Taranaki Seismicity: July 2013 to June 2014

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EXECUTIVE SUMMARY

During the period July 2013 to June 2014, 236 earthquakes were located in the Taranaki region by GeoNet. This accounts for about 2% of the earthquakes located in New Zealand in a typical year. The long-term pattern of earthquakes followed that seen in previous years with most of the shallow earthquakes (5-25 km) either in a north-east – south-west trending swath west of Mt Taranaki, or in a cluster north-east of Stratford; the earthquakes to the south-east are deeper.

Although a few earthquakes were located near Mt Taranaki, we conclude that during the period July 2013 to June 2014 seismic activity on the Taranaki Peninsula was not volcanologically significant.

During the year no changes were made to the seismograph network in Taranaki. In terms of assessing the effectiveness of the network, technical problems are generally no longer an issue as the new and upgraded sites rarely experience problems.

The introduction nationally of GeoNet Rapid has had a detrimental effect on the capability to detect and locate smaller earthquakes in Taranaki. Operating a separate install as a temporary measures during 2013-14 has provided a remedy. An approach involving a combination of software improvements and additional monitoring sites is being investigated.

1.0 INTRODUCTION

This report summarises earthquake occurrence in Taranaki for the period 1 July 2013 to 30 June 2014. The Taranaki Volcano-Seismic Network was commissioned by DSIR in late-1993, with the first usable data being recorded in January 1994. Since that time data have been recorded almost continuously.

1.1 ANALYSIS HISTORY

The Taranaki Research Group at Auckland University was responsible for processing data recorded by the network from January 1994 until June 1997. These data were regularly reported to Taranaki Regional Council (TRC), and data from the period January 1994 to March 1995 were summarised in Cavill *et al*. (1997). In July 1997, GNS Science took over responsibility for data analysis and annual reporting under contract to TRC.

In 2001, the GeoNet project started to improve the existing network for monitoring earthquakes in New Zealand. In 2005, planning began for upgrading seismographs in Taranaki to an equivalent standard to that in other parts of New Zealand. With this upgrade came two important changes. Firstly, the role of the network expanded from one of solely monitoring Mt Taranaki to both monitoring Mt Taranaki and contributing to the New Zealand network as a whole by providing essential earthquake recording capability in the western part of the North Island.

Secondly, the concept of a “Taranaki volcano network”, with all data sent to, and recorded at, a common point became less appropriate as multiple data hubs began to be used to send data to GeoNet data centres. Sites in Taranaki lost any distinction they may have had from other seismographs in New Zealand. For these reasons we feel that the term “Taranaki Volcano-Seismic Network” no longer has the meaning it used to, and by referring to a Taranaki-specific network can be both confusing and not convey the information that was intended. For these reasons we are no longer using the term.

2.0 SEISMOGRAPHS

The network upgrade in Taranaki was completed in 2010. Since then a new instrument was installed in a borehole replacing a nearby noisy site, in October 2012 (NBEZ, Figure 2.1). No changes to the network were undertaken during 2013-14.

There are currently nine seismographs in the Taranaki area continuously sending data to GeoNet data centres in Taupo and Wellington for analysis. Data is sent via hubs located at the Taranaki Emergency Management Office in New Plymouth; at Kahui Road west of Mt Taranaki; and at Eltham.

As discussed above, the distinction between Taranaki seismographs and others seismographs in New Zealand has become less in recent years. Several seismographs outside Taranaki record small or moderate earthquakes that occur in Taranaki, aiding in locating these earthquakes. The nearest of these sites are Vera Rd – east of Whangamomona, Hauiti – inland from Awakino, and Wanganui – north-west of Wanganui city.

