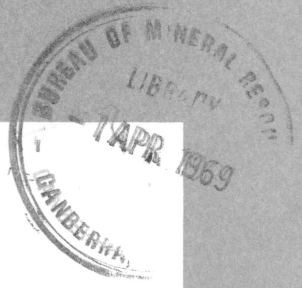
COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



Record No. 1968 / 142

Preliminary Report on the 14 October 1968 Earthquake at Meckering, Western Australia

by

I.B. Everingham

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ILLUSTRATIONS

SUMMARY

An earthquake occurred on 14 October 1968 near the small country town of Meckering, Western Australia. The town (population 600) was wrecked and twenty people were injured, but there was no loss of life.

Pewliminary results show that the earthquake had a magnitude of about 6.9; the maximum Modified Mercalli intensity was at least IX. It occurred at 02h 58m 51s Universal Time, in latitude 31°37' S, longitude 116°58' E at a very shallow depth; it was probably the third largest Australian earthquake recorded to date.

The earth fractured in an arcuate zone over 32 kilometres (20 miles) long, trending approximately north-south, and convex westwards. A relative uplift of the region east of the fracture formed a scarp which was up to 1.5 metres (5 feet) high. Overthrusting to the west by up to 2 metres (7 feet) and right-hand strike-slip displacement of up to 0.9 metres (3 feet) were also observed at the fracture zone.

1. INTRODUCTION

Meckering, with a population of about 600 in October 1968, is situated in a farming area about 130 kilometres inland from the Western Australia State capital, Perth (see Plate 1). On 14 October 1968 an earthquake wrecked the town and most of the farm houses in the general area, caused injuries to twenty people, broke railway lines, and ruptured major roads leading to Meckering (see Plate 2). Sufficient shaking occurred in Perth to alarm most residents and to cause minor damage to many older buildings.

A summary of the effects of the earthquake was given in the weekly newspaper "This Week at Home" for 21 October 1968 and is quoted here in full:

"An earthquake swept across the southern half of WA early this week, flattening the wheatbelt town of Meckering (population 600) 84 miles east of Perth.

"More than three-quarters of the town was reduced to rubble and the remaining houses have sections of wall missing as a result of the shock which lasted about 40 seconds.

"It was the most severe earthquake recorded in Australian history. It registered 6.9 on the Richter scale. Seventeen people from Meckering and three men from York, with injuries ranging from broken legs to concussion, cuts, bruises, and shock were admitted to hospitals at Cunderdin, York, and Perth. At York, 25 miles from Meckering, the three men were injured when the balcony of the two-storey Imperial Hotel collapsed in the town's main street. In Perth city buildings cracked, walls, and ceilings collapsed amid a deep rumbling pierced by the crashing of plate glass as the quake shook the city for about half a minute. There was panic in hotels and theatres packed with patrons - many of them children - on the rainy Queen's birthday holiday. Traffic police closed off one lane of the Kwinana Freeway where a 12-yard split in the pavement opened up half a mile from the Como end. At St Mary's Cathedral, a stone cross weighing about 200lb fell 100 ft to the ground during the quake and embedded itself 3 ft in a lawn. Paving on all sides of the cathedral was littered with shattered masonry. Decorative stone sections were flung from the cathedral spires. Many pieces smashed through concrete paving. Some fragments weighed about 100 lb. At St George's Cathedral verger R. Charles was polishing church ornaments when he felt the tremor. He sprinted for the front door and as he reached the doorway a stone cross weighing 40 lb hurtled into the ground about 6 ft ahead of him. He ran out a side door into the open. A 10 ft by 9 ft plate glass window was flung on to the footpath outside a cafe.

"Watchers on the William Street/St George's Terrace corner saw a big crack appear in the top of Elders Building. The whole top section of the William Street wall appeared to be on the brink of falling into the street before the crack closed again as the tremor subsided. People on the opposite corner stood petrified as other pedestrians walked past the building and across the road apparently

unaware of what was happening.

"Within 10 minutes of the quake, police had cordoned off a section of Hay Street between Victoria Avenue and Hill Street, East Perth. A second slight tremor came about an hour after the first. The earthquake appeared to have been centred on Meckering but tremors were felt as far away as Geraldton, Kalgoorlie, Esperance, and Albany. The most serious damage seemed to be in an area beginning about seven and a half miles south of Meckering, one mile north and four miles west of the town. Huge faults, about 5 ft high and several miles long, appeared at these points. Both narrow and standard railway tracks were broken in the earthquake, and a water main burst near these breakages. Power and telephone lines were also cut in the town. The Meckering wheat silo broke open, spilling wheat on to the ground.

"Most of the town's population had grim stories to tell. Mrs. V. Norman, wife of a Meckering stock firm agent, had moved to the town only two days ago and was in her home with daughters Keile (5), Toni (3), and Vicki (3 weeks). The home, which had been renovated at a cost of about $7000 in past weeks was almost destroyed. 'I didn't realise what was happening', she said, 'There was a big shake and suddenly the walls seemed to be falling on top of me. I screamed and ran to the children'.

"Butcher V.M. Edwards, who has been in the town for 30 years, was in the backyard of his home as the quake struck. He was knocked over three times by its force. 'The third time I thought that the ground was going to open up and that I would fall into it' he said. 'I grabbed hold of a post but it shook me away. It was horrifying'.

"The State Government and other organisations this week announced several relief moves".

2. OBSERVATIONS AND RESULTS

Instrumental data

Interpretation of recordings from four stations in Western Australia gave the following provisional results:

Epicentre	latitude	31°37' S
	longitude	116°58' E
Depth	approximately 7 km	
Origin time	02h 58m 50.9s Universal Time	

A reliable magnitude could not be determined from the local station seismograms because the traces disappeared where the relevant recordings of ground amplitude were required.

The preliminary determinations of epicentre and other data made by the United States Coast and Geodetic Survey were:

Co-ordinates	31.5°S, 117.0°E
Depth	0 km
Origin Time	02h 58m 47.8s Universal Time
Magnitude	m_b 6.0 (13 stations)
	MS 6.8 (13 stations)

An overall appreciation of magnitude data suggests a magnitude (M_L - commonly termed the Richter magnitude) of 6.9. See Appendix for information on magnitudes.

The epicentre as determined by the local network is close to Meckering, which is located in the eastern part of an area of known seismic activity named the Yandanooka/Cape Riche Lineament (Everingham, 1966).

The fracture zone

From a brief survey of the Meckering area it was found that fracturing of the Earth's crust had occurred along an arc 32 km (20 miles) long, which trended roughly north-south with its convex side to the west. At the fracture zone a distinct scarp was formed by the movement of the eastern side upwards by up to 1.5 metres (5 feet). A crustal shortening of up to 2 metres (7 feet) was also evident at the fracture zone, and the east block moved south by up to 0.9 metres (3 feet) relative to the area west of the fracture. Plate 2 shows the surface trace of the fracture zone and the ground displacements at several places on it. Plates 8 to 15 illustrate effects along the fracture zone.

The effects at the surface are believed to be due to shallow thrust-faulting with a right-hand strike-slip component.

The fault plane apparently has a shallow east dip of about 35° judging by the ground displacements. The fault trace suggests conchoidal fracture. If the fracture zone is concave towards the surface, and does not extend much further east than its northern and southern surface extremities, its maximum depth need only be a few kilometres.

The impression is that chipping occurred on a large scale. Roughly east-west compressional forces would cause such a fracture, and crustal warping involving uplift on one or both sides of an axis running about north-south through the zone of seismicity could cause the compression. As the area is near the margin of the topographic feature known as the Salt Lake Region the above explanation seems worthy of further investigation.

Isoseismals and damage

Preliminary results (Gregson & Everingham, in preparation) of an isoseismal survey (500 questionnaires) revealed that the earthquake was felt within a radius of about 650 km (400 miles). Within about 5 km (3 miles) of the earthquake fracture MM (Modified Mercalli) intensities were VIII or greater, and the radius of the MM VI isoseismal was about 80 km (50 miles). Intensities in Perth were within a closed MM VI isoseismal, i.e the intensity was greater than for surrounding areas, because of the sub-soil conditions there.

