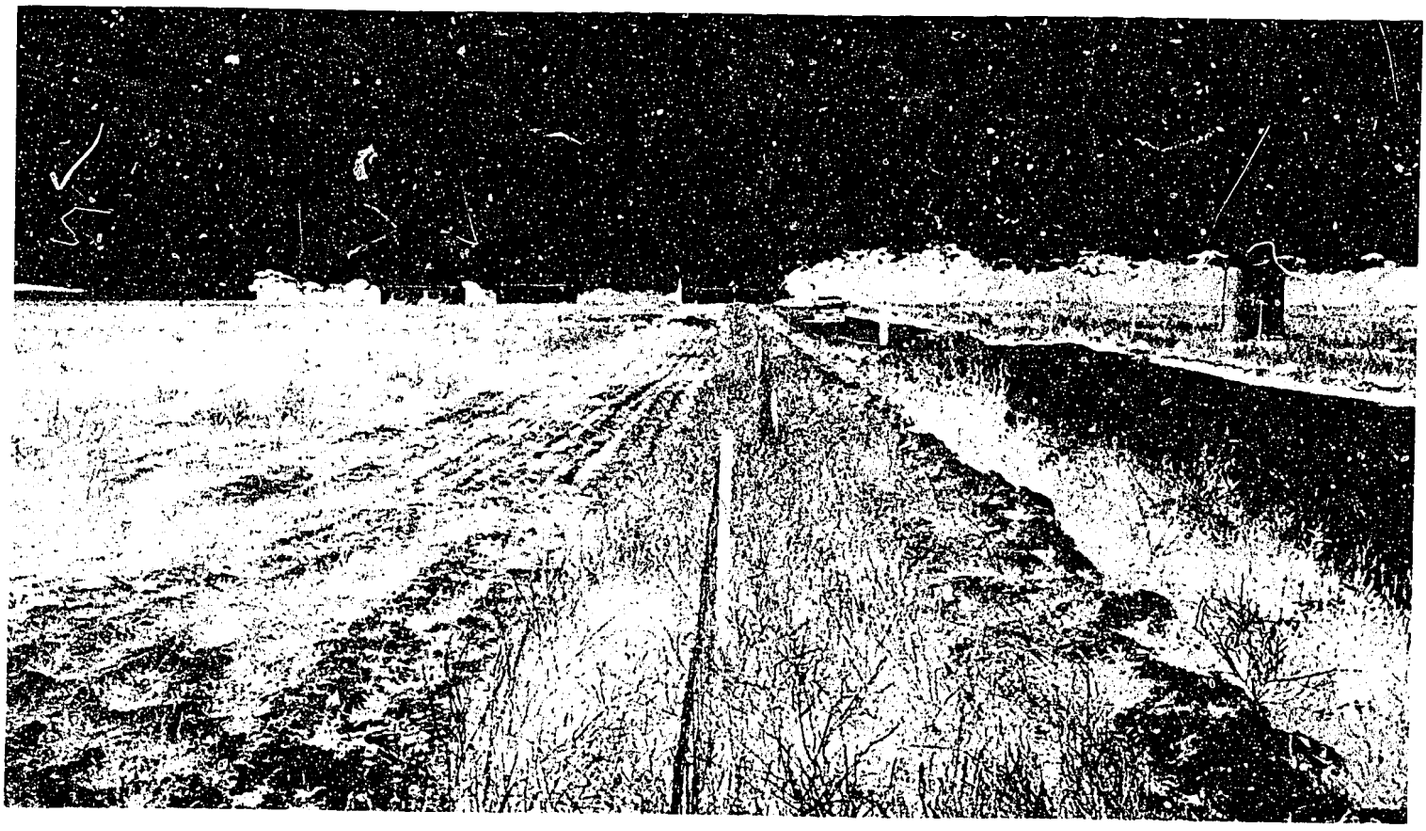
7 Southern fracture zone looking south along main road 1.0 km north of Cadoux.