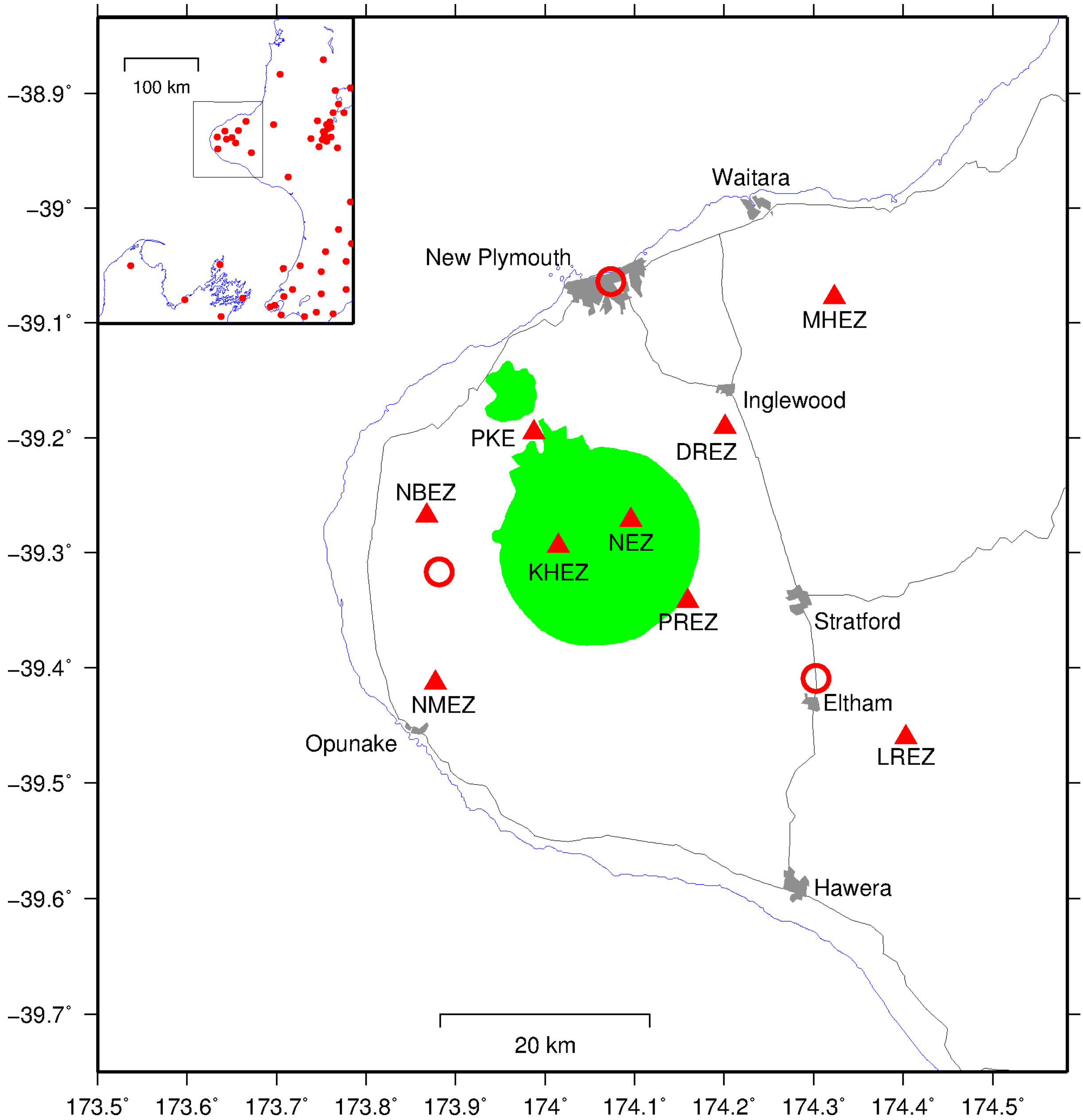

Figure 2.1 A map of the seismographs located in Taranaki. Seismograph sites are indicated by triangles and labelled by their three or four-letter site codes. The network shown (red triangles) is that at the end of the 2014 reporting period. NEZ is North Egmont, NWEZ is Newall Road, NBEZ is Newall Road Borehole, PKE is Pukeiti, DREZ is Durham Road, MHEZ is Mangahewa, NMEZ is Namu Road, KHEZ is Kahui Hut, PREZ is Palmer Road, and LREZ is Lake Rotokare. Data collection (hub) sites are shown by red circles. Population centres are shaded dark grey and named. The Egmont National Park is shown as a green shaded area. Major roads are shown as grey lines. The inset shows Taranaki and additional nearby GeoNet seismographs (red dots) that are sometimes used in locating earthquakes in Taranaki.

3.0 DATA ANALYSIS

Seismic data from Taranaki are continuously transmitted to GeoNet data centres in Taupo and Wellington. In near real-time, an automatic earthquake detection program is used to search for signals that may be caused by earthquakes. When the signal from an earthquake is detected, the program attempts to estimate the arrival time of the earthquake waves at each of the seismographs (in Taranaki and elsewhere) and an attempt is made to automatically locate the earthquake.

The real-time earthquake analysis system used by GeoNet is known as GeoNet Rapid[1] and uses the SeisComP3[2] analysis system. It is capable of automatically obtaining a reasonably accurate location for all moderate size earthquakes within 1-2 minutes of an earthquake's occurrence. In most cases the automatic locations are sufficiently accurate for rapid notification of these events to the public and responding authorities without requiring additional manual checking and analysis. GeoNet Rapid has been very successful in this regard, but there have been some shortcomings as well. Because of the way GeoNet Rapid is configured, it is less sensitive to smaller earthquakes in Taranaki than the system that operated before January 2012 was. This is discussed further later in this report.

In compiling this report we have used data from the GeoNet earthquake catalogue[3], as it is the official record of seismicity in New Zealand, despite its shortcomings in the Taranaki area. The catalogue currently comprises locations from the previous analysis system up to December 2011 and GeoNet Rapid locations from January 2012. The review of locations since January 2012 is not fully completed due to the transition from the old to new system occurs. Details can be found on the GeoNet website[4] relating to the gap.

Because automatic locations from GeoNet are sufficiently accurate for rapid notification, many of the locations, particularly for events smaller than magnitude 3 are not manually reviewed. In displaying the locations of earthquakes in Taranaki we have distinguished between automatic and reviewed locations. In some cases automatic locations may be less reliable than reviewed ones.

In previous reports the earthquakes felt in Taranaki were discussed. It is currently not possible to extract from the New Zealand earthquake catalogue the locations of earthquakes that were reported felt so this discussion is not included in this report.

1 http://info.geonet.org.nz/pages/viewpage.action?pageId=1475537

2 http://info.geonet.org.nz/display/appdata/SeisComP3

3 http://info.geonet.org.nz/display/appdata/Earthquake+Catalogue

4 http://info.geonet.org.nz/display/appdata/The+Gap

4.0 DATA RELIABILITY

The reliability of earthquake locations determined from seismic networks depends on several factors. These include:

- the number of instruments at which an earthquake is recorded. Small earthquakes are often poorly recorded or recorded on only a few instruments. Locations for these earthquakes are not as good as those for larger events which are well recorded at many more instruments distributed over a range of distance and directions;
- how far an earthquake is from the network. There is little control on the location of earthquakes well outside a network so these are usually poorly located; in the case of Taranaki this particularly applies to offshore earthquakes;
- technical problems with a seismic network; these degrade data quality and reduce the number of sites at which an earthquake can be recorded.

If there are insufficient data to locate an earthquake well, it is common practice to fix the depth of that earthquake at some appropriate value, while still calculating the earthquake time and position. In particular, this situation often arises with shallow earthquakes when the event is farther from the nearest seismograph than it is deep. For Taranaki is usually occurs for earthquakes offshore. Historically, ~20% of earthquakes in Taranaki have had a fixed depth.

