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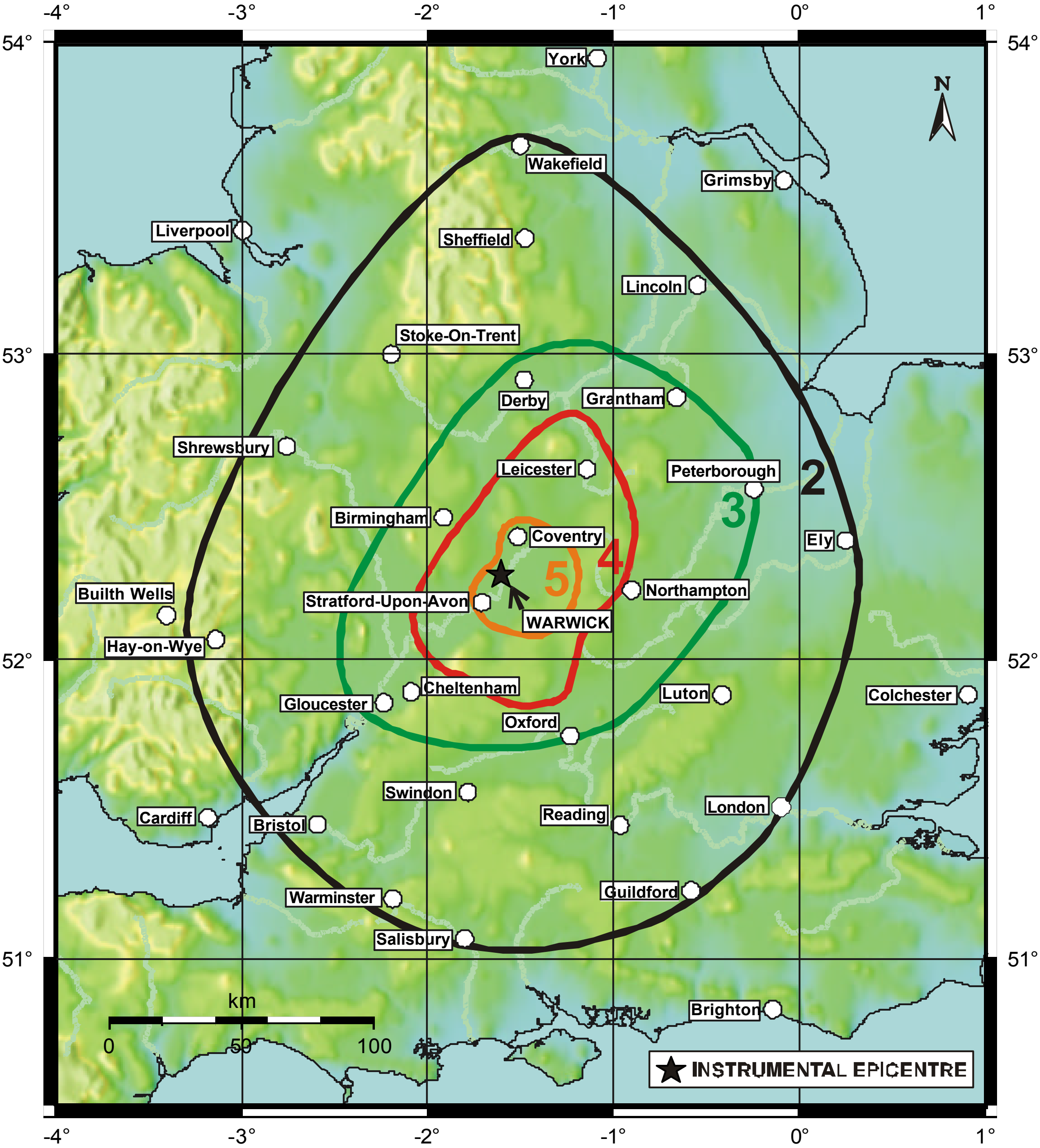
THE 4.2 ML WARWICK EARTHQUAKE OF 23 SEPTEMBER 2000



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12 March, 2002

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THE ML 4.2 WARWICK EARTHQUAKE OF 23 SEPTEMBER 2000

1. SUMMARY

On 23 September 2000, many residents of Warwick were awoken by an earthquake of local magnitude (ML) 4.2, at 05:25 am (04:25 UTC). It was felt up to a maximum intensity of about 5 on the European Macroseismic Scale (EMS) (Grünthal, 1998) in Warwick, Leamington Spa and Stratford-Upon-Avon, close to the epicentre, and was felt over a total area of about 50,000 km^2 (Isoseismal 2). The earthquake was located about 2 km west of the city of Warwick at a depth of 14.4 km. This is the largest earthquake to occur in the UK since the 5.1 ML Bishops Castle earthquake of 2 April 1990, which was located near the Welsh border, about 100 km WNW of Warwick. The well-constrained focal mechanism for the Warwick earthquake indicates almost pure normal faulting on a NW-striking fault plane, either dipping moderately to the NE or to the SW. The T-axis is horizontal and strikes NE-SW and the P-axis is vertical. The location and orientation of one of the possible fault planes is consistent with the strike and dip of the SW-dipping Whitnash fault, which lies 5 km east of the earthquake epicentre. However, seismic lines reveal many similarly oriented buried faults in the region, and so the earthquake could equally have occurred on a buried fault parallel to the Whitnash fault.

2. INTRODUCTION

The 4.2 ML Warwick earthquake is the largest earthquake to occur in the mainland UK since the Bishops Castle earthquake of 2 April 1990 event (5.1 ML), which was located 100 km to the WNW (Figure 1). The size of the event is not unexpected in the UK, as magnitude 4.0 ML and larger events occur about once every two years. The last event of similar size was the Arran earthquake (4.0 ML), which occurred on 4 March 1999 (Bott et al, 2002). The Warwick earthquake occurred in an area where few historic and instrumental earthquakes have previously occurred. Only 7 events have been instrumentally located within 20 km of Warwick since 1970. Historically, a few similar-sized events have occurred between 40-50 km away (1768, 4.1 ML Tewksbury; 1937, 4.0 ML Walsall; and 1940, 4.0 ML Coalville) (Figure 1). The largest recent instrumental event (May 1994, 3.0 ML) occurred 17 km to the southwest of the Warwick earthquake and was felt in Stratford-upon-Avon (Figure 1). The Warwick earthquake occurs at a transition zone between a more seismically active region to the northwest and a relatively aseismic region to the southeast, which can be observed in both the instrumental and historic earthquake catalogues. This event also had no aftershocks indicating that it could be a high stress drop event, with all the stress being relieved at once. Faulting possibly occurred along a pre-existing zone of weakness of similar faulting style and favourably oriented to the current stress conditions. Other events of magnitude greater than or equal to 4.0 ML in Britain are investigated to determine the existence and expected number of aftershocks and foreshocks.

TheWarwick earthquake was felt up to a maximum intensity of about 5 EMS in Warwick, Leamington Spa and Stratford-Upon-Avon, close to the epicentre. The area of isoseismal 2 EMS was about 50,000 km^2, including Cheadle (85 km to the north), Gloucester (65 km to the south), Peterborough (95 km to the east), and even as far as Builth Wells (100 km to the west). Over 2,400 responses to newspaper questionnaires and through the BGS 'Earthquakes' website (http://www.gsrg.nmh.ac.uk) were received on the felt effects of this earthquake, which were used to construct a macroseismic map for this event (Figures 12 & 13). No significant damage was reported for this event.

3. EARTHQUAKE LOCATION

The Warwick earthquake was recorded on BGS seismograph stations throughout the UK and data mostly from the Hereford, Swindon and Keyworth networks were used along with the LOWNET velocity model to obtain a location. Figure 2 illustrates the geographic distribution of stations with respect to the epicentre, used for the location. Arrival times at these stations are listed in Table 1. Location output and magnitude calculations are also provided in Tables 2a and 2b. The LOWNET velocity model (Table 3) was derived from the LISPB refraction profile (Bamford et al, 1976; Bamford et al, 1978; Assumpcao and Bamford, 1978). This velocity model is a good average UK velocity model and provides reasonable locations for most UK earthquakes; epicentres for larger events locating close to where they are most strongly felt.

Seismograms of the Warwick earthquake as recorded on the Hereford network are shown in Figure 3. The location of the epicentre is approximately 2 km west of the city of Warwick itself. The estimated error in epicentral location is calculated to be 0.9 km and the depth was computed at 14.4 km ± 7.5 km, indicating a range of between 6.9 and 21.9 km in depth. The depth is not particularly well constrained, the closest station being 39 km away (station SSW). The local magnitude, an average taken from three orthogonal pairs of horizontal components from strong motion instruments, was 4.2 ML (Table 2b).

The overall location quality of the hypocentral solution obtained using HYPO71 (Lee and Lahr, 1975) is classified as 'fair' C (B*C), with a 'good' statistical fit for the data (B) and 'fair' azimuthal distribution of stations (C) with an azimuthal gap of 95º. The location errors were calculated relocating the event 50 times using HYPO71 and by randomly perturbing the velocity structure by ± 10% and also the phase arrival times. A one standard deviation change in location is quoted for the epicentral and depth errors, which are estimated to be 0.9 km and 7.5 km, respectively. Table 4 lists the details of the error analysis. A plot of the perturbed epicentres reveals an elliptical region approximately 2 km long and about 1 km wide. The direction of elongation is WNW-ESE and reflects the station configuration with respect to the epicentral location (Figure 2).

There were no aftershocks recorded for this event, which is unusual for events of this size in the UK. The 1999 Arran earthquake (4.0 ML) had two aftershocks, the Bishops Castle (5.1 ML) had six, and the 1984 Lleyn Peninsula event (5.4 ML) had well over 200. The foreshock and aftershock activity of moderate-sized earthquakes in southern Britain is investigated in Section 7 of this report.

4. FOCAL MECHANISM

A focal mechanism was computed for the Warwick earthquake using the program FOCMEC (Snoke et al, 1984). This program can utilise both P-wave first motions, as well as SV/P amplitude ratios. It works on a grid-search method to find out which solutions fit the data and lists all possible solutions. The user specifies the number of allowed polarity errors and the increment in degrees for the grid search. Using all available data from the UK seismographic network and the UKNET broadband network operated by AWE, eighteen impulsive P-polarities were used, of which two were dilatational and eighteen compressional. One SV/P amplitude ratio for station CWF was also added. The resulting focal mechanism (Figure 4) is well constrained with just eleven possible and similar solutions with no polarity errors and a 5º-grid increment. The SV/P amplitude ratio does not provide much additional constraint to the solution, but was included here for completeness. The focal mechanism shows almost pure normal faulting on a NW-striking fault plane dipping moderately either to the northeast or to the southwest. The 'average' P-axis' is vertical and the T-axis is horizontal and strikes northeast-southwest. The maximum horizontal stress, or intermediate stress axis, strikes NW, and is consistent with the regional compressional stresses. These are thought to be due to the ridge push force from the Mid-Atlantic ridge located to the north and west, and from the northward collision of Africa into Europe to the south.

Since the focal depth (14.4 km) for this event was poorly constrained, focal mechanisms were determined for a series of fixed depths, to determine if this had a strong influence on the resulting mechanism. As can be observed (Figure 5), the focal mechanisms for depths between 12 and 18 km are not significantly different from that calculated for a depth of 14.4 km (Figure 4), with a similar or fewer number of possible solutions. However, for depths of less than 12 km and over 18 km, the number of possible fault-plane solutions increases, though the focal mechanisms still represent predominantly normal faulting. The only difference is that the dip and strike of both focal planes are less constrained, because the station polarities mostly plot around the edge of the focal sphere (Figure 5). The instrumentally calculated depth of 14.4 km has large potential errors (±7.5 km), but the macroseismic depth (12-13 km) is in good agreement with this estimate. The focal mechanisms shown here indicate that this earthquake was a normal faulting event for a depth range of 8 to 22 km.

5. MEASURED GROUND ACCELERATION

Ground accelerations for this event were measured on three strong motion instruments. The ground accelerations are summarised in Table 5, the largest being recorded at Keyworth, in Nottinghamshire, a distance of 76 km from the epicentre. The measured accelerations were 17.3 mm/sec^2 on the vertical component, 16.6 mm/sec^2 on the north-south component and 20.8 mm/sec^2 on the east-west component (Figure 6). A response spectra (pseudo-relative velocity) was calculated for station KEY2 and indicates that energy in the 5-6 Hz range was excited during this earthquake at this site (Figure 7). Both peak vertical and horizontal accelerations were also measured from unsaturated velocity records from high and low gain seismographs and are shown as a function of distance in Figure 8. Predicted peak horizontal ground accelerations from several empirical attenuation relations (PML, 1982; Ambraseys and Bommer, 1991; Dahle et al, 1990) for an M_S 4.0 event are also shown. These relations are currently used for seismic hazard studies in the UK and generally overpredict the ground accelerations for the distances shown, as has been observed for other UK earthquakes (e.g the recent 1999 ML 4.0 Arran earthquake, Bott et al, 2002; Musson et al, 1994). However, the predicted horizontal peak ground accelerations shown here are for a surface-wave magnitude (M_S) 4.0 event, equivalent to a magnitude 4.4 ML, given the relationship between M_S and ML of Marrow, (1992) and so slightly larger than the Warwick event. The empirical attenuation relations were also developed from recordings of events of M_S = 4.0 from both Europe and California and so may not be appropriate for the UK. However, one would expect the attenuation of peak ground accelerations for small events to differ from that of events large enough to cause significant damage to structures, due to the difference in both the frequency content and the duration of the highest accelerations. The average ratio between horizontal and vertical accelerations measured for the Warwick earthquake is 1.53 (the range is 0.94-2.56), though only 18 measurements with two components were determined and these are from stations at distances between 76 and 800 km (Figure 8).

6. GEOLOGICAL AND STRUCTURAL SETTING

The geology under the Warwick area (BGS, 1984, 1989; Old et al, 1987) comprises a thick sequence of Carboniferous and Permian rocks, unconformably overlain by Triassic and Jurassic rocks (Figure 9). The Carboniferous and Permian rocks are sedimentary, varying from deltaic coal measures of the Warwick coalfield, to subaerial red sandstones, marls, and fluviatile rocks. The Triassic stratigraphy is similar but becomes brackish up section eventually resulting in marine conditions towards the upper Triassic and into the Jurassic. The Carboniferous lower and middle Coal Measures unconformably overlie the Cambrian Merevale Shales.

The geologic record around Warwick reveals several periods of deformation (BGS, 1984, 1989; Old et al, 1987; Chadwick and Evans, 1995). Basement rocks, beneath the Carboniferous cover strata, are not well understood, though it is likely that major fault lines were developed or reactivated during the Caledonian tectonic events of the early Devonian. Carboniferous times were marked by extensional basin development, manifest in the Warwick area as sequences of upper-Carboniferous post-rift strata. Basin inversion occurred after deposition of the Enville Group (the end- Carboniferous Variscan events) with localised fault reversals and associated folding. Subsequent regional erosion led to development of the sub-Triassic unconformity. Triassic through early Cretaceous times were marked by renewed extensional basin formation. Subsequent to this, the major structural events are likely to have been related to Cenozoic basin inversion, though hard evidence of this is lacking in the Warwick area.

The Knowle basin and also the Worcester basin further to the west were both formed as a result of roughly E-W directed Permo-Triassic extension (Andy Chadwick, BGS, written communication, 2000). The major Permo-Triassic basin-bounding faults lie within the hanging-wall blocks of underlying Variscan thrusts and were probably formed by reactivation of these older structures (Chadwick and Evans, 1995). A series of Permo-Triassic and younger, N-S and NW-SE-striking normal faults crosscut the region. Some of these are associated with the Meriden fault, which lies to the west of Warwick and marks the eastern boundary of the Knowle basin and the western edge of the Warwickshire coalfield.

The structural development of the region appears to have been influenced by basement structural trends that have been periodically reactivated through the geologic record and under different tectonic regimes. Some N-S basement structural trends in the region are thought to date back to the Precambrian (Pharoah et al 1987) and were thus also reactivated during Variscan times. Faulting continued into the Jurassic and Cretaceous, resulting in a few NW-SE-oriented faults which also cut lower Jurassic rocks, such as the Whitnash and Princethorpe faults (Figure 9).

The preliminary instrumental location of the Warwick earthquake places it just west of the W-dipping Warwick fault (Figure 9) which along with other parallel faults form part of a series of Permo-Triassic and younger, steeply-dipping normal faults, with either approximate N-S or NW-SE strike. The depth of the Warwick earthquake of 14.4 km is not particularly well constrained because the closest seismograph station to record the earthquake was 40 km away. Location errors are of the order of 1 km horizontally and 7.5 km in depth, indicating that the proximity to the Warwick fault does not necessarily indicate it as the source structure. The preliminary focal mechanism indicates almost pure normal faulting on a NW-SE oriented plane, dipping either to the NE or to the SW. The style and orientation of the focal mechanism (Figure 4) is more consistent with the NW-trending W-dipping Whitnash fault that lies about 5km to the east of the earthquake epicentre. Equally likely, the Warwick earthquake may have occurred on an unidentified buried fault. Seismic lines from the Worcester basin (Chadwick and Evans, 1995) reveal many such buried faults. The minimum compressive stress direction derived from the focal mechanism is consistent with the regional minimum horizontal stress being oriented NE-SW as determined from borehole breakouts and from other focal mechanisms (Brereton and Evans 1987; Marrow and Walker, 1988; Ritchie and Walker, 1991; Marrow and Henni, 1994). The maximum horizontal stress (intermediate stress axis) is oriented NW-SE and is consistent with the regional NW-SE compression which is thought to result from the ridge-push force from the mid-Atlantic ridge to the north and west and the northward-collision of Africa into Europe to the south.

7. INSTRUMENTAL SEISMICITY AND ANALYSIS OF DEPENDENT EVENTS

The area around Warwick has experienced few earthquakes, though historically, similar-sized events have occurred some 50 km from this event (Figure 1 and Section 8). There have only been 7 events within 20 km of the Warwick earthquake in the last 30 years of instrumental monitoring, the largest, with a magnitude of 3.0 ML, occurred 17 km to the SW (Figure 1) near Stratford-Upon-Avon. When analyzing the instrumental record, the uniformity of seismographic coverage for the UK must be taken into account, since the station distribution has been gradually developed over a period of 30 years.

Southern Britain has not experienced uniform seismographic coverage with time over the instrumental period (since 1970). In the 1970s, only the network around Edinburgh (LOWNET) was operational, and so during this period, only events of about magnitude 3.0 ML and over would have been uniformly detected under average noise conditions. However, an event of this size would almost certainly have been felt and thus recorded in the catalogue. Since about 1980, earthquakes of 2.5 ML and larger should have been uniformly detected in southern Britain, because of the installation of additional stations in England and Wales. From 1995, earthquakes as small as magnitude 1.5 ML should have been uniformly detected (under average noise conditions), due to a further expansion of the network. Figure 10 illustrates historical and instrumental events of magnitude 3.0 ML and over prior to 1980, and events of magnitude 2.0 ML and over since 1980. Seismic activity is much higher to the north and west of the Warwick event , and lower to the south and east. A plot of only instrumental earthquakes of magnitude 1.5 ML and larger since 1995 (Figure 11) also illustrates the same general pattern, though many of the events in the Midlands are coal-mining related and not tectonic in origin.