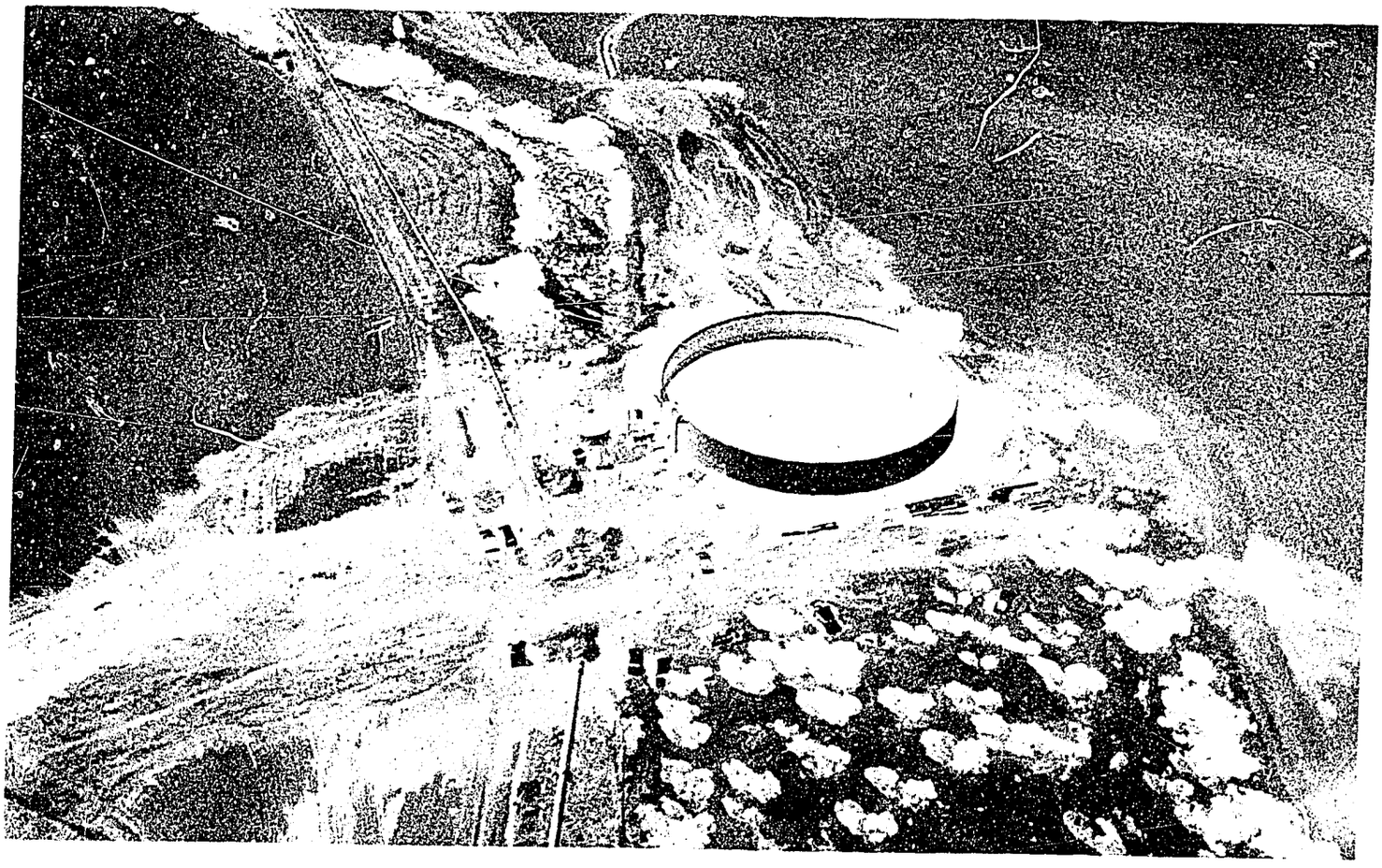
8 Central fracture zone looking west across main road 3.2 km north of Cadoux.



