QUEENSLAND EARTHQUAKES AND THEIR RELATION TO STRUCTURAL FEATURES.

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It may at first sight seem inappropriate that a paper the major interest of which is seismological rather than geological should be included in a volume which is a memorial to the late Professor Sir Edgeworth David ; but David's interests were extremely wide and certainly included the relation of seismic effects to geology, for while it was Woolnough who first suggested that some suitable instrument be installed at the Burrinjuck reservoir to ascertain whether any deflection of the earth's crust would take place as the result of the increased loading as the reservoir filled, it was David, who, after Woolnough was appointed to the Chair of Geology at Perth, suggested to Mr. (later Professor) L. A. Cotton that he undertake the investigation (Cotton, 1915 ; 1921).

A glance at a map showing the recorded epicentres of earthquakes in Australia (Burke–Gaffney, 1951, fig. 1, p. 50) suggests that not only is Queensland much more stable than New South Wales, Victoria, Tasmania and South Australia, but that its freedom from earthquakes is only surpassed by that of the Northern Territory and of Western Australia. Such deductions, however, are not entirely reliable, for prior to 1937 there was not one seismological station in the whole of Queensland's vast area (Bryan, 1938), while the Northern Territory is still lacking in such an installation. And, since highly sensitive instruments were first operated at the University of Queensland Station in 1942, twenty-eight Queensland earthquakes and six aftershocks have been recorded at that station. That one station, especially one situated in the south-east corner of the State, is insufficient adequately to record the seismicity of an area the size of Queensland, is demonstrated by the fact that, since a second station was established at Charters Towers in September, 1957, as part of the Australian International Geophysical Year programme,[1] twelve local shocks have been recorded there in addition to one of those recorded also at Brisbane. Many of these tremors were too slight to be felt (or reported in this sparsely populated State) and there is not the slightest doubt that, were additional stations established, records would be obtained of many more shocks originating within the boundaries of the State.

The earthquakes of April 12th, 1935, (large for Queensland) and recorded in Sydney, Melbourne and Adelaide, and its numerous aftershocks were thoroughly investigated in the field by Bryan and Whitehouse (1938) and all later shocks which were reported felt were investigated by the writer by means of widely distributed questionnaires (based on the Modified Mercalli Intensity Scale). The information available on three earlier earthquakes and deductions from the information collected as above are set out in Table I, while Table II gives the small amount of information available about tremors which have been recorded, but not reported felt ; all these were almost certainly smaller than all of those in Table I except perhaps Nos. 10, 16, 20 and 22.

[1] This station was at the end of the I.G.Y. presented to the University of Queensland by the Australian Academy of Science, and will continue to be operated by the Department of Geology of the University.

TABLE I.

SOME DETAILS OF RECORDED QUEENSLAND EARTHQUAKES.

(Nos. 1–4 were recorded at Riverview; the remainder, except No. 23, at Brisbane.)