The Warwick earthquake therefore appears to be located at a boundary between the more seismically active region to the north and west and a less active region to the south and east. This change in seismic activity could be related to southernmost edge of the last large glacial ice sheet to cover Britain (about 18,000 years before present) and so related to post-glacial relaxation. It might also be related to a change in the basement structural grain with faults to the south not being favourably oriented to the current stress conditions, or it could reflect some other change in the nature of the basement, the aseismic region defined by the London-Brabant platform. Another alternative explanation is that it marks the edge of a region of hot mantle to the north, which lies beneath the majority of the British Isles, and has only been observed in recent tomographic studies (Goes and Govers, 2000; Marquering and Sneider, 1996). The effects of an elevated mantle temperature beneath the UK on its uplift history and on its relation to seismicity in the UK are discussed in Bott and Bott (2002).

The Warwick earthquake did not have any foreshocks or aftershocks and occurs in a region of low seismicity. Other events in the UK instrumental catalogue of similar size are investigated to determine typical foreshock and aftershock activity. The historical record is difficult to analyze in this manner since small aftershocks may not have been felt and thus not reported. The instrumental record, however, can provide additional evidence of dependent events that are too small to be felt. Table 6 summarizes all the instrumental events in the UK of magnitude 4.0 ML and larger, in terms of their dependent event activity. The definition used here for a foreshock is any event occurring in the same region in the week prior to the mainshock, and an aftershock is an event occurring in the same region during the year following the mainshock. Two-thirds of the events have foreshock or aftershock activity or both. The average maximum aftershock magnitude (ML) is 1.5 units below that of the mainshock magnitude, though the difference in magnitudes varies from 0.2 to 3.6 units. Three of the earthquakes without dependent event activity occurred in the early to mid 1970s when few seismographic instruments were operational. These events may have had small dependent events that were not large enough to be felt or detected, much the same as events in the historical catalogue.

Therefore, we can conclude that, despite such a small data set, the Warwick earthquake is unusual in not having any aftershock activity compared to other UK earthquakes of similar size or larger. One explanation for this could be that the earthquake occurred along a pre-existing normal fault of favorable orientation to the current stress conditions resulting in complete stress relief. However, it is thought that aftershocks result from both dynamic and static stress changes caused by the mainshock to the surrounding rocks, and that these stress changes can trigger events on nearby faults that are close to failure. Thus another explanation for the lack of aftershocks is that the Warwick earthquake did not cause the necessary changes in the surrounding stress field to trigger other events, or there are no nearby faults that are close to failure.

8. HISTORICAL SEISMICITY

Historically, Warwick itself has not experienced any earthquakes of this size but the surrounding regions appear to be more seismically active. The largest historical events within 100 km occurred on 6 October 1863 and 17 December 1896 near Hereford with estimated magnitudes of 5.2 and 5.3 ML respectively (Figure 1). The 1863 Hereford earthquake was felt across most of England and Wales and into northern France indicating that it was quite large (similar to the felt area of the 1984 Lleyn Peninsula event), though no significant damage was reported (Musson, 1994). The maximum intensity is only 5 EMS. The 1896 Hereford earthquake, however, was also felt over a similar area, but caused extensive damage to chimneys in Hereford itself, with the worst damage occurring in villages just to the east of Hereford (Musson, 1994). A maximum intensity of 6 EMS has been assigned to this event. This event also had several substantial foreshocks (two of magnitude 4.1 ML) some hours prior to the main event, and a few weak aftershocks. The 1863 event is thought to have been deep, owing to its large felt area and lack of high intensities, whereas the 1896 event is thought to occur at a similar depth to the Warwick event.

The closest historical earthquake to Warwick (about 25 km to the north) was the 31 January 1888 Birmingham event with a magnitude of 3.2 ML. Several similar-sized events to the Warwick earthquake are reported in the historical record about 40 to 50 km from Warwick. These include; the 4.1 ML earthquake at Tewksbury on 21 December 1768, about 45 km to the SW; the 4.0 ML (instrumental magnitude) Walsall earthquake on 9 July 1937, 40 km to the NW; and the 4.0 ML Coalville earthquake on 14 July 1940, about 50 km to the NNE (Figure 1). Musson (1994) believes the magnitude of the 1937 Walsall earthquake to be much lower (~3.0 ML) based on macroseismic evidence and suggests that this might have been a shallow collapse event producing large surface waves. This would explain the high instrumental magnitude but very small felt area, which is commonly observed for shallow mining-induced events (Musson, 1994). The event near Coalville could also be mining related but not much is known about this event.

9. MACROSEISMIC STUDY

Initial reports suggested that the Warwick earthquake had been felt over a wide part of the Midlands and surrounding area, and into Wales. A macroseismic survey was completed using the BGS methodology described in Musson and Henni (1999). Questionnaires were placed in many regional and local newspapers giving extensive coverage over the felt area. Additionally, an electronic questionnaire was made available on the main BGS web site, and on the BBC news site from which 400 e-mailed responses were received, the most for any UK earthquake so far.

The total number of usable replies was 2,460, of which 2,299 were positive and 161 were negative. From the larger settlements sufficient replies were received to allow the assignment of intensities, but many small hamlets and isolated farms contributed single questionnaires, from which it was more difficult to establish reliable values. The total number of places from which replies were received was 283 (after amalgamating replies from very close settlements less than 2 km apart). The large number of replies received is partly a function of the strength of shaking in the most affected area, but is also influenced by the fact that the shock occurred in the heart of the English Midlands, a well-populated area.

The highest intensity experienced was 5 EMS, which was observed quite widely over an area around and south of Coventry, and east of Stratford-Upon-Avon (Figures 12 and 13). In this area, there were many intensity 4 and 5 observations, and some borderline cases. Intensity 5 EMS was generally distinguished by an increased number of reports of objects thrown down, a greater level of alarm, and a greater tendency for the shaking to be described as strong. Objects thrown down included a large vase of flowers, books thrown from shelves, tools from hooks and a clock thrown off a wall. In a number of cases alarms were set off, and in one case at Claybrooke the automatic fuel cut-out in a car (designed to operate in case of a collision to stop engine fires) was triggered. This last occurrence is something of a novelty in macroseismics (such devices being quite recent in manufacture) but evidence of quite strong shaking. In some places (e.g. Daventry) the shock was perceptible out of doors, though the time of day that the event occurred (05:25 BST) meant that few potential observers were outside. There were no reports of people running outside in fright, though some people did go and investigate. Animals (pets, cage birds, horses) were alarmed in many cases. A very common report was the creaking of house joists.

No serious damage was reported. The following excerpts from the macroseismic survey give some idea of the types of minor damage that occurred:

> Coventry South East - "… cement pointing fell out of roof - not there day before …"
>
> Daventry - "… some plaster fell off ceiling above front door …"
>
> Kenilworth - "…cracked cast iron downpipe at the rear of the house … ceiling cracks enlarged … one or two new cracks in internal plaster …"
>
> Nuneaton East - "… plaster fell from wall … damage to window pane … the window cracked …"
>
> Rugby North East - "… ridge tiles shifted …"
>
> Rugby South West - "… some broken china and a fallen roof tile …"

The most distant reports were from Hay-on-Wye and Builth Wells in the west, some 120 km away, Witnesham (near Ipswich) to the east, a distance of just under 200 km, Wakefield to the north, at around 150 km away and Winchester to the south, at about 150 km away. The total felt area is over 51,300 km^2 (Isoseismal 2), as shown in Table 7.

The distribution of intensity points and isoseismals is shown in Figure 12, with an inset map of the epicentral area shown as Figure 13. Isoseismals can be drawn for intensity 5, 4, 3 and 2 EMS. As is usual, not many places can be assigned an unqualified intensity 2 observation. But the scarcity of reports from heavily populated areas such as South Yorkshire and the Thames Valley indicates that the intensity was generally 2 in these areas. The isoseismals show an elongation in the NE-SW azimuth, especially those for intensity 3 and 4. The areas within each isoseismal (rounded to the nearest 100 km^2) are shown in Table 7.

Macroseismic parameters were calculated according to the procedures described in Musson (1996). The magnitude was calculated to be 4.1 ML from both the 3 and 4 isoseismal. The macroseismic depth is around 12-13 km. These values (for both magnitude and depth) are within the error margins of the instrumental determinations, showing that both methods of calculation are in good agreement.

10. CONCLUSIONS AND DISCUSSION

The Warwick earthquake with a magnitude of 4.2 ML, was the largest earthquake in the UK since the 1990 Bishop's Castle earthquake (5.1 ML). It occurred in a region that has not experienced many local earthquakes, though several similar-sized historical earthquakes have occurred in the surrounding regions, 40-50 km away. This earthquake appears to lie at a transition zone between a seismically active region to the north and west (Midlands and Welsh borderlands), and a less active region to the south and east. This transition is evident in both the instrumental and the historical record. In the Midlands to the north, several earthquakes appear to be associated with coal-mining, however more detailed studies (for example, Lovell et al, 1997) reveal that some of the events were also of tectonic origin, since they occurred at greater depths than typical coal-mining related activity and had no mid-week peak of activity. This transition zone might reflect the southern extent of the last large glacial ice-sheet or could be related to some other phenomena, such as a change in the structural grain of the basement or the edge of a region underlain by hot mantle.

The Warwick earthquake did not have any foreshocks or aftershocks, which could indicate complete stress release along the fault, being favorably oriented with respect to the current stress conditions. An investigation into the foreshock and aftershock activity for events with magnitudes = 4.0 ML in southern Britain indicates that this is unusual. About two thirds of the events have at least one aftershock and the other three events with no aftershocks all occurred in the early to mid 1970s when few instruments were recording in the area. Small events, such as ones similar in size to the aftershocks of the Bishops Castle event (the largest had a magnitude of 1.5 ML), could have been missed at this time, not being large enough to be recorded or reported as felt. One of the large historical earthquakes around Hereford (1896, 5.3 ML) had significant foreshock and some weak aftershock activity reported. Another explanation for the lack of aftershock activity could be that the earthquake did not produce large enough stress changes in the surrounding rocks to trigger any events on nearby faults that might be close to failure, or that there were no faults nearby close to failure.

The Warwick earthquake occurred close to the Warwick and the Whitnash faults, two Permo-Triassic or younger faults associated with the Meriden fault which marks the eastern edge of the Knowle basin that lies to the west of Warwick. The Meriden fault occurs along a structural weakness, which appears to have been reactivated throughout geologic history under different tectonic environments. The focal mechanism indicates normal faulting on a NW-trending fault plane, either dipping to the NE or SW. The SW dipping plane is consistent with the strike and dip of the Whitnash fault, 3 km east of the epicentre. The epicentral location is well constrained, but the depth is not, and could be between 6.9 and 21.9 km (1 sd). The calculated depth of 14.4 km, however, appears reasonable and is also consistent with macroseismically-determined source parameters. This earthquake, however, cannot be definitively associated with the Whitnash fault, since many similarly oriented buried faults may exist such as those revealed on seismic lines in the nearby Worcester basin. This earthquake could easily have occurred on a buried fault.

The T-axis determined from the focal mechanism is oriented NE-SW, consistent with horizontal minimum stresses determined from borehole breakouts (Brereton and Evans 1987) and other UK focal mechanisms (Brian Baptie, unpublished work; Ritchie and Walker, 1991; Marrow and Henni, 1994;

Marrow and Walker, 1988). The P-axis is vertical, but the maximum horizontal stress (the intermediate stress of this focal mechanism) is consistent with NW-directed compression. This regional compression is also evident in borehole breakouts (Brereton and Evans 1987) and other focal mechanisms and results from the SE-directed ridge-push force at the Mid-Atlantic ridge and from the NW-ward collision of Africa into Europe (Ritchie and Walker, 1991). This earthquake appears to be a result of reactivation of an older SW-dipping fault that is favourably oriented under the current stress field.

The earthquake was felt over a large area (~50,000 km^2) and a macroseismic map was constructed from the responses to the macroseismic survey. The macroseismic epicentre is about 10 km to the ENE from the instrumental one, but this may be affected by underlying geologic deposits, the source mechanism, and possibly directivity of slip along the fault plane. There is a NE-SW elongation observed in the isoseismal lines, which might result from the radiation pattern of this earthquake. The fault is normal faulting with the P-wave nodal planes (therefore shear-wave maximum) along the focal planes. This would result in larger shear-wave amplitudes in the NE-SW direction.

Recorded ground accelerations from the Warwick earthquake are less than the predicted empirical relations used for UK seismic hazard studies, at least for distances greater than 76 km. This has been observed for other UK earthquakes (Musson et al, 1994; Bott et al, 2002). Three 3-component sets of ground accelerations were recorded for this earthquake on the BGS strong motion accelerometers, the maximum horizontal acceleration being 20.8 mm/sec^2 at a distance of 76 km. In addition, horizontal and vertical peak ground accelerations were measured from all unsaturated velocity instruments by differentiation and removal of the instrument response. These provide a basis from which an empirical attenuation relation for the UK might be determined in the future. The average ratio between horizontal to vertical ground motions was found to be about 1.5, at distances greater than 76 km.

11. ACKNOWLEDGEMENTS

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12. REFERENCES

Ambraseys, N.N., and J.J. Bommer, 1991, The attenuation of ground acceleration in Europe, Earthquake engineering and Structural Dynamics, v. 20, p. 1179-1202.

Asumpcao, M., and Bamford, D., 1978, LIPSB-V. Studies of crustal shear waves, Geophysical Journal of the Royal Astronomical Society, v. 54, p. 61-63.

Bamford, D., Faber, S., Jacob, B., Kaminski, W., Nunn, K., Prodehl, D., Fuchs, K., King, R., and Willmore, P., 1976, A lithosphere seismic profile in Britain-I, Preliminary results, Geophysical Journal of the Royal Astronomical Society, v. 44, p. 145-160.

Bamford, D., Nunn, K., Prodehl, C., and Jacob, B., 1978, LISPB-IV, Crustal structure of northern Britain, Geophysical Journal of the Royal Astronomical Society, v. 54, p 43-60.

British Geological Survey, 1984, Warwick, England and Wales, Sheet 184, 1:50,000 geologic map series.

British Geological Survey, 1989, Redditch, England and Wales, Sheet 183, 1:50,000 geologic map series.

Bott, J.D.J., Henni, P.H.O., and Ford, G.D., 2001, The 4.0 ML Arran earthquake of 4 March 1999, British Geological Survey non-propr ietry commercial report CR/01/120N.

Bott, M.H.P., and Bott, J.D.J., 2002, The Cenozoic uplift and earthquake belt of mainland Britain as a response to an underlying hot, low density upper mantle, report in preparation.

Brereton, N.R. and Evans, C.J., 1987. Rock stress orientations in the UK from borehole breakouts. Report of the Regional Geophysics Research Group, British Geological Survey, Report RG 87/14.

Brune, J.N., 1970. Tectonic stress and the spectra of seismic shear waves from earthquakes. Journal of Geophysical Research, Vol 75, 4997-5009.

Chadwick, R.A., and C.J. Evans, 1995, The timing and direction of Permo-Triassic extension in southern Britain, in Boldy, S.A.R (ed.), Permian and Triassic rifting in Northwest Europe, Geological Society Special Publication No. 91, pp 161-192.

Dahle, A., Bungum, H., and L.B. Kvamme, 1990, Attenuation models inferred from intraplate earthquake recordings, Earthquake Engineering and Structural Dynamics, v. 19, p. 1125-1141.

Grünthal, G., (ed.), 1998. "European Macroseismic Scale 1998", Cahiers du Centre Européen de Géodynamique et de Séismologie, Volume 15, Luxembourg.

Goes, S., and R. Govers, 2000, Shallow mantle temperatures under Europe from P and S wave tomography, Journal of Geophysical Research, c. 105, p. 11,153-11,169.

Kisslinger, C., 1980. Evaluation of S to P amplitude ratios for determining focal mechanisms from regional network observations. Bull.Seism.Soc.Amer., 70, No 4, 999-1014.

Lee, W. and Lahr, J., 1975. HYPO'71 (revised). A computer program for determining hypocentre, magnitude and first motion pattern of local earthquakes, *Open File Rep. U.S. Geol.Surv.* ***75.***

Lovell, J.H., Henni, P.H.O., Ford, G.D., Baker, C., Stimpson, I.G., and Pettitt, W., 1997, Recent seismicity in the Stoke-on-Trent area, Staffordshire, BGS Technical Report WL/97/27.

McKenzie, D.P., 1969. The relationship between fault plane solutions for earthquakes and the directions of the principal stresses. Bull. Seismol. Soc. Am., 59. 591-601

Marquering, H., and R. Sneider, 1996, Shear-wave velocity structure beneath Europe, the northeastern Atlantic and western Asia from waveform inversions including surface-wave mode coupling, Geophysical Journal International, v. 127, p. 283-304.

Marrow, P.C., 1992. UK earthquake magnitudes: A comparison of methods and published results. Brit.Geol.Surv.Glob.Seism., Report No WL/92/36.

Marrow, P.C., and Walker, A.B., 1988. The Lleyn earthquake of 1984 July 19: Aftershock sequence and focal mechanism, Geophys.J., 92:3, 487-493.

Marrow, P.C., and Henni, P.H.O., 1994. Earthquake focal mechanisms and crustal stress in the UK. Brit.Geol.Surv.Glob.Seism., Report No WL/94/37.

Musson, R.M.W., Marrow, P.C., and Winter, P.W., 1994, Attenuation of earthquake ground motion in the UK, report submitted to AEA Technology Consultancy Services (SRD).

Musson, R.M.W., 1996. Determination of parameters for historical British earthquakes, Annali di Geofisica, vol 39, no 5, pp 1041-1048.

Musson, R.M.W. and Henni, P.H.O., 1999. From questionnaires to intensities – Assessing free-form macroseismic data in the UK, Phys. Chem. Earth (A), vol 24 no 6, pp 511-515.

Old. R.A., Sumbler, M.G., and K. Ambrose, 1987, Geology of the country around Warwick, Memoir of the British Geological Survey, Sheet 184 (England and Wales).

Pharaoah, T.C., Webb, P., Thrope, R.S., Beckinsale, R.D., 1987, Geochemical evidence for the tectonic setting of late Proterozoic volcanic suites in the central UK, in Pharoah, T.C., Beckinsale, R.D., Rickard, D.T., (eds.), Geochemistry and mineralisation of Proterozoic volcanic suites, Geological Society of London Special Publication 33, p. 541-552.

Principia Mechanica Limited, 1982, British Earthquakes, volume 1, An analysis of British Earthquakes, Report No. 115/82, June 1982.