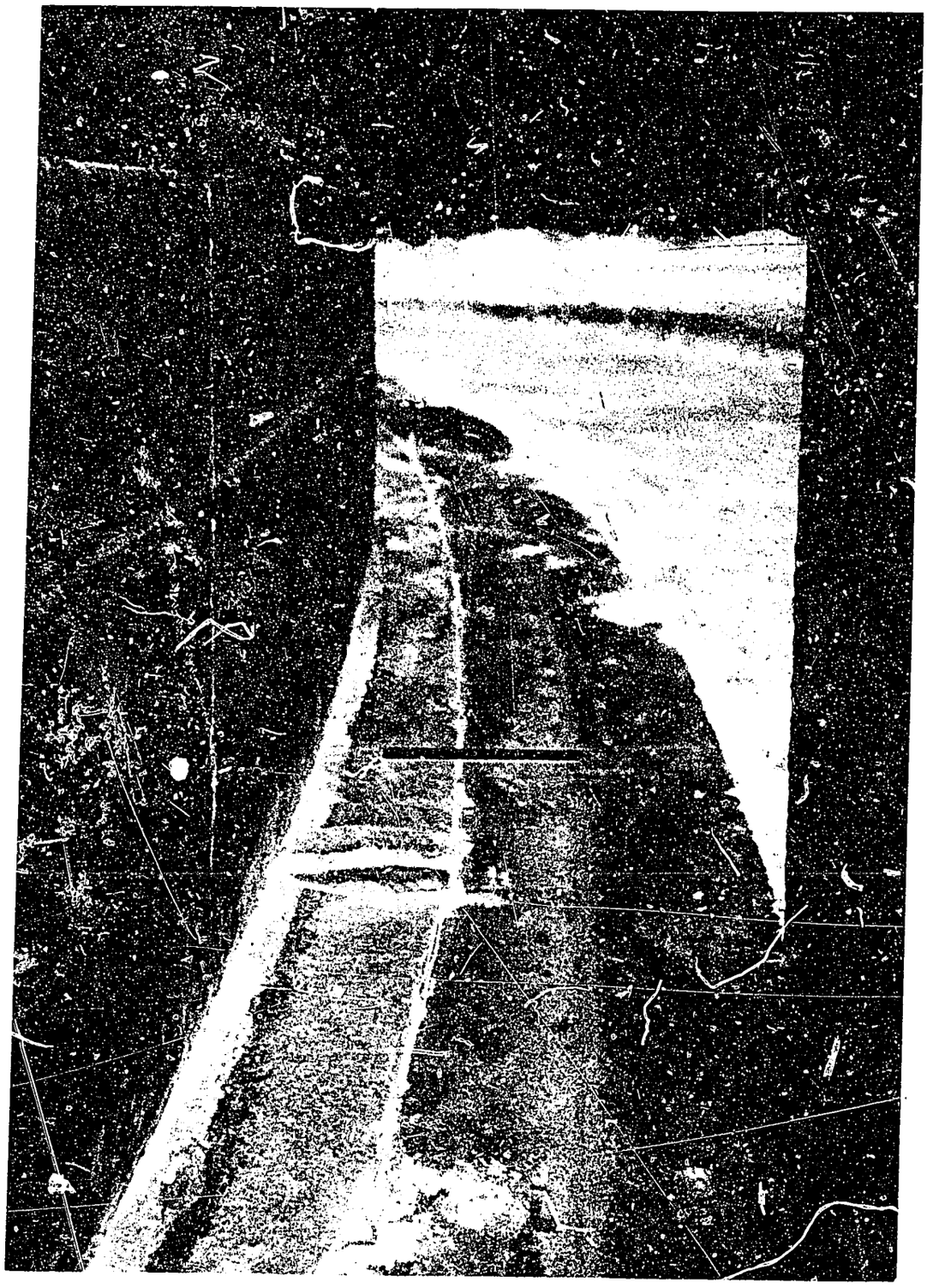
9 Railway (gauge 1.07 m), 1.0 km north of Cadoux.



