THE GAYNDAH EARTHQUAKE OF 1935.

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(Text figures 1 and 2.)

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1. INTRODUCTION.

QUEENSLAND has been remarkably free from earthquakes, at least from those that can be readily appreciated by the human senses.

Although slight local tremors and occasional rumbles that may represent earth noises have been reported from time to time, only two shocks of notable magnitude have occurred within the last twenty-five years.

The first of these occurred on 7th June, 1918, and has been recorded by Hedley.[1] The second, with which this paper is particularly concerned, took place on 12th April, 1935.

Other than notices in the public Press the only account that has yet been published is a short note by Ball.[2] Bryan[3] has briefly referred to the main features in so far as they affect another problem.

2. TIME OF OCCURRENCE.

The Gayndah earthquake occurred towards noon on 12th April, 1935. The exact time could not be determined from local evidence, for there were no clocks of the required exactitude within the meizoseismal area. Nor were prompt observations made of the times shown by those clocks that were available.

Information obtained by courtesy of the Deputy-Director of Posts and Telegraphs shows that—1. The Post Office clock at Gayndah stopped at 11.35 a.m., and 2. The shock reached the Post Office at Wondai (50 miles south of Gayndah) at 11.35 a.m.

The Port Master at Maryborough (70 miles east of Gayndah) reported the shock as having reached there at 11.34½ a.m., but did not check his time against Eastern Australian Standard.

In the absence of more satisfactory local evidence as to the time of the disturbance, recourse was made at a later stage of the investigation to less direct methods. Thus, the position of the epicentre having been determined by local evidence, the several seismological stations in Australia were notified. With the knowledge which they then had of (*a*) the position of the epicentre, (*b*) the distance of the epicentre from their particular recording station, and (*c*) the precise time of arrival of the preliminary phase of the earthquake at that station, calculations as to the time of the disturbance were possible. Estimates arrived at on this basis are as follows:—Riverview College 11 hours 32 minutes 00 seconds, Sydney 11 hours 34 minutes 45 seconds, Melbourne 11 hours 34 minutes 08 seconds, and Adelaide 11 hours 35 minutes 03 seconds. The reason for the considerable discrepancies shown in these results is

[1] Trans. Roy. Geog. Soc. Qld., Vol. 1, No. 16, 1925, p. 151.
[2] Qld. Govt. Min. Jour., Vol. 36, No 419, 1935, p. 133.
[3] Proc. Gt. Barrier Reef Committee, Vol. IV., Pt. 2, 1936, p. 50.

almost certainly to be found in the difficulty of determining on the records of small earthquakes the precise moment when the first of the preliminary waves arrive, as these are frequently masked by microseisms.

It will be seen that the indirect method of determining the epicentral time was no more successful than that based on direct local evidence. Averaging the results from Sydney, Melbourne, and Adelaide, we get 11 hours 34 minutes 39 seconds Eastern Australian Standard, or 1 hour 34 minutes 39 seconds Greenwich Mean Time. This corresponds reasonably well with the local estimates, but shows a marked discrepancy from the estimate of Riverview College Observatory, which, it must be remembered, is the best equipped station in Australia.

3. SEISMOLOGICAL RECORDS.

Any attempt at an accurate study of the Gayndah earthquake was made impossible by the fact that at the time there was no seismograph in Queensland itself* or in any adjacent regions to the east, north, or west, the five Australian stations then in operation all lying to the south of a line joining Sydney and Perth. Thus, although each of these stations recorded the earthquake, satisfactory intersections of the individual results were not obtained.

The nearest seismographs are situated at Sydney, New South Wales. Of these that at the Sydney Observatory, although it responded to the tremor at 1 hour 37 minutes G.M.T., does not allow of recording of individual phases of disturbances such as that under consideration, the rate of the machine being too slow.

The other Sydney station (at Riverview College) is better equipped, having Wiechert instruments recording all three components, in addition to a Mainka and a Galitzin.

The following records are extracted from the relevant portions of the Riverview College Seismological Bulletin:—

No.	Date.	Phase.	Time. (Greenwich).	Period.	Amplitude.				Remarks.
					An	Ae	Az		
	1935.		h m s		mm	mm	mm	km	
49	12 April	ePZ	01 34 20	1			0·1	1,080	
		eSZ	36 19	2			0·3	(9·7°)	On N–S and E–W Comp. S in minute mark.
		iNEZ	36 42	2	+ 6·5	+ 8·0	+ 0·8		
		iNZ	36 52	2	+ 12·4		+ 2·0		
		mN	36 55	2	12·4				
		iZ	37 04	2			+ 3·6		Felt in Queensland.
		iNE	37 08	2	− 13·2	+ 21·0			
		mZ	37 09	3			5·1		
		iE	37 12	2		+ 18·7			
		LZ	37 33	5					
		iN	37 42	4	− 13·2				
		iME	37 51	4		− 15·3			
		MZ_1	37 52	4			3·5		
		ME_1	37 59	6		21·8			
		iN	38 02	4	+ 26·0				
		MN	38 06	5	19·4				
		ME_2	38 16	5		27·5 +			F 01 55
		MZ_2	38 24	3			4·9		

* Fortunately this serious deficiency has now been rectified through the generosity of a gentleman, who wishes to remain anonymous, who has presented a Milne-Shaw Seismograph to the University of Queensland. This, and a second similar instrument provided by the Council for Scientific and Industrial Research, are housed in the newly-established University of Queensland Seismological Station. See the preceding article in this volume.