Ritchie, M.E.A., and Walker, A.B., 1991. Focal mechanisms and the determination of stress directions in western Britain, Brit.Geol.Surv.Glob.Seism., Report No WL/91/22.

Shaw, B.E., 1993, Generalized Omori law for aftershocks and foreshocks from a simple dynamics, Geophysical Research Letters, v. 20, p. 907-910.

Snoke, J.A., Munsey, J.W., Teague, A.G. and Bollinger, G.A., 1984. A program for focal mechanism determination by combined use of polarity and Sv/P amplitude ratio data, Earthquake Notes, 55, 15.

TABLE 1
INPUT DATA FOR THE HYPO71 LOCATION PROGRAM

```
HEAD
RESET TEST( 3)=  0.500

  SSW 5158.00N 98 9.01E 291
  CWF 5244.31N 9841.54E 203
  HAE 52 2.21N 9727.40E 260
  KEY 5252.67N 9855.46E  59
  KEY25252.74N 9855.38E  76
  SKP 5143.31N 9911.42E 212
  KTG 5219.58N 9935.89E  83
  SWN 5130.82N 9811.96E 192
  HLM 5231.10N 97 7.16E 429
  KUF 5237.02N 9936.56E  38
  MCH 5159.84N 97 0.10E 219
  HBL252 3.05N 9657.81E 437
  SSP 5225.06N 9653.29E 428
  HEA 5121.50N 9844.17E 100
  HGH 5138.27N 9711.66E 223
  KBI 5315.26N 9828.33E 272
  WOL 5118.77N 9846.63E 158
  HTR 52 4.71N 9643.93E 337
  SWK 51 8.90N 9745.17E 266
  LLW 5250.95N 9620.10E 213
  SCK 5252.78N10045.04E  61
  MMY 5410.56N 98 7.86E 427
  BHM 5112.78N10110.44E 100

  4.000  0.000
  5.900  2.520
  6.450  7.550
  7.000 18.870
  8.000 34.150

  10.  80. 105. 1.73    4    1                        1 1111
SSW IPU  000923042352.81
CWF IPU  000923042355.21       62.00ES 2
HAE IPU  000923042357.29
KEY IPU  000923042358.86
KEY2EP 4 000923042358.88
SKP EP 2 000923042359.25
KTG EP 3 000923042359.33
SWN EP 4 0009230424 0.29       10.78ES 2
HLM IPU  0009230424 0.55
KUF IPU  0009230424 0.65
MCH IPU  0009230424 1.92       13.60ES 2
HBL2EP 4 0009230424 2.25
SSP IPU  0009230424 2.70       14.95ES 2
HEA IPU4 000923042402.68
HGH IPU  0009230424 3.31
KBI IPU1 0009230424 3.68
WOL IPU4 000923042403.49
HTR IPU  0009230424 4.23
SWK IPU1 0009230424 7.45
LLW IPD4 000923042410.20
```

SCK IPU4 000923042413.00
MMY IPU4 000923042417.19
BHM IPD4 000923042420.86

TABLE 2a
OUTPUT FILE FROM HYPO71 LOCATION PROGRAM

```
Date         : 23/ 9/00
Origin time :  4:23:45.83
Epicentre    : 52-16.83 deg N   1-36.63 deg W   (  52.2805 /   -1.6105 )
Grid ref     :   426.570 East /  264.821 North
Depth        :   14.42 kms
Quality      : C B*C

               NO DM GAP M  RMS  ERH  ERZ
Statistics  : 14 39  95 1 0.21  1.0  1.5
Magnitude    :  4.2 ML     (from  6 readings)
Magnitude    : No valid coda readings
```

STN	DIST	AZM	AIN	P-RES	P-WT	S-RES	S-WT
SSW	38.6	205	104	0.02	3.20		
CWF	55.0	22	99	-0.06	2.14	-0.17	1.06
HAE	69.3	247	97	-0.19	1.06		
KEY	75.7	29	96	0.40	1.87		
KTG	82.6	86	96	-0.20	0.47		
SKP	83.0	138	96	-0.34	0.86		
SWN	86.3	189	67	0.21	0.00	0.29	1.15
HLM	90.4	287	67	-0.12	0.62		
KUF	91.1	66	67	-0.11	1.19		
MCH	100.2	252	67	-0.14	0.20	-0.32	0.10
HBL2	100.8	255	67	0.10	0.00		
SSP	103.5	278	67	0.16	0.06	0.20	0.03

TABLE 2b
INDIVIDUAL MAGNITUDES CALCULATED FOR EACH STATION

STATION		MAGNITUDE
KEY2	:	4.4 ML
KEY2	:	4.6 ML
SWN	:	4.0 ML
SWN	:	4.1 ML
HBL2	:	4.2 ML
HBL2	:	4.1 ML

TABLE 3

DEPTH / CRUSTAL VELOCITY MODEL USED IN THE WARWICK EARTHQUAKE LOCATION

Depth to top of layer (km)	P-wave velocity (km/sec)	Vp/Vs
0.00	4.00	1.73
2.52	5.90	
7.55	6.45	
18.87	7.00	
34.15	8.00	

TABLE 4
ERROR DIAGNOSTICS: 50 PERTURBED HYPOCENTRES

The initial epicentre, using a trial depth of 10.00 km
was 4:23:45.83 426.57 km E, 264.82 km N Depth 14.42 km

Subsequent epicentres.....

Origin time	kmE	kmN	Depth	Epicentre change(km)	Depth change(km)
4:23:45.47	426.25	264.99	0.32	0.36	-14.10
4:23:45.59	426.68	264.54	17.44	0.30	3.02
4:23:45.85	425.62	265.60	7.24	1.22	-7.18
4:23:45.91	425.79	265.43	0.26	0.99	-14.16
4:23:45.42	426.68	264.88	17.36	0.13	2.94
4:23:45.87	426.28	265.06	14.17	0.37	-0.25
4:23:45.72	427.02	268.88	15.09	4.09	0.67
4:23:45.12	426.52	264.36	22.67	0.47	8.25
4:23:45.65	426.59	265.10	10.64	0.28	-3.78
4:23:45.66	426.39	265.28	5.31	0.50	-9.11
4:23:45.67	426.03	265.19	2.27	0.65	-12.15
4:23:45.51	426.57	265.04	15.38	0.22	0.96
4:23:45.32	426.48	264.64	19.39	0.21	4.97
4:23:45.87	425.89	265.04	20.15	0.72	5.73
4:23:45.51	427.47	264.47	7.75	0.96	-6.67
4:23:45.94	427.02	265.08	7.66	0.52	-6.76
4:23:45.77	426.68	265.12	11.24	0.32	-3.18
4:23:45.39	425.65	263.67	2.98	1.47	-11.44
4:23:45.33	426.71	264.82	16.29	0.14	1.87
4:23:45.72	425.89	265.02	1.58	0.71	-12.84
4:23:45.81	426.41	266.92	10.89	2.10	-3.53
4:23:45.62	426.75	264.84	13.68	0.18	-0.74
4:23:45.82	426.83	264.77	11.15	0.27	-3.27
4:23:46.30	425.99	264.86	10.00	0.58	-4.42
4:23:45.87	425.88	265.02	0.77	0.72	-13.65
4:23:45.94	426.52	264.69	10.00	0.14	-4.42
4:23:45.45	426.63	264.99	16.39	0.18	1.97
4:23:46.09	426.06	265.11	10.00	0.59	-4.42
4:23:46.12	427.55	263.95	19.73	1.31	5.31
4:23:45.78	426.35	265.08	6.56	0.34	-7.86
4:23:44.81	426.52	264.21	23.27	0.61	8.85
4:23:45.11	426.77	265.03	18.29	0.29	3.87
4:23:45.87	427.82	264.31	10.13	1.35	-4.29
4:23:45.87	426.13	265.32	0.55	0.66	-13.87
4:23:45.71	426.75	264.58	13.27	0.30	-1.15
4:23:45.53	425.89	265.10	1.59	0.74	-12.83
4:23:44.69	426.54	264.30	25.27	0.52	10.85
4:23:44.63	427.19	263.97	24.65	1.05	10.23
4:23:45.49	426.73	265.01	16.11	0.24	1.69
4:23:45.84	426.01	265.06	10.00	0.61	-4.42
4:23:44.31	425.49	264.43	14.88	1.15	0.46
4:23:45.80	425.48	265.26	1.20	1.18	-13.22
4:23:45.36	426.35	264.84	0.30	0.22	-14.12
4:23:45.54	426.53	265.34	8.83	0.52	-5.59
4:23:44.97	425.99	265.36	17.58	0.79	3.16
4:23:46.00	426.43	264.89	11.79	0.16	-2.63
4:23:44.91	426.51	264.75	20.21	0.09	5.79
4:23:45.61	425.76	265.23	0.72	0.91	-13.70
4:23:45.76	426.43	265.21	9.38	0.41	-5.04
4:23:45.91	426.90	264.73	9.91	0.34	-4.51

Epicentre standard deviation = 0.93 km

Depth   standard deviation =   7.53 km

TABLE 5

PEAK GROUND ACCELERATIONS MEASURED ON STRONG MOTION INSTRUMENTS FOR THE WARWICK EARTHQUAKE

STATION	DISTANCE (KM)	VERTICAL ACCELERATION (mm/sec^2)	N-S HORIZONTAL ACCELERATION (mm/sec^2)	E-W HORIZONTAL ACCELERATION (mm/sec^2)
KEY2	76	17.2	16.6	20.8
SWN	87	7.1	5.5	6.6
HBL2	101	5.0	7.1	5.5

TABLE 6

DEPENDENT EVENTS FOR UK EARTHQUAKES OF MAGNITUDE = 4.0 ML (1970-DATE)

Date	Location	Magnitude (ML)	Depth (km)	Number of Foreshocks§	Number of Aftershocks*	Magnitude of largest AS or FS
9/8/1970	Kirby Stephen	4.1	20.9	-	-	-
7/3/1972	Todmorden	4.0	6.0	-	-	-
25/2/1974	Newport	4.1	0.1	1	1	3.9 (FS)
6/8/1974	Kintail	4.4	22.0	7	18	4.0 (FS)
3/11/1976	Widnes	4.5	2.0	-	-	-
26/12/1979	Longtown	4.7	4.5	-	75	3.8 (2 AS's)
19/7/1984	Lleyn Peninsula	5.4	20.7	-	82	4.3 (AS)
29/9/1986	Oban	4.1	23.3	2	8	1.7 (FS)
2/4/1990	Bishops Castle	5.1	14.1	-	6	1.5 (AS)
15/2/1994	Norwich	4.0	7.3	-	1	2.8 (AS)
4/3/1999	Arran	4.0	19.0	-	2	1.6 (AS)
23/9/2000	Warwick	4.2	13.1	-	-	-

§ Within the week preceding the event

* Within 1 year following the event

TABLE 7

MACROSEISMIC RESULTS

Isoseismal (EMS)	*Area (km^2)*
2	51,300
3	14,900
4	4,700
5	700

Macroseismic magnitude	4.1 (A_3), 4.1 (A_4) (instrumental 4.2 ML)
Macroseismic depth (km)	12-13 (instrumental 14.4 km)
Maximum intensity (I_{max})	5 EMS (Warwick, Royal Leamington Spa and Stratford-Upon-Avon)

Placename	Grid East	Grid North	Intensity	Longitude	Latitude	TOTAL RESPONSES	Positive Responses	Negative Responses	VIBRATION FELT TOTAL	FELT STRONGLY	MOD - UNSPEC	FELT WEAKLY	NOT FELT	NOISE HEARD TOTAL	LOUD NOISE	MOD - UNSPEC	SOFT NOISE	NOT HEARD	FELT - HEARD BY OTHERS	SELF ALARMED	OTHERS ALARMED	WINDOWS RATTLE	WINDOWS DO NOT RATTLE	OBJECTS RATTLE	OBJECTS DO NOT RATTLE	HANGING - SWING	OBJECTS UPSET	OBJECTS ARE NOT UPSET	DAMAGE - B1	DAMAGE - B2
Abingdon	451.000	198.000	F	-1.262	51.678	2	1	1	1	0	1	0	1	1	0	1	0	1	1	0	0	0	0	0	1	0	0	1	0	0
Alcester	409.000	257.000	4	-1.868	52.211	19	19	0	14	0	14	0	3	13	2	11	0	3	9	1	1	5	8	5	8	0	1	14	1	0
Alvechurch	402.000	273.000	3-4	-1.971	52.355	4	4	0	3	0	3	0	1	2	0	2	0	1	0	0	0	1	3	1	2	0	0	4	0	0
Alvescot	428.000	206.000	F	-1.594	51.752	2	2	0	1	0	1	0	1	1	0	1	0	1	1	0	0	0	2	0	2	0	1	1	0	0
Ampthill	503.000	238.000	F	-0.498	52.030	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
Anstey	455.000	309.000	F	-1.186	52.676	2	2	0	1	0	0	1	1	2	0	2	0	0	0	0	0	1	0	2	0	1	0	2	0	0
Ansty	440.000	284.000	F	-1.411	52.452	2	2	0	2	0	2	0	0	0	0	0	0	1	0	1	1	0	1	0	1	0	0	1	0	0
Ardley	453.000	226.000	F	-1.229	51.930	2	2	0	1	0	1	0	0	1	0	1	0	0	2	0	0	0	0	1	0	0	1	1	0	0
Ash Green	434.000	285.000	4	-1.500	52.462	6	6	0	5	1	4	0	1	4	1	3	0	0	1	2	0	3	3	3	3	0	0	6	0	0
Ashby-de-la-Zouch	436.000	314.000	3	-1.467	52.722	4	4	0	2	1	1	0	1	3	0	3	0	0	1	1	0	0	3	0	3	0	0	4	0	0
Aslacton	616.000	289.000	1	1.179	52.456	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
Astwood Bank	403.000	262.000	3	-1.956	52.256	7	7	0	5	0	5	0	2	5	0	5	0	1	1	0	0	1	5	1	5	0	0	6	0	0
Atherstone	431.000	298.000	4	-1.542	52.579	9	9	0	6	1	5	0	2	3	1	2	0	4	3	2	1	2	3	2	5	0	0	8	0	0
Avening	388.000	198.000	1	-2.174	51.680	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0
Aylesbury	484.000	208.000	1	-0.783	51.764	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Badby	457.000	260.000	4	-1.165	52.235	17	17	0	14	0	14	0	3	14	4	9	1	1	8	6	6	5	10	1	10	1	5	11	0	0
Badsey	407.000	243.000	F	-1.898	52.085	1	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Balsall Common	424.000	279.000	3-4	-1.647	52.408	10	9	1	4	0	3	1	6	5	0	5	0	2	0	0	0	2	5	2	3	0	0	5	0	0
Banbury	445.000	240.000	4-5	-1.344	52.056	40	36	4	36	3	33	0	4	22	4	15	3	8	13	6	5	11	18	8	15	2	3	31	0	0
Barby	455.000	271.000	4-5	-1.193	52.334	6	6	0	4	1	3	0	0	4	1	3	0	1	3	0	0	5	0	2	2	1	1	3	0	0
Barrow upon Soar	456.000	317.000	4	-1.170	52.747	8	8	0	7	0	6	1	0	7	2	4	1	0	2	1	0	2	4	4	4	0	1	7	0	0
Bath	375.000	165.000	F	-2.359	51.383	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
Bedworth	436.000	287.000	4	-1.470	52.479	8	8	0	8	2	5	1	0	10	1	5	4	1	3	2	0	3	3	0	6	0	0	6	0	0
Birmingham - Bourneville	404.000	281.000	3-4	-1.941	52.427	6	6	0	6	0	6	0	0	6	0	6	0	0	3	0	0	2	2	2	2	0	0	6	0	0
Birmingham - Bromford	413.000	290.000	3	-1.808	52.507	9	5	4	2	2	0	0	6	2	2	0	0	3	1	1	0	3	3	3	2	0	0	5	0	0
Birmingham - Fordbridge	417.000	287.000	3-4	-1.750	52.480	3	3	0	3	0	3	0	0	1	0	1	0	1	1	0	0	1	1	1	1	0	0	3	0	0

TABLE 8 - SYNOPSIS OF RESPONSES FOR THE WARWICK EARTHQUAKE OF THE 23RD SEPTEMBER 2000

Placename	Grid East	Grid North	Intensity	Longitude	Latitude	TOTAL RESPONSES	Positive Responses	Negative Responses	VIBRATION FELT TOTAL	FELT STRONGLY	MOD - UNSPEC	FELT WEAKLY	NOT FELT	NOISE HEARD TOTAL	LOUD NOISE	MOD - UNSPEC	SOFT NOISE	NOT HEARD	FELT - HEARD BY OTHERS	SELF ALARMED	OTHERS ALARMED	WINDOWS RATTLE	WINDOWS DO NOT RATTLE	OBJECTS RATTLE	OBJECTS DO NOT RATTLE	HANGING - SWING	OBJECTS UPSET	OBJECTS ARE NOT UPSET	DAMAGE - B1	DAMAGE - B2
Birmingham - Handsworth	404.000	290.000	1	-1.941	52.508	1	0	1	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Birmingham - King's Norton	405.000	279.000	3-4	-1.926	52.409	7	6	1	4	0	4	0	2	3	1	2	0	2	0	1	0	3	2	0	4	0	0	5	0	0
Birmingham - Moseley	408.000	283.000	3-4	-1.882	52.445	7	7	0	5	0	4	1	1	7	1	5	1	0	1	0	0	1	4	3	3	1	0	6	1	0
Birmingham - Olton	414.000	282.000	4	-1.794	52.435	8	8	0	6	0	5	1	0	3	1	1	1	0	2	0	0	4	2	4	2	2	3	3	0	0
Birmingham - Ridgacre	402.000	285.000	3	-1.971	52.463	3	3	0	0	0	0	0	3	2	0	2	0	0	1	1	1	1	2	0	2	0	0	3	0	0
Birmingham - Shirley	413.000	280.000	4	-1.809	52.417	30	26	4	14	0	12	2	6	17	1	13	3	3	7	1	1	10	12	6	13	1	3	19	0	0
Birmingham - Warley Woods	401.000	286.000	1	-1.985	52.472	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
Birmingham - Yardley	413.000	286.000	3-4	-1.809	52.471	9	8	1	4	1	3	0	2	5	0	5	0	2	2	1	1	1	7	0	6	0	1	7	0	0
Bishop's Itchington	441.000	257.000	5	-1.400	52.209	10	9	1	7	5	2	0	2	8	6	2	0	1	3	3	3	6	1	3	3	0	0	8	1	0
Bishop's Tachbrook	433.000	259.000	4-5	-1.517	52.228	4	4	0	4	3	1	0	0	2	1	1	0	1	3	1	1	3	0	4	0	0	0	4	0	0
Blaby	457.000	297.000	F	-1.159	52.567	2	2	0	1	0	1	0	0	1	0	1	0	0	1	0	0	1	1	1	1	0	0	2	0	0
Bladon	440.000	214.000	4	-1.420	51.823	4	4	0	4	0	4	0	0	4	1	3	0	0	1	1	0	2	2	3	1	0	0	4	0	0
Bleasby	471.000	350.000	F	-0.941	53.042	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
Blockley	418.000	232.000	4	-1.738	51.986	11	11	0	9	0	9	0	1	6	4	2	0	3	6	3	0	2	8	1	10	0	0	11	0	0
Bodicote	447.000	238.000	4	-1.315	52.038	10	10	0	9	2	7	0	1	9	2	7	0	1	5	1	1	2	6	5	1	0	0	9	0	0
Boston	532.000	344.000	1	-0.034	52.977	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
Bourton-on-the-Water	418.000	219.000	F	-1.739	51.869	2	2	0	2	0	0	2	0	1	0	0	1	1	1	0	0	0	2	0	2	0	0	2	0	0
Brackley	459.000	237.000	3-4	-1.140	52.028	4	4	0	4	0	4	0	0	2	0	2	0	2	1	0	0	0	4	2	2	0	0	4	0	0
Bracknell	484.000	170.000	F	-0.792	51.422	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
Braunston/Welton	456.000	265.000	4	-1.179	52.280	16	16	0	13	2	11	0	1	13	3	10	0	1	14	5	8	8	5	8	3	3	1	14	0	0
Bristol	361.000	171.000	2	-2.561	51.436	3	1	2	0	0	0	0	3	1	0	1	0	2	0	0	0	0	1	0	1	1	0	3	0	0
Broadway	409.000	237.000	4	-1.869	52.031	7	7	0	7	0	6	1	0	4	1	2	1	2	1	2	1	4	3	4	1	0	0	7	0	0
Bromsgrove	396.000	270.000	3	-2.059	52.328	5	4	1	1	0	1	0	3	4	1	3	0	1	0	0	0	1	2	0	1	0	1	3	0	0
Buckingham	470.000	235.000	3-4	-0.980	52.009	4	4	0	3	0	3	0	1	3	0	3	0	0	1	0	0	1	2	2	2	0	0	4	0	0
Builth Wells	313.000	246.000	F	-3.270	52.105	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0
Bulkington	440.000	287.000	4	-1.411	52.479	12	12	0	10	2	8	0	2	5	1	4	0	2	6	4	1	6	5	2	7	0	0	11	0	0
Burbage	443.000	293.000	4	-1.366	52.533	32	29	3	26	2	23	1	5	27	5	22	0	4	13	6	2	12	11	13	8	2	3	27	0	0