10 Fence displacement 4.0 km south of Cadoux, looking south. Note fence crosses scarp twice.

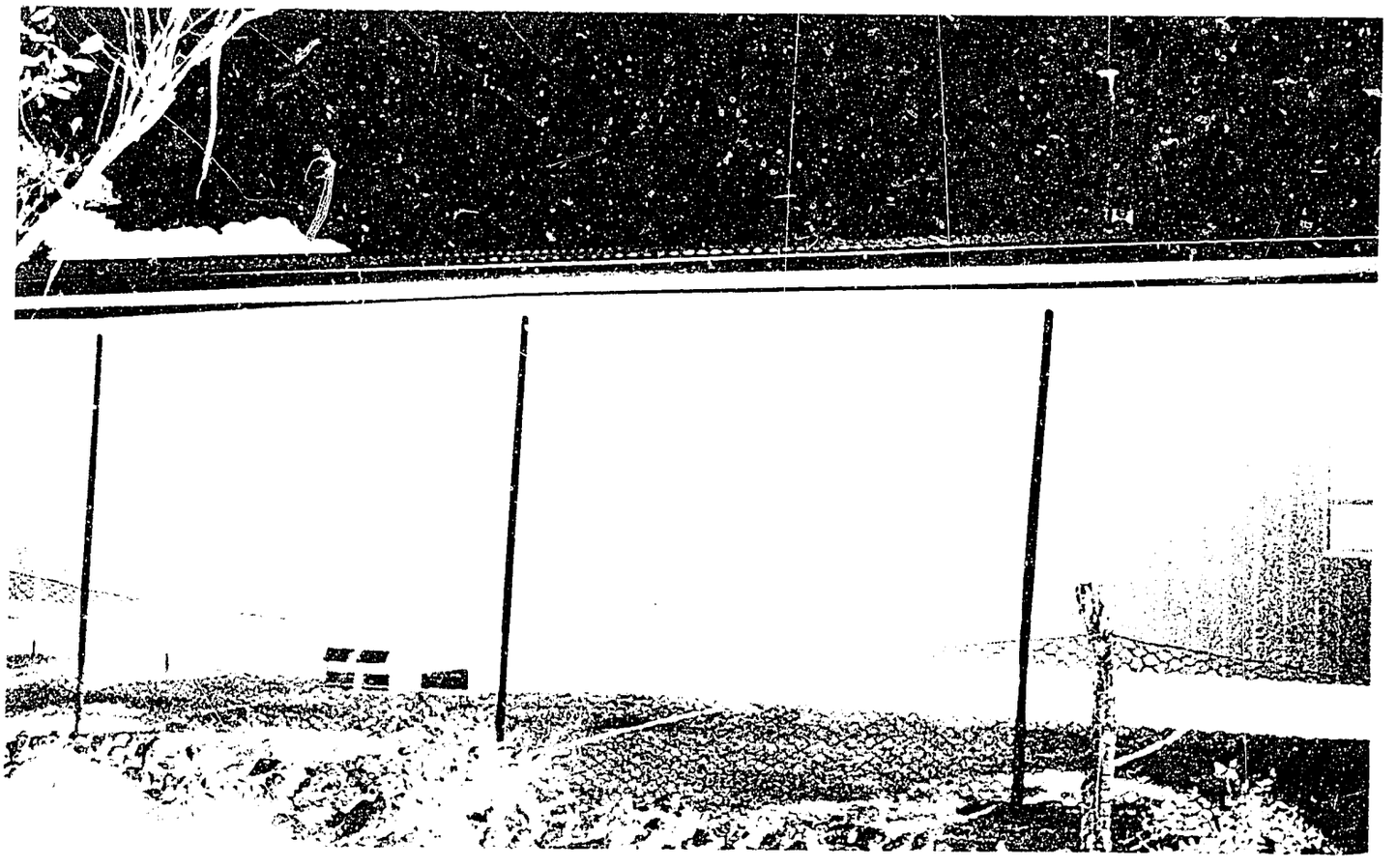


11 Nine million litre water tank