The seismograph at Melbourne Observatory (a Milne-Shaw registering the East-West component) recorded the tremor, but the P waves were rather obscure owing to microseisms. The exact time of the emergence of the S waves is also somewhat doubtful, but the L waves are more definitely recorded at 1 hour 39 minutes 41 seconds. At 40 minutes 06 seconds the maximum showed an amplitude of 6·4 mm. and a period of 4 seconds.

At Adelaide Observatory a Milne-Shaw instrument registering the North-South component recorded the arrival of the P waves at 1 hour 38 minutes 59 seconds, the S at 1 hour 41 minutes 04 seconds, and the L at 1 hour 41 minutes 20 seconds, with a maximum disturbance of 1·9 mm. of waves of 7·5 seconds period at 1 hour 42 minutes 40 seconds. The calculated epicentral distance based on these observations was 1240 kilometres.

At Perth is a Milne-Shaw instrument recording the North-South component. The time of arrival of the P and PP waves is somewhat doubtful owing to their traces being mixed with microseisms as large as themselves, but may be 1 hour 38 minutes 07 seconds and 1 hour 39 minutes 25 seconds respectively. The S waves are more confidently placed at 1 hour 43 minutes 55 seconds. The L waves arrived at 1 hour 48 minutes 05 seconds. The epicentral distance based on the times of arrival of S and L was calculated at 2390 miles (3848 kilometres).

The Dominion Observatory at Wellington, New Zealand, reported that no records of the tremor were recorded by any instrument in New Zealand.

The authors are most grateful for this information, which has been supplied by the officers in charge of the respective stations, but these records, although of great interest, could not be used as a basis for exact work, as they are somewhat discordant. Thus it would be impossible to fix the position of the epicentre even approximately from a correlation of the data contained in the several reports.

4. COLLECTION OF EVIDENCE.

The authors early realised the possibility of obtaining some light on the nature and origin of the earthquake if a sufficient number of reliable reports could be gathered from the personal experience of people situated within the area perceptibly affected. In view of this possibility, an immediate appeal for information was made through the Brisbane press and by means of the Australian Broadcasting Stations at Brisbane (4QG) and Rockhampton (4RK).

These appeals brought forth a most gratifying response in the shape of numerous replies. Most of these appeared to be thoroughly reliable, while very few were worthless. Some contained information collected by the sender from a number of different sources, and several were prepared with a scientific precision and exactitude that must have involved a great deal of patient work.

In addition to these replies there were available the numerous messages sent in to the Brisbane newspapers by country correspondents and the more localised details set out in those country newspapers published in the affected area.

In order to fill the numerous gaps in our knowledge that remained after these replies had been received, a questionnaire was drawn up based on the Rossi-Forel Scale and despatched to school masters and others likely to be in a position to help. Nearly all of the forms were completed and returned, thus affording a great deal of additional information. As a result of these various methods reports have been collected from nearly 200 localities.

5. INTERPRETATION OF DATA.

The information thus obtained was summarised and placed on numbered cards on which the names of the localities did not appear. The intensity represented by each summarised account was then assessed independently by each of the authors and the localities *afterwards* ascertained by reference to a key. In this way it was hoped to ensure a more complete detachment in the investigation, and in particular to prevent the overemphasis of geologically "likely" districts.

