

Historical earthquakes in Tasmania

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Abstract Several hundred earthquakes felt in Australia have been documented in three volumes of the *Isoseismal Atlas of Australia* but sources have not yet been exhausted as we demonstrate with new information on some interesting earthquakes in Tasmania. This new information has come about thanks to a courageous initiative of the Australian National Library, making scanned, searchable newspapers publicly available on the internet. The interpretation of this new data is important for better hazard assessments as it reduces the uncertainty of early earthquake locations and extends the earthquake database backwards, to better define source zones and lower the magnitude threshold of completeness intervals. The earthquakes investigated here occurred between 1910 and 1932, well before the first seismograph commenced operation in Tasmania in 1958. This is the first of a series of reports on historical earthquakes in the Australian states.

TASMANIA

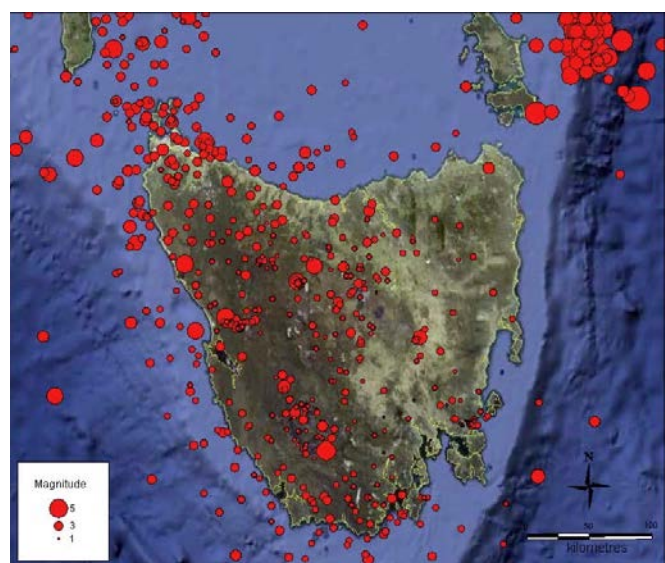
The series of state reports starts in Tasmania in recognition of the high level of seismicity observed in the 19th century as documented by Ripper (1963), and later Michael-Leiba (1989), in contrast with its apparent quiescence today. There is also a marked apparent change in earthquake locations, 18th century events clustered off northeastern Tasmania, whereas more recent events are located in Western Tasmania as shown on the epicentre map below. The two known geologically recent prehistoric fault scarps are both in the southwest of the state near Lake Pedder, evidence of major earthquakes in the not-so-distant past.

The most destructive earthquake in Tasmania since European settlement and the most destructive in Australia between the 1903 Warrnambool and 1954 Adelaide earthquakes, seems to have been overlooked with time. A contemporary newspaper commented that it was lucky no one was killed, with the collapse of the top of a brick chimney at the old Launceston hospital puncturing the roof above an operating theatre, another chimney ruined at a private home, and a large stone ornament dislodged into the street from the spire of St Andrews Church. New isoseismal maps have been prepared for this destructive earthquake and other earthquakes of interest that were found during the study of this event.

Introduction

The seismicity of Tasmania has been well studied. Ripper (1963) detailed the extraordinary swarm of strong earthquakes at the end of the 19th century, more than 2500 of them felt, the largest of which caused minor damage in Launceston and was felt as far as Kiandra NSW, south of Sydney, about 800km away.

Figure 1 Seismicity of Tasmania, 1880 – 2010 (Payne & others, 2010). The 19th century earthquakes are off the NE coast, the smaller post-1958 earthquakes are mostly in the western half of the island.



Hogben (1912) mapped an earthquake off the northwest coast of Tasmania on 13 January 1910 which should have been felt throughout Tasmania and in Victoria so McCue (2001), using data from New Zealand and Riverview, re-located it. The revised epicenter was off the northeast coast at 44°S, 155°E and its magnitude was 6.0 from the Riverview amplitude and distance. Needless to say it wasn't reported felt in Tasmania or Victoria.

Underwood (1973) produced the first hazard map of Tasmania which was modified for the building code by McEwin & others (1976). New versions were published by McCue (1978) and Michael-Leiba & Gaull (1989). Michael-Leiba (1989) drew isoseismal maps for many of the larger earthquakes enabling her to assess their magnitude.