close to northern fracture zone after water escaped.



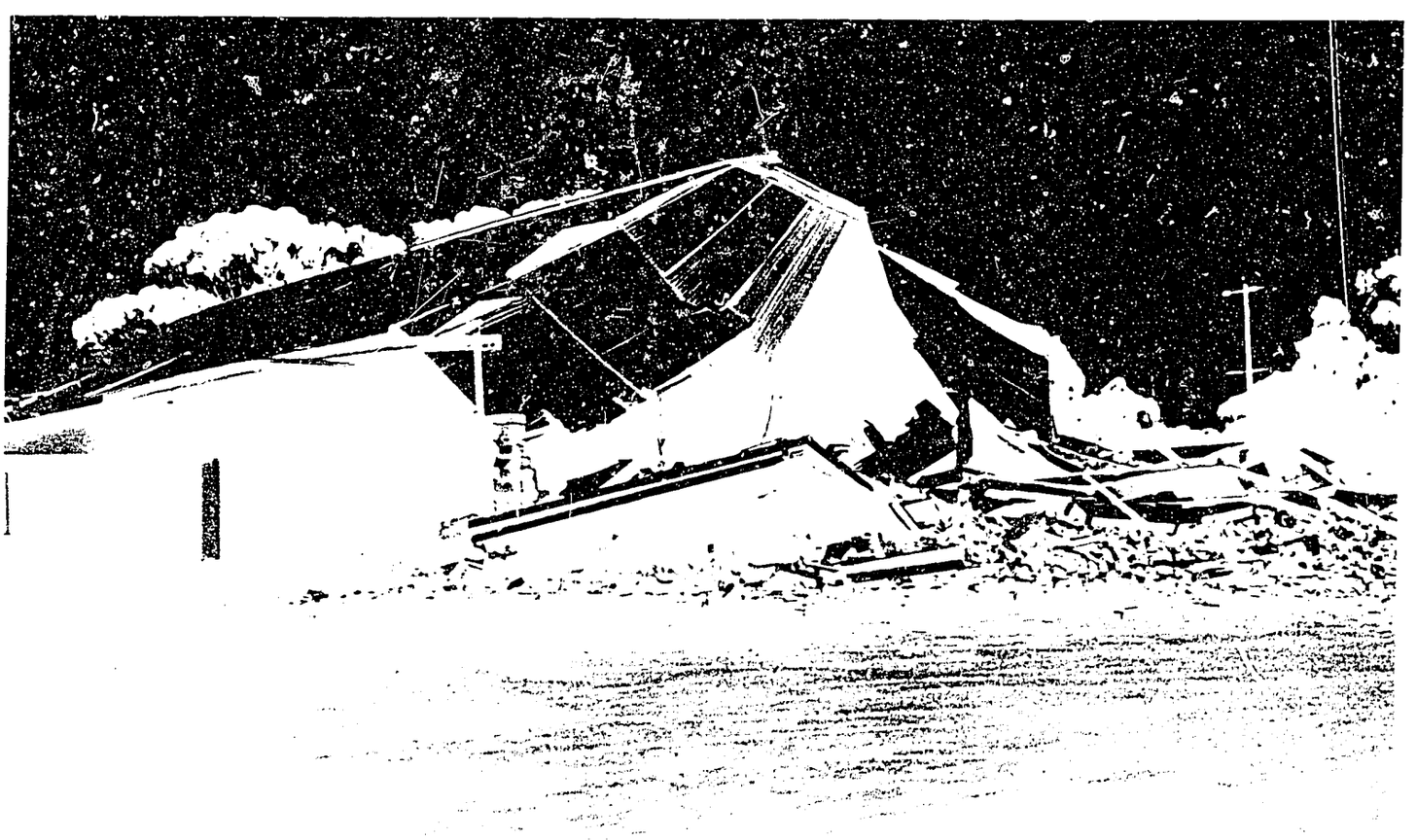
12 Tank looking east showing displacement to the north (43 cm maximum).