Brick and stone homes, mostly built at least 40 years ago, were completely destroyed in areas near the fracture zone, whereas asbestos (timber-framed) and timber homes and iron sheds (timber and steel framed) in the same area withstood the shaking (notice the fibro-cement shop in Plate 6). A large re-inforced concrete wheat silo only two kilometres (1.2 miles) east of the fault suffered only superficial damage.

Aftershocks toppled some badly cracked walls and appeared to add slightly to damage, i.e. effects of tremors were cumulative.

Up to about 50 km (30 miles) from the earthquake region, increases and decreases in the water flow in wells were reported. In the only well inspected (Robinson's, two miles west of the fracture) it was found that a small fault about 0.4 mile in length, with about one inch of transcurrent movement, terminated near the well. The Mortlock River (east branch) was dammed by the main fracture (Plate 10a) and as the area is so flat many minor changes in drainage patterns will be inevitable, particularly where streams flow towards the scarp from the region to the west of it.

A man was driving a car about one hundred yards from the earthquake fault area on the Great Eastern Highway when the earth arose ahead of him. No dust or blinding flash was noted. One instant the road was flat and the next a five-foot scarp was there and the driver was forced to pull up.

Several people as far away as Greenhills who were outside when the earthquake occurred reported seeing groundwaves.

It was of interest to discover from a comparison of isoseismal radii from the 1941 Meeberrie and the 1968 Meckering earthquakes that the Meeberrie event was of larger magnitude, probably $7\frac{1}{2}$. Its original magnitude determination was probably in error because it was deeper than had been assumed (Gregson & Everingham, in preparation). Similarly isoseismals show that the Kingston-Beachport earthquake of 1897 may have been of greater magnitude than the Meckering event.

Plates 4 to 7 indicate damage caused in Meckering and Plates 16 and 17 show damage in the Perth metropolitan area.

Foreshocks and aftershocks

Two Willmore seismographs at field stations at Morawa, Jurien Bay, and later at two points near Meckering, were used to record aftershocks. In addition, Mr H.A. Doyle of the Australian National University, Canberra, installed a magnetic tape seismograph to record continuously from October 17th at Greenhills.

The main tremors in the Meckering area recorded during the period October 1st to November 30th 1968 are listed in the Table. Most aftershocks are within about 8 km of the trace of fracture zone and to the east of it.

Three foreshocks felt at Meckering on October 3rd caused slight alarm but no significant damage was reported. The shaking and noise was described as "ten times as bad as that caused by any train". The railway is along one side of the township. Small tremors also occurred about four hours prior to the main event and all foreshocks were in the general region of the main earthquake epicentre shown in Plate 2.

Most of the events listed were perceptible in Perth, those with magnitude greater than 5 very clearly.

Plate 3 illustrates (a) the minor renewals of activity after the main event and (b) the overall diminution of activity.

It is interesting to find that half of the larger earthquakes occurred at times between 0230 and 0430 Universal Time (10.20 - 12.30 WST). A triggering influence should be investigated.

3. EARTHQUAKE FREQUENCY

Calculations may be made to give a rough idea of the order of frequency of larger earthquakes in the active region across the south-west corner of the State.

Including the Meckering 1968 events it was found that over the past nine years tremors with magnitude greater than 3.5 occurred on the average of four times per year and there have been about six times as many events with magnitude M as there have been with magnitude M + 1. On the basis of these results an earthquake with magnitud greater than 6.5 would occur on an average, about every 50 years and one of magnitude greater than 5.5 every 10 years. However, it is considered that to expect large earthquakes as often as this would be pessimistic for two reasons. Firstly, records kept from about 1840 suggest a lower average frequency of occurrence and secondly, data used above are swamped by the mass of short-term Meckering data.

4. ACKNOWLEDGEMENTS

Plates 4, 5a, 7a, 8b, 12a, 12b, 13b, 16, 17a and 17b are reproduced by permission of West Australian Newspapers Ltd, and Plate 15 by permission of ABC TV Channel 2, Perth.

5. REFERENCES

EVERINGHAM, I.B. 1966 Seismicity of Western Australia. Bur. Min. Resour. Aust. Rec. 1966/127.

GREGSON, P.J. and EVERINGHAM, I.B. Isoseismal maps of the Meckering earthquake (14th October 1968) Bur. Min. Resour. Aust. Rec. (in preparation).

RICHTER, C.F. 1958 ELEMENTARY SEISMOLOGY. Freeman, San Francisco.

TABLE

EARTHQUAKES IN THE MECKERING AREA ($M_L > 3.5$)

(October 3rd to November 30th 1968)

DATE	UNIVERSAL TIME	M_L
Oct 03	0303	3.8
03	0318	3.7
03	0355	4.2
14	0259	7.4
14	0358	4.0
14	0409	4.6
14	0454	3.8
14	0648	4.2
14	0929	3.8
15	0249	3.6
15	0330	5.7
15	1246	3.8
16	0055	4.2
16	0824	3.7
18	1032	4.1
20	1504	3.8
21	1533	4.6
22	0104	4.1
25	1318	3.7
25	2331	3.9
26	0422	4.9
26	1331	3.6
29	0328	3.8
29	1400	3.8
30	0250	3.7
31	0059	4.1
31	0104	3.8
Nov 04	0343	3.8
23	0010	3.7
28	1417	4.0
28	2112	3.7

APPENDIX

MAGNITUDE DETERMINATION

Magnitude is a quantity that is intended to rate earthquakes according to their 'size'. It is determined from the trace amplitude on a seismogram and ideally, of course, all such determinations from seismograms obtained at different locations should yield the same value of magnitude for a particular earthquake. Intensity, on the other hand, refers to the degree of shaking at a specified place. This is not based on measurement but is a rating assigned by an experienced observer using a descriptive scale (Richter, 1958). It is the latter figure that is usually of interest to insurance assessors and others concerned with earthquake damage.

The procedure for determining magnitudes is far from straightforward and the complexities involved are clearly indicated by Richter (1958) and others. Chiefly because of the different characteristics of seismograms of earthquakes at different epicentral distances and depths of focus, three main types of magnitude scale have emerged: local earthquake magnitude scales (M_L); surface wave magnitude scale (M or MS); and body wave magnitude scale (m or m_b).

The original local magnitude scale (M_L) was devised by Richter for earthquakes in Southern California using standard Wood-Anderson seismographs and is the value frequently referred to as the 'Richter magnitude' or 'magnitude on the Richter Scale'. With the installation of many short-period, high-magnification, electromagnetic seismographs (e.g. Benioff instruments), it has been possible in some regions to obtain consistent Richter local magnitudes from the records of such instruments after allowing for the different magnification and assuming the same amplitude-to-distance relation found by Richter for Southern California. This is the procedure adopted by Australian stations close to an earthquake.

In general it is difficult to extend a local magnitude scale to distances beyond about 600 km, and an alternative scale has been developed, initially devised by Gutenberg and Richter, which uses the computed ground amplitude of surface waves with periods near 20 seconds. This scale (designated M or MS) was particularly useful when few stations were equipped with high-magnification, short-period instruments.

Since deep focus earthquakes do not register surface waves of appreciable amplitude with periods near 20 seconds, a magnitude scale for such earthquakes must be founded on records of body waves. This scale (M or m_b) was devised by Gutenberg, and requires a knowledge, obtained from seismograms, of log (A/T) where A is the amplitude of the ground motion and T the corresponding period. The value of m is determined from the equation.

$$m = A_o + \log (A/T)$$

where A_o is an empirical constant which is a function of distance.