Isoseismal maps for Australian earthquakes are compiled in three atlases by Everingham & others (1982), Rynn & others (1987) and McCue (1996). Included in these volumes are isoseismal maps of 4, 0 and 15 Tasmanian earthquakes respectively.

Shirley (1980) and Richardson (1989) wrote relatively recently about the seismicity of Tasmania and a review was compiled by Gibson & others (2000).

Most of the post-1960 onshore foci are in the ancient Pre-Cambrian rocks of western Tasmania while the dramatic sequence of late 19th century events are northeast of the state. Perhaps the older crust is more highly fractured than the Paleozoic crust of eastern Tasmania, the two geological provinces separated by the Tamar Fracture System.

Carey and Newstead (1960) discovered a fault scarp on the shore of Lake Pedder formed by a series of large earthquakes in SW Tasmania in prehistoric times. The historical and instrumental records are very short so van Dissen & others (1997) mapped the fault scarps and assessed the magnitude of the causative earthquake(s) at about 7. Dating of the sequence has since been determined by Clark & others (2011).

Whilst these large early earthquakes have been widely noted, the hazard map of Tasmania (AS1170.4 - 2007) suggests the state is relatively quiet compared with Victoria, South Australia or New South Wales because earthquake damage was minimal in Tasmania in these large historical earthquakes. Buildings in the eastern part of the state were seen to be much less at risk than those in the western half.

This author was most surprised then to come across an earthquake there in 1929 that caused similar damage to those later earthquakes in Adelaide and Newcastle that put the latter cities on the engineers' radar and into the hazard map.

The recent on-line publishing of their scanned collection of some early Australian newspapers by the Australian National Library, made this discovery possible. The TROVE site allows users to correct the OCR of the scanned images which makes the collection even more valuable as this corrected text can be searched online by all. Examples of corrected text and scanned newspapers are documented below.

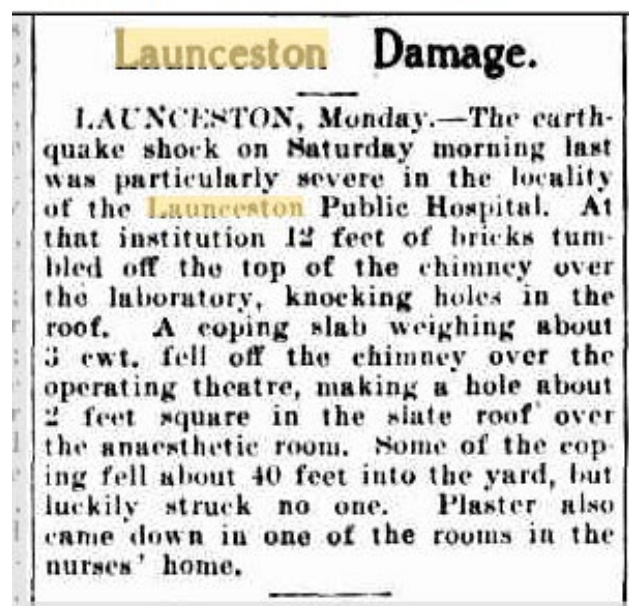
December 28, 1929

Damage, felt reports and isoseismal map

Figure 2 Extract from the Burnie Advocate of Tuesday 31 December 1929.

Various newspapers reported the 1929 earthquake and the story titled *Launceston*

Advocate (Burnie, Tas. : 1890 - 1954) (about) ◀ Tuesd



Damage in the north coast-based Burnie Advocate is shown in Figure 2.

Significant damage was done, luckily no one was killed or injured. The earthquake was felt in the State capital: the Hobart Mercury of Monday 30 December 1929 page 5 reports the following story: *Shortly before half-past eleven on Saturday morning a very noticeable earth tremor was experienced in Hobart and its surroundings. The pronounced vibration was felt in all parts of "The Mercury" building, the rattling of windows accompanying the earth movement.*

In city offices and establishments generally the same disturbance was noted. In domestic residences bells rang of their own accord, crockery danced, and clotheslines heaved. No actual damage to property is reported.

The disturbance registered itself at the Hobart observatory at Anglesea Barracks by a sudden violent movement on the part of the sensitive instrument (Ed. a barometer), indicating that it was centred in a distant earthquake of more than ordinary severity.

The earth tremor was felt very clearly throughout the Huon about 11.25 on Saturday morning. Windows rattled, and crockery and pictures shook perceptibly. It was very noticeable at Cygnet among the yachts at anchor in the bay, the boats tossing about as if in the wash of a large steamer (Ed. this seems to be a description of a seiche in the bay).

