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The seismicity of the British Isles to 1600

Earth Hazards and Systems

Internal Report OR/08/049

BRITISH GEOLOGICAL SURVEY

EARTH HAZARDS AND SYSTEMS

INTERNAL REPORT OR/08/049

The seismicity of the British Isles to 1600

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Foreword

This report is the product of a study by the British Geological Survey (BGS), partly in support of work package NA4 of the NERIES project. A large amount of research was done during the 1980s by BGS and others on the historical seismicity of the UK. This was used as the basis of a catalogue of British earthquakes published in 1994, which acted as a synopsis of all previous research (Musson 1994). However, this catalogue concentrates chiefly on the period after 1700. Events prior to this date are treated in a fairly cursory fashion.

This report looks at an earlier period by examining all known earthquakes in the British Isles up to the year 1600 and presenting discussion of each, drawing on a mixture of previous studies and original material. Tables of places and intensities are presented where possible; however, the practice is not followed of assuming that an entry in the annals of a monastery means that the earthquake was necessarily felt in that monastery, unless it is specifically stated. Thus, for many events that are noted without any details in original sources, one can reliably deduce very little.

Some events that have been previously accepted by previous catalogues, e.g. Davison (1924) are concluded to be dubious or fake, and these are generally included even in cases where it was established some time ago (e.g. in Ambraseys and Melville 1983) that these events were wrong (usually misdatings of other earthquakes). It is difficult to maintain a completely consistent approach to including comments on fake events – to try and include every mention that has ever been made of any earthquake would lead to the unhelpful inclusion of many obscure references. Is it necessary, when Burton (1734) writes that "In 1300 … A great Earthquake in London, which was especially felt on the Banks of the River Thames …", to include an entry for the year 1300 in order to point out that the author means "in the 13th century", and that this is a reference to an earthquake in 1274? Also, no mention is made of various pre-millennium earthquakes that can in all cases be traced back to Short (1749), which have long been regarded as spurious (Musson 2005). Events described in original sources as earthquakes, but which are very obviously landslips (like the celebrated Marcle Hill landslip of 1571), are also not included.

Acknowledgements

The author would like to thank British Energy for allowing access to some material previously inaccessible. This work continues research into historical British earthquakes that was begun by Paul Burton, Graham Neilson and myself in the early 1980s, and draws upon material gathered at that time. This report is published with the permission of the Executive Director of the British Geological Survey (NERC).

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Summary

This report provides a synopsis of state-of-the-art knowledge concerning earthquakes in the British Isles in the period up to 1600. In particular, emphasis is placed on the presentation of intensity data points (IDPs) for each event, allowing that “intensity” *sensu lato* may include “felt”, and “points” may be locatable to no more than broad areas. The report draws to some degree on previous studies compiled since 1980. Presentation of full source material and discussion of dating issues and related problems is left in part to the original studies, as indicated.

1 Introduction

The beginning of the 18th century marks a watershed in the study of historical British earthquakes. The reason is very simple – it marks the beginning of the newspaper press in Britain. As discussed in Musson (1985) and elsewhere, newspapers are particularly valuable in historical earthquake studies because (a) they are published regularly and continuously, and (b) it is their specific job to report things that happened in the region for which their readership is located. Thus, given a reference to an earthquake in Yorkshire in 1768, one can turn to the local newspapers of the day in the expectation of finding accounts of the event. If the earthquake is not mentioned, this is itself significant; not necessarily implying that the earthquake did not happen or was not felt, but indicating that it was not newsworthy. For any similar reference 100 years earlier, there is nothing one can turn to. As shown in Musson (2004b), it seems evident that a significant earthquake occurred in Northern England/Southern Scotland in 1668 for which no contemporary account has ever been found. There is no body of material that one can examine with an expectation of finding confirmation. There may have existed at one time letters mentioning the earthquake, memoranda in notebooks, and other ephemerical documents, now lost, destroyed or hidden.

As a result, the year 1700 marks a change in the completeness threshold for the UK earthquake catalogue. After 1700, at least for some parts of the country, the record is probably complete or near-complete down to around 4 Mw in magnitude (Musson 1994). Before that, completion is not only much worse, it is rather hard to judge how bad it is. The missing earthquake of 1668 is a rare example of being able to know something about an earthquake that is lost to the catalogue (Musson 2004b). But equally, if one report had actually survived, it would be hard to interpret correctly. Suppose there had been known a surviving letter from Lancaster, stating that a shock was weakly felt there on 16 June 1668. This could be taken, in the absence of any other evidence, as a small local earthquake in Lancashire; but in fact, it might be a sole surviving account from the periphery of a larger event.

After 1700 one can be fairly sure that one can discriminate in the historical record between small and large earthquakes (in this context, above or below 4 Mw), with the exception of a few cases of offshore earthquakes where the epicentre is an unknown distance from land. Before 1700, this is often not possible, and thus almost any reported earthquake is at least potentially an event of engineering significance.

In this report, what is known about the early, pre-1600, seismicity of the British Isles is drawn together into a single reference; the period 1601-1700 will be covered in a future study. It is not intended here to present full studies of each earthquake. The intention is rather to pull together all interpretations from 20th century studies into a consistent format, and to extract the fundamental data in the form of intensity data points (IDPs) for each event, as a basis for future assessment of earthquake parameters. Detailed discussion of each event, especially regarding dating, and full presentation of source materials and references, is in many cases left to the studies cited, unless reference to original source material is necessary. Also, no attempt has been made to collect and dismiss every spurious earthquake notice for the period in later texts, some of which are quite obscure. Especially, the well-known pre-millennium events from Short (1749) are not listed, having been rejected as inauthentic since Davison (1924), though they still occasionally get referred to (see the discussion in Musson 2005). Events that are obviously non-seismic are also not included, despite being referred to as earthquakes in original source material (the word “earthquake” also formerly had the meaning of “landslip”). Some fake events are included where it is felt that drawing attention to them is useful. Entries are included for all events that are considered to be possibly real earthquakes.

One can propose a hierarchy of doubt as follows:

- Genuine – the earthquake definitely occurred as described (the date and place are correct, and it really was an earthquake).
- Uncertain – the earthquake probably occurred as described, but there is a chance it did not.
- Doubtful – one cannot say whether it is more likely or less likely that this earthquake occurred as described.
- Very Doubtful – probably this earthquake did not occur as described.
- Fake – The earthquake definitely did not occur as described (it occurred on a different date, or in a different place, or was some other phenomenon, or was invented).

A distinction is made here between parametric earthquake catalogues (PECs) and roots, following Stucchi et al. (1999). A parametric earthquake catalogue is a work which primarily presents earthquakes as a table of parameters, where each determination is based on an earthquake study that evaluated those parameters. This study, in turn, is the "root" of the entry in the PEC. This division was previously used in a British context by Musson (1996).

Since then, the root classification scheme has been revised by Stucchi (2007), so that each root can be classified according to the following scheme of levels (Table 1).

Root level	*Meaning*
1	Studies conducted according to modern historical practices, with IDPs.
2	Older studies, or unfinished assemblages of source materials.
3	Other PECs.
4	Unknown.

Table 1 - Root level classification

For Britain, for the period of interest in this study (-1600), two references have been classed as PECs – these are Ove Arup (1993) and Musson (1994). The main references treated as roots are Davison (1924), Principia (1982), Soil Mechanics (1982), Ambraseys and Melville (1983), various reports by the Seismic Hazard Working Party (SHWP 1987 etc) and a number of individual papers. One possible PEC which is not included is the incomplete working file of Lilwall (Burton et al. 1984). For the period concerned here, the entries are taken from Davison (1924) with latitudes and longitudes added, and arbitrary magnitude vales. The work was not intended for publication, but was obtained and cited extensively by Soil Mechanics (1982). See Musson (2004a).

Section 2 of the report provides some necessary insight into the problems of dealing with earthquakes in this period.

Section 3 provides discussions of each individual earthquake, except for some fake events as previously indicated. Maps are provided wherever possible, and these have been drawn with a small selection of "standard" limits to facilitate comparison. Data are presented in tabular form where possible, but not parameters.

2 Interpreting medieval earthquakes

It should be a principle of historical research not to read into any source document more than it can reliably bear. In particular, any source has to be taken together with its context. Reading a document in the light of the original author's intentions in compiling it, and not according to what the modern reader would like it to mean, is fundamental to correct procedures in historical research.

However, this was frequently ignored in studies conducted in the 1980s. It appears that in many studies, so great was the desire to determine earthquake parameters, that many inferences were drawn which cannot be supported by the data. These include the assumption that mention of an earthquake in a chronicle, without details, means that the earthquake was felt at the location where the chronicle was compiled, and worse, that a minimum intensity can be assigned on the basis of such an inference. Often this “minimum intensity” is then subtly transformed into “the” intensity and plotted as such (e.g. SHWP 1987). For instance, in treating the earthquake of 4 August 1133, SHWP (1987) present an apparent intensity map with seven IDPs shown as firm intensity values (4) and one qualified one (“5-“, presumably to be read as 4-5) – in fact, only the last of these is supported by any data. The rather precisely located epicentre, located on the basis of the centroid of this “felt area”, is thus an illusion.

The reasons why this sort of inference is unreliable have been gone into by Musson (1998, 2004b). Monastic chroniclers recorded things that they felt were of note, and what these things were, and why they were of note, varied. In the case of "prodigies" (remarkable occurrences) such as earthquakes, the importance of these to the medieval mind was that they were portents, either of God's wrath or coming political events. They were not seen as natural occurrences.

The corollary to this is that if an earthquake is memorable because it may be a portent, it is not all that important exactly where it occurs, or how severe it is. The important thing is the date of its occurrence, and this is probably one reason why many chronicles record the occurrence of earthquakes with absolutely no details beyond the date, while the date is recorded carefully, using more than one dating system.

Consequently, if the chronicle of a particular abbey mentions any earthquake, this does not necessarily mean the earthquake was felt at that abbey, unless this is specifically stated or there is other internal evidence to suggest this.

On the other hand, the absence of mention of an earthquake in a chronicle is not necessarily evidence that the earthquake was not felt at that place. It may indicate that the writer himself did not feel the earthquake (for a variety of possible reasons) or that he did not consider it worth recording.

One can make comparisons with the reporting by medieval chroniclers of severe storms, which are more frequent, more damaging, and more widely observed in Britain than are earthquakes (Musson 2004b). The lack of such reports on a regular basis shows the general lack of interest shown in such phenomena by monastic annalists.

This is the reason why early earthquakes that are given quite full parameters in Ove Arup (1993) are given almost no details in Musson (1994). In the later of the two catalogues, parameters derived from unsupported inferences are eschewed. Similarly in the case of the present report: the material presented for each earthquake is confined to what is actually given by the source materials.

The waters are muddied further by the habit of annalists of copying freely from other chronicles, sometime inaccurately. A good description of how Medieval annals were compiled, how they copied from one another, and how they often copied from sets of annals now lost, is given by Gransden (1974). While some chronicles do have a strong bias to local affairs, an earthquake, when considered as a portent, is not necessarily a local issue. Where it was felt is almost immaterial, since the interest is in what national event it may portend. Thus an earthquake report, found only in one monastic annal, may have been copied from another set of annals now lost, compiled at a different monastery.

In general, therefore, in this report, data points are not plotted for the location of monastic annals that happen to mention an earthquake without details. Some later documents, on the other hand, do allow reasonable conjecture that they refer to the earthquake being felt at the writer’s location; each case has to be taken on its own terms and a judgement made. More speculative instances are indicated.

A separate problem is presented in some cases where source materials do give specific details of earthquake effects. Damage to specific churches or cathedrals is mentioned for earthquakes in 1185, 1247, 1248 and 1275, which has caused some studies (a) to assign high intensities at these locations, and (b) locate the earthquake at the high intensity location. Assigning intensity on the basis of damage to single, anomalous structures is unreliable (Grünthal 1998). Furthermore, vulnerability may be compounded by geotechnical problems (Woo 1991). As a result, one really cannot assume that the destruction of the church of St Michael, perched on top of Glastonbury Tor, indicates that the epicentre of the 11 September 1275 earthquake was close to Glastonbury.

3 The earthquakes

In this section of the report, each known earthquake in the period is considered in detail, and the actual macroseismic data suitable for interpretation are given. Intensities are given using the EMS-98 scale. An intensity of "F" indicates felt, and "D" indicates damage (presumably an intensity greater than 5 EMS), where it was felt to be impossible to estimate a numerical intensity, even speculatively.

3.1 60 EAST ANGLIA

In the Annals of Tacitus, a number of strange phenomena are described as occurring in south-eastern England just before the revolt led by Boudica in 60 or 61 AD; in fact, these events were seen as portentous, and were partly responsible for inspiring the revolt itself. The passage in question, in the translation of Church and Brodribb (1942) reads as follows:

> *Meanwhile, without any evident cause, the statue of Victory at Camulodunum* [Colchester] *fell prostrate and turned its back to the enemy, as though it fled before them. Women excited to frenzy prophesied impending destruction; ravings in a strange tongue, it was said, were heard in their Senate-house; their theatre resounded with wailings, and in the estuary of the Tamesa* [Thames] *had been seen the appearance of an overthrown town; even the ocean had worn the aspect of blood, and, when the tide ebbed, there had been left the likenesses of human forms, marvels interpreted by the Britons, as hopeful, by the veterans, as alarming.*

It has recently been suggested by the archaeologist Raphael Isserlin (Keys 2007) that this passage may be a garbled description of an earthquake. The obvious item is the fall of the statue (could have been thrown down by an earthquake). The wailings could relate to earthquake sounds, and the reddened sea could be an effect of earthquake-induced turbidity (and there are red clays near Colchester that would provide the right colour). The "appearance of an overthrown town" might be an oblique reference to actual damage. This is evidently rather speculative, but it is interestingly suggestive that the most plausibly seismic effect is reported from Colchester, the site of the intensity 8 EMS earthquake of 22 April 1884. There is no way of determining the case for sure.

DOUBTFUL

3.2 601 LAOIS

The earliest contender for the title of "first recorded British earthquake" is an entry in the Annals of Ulster (Balé and Purcell 2003 is the most recent edition) for 601 – "An earthquake in Bairche." Bairche (or Ui Bairrche) was a kingdom in the south-east of what is now County Laois. There is a general problem with all events of this type, that the word used for earthquake, "terra motus", was also used for landslides, landslips, rockfalls, bog-bursts and other similar phenomena. The fact that Ireland is so aseismic makes one particularly inclined to suspect that

something other than a real earthquake may be being described. Principia (1982), using a Victorian edition of the Annals of Ulster, give the location as Mourne (County Down) and the year as 600.

Claims for an Irish earthquake in 448 (e.g. Cusck 1868) rest on a misinterpretation of a note in the Annals of Ulster referring to an earthquake in Constantinople.

DOUBTFUL

3.3 664 BRITAIN

An earthquake in Britain in this year is reported without any details by the Annals of Ulster (Balé and Purcell 2003). The same problem applies, that this may not actually be a real earthquake. Principia (1982) suggest Brittany may be meant.

DOUBTFUL

3.4 680 IRELAND

This is described as an “extreme great wind and earthquake” in Ireland in the Annals of Clonmacnoise (Murphy 1896). It may well not be an earthquake and there is evidently confusion between this event and the following one.

MISDATED AND DOUBTFUL

3.5 684 ISLE OF MAN

SHWP (1989) give this as an earthquake with epicentre in the Irish Sea of magnitude around 4.5 Ms, and a similar suggestion is made by Musson (1994), on the grounds that the earthquake was described as felt in the Isle of Man, Ireland, and Britain. In fact, appearances are deceptive. The documentation of this event is instructive, and has been studied in detail by Dumville (1984). The earthquake is mentioned in five chronicles as follows:

Annales Cambriae: *Terremotus in Eubonia factus est magnus.*

Annals of Ulster: *Uentus magnus. Terremotus in insola.*

Annals of Tigernach: *Uentus magnus. Terrimotus in Ibernia insola*.

Chronicum Scotorum: *Uentus magnus et terraemotus in Hibernia insola.*

Annals of Clonmacnoise: *There was an extreame great winde and earthquake in Ireland.*

The year is given variously as 684 or 685, but 680 in Annals of Clonmacnoise. A variant MS of the Annales Cambriae has Britannia in place of Eubonia (Isle of Man).

The sequence of texts, when ordered as above, is suggestive. Dumville (1984) argues that "insola" (island) means here "Isle of Man", and therefore that the Annals of Ulster entry is effectively the same as that in Annales Cambriae. The compiler of Annals of Tigernach then assumed that Ireland was the island mentioned, and added specific reference to Ireland which was then copied by the later chronicles. Dumville (1984) finds it most likely that all of these trace back to a single original report in a chronicle now lost, originating in North Britain, probably in Strathclyde, which was well-informed about affairs in the Isle of Man. There is no reason to suppose that anything was actually observed outside the Isle of Man, and the actual event may have been a landslip caused by a storm.

DOUBTFUL

3.6 DECEMBER 707 ULSTER

The Annals of Ulster (Balé and Purcell 2003) record two earthquakes in the same week in the December 707 in the northern part of Ireland. While the same uncertainty arises as to whether an earthquake in the modern sense of the word is meant, two events the same week sounds as if it may be an earthquake followed by an aftershock. Or it could be two landslips after a period of bad weather. Principia (1982) give the year as 706.

DOUBTFUL

3.7 OCTOBER 721 IRELAND?

This is again from the Annals of Ulster (Balé and Purcell 2003), and no details are recorded, not even a place, so one assumes Ireland as the location, but it could also be western Scotland given the links between Ulster and western Scotland at this time. Again, one cannot be sure that a seismic event is being referred to. Principia (1982) give the year as 720.

DOUBTFUL

3.8 8 FEBRUARY 730 IRELAND?

This is the first event for which we have an exact date, but otherwise the case is exactly as with the 721 event as regards source and lack of other information.

DOUBTFUL

3.9 12 APRIL 740 ISLAY

Again, from the Annals of Ulster (Balé and Purcell 2003) – this time we have both an exact date and a location. Islay, like Ireland, is virtually free of seismicity in modern times.

DOUBTFUL

3.10 974 ENGLAND

The earthquake of 974 appears as entry number 1 in Davison's (1924) catalogue, and described as it is by the source, Florence of Worcester (Stevenson 1853-6), as affecting all England, it really is the first earthquake in the British Isles where one can be certain that a genuine seismic event is being referred to. According to Goutoulas (1653) this earthquake threw down houses and killed people; whether Goutoulas was citing a source now lost or made this detail up one cannot tell. SHWP (1987) state that an epicentre in the Hereford-Worcester area may be assumed, on no other grounds than that it is described in a Worcester source. The epicentre could be anywhere in England.

EARTHQUAKE BUT NO DATA

3.11 25 DECEMBER 1034 STIRLING

This event, originating from the chronicle of Boece (1527) is clearly a landslide or bog-burst of some description. Ambraseys and Melville (1983) allow for the possibility that it might have been earthquake triggered, but there is no reason to suppose it was.

NOT AN EARTHQUAKE

3.12 1 MAY 1048 MIDLANDS

The chronicles citing this event are listed by Davison (1924). It was described as great, and felt at “Worcester, Wic, Derby and many other places”, suggesting an epicentre somewhere in the English Midlands and a magnitude of at least 4 Mw.

Place	*Latitude*	*Longitude*	*Intensity*
Derby	52.93	-1.50	F
Warwick	52.28	-1.58	F
Worcester	52.20	-2.20	F

Table 2 - Data for the earthquake of 1 May 1048

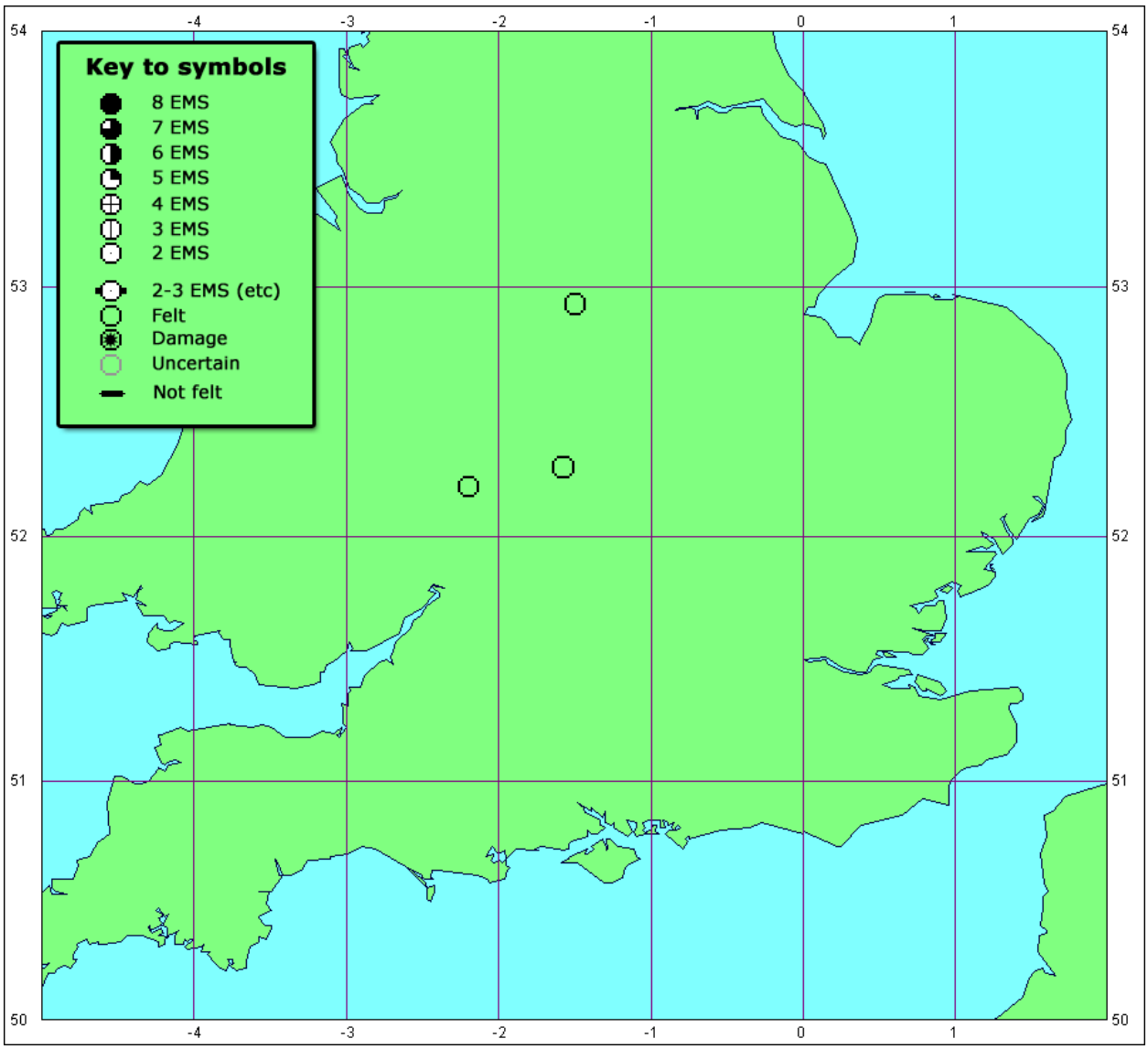

Figure 1 - The earthquake of 1 May 1048

3.13 4 JULY 1060 ENGLAND

The sole source for this earthquake gives the date, and that "there was a great earthquake" (Ingram 1823). The epicentre, magnitude, intensity and even felt area given by Ove Arup (1993) are therefore pure speculation. The chronicler's sentence immediately runs on to say " … and King Henry died in France." It is not even specifically stated that the earthquake occurred in England, though one assumes so.

EARTHQUAKE BUT NO DATA

3.14 1067 ENGLAND

This event, listed by Davison (1924), is shown by Ambraseys and Melville to be false, and is presumed to be a duplication of the 11 August 1089 event.

MISDATED EARTHQUAKE

3.15 22 APRIL 1076 NORTH SEA

Monastic annals describe this as "general" and "all over England", but later sources appear to conflate this event with that of 27 March 1081, often resulting in the date 27 March 1076 appearing, and perhaps also with 11 August 1089. According to Ambraseys and Melville (1983) the earthquake was felt in Northern France and may have been felt in Denmark, and they suggest that this may be a large earthquake with epicentre in the southern North Sea. It is not clear that there is any definite evidence that this earthquake was actually felt in England, though as Ambraseys and Melville (1983) point out, it may well have been. The account in SHWP (1995) largely follows Ambraseys and Melville (1983), and suggests northern Burgundy as the most likely location for the epicentre.

EXTRA-BRITISH EARTHQUAKE

3.16 25 DECEMBER 1079 EXETER

The sole source for this event is an entry in a short 14th century chronicle written in Exeter (Reichel 1907) describing a storm accompanied by an earthquake which "made great havoc of houses and smote the hearts of all with such fear …". The dating of the event is uncertain (Musson 1989a). Barlow (1983) describes the chronicle as inaccurate in its dating. SHWP (1987) dismiss the event as a storm without any earthquake. This is possible; however earthquakes *do* sometimes occur during storms, the Caernarfon earthquake of 1852 and the 1979 Carlisle earthquake being but two examples. If it was genuine, it seems to have been damaging, but there is no indication that the effects were widespread.

DOUBTFUL

Place	*Latitude*	*Longitude*	*Intensity*
Exeter	50.70	-3.53	D

Table 3 - Data for the earthquake of 25 December 1079

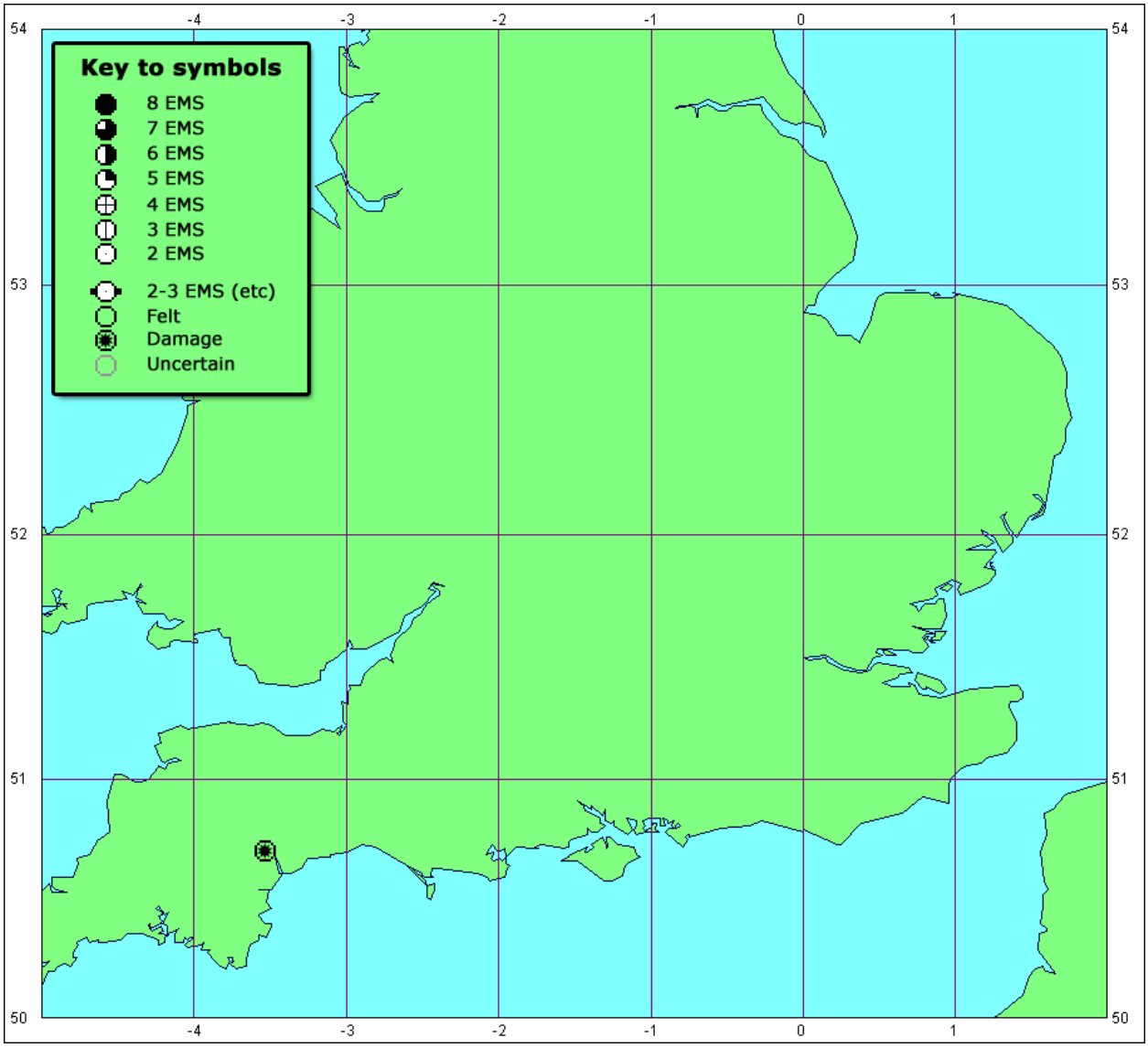

Figure 2 - The earthquake of 25 December 1079

3.17 27 MARCH 1081 ARDENNES?

This is clearly an earthquake with an epicentre somewhere in or near Belgium, perhaps analogous with the 1692 Verviers earthquake. As with the previous earthquake, there is no clear evidence that it was felt in England, though it may have been. SHWP (1995) suggest an epicentre near Brussels.

EXTRA-BRITISH EARTHQUAKE

3.18 1088 ENGLAND

This is listed by Davison (1924) but is an error for the 11 August 1089 earthquake (Ambraseys and Melville 1983).

MISDATED EARTHQUAKE

3.19 11 AUGUST 1089 ENGLAND

This earthquake is described as a great earthquake throughout all England, with the detail added by William of Malmesbury (Stevenson 1853-6) that all the buildings were lifted up and then

settled again as before (which does not seem to indicate damage). It is mentioned in both the surviving medieval chronicles of Scotland, but these entries are simply copied from English sources, so nothing can be deduced about the perceptibility of the shock in Scotland (Musson 2008). The purported intensity map in SHWP (1987) is purely speculative, as is their conclusion that the epicentre was in Herefordshire. Despite the lack of data, it seems likely, from the number of repetitions of the accounts, that this was one of the larger events of the period. This is also the only British earthquake to be mentioned by Robert of Torigni in Mont-St-Michel (Howlett 1889) who notes that "this year there was a terrible earthquake". While this might be interpreted as indicating the earthquake was felt in France, this would not be justified. The earlier part of Torigni's chronicle is copied from the Chronicon of Sigebert of Gembloux, but Torigni, feeling that Sigebert gave insufficient coverage of English affairs, inserted material from the *Historia Anglorum* of Henry of Huntingdon (whom he knew). It so happens that the 1089 earthquake is the only British event mentioned by Henry (Arnold 1879). See Ambraseys and Melville (1983) for an account of the confusion of dating this event has given rise to.

EARTHQUAKE BUT NO DATA

3.20 1110 SHREWSBURY

This event is described as "severe" by Florence of Worcester and as "great" by Simeon of Durham, but both mention only Shrewsbury as the location of it (Stevenson 1853-6).

Place	*Latitude*	*Longitude*	*Intensity*
Shrewsbury	52.72	-2.73	F

Table 4 - Data for the earthquake of 1110

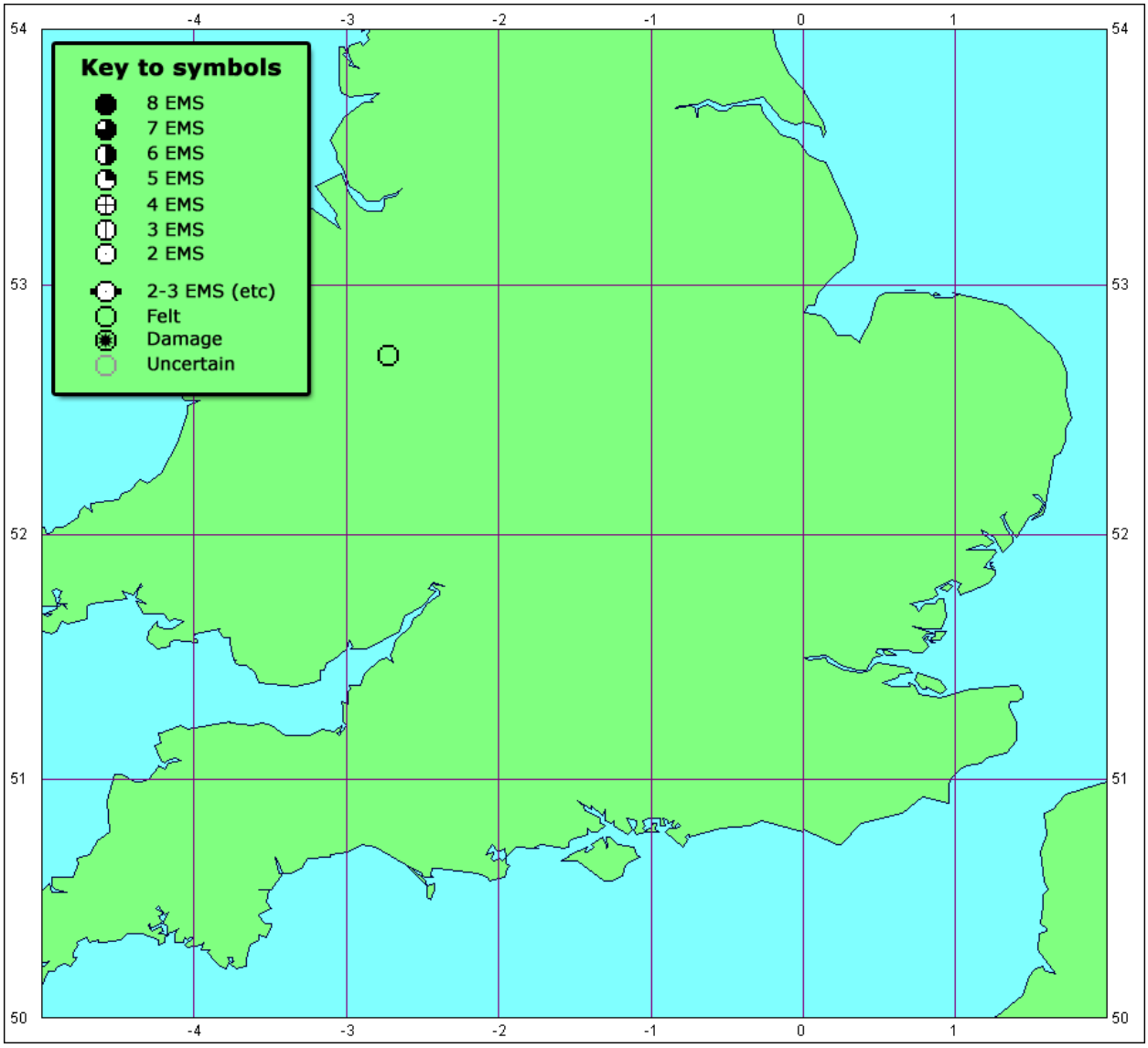

Figure 3 - The earthquake of 1110

3.21 13 DECEMBER 1116 ENGLAND

This event is listed by Davison (1924), but even he recognises the possibility (or rather, fact) that this is a misdated reference to the great earthquake of 3 January 1117 in northern Italy.