During the reporting period there were no technical problems that caused substantial loss of data from sites used to locate earthquakes in Taranaki.

5.0 RESULTS

In this section we report on results obtained from the GeoNet earthquake catalogue and follow the format used for previous reports.

Two hundred and thirty-six (236) earthquakes were located in the Taranaki region by GeoNet between July 2013 and June 2014 (Figure 5.1). In a typical year this equate to about 2% of total number of earthquakes located in New Zealand.

Shallow earthquakes (for the purpose of this report, those with a depth less than 50 km) were concentrated in a north-east to south-west trending swath west of Mt Taranaki, with a few in a cluster west of the National Park. Very few events have occurred north-east of Stratford (Figure 5.1). Deep earthquakes (for the purpose of this report, those with a depth greater than 50 km) were mainly located in the Hawera region beneath south-east Taranaki (Figure 5.1).

The depths of earthquakes in Taranaki shallower than 50 km are shown in Figure 5.2a, and Figure 5.2b. Although a search of GeoNet Rapid locations does not currently indicate if an earthquake has a fixed depth or not, it is evident from Figure 5.2 that some are fixed at a depth of 5 km.

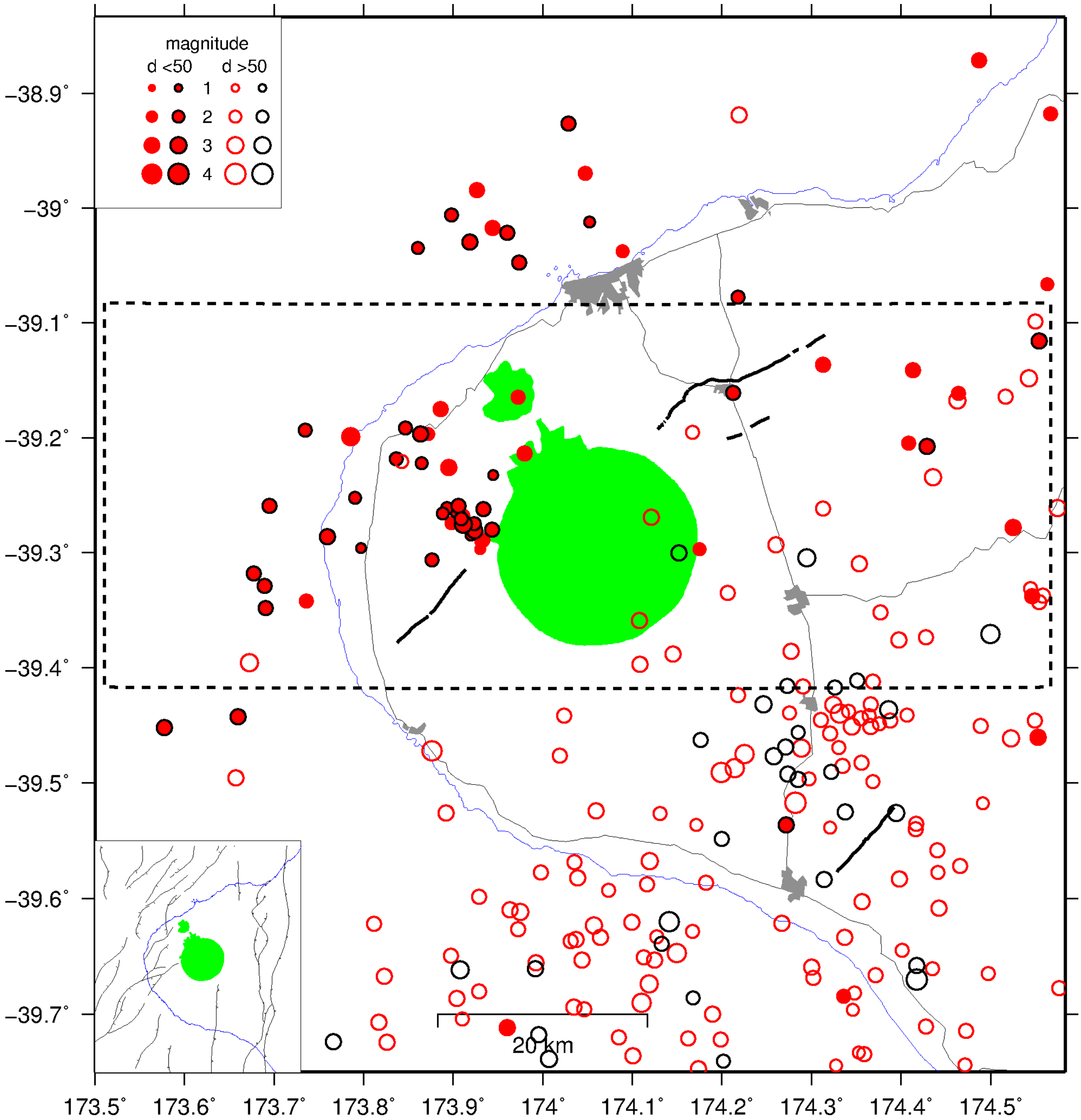

Figure 5.1 A map of all earthquakes located in Taranaki by GeoNet between July 2013 and June 2014. Closed circles indicate earthquakes less than 50 km deep and open circles those more than 50 km deep. Earthquakes that have been manually reviewed have a symbol that is surrounded by a black ring, those without the black ring are automatic locations. The size of the symbol is proportional to the magnitude of the earthquake, and representative symbols are shown in the top left corner of the diagram. Population centres are shaded dark grey and Egmont National Park is shaded green. Major roads and mapped active faults (thick black lines) are also shown. The dashed box marks the location of the cross-section in Figure 5.2a. The lower left inset shows mapped faults that offset the basement rocks, but are not considered active.