Figure 3 Burnie Advocate, Tuesday 31 December 1929. The earthquake was strongly felt on board the collier Kiwitea (approximate position at the time is where the ship icon is plotted on the isoseismal map (Figure 4), southeast of Cape Barren Island).

A number of chimneys partially collapsed or cracked, the most severe being in a private house in Paterson Street, and the old Launceston Public Hospital, where a kitchen chimney gave way. At St. Andrew's Church, Paterson Street, a stone ornament at the top of the spire was dislodged, and fell into the street.

Lighthouse reports

A search was undertaken to locate Tasmanian and Victorian lighthouse records in Australian Archives, Canberra. Lighthouse keepers kept meticulous logbooks of meteorological and other observations such as earthquakes but the logbooks are kept in the States. The author arranged to visit the Melbourne Office of Australian Archives and found no mention in the logbooks of the four nearest Victorian lighthouses, the closest on Wilson's Promontory (shown as '0' on the map, figure 4). Ian Ripper examined the Tasmanian lighthouse keepers' records at the archives office in Hobart during his visit there in early 2012 and was well rewarded with four keepers noting the shaking.

From these and many other reports in Tasmanian newspapers an isoseismal map was constructed (Figure 4). No photos of the damage were discovered which is disappointing. There are a number of intensity reports that seem to be inconsistent with the contoured rating but such outliers are often observed and may reflect shallow geological features, like the sediment-filled Tamar Graben under Launceston, which are known to amplify shaking at some frequencies. Alternatively, such outliers may simply reflect a lack of factual reporting.

The high intensities on Flinders Island are surprising, probably the reason for the Geoscience Australia (GA) epicentre being where it is. One could play a bit with the contours but that would



not change the interpretation that this was a moderate shallow earthquake under northeastern Tasmania rather than an offshore earthquake like the large ones in the 1880s and 1890s (Ripper, 1963; Michael-Leiba, 1989).

The report about the shock being felt at sea on board the *Kiwitea* is interesting but doesn't exclude either epicentre. Another observation, by Mr E. J. Gillian from Devonport, that there were two shocks with an interval of only a few seconds in between would support an epicentre within 20 to 40 km or so, if what he felt were the separate P and S waves.

Earthquake location and magnitude

A search of the GA database restricted to Tasmania in 1929 returned zero events but changing the selection criteria to Australia gave the top row in the following table. The bottom line is the epicentre shown on the isoseismal map at the centre of the high intensity contour (Figure 4).

There were few regional seismograph stations operating in 1929; Melbourne, Riverview, Adelaide, Perth and Christchurch and of these only Riverview was equipped to record local earthquakes. The uncertainty in the GA database location by Everingham, Denham and Greenhalgh (EDG 1987) is much larger than the 2nd decimal place of the reported epicentre would indicate, perhaps $\pm 1.0^\circ$ at best. The GA database epicentre is 200km from the centre of the MM6 isoseismal contour shown in Figure 4, the point adopted as our epicentre. Burke-Gaffney's (B-G 1951) solution is closer to our epicentre.

Table 1 1929 earthquake details reported by different sources

<i>Date</i>	<i>Time UTC</i>	<i>Lat °S</i>	<i>Long °E</i>	<i>Mag</i>	<i>Approx Location</i>	<i>Source</i>
28 12 1929	01:22	39.69	149.45	5.2 Ms	E of Flinders Is	EDG 1987
		40.0	148.5	5.0 ML	W of Flinders Is	B-G 1951
		41.54	147.56	5.6 ML	NW Tasmania	This paper

The surface-wave magnitude Ms was measured on the Riverview seismogram by Everingham & others (EDG, 1987). Using the method relating magnitude to radius of perceptibility (McCue, 1980) and allowing for a reasonable MM 3 contour yields an ML equivalent of 5.6 which is compatible with the damage observed, and is similar, within the uncertainties, to the magnitude reported by EDG (their computed value would be slightly larger with the greater epicentral distance to Riverview).

At 200 km distance from the epicentre of the Newcastle earthquake, the intensity was 3 to 4 so if the GA epicentre of the 1929 earthquake is correct, the earthquake should have been felt in Victoria and the intensity in NE Tasmania should not have exceeded 4 except at sites like Launceston renowned for its site amplification effects. The shaking would have been all but imperceptible in Hobart.