MISDATED AND MISPLACED EARTHQUAKE

3.22 1117 ENGLAND

On 3 January 1117 there occurred a great earthquake in northern Italy, which caused many deaths and was widely reported across Europe (see Guidoboni 1983). The chronicle of the abbey of Croyland is one of the English sources that explicitly describes this Italian event, but continues by reporting that, “many parts of England, also, were most dreadfully affected with this earthquake”, and damage occurred to Croyland church, which was under reconstruction and roofless at the time (Riley 1854). No other source mentions an earthquake in England at this time, though the Annals of Worcester contain a report of the northern Italy event without any mention of where it occurred (Luard 1869). One infers that the Worcester account must be describing the Lombardy event despite the absence of any location, since it is stated that many people perished.

It is somewhat curious, given that the 3 January 1117 earthquake has recently been interpreted as three separate events, in southern Germany, northern Italy and Tuscany (Guidoboni et al. 2005) to find what appears to be a further separate earthquake at about the same date described as affecting England. Martínez Solares and Mezcua Rodríguez (2002) even list an event on 3 January 1117 in Lisbon.).

Given that it is not credible that the Verona earthquake could have been perceptible in England, the alternatives are: (a) a significant earthquake in England close in time to the Verona event, as reported in the Croyland chronicle (but not the event alluded to in the Worcester Annals); (b) an earthquake local to Croyland at this time, exaggerated by the chronicle; (c) the damage to the church at Croyland was due to the temporary instability of the structure, and was falsely blamed on the Verona earthquake, which was very much in the news at the time. Ambraseys and Melville (1982) consider this to be a genuine earthquake, but give the date as 1117 or 1118, given that the description of the damage to Croyland is sandwiched between the description of the Verona earthquake (in 1117) and the death of Queen Matilda (in 1118). However, the source is precise in saying that “this earthquake” (of 1117) was the one felt in England. Ambraseys and Melville (1982) also provide an account of some duplications of this event under incorrect dates in later works. The conclusion drawn here is that if an earthquake was responsible for the damage to Croyland church, then it occurred in 1117, but it is quite likely that no such earthquake occurred in England.

DOUBTFUL

Place	*Latitude*	*Longitude*	*Intensity*
Croyland	52.67	-0.15	D

Table 5 - Data for the earthquake of 1117

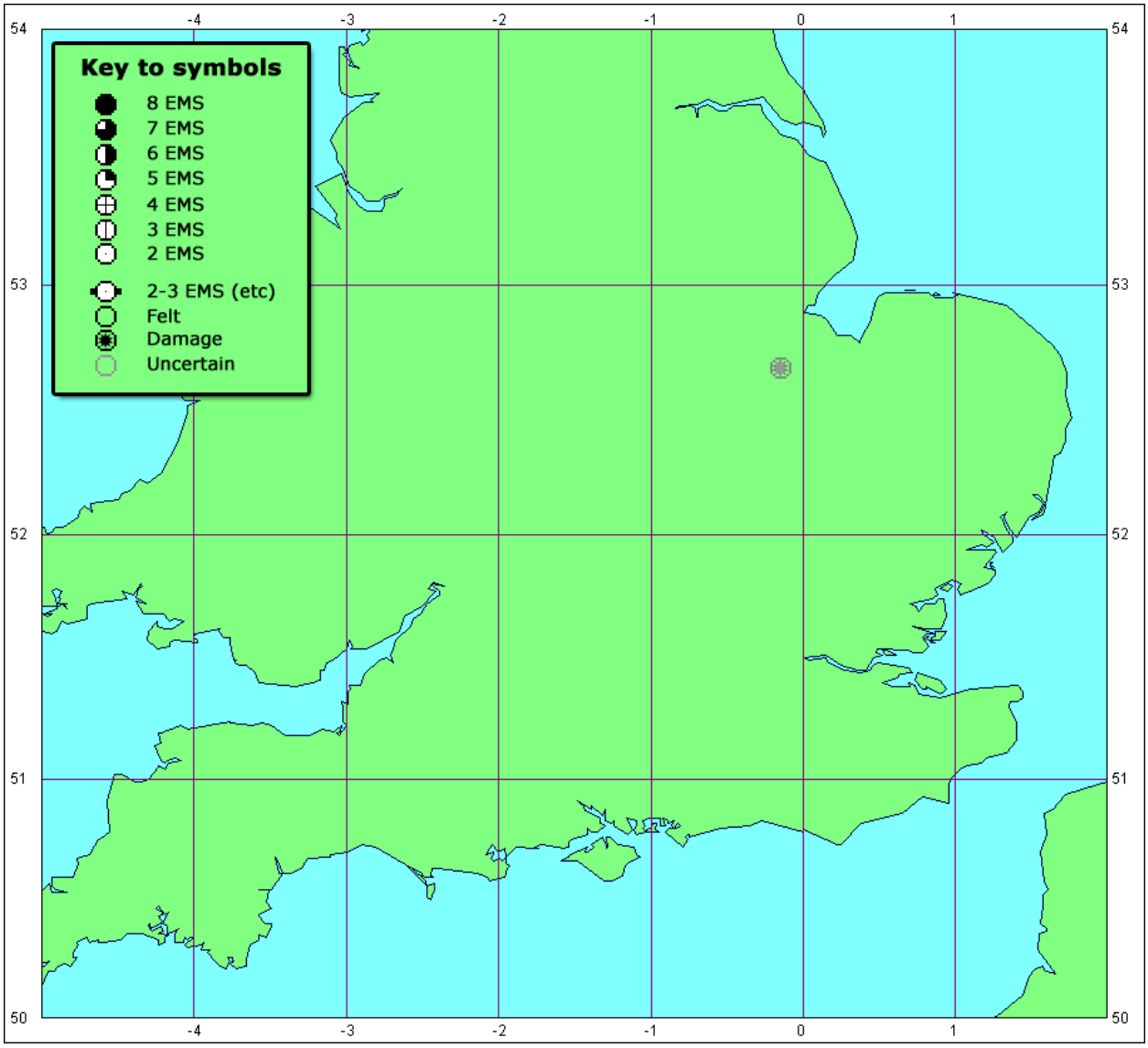

Figure 4 - The earthquake of 1117

3.23 28 SEPTEMBER 1119 WESTERN ENGLAND

The majority of chronicles that mention this event state that this was a great earthquake in many places, but strongest in Gloucestershire and Worcestershire. However, the contemporary Ordericus Vitalis, writing in Normandy but originally from Shrewsbury and thus with an interest in that part of the world, records that the shock was strongly felt throughout Cheshire, Shropshire, Herefordshire and Gloucester, which caused cracks to appear in the walls and masonry of churches all over these four counties (Chibnall 1980). It was also felt “in the neighbouring regions”, and “the inhabitants were left pale and trembling”. This is therefore a damaging earthquake with an epicentre in Herefordshire or Shropshire, perhaps not dissimilar to the 1990 Bishop’s Castle earthquake. Maximum intensity was presumably at least 6 EMS, though one cannot tell precisely where, and it is uncertain how far the area of damage extended. (Ordericus Vitalis continues by mentioning that shortly after the earthquake, a number of church dignitaries in England and Normandy died, implying the earthquake was a portent.)

Nicholls and Taylor (1881), on unknown evidence, state that the earthquake was violent, and felt in Bristol, Somerset, Worcestershire and Gloucestershire. SHWP (1987) suggest this is a confusion with the 1122 earthquake, which is surely correct.

Place	*Latitude*	*Longitude*	*Intensity*
Cheshire	53.17	-2.58	D
Gloucestershire	51.83	-2.17	D
Herefordshire	52.08	-2.75	D
Shropshire	52.67	-2.75	D
Worcestershire	52.17	-2.17	D

Table 6 - Data for the earthquake of 28 September 1119

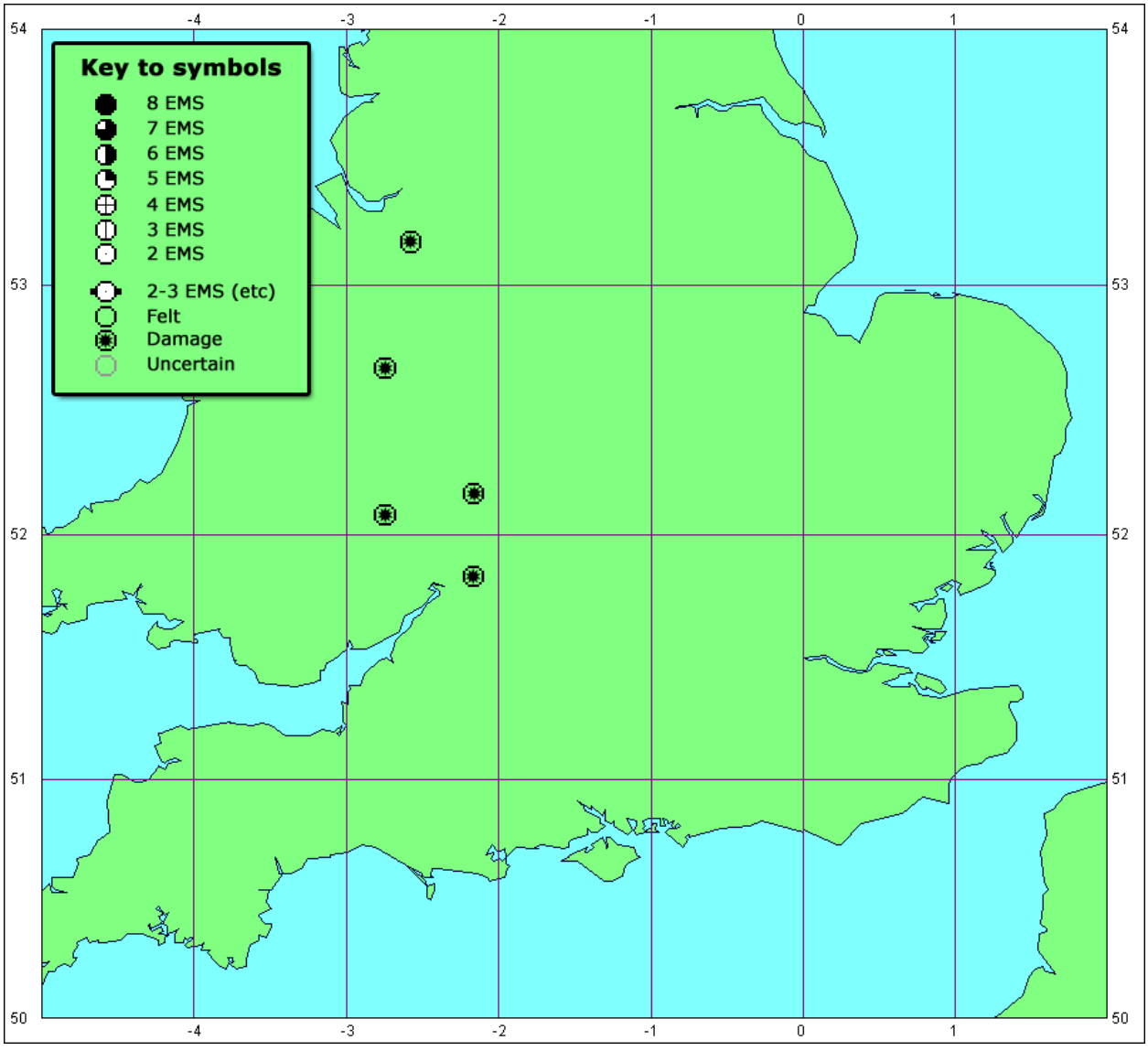

Figure 5 - The earthquake of 28 September 1119

3.24 28 SEPTEMBER 1120 ENGLAND

This listed by Davison (1924) on the authority of Stow (1580), who clearly is referring to the 28 September 1119 event, and Short (1749), who refers to the Trentino ("Vale of Trent").

MISDATED EARTHQUAKE

3.25 25 JULY 1122 SOUTHWEST ENGLAND

The Anglo-Saxon Chronicle states that this was “a very great earthquake over all Somersetshire and in Gloucestershire” (Ingram 1823) without further detail. The Margam Annals give the date and time (“media nocte”) and nothing else (Luard 1864). The epicentre could be in Somerset or South Wales. The interpretation by SHWP (1987) that this was a Newport/Monmouth event is very reasonable.

Place	*Latitude*	*Longitude*	*Intensity*
Gloucestershire	51.83	-2.17	F
Somersetshire	51.08	-3.00	F

Table 7 - Data for the earthquake of 25 July 1122

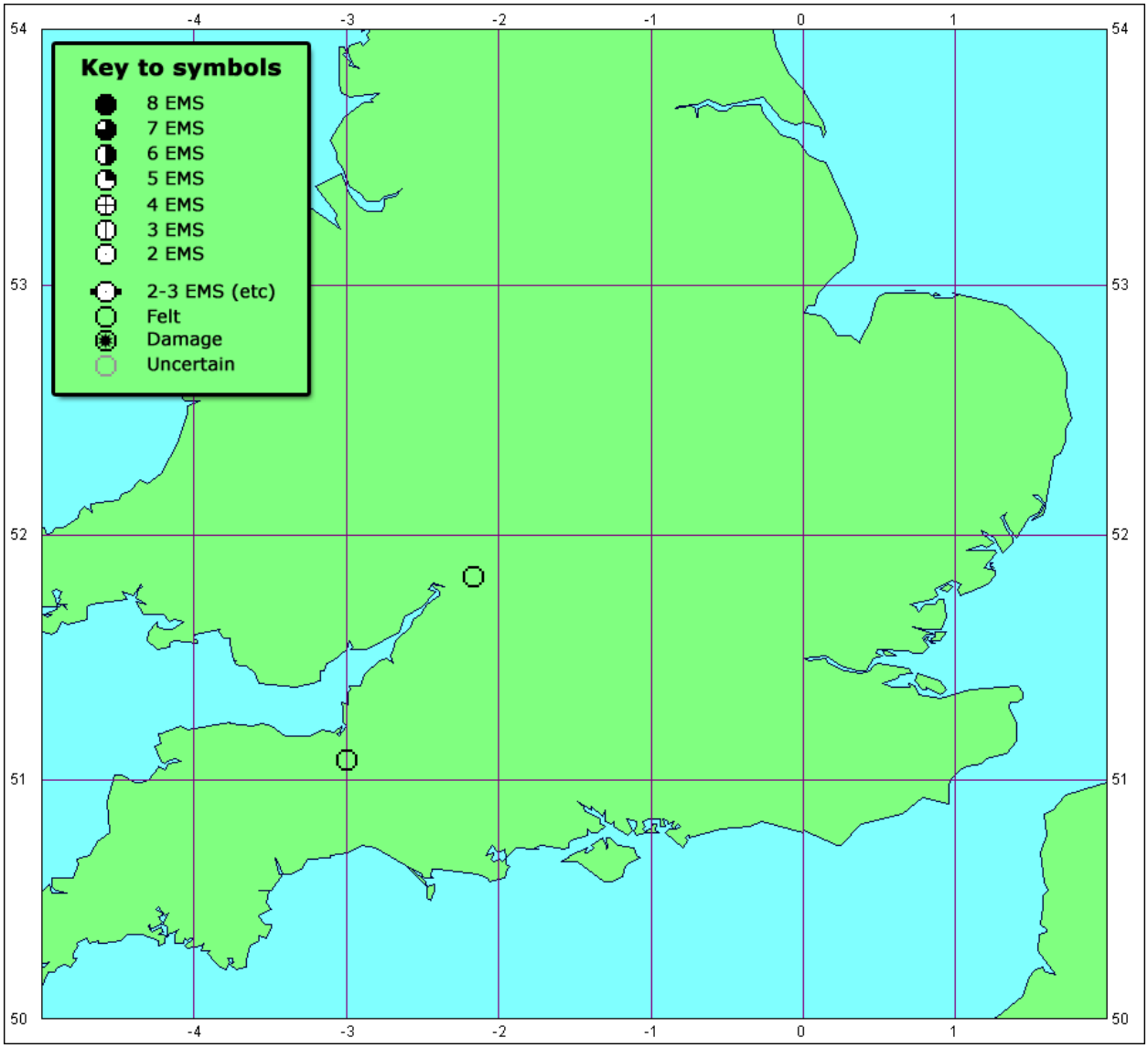

Figure 6 - The earthquake of 25 July 1122

3.26 5 DECEMBER 1129 ENGLAND

Described as a great earthquake shortly before dawn by the Anglo-Saxon Chronicle Ingram 1823), with no mention of any places. Ambraseys and Melville (1983) suggest it may have been local to the Peterborough region on the grounds that the MS containing the record was compiled in Peterborough (but who knows what the source of the annalist's information was?). See Ambraseys and Melville (1983) for a discussion of possible duplications of this event.

EARTHQUAKE BUT NO DATA

3.27 1132 ENGLAND

A reference in Davison (1924) to an earthquake in 1132 is clearly a misdated reference to the 4 August 1133 earthquake (SHWP 1987).

MISDATED EARTHQUAKE

3.28 4 AUGUST 1133 WESTERN BRITAIN

This earthquake is unusual for the period in that one of the sources gives an eye-witness account. William of Malmesbury records that "the wall of the house in which I was sitting was lifted up by two shocks, and settled again with a third" (Stevenson 1853-6). Otherwise it is merely reported as felt in many parts of England. One can hardly assign intensity to this scanty report from Malmesbury, though one would conclude the intensity was less than 6 EMS. A curious account in John of Hexham (Stevenson 1853-6) describes ships breaking loose from anchor despite the sea being calm, but this is dated two days before the earthquake and must be unrelated. SHWP (1987) make a selection of chronicles, assume intensity 4 at all the locations where these chronicles were compiled, and arrive at an epicentre near Shepton Mallet, Somerset. Realistically, the epicentre could be anywhere within a 150 km or so radius of Malmesbury, in any direction.

Place	*Latitude*	*Longitude*	*Intensity*
Malmesbury	51.59	-2.1	F

Table 8 - Data for the earthquake of 4 August 1133

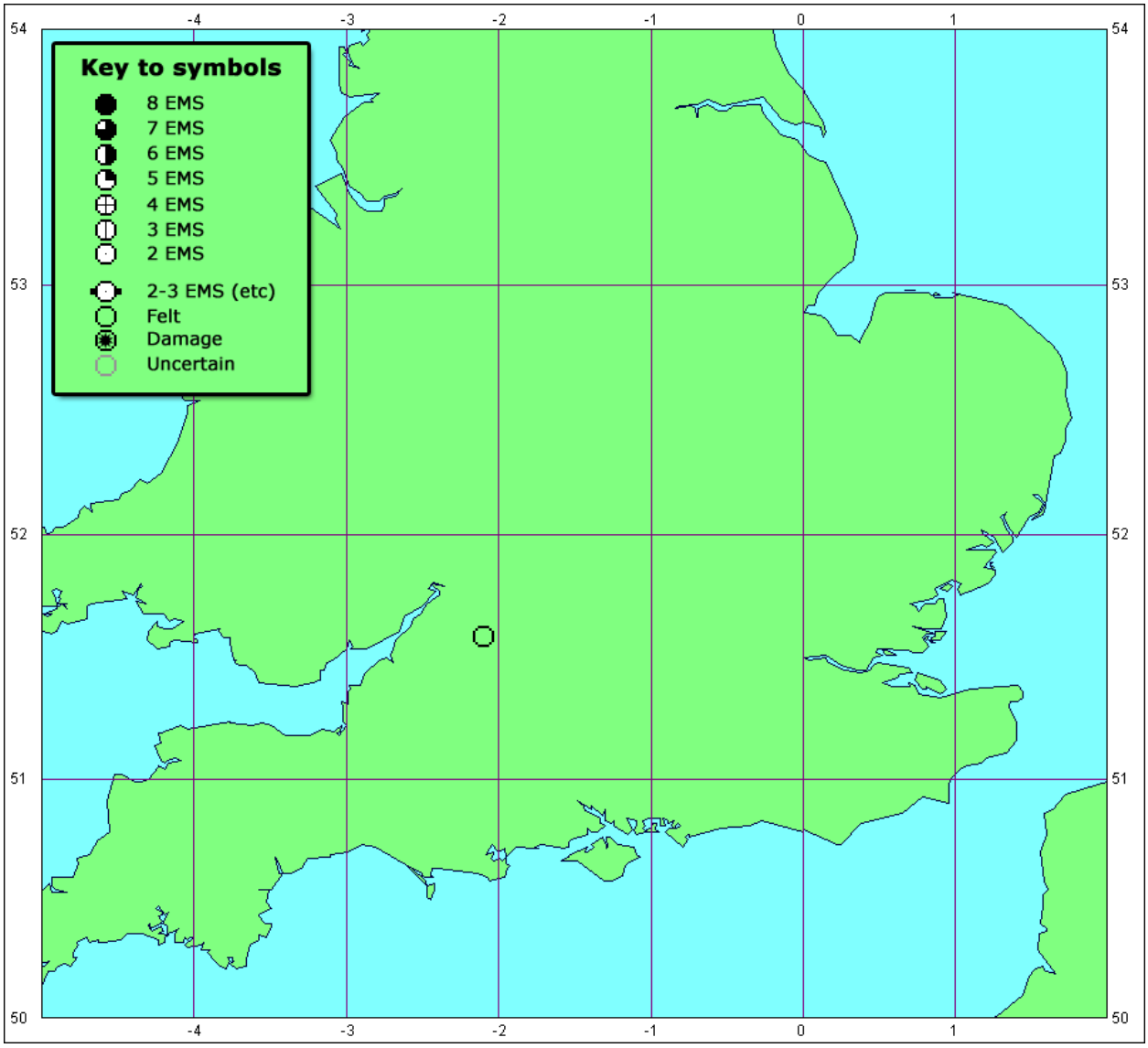

Figure 7 - The earthquake of 4 August 1133

3.29 DECEMBER 1140 LINCOLN

The sole source, John of Hexham, dates this event as after Christmas Day in 1142 (Stevenson 1853-6), but Ambraseys and Melville (1983) argue that the year should have been 1140, from relative dating with respect to the siege of Lincoln, and this is followed here. Three shocks are described, without other detail.

Place	*Latitude*	*Longitude*	*Intensity*
Lincoln	53.23	-0.53	F

Table 9 - Data for the earthquake of December 1140

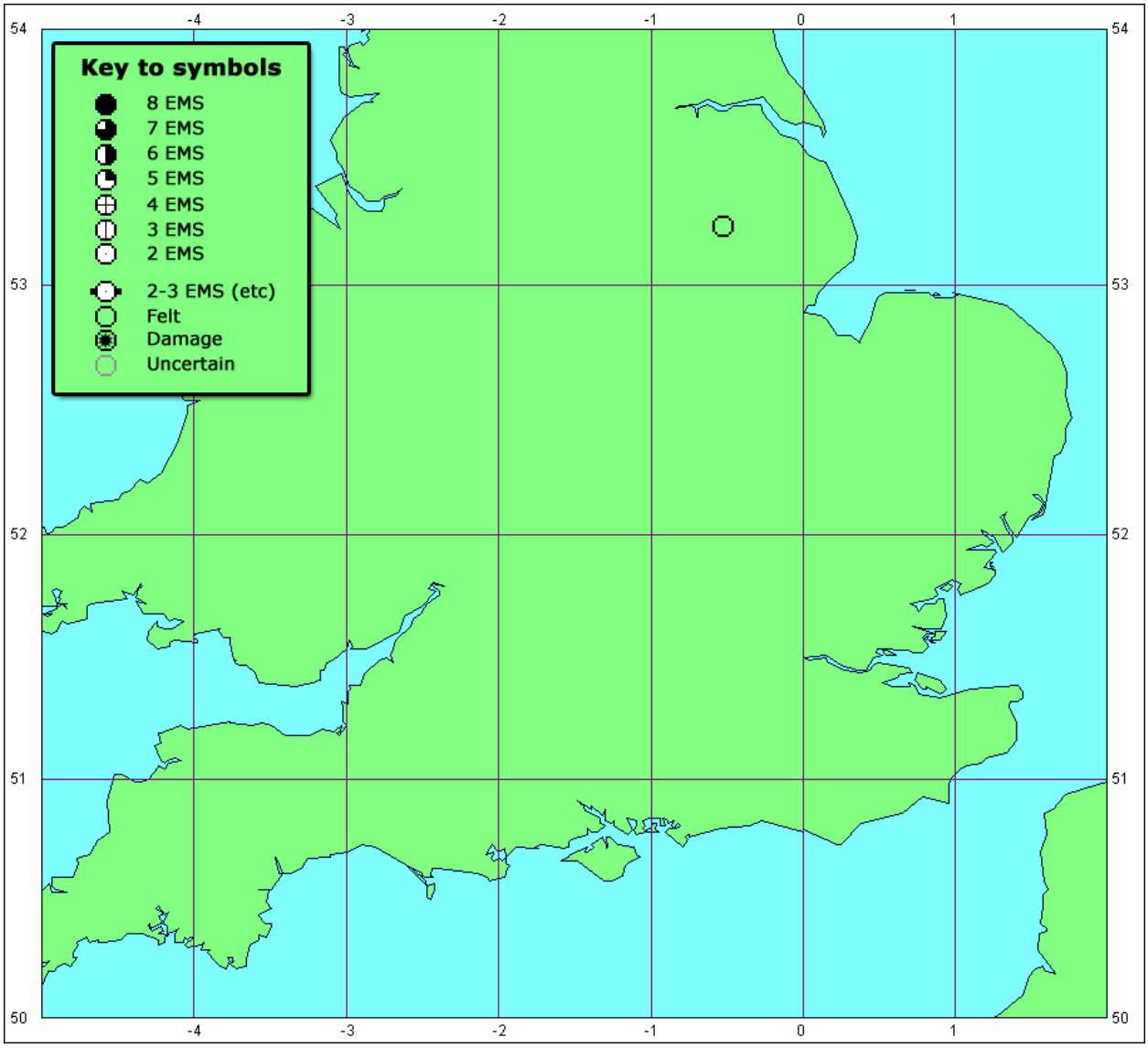

Figure 8 - The earthquake of December 1140

3.30 1158 ENGLAND

"An earthquake occurred in many places of England" is the sole information for this event. Principia (1982) suggest this may have been a Kentish earthquake on the grounds that the earliest writer to include mention of it was based in Canterbury (Gervase, writing circa 1188; Stubbs 1879). SHWP (1995) draw attention to Gervase's parochial interests in his writing as suggesting this must be an earthquake local to Canterbury; but Gervase also used second-hand information even for the period he could remember (Gransden 1974), so, without knowing the provenance of Gervase's information, one cannot safely conclude anything. Sources also mention in the same sentence that the River Thames dried up this year; it does not seem likely that there is any connection. According to Ambraseys and Melville (1982), and repeated by Principia (1982), the date of the earthquake is given as 1 May by Matthew Paris (Luard 1890), but in fact Matthew Paris does not mention the event; and the error is due to a misreading of MXLVIII as MCLVIII. The epicentre, intensity and magnitude given by SHWP (1995) are speculative only.

EARTHQUAKE BUT NO DATA

3.31 DECEMBER 1164 SE ENGLAND

This illustrates well the fragility of data for this period. A passage in the Historia Anglorum of Matthew Paris reads, “At the end of that year, that is, in Advent, and again on 25 January, there was an earthquake in Ely and Norfolk and Suffolk” (Madden 1866). This would appear to indicate two earthquakes in East Anglia. However, an exactly contemporary source, John of Salisbury, writing to Thomas a Becket from Rheims in January 1165, states, “It is said that there was recently an earthquake in England round Canterbury and London and Winchester, but the truth of the matter is not clear to me” (Millor and Brooke 1979). An earthquake in Advent would fit “recently”, and there is no other known event he could be referring to, so it seems likely that Matthew Paris, writing the following century, has run two separate earthquakes together. In his Chronica Majora only the January 1165 earthquake is mentioned (Luard 1874). Other sources for 1165 also fail to mention any earthquake the previous year. Most likely, then, the 1164 earthquake originated somewhere in south-east England, with Kent or Sussex being favoured choices. SHWP (1995) discount this event, on the grounds that either John was referring to the 25 January 1165 earthquake, or his information was incorrect, due to the lack of confirmation of a December event in any other contemporary source. However, since the chronicles of the time are clearly incomplete as a seismic record, it would be wrong to place much weight on their silences.

Place	*Latitude*	*Longitude*	*Intensity*
Canterbury	51.27	1.08	F
London	51.51	-0.08	F
Winchester	51.02	-1.32	F

Table 10 - Data for the earthquake of December 1164

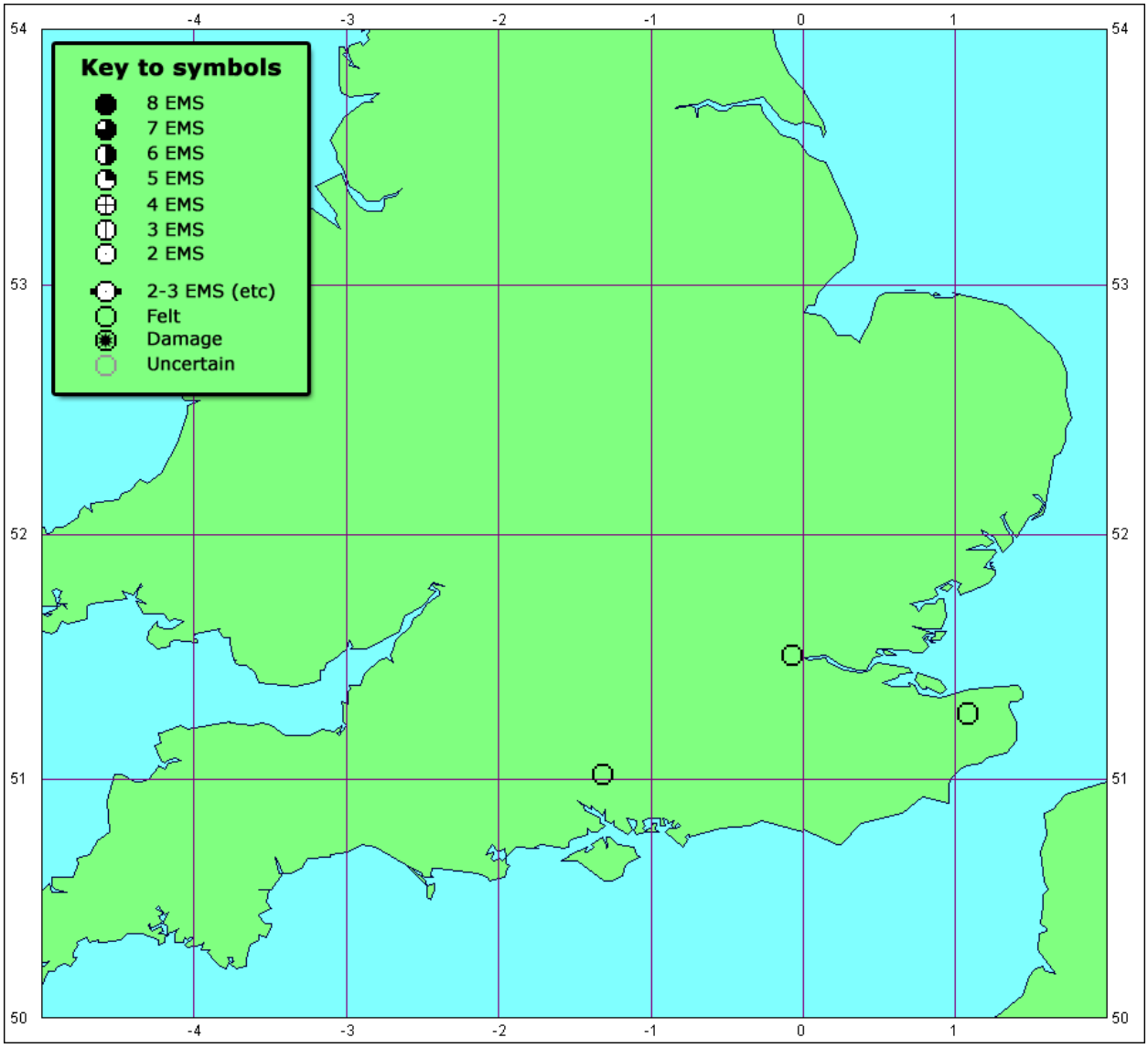

Figure 9 - The earthquake of December 1164

3.32 25 JANUARY 1165 EAST ANGLIA

In Gervase's chronicle (Stubbs 1879) this is simply referred to as a great earthquake in England in the middle of the night of the Feast of the Conversion of St Paul (25 January). Matthew Paris, writing the following century, states that the earthquake occurred in Ely, Norfolk and Suffolk, and that people standing fell down, and bells were rung. Ambraseys and Melville (1983) date the event to 26 January (they assume it occurred after midnight), and some chronicles place the event in 1164 through a misreading of Matthew Paris (e.g. the Annals of Bermondsey, Luard 1866).

Ambraseys and Melville (1983) make an interesting case for this being a large North Sea event similar to 1931 on the strength of an entry in the Chronicle of Meaux, Yorkshire (Bond 1866). This chronicle is arranged in chapters according to the abbots of Meaux, with events pertaining to the abbey in the main chapter, followed by an appendix giving an account of contemporary secular events. In the appendix to the chapter on the times of the second abbot, Abbot Phillip (1160-1182), the author of the chronicle mentions that during the reign of Pope Alexander III (1159-1181) and the three antipopes of his time, there were great earthquakes in various places – "per Anglia videlicet et Norwagium et alia loca longinqua". The text continues with mention of earthquakes in Syria and Sicily (events in 1170 and 1169 respectively). Ambraseys and Melville (1983) propose that the 1165 earthquake is the only significant English event in the period, and

therefore is the most likely candidate, and may thus have been felt both in Meaux and in Norway. There are two problems with this. Obviously, there is no necessity, from the text, for the event in Norway to be the same as the one in England, so it may be that an independent Norwegian earthquake (otherwise unknown) occurred some time in this period. Secondly, from other sources it appears that the effects of this earthquake were localised to East Anglia, rather than it being a great earthquake throughout England. It is much more likely that the earthquake being referred to is the 1185 earthquake, which only misses the relevant time window by a few years. Considering that the chronicle was composed around 1394-1400, such an error would be understandable. Ironically, a rubric in Bond's (1866) edition of the chronicle gives the dates 1159-1185 for the period in question, but this must be a misprint.

The ringing of church bells is usually a good indicator of intensity 6, and this is consistent with people losing their balance and falling. Exactly where or how widespread intensity 6 was observed within the Ely-Norfolk-Suffolk area is uncertain. The epicentre may have been similar to that of the 15 February 1994 Swaffham earthquake, but with a larger magnitude (at least 4 Mw).