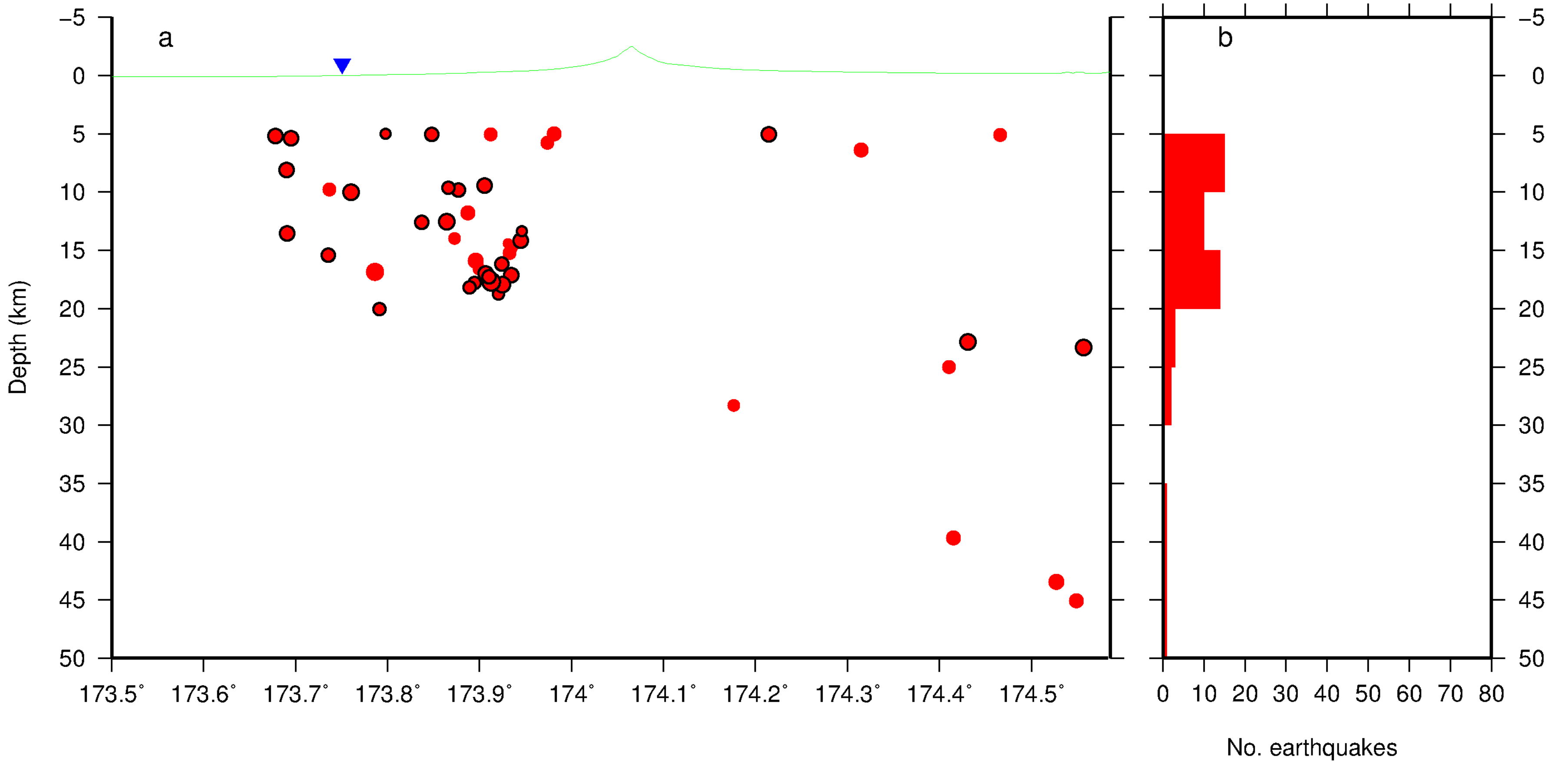

Figure 5.2 a. An east-west cross-section showing earthquakes less than 50 km deep located in Taranaki between July 2013 and June 2014. The symbols are the same as Figure 5.1, those that have been manually reviewed have a symbol that is surrounded by a black ring, those without the black ring are automatic locations. No distinction is made between earthquakes for which the depth was calculated and those for which it was fixed, although is it clear that several have been fixed at 5 km. Topography is shown in the upper part of the diagram, with the inverted triangle marking the position of the coast at Cape Egmont. The horizontal: vertical scale is 1:1. The location of the cross-section is shown as a dashed box in Figure 5.1.

b. Histogram of the depths of the earthquakes shown in Figure 5.2a. The 5-10 km range includes events fixed at 5 km depth.

6.0 DISCUSSION

In this section we compare the seismicity for July 2013 to June 2014 with the activity in Taranaki since 1994. We include a discussion of any long-term similarities, differences and trends that may be apparent. We assess the volcanic significance of the recent data and comment on the network effectiveness. We also continue a discussion begun last year on some consequences of the introduction of GeoNet Rapid for locating seismicity in Taranaki, including monitoring of Mt Taranaki volcano.

6.1 LONG-TERM DATA

6.1.1 Larger earthquakes

In previous reports we have summarised the occurrence of all earthquakes located in Taranaki since January 1994. A seismic network can only locate earthquakes above a certain magnitude and records only some of the earthquakes of lower magnitudes[5]. Summarising all earthquakes may therefore be a little misleading. Differences in the distribution may reflect differences in location threshold rather than what earthquakes actually occurred. For an area similar to that shown in Figure 2.1, but excluding earthquakes more than 20 km offshore, Sherburn and White (2005) showed that for the period 1994-2001 the GNS Science catalogue is complete down to magnitude 2.7[6].