Placename	Grid East	Grid North	Intensity	Longitude	Latitude	TOTAL RESPONSES	Positive Responses	Negative Responses	VIBRATION FELT TOTAL	FELT STRONGLY	MOD - UNSPEC	FELT WEAKLY	NOT FELT	NOISE HEARD TOTAL	LOUD NOISE	MOD - UNSPEC	SOFT NOISE	NOT HEARD	FELT - HEARD BY OTHERS	SELF ALARMED	OTHERS ALARMED	WINDOWS RATTLE	WINDOWS DO NOT RATTLE	OBJECTS RATTLE	OBJECTS DO NOT RATTLE	HANGING - SWING	OBJECTS UPSET	OBJECTS ARE NOT UPSET	DAMAGE - B1	DAMAGE - B2
Burton Joyce	465.000	344.000	3	-1.032	52.989	5	5	0	5	0	5	0	0	1	0	1	0	4	1	1	0	0	5	0	4	0	0	5	0	0
Burton Latimer	488.000	277.000	3-4	-0.707	52.384	11	11	0	10	0	10	0	1	10	3	6	1	0	2	1	1	3	7	4	5	0	1	8	1	0
Byfield	450.000	252.000	4	-1.269	52.164	14	14	0	11	0	11	0	2	10	0	9	1	2	8	1	1	8	5	4	6	4	2	12	0	0
Calverton	461.000	349.000	F	-1.090	53.034	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	1	1	0	0	0	1	0	0
Cambridge	552.000	256.000	F	0.223	52.181	2	1	1	0	0	0	0	1	1	0	1	0	1	0	1	0	1	0	0	1	0	0	1	0	0
Castle Donnington	444.000	327.000	3	-1.347	52.838	10	9	1	7	0	4	3	1	5	0	5	0	2	2	2	2	2	4	2	4	0	0	8	0	0
Castle Douglas	277.000	562.000	1	-3.920	54.937	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Charlbury	436.000	219.000	F	-1.477	51.868	3	2	1	2	0	2	0	1	0	0	0	0	2	0	1	0	0	1	1	0	1	0	2	0	0
Cheltenham Centre	395.000	221.000	3	-2.073	51.887	5	5	0	3	0	3	0	0	2	0	2	0	3	1	1	1	1	3	2	2	0	0	5	0	0
Cheltenham East	397.000	222.000	3	-2.044	51.896	4	4	0	3	0	3	0	1	3	0	2	1	1	0	1	0	2	2	1	2	0	0	4	0	0
Cheltenham South	396.000	220.000	3-4	-2.058	51.878	6	6	0	4	0	1	3	1	4	0	2	2	0	0	0	0	2	4	0	4	0	0	6	0	0
Cheltenham West	393.000	224.000	3	-2.102	51.914	5	5	0	3	0	1	2	0	3	0	1	2	0	1	1	0	3	2	0	2	0	0	5	0	0
Chippenham	391.000	175.000	F	-2.130	51.473	1	1	0	1	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Chipping Campden	415.000	239.000	4	-1.781	52.049	8	8	0	6	0	6	0	2	7	1	6	0	1	4	2	1	3	2	3	4	0	0	8	0	0
Chipping Norton	431.000	227.000	4	-1.549	51.940	7	7	0	6	0	4	2	1	3	2	1	0	1	0	0	0	1	4	2	3	2	1	6	0	0
Churchover	451.000	279.000	4	-1.250	52.406	11	11	0	8	1	6	1	3	8	2	6	0	3	10	1	2	5	4	4	2	1	0	10	0	0
Claveron	421.000	265.000	4	-1.692	52.282	10	9	1	7	2	5	0	2	8	6	2	0	2	6	3	2	6	3	7	1	0	0	8	1	0
Claybrooke	449.000	288.000	4-5	-1.278	52.487	3	3	0	2	1	1	0	1	2	0	2	0	0	3	1	2	2	0	3	0	1	1	2	0	0
Clifton	455.000	334.000	F	-1.182	52.900	2	2	0	1	0	1	0	1	0	0	0	0	2	1	0	0	0	2	1	1	0	0	2	0	0
Clifton-upon-Dunsmore	454.000	277.000	4	-1.206	52.388	3	3	0	1	1	0	0	1	3	0	3	0	0	2	1	1	1	0	1	0	0	0	3	0	0
Coleshill	420.000	289.000	3	-1.705	52.498	7	6	1	4	0	4	0	2	3	1	2	0	3	1	1	0	0	4	1	2	1	0	5	0	0
Condicote	415.000	228.000	3-4	-1.782	51.950	3	3	0	3	0	3	0	0	2	0	2	0	1	2	0	0	1	1	1	2	0	0	3	0	0
Corley	430.000	286.000	3-4	-1.558	52.471	4	4	0	4	1	3	0	0	4	1	2	1	0	0	0	1	1	3	0	3	0	0	4	0	0
Cossington	460.000	314.000	F	-1.112	52.720	2	2	0	2	0	2	0	0	2	1	1	0	0	1	1	0	2	0	2	0	0	0	3	0	0
Costick	458.000	326.000	F	-1.139	52.828	2	2	0	2	0	1	1	0	2	0	1	1	0	0	0	0	0	1	1	1	0	0	2	0	0
Coventry Centre	434.000	279.000	5	-1.500	52.408	97	95	2	65	18	44	3	25	65	21	44	0	15	34	23	9	36	43	28	25	7	12	61	5	0
Coventry East	437.000	279.000	4	-1.456	52.407	29	28	1	17	5	12	0	9	18	4	14	0	7	10	6	3	10	16	4	11	0	2	23	1	0

Placename	Grid East	Grid North	Intensity	Longitude	Latitude	TOTAL RESPONSES	Positive Responses	Negative Responses	VIBRATION FELT TOTAL	FELT STRONGLY	MOD - UNSPEC	FELT WEAKLY	NOT FELT	NOISE HEARD TOTAL	LOUD NOISE	MOD - UNSPEC	SOFT NOISE	NOT HEARD	FELT - HEARD BY OTHERS	SELF ALARMED	OTHERS ALARMED	WINDOWS RATTLE	WINDOWS DO NOT RATTLE	OBJECTS RATTLE	OBJECTS DO NOT RATTLE	HANGING - SWING	OBJECTS UPSET	OBJECTS ARE NOT UPSET	DAMAGE - B1	DAMAGE - B2
Coventry North	433.000	283.000	5	-1.514	52.444	63	61	2	45	7	34	4	15	40	13	24	3	8	14	14	5	21	25	14	25	3	8	46	2	0
Coventry North East	436.000	281.000	5	-1.471	52.425	67	65	2	46	11	31	4	10	44	14	30	0	9	20	22	6	34	25	23	23	7	10	53	1	0
Coventry South East	435.000	277.000	5	-1.486	52.390	89	89	0	64	12	47	5	17	63	21	39	3	18	45	32	12	31	40	24	30	5	13	65	1	0
Coventry West	430.000	278.000	4-5	-1.559	52.399	30	27	3	18	2	14	2	10	0	4	13	2	5	11	10	4	9	13	12	8	0	2	23	0	0
Cropthorne	399.000	245.000	4	-2.015	52.103	7	6	1	6	0	6	0	1	2	0	2	0	2	5	1	1	4	3	2	2	0	0	6	0	0
Croughton	454.000	233.000	F	-1.213	51.992	1	1	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0	0	1	0	0
Crowle	393.000	255.000	4	-2.102	52.193	5	5	0	2	0	2	0	1	3	0	1	2	0	2	2	1	2	2	4	0	0	0	5	0	0
Daglingworth	399.000	205.000	F	-2.014	51.743	1	1	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	1	1	0	0	0	1	0	0
Daventry	457.000	263.000	5	-1.165	52.262	43	42	1	39	5	33	1	4	31	11	20	0	2	25	9	7	24	12	12	9	11	9	32	1	0
Deddington	446.000	232.000	F	-1.330	51.984	2	1	1	1	0	1	0	1	1	0	1	0	1	0	0	0	0	1	0	0	0	0	2	0	0
Deenethorpe	496.000	292.000	F	-0.585	52.517	1	1	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0
Derby North	436.000	339.000	3	-1.464	52.947	4	4	0	4	0	2	2	0	1	0	1	0	2	0	1	0	1	2	1	2	0	0	4	0	0
Derby West	432.000	333.000	3	-1.524	52.893	4	3	1	3	0	3	0	1	2	0	1	1	2	0	0	0	0	3	0	3	0	0	3	0	0
Desford	449.000	304.000	4	-1.276	52.631	6	6	0	6	1	2	3	0	5	0	3	2	0	1	0	0	1	5	3	3	0	0	6	0	0
Dorridge	417.000	276.000	4	-1.750	52.381	35	33	2	20	3	15	2	13	26	10	15	1	4	18	4	5	12	12	7	16	0	1	31	0	0
Droitwich	389.000	263.000	3	-2.161	52.265	6	6	0	5	0	5	0	0	3	0	3	0	1	2	0	2	1	3	1	3	0	0	5	0	0
Earl Shilton	446.000	297.000	4	-1.321	52.569	8	8	0	4	0	4	0	4	8	1	7	0	0	4	1	1	0	5	3	3	0	2	5	0	0
East Haddon	465.000	267.000	F	-1.047	52.297	2	2	0	1	0	1	0	0	1	0	1	0	0	1	0	0	2	0	0	0	0	0	2	0	0
Elston	476.000	348.000	F	-0.867	53.024	1	1	0	1	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0
Ely	554.000	280.000	F	0.264	52.396	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
Enstone	438.000	224.000	F	-1.447	51.913	2	2	0	2	0	2	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	2	0	0
Ettington	427.000	249.000	5	-1.605	52.138	8	8	0	7	4	3	0	1	7	1	6	0	1	4	3	3	5	1	5	1	1	1	7	0	0
Evesham	403.000	245.000	4	-1.956	52.103	7	7	0	5	0	5	0	2	7	3	4	0	0	1	1	0	4	2	2	4	0	1	4	0	0
Fenny Compton	441.000	252.000	4-5	-1.401	52.164	7	7	0	7	2	5	0	0	5	0	5	0	1	5	2	0	3	2	2	3	1	1	6	1	0
Fenny Drayton	438.000	297.000	4	-1.439	52.569	3	3	0	2	0	2	0	1	2	1	1	0	0	0	0	0	1	2	1	0	0	0	3	0	0
Filkins	422.000	207.000	1	-1.681	51.761	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Fiskerton	472.000	351.000	F	-0.926	53.051	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Placename	Grid East	Grid North	Intensity	Longitude	Latitude	TOTAL RESPONSES	Positive Responses	Negative Responses	VIBRATION FELT TOTAL	FELT STRONGLY	MOD - UNSPEC	FELT WEAKLY	NOT FELT	NOISE HEARD TOTAL	LOUD NOISE	MOD - UNSPEC	SOFT NOISE	NOT HEARD	FELT - HEARD BY OTHERS	SELF ALARMED	OTHERS ALARMED	WINDOWS RATTLE	WINDOWS DO NOT RATTLE	OBJECTS RATTLE	OBJECTS DO NOT RATTLE	HANGING - SWING	OBJECTS UPSET	OBJECTS ARE NOT UPSET	DAMAGE - B1	DAMAGE - B2
Fleckney	464.000	294.000	3-4	-1.056	52.540	3	3	0	2	0	1	1	1	3	0	3	0	0	0	0	0	1	1	1	2	0	0	3	0	0
Frome	375.000	145.000	F	-2.358	51.203	1	1	0	1	0	1	0	0	1	0	1	0	0	1	0	0	1	0	1	0	1	0	1	0	0
Gaddesby	469.000	313.000	F	-0.979	52.710	1	1	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	1	1	0	0	0	1	0	0
Glasbury	316.000	240.000	F	-3.225	52.052	1	1	0	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0
Gloucester North East	386.000	220.000	4	-2.203	51.878	9	9	0	6	0	4	2	3	4	0	1	3	2	3	3	0	7	2	4	3	0	0	8	0	0
Gloucester South	384.000	215.000	3	-2.232	51.833	4	4	0	3	0	3	0	1	4	0	4	0	0	1	2	0	0	3	1	3	0	0	4	0	0
Grandborough	449.000	266.000	4	-1.282	52.290	5	5	0	3	0	2	1	2	4	1	3	0	0	3	4	2	2	3	2	2	1	0	4	0	0
Great Oakley	487.000	286.000	F	-0.719	52.465	1	1	0	1	0	1	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	1	0	0
Great Wolford	425.000	235.000	F	-1.636	52.012	1	1	0	1	1	0	0	0	1	0	1	0	0	1	0	0	1	0	0	1	1	0	1	0	0
Groby	452.000	307.000	4	-1.231	52.658	10	9	1	6	0	5	1	4	6	1	5	0	3	2	3	0	3	5	2	5	0	0	9	1	0
Hagley	390.000	279.000	3	-2.147	52.409	5	3	2	0	0	0	0	5	3	0	2	1	1	1	0	0	0	3	0	3	0	0	4	0	0
Halford	426.000	245.000	4-5	-1.620	52.102	3	3	0	3	1	2	0	0	2	0	2	0	0	3	1	2	3	0	2	1	0	0	2	1	0
Hampton in Arden	420.000	281.000	4	-1.706	52.426	9	7	2	4	0	3	1	2	6	3	3	0	2	4	3	2	4	4	2	4	4	1	6	0	0
Hampton on the Hill	425.000	262.000	5	-1.634	52.255	36	34	2	27	6	20	1	6	27	12	15	0	6	20	8	6	15	9	12	11	3	4	27	0	0
Hannington	481.000	271.000	1	-0.811	52.331	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Harbury	438.000	260.000	4	-1.443	52.236	11	11	0	7	3	4	0	3	8	3	5	0	1	7	5	4	7	4	4	5	0	1	9	0	0
Harby	488.000	371.000	F	-0.682	53.228	1	1	0	0	0	0	0	1	1	0	1	0	0	1	1	0	1	0	1	0	0	0	1	0	0
Harpole	469.000	261.000	F	-0.989	52.242	2	2	0	2	0	2	0	0	1	0	1	0	1	1	1	0	1	0	1	0	0	0	1	0	0
Harvington	407.000	249.000	F	-1.898	52.139	3	3	0	3	0	3	0	0	2	0	1	1	1	1	0	0	2	1	0	2	0	0	3	0	0
Haselbech	470.000	277.000	F	-0.971	52.386	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0
Hathern	450.000	322.000	F	-1.258	52.793	2	2	0	1	0	1	0	1	2	0	2	0	0	0	0	0	1	0	0	0	1	0	2	0	0
Helmdon	459.000	243.000	3	-1.139	52.082	3	3	0	3	0	3	0	0	1	1	0	0	2	2	0	0	0	3	0	3	0	0	3	0	0
Hereford	360.000	240.000	F	-2.583	52.057	2	2	0	1	0	1	0	0	2	1	1	0	0	0	0	0	0	1	0	2	0	0	2	0	0
High Wycombe	485.000	191.000	F	-0.772	51.611	7	1	6	0	0	0	0	7	1	0	1	0	6	0	0	1	2	2	0	2	0	0	3	0	0
Histon	544.000	263.000	F	0.109	52.246	1	1	0	0	0	0	0	2	1	0	1	0	0	0	1	0	0	1	0	1	0	0	1	0	0
Hockley Heath	414.000	272.000	3-4	-1.794	52.346	4	4	0	4	0	4	0	0	4	2	2	0	0	1	1	0	1	0	2	1	0	0	4	0	0
Holmes Chapel	376.000	367.000	1	-2.359	53.199	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Placename	Grid East	Grid North	Intensity	Longitude	Latitude	TOTAL RESPONSES	Positive Responses	Negative Responses	VIBRATION FELT TOTAL	FELT STRONGLY	MOD - UNSPEC	FELT WEAKLY	NOT FELT	NOISE HEARD TOTAL	LOUD NOISE	MOD - UNSPEC	SOFT NOISE	NOT HEARD	FELT - HEARD BY OTHERS	SELF ALARMED	OTHERS ALARMED	WINDOWS RATTLE	WINDOWS DO NOT RATTLE	OBJECTS RATTLE	OBJECTS DO NOT RATTLE	HANGING - SWING	OBJECTS UPSET	OBJECTS ARE NOT UPSET	DAMAGE - B1	DAMAGE - B2
Hook Norton	436.000	235.000	4	-1.475	52.012	14	14	0	13	1	12	0	1	9	1	8	0	2	10	5	3	3	4	6	3	1	0	14	2	0
Hornton	440.000	243.000	5	-1.416	52.083	9	9	0	7	2	5	0	2	8	2	6	0	1	5	5	2	1	6	3	3	1	2	5	3	0
Irthlingborough	496.000	268.000	F	-0.592	52.301	2	1	1	0	0	0	0	2	1	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0
Keele	381.000	345.000	1	-2.283	53.002	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
Kenilworth	429.000	272.000	5	-1.574	52.345	89	87	2	60	16	43	1	0	64	12	51	1	0	36	24	7	26	42	27	34	5	6	72	2	0
Kennington	452.000	202.000	1	-1.247	51.714	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Keyworth	462.000	331.000	4	-1.079	52.873	13	13	0	12	0	12	0	1	7	2	3	2	5	8	7	2	6	7	2	5	2	2	10	0	0
Kidderminster	382.000	277.000	F	-2.265	52.390	2	2	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	2	1	0
Kidlington	449.000	214.000	4	-1.289	51.822	6	6	0	6	0	6	0	0	2	0	2	0	2	2	1	0	1	4	3	3	0	0	5	0	0
Kineton	433.000	253.000	5	-1.517	52.174	25	25	0	19	3	16	0	5	19	8	11	0	3	15	7	4	7	10	10	7	5	3	18	4	0
Kingham	426.000	224.000	4	-1.622	51.913	4	4	0	2	0	2	0	2	3	1	2	0	1	1	0	0	0	1	1	1	0	0	3	0	0
Kingsclere	477.000	184.000	1	-0.889	51.549	3	0	3	0	0	0	0	3	0	0	0	0	3	0	0	0	0	1	0	1	0	0	1	0	0
Kirtlington	452.000	219.000	F	-1.245	51.867	3	3	0	2	1	1	0	1	2	0	2	0	0	2	0	0	1	0	1	0	0	1	2	0	0
Lambley	463.000	345.000	F	-1.061	52.998	1	1	0	1	0	1	0	0	1	0	0	1	0	0	1	0	1	0	1	0	0	1	0	0	0
Leamington Spa North	432.000	268.000	5	-1.531	52.309	115	113	2	91	33	57	1	17	87	35	51	1	20	63	44	26	55	40	29	44	8	10	94	2	0
Leamington Spa South	433.000	264.000	4	-1.516	52.273	52	48	4	44	10	33	1	6	40	10	29	1	6	25	16	8	21	14	16	18	6	1	39	0	0
Leek Wooton	429.000	269.000	4	-1.575	52.318	6	6	0	6	0	6	0	0	5	2	3	0	0	4	0	1	3	3	4	1	0	0	6	0	0
Lees	426.000	337.000	F	-1.613	52.929	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Leicester Centre	459.000	301.000	3-4	-1.129	52.603	4	2	2	2	0	2	0	2	0	0	0	0	2	0	0	0	2	1	2	1	0	0	3	0	0
Leicester East	463.000	303.000	2-3	-1.069	52.621	3	2	1	2	0	2	0	1	2	0	2	0	1	1	0	0	0	2	0	2	0	0	3	0	0
Leicester North West	456.000	306.000	3-4	-1.172	52.648	13	10	3	9	1	7	1	4	7	1	5	1	4	0	0	0	3	5	3	6	0	0	12	0	0
Leicester West	454.000	303.000	3	-1.202	52.622	5	2	3	1	0	1	0	4	1	0	1	0	4	1	0	0	1	2	0	0	0	0	4	0	0
Lincoln	495.000	368.000	F	-0.578	53.200	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Littleworth	389.000	250.000	F	-2.161	52.148	2	2	0	2	0	2	0	0	2	1	1	0	0	1	0	0	2	0	0	1	1	1	1	0	0
Long Eaton	448.000	333.000	F	-1.286	52.892	3	3	0	3	0	2	1	0	3	0	1	2	0	1	1	0	1	2	1	1	0	0	3	0	0
Long Itchington	442.000	264.000	5	-1.384	52.272	29	29	0	22	5	17	0	3	19	7	12	0	4	17	11	9	13	9	17	8	1	4	24	2	0
Long Lawford	447.000	276.000	4	-1.309	52.380	6	6	0	6	0	6	0	0	4	1	3	0	1	3	4	1	4	0	1	1	0	1	4	0	0