It is interesting to compare this epicentre and isoseismal map with that of the similar-sized Ms 5.4 earthquake on 14 September 1946 located east of Flinders Island (Everingham & others, 1987). The 1946 event caused no damage other than breakage of crockery and ornaments and was felt almost as strongly in Victoria as Tasmania (Michael-Leiba and Jensen, 1992). The Burnie Advocate of 16 September 1946 reports: *Mr. A. Kirkcaldy, F.R.A.S. of Upton street, who said that earthquakes were uncommon in Tasmania, added that the tremor yesterday morning was not as severe as that felt about the time of the 1929 flood.*

On these grounds we suggest an onshore epicentre for the 1929 earthquake as indicated on the map (Figure 4).

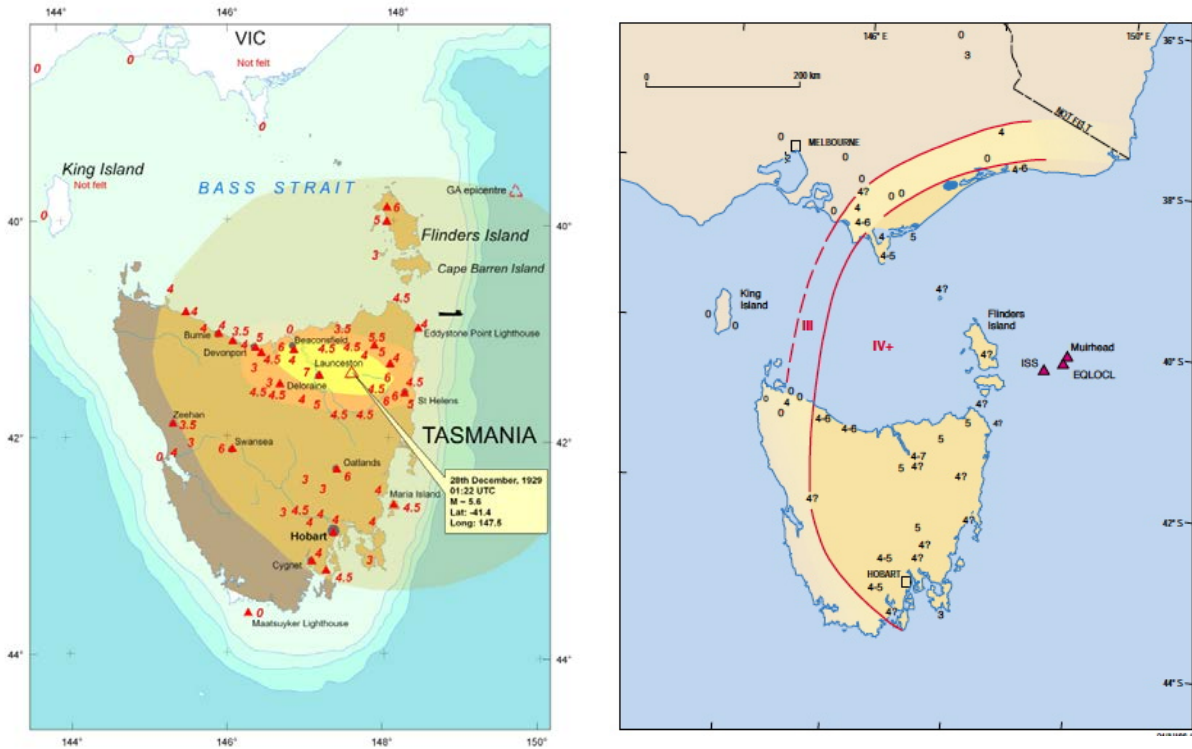


Figure 4 Isoseismal maps, Modified Mercalli intensities based on newspaper reports and lighthouse keepers logs; 1929 on left, 1946 (from Michael-Leiba and Jensen, 1992) on right.

There is no information to assess focal depth except for the high intensities in the mezoseismal area so we presume the earthquake was shallow and in the upper crust.