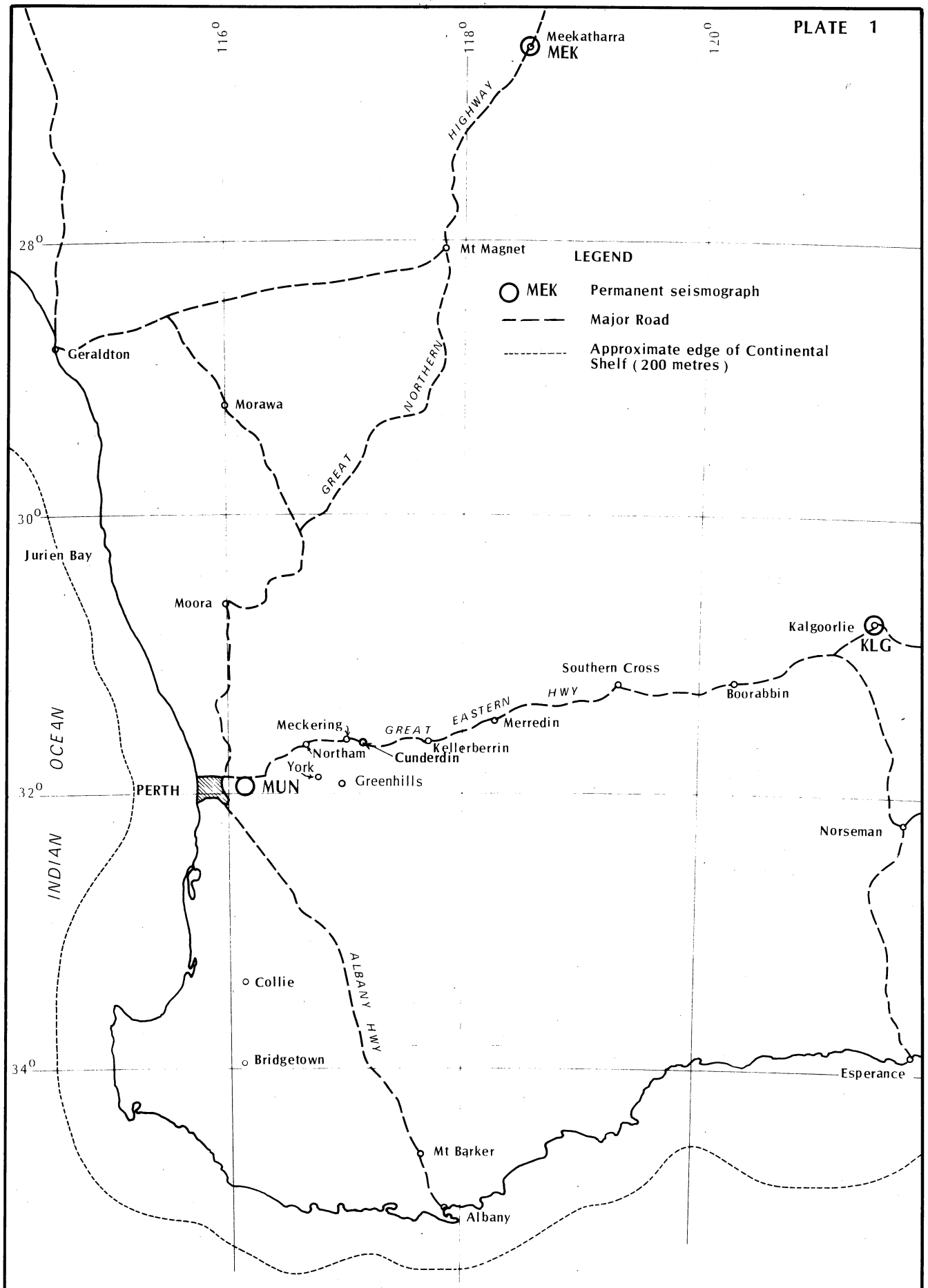
Several transformation formulae relating the three scales have been published by different authors. For example, Richter (1958) suggests:

$$\left.\begin{aligned} m &= 1.7 + 0.8\, M_L - 0.01\, M_L^2 \\ &\approx 1.8 + 0.73\, M_L \end{aligned}\right\} \quad \text{within the } M_L \text{ range 1 to 6}$$

and $m = 2.5 + 0.63\, M$

Because these relations have been determined empirically, independent magnitude estimates (M_L, M, m) for a single event are often not mutually consistent when compared using these, or similar, formulae.

PLATE 1



LOCALITY MAP

Compiled from Geographic Map of Australia - NMP 65 139 (BASED ON WA B0-3)

TO ACCOMPANY RECORD No.1968/142

G82/ 4-79

PLATE 2

DOWERIN

18"

3" 1"

27"

GOOMALLING

54"

56"
(14)

6"

48"

PROVISIONAL EPICENTRE

42"
(11a)

(5a)(6)(7a)

6"

MECKERING

(4)

(5b)

51"

(15)

52"

GREAT EASTERN HIGHWAY

(8a)

(12b)

(8b)

(11b)

East Branch

TRUE NORTH
(approximate)

63"

(10b)

River

Mortlock

42"

36"

(10a)

(12a)

51"

48"

KOOLBUNINE ROAD

24"

(13b)

YORK

HARDY ROAD

minor fractures

(7b)

(13a)

48"

(9b)

(9a)

36"

YORK

24"

15"

3"

Mortlock

River

LEGEND

Road

Railway

Fracture trace

Relative displacement of eastern side

5 feet
2 metres
Horizontal

52" Vertical (up)

(12a) or (12a) Position of photograph and plate number

SCALES
(approximate)

0 1 2 3 MILES

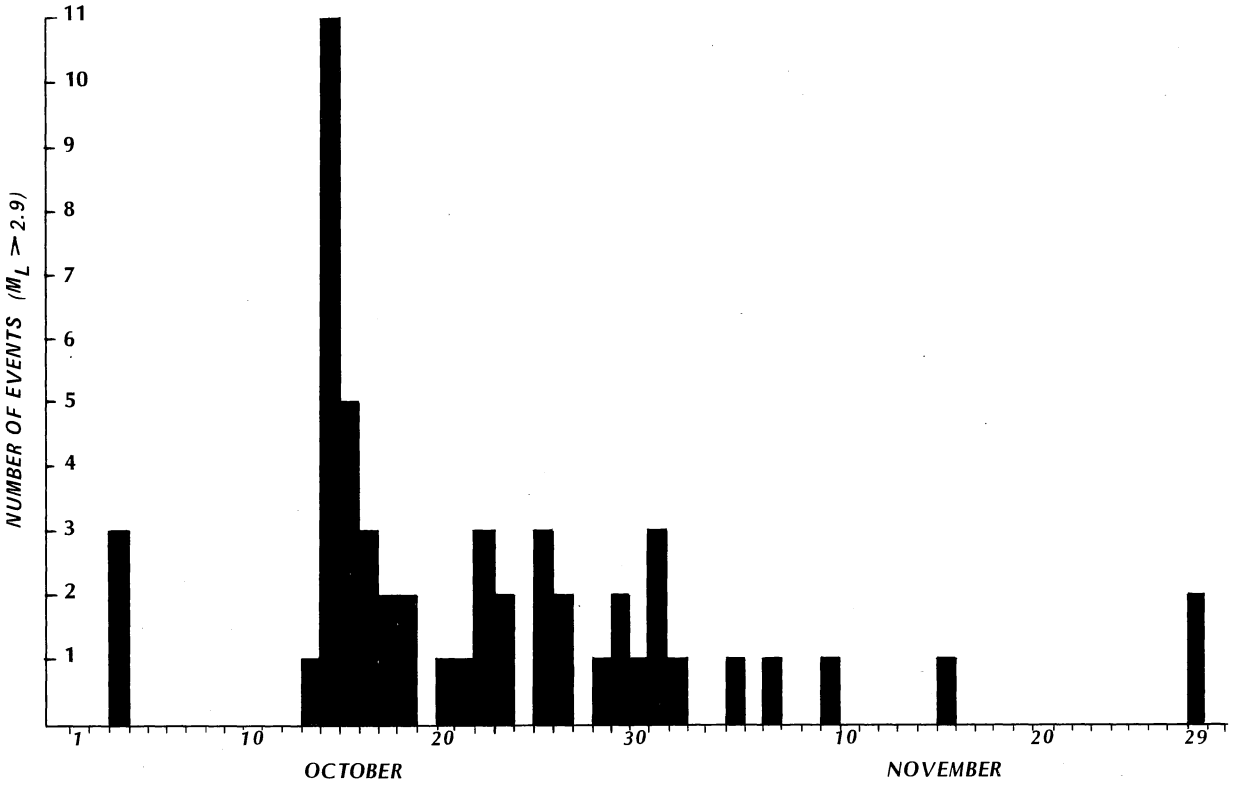
0 1 2 3 4 KILOMETRES

DETAILED MAP OF FRACTURE ZONE

MECKERING EARTHQUAKE WA 1968

TO ACCOMPANY RECORD No. 1968/142

G82/4-81



MECKERING AREA (October-November 1968)