Placename	Grid East	Grid North	Intensity	Longitude	Latitude	TOTAL RESPONSES	Positive Responses	Negative Responses	VIBRATION FELT TOTAL	FELT STRONGLY	MOD - UNSPEC	FELT WEAKLY	NOT FELT	NOISE HEARD TOTAL	LOUD NOISE	MOD - UNSPEC	SOFT NOISE	NOT HEARD	FELT - HEARD BY OTHERS	SELF ALARMED	OTHERS ALARMED	WINDOWS RATTLE	WINDOWS DO NOT RATTLE	OBJECTS RATTLE	OBJECTS DO NOT RATTLE	HANGING - SWING	OBJECTS UPSET	OBJECTS ARE NOT UPSET	DAMAGE - B1	DAMAGE - B2
Loughborough	453.000	319.000	4	-1.214	52.766	16	16	0	11	0	9	2	4	13	0	11	2	0	3	4	0	3	10	2	10	1	0	16	0	0
Lowdham	467.000	347.000	F	-1.001	53.016	3	3	0	2	0	2	0	1	3	1	2	0	0	1	1	1	3	0	0	2	0	0	3	0	0
Luddington	417.000	252.000	4	-1.751	52.166	4	4	0	3	1	1	1	1	3	3	0	0	0	3	2	2	2	2	3	0	2	1	3	0	0
Lutterworth	454.000	284.000	4	-1.205	52.451	13	13	0	9	1	5	3	3	10	1	9	0	2	9	2	2	7	6	6	6	0	3	10	0	0
Mansfield	455.000	360.000	F	-1.178	53.134	1	1	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0
Market Bosworth	440.000	303.000	F	-1.409	52.623	1	1	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0
Market Harborough East	475.000	284.000	F	-0.896	52.448	3	3	0	1	0	1	0	2	2	1	1	0	0	2	0	0	1	2	2	0	0	0	3	0	0
Market Harborough South	472.000	286.000	4	-0.940	52.467	15	15	0	10	0	9	1	1	14	1	13	0	0	7	2	3	6	6	5	4	1	0	13	2	0
Market Harborough West	472.000	288.000	4	-0.940	52.485	9	8	1	7	0	7	0	2	4	0	4	0	3	3	2	1	3	5	5	3	1	0	8	0	0
Markfield	449.000	310.000	F	-1.275	52.685	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	0
Marlow	486.000	183.000	1	-0.760	51.539	15	0	15	0	0	0	0	15	0	0	0	0	14	0	0	0	0	10	0	10	0	0	10	0	0
Matlock	430.000	360.000	F	-1.552	53.136	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0
Mears-Ashby	486.000	267.000	F	-0.739	52.294	2	2	0	1	0	1	0	0	0	0	0	0	1	0	0	0	1	1	1	1	0	0	2	0	0
Melton Mowbray	475.000	319.000	F	-0.888	52.763	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
Mickleton	416.000	243.000	4	-1.766	52.085	7	7	0	6	0	4	2	1	6	2	4	0	1	2	2	0	1	3	1	1	0	0	5	0	0
Middle Barton	444.000	226.000	4	-1.360	51.930	8	8	0	6	2	3	1	1	5	1	4	0	1	3	3	2	4	3	0	6	0	0	8	1	0
Middleton	482.000	290.000	F	-0.792	52.501	3	3	0	3	1	1	1	0	0	0	0	0	2	1	0	0	1	2	1	2	0	0	3	0	0
Middleton Cheney	450.000	242.000	4	-1.270	52.074	9	8	1	5	1	4	0	4	4	2	2	0	1	2	3	0	2	4	3	6	1	1	8	0	0
Milcombe	442.000	235.000	4	-1.388	52.011	10	10	0	7	0	7	0	2	9	2	7	0	1	6	0	0	3	7	3	6	0	0	10	0	0
Milton Keynes	485.000	242.000	3	-0.760	52.069	3	2	1	2	0	1	1	1	1	0	1	0	1	1	0	0	0	3	0	3	0	0	3	0	0
Mollington	444.000	247.000	4-5	-1.357	52.119	11	11	0	8	1	7	0	3	7	1	6	0	2	6	3	1	5	4	4	4	2	2	9	2	0
Monmouth	350.000	208.000	?	-2.725	51.768	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
Mountsorrel	459.000	314.000	4	-1.126	52.720	7	7	0	5	1	3	1	1	7	1	6	0	0	2	0	0	3	3	2	3	0	0	7	1	0
Mowsley	465.000	289.000	F	-1.042	52.495	2	1	1	1	0	1	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Muston	483.000	338.000	F	-0.765	52.933	2	2	0	2	0	1	1	0	1	0	1	0	1	0	0	0	1	1	0	1	1	1	1	0	0
Napton on the Hill	446.000	261.000	4	-1.326	52.245	5	4	1	3	1	2	0	1	4	0	4	0	1	5	1	1	2	2	2	1	2	1	4	0	0
Narborough	454.000	297.000	3	-1.203	52.568	7	5	2	3	0	3	0	4	3	0	3	0	2	0	0	0	0	4	1	4	0	0	6	0	0

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New Maldem	521.000	168.000	F	-0.260	51.398	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0
Newark-on-Trent	483.000	352.000	F	-0.761	53.058	2	2	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2	0	0
Newbold on Stour	424.000	247.000	F	-1.649	52.120	3	3	0	3	0	3	0	0	2	0	2	0	1	1	1	0	0	3	1	2	0	0	3	0	0
Newton Burgoland	437.000	309.000	F	-1.453	52.677	1	1	0	1	0	1	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	0	1	0	0
Northampton North East	478.000	264.000	4	-0.857	52.268	7	7	0	4	0	4	0	2	6	1	5	0	0	5	1	0	2	5	3	2	1	2	5	1	0
Northampton West	473.000	261.000	3	-0.931	52.242	6	6	0	4	0	4	0	2	2	0	2	0	3	2	2	0	2	4	1	5	0	1	5	0	0
Nottingham North	458.000	345.000	3	-1.136	52.999	5	5	0	4	0	2	2	1	2	0	1	1	2	2	2	0	3	1	1	0	0	1	3	0	0
Nottingham North East	459.000	342.000	3	-1.121	52.972	5	5	0	3	0	1	2	1	2	0	1	1	0	0	1	0	2	3	1	1	1	0	4	0	0
Nottingham North North West	454.000	346.000	F	-1.195	53.008	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0
Nottingham West	450.000	336.000	F	-1.256	52.919	2	2	0	2	0	0	2	0	2	0	0	2	0	0	0	0	1	1	0	0	0	1	1	0	0
Nuneaton East	437.000	291.000	5	-1.455	52.515	52	50	2	43	6	34	3	8	39	8	29	2	8	18	14	6	19	23	17	22	5	6	42	2	0
Nuneaton North West	435.000	293.000	4	-1.484	52.533	14	14	0	13	2	8	3	1	9	4	4	1	2	4	6	4	5	5	6	4	4	3	9	0	0
Nuneaton South	436.000	290.000	3-4	-1.470	52.506	7	6	1	2	0	2	0	0	2	1	1	0	5	2	0	2	0	5	0	5	1	1	5	0	0
Oakham	486.000	309.000	F	-0.728	52.672	2	2	0	2	0	1	1	0	2	0	2	0	0	0	0	0	1	1	1	1	0	0	2	0	0
Odiham	474.000	151.000	F	-0.940	51.253	1	1	0	1	0	1	0	0	1	0	1	0	0	0	1	1	1	0	0	1	0	0	1	0	0
Offchurch	437.000	267.000	5	-1.457	52.299	13	13	0	9	4	5	0	3	7	1	6	0	0	10	7	3	6	4	6	3	0	2	10	0	0
Ollerton	465.000	367.000	F	-1.027	53.196	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Oundle	506.000	297.000	3	-0.436	52.560	4	4	0	4	0	4	0	0	3	0	3	0	0	1	0	0	1	3	1	3	0	0	3	0	0
Overstone	481.000	265.000	4	-0.813	52.277	5	5	0	4	0	4	0	0	3	1	1	1	2	2	1	0	2	2	0	0	2	0	5	0	0
Oxford Centre	453.000	208.000	F	-1.232	51.768	3	1	2	0	0	0	0	2	1	0	1	0	2	0	0	0	0	0	0	0	0	0	1	0	0
Oxford South	454.000	204.000	1	-1.218	51.732	3	0	3	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	0	0
Oxford West	447.000	206.000	F	-1.319	51.750	3	2	1	1	0	1	0	2	1	0	1	0	1	1	1	0	1	0	0	2	0	0	3	0	0
Pebworth	416.000	247.000	4	-1.766	52.121	4	4	0	3	0	3	0	1	4	1	3	0	0	3	0	1	2	1	2	2	0	0	3	0	0
Peterborough	517.000	301.000	3-4	-0.273	52.594	7	7	0	5	0	5	0	1	5	0	3	2	0	2	3	0	3	1	2	3	0	0	5	0	0
Priors Marston	448.000	257.000	4	-1.297	52.209	9	6	3	6	1	4	1	3	5	0	5	0	2	4	3	0	4	4	0	3	1	1	7	1	0
Purley-on-Thames	467.000	175.000	F	-1.035	51.470	1	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0
Radcliffe on Trent	465.000	337.000	F	-1.033	52.926	4	4	0	3	0	2	1	1	3	1	1	1	0	1	1	0	3	1	1	0	0	0	3	0	0

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Redditch West	403.000	266.000	3-4	-1.956	52.292	13	12	1	9	0	7	2	3	8	1	7	0	4	5	5	2	2	6	3	3	0	0	9	0	0
Repton	430.000	326.000	1	-1.555	52.830	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
Retford	478.000	382.000	F	-0.829	53.329	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0
Ringstead	499.000	275.000	F	-0.546	52.364	1	1	0	1	0	1	0	0	0	0	0	0	1	1	1	0	0	1	0	1	0	0	1	0	0
Rotherby	468.000	317.000	F	-0.993	52.746	1	1	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	1	0	1	0	0	1	0	0
Rothley	458.000	312.000	4	-1.142	52.702	5	5	0	3	0	3	0	1	3	1	2	0	1	1	1	0	2	2	3	1	0	0	4	0	0
Rothwell	481.000	282.000	3-4	-0.809	52.430	4	4	0	3	0	3	0	1	4	0	3	1	0	3	1	1	1	2	1	2	1	0	4	0	0
Rowington	422.000	269.000	4	-1.677	52.318	9	9	0	8	0	8	0	1	5	0	5	0	1	5	2	1	3	3	4	4	0	0	8	0	0
Royston	531.000	242.000	F	-0.089	52.060	3	1	2	0	0	0	0	3	1	0	1	0	2	0	0	0	1	2	0	3	0	0	3	0	0
Rugby North East	452.000	276.000	5	-1.236	52.379	28	28	0	22	7	15	0	6	21	3	16	2	3	17	6	6	11	11	12	10	1	3	25	1	0
Rugby South East	452.000	273.000	4	-1.236	52.352	10	10	0	5	1	4	0	4	6	1	5	0	2	3	3	1	7	3	1	4	0	1	9	1	0
Rugby South West	448.000	273.000	5	-1.295	52.353	40	39	1	32	13	19	0	5	27	4	21	2	2	18	16	11	18	10	9	17	3	4	30	1	0
Sapcote	451.000	293.000	F	-1.248	52.532	2	1	1	1	0	0	1	1	1	0	1	0	1	1	0	0	0	1	0	1	0	0	2	0	0
Sheffield	432.000	386.000	2	-1.519	53.370	1	1	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Shepshed	446.000	320.000	F	-1.318	52.775	2	2	0	2	0	2	0	0	2	0	2	0	0	0	0	0	1	1	1	1	0	0	2	0	0
Shipstoun on Stour	426.000	240.000	4	-1.621	52.057	19	19	0	15	1	12	2	4	14	4	10	0	2	10	4	4	3	10	5	9	0	2	16	0	0
Shrewsbury	351.000	311.000	1	-2.725	52.694	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
Slawston	476.000	294.000	4-5	-0.879	52.538	5	5	0	4	0	4	0	1	4	2	2	0	0	2	1	1	3	2	2	2	0	1	4	1	0
Sleaford	507.000	346.000	F	-0.405	53.000	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0
South Kilworth	459.000	280.000	F	-1.132	52.414	2	2	0	1	0	1	0	0	2	0	2	0	0	1	0	1	2	0	0	1	0	0	3	0	0
Southmoor	440.000	198.000	F	-1.421	51.679	1	1	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0
St Ives	530.000	273.000	F	-0.092	52.339	1	1	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	1	0	1	0	0	1	0	0
Stoneleigh	435.000	273.000	4	-1.486	52.354	17	17	0	17	4	13	0	0	12	2	9	1	3	10	6	3	5	6	6	6	1	1	14	0	0
Stratford upon Avon East	423.000	255.000	4	-1.663	52.192	33	32	1	25	8	15	2	6	26	8	18	0	4	22	7	10	15	13	10	14	2	1	30	0	0
Stratford upon Avon West	419.000	256.000	5	-1.722	52.201	85	83	2	62	20	41	1	0	64	22	42	0	6	53	26	17	40	32	21	39	4	7	70	3	0
Stretton-on-Dunsmore	442.000	271.000	4	-1.384	52.335	11	11	0	9	4	5	0	2	7	5	2	0	2	6	4	1	6	4	5	3	0	1	10	0	0
Stretton-under-Fosse	446.000	281.000	4	-1.323	52.425	4	4	0	4	0	3	1	0	2	0	2	0	2	2	2	0	1	2	1	1	0	0	3	0	0