13 Damage to cement brick house, adjacent to southern fracture zone.



14 Transportable house. Southern fracture zone runs beneath house.

15 Damage to school house. Brick chimneys fallen through iron roof.



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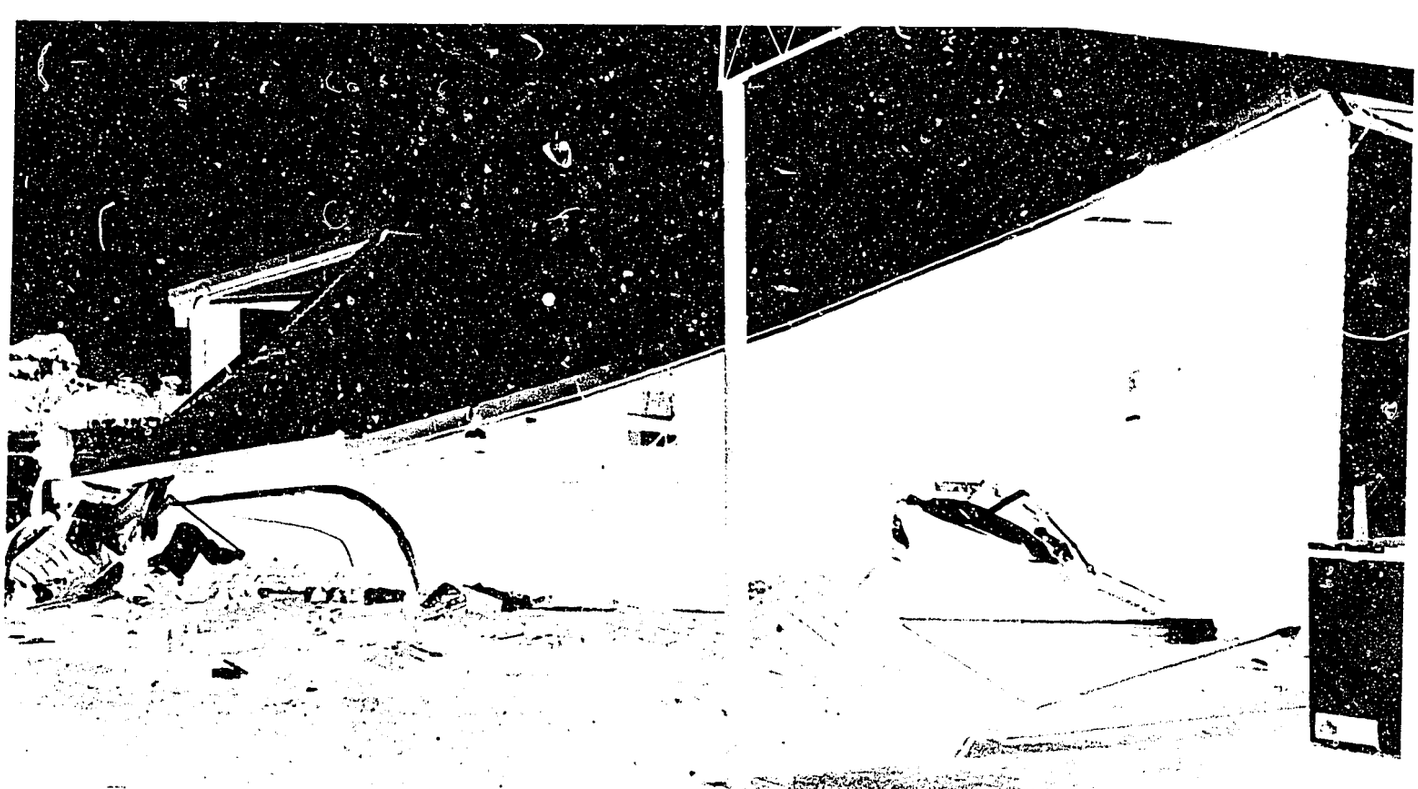
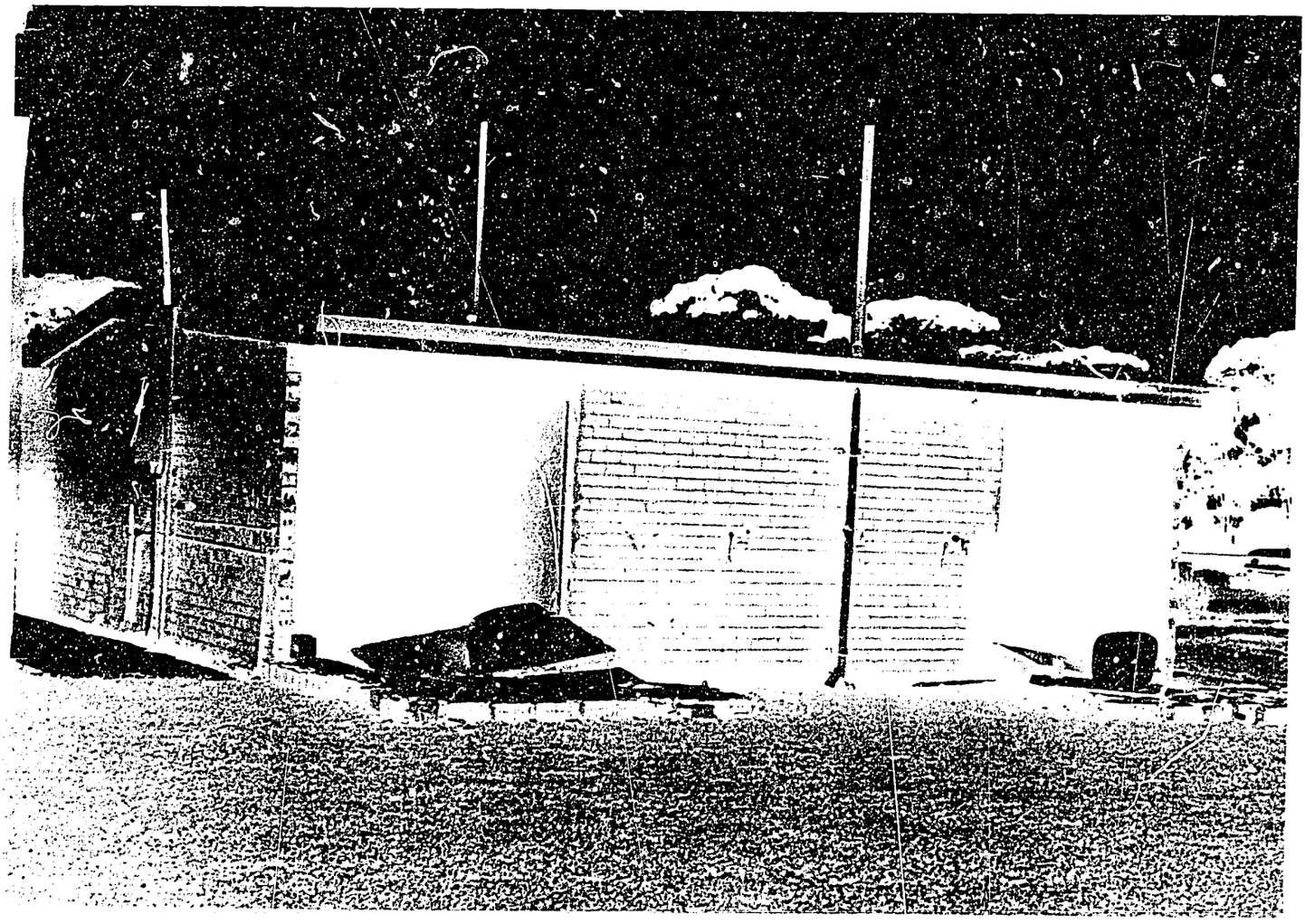