DAILY EARTHQUAKE TOTALS

To accompany Record No. 1968/142

G82/4-80

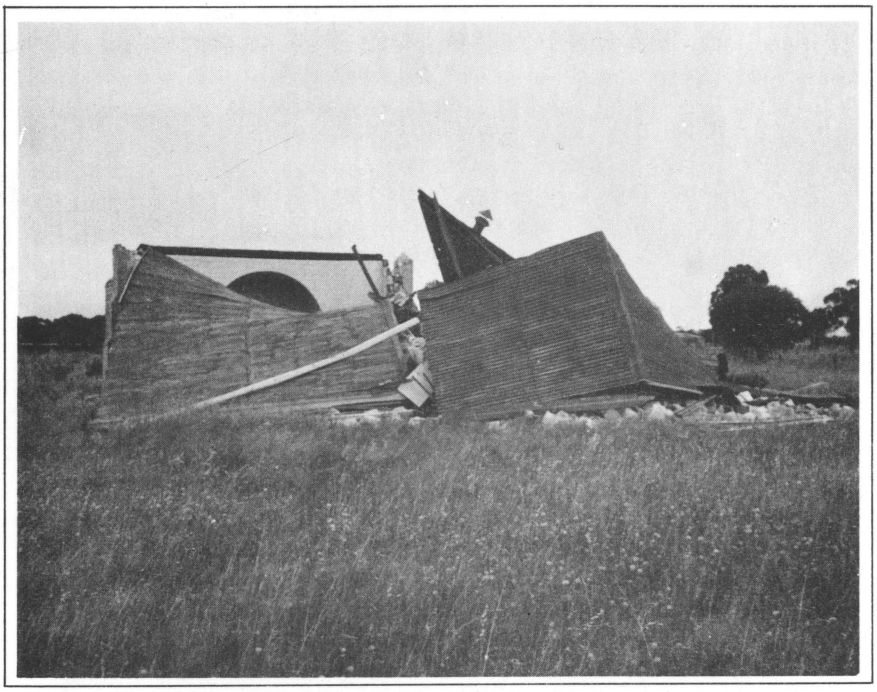
Aerial view of Meckering looking South (14 Oct 1968)

Photograph reproduced by courtesy of West Australian Newspapers Ltd

To accompany Record No. 1968/142

DAMAGE - MECKERING; (a) Hotel

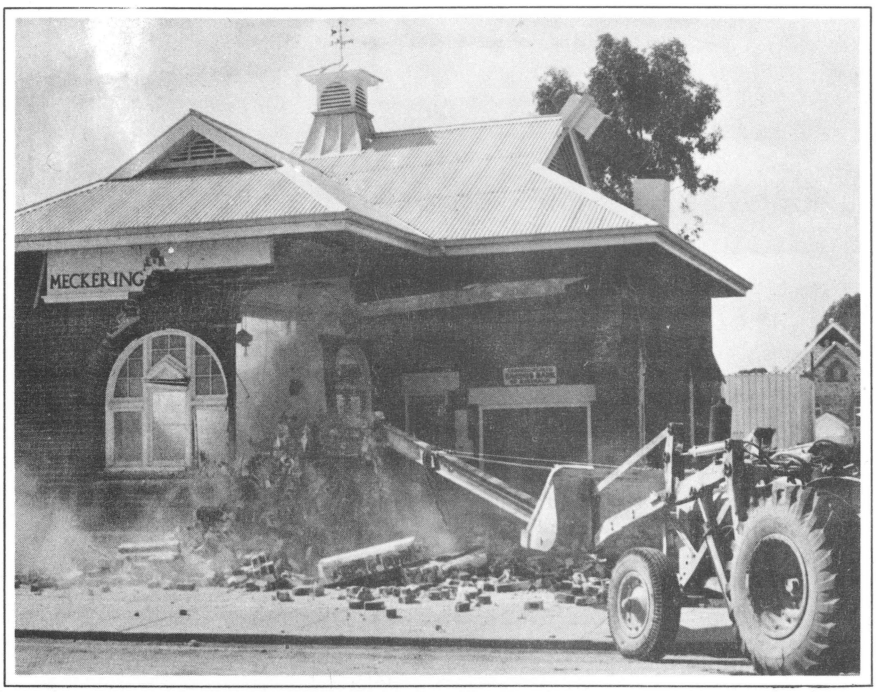
Photograph reproduced by courtesy of West Australian Newspapers Ltd



(b) Church

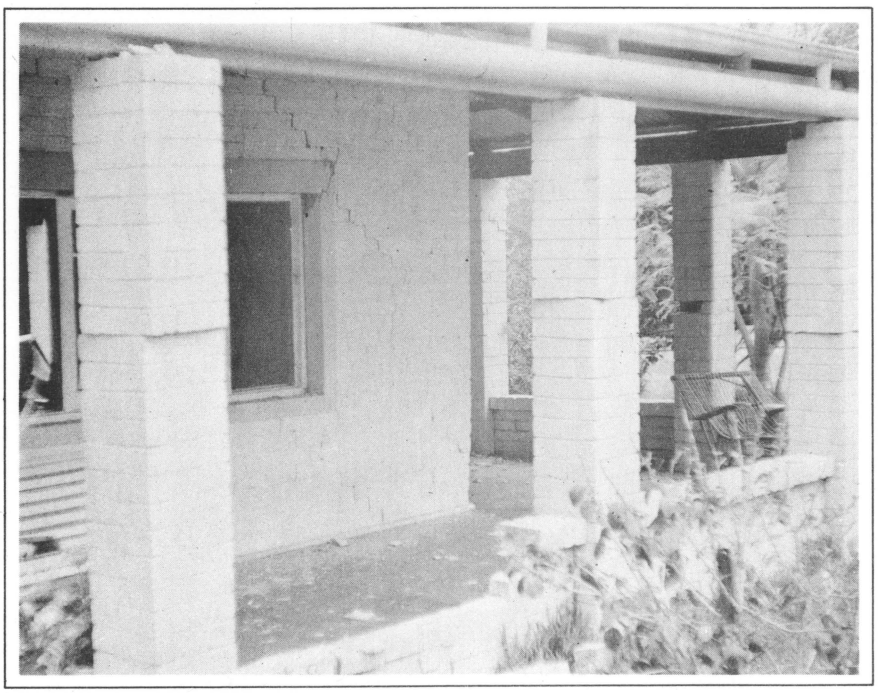
DAMAGE - MECKERING: Fibro-cement baker's shop relatively undamaged

To accompany Record No. 1968/142

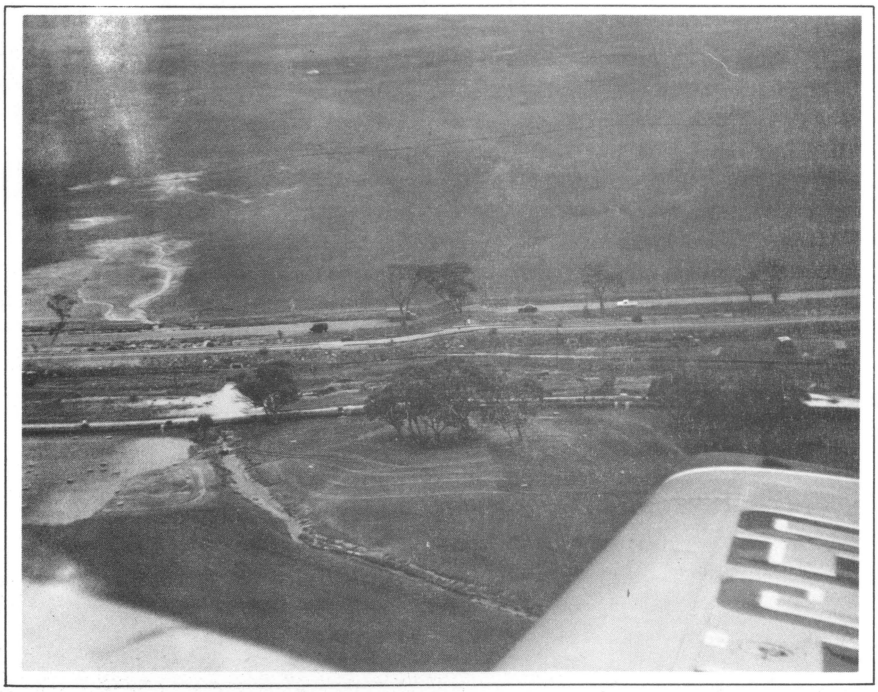


DAMAGE - MECKERING: (a) Post Office being wrecked because of severe damage.