Placename	Grid East	Grid North	Intensity	Longitude	Latitude	TOTAL RESPONSES	Positive Responses	Negative Responses	VIBRATION FELT TOTAL	FELT STRONGLY	MOD - UNSPEC	FELT WEAKLY	NOT FELT	NOISE HEARD TOTAL	LOUD NOISE	MOD - UNSPEC	SOFT NOISE	NOT HEARD	FELT - HEARD BY OTHERS	SELF ALARMED	OTHERS ALARMED	WINDOWS RATTLE	WINDOWS DO NOT RATTLE	OBJECTS RATTLE	OBJECTS DO NOT RATTLE	HANGING - SWING	OBJECTS UPSET	OBJECTS ARE NOT UPSET	DAMAGE - B1	DAMAGE - B2
Stroud	384.000	205.000	F	-2.232	51.743	2	1	1	0	0	0	0	2	1	0	0	1	0	0	0	0	1	1	1	0	0	0	2	0	0
Stubton	486.000	349.000	F	-0.717	53.031	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Sutton Coalfield	413.000	295.000	3	-1.808	52.552	4	2	2	1	0	1	0	3	1	0	0	1	2	1	0	0	1	1	0	2	0	1	3	0	0
Syston	463.000	312.000	4	-1.068	52.702	8	7	1	3	0	3	0	3	6	0	6	0	1	3	2	1	1	2	3	1	0	0	7	0	0
Tadmarton	440.000	239.000	4	-1.417	52.048	9	9	0	9	1	8	0	0	6	1	5	0	2	5	2	3	3	3	2	5	0	0	8	0	0
Tamworth	421.000	305.000	F	-1.690	52.642	2	2	0	2	0	2	0	0	2	1	1	0	0	0	1	0	0	2	1	1	1	1	1	1	0
Taunton	324.000	124.000	?	-3.083	51.010	2	1	1	0	0	0	0	2	0	0	0	0	2	1	0	0	0	1	0	1	0	0	1	0	0
Tewksbury	392.000	236.000	F	-2.117	52.022	2	2	0	1	0	1	0	1	2	0	1	1	0	1	0	1	1	1	0	1	0	1	1	0	0
Thorpe by Water	489.000	296.000	F	-0.687	52.554	1	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0
Thorpe Satchville	473.000	312.000	F	-0.920	52.700	1	1	0	1	0	0	1	0	1	1	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0
Todenham	425.000	233.000	3	-1.636	51.994	4	4	0	1	0	1	0	3	3	1	2	0	1	2	1	0	0	4	0	4	0	0	4	0	0
Toot Baldon	458.000	201.000	1	-1.161	51.704	2	0	2	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Towcester	468.000	251.000	3	-1.006	52.153	7	6	1	5	0	3	2	2	6	0	3	3	1	0	0	0	1	6	1	4	1	1	5	0	0
Turkdean	411.000	217.000	F	-1.840	51.851	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0
Tysoe	435.000	246.000	4	-1.489	52.111	15	15	0	13	0	12	1	2	11	2	8	1	2	12	2	2	7	7	4	7	0	0	14	2	0
Wakefield	432.000	416.000	F	-1.516	53.639	1	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0
Walsall	400.000	297.000	1	-2.000	52.570	2	0	2	0	0	0	0	2	0	0	0	0	2	0	0	0	0	1	0	1	0	0	1	0	0
Warwick	429.000	265.000	5	-1.575	52.282	102	94	8	79	33	43	3	18	73	23	46	4	15	51	45	27	47	33	33	31	11	8	79	2	0
Wedmore	344.000	148.000	1	-2.802	51.228	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Weedon	464.000	258.000	4	-1.063	52.216	6	6	0	5	0	5	0	0	5	1	4	0	0	3	1	0	3	1	3	2	1	0	6	0	0
Wellesbourne	427.000	254.000	4	-1.605	52.183	25	23	2	19	1	17	1	6	17	6	10	1	3	15	3	6	10	11	9	11	0	3	21	0	0
Wendover	484.000	208.000	1	-0.783	51.764	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0
West Bridgford	458.000	337.000	3-4	-1.137	52.927	8	8	0	3	0	3	0	4	5	1	4	0	3	1	1	0	0	6	1	4	1	1	3	0	0
Whissendene	483.000	314.000	F	-0.771	52.717	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Whitchurch	355.000	334.000	F	-2.669	52.901	1	1	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0	1	0	1	0	0	1	0	0
Whitwick	444.000	316.000	F	-1.348	52.739	2	1	1	1	0	1	0	0	1	0	1	0	1	1	0	0	0	0	1	0	0	0	1	0	0
Wigston	460.000	298.000	F	-1.115	52.576	2	2	0	1	0	1	0	1	2	1	1	0	0	0	1	0	0	1	0	1	0	0	1	0	0

Placename	Grid East	Grid North	Intensity	Longitude	Latitude	TOTAL RESPONSES	Positive Responses	Negative Responses	VIBRATION FELT TOTAL	FELT STRONGLY	MOD - UNSPEC	FELT WEAKLY	NOT FELT	NOISE HEARD TOTAL	LOUD NOISE	MOD - UNSPEC	SOFT NOISE	NOT HEARD	FELT - HEARD BY OTHERS	SELF ALARMED	OTHERS ALARMED	WINDOWS RATTLE	WINDOWS DO NOT RATTLE	OBJECTS RATTLE	OBJECTS DO NOT RATTLE	HANGING - SWING	OBJECTS UPSET	OBJECTS ARE NOT UPSET	DAMAGE - B1	DAMAGE - B2
Winchcombe	403.000	229.000	4	-1.956	51.959	5	5	0	4	0	3	1	1	3	0	1	2	1	1	0	0	1	4	4	1	0	0	5	0	0
Winchester	448.000	129.000	F	-1.315	51.058	1	1	0	1	0	0	1	0	1	0	1	0	0	1	0	0	1	0	0	1	0	0	1	1	0
Winwick	463.000	272.000	4	-1.075	52.342	5	4	1	3	0	3	0	2	4	1	2	1	1	3	0	0	2	2	2	1	2	1	2	0	0
Witnesham	618.000	251.000	F	1.184	52.114	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0
Witney	435.000	210.000	F	-1.493	51.787	3	2	1	2	0	2	0	1	1	0	0	1	1	0	0	0	1	1	1	1	0	1	1	0	0
Wolverhampton	390.000	295.000	?	-2.148	52.552	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Wolvey	443.000	288.000	3-4	-1.367	52.488	5	4	1	4	0	4	0	1	3	0	3	0	2	3	1	1	3	1	2	1	1	0	4	0	0
Woodmancote	397.000	226.000	4	-2.044	51.932	9	9	0	6	0	5	1	2	7	1	4	2	1	1	1	0	1	6	5	1	0	0	7	0	0
Woodstock	445.000	217.000	F	-1.347	51.849	2	2	0	1	0	0	1	1	2	0	2	0	0	0	0	0	0	2	1	1	0	0	2	0	0
Woodwalton	521.000	280.000	F	-0.221	52.404	1	1	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	1	1	0	0	0	1	0	0
Wooten Wawen	415.000	263.000	3-4	-1.780	52.265	9	8	1	7	0	7	0	2	5	0	5	0	2	3	0	0	2	6	1	6	0	0	9	0	0
Worcester North	385.000	259.000	3	-2.220	52.229	4	4	0	1	0	1	0	3	2	0	1	1	2	1	2	0	0	3	1	2	0	0	4	0	0
Worcester North East	387.000	255.000	3-4	-2.190	52.193	4	4	0	3	0	3	0	1	4	1	2	1	0	0	1	0	2	2	2	0	0	0	3	0	0
						2460	2299	161	1754	303	1334	117	501	1643	407	1142	94	420	1005	592	320	890	1026	712	935	157	196	1958	59	0

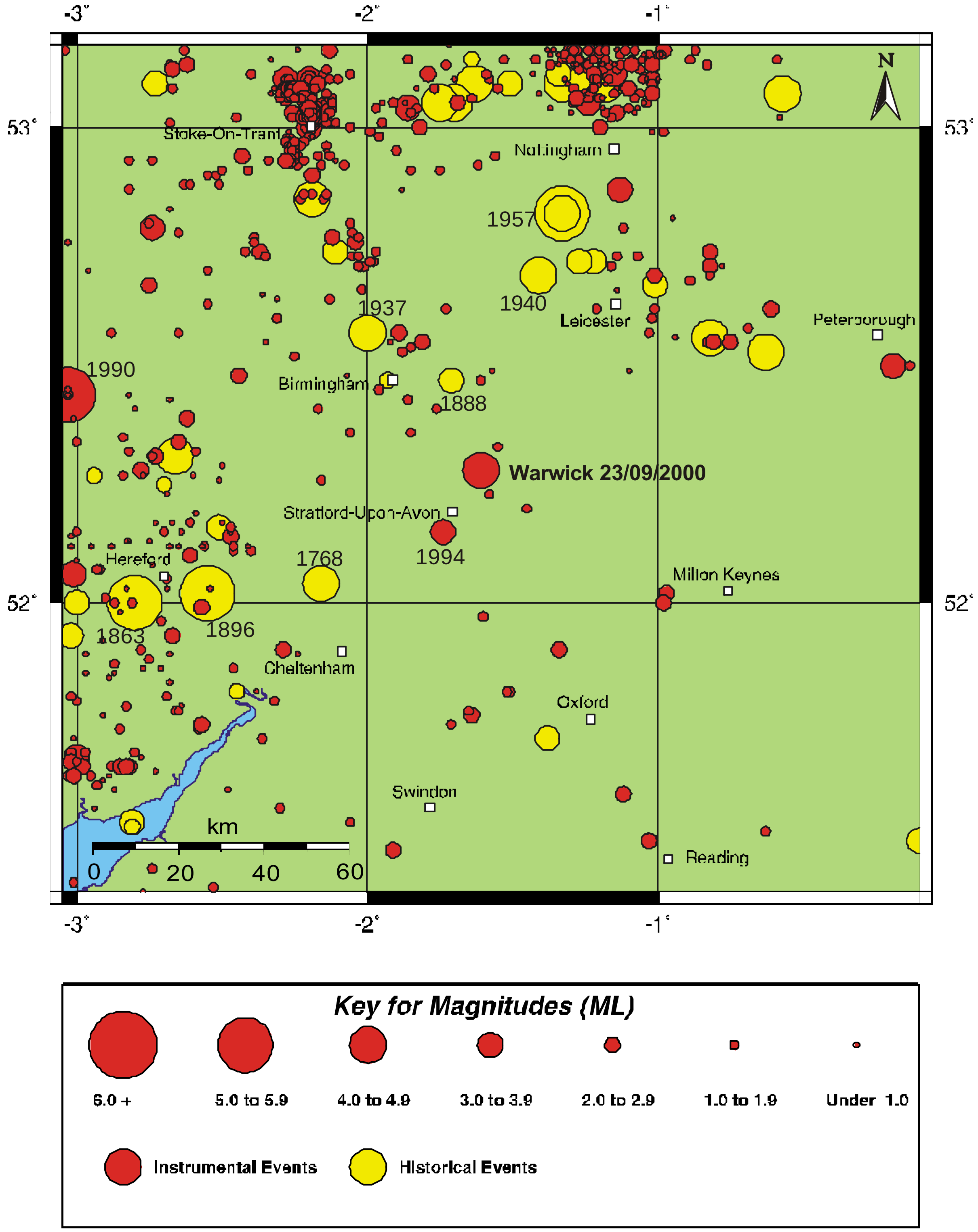

Figure 1. Historical and Instrumental seismicity within100 km of the Warwick earthquake.

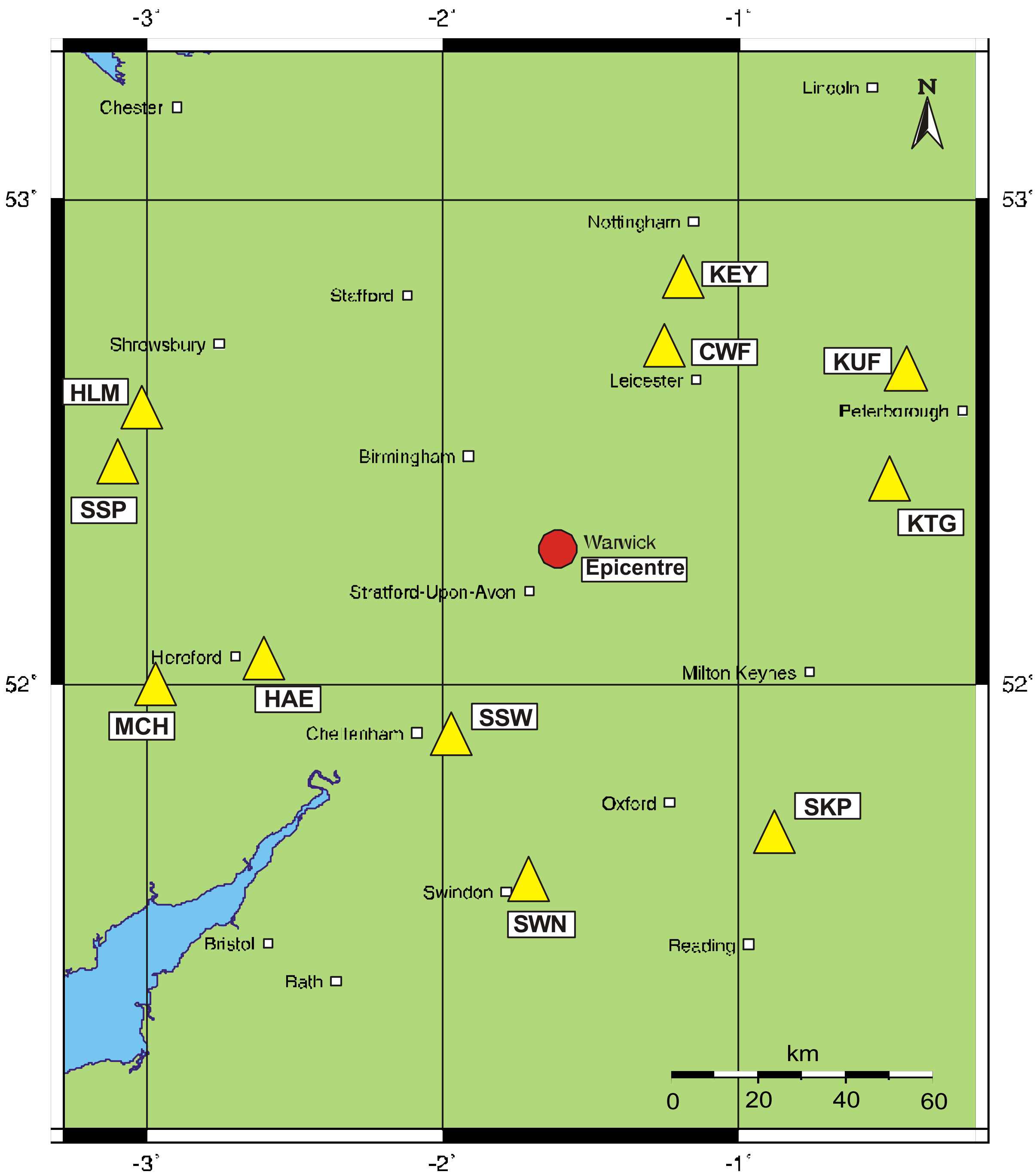

Figure 2. Stations used to locate the 23 September 2000 Warwick earthquake

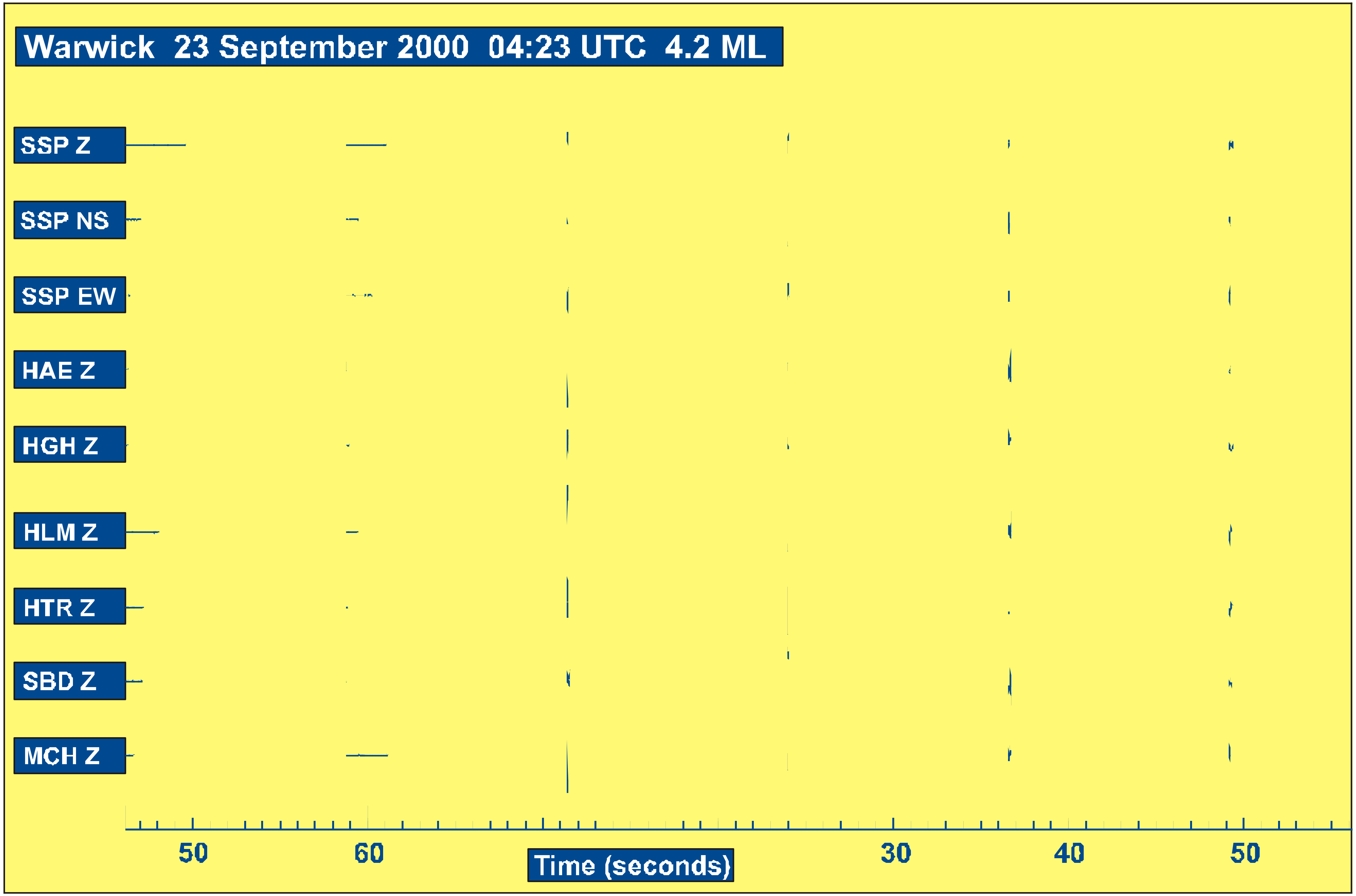

Figure 3. The Warwick earthquake as recorded on the Hereford network

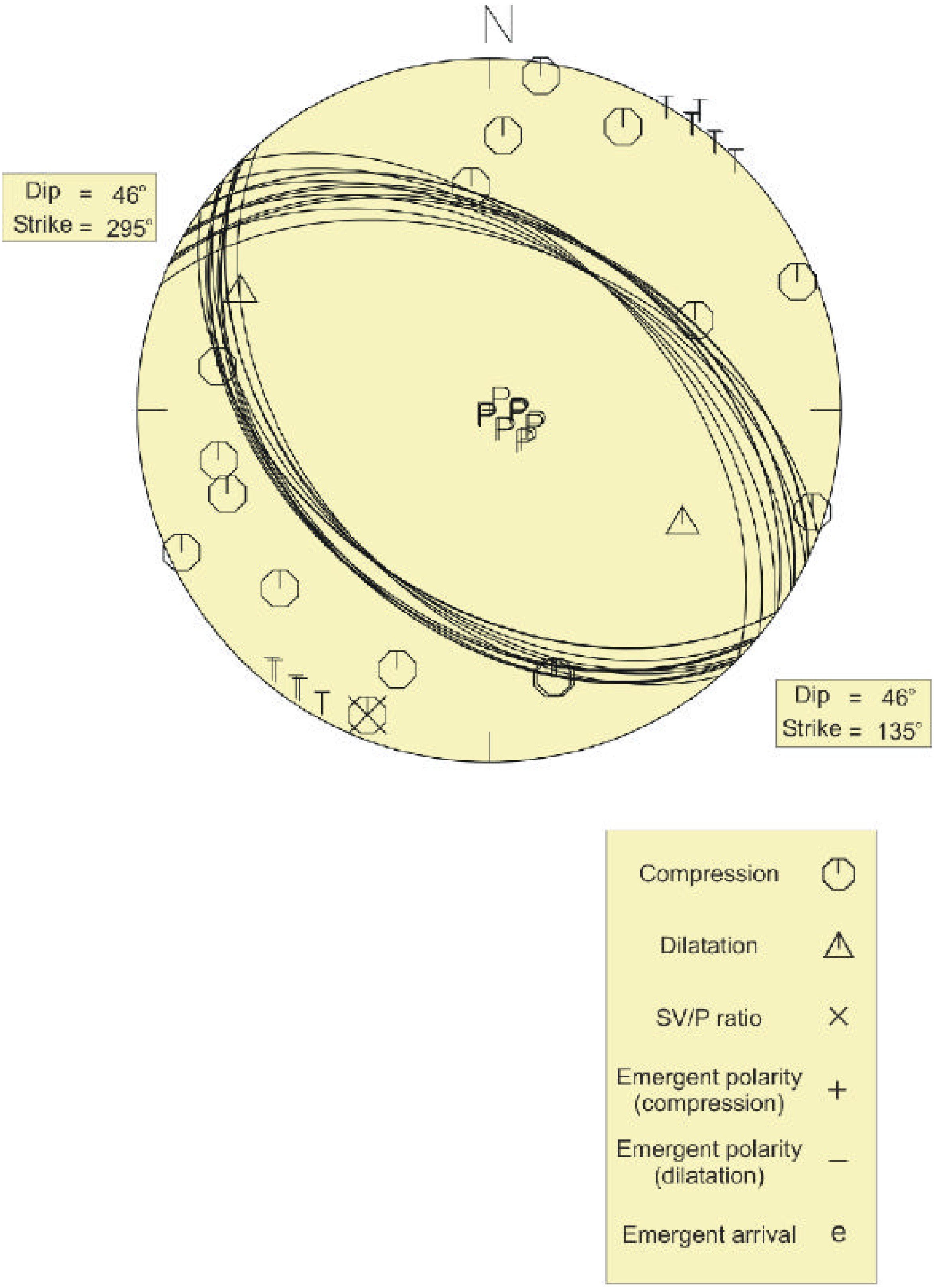

Figure 4. Lower hemisphere projection of the focal Mechanism for the Warwick earthquake