Place	*Latitude*	*Longitude*	*Intensity*
Ely	52.40	0.27	F
Norfolk	52.67	1.00	F
Suffolk	52.17	1.00	F

Table 11 - Data for the earthquake of 26 January 1165

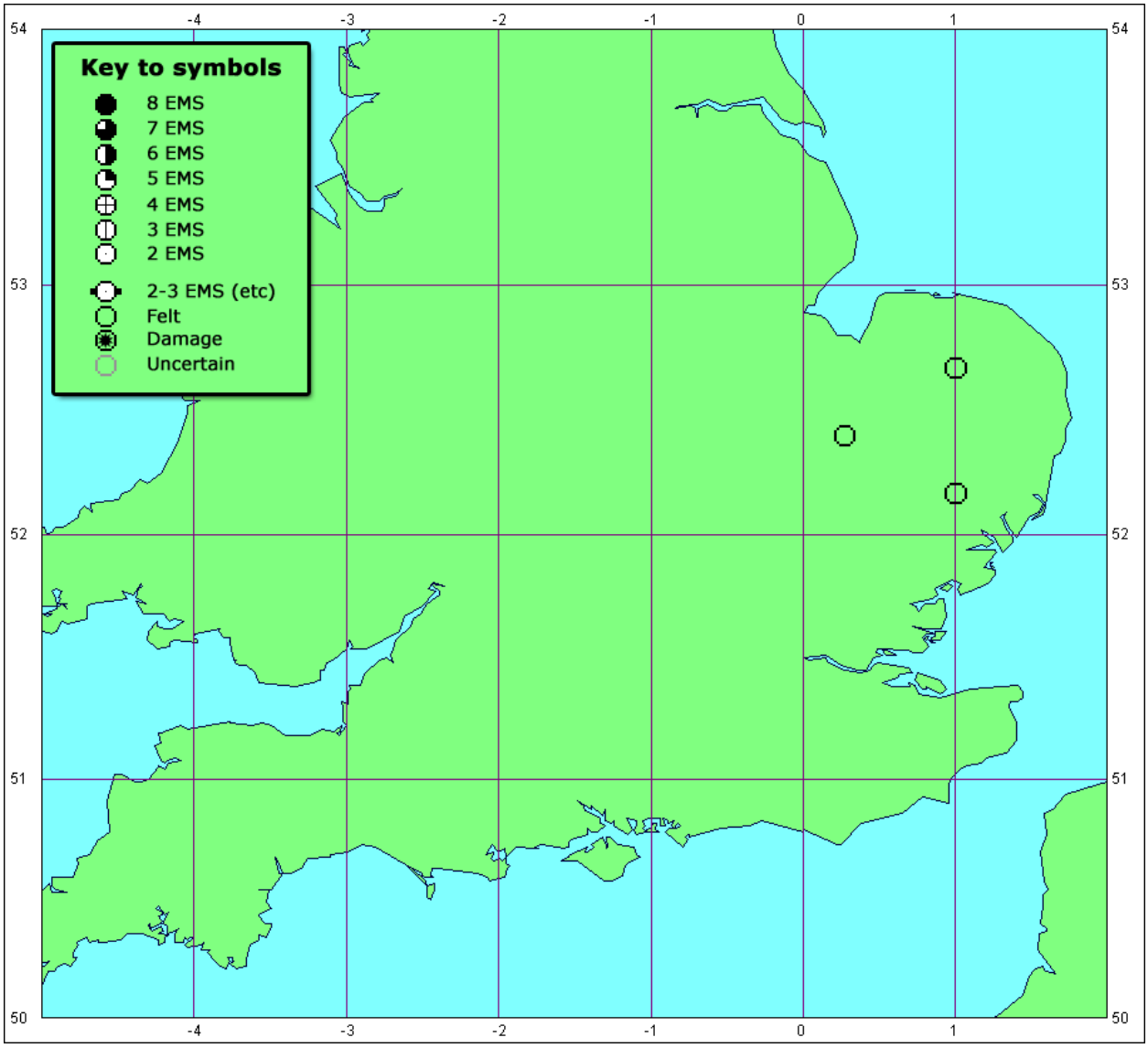

Figure 10 -The earthquake of 26 January 1165

3.33 17 FEBRUARY 1168 ENGLAND

An earthquake in England on this date is listed by Principia (1982) on the authority of Trivet (Hog 1845), but flagged as doubtful on account of being associated with a fireball (and therefore likely to have been a bolide event). Ambraseys and Melville (1983) are undecided as to whether the event was spurious, a reference to the 1158 earthquake, or a separate event. In fact, this is a case that can be at least partly resolved with a little background information: some warning should be raised when one sees that most of Trivet's material for this year relates to affairs in France. Trivet began work on his chronicle in Paris in the latter part of the 13th century, extracting material from French and Norman chronicles (Hog 1845), and a quick check reveals that this entry is lifted from Robert of Torigni's chronicle (Howlett 1889) with the date out by one day (should be 16 February). Whether this is an earthquake or a bolide, it must be considered a French event, not an English one.

MISLOCATED AND VERY DOUBTFUL

3.34 25 APRIL 1180 NOTTINGHAM

According to Davison (1924), citing Baker's Chronicle (Baker 1643), an earthquake at Nottingham and throughout the Midland counties caused many houses to be thrown down. In

fact, Baker (1643) doesn't mention Nottingham or the Midland counties, and simply describes the 1185 Lincoln earthquake with the wrong date. The reference to Nottingham is inserted by Lowe (1870) on no listed authority.

MISDATED EARTHQUAKE

3.35 15 APRIL 1185 EAST MIDLANDS

This is one of the largest and most interesting earthquakes of the period. The following facts can be gleaned from the sources: it was felt throughout all of England, but especially in the north; it was the worst ever known in England; stones were split ("petrae enim scissae sunt"); stone houses were thrown down; and Lincoln Cathedral was badly damaged (split from top to bottom). The damage to Lincoln cathedral has been debated. "… the extent of the damage is an inference from the other parts of the building which show no vestige of other earlier work. What has survived [of the pre-earthquake building] is the lower central part of the west end and the lower part of its two attached angle towers" (Johns, 1981 *pers. comm.*). Kidson (1986), however, is dismissive, and supposes that the prime cause of the collapse (probably a vault collapse) was poor construction or design, with failure perhaps being touched off by the earthquake. Intensity cannot be inferred from the damage to Lincoln cathedral; and as Woo (1991) points out, the structure may have been more vulnerable for geotechnical reasons. However, the information that masonry houses were thrown down implies an intensity more than 7 EMS at unspecified locations. Diceto, writing in London, says that the earthquake occurred in northern regions and that "in some places buildings were destroyed" (Stubbs 1876). There is no particular reason to suppose the epicentre was close to Lincoln; Davison (1931) suggested that this may have been a North Sea earthquake, a possibility also considered by Musson (1994). However, there are tantalising references to folklore concerning villages completely destroyed by this earthquake in Nottinghamshire. Two that are named are Raleigh (between Oxton and Southwell), specifically said to have been destroyed in 1185 (Mayfield 1976), and Danethorpe, south of Brough, for which the date of the earthquake is not given (Throsby 1790, also Beresford 1987, who makes no reference to Raleigh in his list of abandoned villages in the county). A further candidate might be Grimston, near Wellow, but the only reference to this having been destroyed by an earthquake is from a personal communication; written sources suggest that Grimston was a victim of the expansion of the lands of Rufford Abbey (Beresford 1987). An epicentre in Nottinghamshire would be entirely consistent with the available information for this earthquake (see Figure 1). Archaeological investigation would be interesting. On the other hand, there is faint reason to suppose that the earthquake was felt in Norway (see Section 3.21), in which case this would suggest it was a North Sea earthquake. What seems evident from the sources is that the level of damage was considerable, suggesting that this must have been one of the largest British earthquakes, with magnitude above 5 Mw.

Place	*Latitude*	*Longitude*	*Intensity*
Danethorpe	53.02	-0.75	D?
Lincoln	53.23	-0.53	D
Raleigh	53.07	-1.02	D?

Table 12 - Data for the earthquake of 15 April 1185

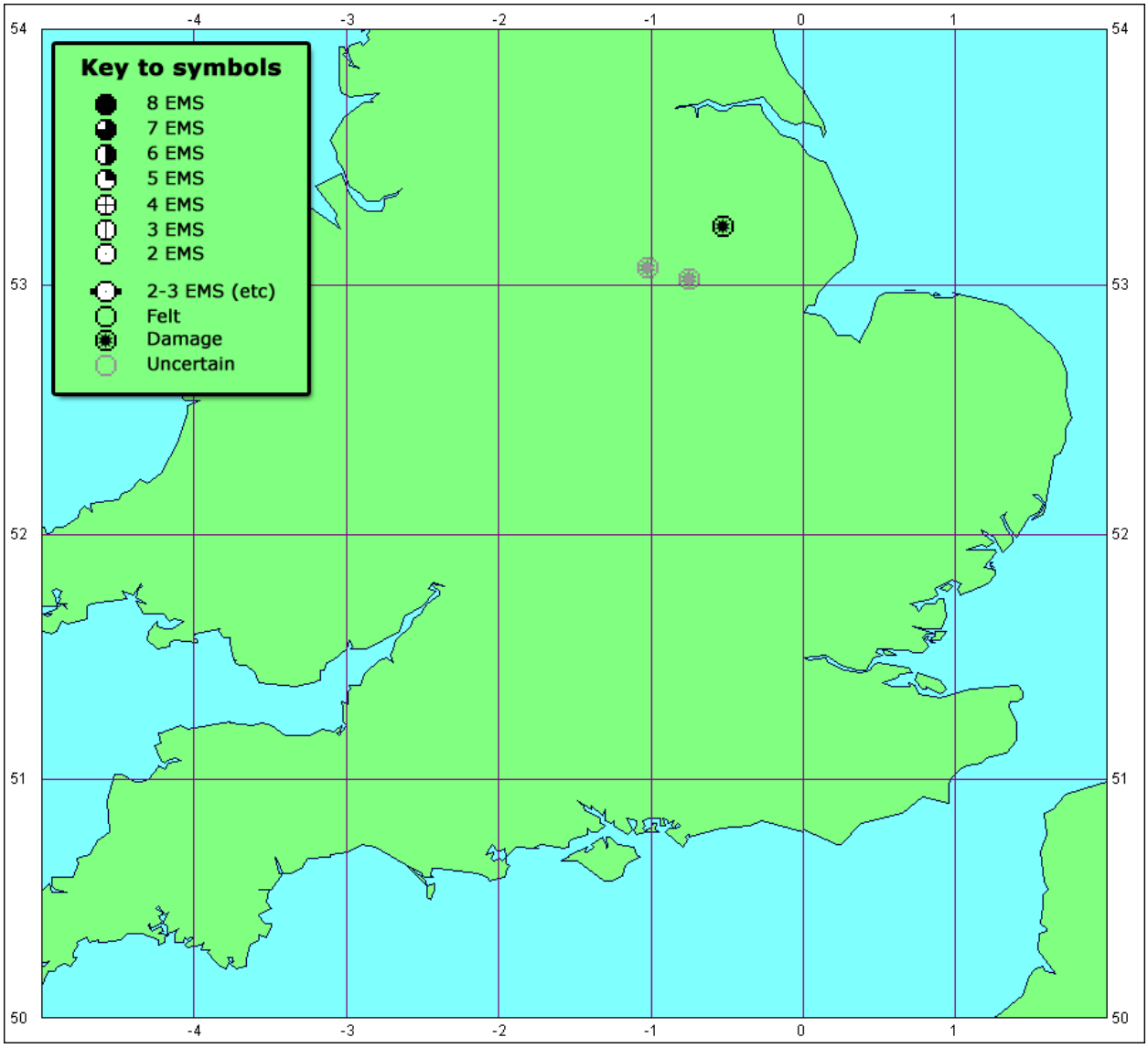

Figure 11 - The earthquake of 15 April 1185

3.36 SEPTEMBER 1186 ENGLAND

This earthquake is described as “dubious” by Principia (1982), and Ambraseys and Melville (1983) consider it a duplication of 1185. The earliest source is Roger of Wendover (Hewlett 1886), who describes it as a great and terrible earthquake over the whole world, and even in England, that destroyed many buildings. However, he gives no month, and the report has been interpreted to refer to September because of the interpolation of the report in the middle of a long account of events in the Holy Land, which is not necessarily a reliable indication. The tenor of Wendover’s description (and it is the only earthquake he mentions) indicates clearly that this is a duplication of the 1185 event.

MISDATED EARTHQUAKE

3.37 1197 ENGLAND

Mentioned without any detail whatever by the Annals of Tewkesbury and the Annals of Worcester (the latter possibly copying the former – Luard, 1864, 1869). Principia (1982) consider it probably a duplication of the 15 May 1201 event, which is also suggested by Ambraseys and Melville (1983), the reason being that the sources also mention a comet this year, when there was no comet. In fact, the entry consists of several unconnected sentences, and the

mention of the earthquake is sandwiched between mention of a comet and a statement that Philip was consecrated Bishop of Durham, which did indeed occur in 1197.

EARTHQUAKE BUT NO DATA

3.38 JANUARY 1199 SCOTLAND

References to an earthquake in 1199 in Principia (1982), Ambraseys and Melville (1983) and Musson (1994) are all misdated, following Fleming (1580), who misreads his source, which is Boece (1536) or Holinshed (1577).

MISDATED EARTHQUAKE

3.39 9 JANUARY 1201 YORK

According to Roger Howden (Stubbs 1871), this earthquake was heard (not felt) in York and the surrounding districts.

Place	*Latitude*	*Longitude*	*Intensity*
York	53.97	-1.08	F

Table 13 - Data for the earthquake of 9 January 1201

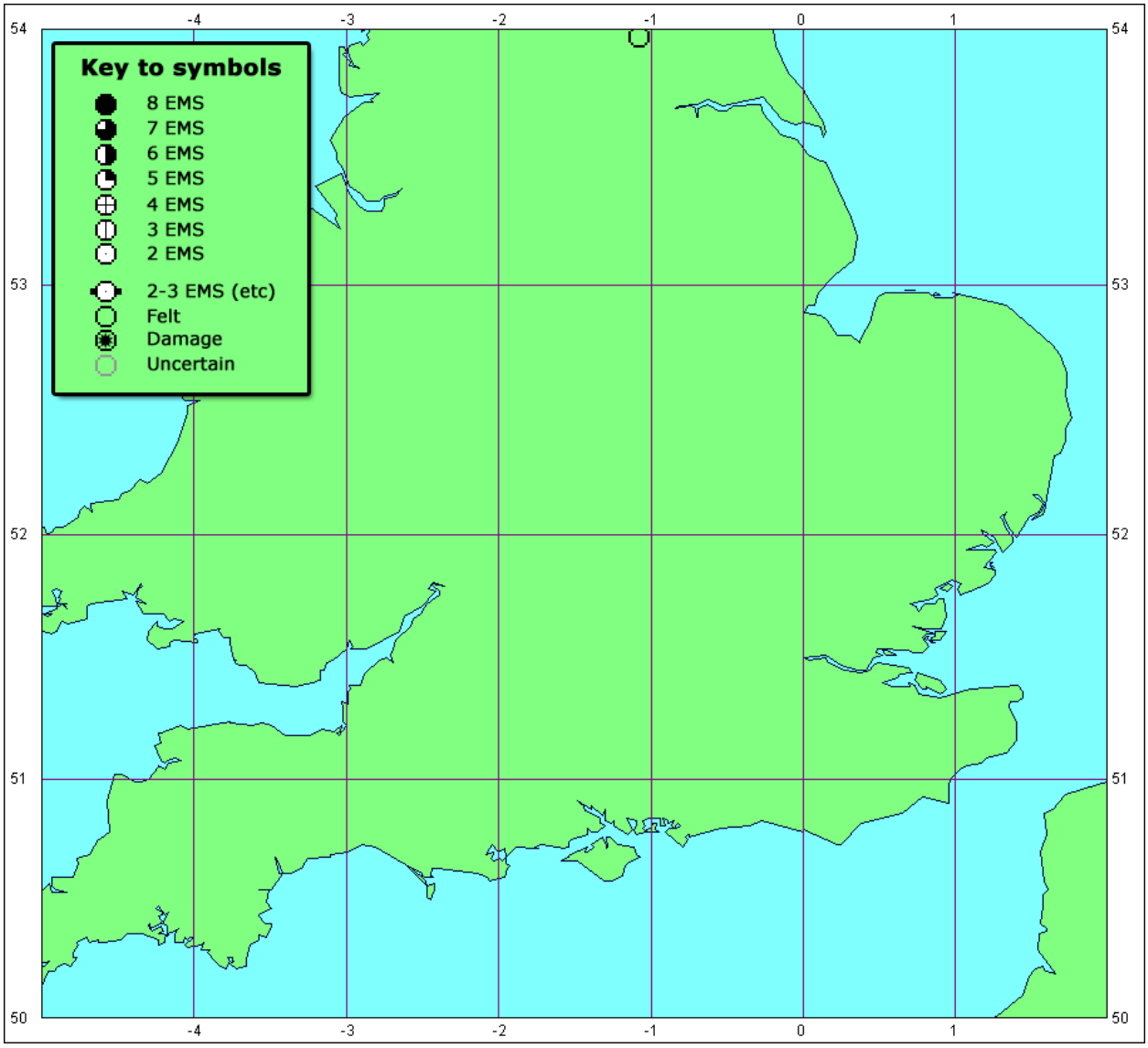

Figure 12 -The earthquake of 9 January 1201

3.40 22 MAY 1201 SOMERSET

The fullest account of this event is in the Annals of Winchester (Luard 1865). Shocks were felt over the space of two hours in Montacute, Somerset, and for seven miles around, which astonished the monks. Ralph de Diceto describes it as a great earthquake in the regions of Somerset and Dorset (Montacute is near the border of these counties) and states that those standing were thrown down (Stubbs 1876). This would appear to be a relatively minor earthquake, less than 4 Mw, with relatively high intensity – at least 5 and perhaps 6 EMS over a small area. The two sources give different dates; PML (1982) follows the Winchester Annals in giving 15 May. For reasons to prefer 22 May, and a discussion of possible duplications of this event, see SHWP (1987).

Place	*Latitude*	*Longitude*	*Intensity*
Montacute	50.95	-2.72	5-6

Table 14 - Data for the earthquake of 22 May 1201

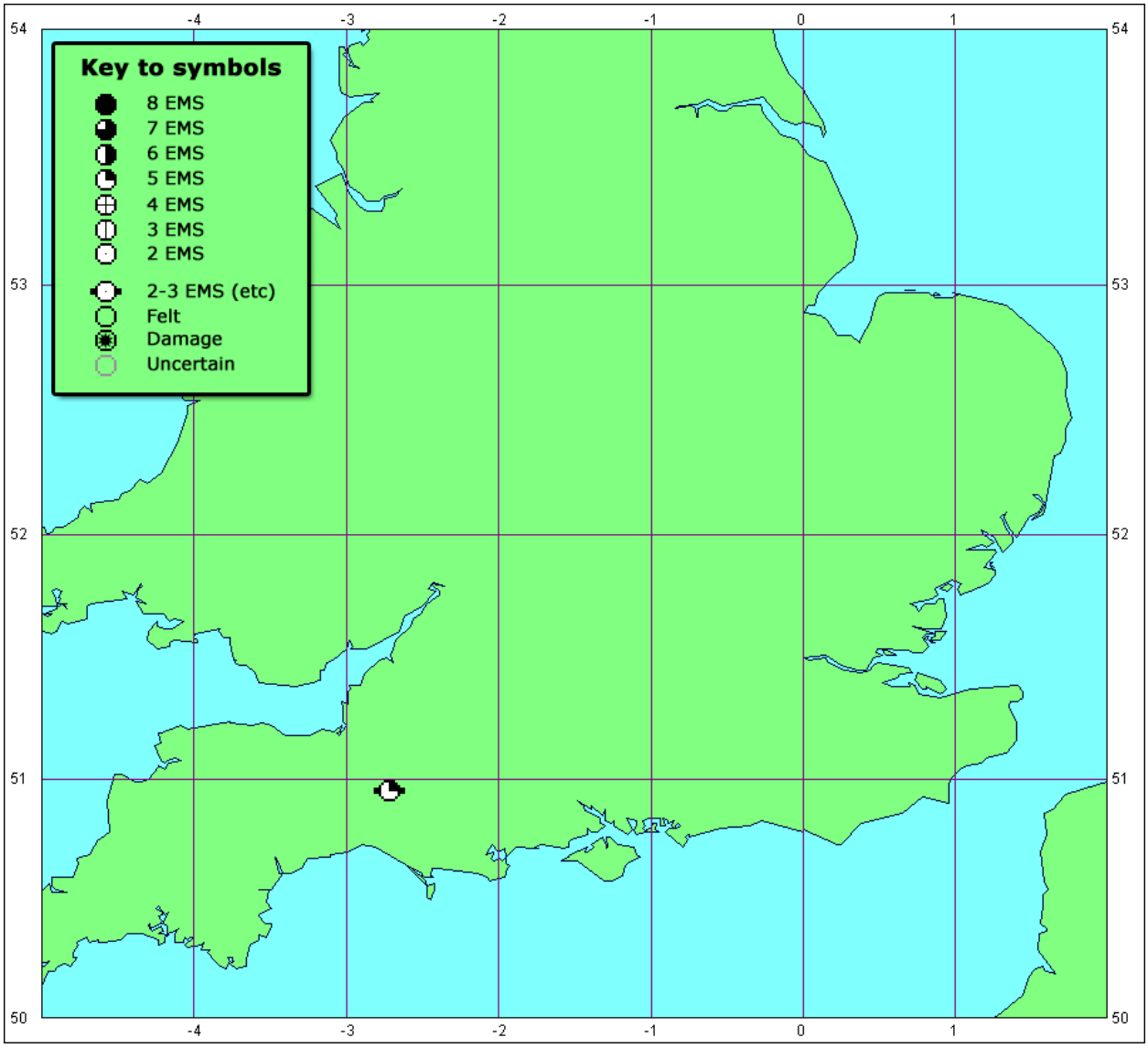

Figure 13 - The earthquake of 22 May 1201

3.41 6 JANUARY 1202 SCOTLAND

This earthquake has been misdated by all authors except Girardi (1653), but the correct year is clear when one reads the original source (Boece 1536, Holinshed 1577) carefully, and compares the chronology of other events mentioned. The fact that the earliest source is 16th century, for a 13th century earthquake, should not cause the authenticity of the event to be doubted, given the scarcity of Scottish source material for the period; in it quite possible that Boece had access to materials now lost. He states that from the Twelfthtide (6 January) until February, there were very terrible earthquakes every day. Such sequences are typical for Inverness, Comrie and the area around Stirling, but earthquakes in the latter two places would be more likely to be reported. The possibility that this is the earliest Comrie swarm on record makes an attractive hypothesis, but is only supposition.

EARTHQUAKE BUT NO DATA

3.42 1202 ENGLAND

In the Tewkesbury annals it is stated that there were earthquakes in many parts of England in 1202 (Luard 1864). Davison (1924) treats this is as doubtful (it is not listed in the main catalogue) and SHWP (1987) suggest it refers to one or other of the 1201 earthquakes discussed above.

DOUBTFUL

3.43 1219 ENGLAND

Mention of an earthquake in England in 1219 together with storms is found in Polydore Virgil (Hay 1950) but not supported by earlier records. This is probably the source for various reports of earthquakes in 1221 and 1222 (e.g. in Mallet 1852). These are dismissed by Ambraseys and Melville (1983) as spurious.

NOT AN EARTHQUAKE

3.44 23 APRIL 1228 ENGLAND

Described in the Tewkesbury annals as an earthquake in many parts of England (Luard 1864). This earthquake is another example of an "inferred" intensity map in SHWP (1987) who arrive at intensities for Margam and Tewkesbury on the basis of chronicle entries that do not state that the earthquake was felt there, and assign an epicentre near Newport.

EARTHQUAKE BUT NO DATA

3.45 10 FEBRUARY 1233 HUNTINGDON

An obscure earthquake mentioned in connection with a thunderstorm in a London chronicle (Anon 1827) without any place attached, and as associated with Huntingdon and region by Fabyan (Ellis 1811) without a precise date. However, Roger of Wendover (Hewlett 1887) and Matthew Paris (Madden 1866) give thunderstorms (but no earthquake) in November of this year, which may be the reason for Holinshed (1577) arriving at an earthquake in Huntingdon in November 1233, which is then cited by Davison (1924). Ambraseys and Melville (1983) make a tentative conclusion that an earthquake was felt in Huntingdon and Peterborough and possibly as far as London, though given the association with thunderstorms, the event is "of very dubious seismic origin". See Ambraseys and Melville (1983) for various possible misdatings of the event. Either the earthquake or the thunderstorms were said to be terrifying at Huntingdon.

DOUBTFUL

Place	*Latitude*	*Longitude*	*Intensity*
Huntingdon	52.33	-0.18	F

Table 15 - Data for the earthquake of 10 February 1233

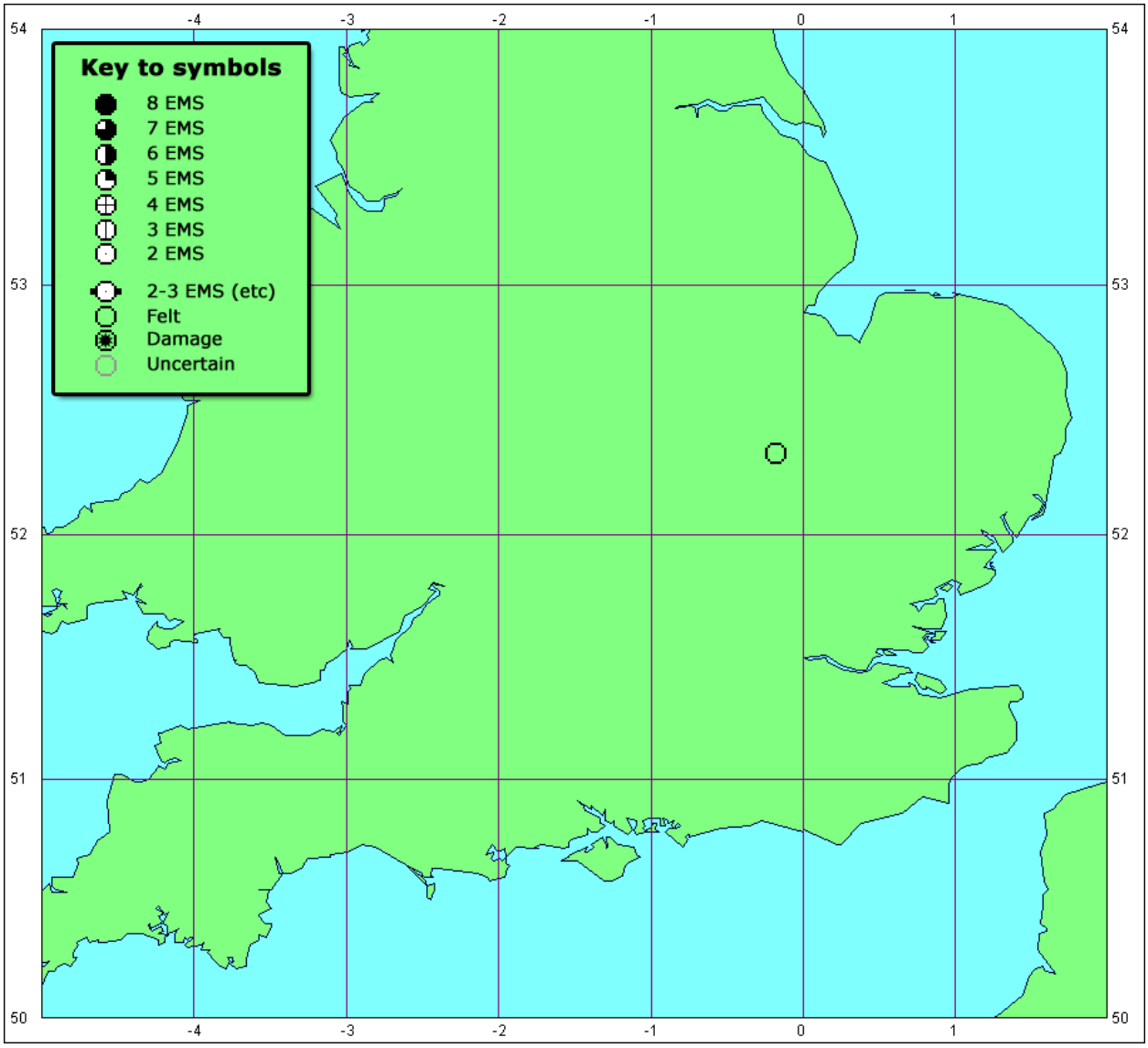

Figure 14 - The earthquake of 10 February 1233

3.46 1242 ENGLAND

An entry in the short chronicle of the Church of Exeter (Reichel 1907) states that there was an earthquake all over England in 1242. In the absence of any other reports, it seems almost certain that this is a misdated reference to the great earthquake of 1247.

MISDATED EARTHQUAKE

3.47 11 MARCH 1246 ENGLAND

This appears as a great earthquake throughout all England and in Ireland in Davison (1924). The date is clearly wrong, as the sources all give x kal Martii, or occasionally xi kal Martii, which cannot be construed as 11 March. The earthquake being described is clearly that of 20 February 1247.

MISDATED EARTHQUAKE

3.48 1 JUNE 1246 CANTERBURY

This earthquake in Davison (1924) is referred back to Perrey (1849), who cites Montbéliard (1761) and Krüger (1752). Mallet (1852) also lists the event, with a mention that von Hoff (1840) gives the date as 19 May. Von Hoff (1840) cites Grey (1750) and also lists Grey's sources, which include Higden's Polychronicon and the chronicles of Fabyan and Thomas Walsingham; these are also cited by Mallet (1852). However, these chronicles that are cited all relate to the earthquake of 21 May 1382, and how it came to be so misdated is hard to fathom.

MISDATED EARTHQUAKE

3.49 13 FEBRUARY 1247 LONDON

This earthquake is very problematic. The source is Matthew Paris, who gives two versions. In the Historia Anglorum, he simply states that on the ides of February (13 February) an earthquake in various places in England shook and damaged buildings, which was unusual (Madden 1866). In the account of the same event in the Chronica Majora (Luard 1877), he underlines the date by giving it not only as the ides of February, but also the vigil of St Valentine (i.e. the day before 14 February), and adds the detail that it occurred especially in London ("praecipue tamen Londoniis") and was most pronounced ("maxime") on the banks of the River Thames. The difficulty is how to relate this to the earthquake of 20 February 1247 which was felt over most of England and Wales. Either there were two earthquakes a week apart, or Matthew Paris is referring to the 20 February event and has misdated it a week. The chronicle of FitzThedmar (Stapleton 1846, Riley 1863) states that an earthquake was felt in London on 20 February 1247, and gives the same time as other sources for this event. No source mentions two earthquakes occurring in 1247, and in fact, Paris particularly mentions the following year that over a three-year period three earthquakes occurred this side of the Alps: one in Savoy and two in England, the other one being in 1248.

Ambraseys and Melville (1983), Melville (1983) and SHWP (1987) all adopt the conclusion that Paris's account is defective and he has merely misdated the 20 February earthquake by a week, and that London therefore lay on the edge of the felt area of this earthquake, which they centre in the vicinity of Pembroke. However, one is then faced with the difficulty that Matthew Paris is exactly contemporary with the earthquake, is in general notably reliable about chronology, and was living in St Albans, sufficiently close to London to be well-informed as to what was going on there. In contrast, FitzThedmar was writing about 1270, and is therefore more likely to have made an error about the date. Furthermore, Paris underlines the date by giving it in two different forms, both in the Roman manner and with respect to the church year. He also states, in addition to the earthquake being damaging, that it was worst in London and on the banks of the Thames. Since the earthquake of 20 February caused damage in Pembrokeshire, it is not likely that the same earthquake would also be damaging houses in London. As a result, those studies that choose to interpret a single event on 20 February not only have to argue that Paris gets the date wrong, but also that his statement that the earthquake was strongest (or even strong) in London is also completely wrong. While this is convenient in order to support a simple seismological interpretation of one large earthquake in Wales, it is difficult to justify, from the historian's perspective, discarding one's best witness because his testimony doesn't fit one's hypothesis.

There is no reason seismologically why a relatively minor earthquake in London, similar to the two London earthquakes of 1750, should not be followed a week later by a large earthquake in Wales, and while it is slightly disturbing that no source mentions earthquakes on both days, this is the interpretation that best fits the source material. While one cannot assign any intensity, the shock was evidently damaging.