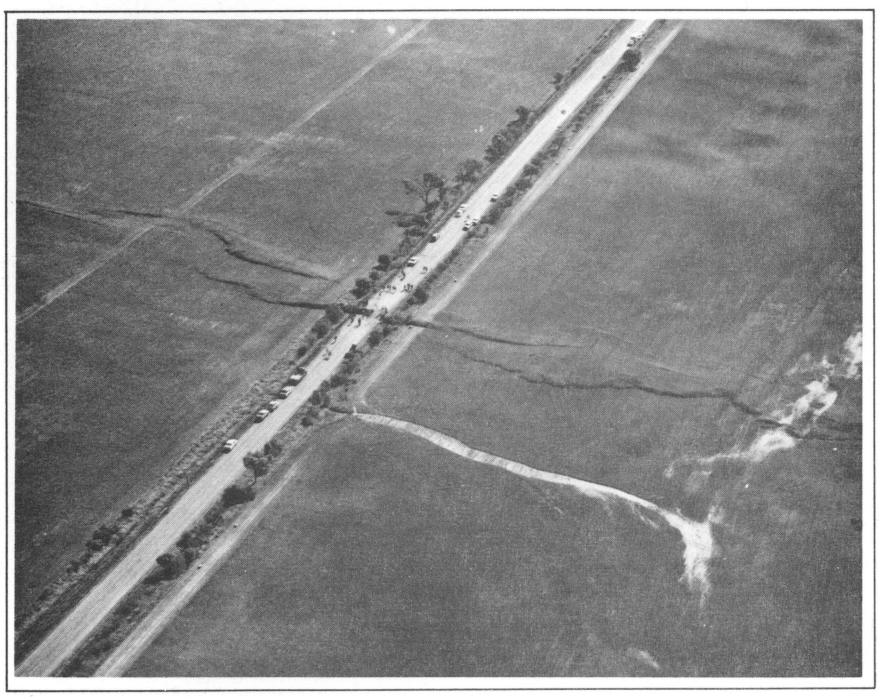
Photograph reproduced by courtesy of West Australian Newspapers Ltd



(b) Brick house, 1 mile west of fracture, looking north-west

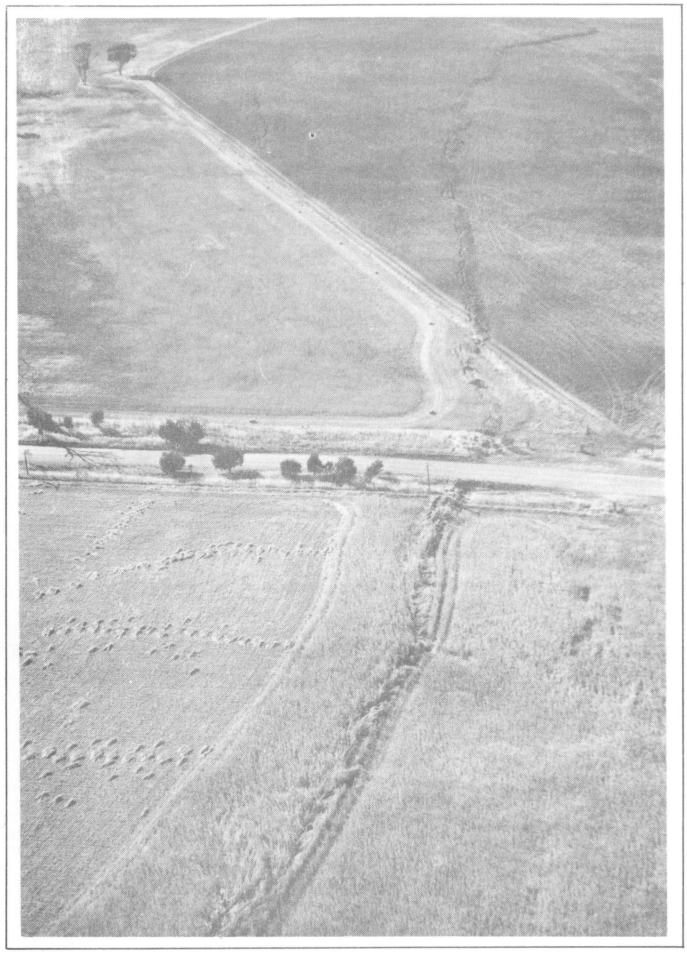


FRACTURE ZONE: (a) Railway cut 1½ miles west of Meckering, looking north. Railway shortening 7 feet. East side up. Pipeline break not visible. (note trees still upright)



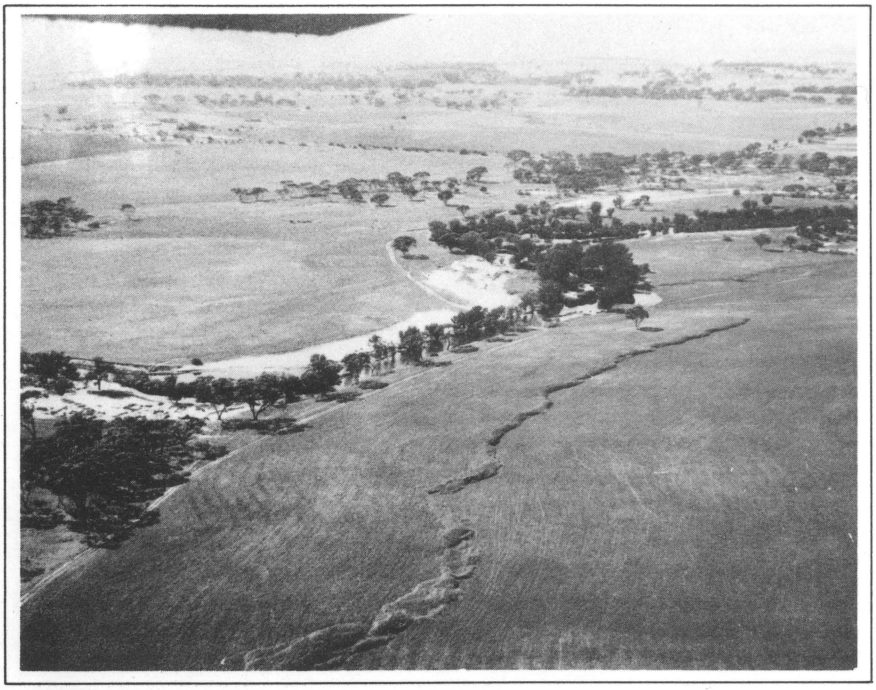
(b) Great Eastern Highway, looking north-east.