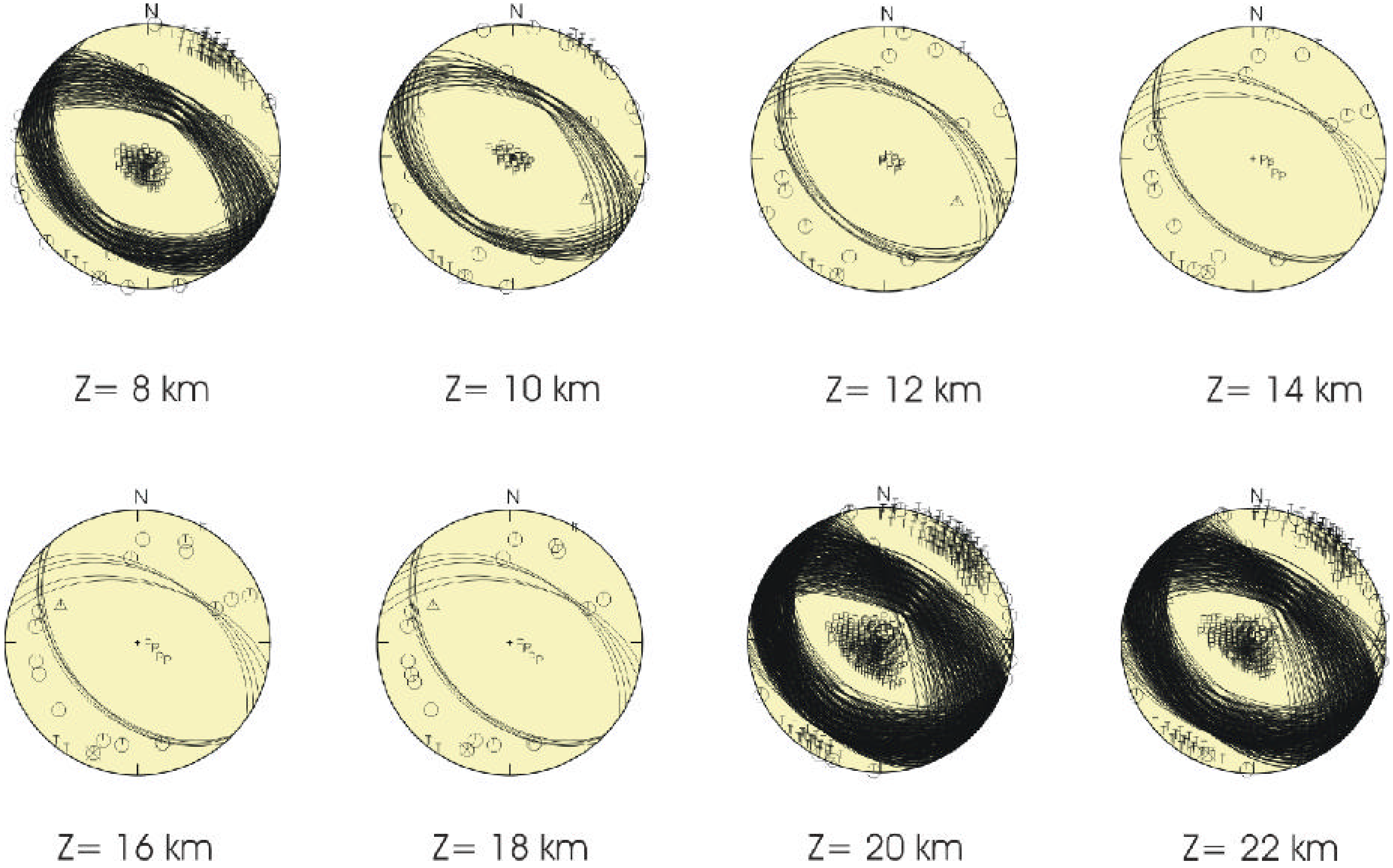

Figure 5. Computed focal mechanisms for the Warwick event at various fixed depths

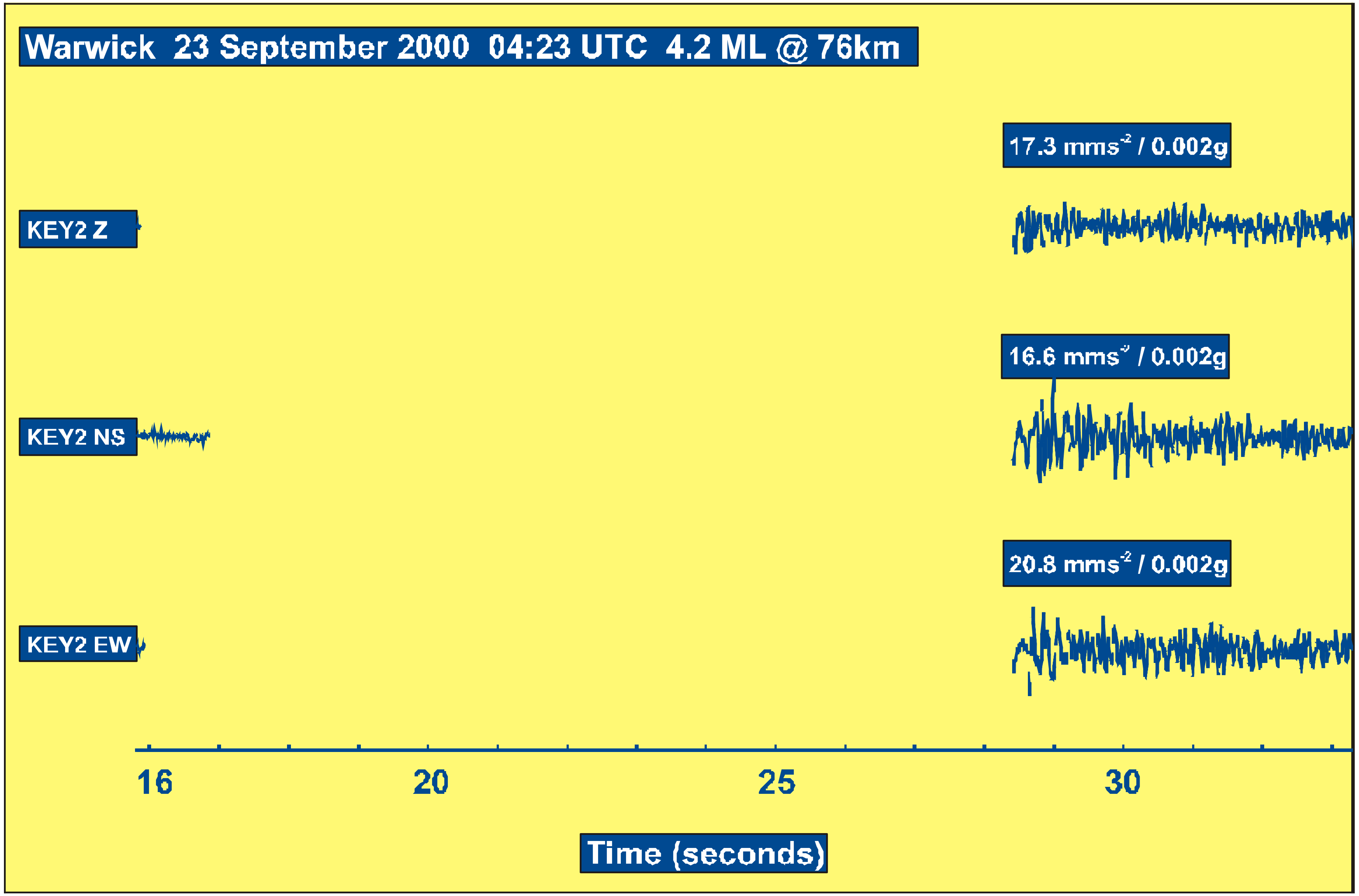

Figure 6. Ground accelerations from the Warwick earthquake measured on the strong motion instrument KEY2 at 76 km

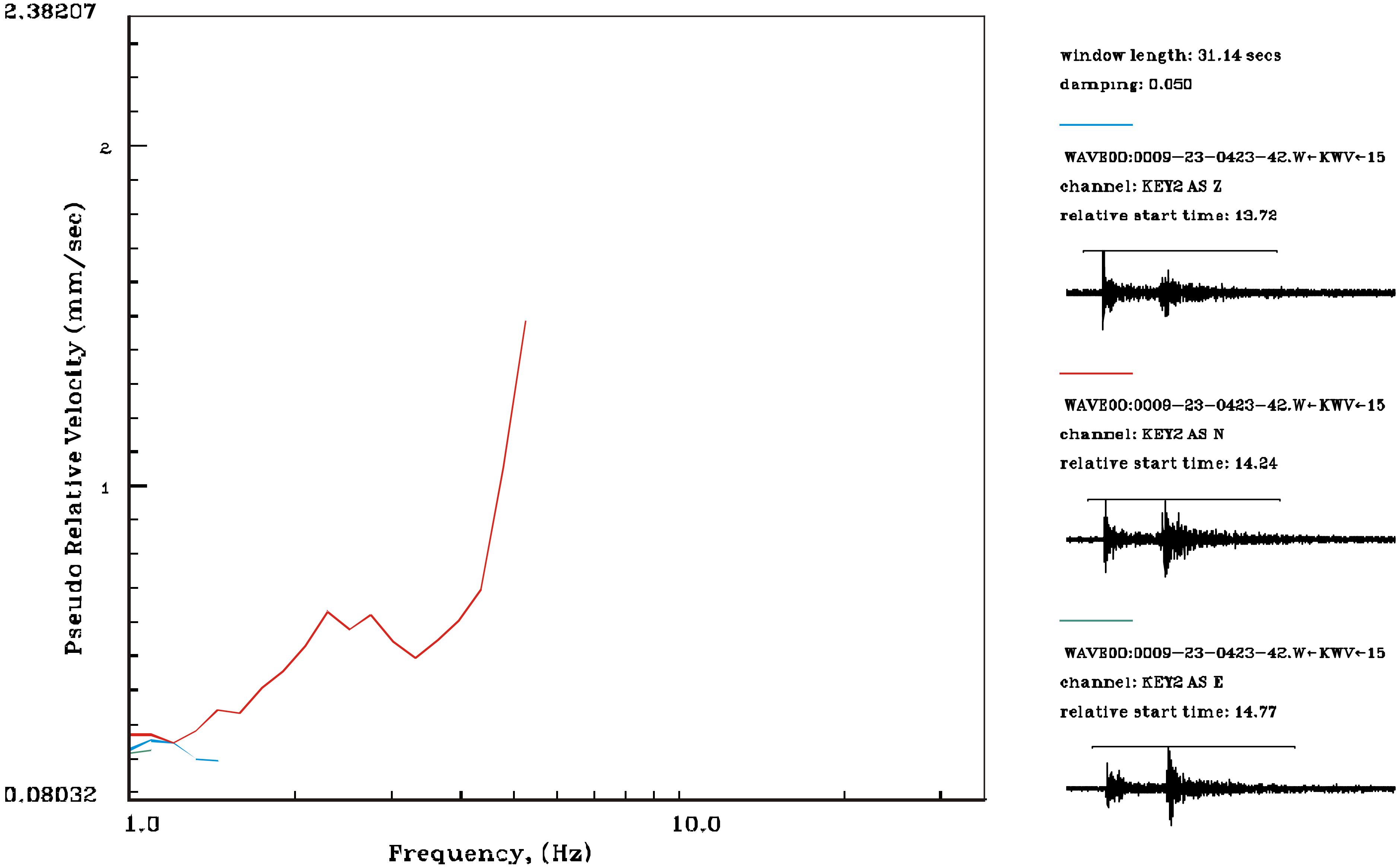

Figure 7. Response spectra for station KEY2 for the Warwick earthquake at 76 km, 5% damping.

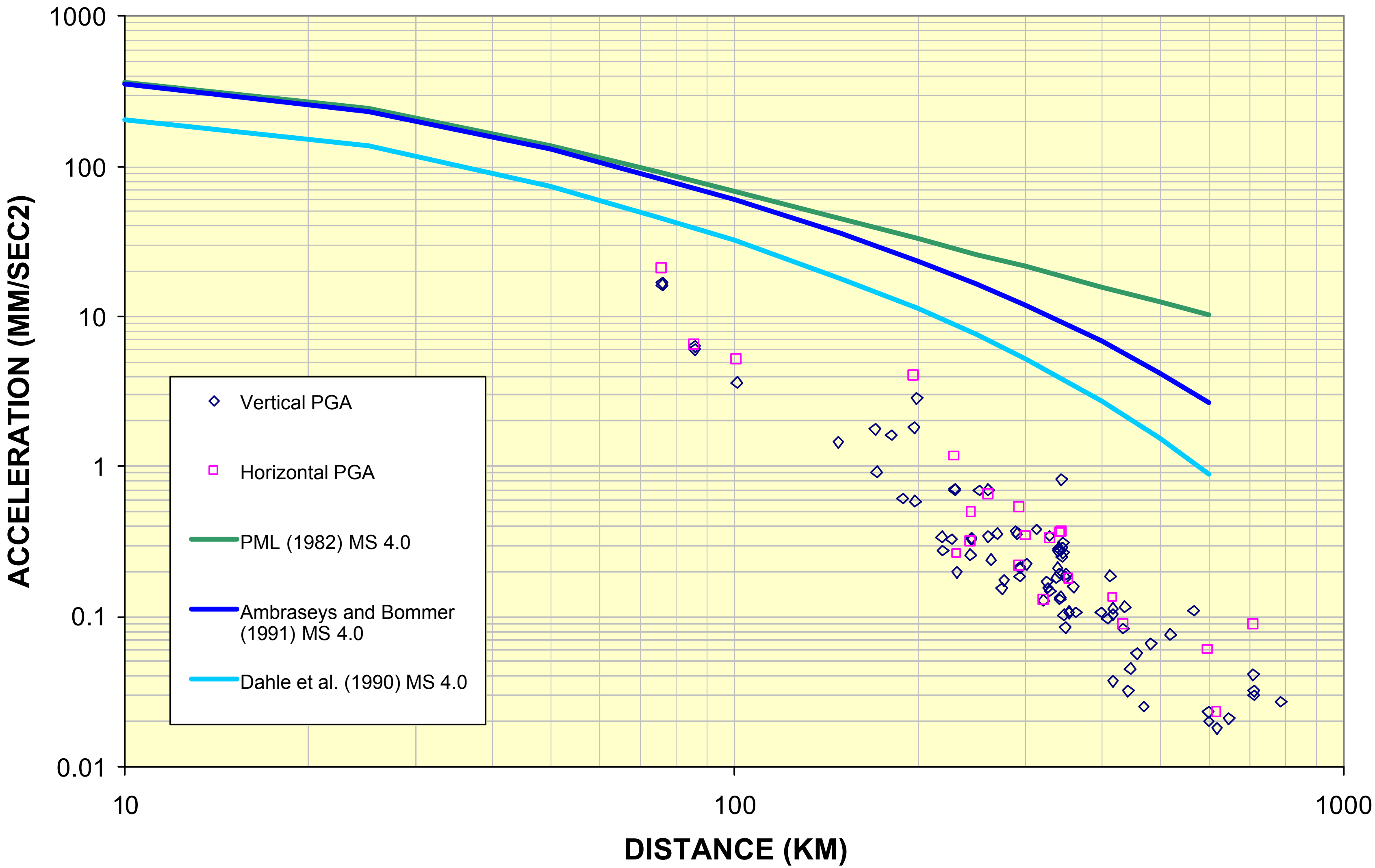

Figure 8. Measured horizontal and vertical peak ground accelerations for the ML 4.2 Warwick earthquake compared to empirical attenuation curves for a MS 4.0 event