In summarising data since 1994 we therefore show all located earthquakes in Figure 6.1 and earthquakes above the M2.7 threshold in Figure 6.2. Although earthquakes immediately west of Mt Taranaki dominate the catalogue, this is largely a result of the location threshold onshore being significantly lower than that offshore. Considering only earthquakes of M2.7 and larger (Figure 6.2), there doesn't appear to be any distinction between the level of activity onshore west of Mt Taranaki and that offshore north and south of the Taranaki Peninsula.

However, by showing only the larger earthquakes we may inadvertently miss some important data (i.e., less well-located and smaller earthquakes). In Figure 6.1 there are more than 100 earthquakes shown beneath Mt Taranaki, which gives the impression that there is a low, but significant, level of seismicity beneath the volcano, and raises questions about the possible volcanic significance of these events. However, only a few of these earthquakes are large enough to be shown in Figure 6.2, and many may therefore have locations that are less reliable (particularly those from the 1990s), and may possibly have been mis-located from the more active area immediately west of Mt Taranaki. This does not mean that we should only consider Taranaki earthquakes of M2.7 and larger because a sequence of small earthquakes beneath Mt Taranaki may still have significance as a volcanic unrest precursor. This point is discussed later in regard to the current GeoNet analysis system.

5 This is called the location threshold or magnitude of completeness, and can depend on the area considered, the time interval, and on the analysis procedures used.

6 With additional seismographs in Taranaki and improvements to existing instruments that completeness threshold is now a little conservative. For the area east of Mt Taranaki recent work has shown that the completeness threshold is now closer to magnitude 2.0. However, for the sake of comparison with previous reports we will continue to use a threshold of magnitude 2.7.

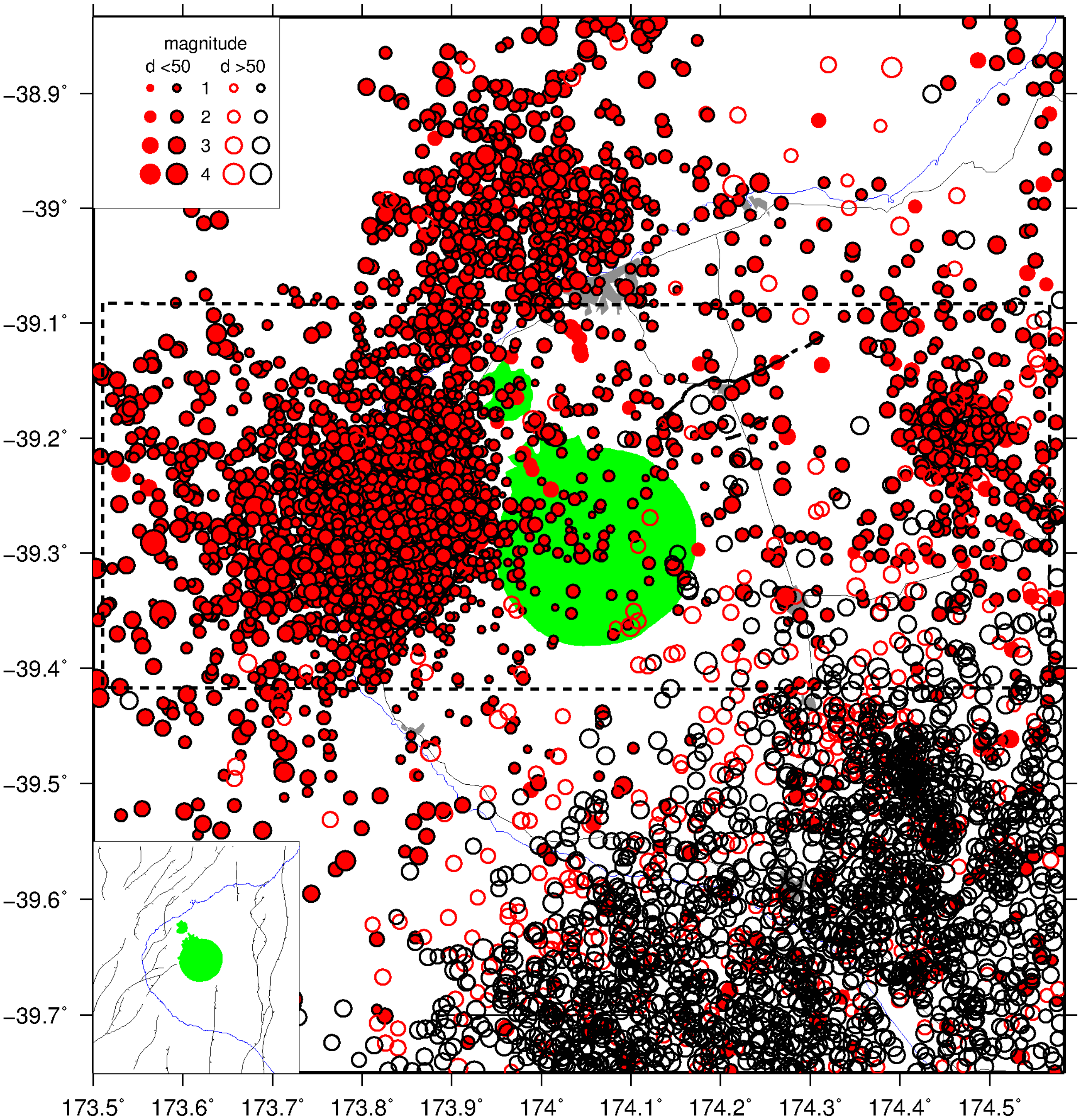

Figure 6.1 A map of all earthquakes located in Taranaki between January 1994 and June 2014. Symbols are as described in Figure 5.1.