Photograph reproduced by courtesy of West Australian Newspapers Ltd



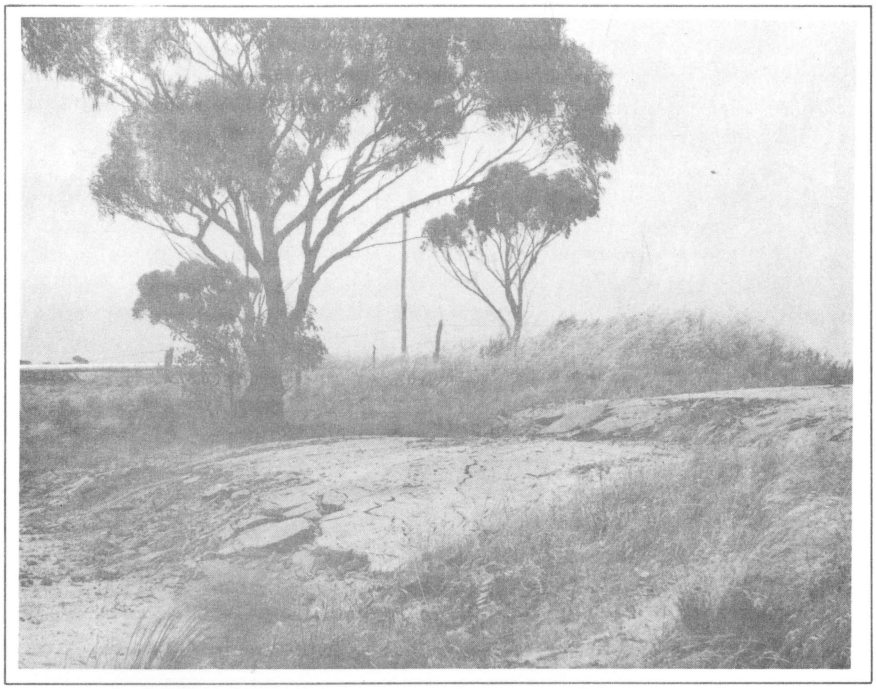
FRACTURE ZONE: (a) Hardy road, 7½ miles south of railway, looking south-east.

(b) Hardy road 7½ miles south of railway, looking south-east.



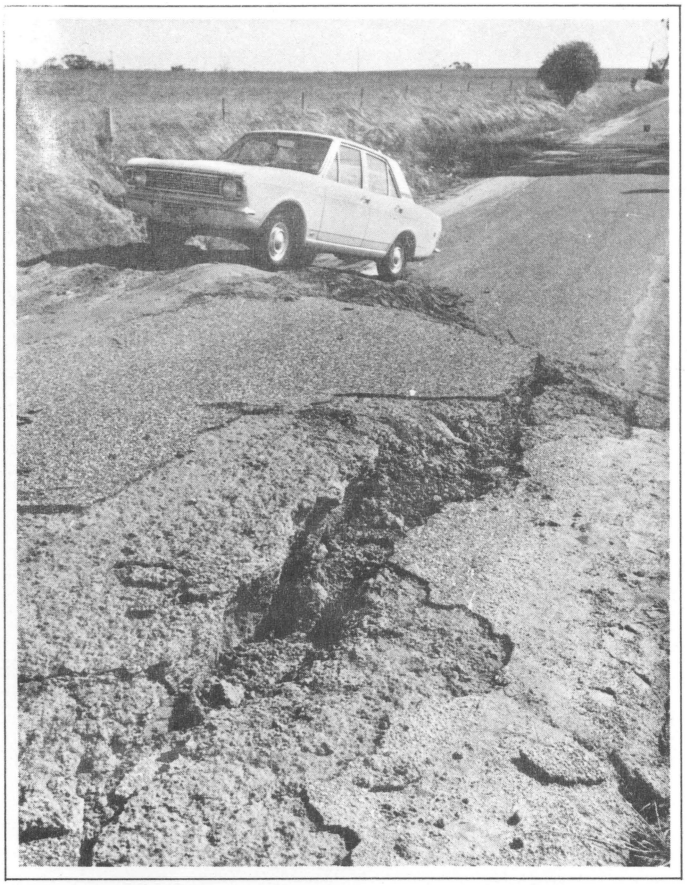
FRACTURE ZONE: (a) Mortlock River dammed 3½ miles south of railway, looking south-east.

(b) 2 miles south of railway, looking north-east.

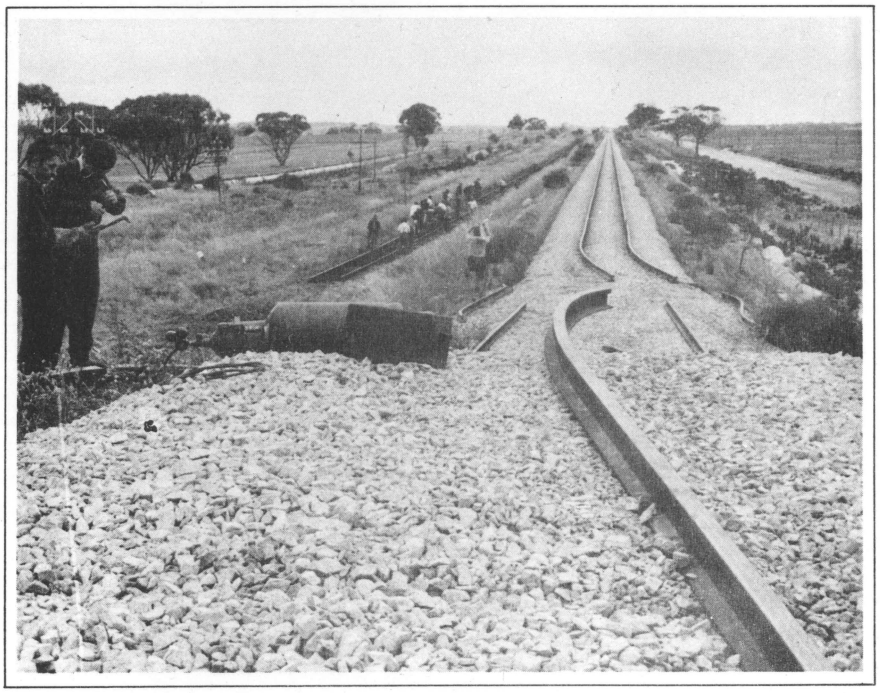


FRACTURE ZONE: (a) Goomalling road 1 mile north-west of Meckering.

(b) ½ mile south of railway, looking west from east of fracture zone

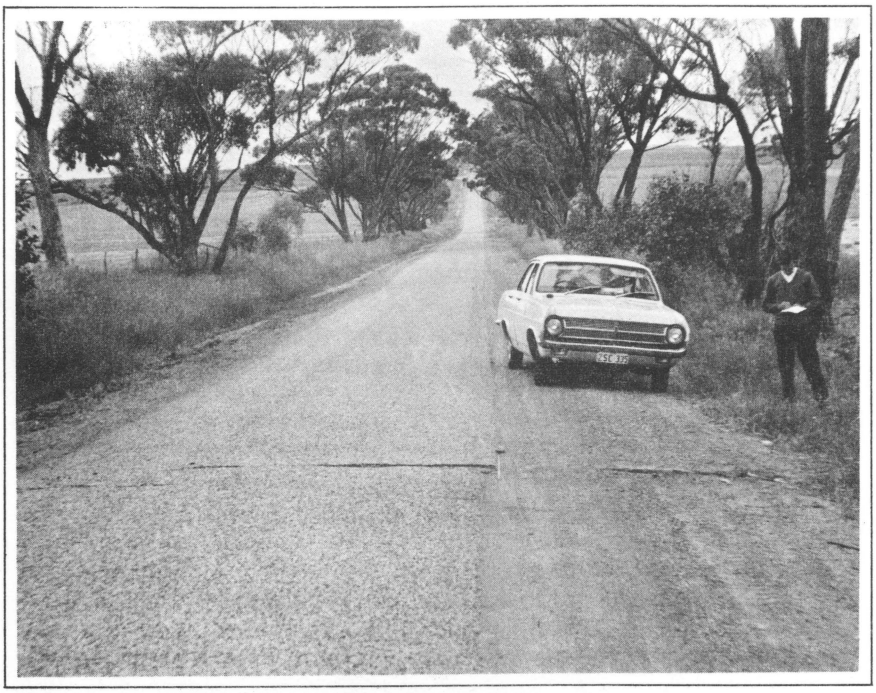


FRACTURE ZONE: (a) York road, 5 miles south of railway, looking west.