6. USE OF THE ROSSI-FOREL SCALE.

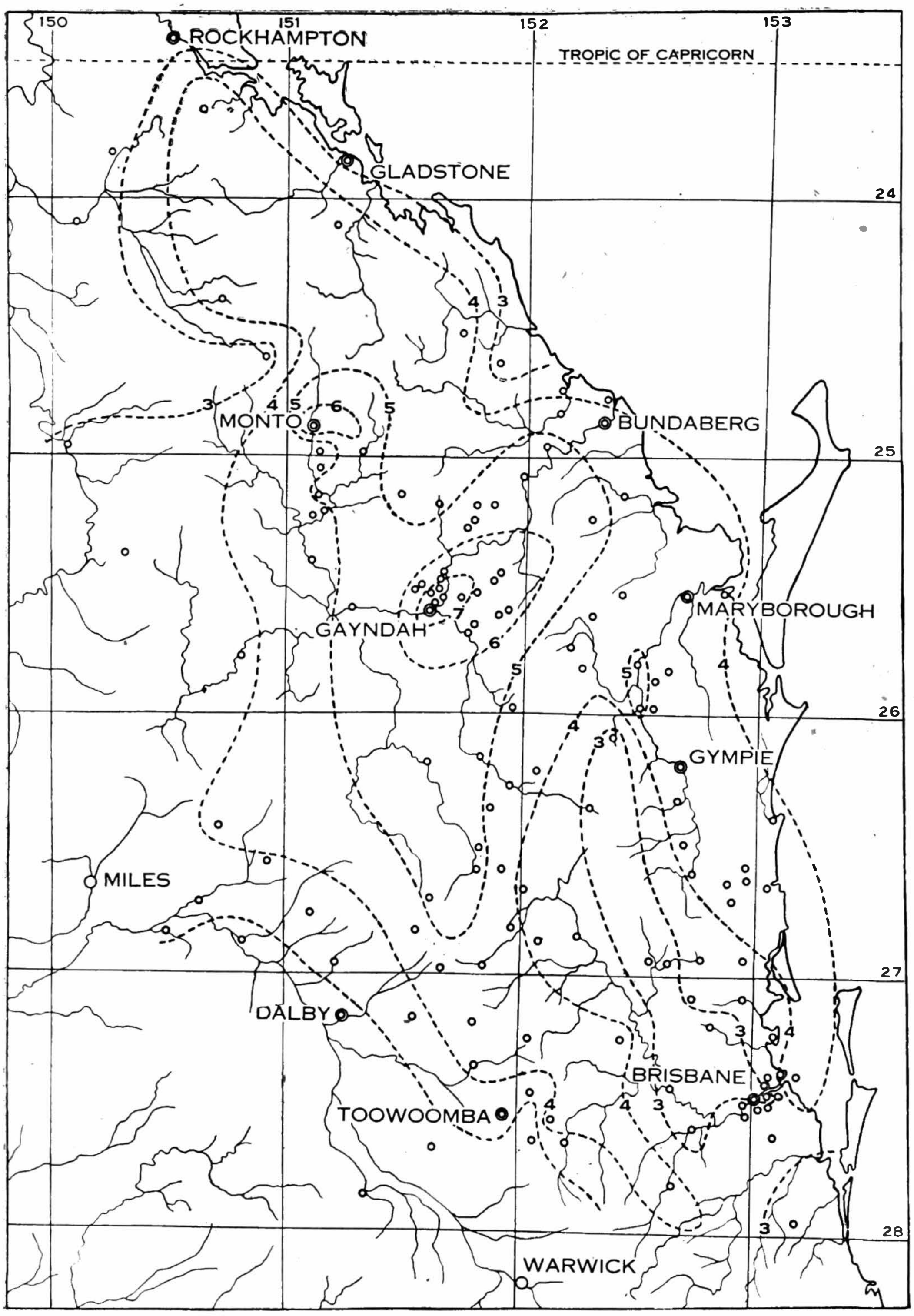
The intensity assessed for each locality was expressed in terms of the Rossi-Forel scale. Although this has long been used internationally and has met with general acceptance, it is not easily applied to conditions in Queensland.* Originally constructed for use in investigating earthquakes in Italy, it is particularly suitable for a country where the people are largely concentrated into towns, where they live in brick and rubble houses that are in many cases not soundly constructed, and where brick chimneys are numerous. Thus intensity No. 8 on the Rossi-Forel scale is based solely on " fall of chimneys, cracks in the walls of buildings." It is obviously impossible to apply these criteria in the smaller country towns of Queensland, where the vast majority of people live in wooden ("frame") houses which have no brick chimneys. Again, intensity No. 7 is based in part on ". . . general panic, without damage to buildings." But is the panic point the same in a Sicilian slum and on an Australian farm? It is doubtful. In view of the relatively scattered population, the absence of brick houses and chimneys, and the somewhat phlegmatic character of the average Australian country man, it may be that the absolute intensities in this paper have been somewhat underestimated in terms of the Rossi-Forel scale. With regard to the estimation of relative intensities the authors feel considerably more confidence.

7. DISTRIBUTION OF APPARENT INTENSITY.

One of the maps accompanying this paper (text figure 1) shows a series of isoseismal lines, each based on the assessed intensity in terms of the R.F. scale. It should be noted that such a map shows the distribution of *apparent intensity,* not of intrinsic intensity, the distribution of which should be far more regularly concentric.