Number and Date	Time (G.M.T.) of P at the recording station.	Epicentre		Quality.	Magnitude M. or Intensity.	General Locality and Remarks
		Lat. S.	Long. E.			
	H M S					
1. 1913 May 1st	16–20–17	27	152·5	c	M.4	Kilcoy
2. 1913 Dec. 18th	13–54·0	20	147	b	M.4	40 miles east of Charters Towers. Epicentre determined by Gutenberg.
3. 1918 June 16th	18–14–15	24	154	c	M.6	About 200 M. east of Gladstone. Epicentre determined by Pigot; but its position is doubtful (see Bryan 1946, pp. 49–50).
4. 1935 April 12th	01–32–34	26	151·1	c	M.5	60 m. S.W. of Gayndah. Epicentre by Bryan and Whitehouse. More than eighty aftershocks including strong ones on May 23rd 1935, July 19th 1935 and Oct. 7th 1937.
5. 1947 June 11th	10–03–13	25·5	152·7	c	V	Maryborough
6. 1950 April 5th	19–50–52	21·1	149·2	c	V	Mackay
7. 1950 June 19th	About 09–00	17·5	145·5	d	III	Epicentre probably S.E. of Atherton near the edge of the Tableland.
8. 1951 Dec. 30th	20–34–44	25·8	150·9	c	IV	Mundubbera. Recorded aftershocks at 21.41.08; 21.42.23; 21.44.29 and at 22.40.49 on the same day.
9. 1952 June 24th	01–34–39	25·5	152·8	c	V	Maryborough. Epicentre very close to that of No. 5.
10. 1953 Feb. 6th	17–50–30	near 24·5	150·7	d	II	Monto. Epicentre near Dawes.
11. 1953 Dec. 3rd	15–43–43	24·5	151·5	c	IV	Many Peaks.
12. 1954 May 4th	07·1	17·7	146	d	III	Mourilyan. Surface waves only recorded.
13. 1954 Sept. 19th	10–38–11	28·5	148·5	d	IV	St. George. Felt also in north-central N.S.W.
14. 1954 Sept. 21st	20–29–59	25·5	152	d	III	Biggenden
15. 1955 Feb. 1st	11–09–55	26·2	151·2	c	IV	Murgon.
16. 1955 April 10th	22–36–36	26·7	152·2	d	II	Mt. Stanley near Nanango
17. 1955 Sept. 10th	06–13–31	26	151	d	III	Mundubbera.
18. 1955 Dec. 1st	05–34–37	25·2	151·7	d	III	Mt. Perry.
19. 1956 Jan. 29th	03–49–13					Not reported felt. (1.45 a.m. local time.) $\Delta_{S-P} = 3·7°$.
20. 1956 Nov. 30th	21–51–56	near 27·5	153·7		II	Felt at Pt. Lookout, Stradbroke Island and in Moreton Bay. Epicentre perhaps a few miles east of Pt. Lookout near 27·5S; 153·7E.
22. 1957 April 1st	15–50–39	25·5	150·7	d	II	Mundubbera. $\Delta_{S-P} = 2·6°$.
23. 1957 April 29th	16·5	near No. 18				Mt. Perry. Not recorded.
44. 1958 Dec. 1st	10–38–33	16·5	145·5	c	V	Cairns. Aftershock at about 10.38.30 not recorded; aftershocks recorded at Charters Towers at 18.05.18 on December 1st and at 19.44.13 on January 2nd.

The probable accuracy of the determination of the epicentre is indicated by: a — very good, b — good, c — fair, d — poor.

On the map (Figure 1) all known epicentres and such well established structural features[2] as seem pertinent to the problem under discussion, have been plotted.

A glance at the map shows an obvious fact—all epicentres except two Nos. 3 and 13 are in the region between the Main Divide and the coast, the main area in which highly folded and faulted rocks occur.

The shocks near Maryborough, Nos. 5 and 9, among the largest recorded, lie within the Maryborough Basin, the strata of which were strongly folded in Upper Cretaceous times, and these shocks may well be related to readjustments connected with that folding or faults associated with it. It is in the area to the west of this Basin to as far as 130 miles west of it that the majority of the earthquakes have occurred (Nos. 4, 8, 10, 11, 14, 15, 17–19, 22 and 23) including

TABLE II.

Additional Tremors not Reported Felt and from which the P Phase only was Recorded.

B=Brisbane. C.T.=Charters Towers where regular recording began on September 15th 1957.

Number and Date	Time (G.M.T.) of P	Station and Remarks	Number and Date	Time (G.M.T.) of P	Station and Remarks
	h m s			h m s	
21. 1957 March 3	20–20–15	B	33. 1958 Feb. 20	10–17–13	C.T.
24. 1957 Sept. 10	08–30–16	B	34. 1958 May 31	16–16–22	C.T.
			35. 1958 June 20	06–41–21	B
25. 1957 Oct. 10	22–04–36	C.T.			$\Delta_{S-P}=4\cdot8°$
26. 1957 Nov. 9	21–23–41	C.T.	36. 1958 July 2	00–33–08	B
				00–33–23	C.T.
27. 1957 Nov. 26	05–06–11	C.T.	37. 1958 July 7	17–07–52	C.T.
28. 1957 Nov. 26	23–38–37	B. Probably slightly	38. 1958 July 30	02–12–13	C.T.
			39. 1958 Sept. 8	06–26–26	B
29. 1957 Nov. 26	23–41–28	B. deep	40. 1958 Oct. 4	02–10–54	C.T.
30. 1958 Jan. 18	20–39–21	B	41. 1958 Nov. 5	05–16–33	C.T.
31. 1958 Jan. 18	21–10–47	B	42. 1958 Nov. 11	06–12–54	C.T.
32. 1958 Feb. 20	08–22–44	C.T.	43. 1958 Nov. 30	10–20–33	C.T.