UNCERTAIN

Place	*Latitude*	*Longitude*	*Intensity*
London	51.51	-0.08	D

Table 16 - Data for the earthquake of 13 February 1247

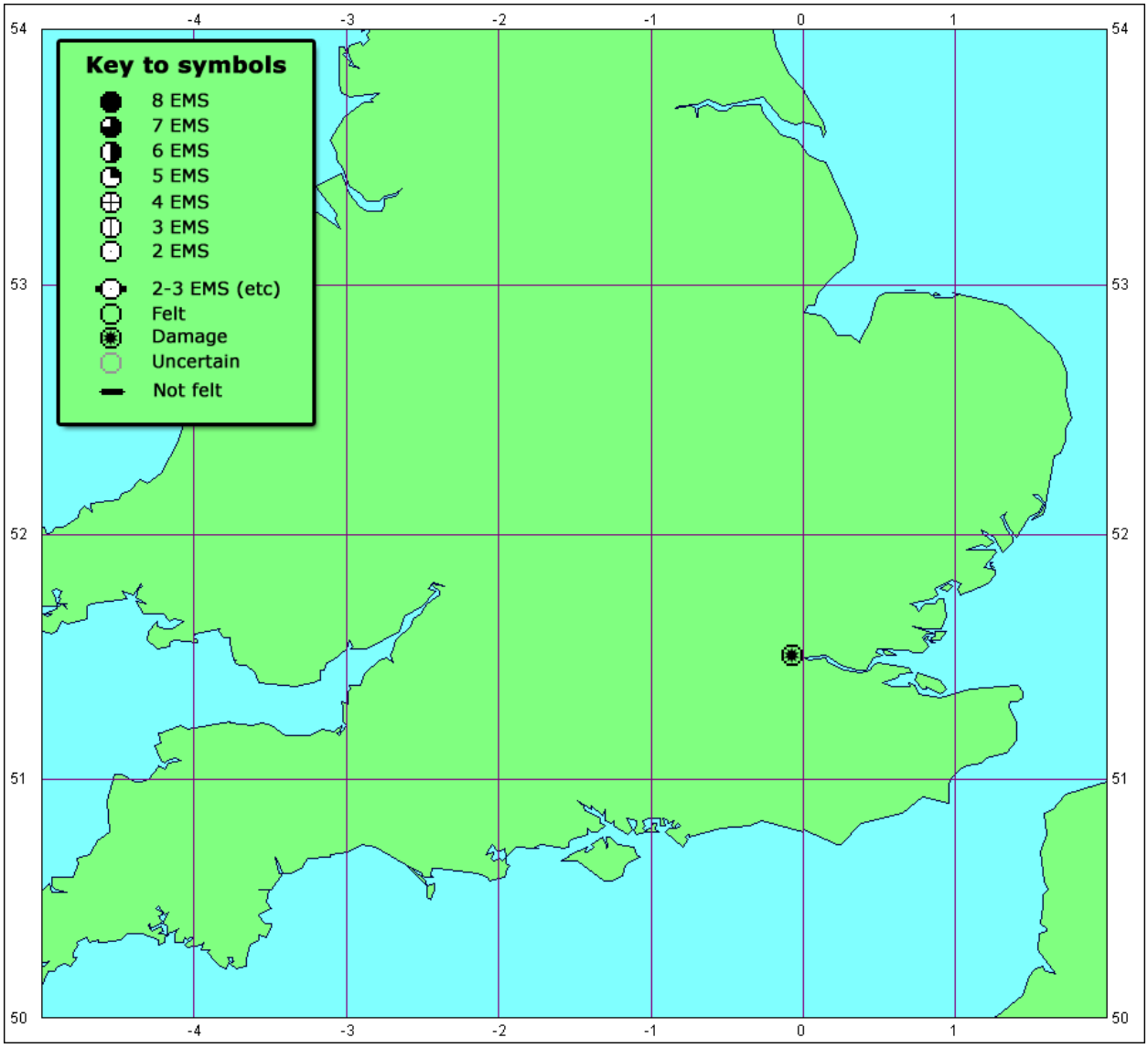

Figure 15 - The earthquake of 13 February 1247

3.50 20 FEBRUARY 1247 WALES

It is clear that this earthquake is one of the larger of this period, but the location of the epicentre is still in doubt. There are general descriptions that the earthquake was felt throughout the whole of England, especially in the west (Luard 1865). The two main Welsh chronicles indicate that it was felt throughout Wales (Williams 1860, Jones 1952, 1955) and was also felt in Ireland (which is also mentioned in some English chronicles); it damaged ("corruit") the cathedral of St Davids and "rupes scissae sunt" (stones were split). The chronicle of the Abbey of St Werburgh at Chester records that the earthquake was felt in Holywell (Christie 1887). There is confirmation from Irish sources that it was felt in Ireland (O'Hinnse 1947), and also a note that it was felt in Scotland (Färber 2000). A 14th century report that it was felt in France (Giles 1845) most likely results from a confusion between Gallia (France) and Wallia (Wales). It may have been felt also in London (see the discussion of the previous event). There is also the faint possibility that it caused damage in Downpatrick, Co. Down. According to Chart (1940), writing about

Downpatrick Cathedral, “destruction by an earthquake occurred in 1245”. While this could be a dating error for 1247, it is hard to see what the basis for this is, and the opinion of the present Cathedral Historian is that this is no more than a myth (Wilkinson 1996 *pers. comm.*). The extent of the damage to the cathedral of St Davids cannot really be discerned from the present fabric, but may have been to the arcades of the presbytery, which were altered at about this date (Evans 1991). Owing to the inadequacy of the original foundations (Evans 1991) it is likely the building was somewhat vulnerable, and the assumption that because of damage to one building, the epicentre of this earthquake must have been in Pembrokeshire is unsound. However, neither can one rule out such a hypothesis. An alternative possibility, again hypothetical, is that the epicentre was in Snowdonia, and this earthquake was analogous to the large (~ 5 Mw) events there in 1690, 1852 and 1984. The fact that Snowdonia has such a record of activity makes this hypothesis all the more plausible. It is also likely by comparison with those events (but also with the earthquakes in south-west Wales in 1892 and 1893) that they would be felt in most of England but not as far as London or St Albans, which would explain the absence of a precise mention of this earthquake by Matthew Paris (see previous section). If there is any truth to the supposition that Downpatrick was affected (not very likely) then this would, of course, favour an epicentre in north-west Wales. The report that the earthquake was felt in Scotland also favours an epicentre in north-west Wales; the comparable earthquakes in 1852 and 1984 were felt in all four countries. The description of the earthquakes in the Waverly annals is one of the fuller ones (Luard 1865), and speaks of buildings being shaken up to the point of collapse, dishes being thrown off tables and people running out terrified, indicating intensities around 5-6 EMS in some places (but this is not indication of what the intensity might have been at the epicentre, wherever that was).

Place	*Latitude*	*Longitude*	*Intensity*
Downpatrick	54.32	-5.70	D?
Holywell	53.28	-3.25	F
London	51.51	-0.08	F?
St Davids	51.88	-5.27	D

Table 17 - Data for the earthquake of 20 February 1247

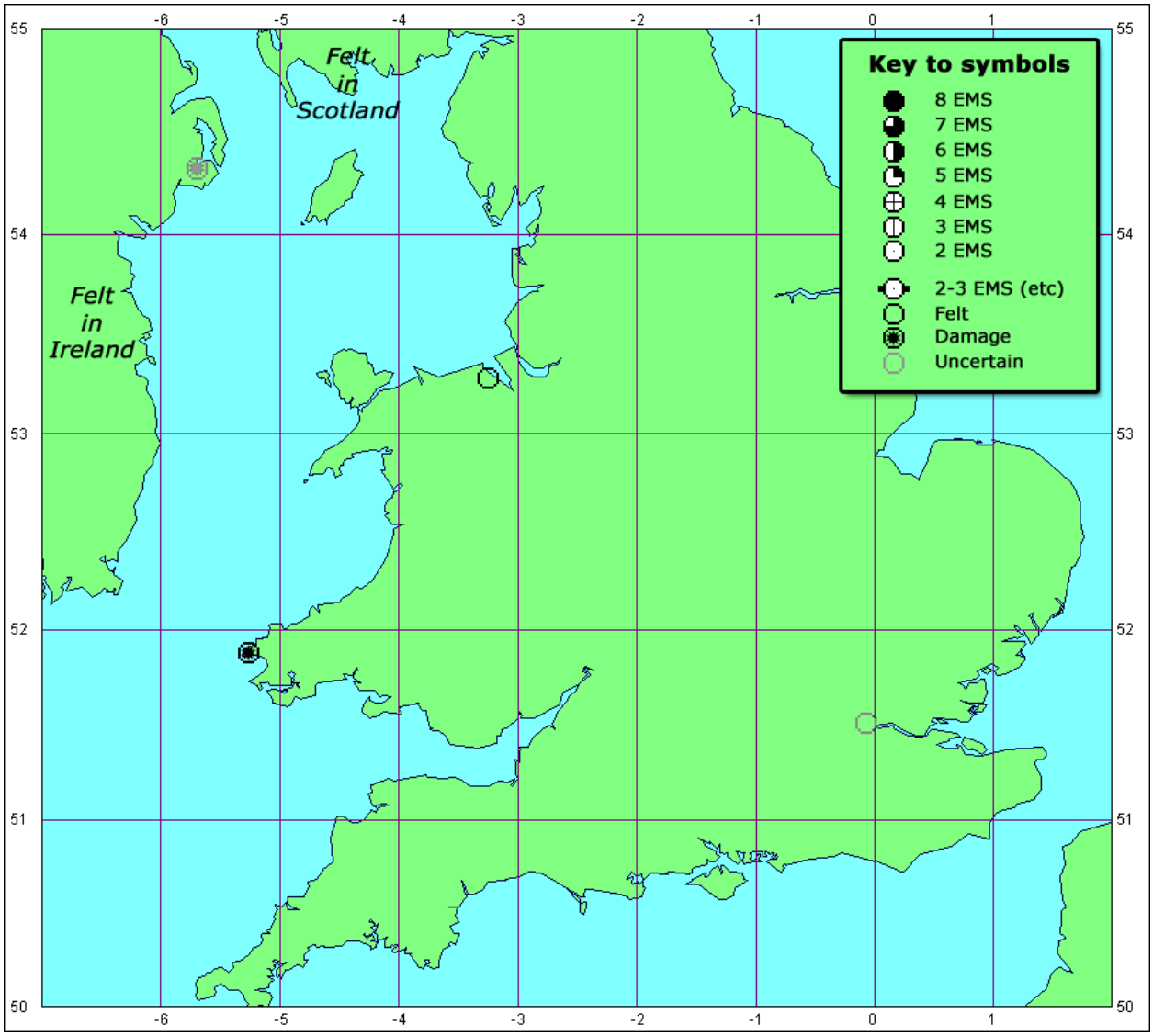

Figure 16- The earthquake of 20 February 1247

3.51 23 DECEMBER 1248 SOMERSET

In the space of 60 years, three British cathedrals were damaged by earthquakes; the third being Wells Cathedral in Somerset. The principal source is the contemporary account by Matthew Paris (Madden 1866) who had direct information from the Bishop of Bath. General damage is described: “walls of buildings were burst asunder, the stones were torn from their places, and gaps appeared in the ruined walls … the tops of chimneys, parapets, and pillars were shifted [“motae sunt”], but the bases and foundations of them were not at all disturbed …”. The only place specifically mentioned is Wells, where the “tholus” of the cathedral (“a mass of great weight and size”) fell in. This damage is discussed by Reid (1973); the primary meaning of “tholus” was a dome of some sort, but could be used for any architectural ornament crowning a building. However, the chapter records do not mention the damage and there are no apparent signs of damage to the 12th century piers or capitals. Church (1894) notes that the Bishop of Bath himself was in Rome at the time of the earthquake and was thus not an eye-witness (and may have exaggerated the amount of damage). Wright (1951) considers that the whole of the lantern of the central tower fell, but as Reid (1973) points out, if this is correct, it must have been rebuilt with the same stones, since these are clearly earlier than 1248. No other place is mentioned in any of the accounts, but an unidentified Exeter chronicle cited by Polwhele (1793) describes the earthquake as affecting “these western parts”. The date of the earthquake is frequently given as 21 December (e.g. Davison 1924); Paris writes “quarto die ante Natale Domini” which has been

interpreted as “four days before Christmas”. SHWP (1987) read this as “the Wednesday before Christmas”, i.e. the fourth day of the week. Since the Worcester Annals (Luard 1869) give the date as “Decimo kal Januarii” this is evidently correct. Soil Mechanics (1982) and SHWP (1987) assume all the damage must have occurred at Wells, but given the doubt over what happened at Wells Cathedral, this is not certain. The maximum intensity, from the general description, would seem to have been around 7 EMS. Melville (1983) suggests this earthquake may be an aftershock of the 1247 event, which seems very unlikely.

Place	*Latitude*	*Longitude*	*Intensity*
Wells	51.21	-2.65	D

Table 18 - Data for the earthquake of 23 December 1248

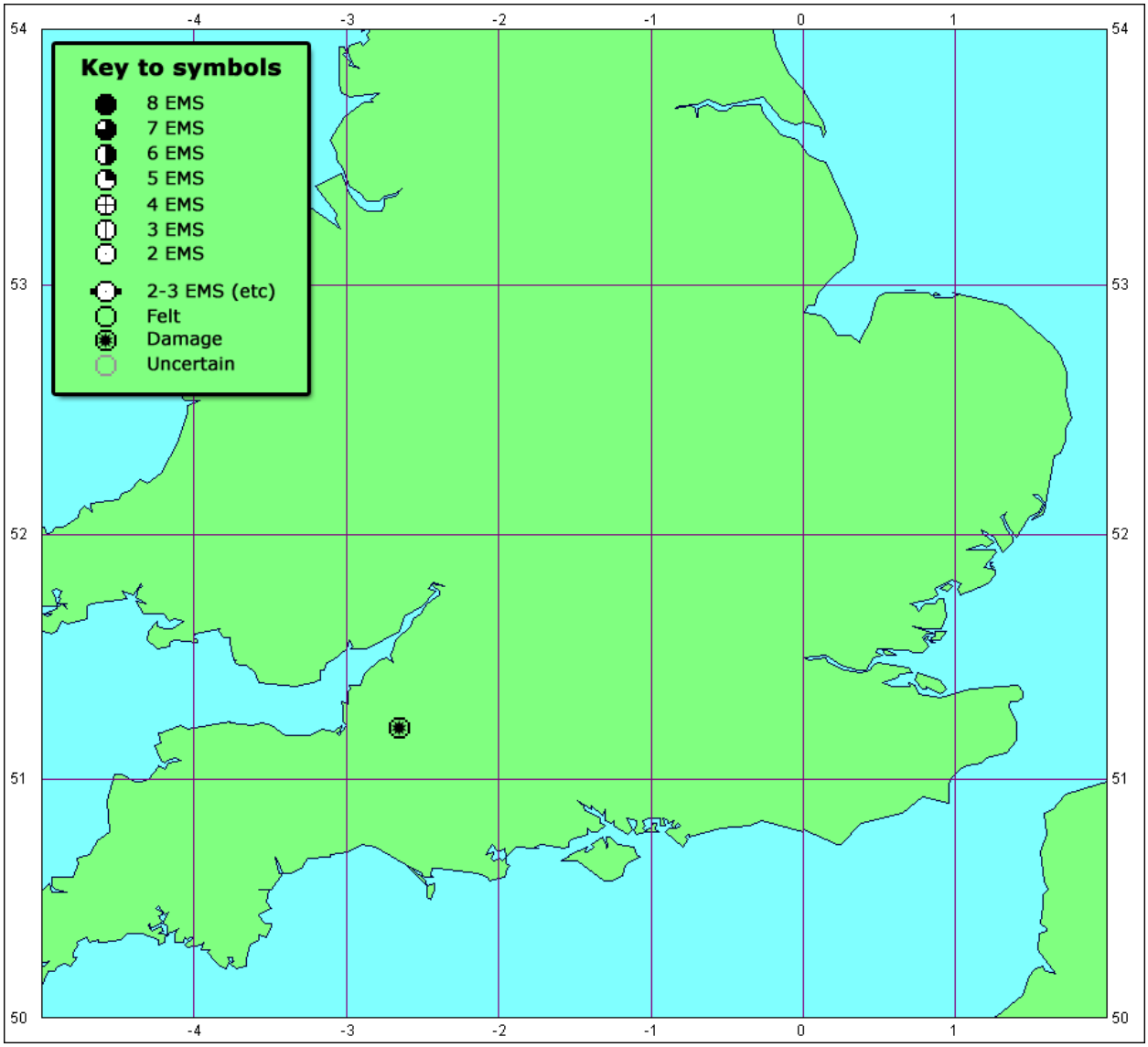

Figure 17 -The earthquake of 23 December 1248

3.52 30 JUNE 1250 ENGLAND

There was an earthquake on this day, according to the Annals of Worcester (Luard 1869). Principia (1982) accordingly give the location of the earthquake as Worcester.

EARTHQUAKE BUT NO DATA

3.53 13 DECEMBER 1250 CHILTERNS

Matthew Paris seems to have been an eyewitness of this earthquake, felt in St Albans and the adjacent district (the Chiltern Hills). His description (Luard 1874) includes an account of how birds were alarmed by the shock, and is generally consistent with an intensity of 4 EMS. A remark in Paris's Historia Anglorum (Madden 1866) that earthquakes were frequent in England in 1250 may actually refer to the period 1247-1250, but may also indicate that the 30 June event was felt over a wider area than is apparent from the immediate account of it.

Place	*Latitude*	*Longitude*	*Intensity*
Chiltern Hills	51.67	-0.92	F
St Albans	51.75	-0.33	4

Table 19 - Data for the earthquake of 13 December 1250

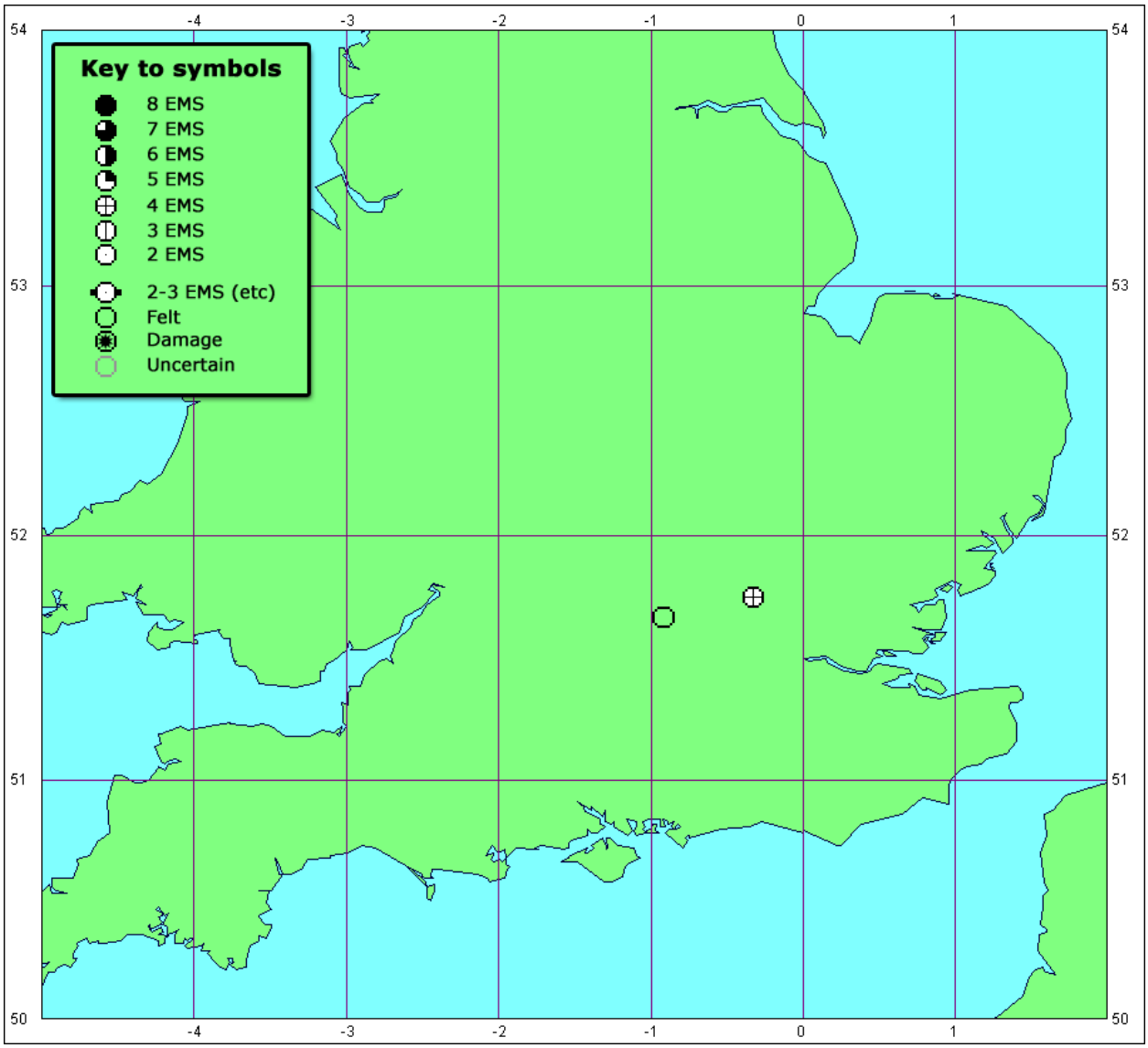

Figure 18 - The earthquake of 13 December 1250

3.54 SEPTEMBER 1255 WALES

Davison (1924) has an earthquake in 1255, in the octave of the feast of St Mary in September. Properly, the octave of the feast of St Mary is 15 September, but in the octaves (plural) is the

period between 9-15 September. Davison's source is Brut y Tywisogion, which actually has the year as 1275 (Jones 1955).

MISDATED EARTHQUAKE

3.55 28 JANUARY 1257 ENGLAND

This earthquake is considered doubtful by Principia (1982) and SHWP (1987) on the grounds that it is mentioned in connection with a strong wind and heavy rain. The original source, the chronicle composed at Stanley Abbey, near Chippenham, Wiltshire, states that on the Sunday before the Purification of the Virgin, before dawn, there was an earthquake with a strong wind and heavy rain, which lasted from All Saints to Pentecost (Howlett 1885). Ambraseys and Melville (1983) reason that, because the earthquake is precisely dated and the bad weather is given a spread of dates, the two events must be separate, which seems not unreasonable. SHWP (1987) suppose that the epicentre must have been in West Wiltshire, which is not necessarily the case.

EARTHQUAKE BUT NO DATA

3.56 1269 IRELAND

An entry in Dowling's Annals, a 16th century source, reads "1269 Terremotus in Hibernia" (Butler 2003). Principia (1982) place the event specifically in Southern Ireland, for reasons that are not obvious. Without any further detail, it is possible that some sort of landslip is referred to. The event is dated 1266 by Holinshed (1577). An example of an Irish "earthquake" that is clearly not seismic (because more detail is provided) is the 1490 Slieve na Gamph event, near Sligo; a hundred people were killed, with horses and cows also, and much putrid fish were thrown up and a new lake formed (Hondelink 2002).

DOUBTFUL

3.57 14 DECEMBER 1269 ENGLAND

Ambraseys and Melville (1983) suggest that this earthquake was perhaps felt around London, from the fact that it is recorded in non-contemporary London chronicles, for instance, the "Short English Chronicle (Lambeth MSS 306), which merely report the date and time and that it was a "great earthquake". Contemporary sources are silent on the event, so it was probably not very great.

EARTHQUAKE BUT NO DATA

3.58 5 DECEMBER 1273 NEWCASTLE

The year of this event is uncertain: the two earliest sources are the continuation of the chronicle of William Rishanger at St Albans (Riley 1865a) and the Worcester annals (Luard 1869), both of which have identical wording, but under 1273 and 1274 respectively. Probably both were copying a common source. The wording runs, "This year, on the Vigil of St Nicholas, an earthquake, lightning, thunder, a fiery dragon and a comet terrified the English". It is reasonably certain that a bolide is being described here. At some point in time this report became associated with Newcastle. Thus Richardson (1861), who gives 1275 as the year, and states that "On St Nicholas's eve great earthquakes were felt in Newcastle, with dreadful thunder and lightning, with a blazing star, and a comet in the appearance of a great dragon, which terrified the people," on the basis of "local records".

NOT AN EARTHQUAKE

3.59 11 SEPTEMBER 1275 SOUTH ENGLAND

As with many of the larger earthquakes of the period, this event has generated much confusion, with many duplicates springing up because of different dates being given, as for instance with the 1255 earthquake discussed above. It also provides another instance where interpreters have been fixated with damage to a single anomalous structure, resulting in probable mislocation of the earthquake's epicentre. In this case, the structure was the church of St Michael perched on Glastonbury Tor. The church seems to have collapsed. As pointed out by Woo (1991), this does not necessarily mean that intensities were generally high in Glastonbury. Otherwise, it is stated that the earthquake was felt in London, Canterbury and Winchester, all places the other side of the country. Furthermore, the Osney Annals (Luard 1869) state that houses and churches in many places in England were thrown down ("subvertebantur") – and also that people were killed, which is something almost never reported (Musson 2003). So clearly, damage was widespread, possibly with intensity as high as 8 EMS. The repetition of reports of the destruction of one particular building is of no significance to the epicentre, and can be compared to the widespread reporting of the damage to the basilica at Assisi in 1997, which was actually on the margin of the felt area of the earthquakes of that year. Some sources (Luard 1865, 1869) state that the shock was felt in many places across the sea, which implies northern France, though SHWP (1987) found no data from French sources. There is no obvious European earthquake of the period that might be being referred to here. The continuator of Gervase of Canterbury (Stubbs 1879) mentions marine incursions associated with the earthquake (though this may be an unrelated storm surge around the same time). Thomas Wykes (Luard 1869) states that the shock was strongest on the south coast of England and less strong in the north. The evidence clearly indicates an epicentre on or off the south coast of England, comparable with the 1750 Portsmouth or 1963 Chichester earthquakes, but with a much higher magnitude – above 5 Mw.

Owing to references to "St Michael on the Mount", the "mount" being Glastonbury Tor, this earthquake has sometimes been cited as a Cornish event, due to confusion with St Michael's Mount in Cornwall – see the discussion in Musson (1989a). It has even been confused with Mont-St Michel in Normandy in SisFrance (2002).

A complete list of sources is given in SHWP (1987), but the map of "inferred intensities" is misleading.

Place	*Latitude*	*Longitude*	*Intensity*
Canterbury	51.27	1.08	F
Glastonbury	51.15	-2.71	D
London	51.51	-0.08	F
Winchester	51.02	-1.32	F

Table 20 - Data for the earthquake of 11 September 1275

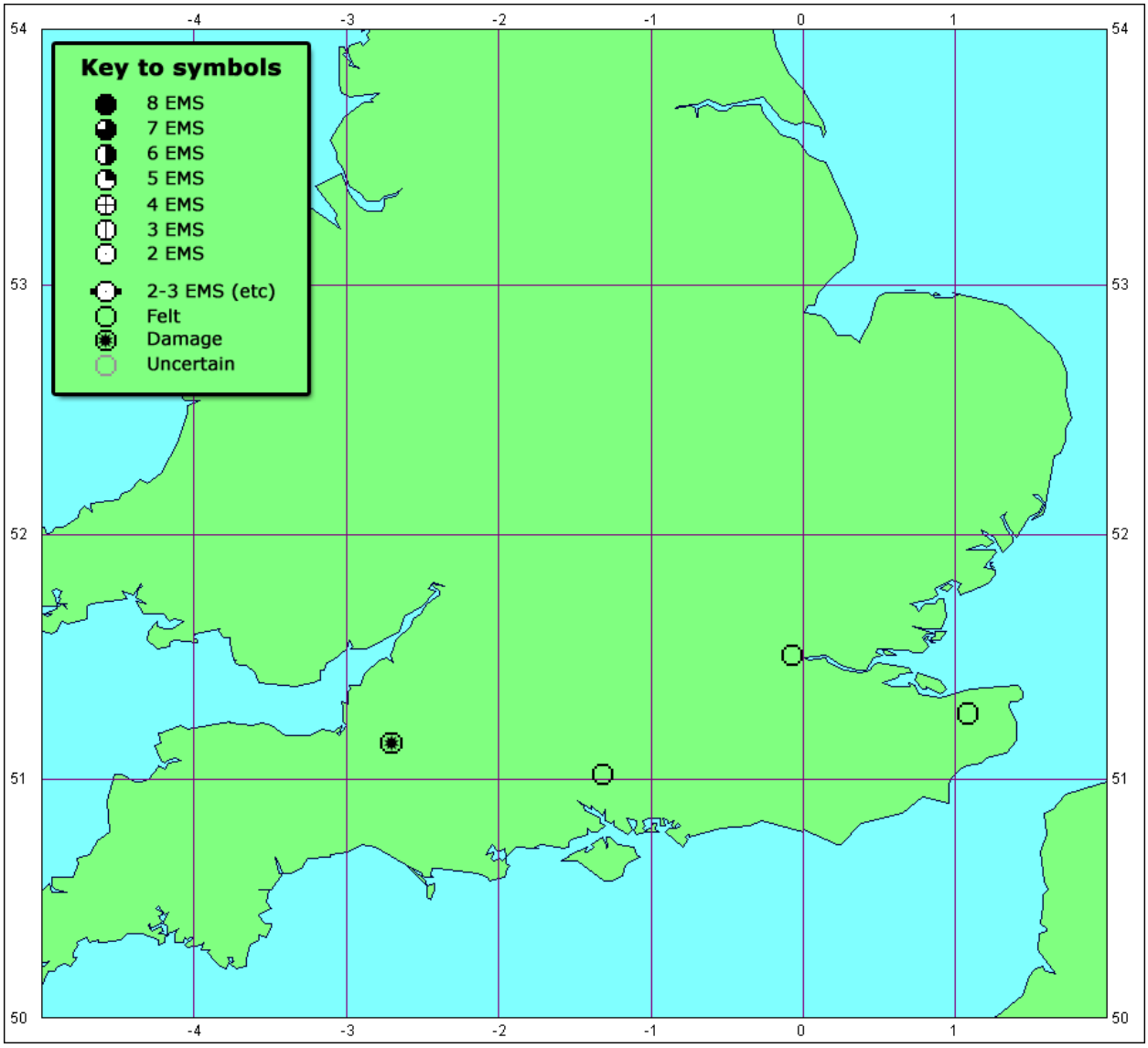

Figure 19 - The earthquake of 11 September 1275

3.60 15 MARCH 1288 WALES

Mentioned without detail in Annales Cambriae as an earthquake in Wales (Williams 1860). Principia (1982) suggest the date may be in error.

EARTHQUAKE BUT NO DATA

3.61 29 APRIL 1297 NORFOLK

Described as a big earthquake in many parts of Norfolk, that affected various parts of England, in the Chronicle of the Abbey of Bury St Edmunds (Gransden 1964). The chronicle of John of Oxnead, of the Abbey of St Benedict of Holm, near Horning, Norfolk, also mentions the event (Ellis 1859).

Place	*Latitude*	*Longitude*	*Intensity*
Norfolk	52.67	1.00	F

Table 21 - Data for the earthquake of 29 April 1297

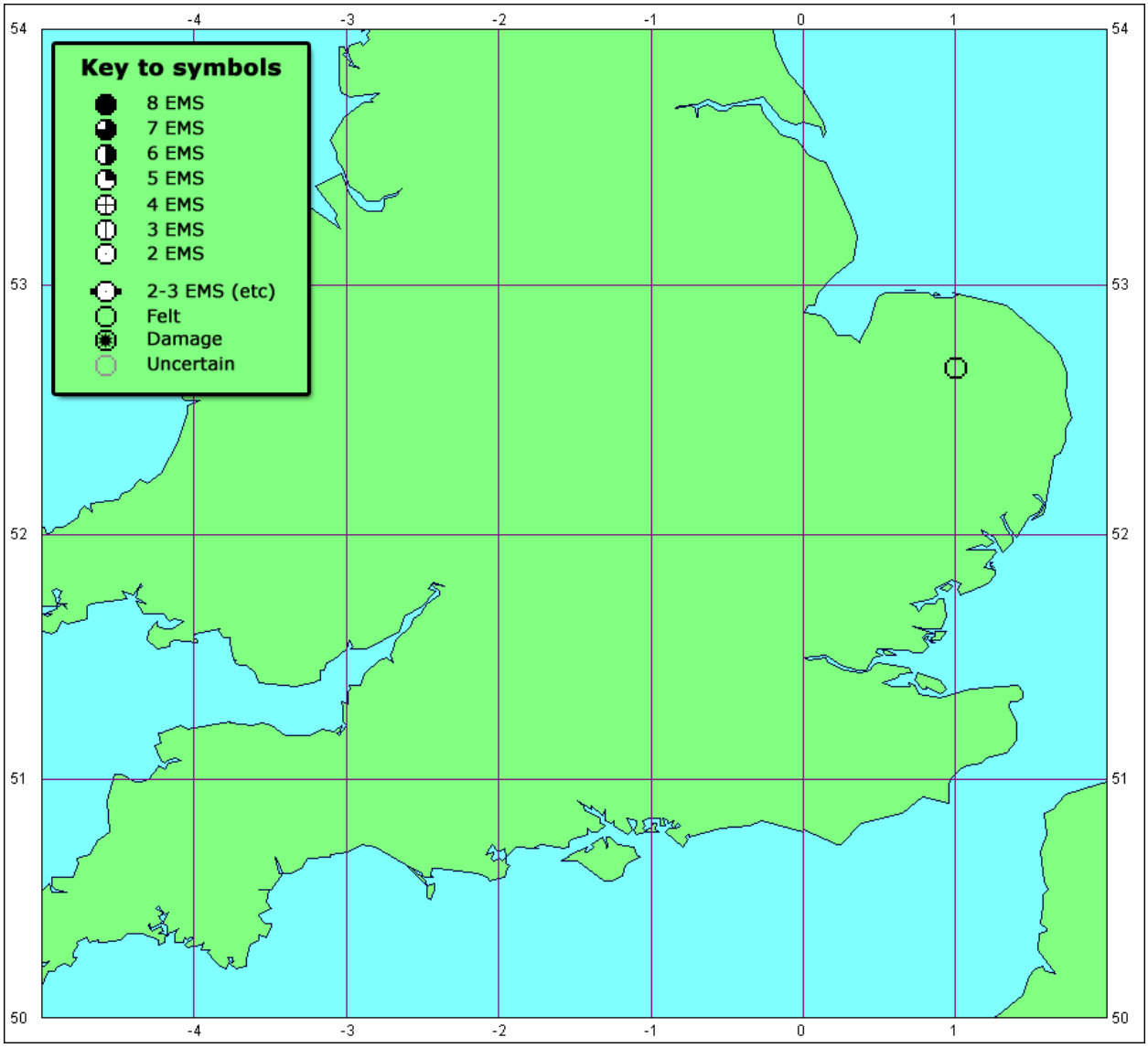

Figure 20 - The earthquake of 29 April 1297

3.62 5 JANUARY 1298 ENGLAND

Davison (1924) lists an earthquake on this date, which is in fact given by sources such as the Annals of Worcester (Luard 1869). The reasons for the confusion are elucidated by Ambraseys and Melville (1983). The correct date is 4 January 1299.

MISDATED EARTHQUAKE

3.63 4 JANUARY 1299 SE ENGLAND

Contemporary sources simply refer to an earthquake before dawn, without details. These include the Chronicle of Bury St Edmunds (Greenway and Sayers 1998), the Annals of Worcester (Luard 1869), and a French Chronicle of London (Riley 1863). A set of 14th century Irish Annals published by William Camden (1607, 1806) states that earthquake was felt from Canterbury to Hampton “but not so violent”. This last phrase can be interpreted as meaning not so violent as the Reatino earthquake of 1 December 1298, which is described in the previous entry of the annals. Camden is then the main source for other authors such as Hasted (1800) who says that the earthquake was not very violent in Canterbury, and was felt as far as Hampton in Middlesex. Most tantalising is a report that the earthquake may have damaged the church of St Andrew, Hitchin, Hertfordshire. This information supposedly comes from a chronicle compiled by

Thomas Cobham of the Priory of White Carmelites in Hitchin. This chronicle was seen and used by the antiquary William Dunnage (d 1815), who says that the MS of the chronicle was in such a poor state that it disintegrated as he read it. Dunnage's transcription was unpublished, but obtained and used by Hine (1927). The details are as follows. In 1292 the church was struck by lightning and seriously damaged. "Six years later … the church was further damaged by the shock of an earthquake. In the centre of the building it gave way altogether, and all one side was shattered. By the next year the church had been restored, but in 1304 the greater part of the roof fell in …" (Hine 1927). It would seem, then, that the church was not in a good state of repair, and may have been a rather vulnerable structure. Nevertheless, it seems plausible that the earthquake was stronger north of London than in Kent. The story of Cobham's chronicle also provides an illustration of how later authors may have had access to source materials not extant today.

Place	*Latitude*	*Longitude*	*Intensity*
Canterbury	51.27	1.08	F
Hampton	51.40	-0.35	F
Hitchin	51.95	-0.27	D?