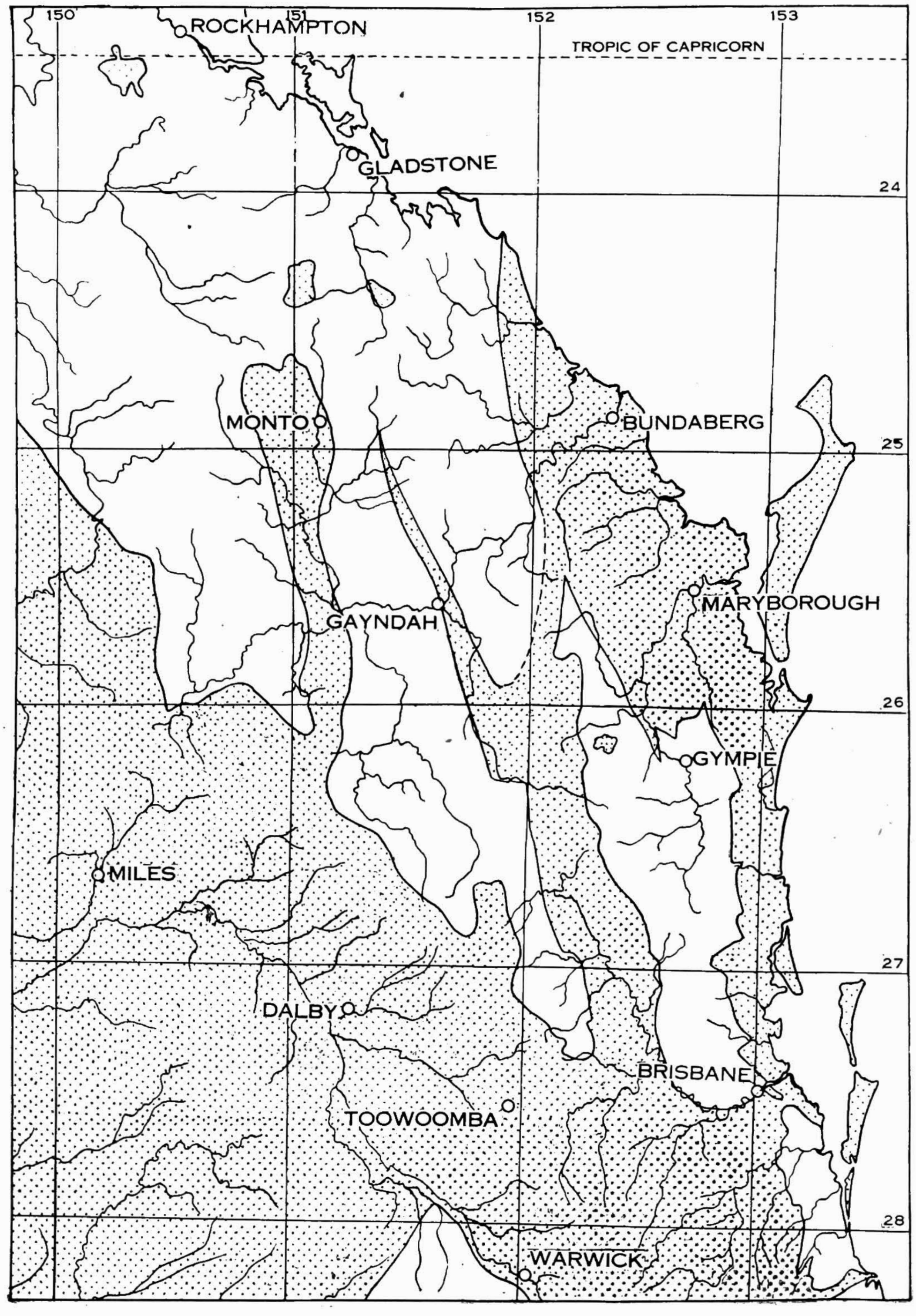
Concerning this question of "apparent" intensity Wood,* who made a detailed study of San Francisco after the earthquake of 1906, writes:— "It is a general fact of observation that strong earthquakes are far more destructive on loose, water-soaked soil, or made ground, than where fresh, crystalline rock outcrops at the surface. This has been observed over and over again. Also, intermediate grades of destructiveness are generally found on ground of intermediate degrees of firmness. . . . It seems obvious that the relationship is one of cause and effect, and the

* An analysis of the records obtained has suggested certain adaptations that may be used for local conditions. Some of these are set out on pages 113 and 114.



Text Fig. 1.

Map of South-Eastern Queensland, showing distribution of Isoseismals. (The small circles represent localities from which detailed reports of the tremor were received.)



Text Fig. 2.

Map of South-Eastern Queensland, showing the distribution of (1) palaeozoic and earlier rocks (plain), and (2) mesozoic and later rocks (stippled areas).

mechanism is considered to be well understood. 'Apparent' seismic intensity, therefore, is in part a function of the geologic materials and structures at or near the surface in the epicentral region. This has long been known. . . ."

In many areas from which numerous reports were received there was a noticeable variation in intensity that quite patently was related to the different geological structures. For instance, in the Brisbane area, nearly 200 miles from the epicentre and towards the limit of the perceptibly affected region, the following examples illustrate this point:—

A. The Pile Light in Moreton Bay near the mouth of the Brisbane River is a structure supported on steel piers. The piers themselves are embedded in blocks of concrete which are not attached to a solid rock foundation but "float" in incoherent sand. Here the earthquake was felt more violently than anywhere else in the Brisbane area. Although the occupants were accustomed to vibrations of the building as a result of the buffetings of heavy seas, nothing like this experience had occurred in many years. Heavy furniture was moved, crockery rattled, water in the rainwater tank slopped over, and a man in bed was almost thrown to the floor. The structure was shaken so severely that an inspection of the foundations by a diver was deemed necessary and was carried out the following day.