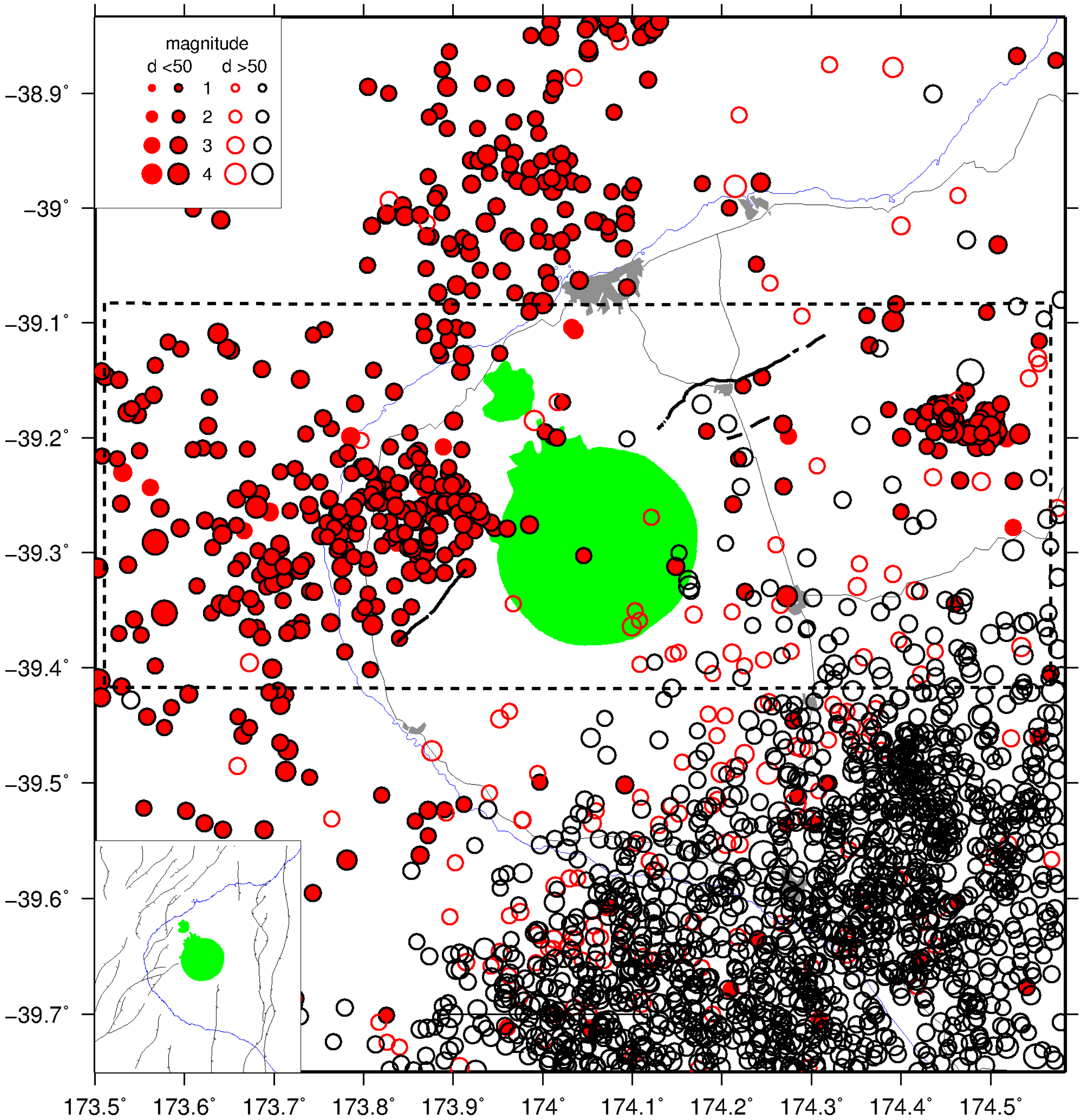

Figure 6.2 A map of earthquakes of M2.7 and larger located in Taranaki between January 1994 and June 2014. Symbols are as described in Figure 5.1.

6.1.2 Long-term distribution

In terms of the distribution of earthquakes, the data for July 2013 to June 2014 (Figure 5.1) are similar to those since 1994 (Figure 6.1 and Figure 6.2). The swath of earthquakes west of Mt Taranaki represents part of the Cape Egmont Fault Zone, a region of seismically active faulting. The deep earthquakes in the Hawera region reflect the bottom of the Pacific plate subducting beneath the North Island. The cluster of earthquakes north-east of Stratford is the western part of a band of activity that continues almost to Mt Ruapehu. All of these are long-term features of the Taranaki seismicity. The persistence of these features implies that the causes of this seismicity has remained unchanged since detailed monitoring began in Taranaki.

6.1.3 Long-term rate

We use two measures to show the long-term rate of shallow (depth less than 50 km) seismicity in the Taranaki region: the number of located earthquakes each month (Figure 6.3) and the cumulative number of earthquakes located since 1994 (Figure 6.4). Both figures show that while there are short-term variations in the rate of activity, the long-term rate of shallow seismicity in the Taranaki region has been relatively uniform. Variations are discussed below.

6.2 VOLCANIC SIGNIFICANCE

While there are no hard and fast rules for assessing whether an earthquake or group of earthquakes are volcanologically significant, the number of earthquakes, their magnitude and the presence or absence of low-frequency earthquakes (McNutt, 2000) are criteria that are often considered. The earthquakes located beneath Mt Taranaki in 2013-14 are not unusual in any of these respects.

Several earthquakes are located each year beneath Mt Taranaki, they are however not thought to be volcanologically significant.