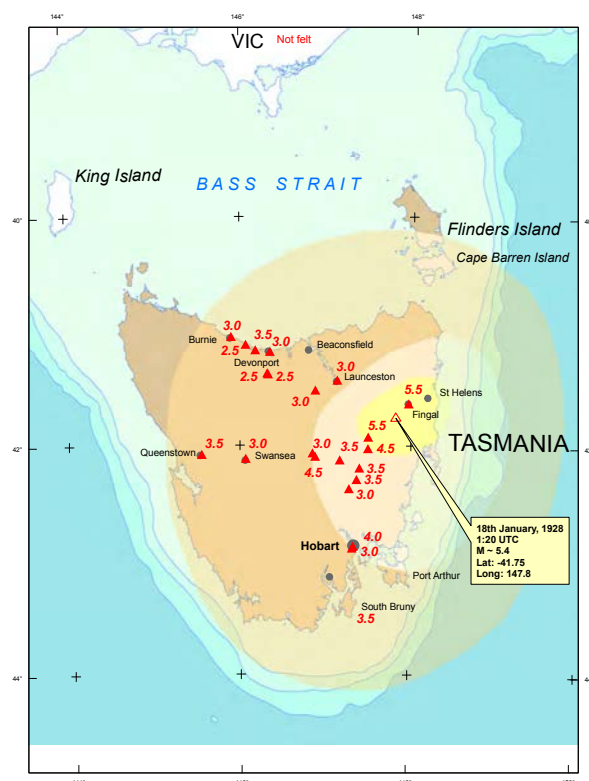
January 19, 1928

Minor damage, felt reports and isoseismal map

Further searching of newspapers revealed that the earthquake of 1929 was not the only forgotten earthquake. Almost two years earlier the northeast of the island was rocked by a smaller but appreciable earthquake. The Hobart Mercury gave a big page 9 spread to the earth tremor: plaster was cracked and dislodged in the Bank of Australasia; in Fingal, the shaking rated severe; at Ross and Campbell Town, books and crockery fell from shelves, the tremor lasting about 5 seconds. It was very noticeable in the Midlands, water tanks swayed on their stands along the Macquarie River where the shaking rated ‘severe’, but it was only slightly felt in Hobart, Launceston and along the northwest coast.

Figure 5 Isoseismal map of the 19 January 1928 earthquake.

One of the comments in the newspaper was that the shaking in Hobart as measured on the Weather Bureau barometer was *not*



nearly as much as during the tremor on September 20 last.

This comment started another search that culminated in the next article concerning an earthquake in September 1927.

September 20, 1927

No damage, felt reports and isoseismal map

This earthquake rated page 7 of the Hobart Mercury, the journalist reporting that it was felt in *The Mercury* office a few minutes after 7pm, following which staff were kept busy answering phone calls from residents enquiring whether the staff too had felt the shaking. Some people hastily vacated their house fearing another stronger quake. At Port Arthur the shaking was rated severe, small articles on shelves being displaced but there was no damage.

Figure 6 Isoseismal map of the 20 September 1927 earthquake. The strongest shaking was reported from Port Arthur.

Mr A. N. Lewis, lecturer in Geology at the University of Tasmania, commented to a reporter from the Examiner newspaper that *the noise and shock were unusual for Tasmania and even the oldest of the old inhabitants cannot recall a tremor accompanied by so much noise.*



The reports were compiled and an isoseismal map drawn up (Figure 6) to determine an approximate epicentre and magnitude, at least .

February 14, 1932

Whilst investigating earthquakes in Victoria in 1932 I came across references to two previously un-catalogued earthquakes in Tasmania the same year, one in the northeast of the state in February, the other in the northwest in October. These were both early morning earthquakes when most people were asleep so the magnitudes derived from the normal radius of perceptibility (MM3) are not well defined. The shaking either woke everyone as the newspaper reports suggest ie MM4 at least, or there are a lot of insomniacs in Tasmania.

No damage was reported in either earthquake but the description from the Swan Island lighthouse would suggest an intensity of MM 5: *the shock was severe while it lasted and the tower shook violently, but no damage was done.* The shaking was reported felt from Flinders Island in the north to Fingal in the south, more than 160 km, and in an eastwest direction from St. Marys to Launceston. From this we derive a minimum magnitude of 4.7.

October 13, 1932

The felt reports were from Trowutta to the northwest and Devonport to the east, and Magnet and Wynyard. Large cracks were reported in the plaster of one house in Wynyard, windows and doors banging in Magnet and roused sleepers elsewhere. One person commented that it wasn't as strong as the earthquake 4 years ago, perhaps referring to the 1929 earthquake mentioned above, nearly 3 years earlier.

The two isoseismal maps are illustrated below.