B. At Cribb Island (a small settlement built on sand just above tide level on the shores of Moreton Bay) seaside cottages were so violently shaken that some people rushed out into the streets in alarm.

C. In some of the suburbs to the south of the City, which are on fresh water shales and sandstones of Triassic age, the tremor was felt by many people at rest and by some in action.

D. In those parts of the city built on metamorphosed sediments of ?Ordovician age the tremor was noticed only by people at rest in the upper portions of tall buildings, and then not very strongly.

The apparent intensity within the Brisbane area thus varied from at least 5 in the R-F. scale to as low as 2, the variation depending upon the compactness of the underlying rock, which in this case was directly related to the age of the geological formation.

When viewed broadly, there are certain interesting inferences that may be drawn from a study of the distribution of apparent intensities. In south-eastern Queensland the strike of the palæozoic rocks is almost constantly a few degrees west of north. Ten degrees west of north may be taken as perhaps the average. Text figure 2 shows the distribution of palæozoic and mesozoic rocks. If this map is compared with Text figure 1, a map of the isoseismals, the following features will be noted:—

i. Adjacent to the epicentral region the isoseismals are elongated in a north-easterly direction—that is, quite independent of the geological "grain."

ii. In spite of this the isoseismals generally in the province are grouped around areas elongated in the direction of the trend lines of the palæozoic rocks. Two such elongated areas are well shown—a zone of low intensities along an axis N.N.W. from Brisbane, and a N.N.W. zone of relatively high intensities between Toowoomba and Rockhampton.

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*"Physics of the Earth—VI. Seismology," Nat. Res. Council, U.S.A., Bull. 90, 1933, Chapter VII., p. 67.

iii. In the south-west of the province, where the greatest development of the mesozoic sediments occur and where the palæozoic rocks are completely covered, the isoseismals seem to lose this N.N.W. relationship and are developed parallel to the palæozoic-mesozoic junction.

It would appear, therefore, that in the major portion of the province, where both palæozoic and mesozoic rocks occur, the trend of the palæozoic series has been the dominant control in the alignment of the isoseismals. In this portion of the region the apparent intensities do not diminish concentrically from the epicentre, but have maxima and minima along certain belts of these older rocks. In contrast to this, in the south-western part of the area, where the palæozoic rocks are completely buried, the intensities seem to diminish in a normal way.

8. POSITION OF EPICENTRE.

The exact positon of the epicentre has not been found, but the evidence points to its being approximately 10 miles north-east of the town of Gayndah at about 25° 30′ S., 151° 40′ E. The area within the innermost isoseismal is somewhat elongate and encloses a number of places where the apparent intensity reached R.F. 7, and it is possible that higher unrecorded intensities may have occurred within this sparsely settled area. This zone of greatest intensity is elongate in a direction E.N.E.-W.S.W. In addition to the main epicentral area near Gayndah there is another smaller area of equal or almost equal intensity at Monto, some 60 miles to the north-west. Somewhat surprisingly the intensity in this latter area seems disconnected from that of the Gayndah area, for, although it has been difficult to obtain information on account of the thinly populated nature of the intervening country, such records as have been obtained all tend to separate the two. The simplest explanation is that the Monto tremor was a subsidiary sympathetic disturbance practically synchronous with the Gayndah shock.

No reliable quantitative estimate can be made on the data available as to the depth of the movement that produced the earthquake, but the fact that the disturbance was clearly recorded at Perth (some 2,220 miles away), and yet unrecorded at Wellington (less distant by 400 miles), suggests a comparatively shallow origin, the Thomson Deep apparently acting as an effective barrier to the propagation of the earthwaves in a south-westerly direction.

9. SELECTED REPORTS.

There was a wealth of pertinent detail in the 200 reports that the authors received.

A survey of these has brought to light certain features that may be useful in future in adapting the Rossi-Forel scale to local conditions. In order to appreciate these it should be noted that in Queensland the usual type of residence is a wooden "frame" house set high on wooden stumps. Water tanks are corrugated, galvanised iron cylinders placed unanchored on wooden platforms supported by wooden blocks. These tanks hold, as the usual maximum, 1,000 gallons of water. The usual type of cooking stove is an iron structure, about 3 feet by 2 feet by 2 feet, supported on small legs.

In areas of intensity 3, of the Rossi Forel Scale, residents reported that the effect was similar to that of a horse rubbing itself upon one of the house stumps. This statement was made so frequently and by so many independent observers that it is worthy of record for future correlation. When the intensity was R.F. 4 water became agitated in the tanks. In the zones of intensity 6 and 7 tanks developed cracks, and leaks were set up in the seams. Two observers in the meizoseismal area (intensity 7) have noted that their tanks of water moved on the platforms. Stoves were shifted in several houses where the intensity was at least 6.