The times of phases set out in the above tables have been taken from the Stations Bulletins prepared by O. A. Jones, O. A. Jones and J. P. Webb or J. P. Webb.

the largest recorded in Queensland, No. 4. These are perhaps related to structures parallel to and associated with the margin of the Maryborough Basin, although the more westerly seem too distant for such a relationship. One of this group, No. 10 near Dawes, is not far west of the north-north-westerly prolongation of a well established fault which brings the Triassic down against the Palæozoic rocks.

One of the largest of the shocks, that near Kilcoy, No. 1, and one of the smallest No. 16, near Mt. Stanley, lie on the east and west side respectively of the rift valley immediately west of the D'Aguilar horst.

In the north of Queensland the typically drowned coast line and many of the features immediately inland suggest extensive recent faulting, most spectacular structures being the Mulgrave Corridor and the scarp of the Atherton Tableland. The structures are illustrated in Figure 2 (after Sussmilch, 1936, section C, fig. 2, p. 111). The positions of the faults are however, not sufficiently well established for them to be plotted on the structural map. The small shocks centred near the eastern edge of the Atherton Tableland (No. 7)

[2] These structural features have been taken from the Structural Map of Queensland, prepared by the Tectonic Map Sub-Committee of the Queensland Division of the Geological Society of Australia.

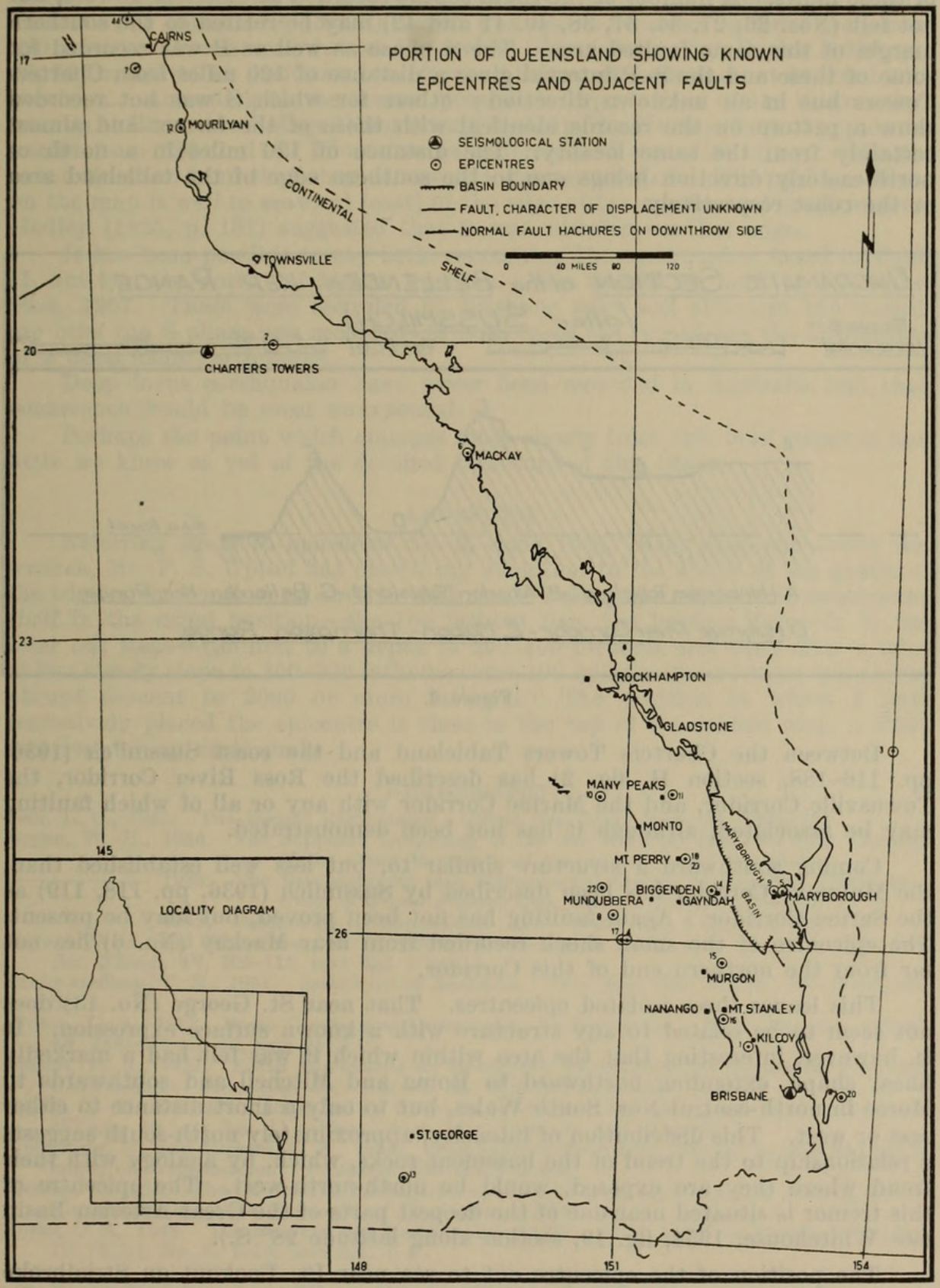
PORTION OF QUEENSLAND SHOWING KNOWN
EPICENTRES AND ADJACENT FAULTS
SEISMOLOGICAL STATION
EPICENTRES
BASIN BOUNDARY
FAULT, CHARACTER OF DISPLACEMENT UNKNOWN
NORMAL FAULT HACHURES ON DOWNTHROW SIDE
0 40 MILES 80 120
CONTINENTAL
SHELF
CAIRNS
MOURILYAN
TOWNSVILLE
CHARTERS TOWERS
MACKAY
ROCKHAMPTON
GLADSTONE
MANY PEAKS
MONTO
MT. PERRY
MUNDUBBERA
BIGGENDEN
GAYNDAH
MARYBOROUGH
MARYBOROUGH BASIN
MURGON
NANANGO
MT. STANLEY
KILCOY
BRISBANE
ST. GEORGE
LOCALITY DIAGRAM
17
20
23
26
145
148
151
154