Table 22 - Data for the earthquake of 4 January 1299

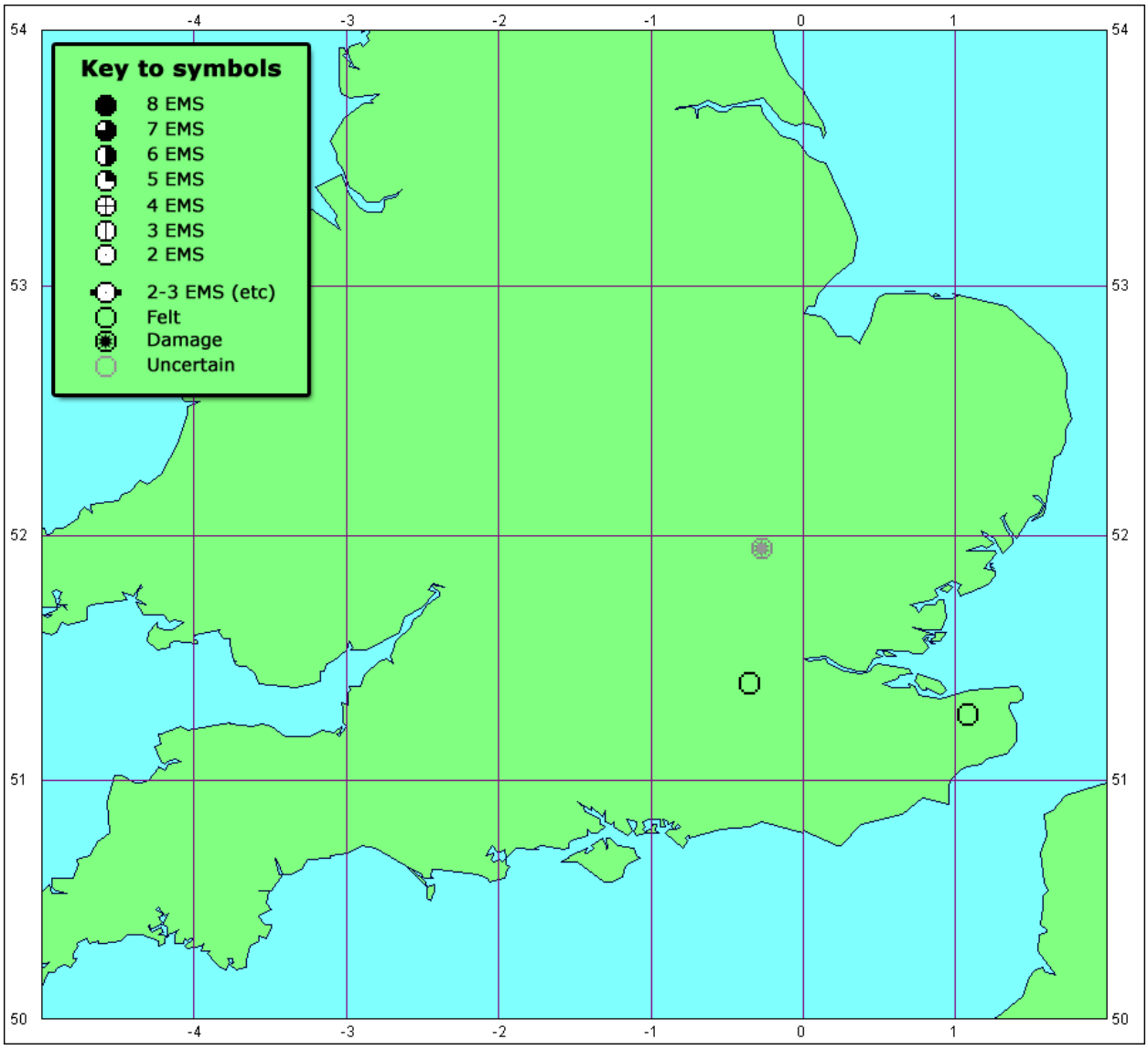

Figure 21 - The earthquake of 4 January 1299

3.64 22 JULY 1300 YORKSHIRE

A reference to an earthquake "heard and witnessed" by many people in Yorkshire is found in a chronicle of St Mary's York (Craster and Thornton 1934).

Place	*Latitude*	*Longitude*	*Intensity*
Yorkshire	54.00	-1.50	F

Table 23 - Data for the earthquake of 22 July 1300

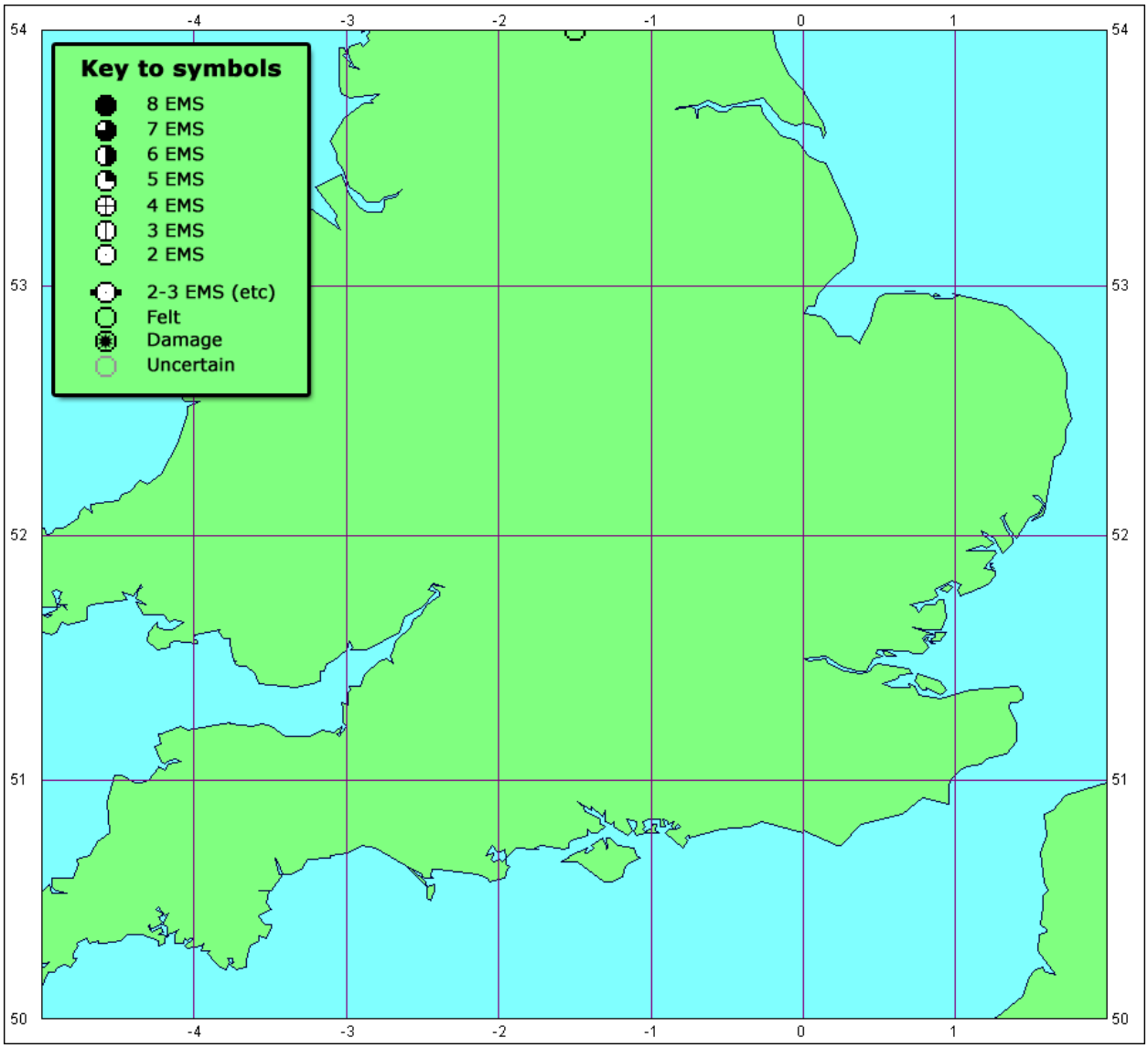

Figure 22 - The earthquake of 22 July 1300

3.65 14 NOVEMBER 1318 ENGLAND

This earthquake appears in Roper (1889) as "one of the most violent ever experienced in this country", and is then duplicated under 14 November 1328 as "the greatest ever known in England". The two original sources listed by Ambraseys and Melville (1983), Trokelowe (Riley 1865b) and Walsingham (Riley 1876) merely state that there was an earthquake in England which terrified many people. Ambraseys and Melville (1983) suggest that the epicentre was in the St Alban's area since both Trokelowe and Walsingham were from St Albans. SHWP (1987) propose an epicentre near Ilchester on the grounds that the earthquake is also mentioned by a

continuator of Trivet (Hall 1722), that this continuator was probably a Dominican and was interested in West Country affairs, and that there was a Dominican Friary at Ilchester. From this, an epicentre, intensity and magnitude are derived. Really, the epicentre could be anywhere. The tradition of this being one of the worst earthquakes in England is most likely due to it being confused with the earthquake of 1382, which was so described, and with good reason. Further confusion may have been occasioned by an entry in the Chronicle of Louth Park Abbey (Venables and Maddison 1891) describing the 1382 earthquake, correctly dated, but inserted immediately before the entry for 1319 – which could be taken as an entry for 1318 with the year entered incorrectly.

EARTHQUAKE BUT NO DATA

3.66 1 DECEMBER 1320 ENGLAND

The Chronicle of Louth Park Abbey records that on the 4th of the Nones of December (2 December) there was a great earthquake, with no further details (Venables and Maddison 1891), while Le Livere de Reis de Brittanie e le Livere de Reis de Engletere (Glover 1865) places the event on 1 December 1319 and describes it as general in England, with much sound. Ambraseys and Melville (1983) prefer the earlier day as Le Livere is a more contemporary source, but argue convincingly that the year must be 1320. Both sources were compiled in Lincolnshire; the notice of the earthquake in Le Livere appears in a continuation compiled at Sempringham, between Grantham and Boston.

EARTHQUAKE BUT NO DATA

3.67 28 MARCH 1343 LINCOLNSHIRE

There is a good contemporary description of this event written by William Merle, who was rector of Driby, Lincolnshire. “At mid-day there was an earthquake, which was so great that in certain parts of Lyndesay [North Lincolnshire – now usually spelled “Lindsey”] the stones in the chimneys fell down, after shaking in very great agitation, and it lasted long enough for the ‘salutatio angelica’ to be said distinctly … [it] was not felt at Oxford” (Symons 1891). The Chronicle of Louth Park Abbey (Venables and Maddison 1891) describes it only as a great earthquake felt in divers places in England, and a number of other chronicles from London (e.g. Lambeth MSS 306) and other parts of eastern England (listed in Ambraseys and Melville 1983) also mention the event with no further details, and sometimes incorrectly dated. The maximum intensity is at least 6 EMS and more likely 7 EMS, and it is highly unusual for the period to have information about a place where the earthquake was *not* felt.

Place	*Latitude*	*Longitude*	*Intensity*
Driby	53.25	0.08	F
Lindsey	53.42	-0.33	6-7
Oxford	51.75	-1.25	1

Table 24 - Data for the earthquake of 28 March 1343

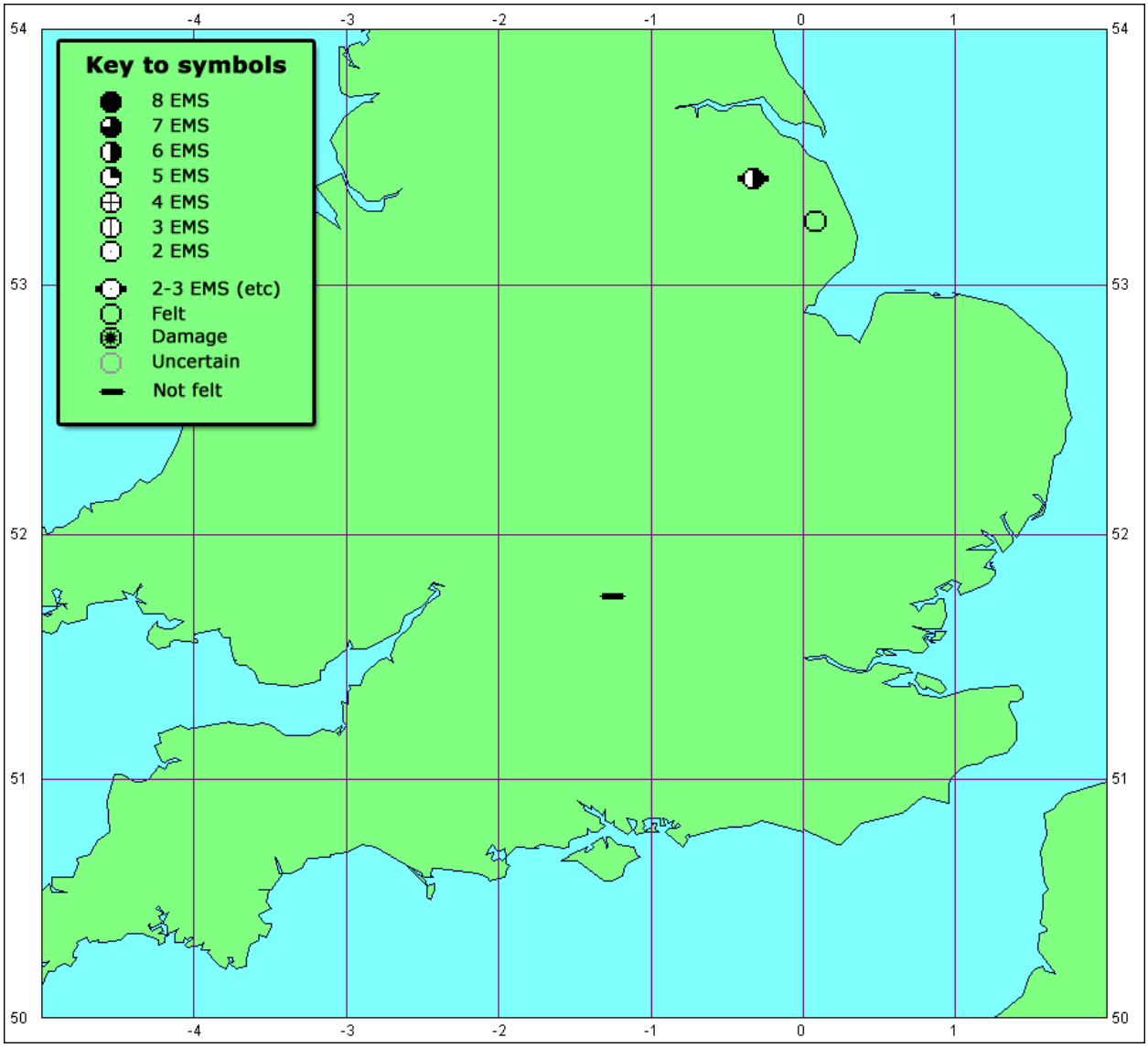

Figure 23 - The earthquake of 28 March 1343

3.68 27 MARCH 1349 HUMBERSIDE

This event is mentioned only in the Chronicle of Meaux Abbey (Bond 1866), which state that the ground was shaken through the length of England and that the monks of Meaux Abbey, at Vespers, were thrown from their stalls (suggesting an intensity of around 6 EMS). Ambraseys and Melville (1983) consider this to be a duplication of the 28 March 1343 earthquake on the grounds that the dates are similar and no source other than the Meaux Chronicle mentions this event. The absence of other accounts could simply mean that the extent of the shock is highly exaggerated, and the times are clearly different, the 1343 event being at mid-day and the 1349 one at Vespers. However, Meaux is just north of Lindsey, where the 1343 earthquake was strongest, so it is possible that the two events are related.

Place	*Latitude*	*Longitude*	*Intensity*
Meaux	53.85	-0.33	5-6

Table 25 - Data for the earthquake of 27 March 1349

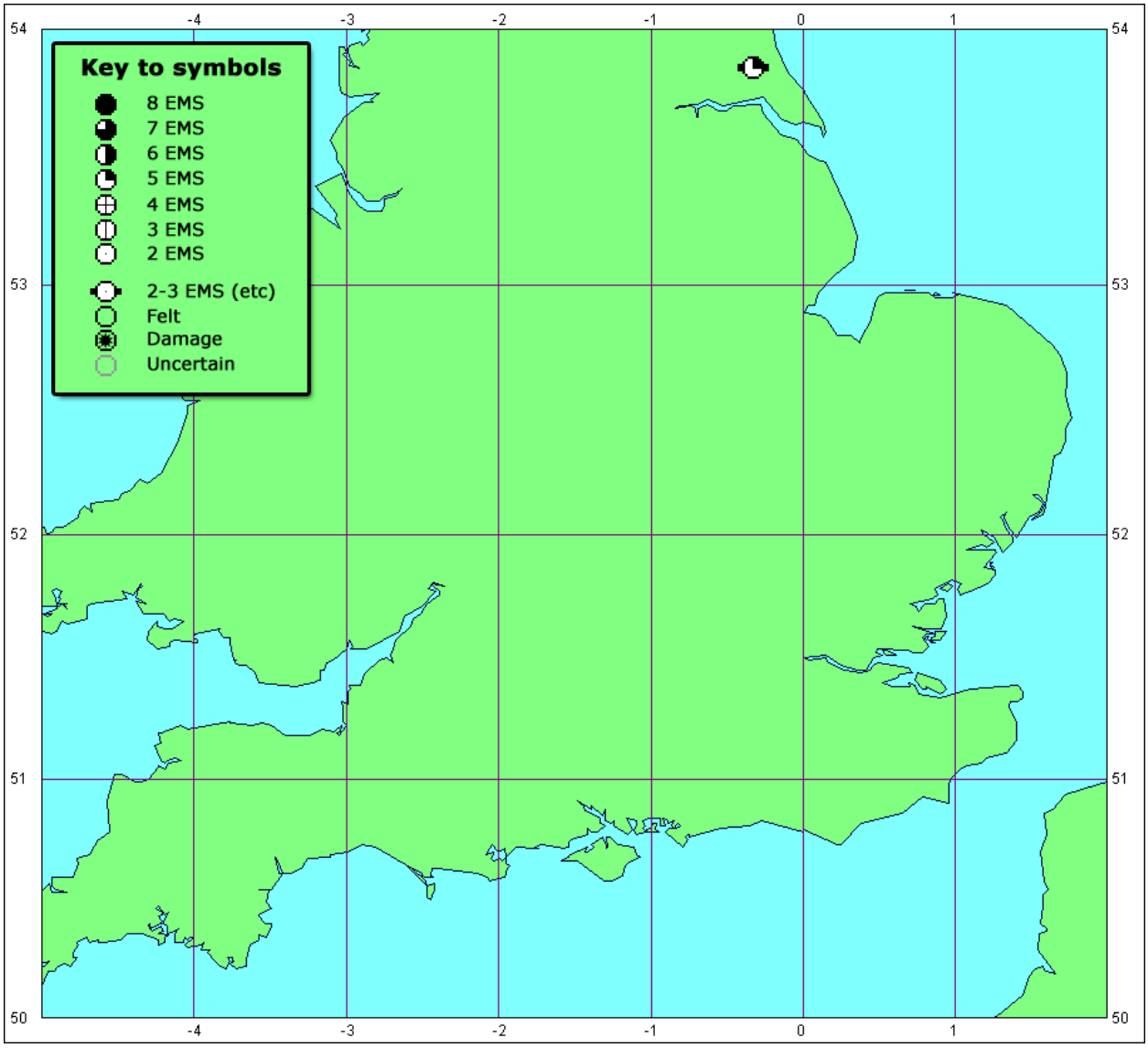

Figure 24 - The earthquake of 27 March 1349

3.69 1356 IRELAND

Principia (1982) list an earthquake in Ireland in 1356, citing Roper (1889) and marking it as "unconfirmed remains dubious". Roper's (1889) source is in fact Short (1749), but unlike the various pre-Millennium events that are obviously fictitious (Musson 2005), this one appears not in the Table that concludes volume two of Short's work, but in the text itself. Generally, Short's text is more reliable and is missing all the fanciful events from the concluding Table; it sometimes includes references, though not, apparently, always accurately (Musson 2005). In this case there is no reference cited, and the entry for 1356 reads as follows: "In *Ireland* a great Earthquake, and Loss of People, Demolition of Cities, Devastation of Countries in several Nations, chiefly in *Spain*, *Germany*, &c." This should be read as meaning that the damage and loss of life occurred in Spain and Germany, rather than Ireland, and these are two genuine European earthquakes being referred to – 24 August 1356 Cabo St Vicente and 18 October 1356 Basel. So it is not impossible that the Irish event is also genuine, though it is not listed in any earlier authority that has come to light. Also, one cannot be sure with vague reports of earthquakes in Ireland whether they are really seismic events at all.

DOUBTFUL

3.70 21 MAY 1382 DOVER STRAITS

This was certainly one of the largest and most damaging earthquakes to have affected the British Isles, along with the 6 April 1580 earthquake, which it strongly resembles. The epicentre was offshore in the region of the Dover Straits, and the effects were observed both in SE England and the Low Countries, though there are fewer continental sources available. The event has been studied extensively in Melville (1982), Ambraseys and Melville (1983), SHWP (1995) and Melville et al (1996). The assessment here draws partly on the last two of these references, though care has to be taken to remove assumptions that the shock was necessarily felt at every place where someone who heard about the event made a note of it. Given that the shock was damaging in London, once can be fairly certain it should have been very perceptibly felt in, for instance, Leicester, though Henry Knighton's Chronicle, a contemporary source written in Leicester, doesn't actually record this (Lumby 1889). Similarly, one must be wary of assigning an intensity to Bruges on the basis of a chronicle *probably* written in Bruges, which says that several buildings were thrown down in *Flanders* (Melville et al. 1996).

While it is common in historical investigations of earthquakes in, say Italy, to look to records of repairs and related expenses as a primary source of information on earthquake damage, in Britain this type of information is almost never available. The 1382 earthquake is an exception, and some of the damage can be reconstructed from documents dealing with repairs. Grove (1981) made a study of Hollingbourne, Kent, and reports that the accounts of William Topclyve who farmed the manor of Hollingbourne for the monks of Canterbury include an entry recording that repairs to the great house and church of Hollingbourne after the earthquake amounted to 48 shillings and twopence. (Grove, 1981, notes for comparison, that in 1375, 25 shillings would buy 100 feet of ashlar stone from local quarries). Financial relief for the rector of Hollingbourne is ordered in a letter from the Archbishop, who indicates that the chancel of the church suffered "grave ruin", and Grove (1981) also notes the extreme thickness of the post-earthquake walls of the nave of the church, and the curious mixture of building materials in the chancel walls. Canterbury Cathedral itself was damaged: the east window of the chapter house, the west window of the church and several other stone buildings inside and outside the monastery were broken, the free-standing bell-tower was destroyed and damage was done to the iron screen of the organ (Davis 1934; see also Blore 1945, Gardiner 1945). Harvey (1945) reports that the Infirmary chapel was seriously damaged, also the east walk of the old cloisters; he suggests that the earthquake led to the stoppage of work on the new nave, in progress since 1378, and which was not resumed until the 1390s. Damage extended as far as London; the archives of St Paul's cathedral contain an indulgence from the year 1387 for the repair of the Cathedral cross from the earthquake damage of five years before (Sparrow Simpson 1880). The Chronicle of Bury St Edmunds states that both St Paul's and Westminster Abbey were damaged (Gransden 1964). An unreferenced memorandum in BGS archives that the church tower of St Bartholomew the Great, London, was destroyed by the earthquake seems to trace back to Webb (1921), who speculates that earthquake damage may have been the reason for rebuilding of the bell tower in 1405. Similar suggestions have been made with regard to other localities – Woodruff (1933) queries whether the rebuilding of the south-west tower of Canterbury Cathedral in 1424 was related to earthquake damage, and Grove (1981) considers that it may be significant that at about this time the church of St Mary's, Maidstone was pulled down and entirely replaced by the present church of All Saints'. Melville et al. (1982) make a similar speculation as regards building work at Saltwood.

Amongst the political songs of the time (Wright, 1859) is found a stanza that reads as follows:

For sothe this was a Lord to drede,
So sodeynly mad mon agast;
Of gold and selver thei tok non hede,
But out of ther houses ful sone thei past.
Chaumbres, chymeneys, al to-barst,

Chirches and castelles foule gon fare;
Pinacles, steples, to grounde [h]it cast;
And al was for warnyng to be ware.

Taking this to be a general description of the effects of the earthquake, most likely in London, one can draw the conclusion of considerable panic, fall of chimneys and other upper parts of buildings such as steeples and an intensity of around 7 EMS, or 6 if one allows for some exaggeration. Sources imply that damage was widespread, and while it is hard to assign intensity directly to the information from Canterbury and Hollingbourne, from comparison with other earthquakes that caused general damage to churches, it is likely that intensities were in the range of 7-8 EMS in Kent. It is quite likely that 8 EMS may have been reached somewhere. In Flanders, the shock was strong enough to cause several buildings to be thrown down, and many chimneys were overturned, suggesting intensities of at least 7 EMS.

The total extent of the felt area is not well documented, but may be assumed to be large. A book of hours in the Fitzwilliam Museum, Cambridge (James MS 57) contains an annotation mentioning the earthquake as “universal throughout the whole of England”.

Melville et al. (1996) consider that in view of the strength of shaking in Flanders and the Netherlands, which is rather better reported than effects in Northern France, the epicentre was most likely north-east of the Dover Straits, offshore from the North Foreland, and this conclusion is endorsed here.

Place	*Latitude*	*Longitude*	*Intensity*
Brussels	50.83	4.33	F
Canterbury	51.27	1.08	7-8
Douai	50.37	3.07	5
Flanders	51.00	4.50	~7
Hesbaye	50.58	5.25	F
Hollingbourne	51.25	0.65	7-8
Leiden	52.15	4.50	5
London	51.51	-0.08	6-7
Maidstone	51.27	0.52	D?
Picardy	50.00	3.50	F
St Omer	50.75	2.25	F
Saltwood	51.08	1.08	D?
Tournai	48.82	0.05	5
Utrecht	52.08	5.13	~4
Ypres	50.85	2.88	5-6

Table 26 - Data for the earthquake of 21 May 1382

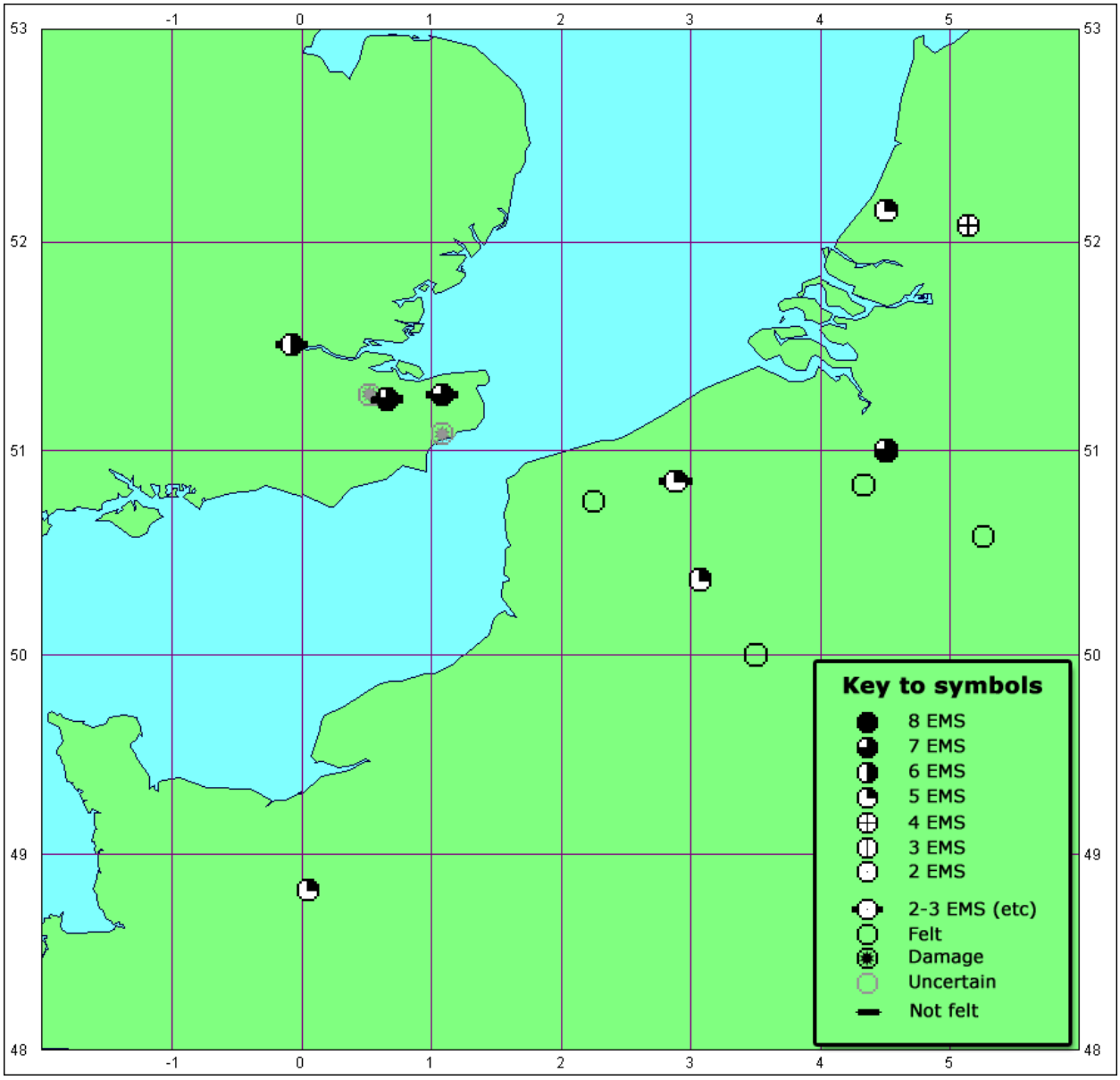

Figure 25 - The earthquake of 21 May 1382

3.71 23 MAY 1382 DOVER STRAITS

Two strong aftershocks immediately succeeded the 21 May 1382 earthquake. The first of these occurred around dawn on 23 May, and is described by Henry Knighton as causing little harm (Lumby 1889). The chronology of the aftershocks is best studied in Melville et al. (1996). It is uncertain how far the 23 May event was felt, but it seems to have been experienced on both sides of the Channel, since Continental sources also have vague mentions of aftershocks at around this time (Melville et al. 1996).

EARTHQUAKE BUT NO DATA

3.72 24 MAY 1382 DOVER STRAITS

The main aftershock occurred on 24 May, around the third hour of the morning, and is described by Henry Knighton as a “waterquake” that caused ships at anchor to shake (Lumby 1889). Other sources give different times of day, and it seems likely that reports of the two main aftershocks have become confused with each other (Melville et al. 1996). Walsingham remarks that it was not as terrible as the main shock (Riley 1864). From reports collected by Melville et al. (1996) it

would appear that the 24 May aftershock was certainly felt in Leiden, Ypres and possibly Gent and Brussels on the continent, and a report from Douai could refer to either the 23 or 24 May events. In England, the extent is not clear, but it is likely to have been felt at least as far as London; Melville et al. (1996) suggest it was felt at London, Canterbury and Rye.

Place	*Latitude*	*Longitude*	*Intensity*
Brussels	50.83	4.33	F?
Canterbury	51.27	1.08	F
Douai	50.37	3.07	F?
Ghent	51.05	3.72	F?
Leiden	52.15	4.50	F
London	51.51	-0.08	F
Rye	50.95	0.73	F
Ypres	50.85	2.88	F

Table 27 - Data for the earthquake of 24 April 1382

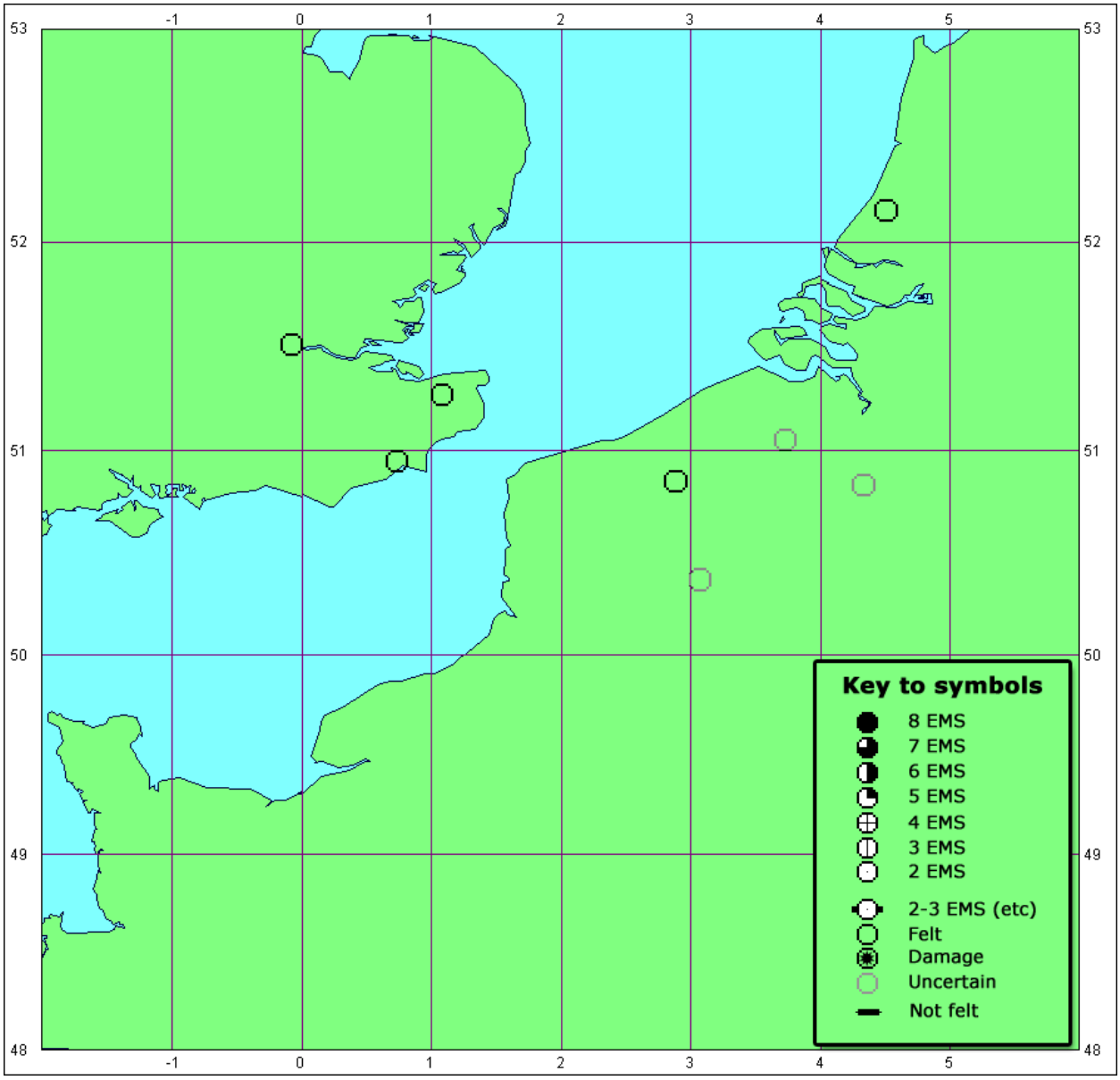

Figure 26 - The earthquake of 24 April 1382

3.73 3 MAY 1385 ENGLAND

The very limited sources for this earthquake, such as Walsingham (Riley 1864), give merely the time (before midnight) and the date. Ambraseys and Melville (1983) suggest the earthquake may have been a late aftershock of the 21 May 1382 event. On the other hand, the main focus of interest at this time was Richard II's invasion of Scotland, so an epicentre in the north of England would be quite possible. Walsingham specifically states that the earthquake was seen as a portent in connection with this campaign.