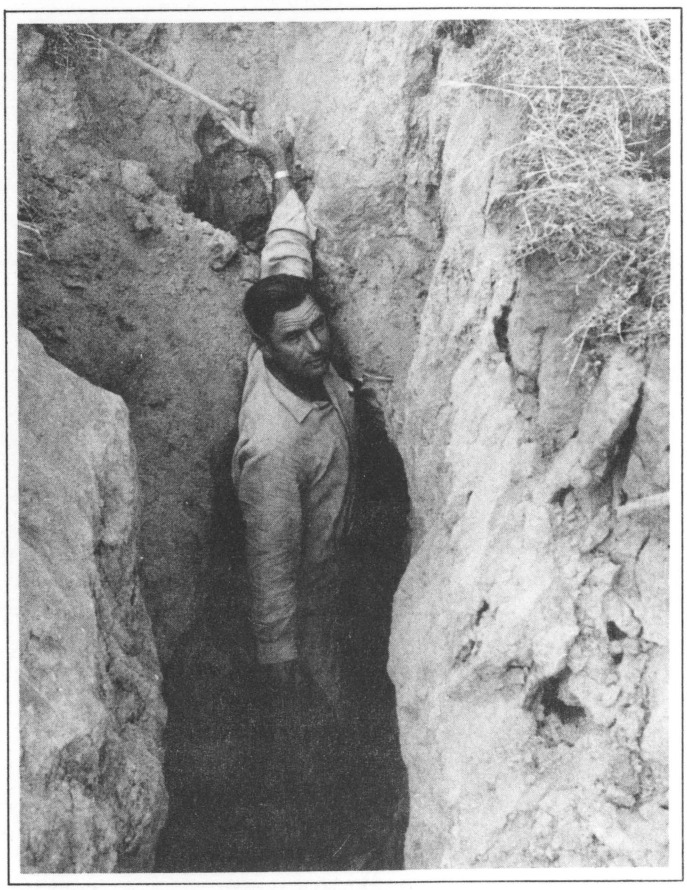


(b) Railway line 2 miles west of Meckering, looking west.

Photographs reproduced by courtesy of West Australian Newspapers Ltd



FRACTURE ZONE: (a) Minor transcurrent fault 1 mile east of major fracture; 7 miles south of railway, looking south. (note en-echelon faulting)



(b) Crack on O.M. Burge's property between Hardy and York Roads where fault is offset.

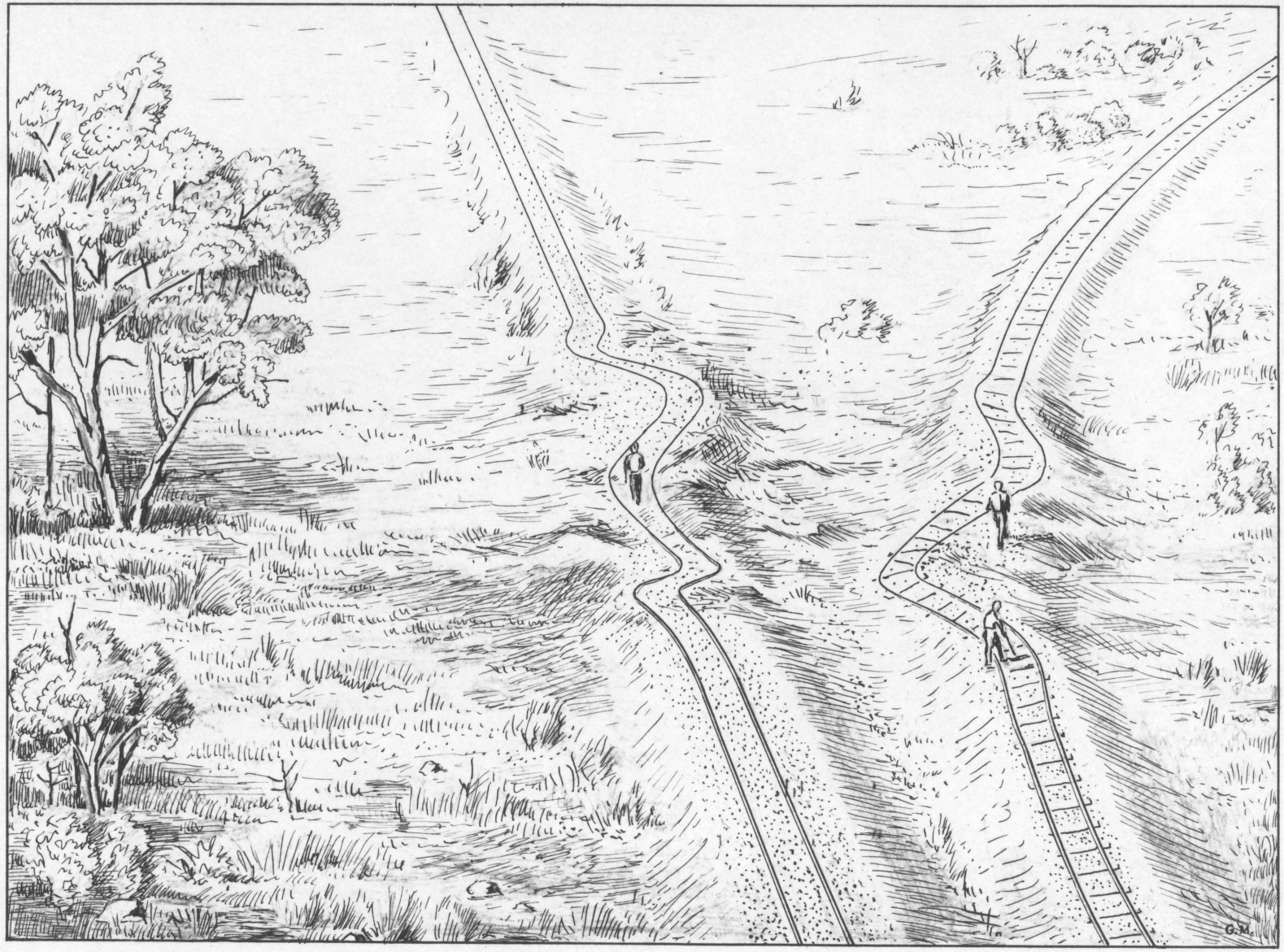
Photograph reproduced by courtesy of West Australian Newspapers Ltd

FRACTURE ZONE: Dowerin road, 1 mile north of Meckering, looking north-east

PLATE 14

To accompany Record No. 1968/142

G82/4-95



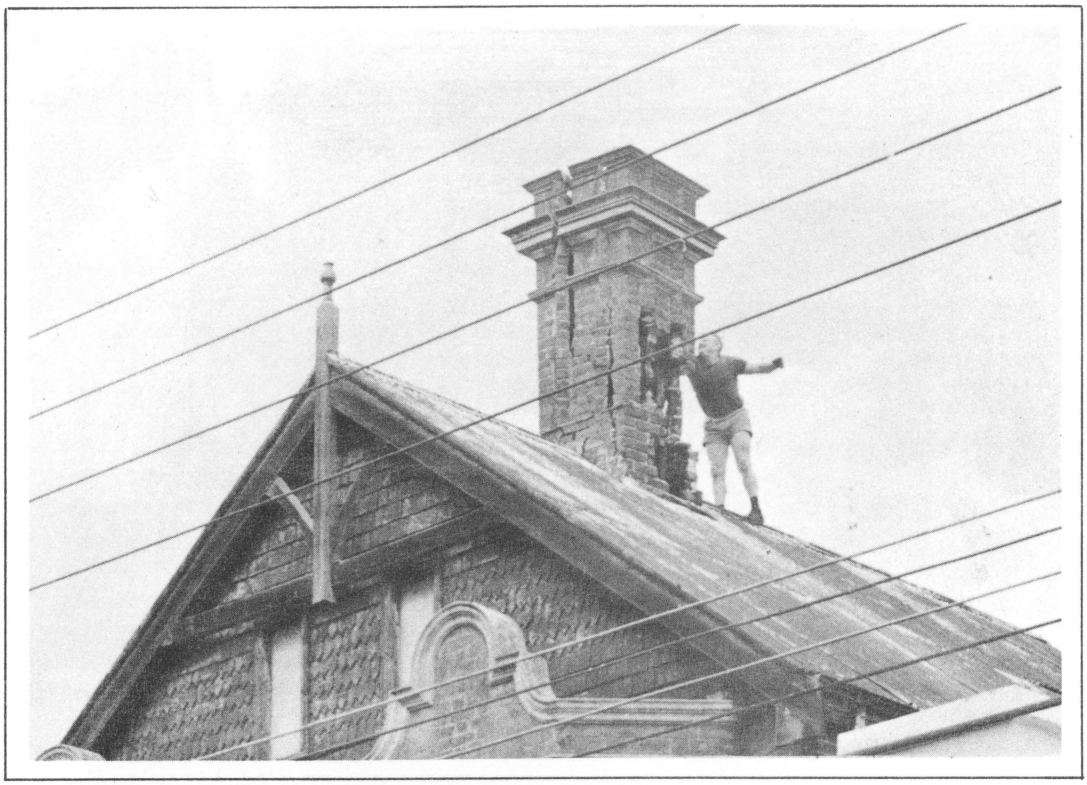
4'8½" railway (left) and 3'6" railway (right), looking east