Results

The parameters of the earthquakes discussed here are summarized in the following table. The uncertainties are ill defined but are estimated to be about one minute in time, 20km in epicentre location (apart from the 1910 event), 10 km depth (ie upper crust) and 0.3 in Richter magnitude.

Table 2 Details of earthquakes discussed in this text

<i>Date</i>	<i>Time UTC</i>	<i>Latitude °S</i>	<i>Longitude °E</i>	<i>Depth</i>	<i>Magnitude</i>
1910 01 13	00:16	44	155	10 ± 10	6.0
1927 09 20	09:00	43.3	148.2	"	4.3
1928 01 19	01:20	41.75	147.8	"	5.4
1929 12 28	01:22	41.54	147.56	"	5.6
1932 02 14	15:30	40.8	148.6	"	4.7 – 5.0
1932 10 13	16:30	40.75	145.25	"	4.5 – 5.0

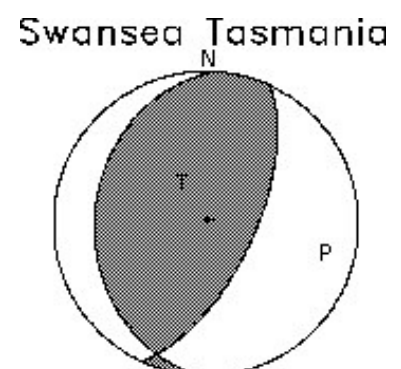
The past record of seismicity in northeastern Tasmania indicates that this part of the state is highly stressed. The network of seismographs is not usually sufficiently dense to undertake focal mechanisms using first-motions of the P wave so the earthquake mechanisms are unknown. However, for a short period in late 2009 a dense network of broad-band seismographs was deployed by the University of Tasmania's Anya Reading for Kuth Energy in the northeast of the state. During the deployment, a small earthquake (magnitude ML 3.8) fortuitously occurred near Swansea where it was felt. Using first motion data from this temporary deployment, the Tasmanian Hydro network and the jointly managed University of Tasmania and GA stations TAU and MOO, the author determined the focal mechanism in Figure 7. The diagram shows a typical thrust mechanism, the principal stress acting in an ESE direction.

Figure 7 Focal mechanism of the 7 December 2009 Swansea Tasmania earthquake, magnitude 3.8.

A large Recent fault scarp at Lake Edgar was identified as such by Carey and Newstead (1960) and first trenched and investigated by van Dissen & others (1997). It too is indicative of compression with a near horizontal principal stress direction approximately east-west. The importance of such studies is that they indicate that the current stress field in Northeast and Central Tasmania is similar to that in the southeast of continental Australia, a single large stress domain.

Discussion

Why these earthquakes have been forgotten is hard to fathom although the economic depression and two world wars followed the 19th century sequence off the NE coast of



Tasmania. This earlier sequence had drawn international interest, before Tasmania finally acquired a seismograph network to systematically record such events, thanks to the energy and foresight of Professor Sam Carey at the University of Tasmania. Unfortunately, the current seismograph network is no longer supported by the Tasmanian government and the data from it are not routinely published or widely available.

Hopefully, there are no more 'surprise past earthquakes' in Tasmania greater than magnitude 5.0 and these events will fill the gap in the earthquake database between the late 19th century earthquake storm and the modern era of seismographic monitoring. Another search when more newspapers have been digitized should get the threshold down to magnitude 4.

More thought will have to be given to the weighting of hazard between eastern and western Tasmania, tempered by the thought that future earthquakes in Tasmania will no doubt bring as many surprises as did the historical ones. Source zones based on regional or global models will obviously give very different results but to do the regional model well, we need as long a database as possible.

Being prepared for disasters is the obvious lesson; site, design and build to withstand earthquakes as we do routinely for rare floods and occasional strong winds.

Acknowledgment

Gayle Young most generously gave her time to draw up the isoseismal maps. Ian Ripper traded recreational time to search through the lighthouse keepers' logs in Hobart. I would like to thank helpful staff in Commonwealth Archives in Canberra and Hobart and their State counterparts in Melbourne and Hobart. The National Library of Australia is commended for their initiative in scanning the early Australian newspapers and establishing TROVE and allowing the public free access as encouragement to correct the OCR. Sonja Lenz reviewed the manuscript, but any errors are mine. Kuth Energy sponsored a review of earthquake hazard in NE Tasmania, one outcome of which was the focal mechanism of the Swansea earthquake.

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