Three reports from residents within the meizoseismal area may be quoted—

(1) Mr. R. T. Netterfield, living some 7 miles north-west of Wetheron, reported that "about 11.30 a.m. and without warning the first and main 'quake of two connected spasms occurred, accompanied by a heavy 'booming' detonation comparable only to a deep-seated heavy charge of explosive, and too continuous to be placed to any particular point of the compass. The rapid horizontal play (fully a foot) of the ground and surface being on a line south-west to north-east. . . . Green foliage 'tangled' but did not sway. Dead, pliant limbs 'clacked' together like sawn pine on a moving waggon and fell in showers. Cow-dung and light sticks hopped back and forth off the ground, while queer little jets of dust spurted from around tree butts. As nearly as could be judged 8 seconds would be about the duration of this shock. . . . Despite eighteen anchor-bolts my 28 by 36 pine and weather-board house moved an inch on some of its unanchored blocks. All tanks were somewhat damaged. A 5-foot cast-iron separator drew its three large anchoring coach screws. All yard and shed posts were joggled loose, and the rubble in the stock yards shook down level and smooth. . . . Crockery from northern and eastern shelves suffered severely."

(2) "Mount Lawless is a rocky region, and cliffs rise abruptly from the river bed to the height of some 70 feet. Small rocks and stones fell from these cliffs. I noticed that one gum tree of a diameter about 8 inches had fallen from the cliff side. Houses at the foot of Mount Lawless were shifted 1 inch on their blocks, and a stove was moved 1 or 2 inches. Fishermen [in the river] under the cliffs declare that the water rose between 1 and 2 feet. Numerous tanks started leaking. One tank shifted about 9 inches, blocks and all. Trucks on the railway line swayed. Books fell from shelves in the houses, many clocks stopped, and small cracks developed in two cement buildings." (Mr. F. T. Borchardt, Ideraway.)

(3) "At the Bymingo School books and other articles fell from the shelves. Unsound timber fell from a shed. . . . Beams spanning the roof showed that the walls had been displaced for $\frac{1}{8}$ to $\frac{1}{4}$ inch. Marks on stumps after the shock showed that the school had been raised about $\frac{1}{2}$ inch. . . . Several cement floors [in neighbouring buildings] were cracked, and a tank burst. Clocks stopped. . . . Two terrific explosions were followed by the loose earth, twigs, leaves, &c., being raised from 10 inches to 1 foot above the ground. Dead limbs fell from the trees, and buildings shook violently." (Miss M. Pittman, Bymingo.)

The most impressive evidence seen by the authors of the paper on their visit to the area was on the south-western slopes of Mount Lawless, where great masses of trachyte many tons in weight had fallen from the mountain sides. From the trachyte cliffs of the Burnett River near Mr. Netterfield's residence other large blocks had been dislodged. They were informed that these falls took place during the tremor of 12th April.

It may be of value to note some of the effects in localities a little further removed from the epicentre. The head teacher of the Abbeywood school (where the intensity was interpreted as 6) reported that "pictures were shaken from the rail that supported them, and the school clock was moved fully an inch from its centre level mark, but did not stop. Children reported seeing the tree guards in motion. . . . It is reported by others that the ground was seen to move in three small waves. . . . Workers picking corn a short distance from the school reported feeling sick after the shock."

Mr. C. Realf, of Childers (in an area of intensity 6) stated that—"My garage is 60 feet long, with the apex of the roof about 26 feet high running almost north and south. I observed a very pronounced sway of the whole roof from east to west. The movement was enough to cause me to bolt for the open air, and I can state that almost every person in the district left his house. A large quantity of moveable objects leaning against the inside walls of the workshop were overthrown; and from the movement of a 12-foot piece of 2-inch-by-1-inch pine leaning against a beam I estimated the sway to be at least 1 foot. . . . It was comparable to the effect of earth movement caused by heavy shell fire falling too close for comfort."

A report from Yenda, typical of many in isoseismal region 6, stated among other evidence that cattle and horses ran startled in mobs.* A stove shifted an inch out of place. Dead limbs fell from trees, and plaster fell from roofs, and several tanks leaked.

An observer at Goomeri (intensity 5) noted in his report that "motorists while travelling felt the shock by the rear of their cars leaving the ground similar to bumping over some solid object."

From Aramara (intensity 4) Miss M. Bange wrote that—"People in the open, working in the garden or drilling in the school ground, did not notice the shock; but men working with heavy logs on railway trucks and with timber in the scrub felt it. Butchers' hooks danced on the rod. Water in barrels was agitated, and continued so for a few minutes afterwards. Some commodities fell from the shelves in the general store, and doors and windows rattled."

Such are a few reports typical of those from various isoseismal zones.