17 Damage to club house. Collapse of roof after brick wall support collapsed.



18 Damage to club house toilets, looking west.

5. Central fracture zone, looking northwest. North side up approximately 50 cm. (*Reproduced by permission of West Australian Newspapers Ltd*)

6. Southern fracture zone, looking west. West side up near area of maximum displacement. (*Reproduced by permission of West Australian Newspapers Ltd*)

7. Southern fracture zone looking south along main road 1.0 km north of Cadoux. (*Reproduced by permission of West Australian Newspapers Ltd*)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8. Central fracture zone looking west across main road 3.2 km north of Cadoux. (*Reproduced by permission of West Australian Newspapers Ltd*)

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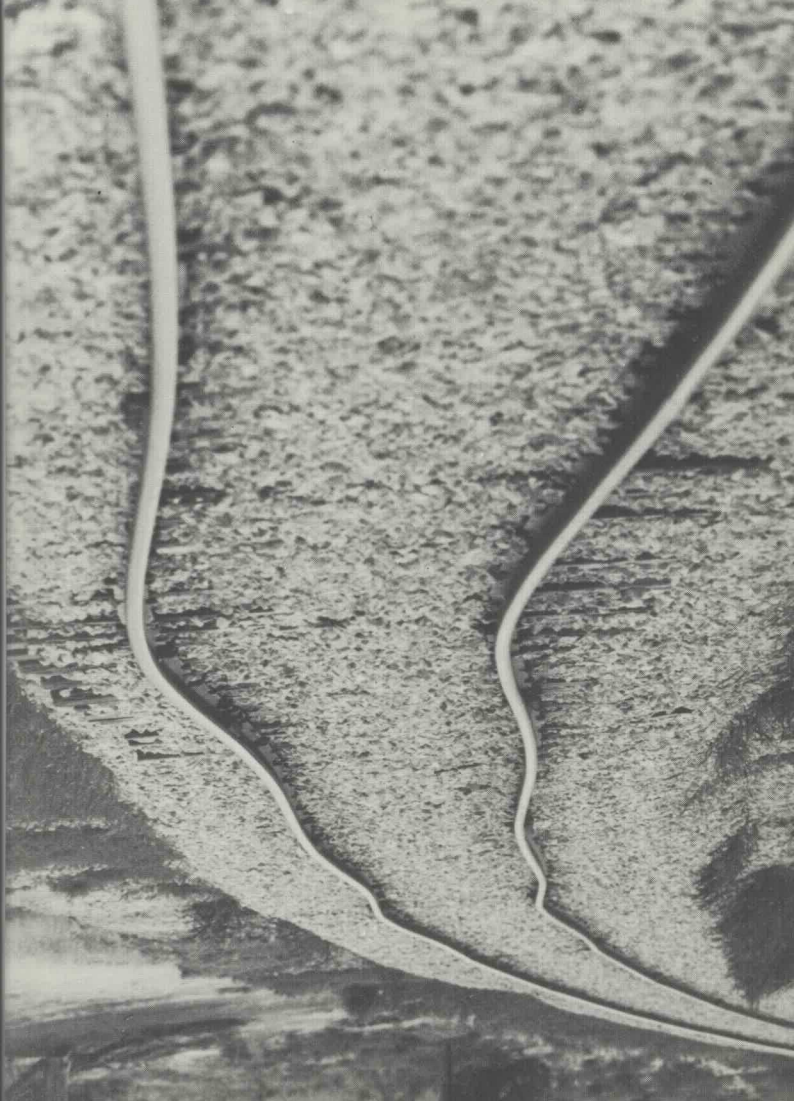