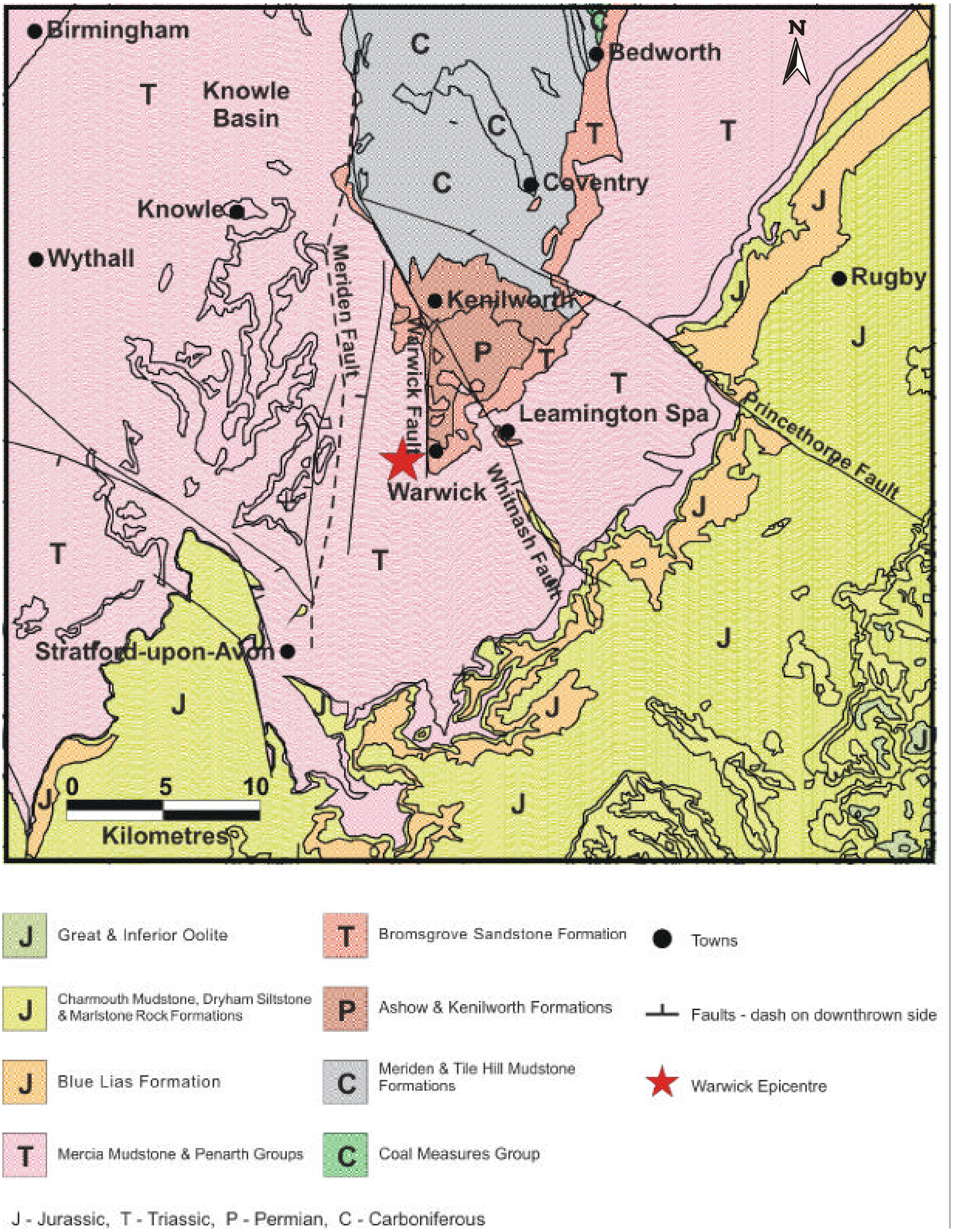

Figure 9. Geological sketch map of the Warwick area showing the location of the 23 September 2000 magnitude 4.2 ML, Warwick earthquake.

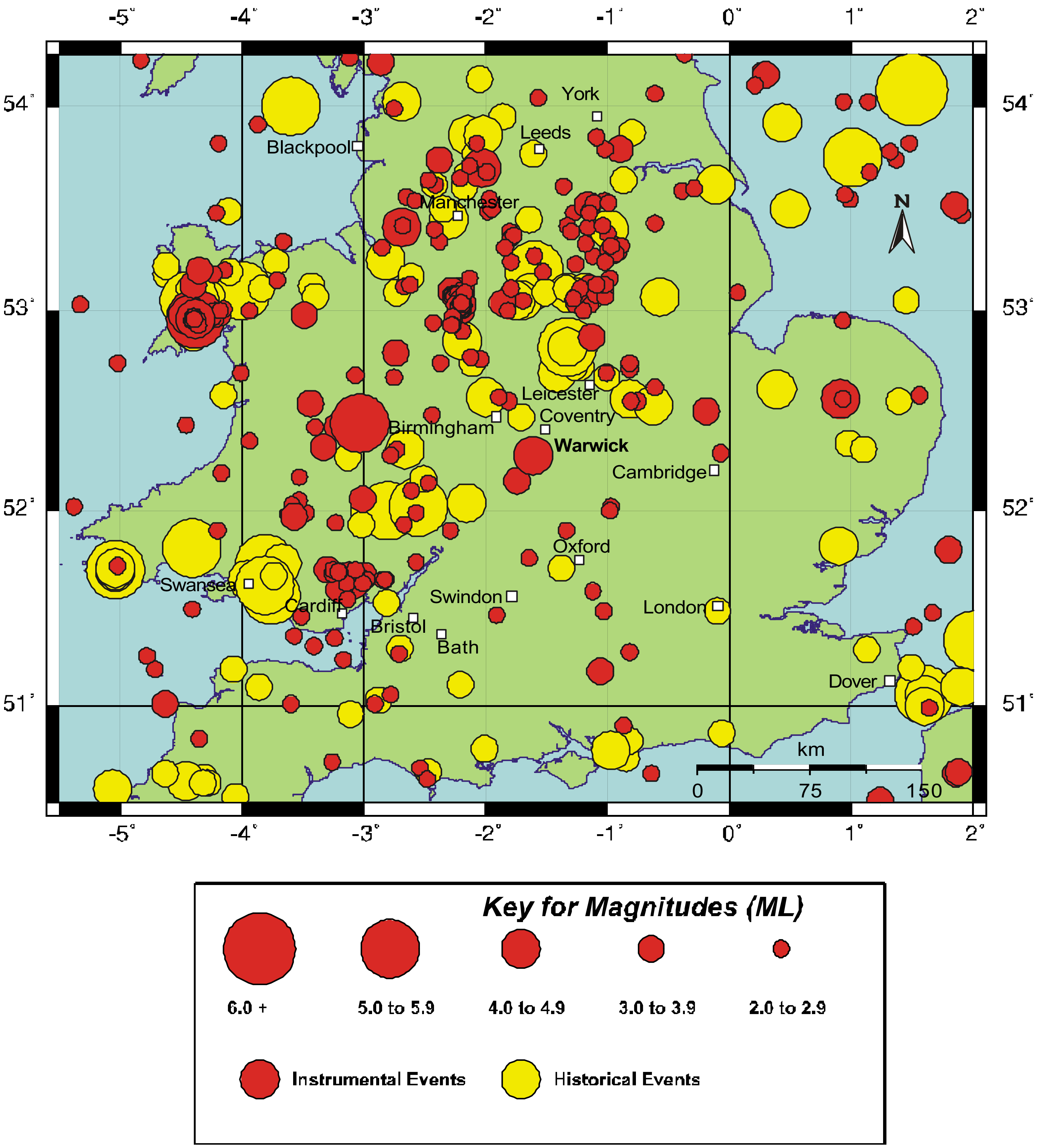

Figure 10. Historical and instrumental earthquakes of southeastern Britain showing all ML > 3.0 events prior to 1980 and all events of ML > 2.0 since 1980.

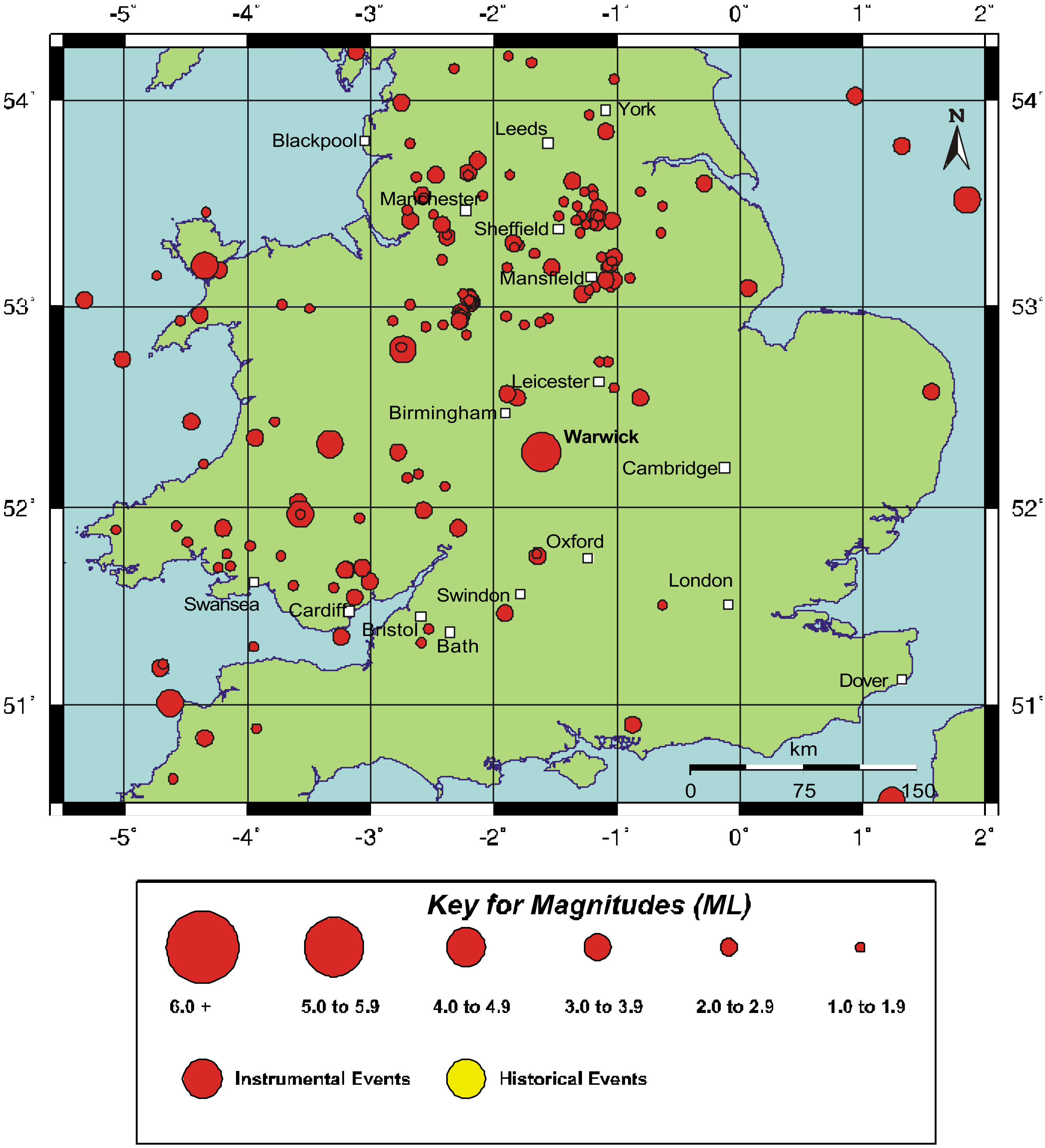

Figure 11. Instrumental seismicity of southern Britain for magnitudes > 1.5 ML from 1995 to 2001

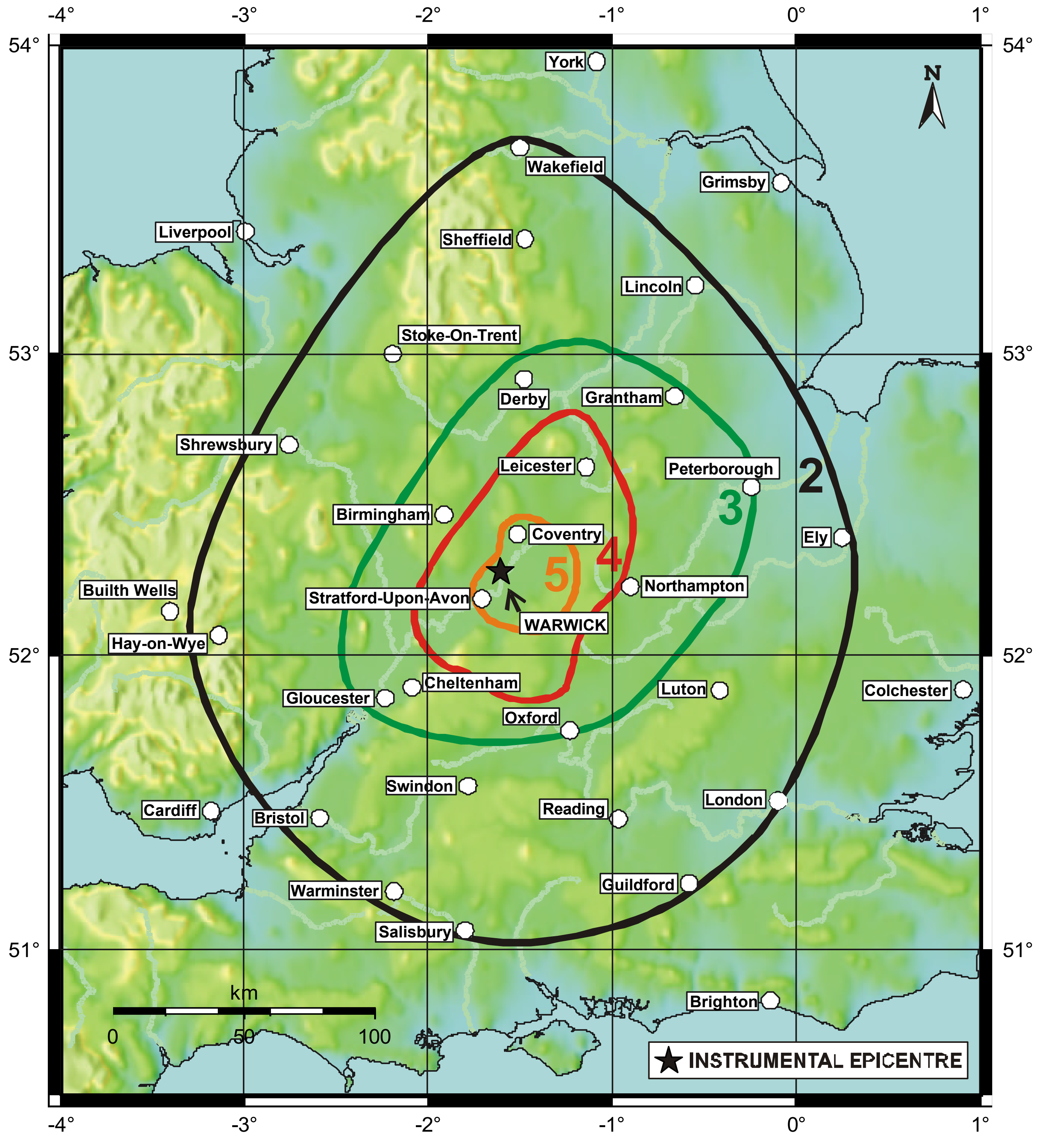

Figure 12. Macroseismic map for the Warwick earthquake

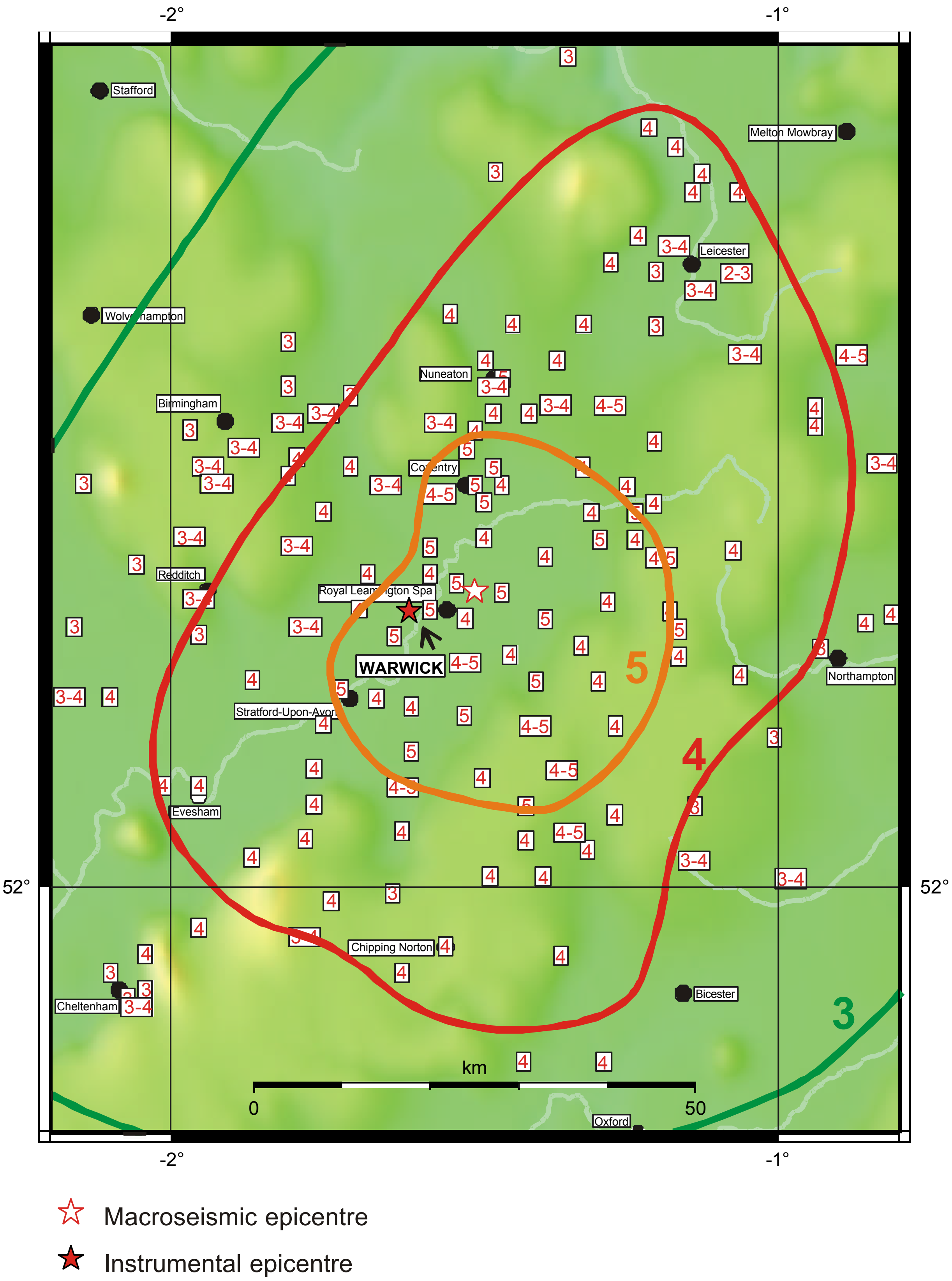

Figure 13. Inset of epicentral region of the macroseismic map of the Warwick earthquake.