(Sketched from a television film negative supplied by courtesy of the Australian Broadcasting Commission)

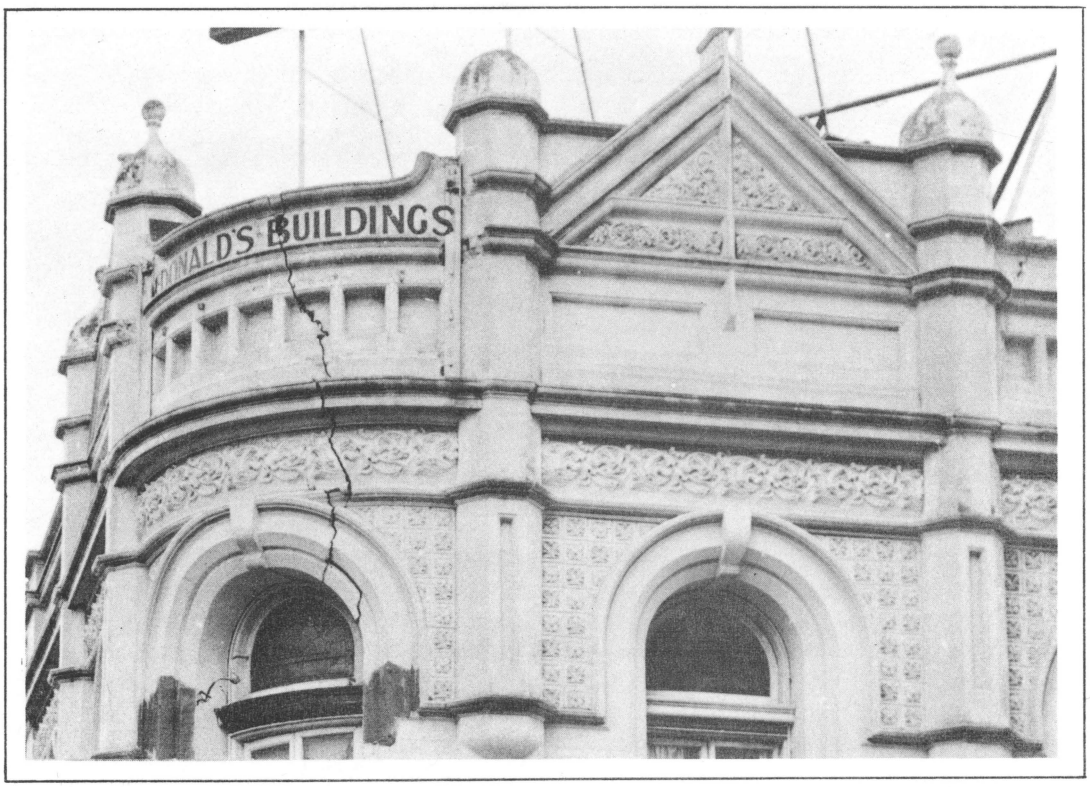
TO ACCOMPANY RECORD No. 1968/142

G82/4–96

PLATE 15

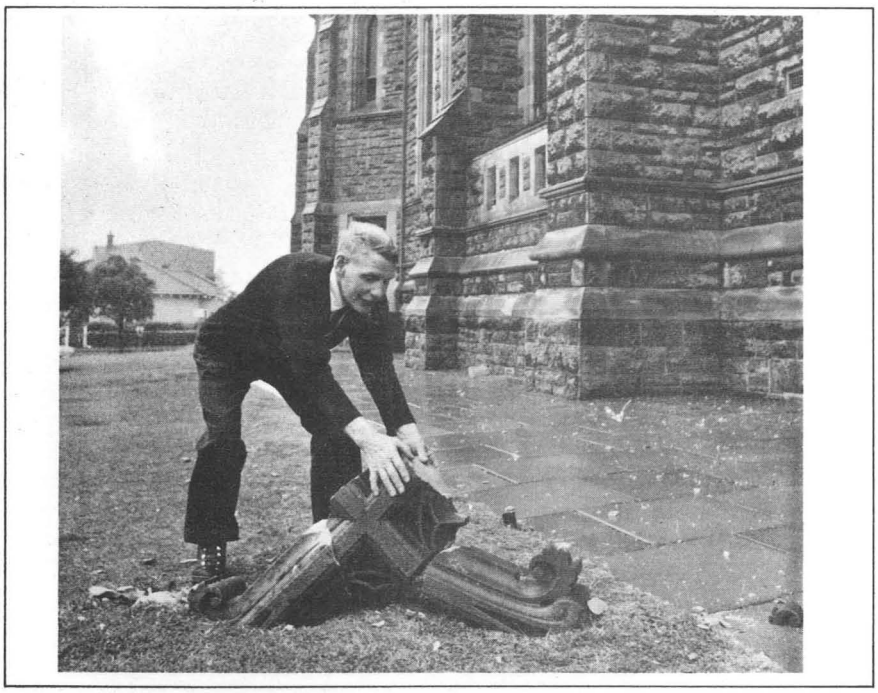


DAMAGE - PERTH Chimney damage



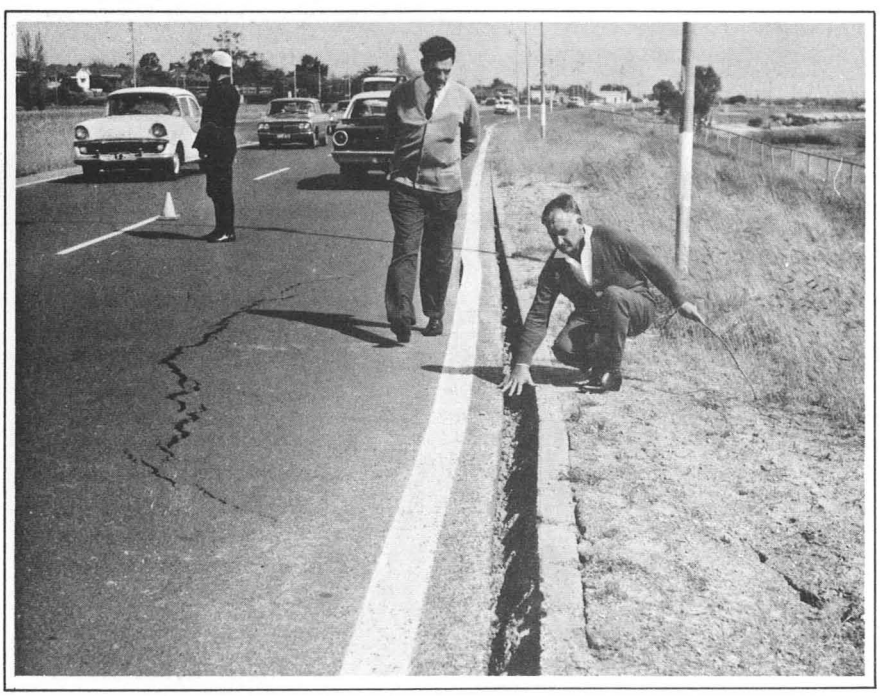
DAMAGE - PERTH Crack in wall

Photographs by courtesy of West Australian Newspapers Ltd



(a) Fallen cross at St Mary's church

DAMAGE - PERTH



(b) Kwinana Freeway - slumping on reclaimed area

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