EARTHQUAKE BUT NO DATA

3.74 18 JULY 1385 ENGLAND

The same remarks concerning the 3 May 1385 event apply again here. The time is given as around the second vigil of the night (Riley 1864). Whether this event had any connection with either the 21 May 1382 or 3 May 1385 earthquakes are matters of speculation.

EARTHQUAKE BUT NO DATA

3.75 28 SEPTEMBER 1426 ENGLAND

According to John Benet's chronicle (Harriss and Harriss 1972) on the eve of St Michael's between 1 and 2 a.m., there was an earthquake over the whole world. Stow (1580) adds lightning and thunder, that the earthquake lasted two hours, and terrified animals and birds. An early chronicle of Shrewsbury gives the date as 27 September and restricts the felt area at least to all over England (rather than the whole world) and keeps the two hour duration. While the description is embellished and dramatised, it need not be discarded as false. Descriptions of long durations may refer to a series of aftershocks in quick succession, which early writers would not necessarily distinguish as separate events. The record from Shrewsbury could indicate a west of England earthquake – but the problem is there are so few local sources from anywhere at this date, and one just happens to survive from Shrewsbury. Given the almost total absence of earthquake records from Britain in the 15th century, compared to rate at which one observes seismicity at other periods, one is inclined to suppose that this may have been one of the larger shocks of the period just from the very survival of any mention of it.

EARTHQUAKE BUT NO DATA

3.76 23 APRIL 1449 SOUTHERN NORTH SEA

This earthquake resembles those of 1382 and 1580 to some degree, but was evidently much weaker, in terms of felt area and the lack of damage. The one place it seems that it was definitely felt is Canterbury, where the account in John Stone's chronicle seems to be an eyewitness account, but he gives no details beyond date and time and that it lasted longer than the time required to say the Lord's Prayer (Searle 1902, Blore 1946). The earthquake is mentioned in some other sources from the southeast of England but again with little or no detail. Melville et al. (1996) sums up the limited impact the event had on the contemporary chronicles of London. The Historia Eliensis (Lambeth MSS 448, Wharton 1691) was compiled in Ely, and states that the earthquake was felt in many parts, but it may be simply based on Stone's chronicle. Effects on the continent are summarised by Melville et al. (1996). They assess an intensity of 5-6 at Bruges, where people were frightened, houses were strongly shaken and boats rocked. Apparently the shock was stronger in Zeeland than in Antwerp, and it was definitely felt in Ypres and Abbeville. It was probably felt at Ten Duinen, St Omer, Ghent and Peronne. In England it is mentioned in sources written in Crowland and Norwich; it is not certain that these are truly local records, but the chronicles of this period are more likely to have been exclusively concerned with local matters than those of an earlier period (Gransden 1974). There may have been aftershocks felt in Bruges (de Meyer 1561). The evidence points to an epicentre in the Southern North Sea, perhaps not far from the Belgian coast.

Place	*Latitude*	*Longitude*	*Intensity*
Abbeville	50.10	1.83	F
Antwerp	51.27	4.42	F
Bruges	51.22	3.23	5-6
Canterbury	51.27	1.08	F
Croyland	52.67	-0.15	F?
Ely	52.40	0.27	F?
Ghent	51.05	3.72	F
London	51.51	-0.08	F
Norwich	52.63	1.30	F?
Peronne	50.57	3.17	F

St Omer	50.75	2.25	F
Ten Duinen	51.10	2.65	F
Ypres	50.85	2.88	F
Zeeland	51.49	3.79	F

Table 28 - Data for the earthquake of 23 April 1449

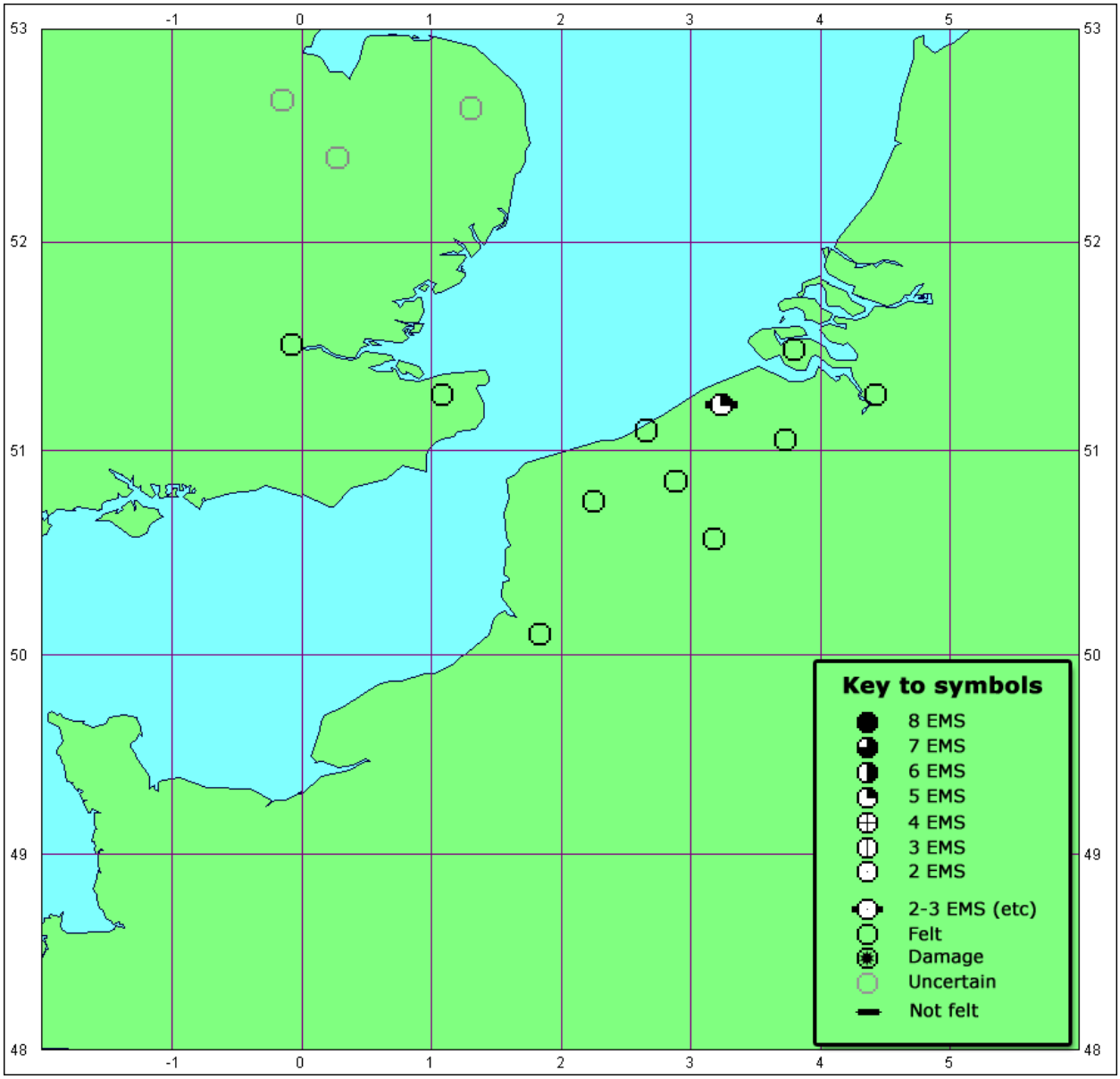

Figure 27 - The earthquake of 23 April 1449

3.77 20 DECEMBER 1456 EAST ANGLIA

The reporting of this event is discussed by Ambraseys and Melville (1983), who argue that it must have been a relatively minor earthquake felt only in East Anglia. It was recorded in Ely and Norwich, was terrifying to those who heard it (one notes in regard to quite a number of events discussed in this report that people are described as hearing rather than feeling the earthquake), and lasted half the time it takes to say an "Ave Maria" (Lambeth MS 448). Probably the maximum intensity was about 5 EMS. It is conspicuous that all the known British earthquakes of the 15th century, with thee exception of the 1426 event, are from southeastern England, and all those from the second half of the 15th century are from East Anglia, which is far from being the

most seismically active part of the country. This is entirely a product of the limited distribution of historical sources for this period (Gransden 1978).

Place	*Latitude*	*Longitude*	*Intensity*
Ely	52.40	0.27	F
Norwich	52.63	1.30	F

Table 29 - Data for the earthquake of 20 December 1456

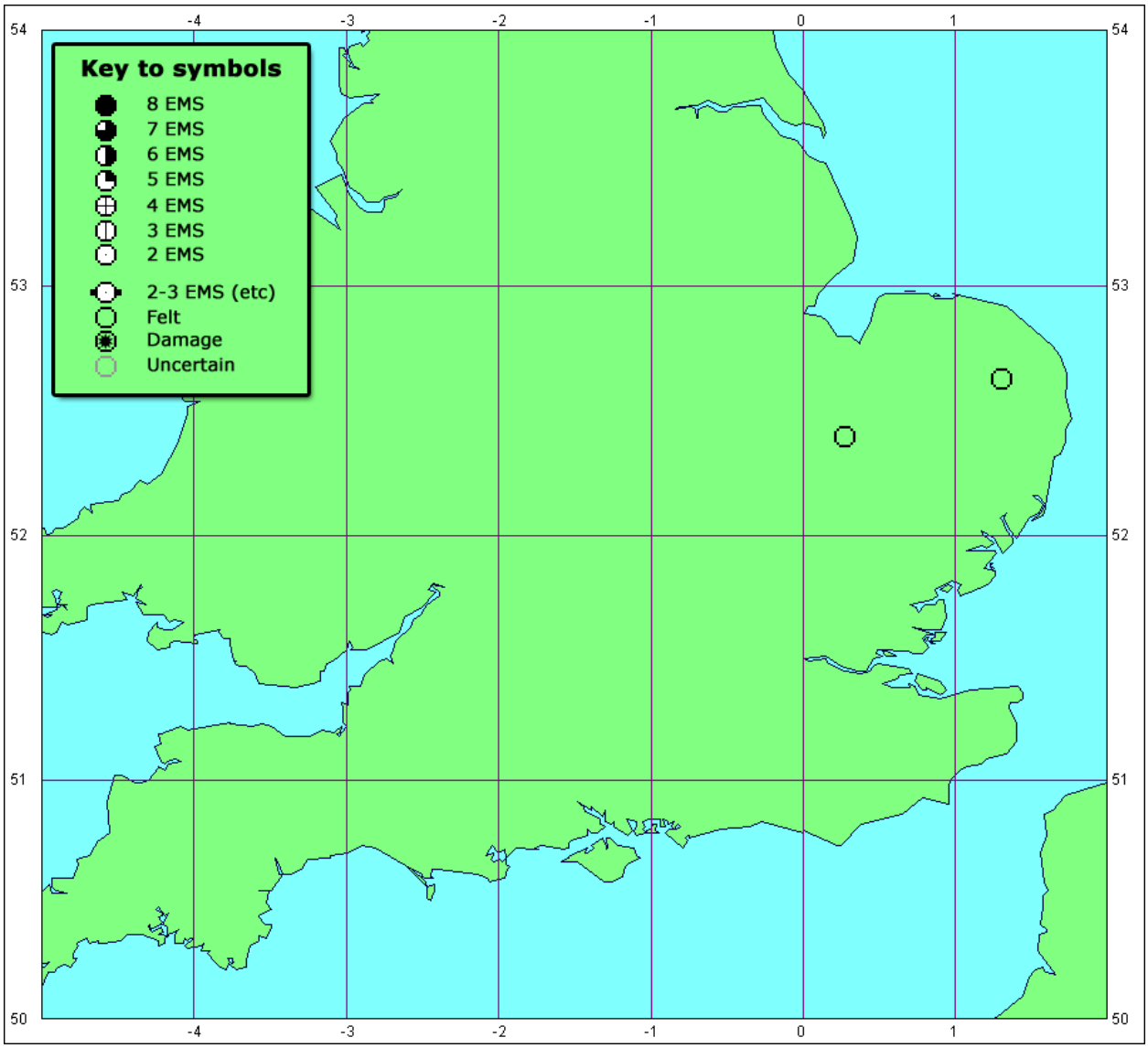

Figure 28 - The earthquake of 20 December 1456

3.78 28 DECEMBER 1480 NORWICH

The single source from which all accounts of this earthquake derive is a fairly detailed description by Neville (1575). It is described as having affected Norwich and almost the whole of England, and evidently caused a great deal of damage. Spires and towers of churches and houses, and many chimneys fell into the streets or through the roofs. In many places, buildings are said to have been destroyed or reduced to ruins. Blomefield (1806) records that in 1481 all the gates and towers of Norwich were repaired, and though it is not explicitly stated that this was due to earthquake damage, it would be surprising if the two were unrelated. Damage to city walls is not reported for any other British earthquake. It seems then, that the damage in Norwich was

severe, Neville's account, written the following century, being corroborated to some degree by the evidence for extensive repair work the following year. However, from Neville's account, it seems the area of heavy damage was wider than only Norwich. The obvious comparison is with the 1884 Colchester earthquake, which, due a shallow focus, was destructive in the villages south of Colchester; however, the high intensity attenuated rapidly, and while it was felt to some degree over much of England, the area of intensity 4 EMS and above was restricted to East Anglia (Musson et al. 1990). A similar pattern could explain the lack of other references to this somewhat tantalising event. The maximum intensity must have been at least 8 EMS. There is some reason to suppose the earthquake occurred in July, as discussed by Ambraseys and Melville (1983); they prefer the December date and this is followed here.

Place	*Latitude*	*Longitude*	*Intensity*
Norwich	52.63	1.30	8

Table 30 - Data for the earthquake of 28 December 1480

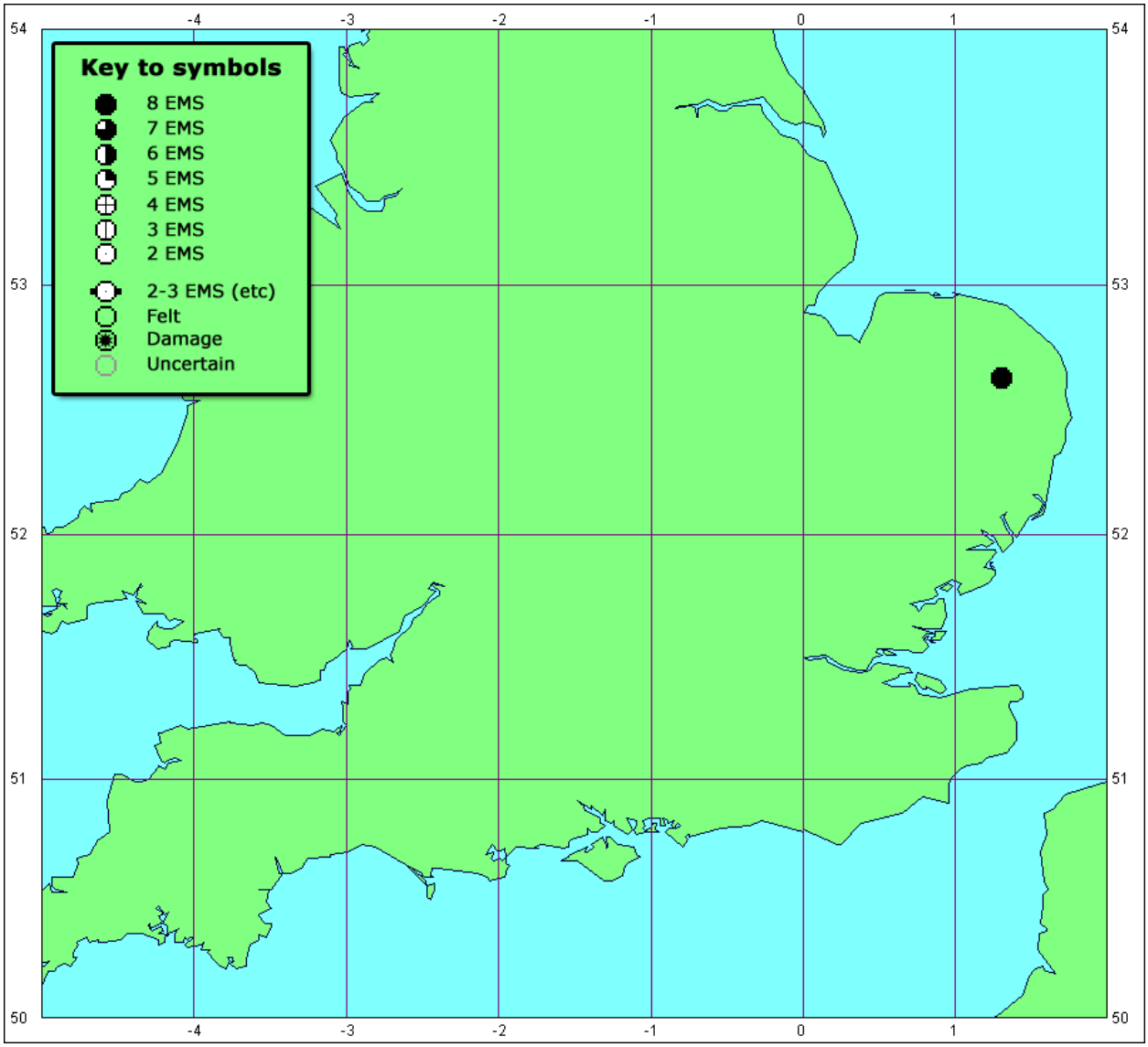

Figure 29 - The earthquake of 28 December 1480

3.79 21 DECEMBER 1487 NORWICH

This event is possibly a late aftershock of the preceding one. It is described in the Historia Eliensis in very similar terms to the 1456 event – once again, it was terrifying (Wharton 1691) -

and is mentioned with no details by Neville (1575), and Blomefield (1806), whose source is not given (and is evidently not Neville). The intensity was perhaps around 5 EMS. The main problem is the date; the Ely record (Lambeth MS 448) gives the feast of St Thomas the Martyr (29 December) 1488, while Blomefield's source gives St Thomas's Day 1487 - 21 December, the feast of St Thomas the Apostle. Neville (1575) gives only the regnal year, which fits 1487 but not 1488. Ambraseys and Melville (1983) prefer 29 December 1488; here the earlier date is preferred (since two out of three sources give 1487 against 1488), but the issue is undecidable and either could be correct.

Place	*Latitude*	*Longitude*	*Intensity*
Ely	52.40	0.27	F
Norwich	52.63	1.30	F

Table 31 - Data for the earthquake of 21 December 1487

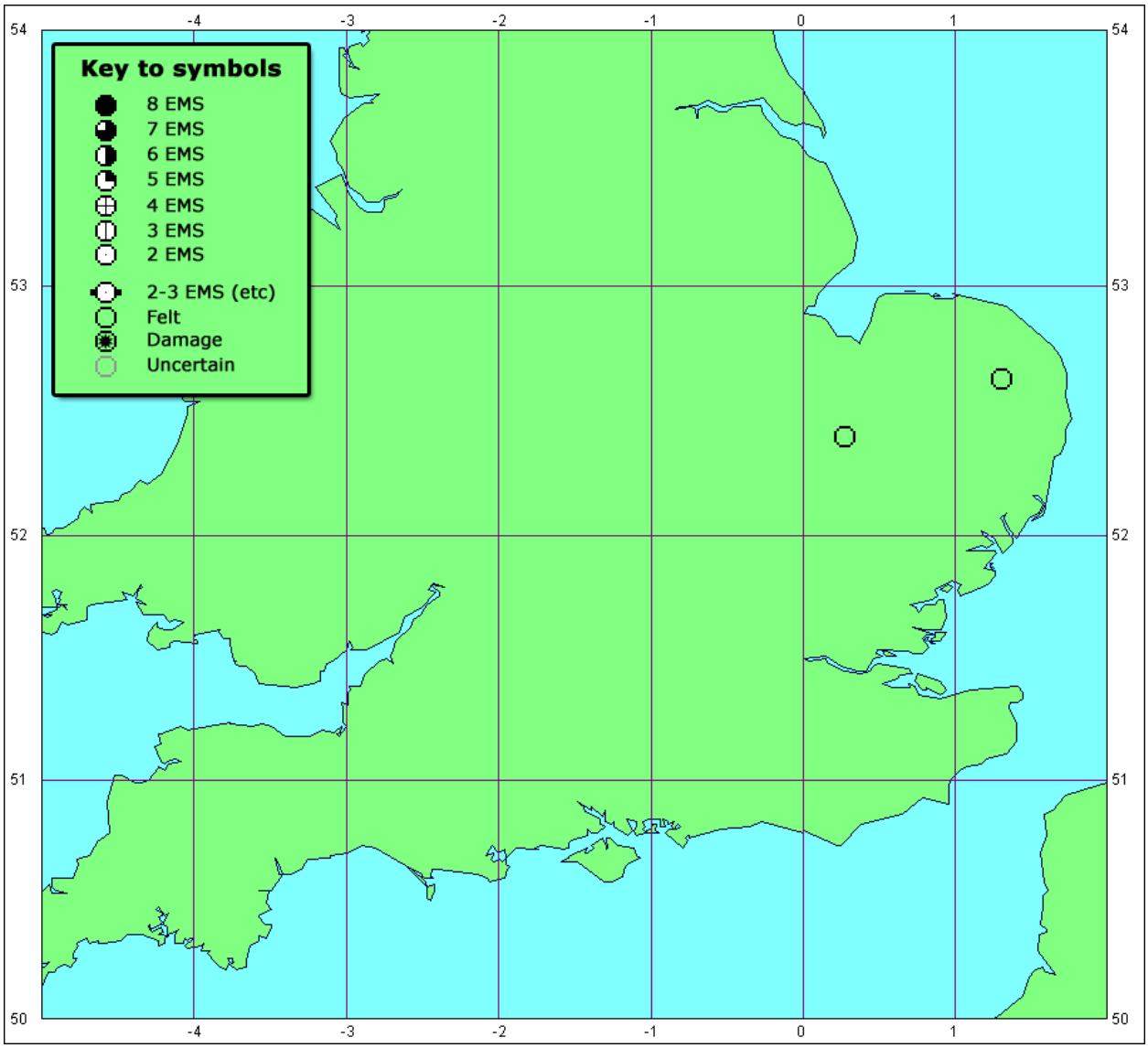

Figure 30 - The earthquake of 21 December 1487

3.80 19 SEPTEMBER 1508 VIKING GRABEN/ OFF HEBRIDES

This earthquake has been discussed in great detail by Musson (2004b, 2008). There are only three sources for it (Leslie 1578, Holinshed 1577 and Balfour 1825), none of which are coeval.

Leslie was writing in around 1570 and Balfour in around 1650, and Holinshed may have copied Leslie. It is described as having been felt throughout Scotland and England (this is unique), was frightening, and was felt especially in churches. It seemed to be of long duration. The absence of any mention of damage is particularly notable, given the little detail that it was more noticeable in churches, and this argues against the idea that the earthquake had an epicentre in the Borders region. Musson (1994) compares the event to the 1927 Viking Graben earthquake. Musson (2008) suggests the possibility that this is actually a large passive margin event west of the Outer Hebrides, similar to the 1929 Grand Banks earthquake (Newfoundland), with a magnitude around 7 Mw. If one could find (a) a record from Norway, (b) a record from Ireland, (c) reliable evidence for an early 16th century tsunami from the Hebrides or Donegal, it might be possible to resolve the issue, but at present it is not.

EARTHQUAKE BUT NO DATA

3.81 25 JULY 1534 NORTH WALES

As with the previous event, this appears to be a highly significant earthquake about which very little is know because of the dearth of good sources for the period. The exact date is unknown, but was a few days either side of 25 July, the date used here (and not 1 July, as given by Ove Arup 1993; the date is given July with no day by Musson 1994). The earthquake is mentioned by Ware (1662) in an account based on a contemporary narrative; it was felt in Dublin at 5 a.m.and was considered a wonder because earthquakes are so rare in Ireland. Evidence from the other side of the Irish Sea is much less precise, and consists of a Welsh poem found in two separate manuscripts, which gives only the year and that “the whole world shook at once” (NLW MS 436-B f38v, NLW Llangadfan Parochial Records no 1, f16v). The manuscripts are both 18th century, most likely transcriptions of an earlier orally-transmitted version, and the location of the manuscripts (both from North Wales) do not necessarily give any clue to the place of composition of the original verse. One must conclude that this was an event of some impact in Wales; widely felt, and also significantly perceptible in Dublin. Clearly the most obvious analogues are the Caernarvonshire earthquakes of 1852 and 1984. Although it is conjecture, most likely this was another similar event.

Place	*Latitude*	*Longitude*	*Intensity*
Dublin	53.34	-6.26	F

Table 32 - Data for the earthquake of 25 July 1534

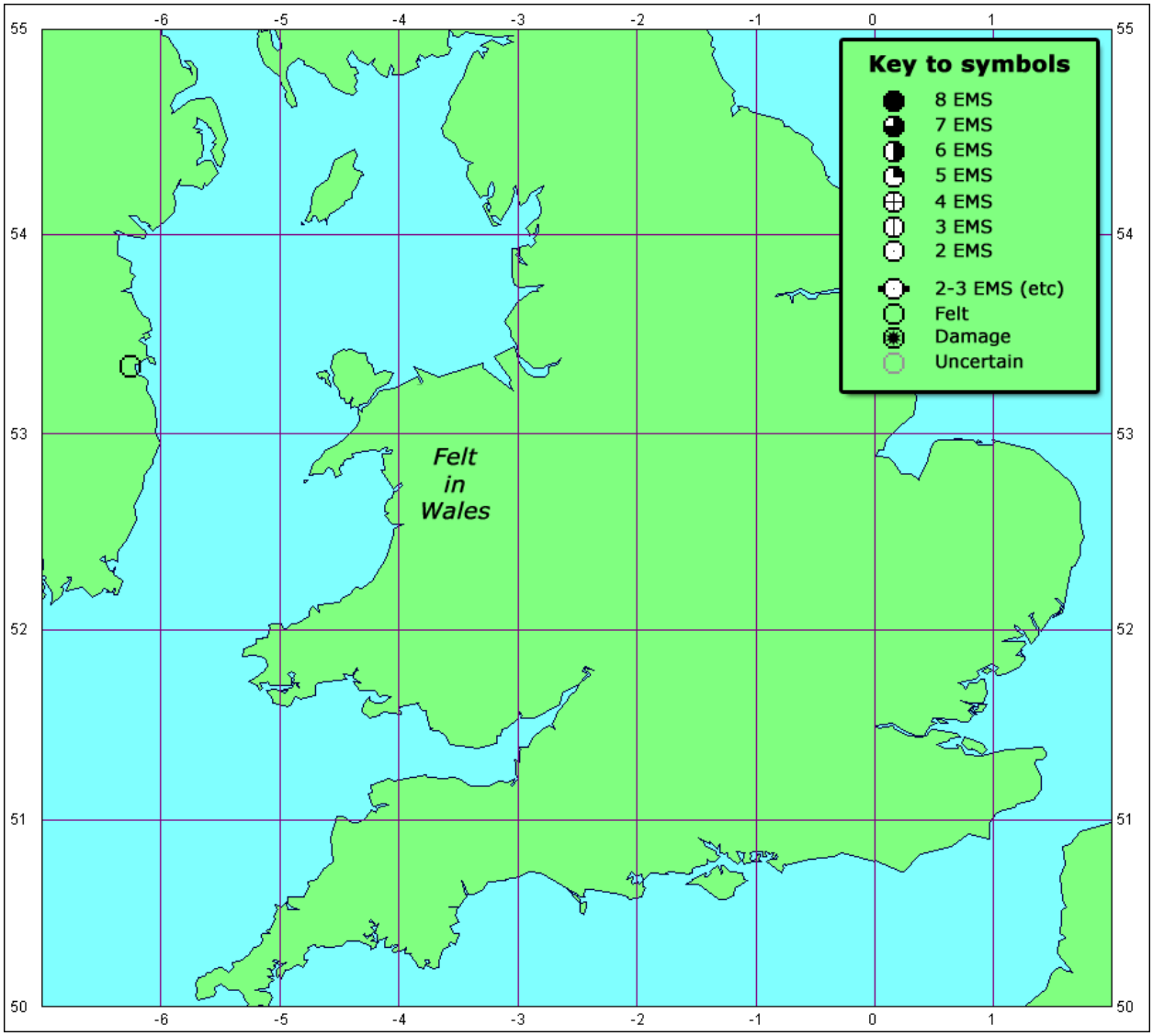

Figure 31 - The earthquake of 25 July 1534

3.82 1536 PLYMOUTH

In the records of the mayors of Plymouth, it is noted that in 1536 a slight shock of an earthquake was felt at Plymouth (Jewitt 1873). This is also mentioned by Firsoff (1957) as a slight shock in Exeter, but Firsoff gives no source, and may have put “Exeter” in error while writing from memory. (It’s assumed here that this is the case.) There is, of course, no telling if this was a local event or the far field effect of a larger earthquake elsewhere, in Cornwall, the Channel, or South Wales.

Place	*Latitude*	*Longitude*	*Intensity*
Plymouth	50.40	-4.14	F

Table 33 - Data for the earthquake of 1536 (Plymouth)

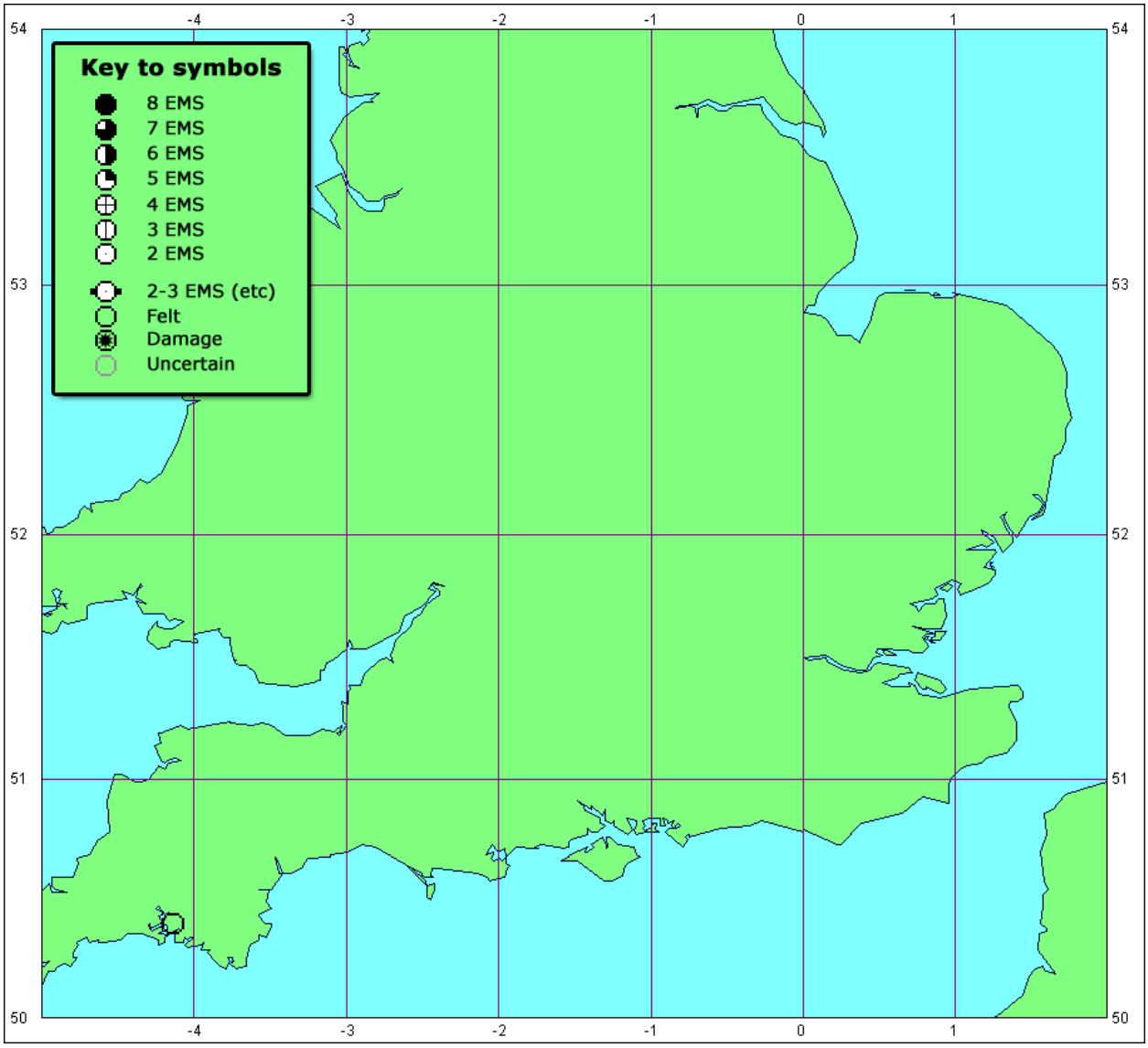

Figure 32 - Data for the earthquake of 1536 (Plymouth)

3.83 1536 SHREWSBURY

In the "historical year" 1536, i.e. 25 March 1536 to 24 March 1537, generally written 1536-7, there was an earthquake felt in Shrewsbury, according to an early chronicle collected by Leighton (1880). No details are known. The date is written here for convenience as 1536.