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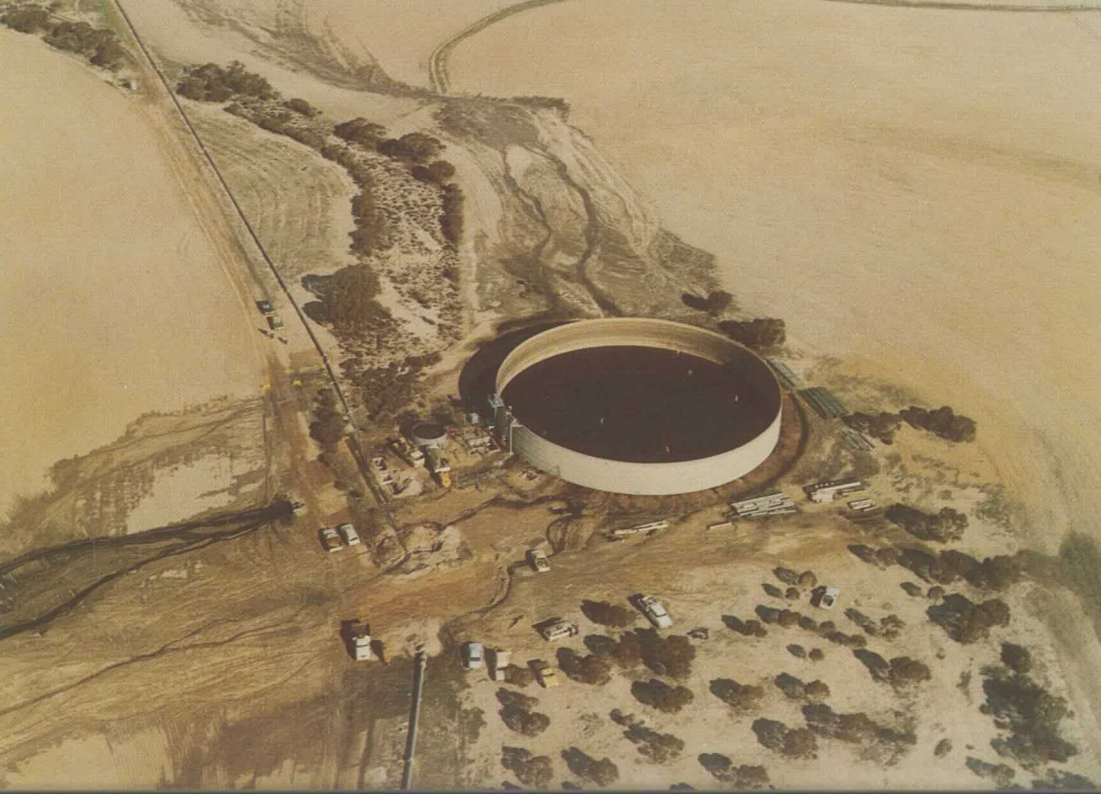

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