6.3 NETWORK EFFECTIVENESS

In the past the effectiveness of the network has been significantly affected by technical problems. However, the seismograph network upgrade between 2005 and 2010 means that they are much more reliable and technical problems are rare. There are always minor technical issues with any network, but none of these had a substantial effect on Taranaki data in 2013-14.

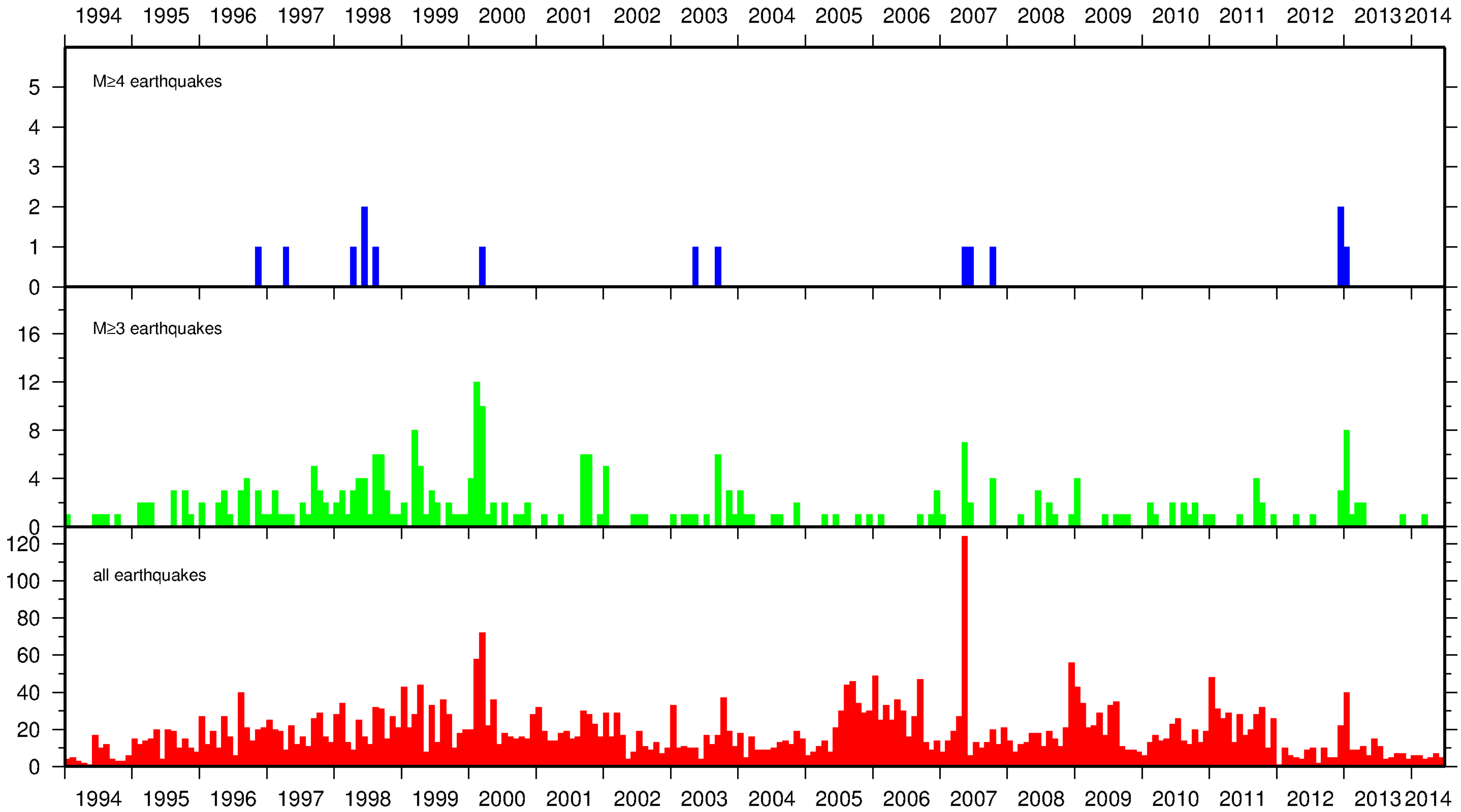

Figure 6.3 Histograms of the number of earthquakes less than 50 km deep that have occurred each month between January 1994 and June 2014 in the area shown in Figure 2.1. Three separate histograms are shown: all earthquakes (bottom), those of magnitude 3 and above (centre) and those of magnitude 4 and above (top). Data up to December 2011 are from the previous analysis system, and those from January 2012 are from the GeoNet Rapid system.