Place	*Latitude*	*Longitude*	*Intensity*
Shrewsbury	52.72	-2.73	F

Table 34 - Data for the earthquake of 1536 (Shrewsbury)

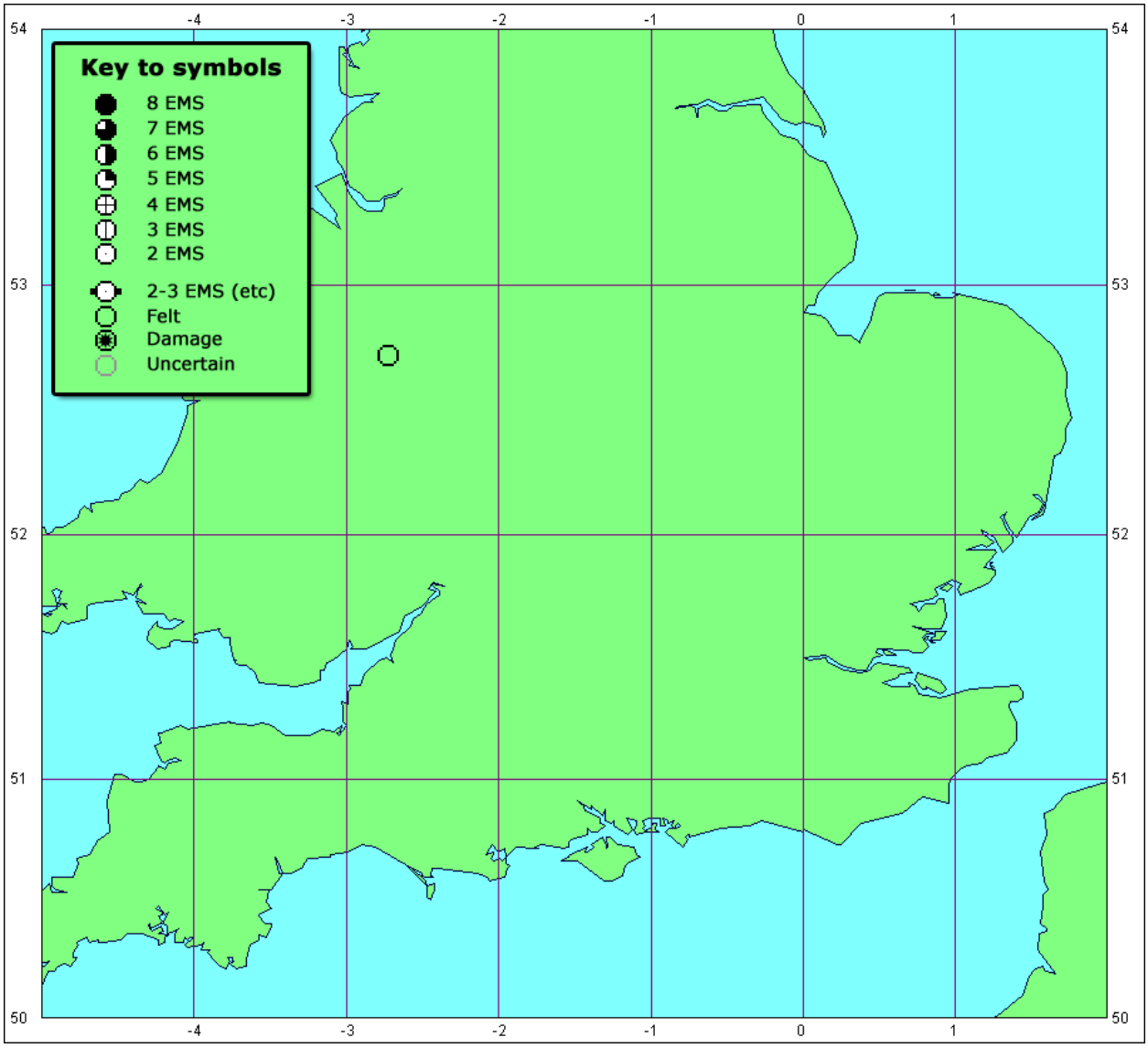

Figure 33 -The earthquake of 1536 (Shrewsbury)

3.84 25 MAY 1551 DORKING

This earthquake is unusually well documented for a small earthquake (< 4 ML) at this period, which is doubtless due to the fact that the epicentre was in the Home Counties, near to London. It is also unusual in having an epicentre in Surrey – this is the only earthquake of any note known to have had an epicentre in Surrey. For all that the earthquake was described in contemporary sources as “terrible” (as by John ab Ulmis writing to Conrad Pellican, Reader’s Index, 1926, vol 28 p52), the worst effects were limited to the fall of hanging objects; joints of meat, according to the diarist Henry Machyn (Nichols 1848). Thus the maximum intensity is not greater than 5 EMS. Dorking, Croydon and Reigate are the places listed as being most effected, but a number of villages round about are also mentioned as having felt the earthquake, which was perceptible as far as Westminster and “dyvers other places in London, and abowte there” (Nichols 1852). Wriothesley’s Chronicle (Hamilton 1875-7) gives a felt area of sixteen miles in length (about 26 km) and a duration of a quarter of an hour, which may refer to an aftershock shortly after the main shock. He states that people were in great fear of God, but no harm was done. One of the places he mentions is described as “Brenchingley”, which can be taken to refer to Bletchingley, Surrey, rather than Brenchley, Kent. Dorking is really the only place where the described effects are specifically mentioned as occurring, so that an intensity may be assigned, but most likely the intensity was also 5 EMS at Croydon and Reigate, at least. As noted by

SHWP (1995), some later authors misdate the earthquake as 1553, due to a misinterpretation of the dating of the event in the last continuation of Fabyan's Chronicle (Ellis 1811). Fabyan died in 1513, but his chronicle was continued to 1559, so its entry for this earthquake is contemporary; it reports an earthquake "in divers places, specially in Southsex". If it was felt in Sussex (not Southsea, as Davison, 1924, interprets it) this would extend the felt area further to the south.

Place	*Latitude*	*Longitude*	*Intensity*
Albury	51.20	-0.48	F
Beddington	51.37	-0.13	F
Bletchingley	51.23	-0.10	F
Croydon	51.38	-0.11	F
Dorking	51.22	-0.33	5
Godstone	51.23	-0.07	F
London	51.51	-0.08	F
Reigate	51.23	-0.22	F
Sutton	51.35	-0.20	F
Titsey	51.27	0.02	F
Westminster	51.50	-0.11	F

Table 35 - Data for the earthquake of 25 May 1551

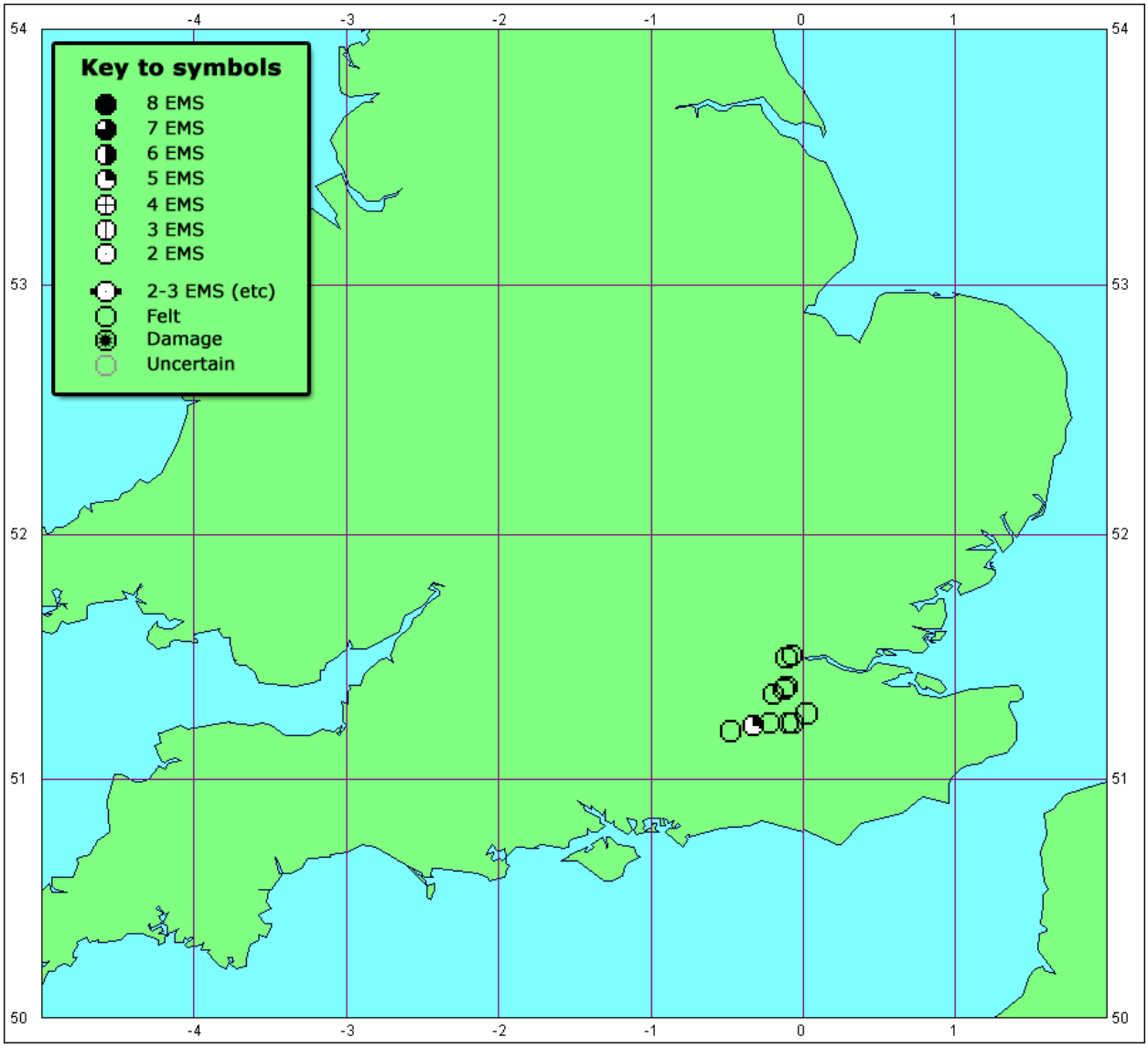

Figure 34 - The earthquake of 25 May 1551

3.85 1553 SUSSEX

See the discussion of the previous event. Interestingly, Smith (1960), writing of Sutton, in Surrey, states that, “In 1553 an earthquake in Sutton is recorded but is open to suspicion, there was a violent explosion at a Malden powder mill about this date”. No source for this is given.

MISDATED EARTHQUAKE

3.86 24 JANUARY 1561 LEICESTERSHIRE

According to Burton (1737), on this date there was “an Earthquake in Leicestershire, which came with a noise in the Air, at a distance; it shook the Houses, and Men could hardly stand, and continued a quarter of an Hour.” No contemporary account has been found, but given that Burton (real name Nathaniel Crouch) was much given to trawling historical miscellanea for curiosities, it is likely that this is a transcription from some source no longer extant. Aside from the typical exaggerated duration, the description is reasonable and suggests strong but not damaging shaking. There may be some connection with the seismicity in the same area recorded for 1563.

Place	*Latitude*	*Longitude*	*Intensity*
Leicestershire	52.67	-1.00	5-6

Table 36 - Data for the earthquake of 24 January 1561

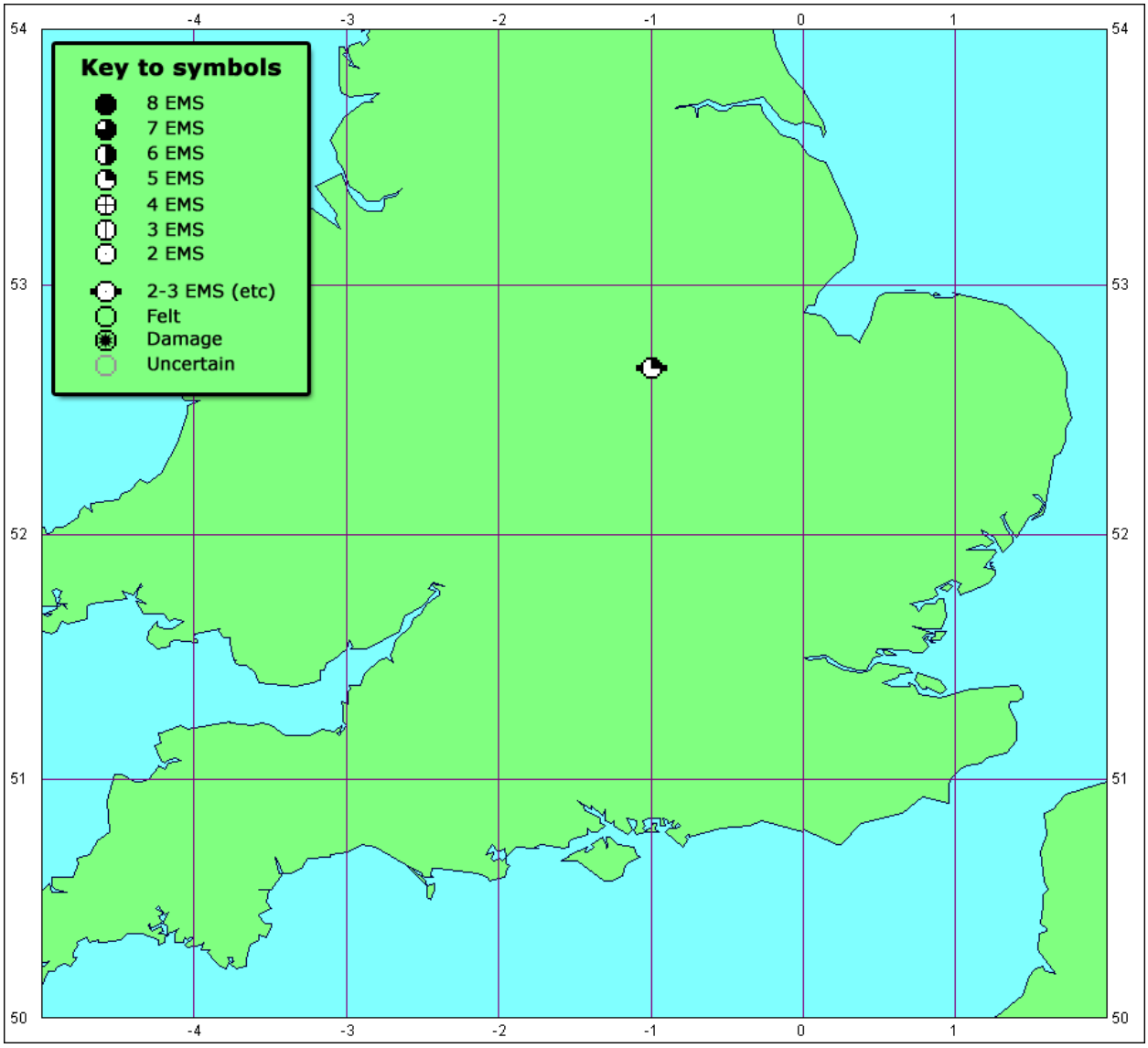

Figure 35 - The earthquake of 24 January 1561

3.87 8 JULY 1563 LINCOLN

This is possibly the start of a sequence of events, but the documentation is so poor it has hard to tell how many distinct events occurred and which are misdated duplicates. The only source for 8 July 1563 is Short (1749), and interestingly, it appears only in Short's main text and not in his summary table. The main text appears to be generally more reliable (Musson 2005). The event is described as affecting Leicestershire and Lincoln.

Place	*Latitude*	*Longitude*	*Intensity*
Leicestershire	52.67	-1.00	F
Lincoln	53.23	-0.53	F

Table 37 - Data for the earthquake of 8 July 1563

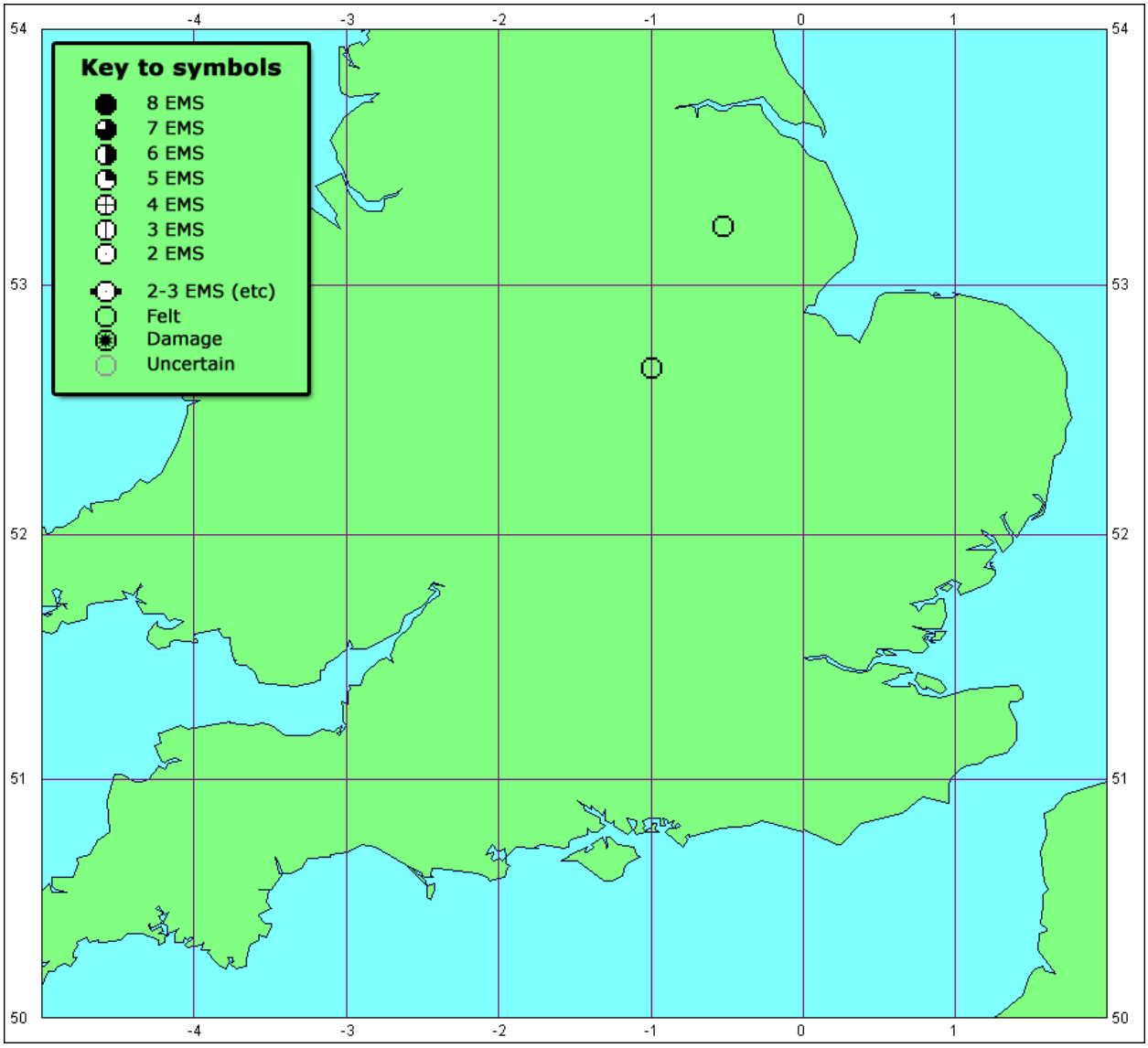

Figure 36 - The earthquake of 8 July 1563

3.88 SEPTEMBER 1563 LINCOLN

If the 1563 Lincoln events are genuinely a sequence, this may be the largest one. It appears in Short (1749) in both text and table, being given as Lincoln in the text and Northern England in the table. The contemporary writer Stow (1580) describes it as being in “divers places of this realme, specially in Lincolne and Northamptonshire.” Short (1749), in the table only, has further Lincoln and Northamptonshire events in September and November 1564. One suspects that September 1564 is the September 1563 event misdated and duplicated, but if so, it may mean that there was a still a further event in November 1563.

Place	*Latitude*	*Longitude*	*Intensity*
Lincoln	53.23	-0.53	F
Northamptonshire	52.25	-0.83	F

Table 38 - Data for the earthquake of September 1563

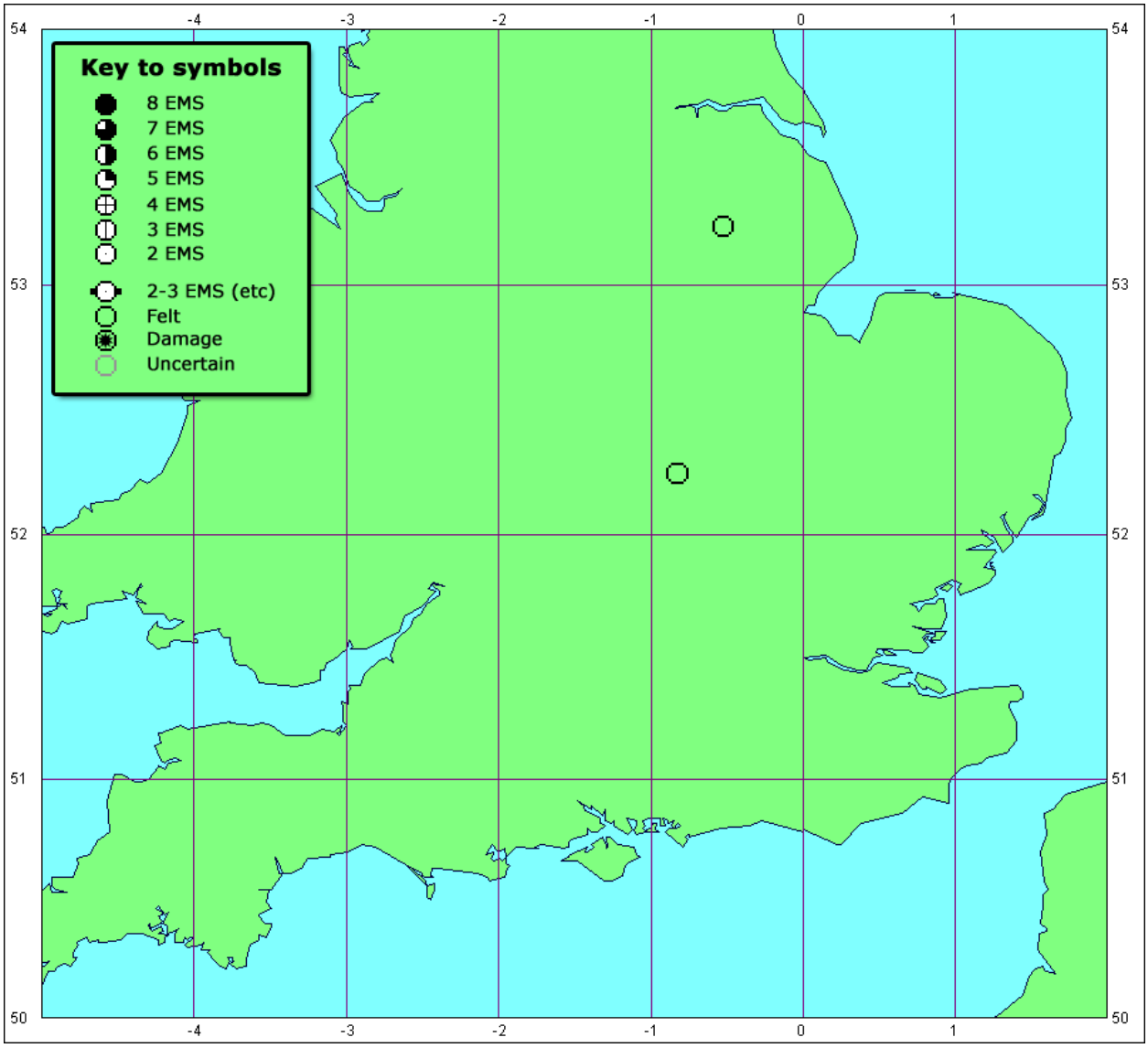

Figure 37 - The earthquake of September 1563

3.89 4 JULY 1570 GLASGOW

This earthquake is known from one contemporary source, a diary kept by a burgess of the city of Glasgow, which reports the date and time ("10 houris at nycht"). Glasgow is the only place mentioned. It "laftit bot ane fschort fpace, bot it caufit the inhabitants of the faid cittie to be in great terrour and feir" (Thomson, 1833). It sounds to have been similar to the 1910 and 1964 Glasgow earthquakes.

Place	*Latitude*	*Longitude*	*Intensity*
Glasgow	55.83	-4.25	5

Table 39 - Data for the earthquake of 4 July 1570

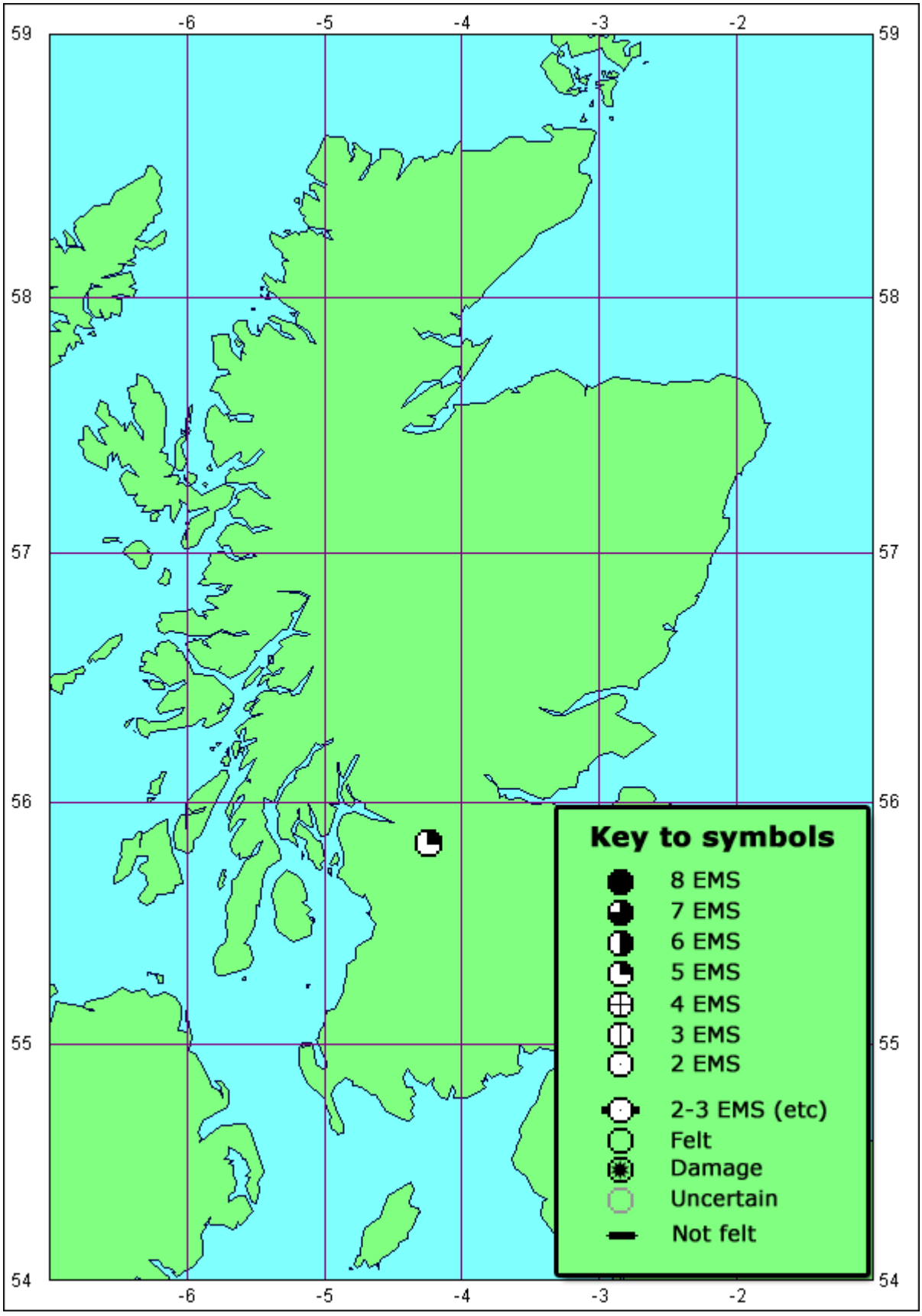

Figure 38 - The earthquake of 4 July 1570

3.90 1573 YORK

Davison (1924) lists a severe earthquake at York on the authority of Roper (1889), whose source is Mayhall (1874). The 18th century antiquarian Thomas Gent, in writing about the execution of the Earl of Northumberland on 22 August 1572 says that the severed head was placed on a pole above Micklegate Bar, "From which about two years after, much about the time when a great earthquake happen'd in York it was stolen away" (Gent 1735). This would place the earthquake in "about" 1574, and there can be little doubt that in fact the large earthquake of February 1575 is what is being alluded to (which would be dated to the "historical" year 1574, when reckoning by 25 March rather than 1 January).

MISDATED EARTHQUAKE

3.91 26 FEBRUARY 1575 MIDLANDS

The principal account of this earthquake is by the contemporary historian John Stow (1580), who reports effects suggestive of intensity 5 and perhaps 6 EMS over a wide area. He mentions first, York, Worcester, Gloucester, Bristol and Hereford, where people ran out of their houses for fear that the buildings would fall (it is implied that this occurred at all the cities mentioned, but this may not be reliable). At Tewkesbury and Bredon, dishes and books fell down. At Norton Chapel (Worcestershire) people ran out in alarm, part of Ruthin castle "fell down" together with some brick chimneys. The bell in the Shire Hall at Denbigh rang twice. This evidence is strongly biased towards the English-Welsh borders, and suggests a Herefordshire or Shropshire event. It comes as a surprise, therefore, that there is also a contemporary account from Hatfield in Yorkshire describing even stronger effects. People were thrown into a panic, as were animals kept indoors. Some old houses and barns were thrown down and part of a gable end at the Manor Hall was damaged. The writer states that if the church had not been so strongly built "it had been layd flat with ye Ground as some in ye Country were … great Damage was done in all ye Country over" (de la Pryme, in Lansdowne MS 897 f36). A further contemporary source from Shrewsbury (Leighton 1880) states that "great yearthquacks happened … for the space of halffe an howre", which may be an allusion to an aftershock shortly after the main shock. Books were thrown down by the shock and birds flew up into the air.

The earthquake prompted the Archbishop of York to write to the Archbishop of Canterbury (then Matthew Parker) to make enquiries; he reports that the earthquake was felt in Yorkshire, Nottinghamshire, Durham (the county rather than the city is evidently meant) and Lancashire (Strype 1821). At York it did no damage ("it shook down not so much as a tile") and people were afraid, but seemingly more as to what the earthquake might be a portent of, than due to the strength of shaking as at Hatfield. Parker replied from London that he never heard of it, and that it was not felt "in the south parts" (Strype 1821).

It is uncertain whether the earthquake was felt in King's Lynn. Richards (1812) has an entry under 1574/5 for an earthquake and plague in the town, but a longer record which may be his source, a borough chronicle compiled about 1590 in the King's Lynn archives (King's Lynn Borough Archives MS, KL/Gd 85) describes an earthquake in York and other places, religious affairs in London, and finally a plague in King's Lynn. It does not state that the earthquake was felt in King's Lynn.

The reports from Ruthin and Hatfield suggest that damage was widespread over a considerable area, and the complete (or even partial) collapse of buildings, even weak ones, is seldom reported in British earthquakes. Principia (1982) downplay the effects in North Wales as long-period effects, but this is not convincing. Effects such as fall of chimneys and the ringing of bells, when they appear in the UK earthquake record, are normally simply indicative of strong shaking. British earthquakes tend not to be effective at generating long-period shaking on account of their modest size. Ambraseys and Melville (1983) consider this earthquake may have

had a similar epicentre to the 1795 Derby earthquake (in the Derby-Mansfield area) but with a higher magnitude.

An epicentre in the Derby-Stafford area seems to be the explanation most consistent with the data; with a strong northeast-southwest elongation of the highest intensities – which, interestingly, was observed in the well-documented 1926 Ludlow earthquake (Musson et al. 1984).

Place	*Latitude*	*Longitude*	*Intensity*
Bredon	52.03	-2.12	5
Bristol	51.45	-2.58	5
Denbigh	53.18	-3.42	5-6
Durham	54.66	-1.75	F
Gloucester	51.83	-2.25	5
Hatfield	53.57	-0.98	6-7
Hereford	52.05	-2.72	5
King’s Lynn	52.75	0.38	?
Lancashire	53.83	-2.50	F
London	51.51	-0.08	1
Norton	51.92	-2.20	5
Nottinghamshire	53.17	-1.00	F
Ruthin	53.12	-3.30	6-7
Shrewsbury	52.72	-2.73	5
Tewkesbury	52.20	-2.15	5
York	53.97	-1.08	4-5

Table 40 - Data for the earthquake of 26 February 1575

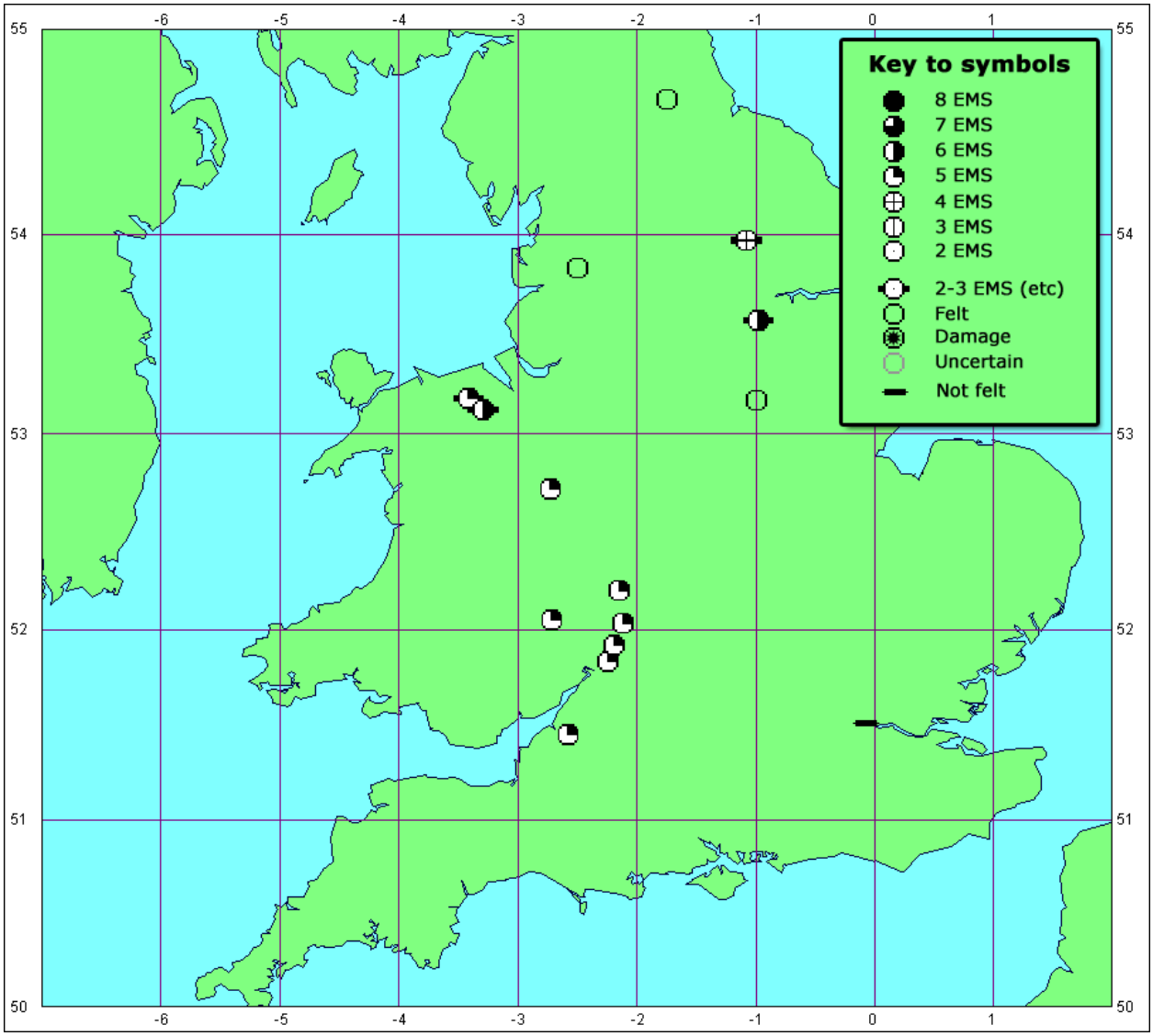

Figure 39 - The earthquake of 26 February 1575

3.92 6 APRIL 1580 DOVER STRAITS

The earthquake of 1580 is one of the largest ever to have affected the British Isles, is one of the most famous of all British earthquakes, and is certainly the best-documented earthquake in the period covered by this report. Accordingly, it has been heavily studied, notably by Soil Mechanics (1982), Ambraseys and Melville (1983), Neilson et al. (1984) and Melville et al. (1996). The account presented here is not intended to be a full description, and draws largely on the four studies listed above, especially the last, which has the fullest collection of continental sources.