Figure 1.

and near Mourilyan (No. 12) and the much larger one near Cairns (No. 44) with its three after-shocks may well be related to readjustments on one or the other of these faults. A number of the small shocks recorded at Charters Towers, but not felt (Nos. 26, 27, 34, 37, 38, 40, 41 and 42) may be related to the southern margin of this same faulted area. The S phase as well as P was recorded for some of these and the S–P interval gives a distance of 120 miles from Charters Towers but in an unknown direction; others for which S was not recorded show a pattern on the records identical with those of the former and almost certainly from the same locality. The distance of 120 miles in a north or north-easterly direction brings one to the southern edge of the tableland area or the coast respectively.

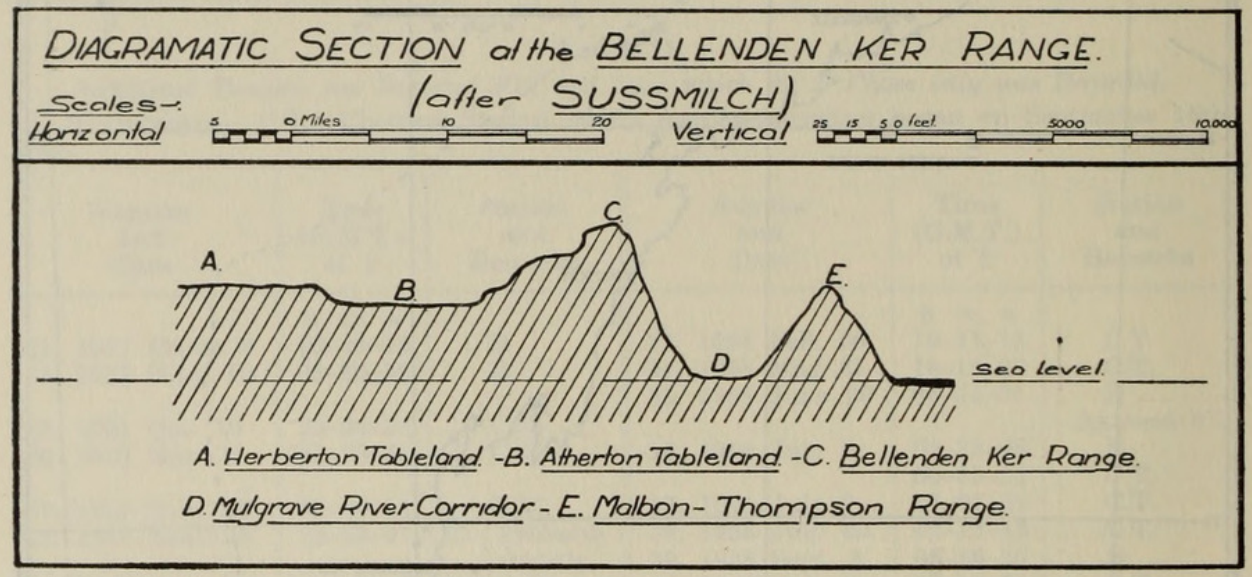

Figure 2.

Between the Charters Towers Tableland and the coast Sussmilch (1936, pp. 116–188, section H, fig. 2) has described the Ross River Corridor, the Townsville Corridor, and the Marine Corridor with any or all of which faulting may be associated, although it has not been demonstrated.

Coming southward a structure similar to, but less well established than, the Mulgrave Corridor has been described by Sussmilch (1936, pp. 118, 119) as the Sarina Corridor. Again faulting has not been proved, but may be present. The epicentre of the small shock recorded from near Mackay (No. 6) lies not far from the northern end of this Corridor.

This leaves three isolated epicentres. That near St. George (No. 13) does not seem to be related to any structure with a known surface expression. It is, however, interesting that the area within which it was felt had a markedly linear shape, extending northward to Roma and Mitchell and southwards to Moree in north-central New South Wales, but to only a short distance to either east or west. This distribution of intensity, approximately north-south suggests a relationship to the trend of the basement rocks, which, by analogy with their trend where they are exposed, would be north-north-west. The epicentre of this tremor is situated near one of the deepest parts of the Great Artesian Basin (see Whitehouse, 1954, fig. 19, section along latitude 28° S.).