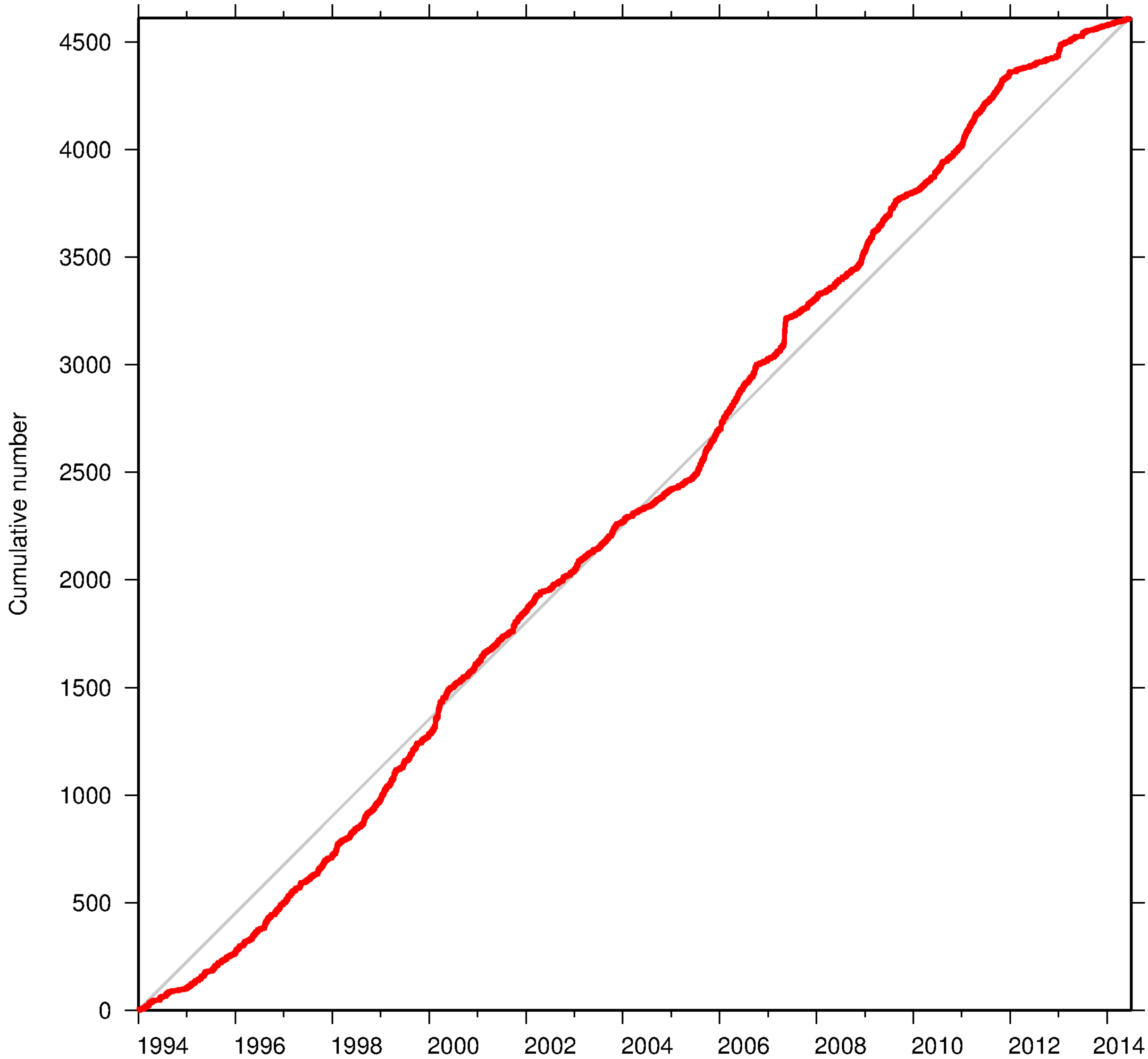

Figure 6.4 The cumulative number of all earthquakes (red line) less than 50 km deep located in the area shown in Figure 2.1 between January 1994 and June 2014. The grey line shows the mean rate, 224 events per year. The main network upgrade began in 2009, but there was no significant change in the number of earthquakes. GeoNet Rapid data are from January 2012 and this corresponds to a reduction in the rate of located earthquakes.

6.4 GEONET RAPID

As mentioned above the introduction of GeoNet Rapid was accompanied by a reduction in the number of locatable earthquakes in the Taranaki region. This was discussed in detail in the 2012-13 report and highlighted in a presentation to the Taranaki Seismic and Volcanic Advisory Group (September 2013).

GeoNet Rapid requires 10 compatible, automatic P-phase arrival picks to create an earthquake event. There are 9 seismographs on the Taranaki peninsula so for an event to be created by the automated system, the seismic waves must be detected and picked at all Taranaki sites plus at least one site outside Taranaki, or, if detected at fewer Taranaki sites, more sites outside Taranaki must also detect it.

GeoNet Rapid is designed to automatically obtain a reasonably accurate location for all moderate sized earthquakes (in other words, likely to be felt) in New Zealand within 1-2 minutes, and does that successfully. However, in the case of Taranaki the threshold of required picks has resulted in a substantial reduction in the number of smaller earthquakes that are located, with obvious implications for the monitoring of Mt Taranaki. This is most likey due to the lack of seismographs to the west (offshore), as this issue is not seen at the other volcanic centres in New Zealand.

6.4.1 How is this being dealt with?

Since mid-2013 GNS Science has been running a special instance of SeisComP3 that requires only 6 P-phase arrival picks to create an earthquake event. This instance has been focussed on the Taranaki region and Mt Tongariro. This system can locate more earthquakes in Taranaki than GeoNet Rapid because it can detect smaller events. It commonly locates earthquakes in Taranaki smaller than magnitude 1.5.

This special instance is not appropriate as a long-term solution as it is not official and it is not operated on a reliable computer server. A pragmatic approach involving a combination of software and hardware improvements is being looked at and will be advanced over the next year.

The use of automatic S-phase picks is possible using a new module developed for SeisComP3. Research into the benefits of that module will begin in September 2014, including assessing its effectiveness with Taranaki data, though the timing of any application to GeoNet Rapid is yet to be determined.

An increase in the number of seismographs on the Taranaki peninsula to make event detection substantially easier without requiring major software changes. Initial investigations into this approach can be looked at in 2014-15 (testing and selecting potential additional sites), but the earliest it could be implemented is 2015-16.

7.0 CONCLUSIONS

Seismic activity on the Taranaki Peninsula continues to be dominated by a swath of earthquakes west of Mt Taranaki, with a few events beneath the volcano. No earthquakes have been recorded that might indicate ongoing volcanic processes or precursors of an eruption at Mt Taranaki. We therefore infer that during the period July 2013 to June 2014 seismic activity on the Taranaki Peninsula was not volcanologically significant.

The introduction of GeoNet Rapid as had a detrimental effect on the capability to detect and locate small earthquakes in Taranaki. An approach involving a combination of software improvements and additional monitoring sites is being investigated.

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