10. AFTERSHOCKS AND SYMPATHETIC DISTURBANCES.

Although this account is concerned primarily with the earthquake of 12th April, 1935, it would be incomplete without some reference to the long train of less intense disturbances which followed. Some of these may be regarded as aftershocks in the strictest sense, and all may be assumed to be more or less directly related to the main shock, although some occurred as long as eight months after the initiation of seismic activity and others were well outside the original meizoseismal region.

The seismic history for the Gayndah area for 1935 may be set out as follows:—

1. The shock of 12th April came without any warning fore-shocks, but was followed by—
2. A large number of after-shocks, each with its accompanying detonation. These occurred intermittently but with declining frequency until 4th May. Then after an interval of eleven days came—

* Several observers noted that cattle and horses were not disturbed by the earth sound, but became very nervous during the period of the tremor.

3. A series of earth tremors occurring intermittently until 23rd May. About a week later there was felt—
4. The relatively strong disturbance of 1st June. The following short account of the tremor is taken from the "Maryborough Chronicle" of 3rd June, 1935:—

   "Between 10.15 and 10.30 on Saturday night Gayndah experienced an earth tremor almost as severe in intensity as that which occurred on 12th April. On this occasion many residents had retired to bed, and received a rude awakening. The shock set houses swaying. Crockery rattled on shelves, and doors swung. No reports of damage were received, but the shock caused alarm to many. . . . Fortunately the shock only lasted a few seconds at the most. . . . Several outlying centres experienced the tremor. Reid's Creek and Ideraway, 10 and 5 miles away from Gayndah respectively, noticed the shock, and Coalstoun Lakes also reported having felt the tremor."

   This shock was not recorded at Riverview College Observatory, nor was it followed by any pronounced system of aftershocks. The fact that it occurred at night may have caused some exaggeration of its intensity.
5. Occasional tremors were recorded during the next five weeks, but became more frequent from 8th July. These ushered in—
6. The relatively strong shock of 19th July, which the "Maryborough Colonist" described as follows:—

   "The Burnett district experienced an earthtremor about 5.30 this morning. The shock in parts was as severe as the tremor of April last. At Mundubbera houses shook violently and tanks on high stands swayed."

   This was not recorded at Riverview College.
7. Further tremors were reported from time to time until 14th December, 1935.*

Consideration of the reports on which these items are based shows that the seismic disturbances of 1935 continued intermittently for eight months† and covered a considerable area, of which the region to the east of Gayndah appears to have been the most sensitive locality and to have been most consistently affected. In the important initial shock Monto appears to have been a subsidiary centre, but at a later date Mundubbera was strongly affected.

11. GEOLOGICAL SIGNIFICANCE.

As geologists the authors were naturally interested in the possible geological significance of the Gayndah earthquake from the announcement of the first sharp shock, and this interest grew with the growth of the long train of aftershocks and sympathetic disturbances reported from the region.

Two questions appeared to be worth investigation. The first concerned the possibility of detecting some unstable geological structure in or adjacent to the epicentre of the initial shock. Was the Gayndah

* As recently as 7th October, 1937, another severe tremor was felt in the area.

† Detailed records during the period from 12th April to 22nd July were kept by Miss M. Pittman, of the Bymingo State School. Seventy-three tremors of varying intensity were felt during this period.

earthquake caused, for example, by a renewal of movement along an old fault plane? The second question was of a more general nature, and was concerned with the reason for the prolonged seismic activity of the year 1935, and the virtual restriction of this activity to the Burnett region. Why should the valley of the Burnett be more susceptible to earthquakes than other parts of the State?

The first attempt to answer these questions was based on an examination of such geological accounts and maps of the area as were in existence. These were not sufficiently detailed to warrant confident conclusions. They were, however, very suggestive. Thus the epicentral area seemed to lie quite close to a major structural line, namely, that separating a great palæozoic terrain to the east, and a narrow strip of mesozoic rocks to the west. Moreover, this junction marked the northern extension of a tectonic feature of the first importance, which was best known in the heavily faulted strip of country between Ipswich and Northbrook. This great system of faults had first been recognised by Cameron.* Its importance and significance was later emphasized by Reid† when he wrote: "In Southern Queensland there appears to be a sharp boundary to the coastal folding of Tertiary age. This boundary takes approximately a regular N.N.W.-S.S.E. line, and passes from Gayndah, through Ipswich, to Beaudesert. Faulting and intense folding mark this line, and west of it the Mesozoic strata are scarcely disturbed; to the east they are, in some cases, only slightly disturbed, but are frequently heavily folded."

At about the same time Bryan,‡ independently, and as the result of a different line of approach, arrived at a similar conclusion with regard to the significance of the Ipswich-Gayndah line, which he regarded as the most important of the four great "anticlinal axes" of Southern Queensland. Bryan tentatively extended this tectonic feature to the north-north-west of Gayndah, and Reid§ subsequently established the presence of heavy faulting near Monto on the line as thus extended. Writing of this he states: "Just to the east of the [Mulgeldie] coal basin lies the junction of Lower Carboniferous and Lower Mesozoic rocks. This junction is marked by great disturbance in both series on the Monto road. . . . This fault line is one of major structural importance, whereby the coalfield was dropped down and overthrust from the east by Lower Carboniferous rocks. This fault line bears approximately 35° west as plotted over a few miles to the north-east of Monto."