The position of the epicentre out to sea near Pt. Lookout on Stradbroke Island (No. 20) is very doubtful; the tremor was felt quite strongly at Pt. Lookout and its effects were noted in Moreton Bay; the position suggested agrees with the distance calculated from the Brisbane seismogram. Could the

shock be related to the Tasmantides (David, 1933, p. 14 and figs. 5, p. 15) or to some fracture in the ocean floor, associated with these astonishing submarine volcanic peaks? There remains Queensland's largest earthquake on record, that of June 16th, 1918, (No. 3), which was felt as far away as Brisbane (about 260 miles). It was recorded at Riverview Observatory, but Bryan (1936, pp. 49, 50) writes " The position of the focus of this earthquake cannot be fixed with precision. According to the several possible interpretations of the seismograph records at Riverview College Observatory, Sydney, the distance from the epicentre varied from 980 to 1180 kilometres (a difference of over 120 miles), while the exact direction from that observatory was also uncertain ". The position shown on the map is well to seaward (east) of the edge of the continental shelf, whereas Hedley (1925, p. 151) suggested that it was situated on that edge.

It has been possible to say little concerning the earthquakes listed in Table II, but two are worthy of further mention—Nos. 28 and 29, both on November 26th, 1957. These were recorded at Brisbane only and although the records are brief (no S phase was recorded) in both cases the record has the appearance of a deep focus earthquake.

Deep focus earthquakes have never been recorded in Australia and their occurrence would be most unexpected.

Perhaps the point which emerges most clearly from this brief paper is how little we know as yet of the detailed structure of this State.

Addendum.

Referring again to epicentre No. 3, June 16th, 1918, since the above was written, Mr. P. S. Upton has drawn my attention to the shape of the profile of the edge of the continental shelf in that area. Taking the edge of the continental shelf in the usual position—the 100 fathom line, the bottom descends in two clear cut steps—the first to a depth of 200–400 fathoms and then after a more or less steady slope to 800–900 fathoms some 100 miles eastward there is a second abrupt descent to 2000 or more fathoms. The position in which I have tentatively placed the epicentre is close to the top of the second step, a likely location for an earthquake.

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