A few miles south of this fault but not in alignment with it (being somewhat further west) Reid describes another important structure as "a fault and crush line which has been mapped in detail from Abercorn to the south-west corner of the coalfield, a distance of eight miles. . . This fault line is apparently not one of very great displacement, but consists of a linear strip perhaps only 10 to 20 chains wide, in which the strata are broken and crushed into postures approaching the vertical, while on either side the rocks are only very gently folded." The inset map accompanying Reid's report shows springs emerging from two points on this second fault line. One of these, called "Soda Springs," is

* Qld. Geol. Sur. Pub. No. 147, p. 2.

† Aust. Assoc. for Adv. of Sci., Vol. 17, 1924, p. 310.

‡ Proc. Roy. Soc. Qld., Vol. 37, p. 35, 1925.

§ Qld. Govt. Min. Jrnl., Vol. 28, p. 185, 1927.

shown where the railway line to Monto crosses the fault line just to the north of Abercorn. (It was at this point that a crack 120 feet long running in the direction of the fault and an accompanying subsidence of 12 inches were discovered on the permanent way by the railway authorities on the day following the earthquake.)

With regard to the Burnett region in general the only significant geological fact that might be related to its seismic sensitivity was that it contained the most striking evidence of recent volcanic action to be found in the southern half of Queensland. In particular the extinct volcano Mount Le Brun,* with its twin crater lakes (The Coalstoun Lakes), might possibly be regarded as a related phenomenon.

The facts enumerated above were all of them suggestive and warranted a closer examination of the geology of the area. Consequently at the first opportunity, which occurred during the University vacation in August, 1935, the authors made a hurried visit to the area accompanied by Dr. D. A. Herbert.

The results of this excursion were most satisfactory, in as far as they provided a clear picture of the geological structure of the critical area, but were disappointing in that they did not reveal any evidence as to the immediate cause of the earthquake.

The authors were not so sanguine as to expect to find newly formed scarps or any other marked disturbance of the surface—the earthquake was not nearly so intense as to warrant such an expectation—but they did hope to find other geological evidence that would enable them to locate the epicentre more definitely and that might throw some light on the origin of the shock.

It is true that the anticipation that the epicentre would be found to be near the junction of the Palæozoic and Mesozoic terrains was justified by an examination in the field, but it is equally true that (1) No part of the meizoseismal area was actually on this junction, (2) The long axis of the meizoseismal area was discordant both with the direction of the junction as locally developed and with the general trend of the Ipswich-Gayndah line, (3) The junction is locally sealed by the presence of a large granitic intrusion.

The only suggestive geological relationship was one that was not anticipated. It concerns the rough coincidence in both size and direction of a large mass of biotite trachyte with the epicentral area as finally determined. The outcrop of the trachyte extended for 7 miles in an E.N.E. direction.

This mass is particularly well developed at its south-western extremity, where it forms the prominent feature known as Mount Lawless. There it is seen to be intrusive into conglomerates of the Upper Esk (Triassic) Series. Another notable exposure is on the banks of the Burnett River where this passes Mr. Netterfield's property.

It is probably very significant that it was at these points that those heavy rock falls occurred that have been noted in an earlier section.

While in the Burnett area the authors took the opportunity of investigating the evidence of recent volcanic activity.† The perfect and, as yet, unmodified form of the cone and craters of Mount Le Brun, and the large quantities of relatively unweathered slaggy material still

* First described and named by N. W. Broun. See Proc. Roy. Soc. Qld., Vol. X., p. 44, 1894 and Vol. XI., p. 88, 1895.

† See Proc. Roy. Soc. Qld., Vol. 47, p. xv., 1935.

lying upon the surface, together with the clear evidence that basaltic lava streams have flowed down the present valleys of the Burnett River, Barambah Creek, and several tributary streams, all clearly demonstrate that important volcanic eruptions have occurred within the present cycle of denudation, and at no distant date.

These facts at first appear to be full of significance when it is borne in mind that the Burnett area is one relatively sensitive to seismic activity—at least as compared with the rest of Queensland—but a more detailed examination of the position in the field showed that Mt. Le Brun, which must be regarded as the focal point of the recent volcanic activity, is situated well outside the meizoseismal area.

There is certainly no direct evidence for regarding the Gayndah disturbance as a volcanic earthquake. But it is equally certain from the shallow depth of the focus that it cannot be considered as a plutonic earthquake. There is then no alternative but to place it in the only remaining category and class it as a tectonic earthquake, in spite of the fact that no close correlation with earlier tectonic phenomena has been established in the field.

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