The earthquake struck on Wednesday in Easter week, at around 18h or a little earlier.

Despite the numerous accounts preserved, three are still some difficulties in assessing intensities for this event. As is so often the case, accounts speak more about damage to special buildings – churches and castles – than to ordinary houses. To take examples only from Kent, the tower of the church of St Peter's, Broadstairs was cracked from top to bottom (Hasted 1800; the repairs can still be seen today – see Figure X), St Peter's and St Mary's churches in Sandwich were both cracked (Boys 1792), and the church of St Peter and St Paul, Sutton (near Dover) was partly thrown down (Hasted 1800). Damage to ordinary houses is mentioned at none of these locations, but one suspects that this is more due to a sense that what happened to plebeian housing was not worth recording, than to an actual absence of damage. Significant damage to churches in British

earthquakes is unusual, and comparable effects are only to be found amongst later events in the case of the 1884 Colchester earthquake, in an area over which the intensity was 7 or 8 EMS. Thus the maximum intensity in England should have been in this range.

Writers who do mention damage to houses are Fleming (1580), Churchyard (1580) and Wood (1796). Fleming (1580) reports householders in London complaining that £20, £30, not even £100 would be enough to meet the cost of repairs. Churchyard (1580) is more precise in describing the fall of chimneys and small pieces of stone and mortar from the tops of houses in London (particularly Shoreditch). Wood (1796), following an entry in the Annals of Merton College (Fletcher 1976) speaks of great damage to both the foundations and roofs of houses and churches in Kent.

The effects in London gave rise to such alarm that many printed pamphlets were rushed out, four of which have survived and provide source information: those by Churchyard (1580), Fleming (1580), Golding (1580) and Twyne (1580 – see also Ockenden 1936). The style of these leans heavily towards the theological; generally more space is given to explaining the need for repentance in the face of this warning from God, than to description of the effects of the earthquake. The work by Fleming (1580), though, is interesting in providing the earliest catalogue of British earthquakes (Musson 2004). A special prayer-book was issued to be read in churches and by families for protection against further shocks (Strype 1821). Churchwarden's accounts from the period sometimes contain entries recording purchase of the prayer-book (price sixpence) as at Wooton St Lawrence, Hants. (Williams 1913). The first of these pamphlets, "A godly newe ballat moving us to repent by ye example of ye earthquake happened in London ye 6. of Aprill 1580" was issued the very next day after the earthquake, price fourpence (Arber 1875). The author is unknown, and no copy has survived, but Collier (1849) cites a MS ballad which he suggests is this one. As it is little known, three stanzas may be given here:

It came at eve, as Aprill day
Shut up its water eye,
And fillde all London with dismaye,
And that all suddenly.
In open streete
Did all men meete
Leaving their houses shaking fearfully.

The belles of as themselves did toll
The knell of all the people:
Huge stones fell downe, and others roll
From tower and from steeple.
These none could shun,
Though fast they run:
They soon ore tooke and killd both whole and creeple.

In one short minute, strange to view,
The cittie stood amazd,
Confusion rangde the wardes all through;
Exhe on his neighbor gaz'de.
All were agast,
But soone it past:
If it continued, London had been razde.

For the role these pamphlets played in contemporary religious (Catholic-Protestant) controversy, see Hamilton (2005). For their social impact, see Walsham (1999).

A curiosity is related, that, the day before the earthquake, at Debden in Essex, a sermon was preached by Laurence Chaderton on the text Joel iii 16 ("The heavens and earth shall shake, but

the Lord will be the hope of His people"). This caused some people to imagine Chaderton was inspired to prophecy, when the earthquake occurred the next day (Shuckburgh 1884).

This earthquake was also the first occasion in Britain on which we specific information on earthquake fatalities (Musson 2003). Two child apprentices, Thomas Gray and Mabel Everite were struck by stones falling from the roof of Christ's Church, Newgate, in London. The boy was killed outright; the girl died of her injuries a few days later.

North and west of London the earthquake was generally felt and alarming at Norwich (Blomfield 1805), Saffron Walden (Harvey 1885) and Oxford (Wood 1796); isolated damage included the fall of the top of the steeple at Stoke, near Hinckley, Leics. (Burton 1777). The shock was certainly felt as far west as Bristol (Seyer 1823) and possibly Stoke St Gregory in Somerset (Somerset RO MS D/P/Sto.St.g. 2/1/1). To the north, it was felt in York, but the statement in, for instance, Roper (1889) that bells were rung and stones fell from buildings in York is certainly a misreading of Camden (1607). An imperfectly dated observation from Edinburgh (Chambers 1858) may represent an intensity 2 EMS in that city (which had perhaps the tallest houses in Britain at this date). Twyne (1580) believed that the shock was felt generally throughout the whole of Britain, including Scotland, but this does not seem to be based on anything.

On the continent, the strongest effects are reported from Calais, where several houses are reported to have been thrown down; the town walls were damaged and part of the watch-tower collapsed (Haton 1862, Bernard 1715, Bellart and Vion 1991). At Boulogne, damage was done to the church of Notre-Dame, and in houses even heavy furniture was displaced (Hauttefeuille and Bernard 1860, Bellart and Vion 1991).

Damage in France extended to Arras (Bellart and Vion 1991), Douai (Registre 1580) and Lille (Particularités 1728), though the last of these (a detailed 18th century account based on unknown source materials) is doubted by Melville et al. (1996) – and may relate to storm damage the following year. Damage in the Rouen-Pontoise area, described in one contemporary source (Discours merveilleux 1580) seems to have been surprisingly high.

In Belgium, the damage seems to have been significant in Oudenaarde, where falling stones and tiles killed some and injured others. Damage to chimneys extended as far as Brussels (Pottre 1861).

The furthest limits of the earthquake on the continent are marked by Amsterdam and Hoorn in the Netherlands (Hooft 1677, Velius 1740), Liège (Lancaster 1901) and possibly Cologne (Le Petit 1604, Camden 1607 – no local sources have been found for this, according to Melville et al. 1996). To the south it was felt not especially strongly in Paris (Haton 1862) and no more distant records have been found in this direction. It was strongly felt as far west as Le Havre (Pleuvri 1796), where a commemorative procession was organised. If in England the religious reaction took the form of a prayer-book, on the continent it took the form of processions. That in Calais was made an annual event, only discontinued in 1701 (Bernard 1715).

One contentious issue is whether this earthquake produced a tsunami, as stated, for instance, by Varley (1996). Such arguments are based on two observations: the first is that at Sandwich in Kent "the sea so foamed, that the ships tottered" (Stow 1601). This is evidently a direct effect of the earthquake shock waves on boats, and possibly seiching, and nothing to do with tsunamis. The second is a contemporary French pamphlet (Discours d'une 1580) which describes the sea flooding in at Calais and Boulogne with great destruction and hundreds of deaths. This is unbelievable, partly because of the lack of any confirmation of these dramatic consequences in other accounts, and partly because the pamphlet describes the loss of ships at sea (which cannot happen in a tsunami) and even uses the phrase "grande horrible tempeste de la mer". It also speaks of further destructive flooding between 4h-5h the following day, again, not consistent with a tsunami. There was no storm on the day of the earthquake, but possibly some slightly later storm has been merged with the reports of the earthquake by the anonymous writer. Melville et al. (1996) suggest that perhaps the earthquake caused the collapse of some embankment

protecting low-lying land, resulting in floods at high tide on the 6th and 7th April – but this does not explain the reported losses of ships at sea. Whatever the explanation, Discours d'une (1580) cannot be taken at face value.

The intensity values given here differ from those in previous studies, but are closest to Melville et al (1996). The difficulty here is giving values to very limited information. Neilson et al (1984), with the aim of comparing different intensity scales, give literal "point intensities" to each damage report, which will not serve here. On the other hand, one should not try and guess what the intensity ought to have been for a location for which there is a bare report that the earthquake was felt, which tends to be the practice in SHWP (1995). In the present study 7-8 EMS has been assigned to Broadstairs and Sutton in Kent (meaning 7 or 8, not 7.5) on the grounds that shaking strong enough to cause the reported damage to churches must have caused a good deal of unreported damage to ordinary houses. However, one cannot really assign any intensity to Dover, where the reports focus on secondary damage to the castle. A "D" has been given to problematic damage cases, including far-field reports and reports that may attribute to the earthquake damage from the storm the following year. For details of the effects in each place, see Neilson et al. (1983), SHWP (1995) and Melville et al. (1996).

Place	*Latitude*	*Longitude*	*Intensity*
Abbeville	50.10	1.83	4-5
Aire	50.63	2.40	6-7
Amiens	49.90	2.30	5
Amsterdam	52.35	4.90	F
Antwerp	51.22	4.42	F
Arras	50.28	2.77	6
Axel	51.27	3.92	F
Beauvais	49.43	2.08	5-6
Béthune	50.53	2.63	D
Bishop's Stortford	51.88	0.15	5-6
Boulogne	50.72	1.62	7
Bristol	51.45	-2.58	F
Broadstairs	51.37	1.45	7-8
Bruges	51.22	3.23	5-6
Brussels	50.83	4.33	6-7
Calais	50.95	1.87	7-8
Cambrai	50.17	3.23	F
Caudebec-en-Caux	49.53	0.73	F
Chateau-Thierry	49.05	3.40	5
Chauny	49.62	3.23	F
Clairmarais	50.77	2.30	F
Cologne	50.93	6.95	F
Dammartin	48.90	1.62	F
Debden	51.97	0.25	F

Dendermonde	51.03	4.10	F
Dieppe	49.92	1.08	5
Douai	50.37	3.08	6
Dover	51.13	1.32	D
Drenthe	52.75	6.50	F
Duisburg	51.43	6.75	F
Dunkirk	51.03	2.83	5-6
Edinburgh	55.95	-3.22	2?
Edwardstone	52.03	0.83	F
Ely	52.40	0.27	5
Ename	50.85	3.63	F
Fécamp	49.75	0.38	5
Friesland	53.05	5.75	F
Gent	51.03	3.70	6-7
Gisors	49.28	1.78	F
Gravesend	51.45	0.40	F
Great Massingham	52.77	0.67	F
Harelbeke	50.85	3.32	F
Hatfield	53.57	-1.00	F
Hazebrouck	50.72	2.53	F
Hoorn	52.63	5.05	F
Hythe	51.08	1.08	6
La Fère	49.67	3.37	F
Laon	49.57	3.62	5
Le Havre	49.50	0.10	5
Leyden	52.17	4.50	5-6
Liège	50.63	5.58	F
Lille	50.65	3.08	D
London	51.50	-0.08	6
Lydden	51.15	1.25	D
Mantes	48.98	1.72	F
Mechelen	51.03	4.48	F
Mons	50.30	3.97	6-7
Montreuil	50.47	1.77	F
Norwich	52.63	1.30	5
Noyon	49.58	3.00	5
Oudenaarde	50.83	3.62	7

Oxford	51.77	-1.25	5
Pamele	50.84	3.61	F
Paris	48.87	2.33	3-4
Pilton	51.17	-2.59	F
Poissy	48.93	2.03	F
Pontoise	49.05	2.08	5-6
Postling	51.10	1.07	D
Rochester	51.40	0.50	F
Rouen	49.43	1.08	6-7
Saffron Walden	52.07	0.25	5
Salisbury	51.08	-1.80	F
Saltwood	51.08	1.08	6-7
Sandown	51.28	1.33	F
Sandwich	51.27	1.34	6
Schiedam	51.92	4.42	6
Soissons	49.38	3.33	F
Saint-Amand-les-Eaux	50.45	3.43	5-6
Saint-Germain-en-Laye	48.88	2.07	F
Saint-Omer	50.75	2.25	F
Staines	51.43	-0.50	F
Stoke Golding	52.57	-1.40	D
Stoke St Gregory	51.04	-2.93	F
Sutton	51.19	1.34	7-8
Tenterden	51.08	0.68	F
Tirlemont	50.80	4.95	5
Valenciennes	50.37	3.53	5
Windsor	51.48	-0.63	F
York	54.00	-1.08	F
Ypres	50.85	2.88	6-7
Zichem	51.00	4.98	D

Table 41 - Data for the earthquake of 6 April 1580

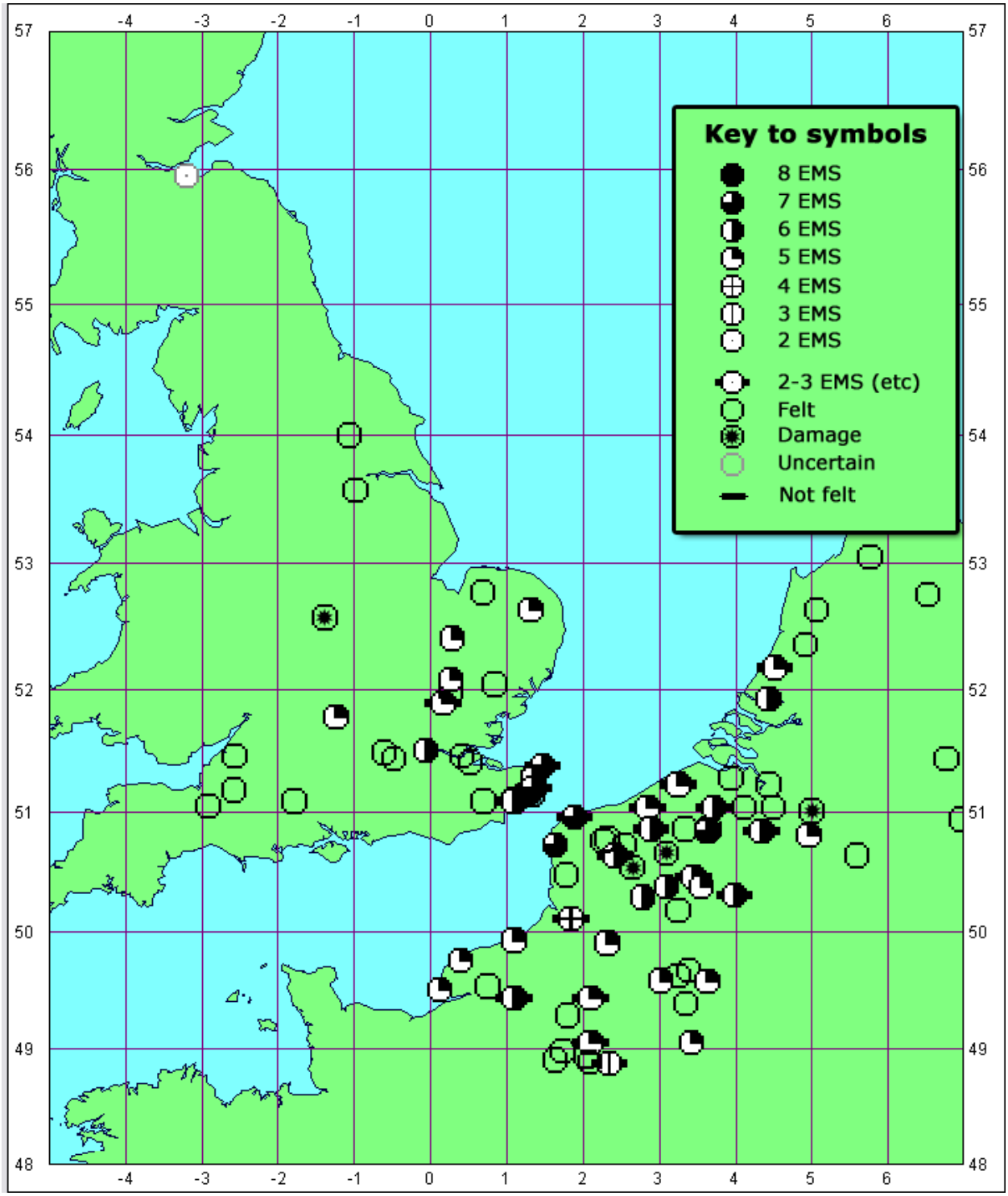

Figure 40 - The earthquake of 6 April 1580

3.93 6 APRIL 1580 DOVER STRAITS (21H)

Two aftershocks are recorded on the same day as the 1580 main shock. The first occurred just before 21h, was of short duration and felt only in east Kent (Stow 1601, Boys 1792).

Place	*Latitude*	*Longitude*	*Intensity*
East Kent	51.13	1.32	F

Table 42 - Data for the earthquake of 6 April 1580 (21h)

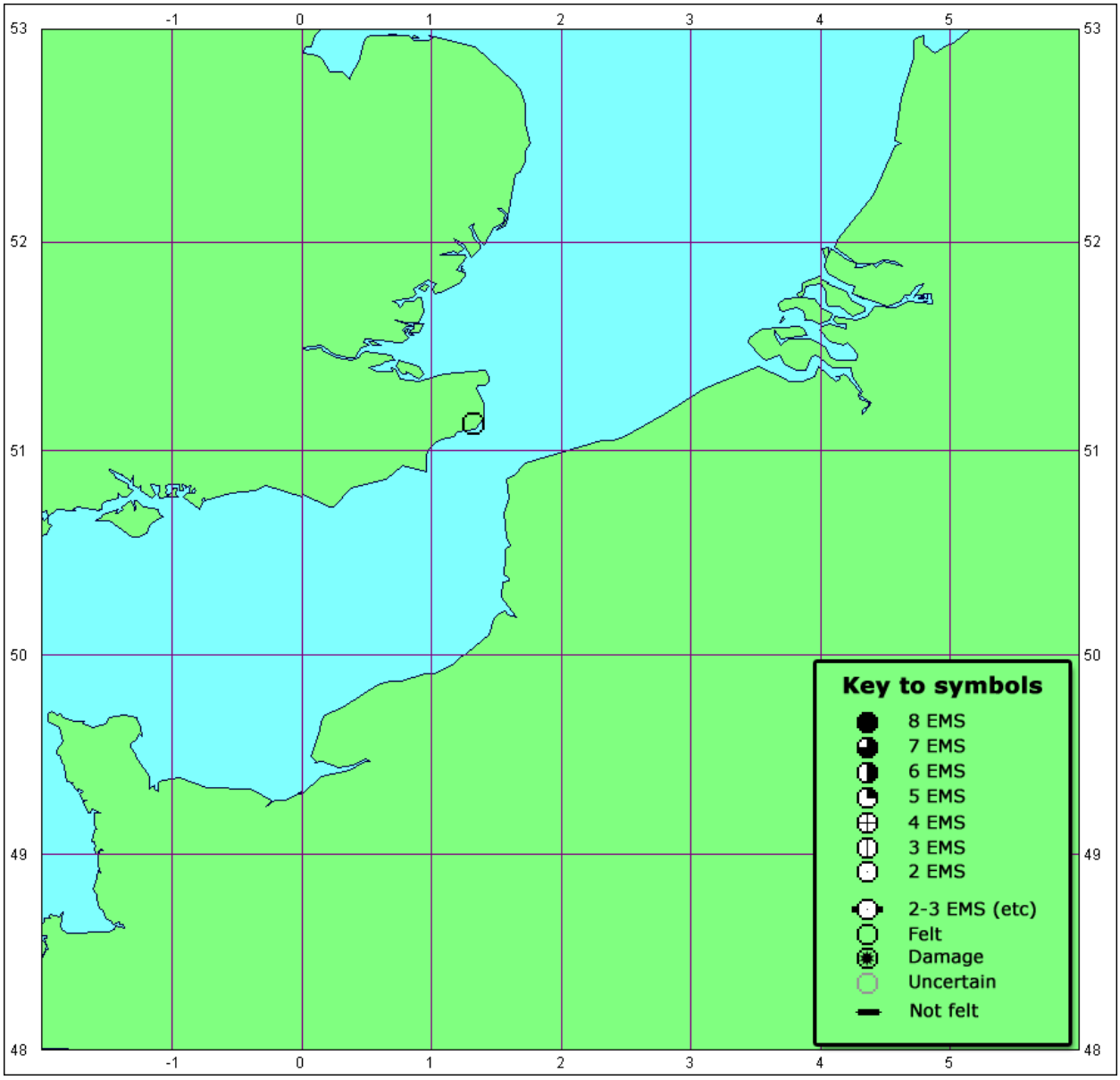

Figure 41 - The earthquake of 6 April 1580 (21h)

3.94 6 APRIL 1580 DOVER STRAITS (23H)

The second aftershock occurred just before 23h, and was again of short duration and felt in east Kent, and very slightly by a few people in Boulogne (Stow 1601, Boys 1792, Bellart and Vion 1991).

Place	*Latitude*	*Longitude*	*Intensity*
Boulogne	50.72	1.62	2-3
East Kent	51.13	1.32	F

Table 43 - Data for the earthquake of 6 April 1580 (23h)

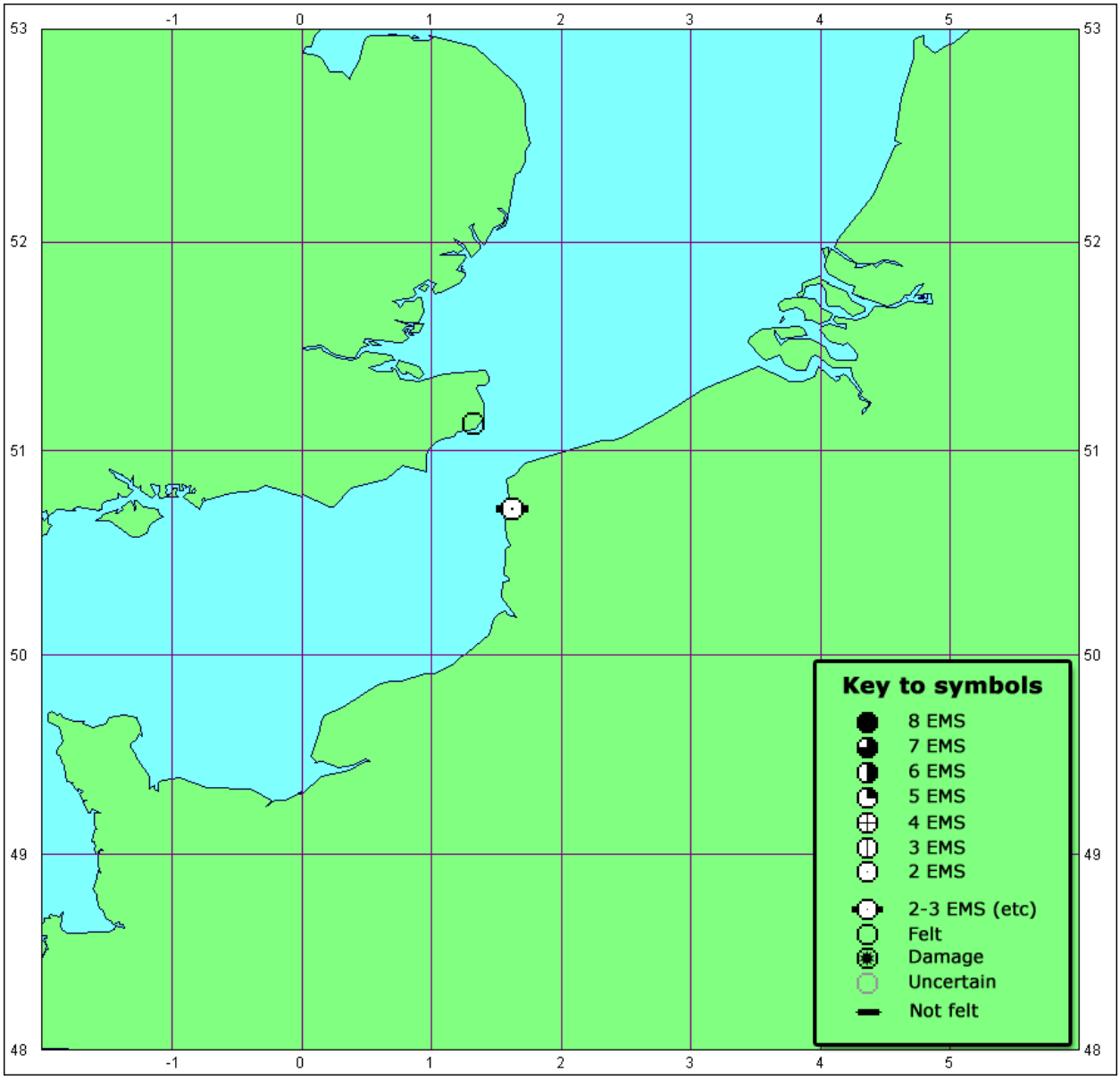

Figure 42 - The earthquake of 6 April 1580 (23h)

3.95 7 APRIL 1580 DOVER STRAITS (4H)

Two further aftershocks occurred the following day after the 1580 main shock. The first occurred at about 4h, in east Kent, described as a slight noise and no shaking (Boys 1792).

Place	*Latitude*	*Longitude*	*Intensity*
East Kent	51.13	1.32	F

Table 44 - Data for the earthquake of 7 April 1580 (4h)

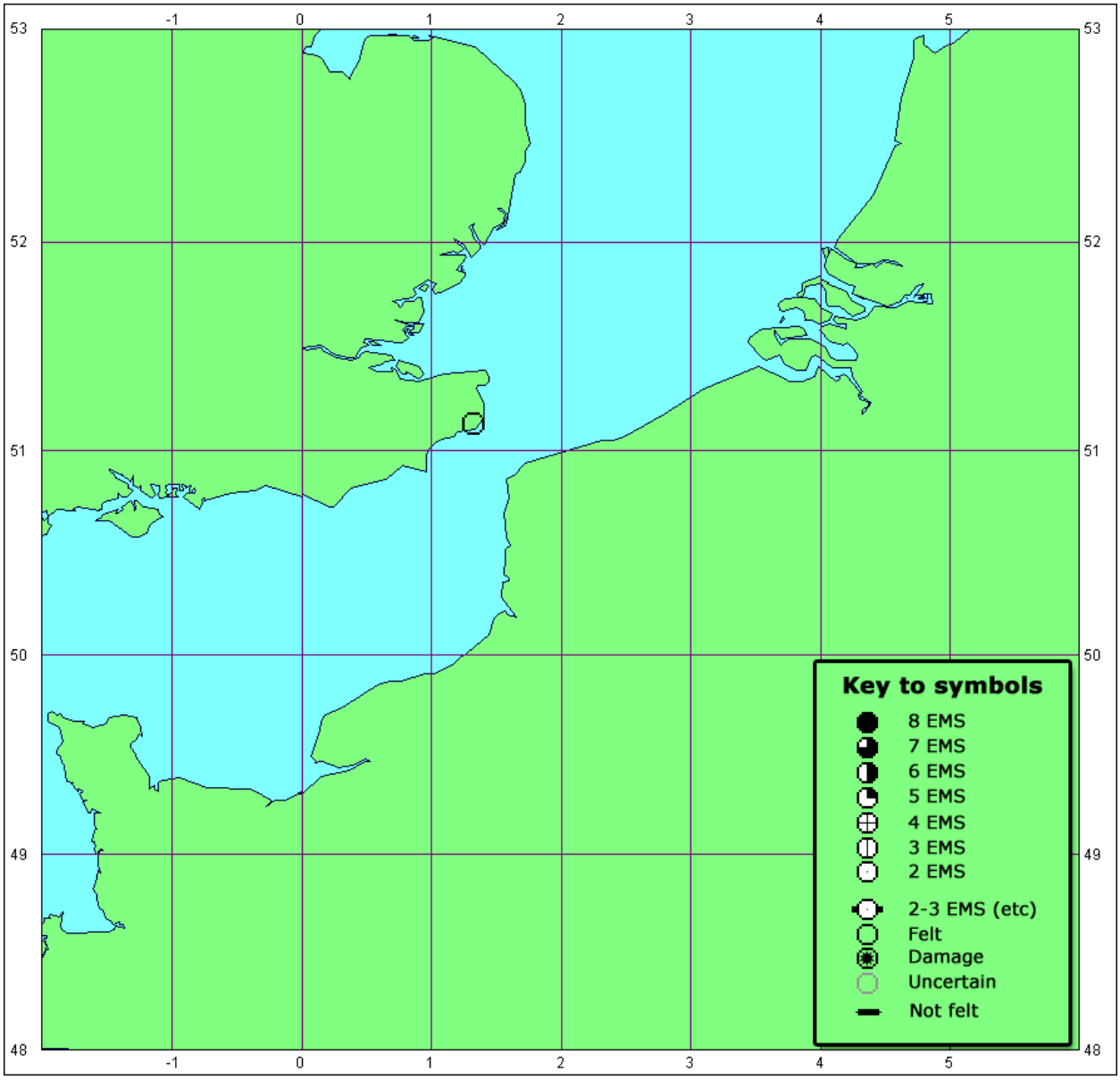

Figure 43 - The earthquake of 7 April 1580 (4h)

3.96 7 APRIL 1580 DOVER STRAITS (4H 30M)

The second aftershock on 7 April occurred at about 4h 30, in east Kent, described as a slight noise and a little shaking (Boys 1792). Reports from the continent concerning the immediate aftershocks are vague and imprecise, and may in some cases relate to the perception of different phase arrivals rather than separate shocks; see the discussion in Melville et al. (1996). Wood (1796) states that in many places the earth shook twice in one night, and in Kent thrice in a fortnight, which suggests the possibility of a further aftershock between 13-18 April not otherwise known. Strype (1821) states that the ground in Kent trembled two or three times the night following the main shock.

Place	*Latitude*	*Longitude*	*Intensity*
East Kent	51.13	1.32	F

Table 45 - Data for the earthquake of 7 April 1580 (4h 30m)

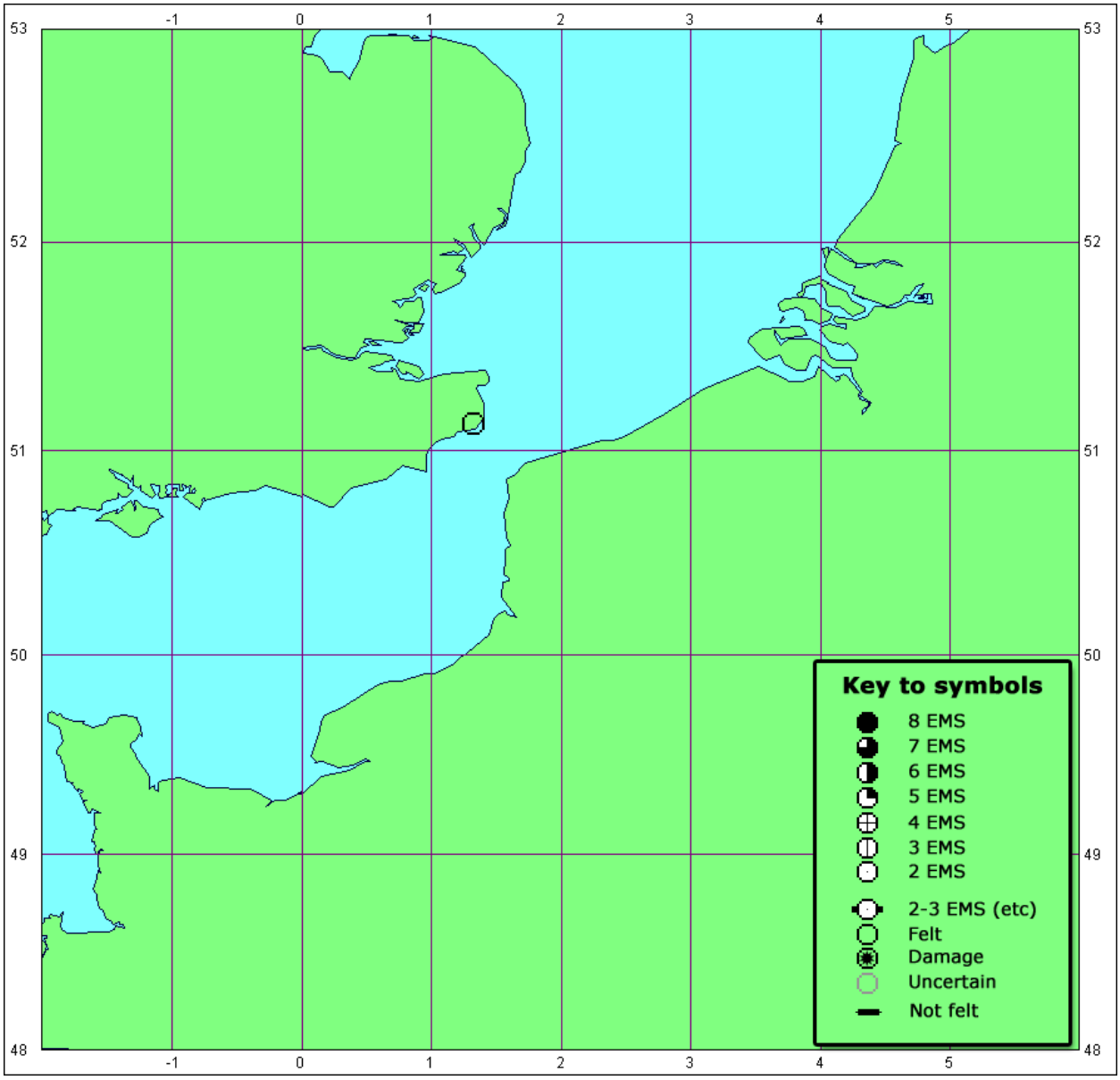

Figure 44 - The earthquake of 7 April 1580 (4h 30m)

3.97 1 MAY 1580 DOVER STRAITS

The largest aftershock did not occur until nearly a month later. It is reported more or less exclusively from England, though Melville et al. (1996) suggest that a report of an event in Bruges on 4 May is this event misdated. It occurred during the night, in various places in Kent, and evidently woke people up and alarmed them sufficiently that they ran out of their houses to the churches to pray for mercy (Holinshed 1587, Stow 1601). This earthquake was the subject of a pamphlet entitled “The second earthquake in Kent”, issued on 16 May by the printer E White, but no copy of this seems to have survived (Collier 1849, Arber 1875). A marginal note in Holinshed (1587) suggests that the author was Thomas Churchyard, and was the source of Holinshed’s information about the effects. Holinshed (1587) and Stow (1601) both give the date as 1 May and the time as after midnight. Ockenden takes this to mean that the event was actually on 2 May, and gives a time of 2h, which does not seem to have any basis. Melville et al. (1996) follow Ockenden respecting both date and time; SisFrance (http://www.sisfrance.net) gives the date as 1 May but retains the 2h time. The intensity seems to have been 5 EMS; but there is no information to tie effects to specific places, so individual intensity assignments have not been made.

Place	*Latitude*	*Longitude*	*Intensity*
Ashford	51.15	0.88	F
Bruges	51.22	3.23	F?
Canterbury	51.28	1.08	F
Dover	51.13	1.32	F
Gravesend	51.45	0.40	F
Great Chart	51.13	0.83	F
Sandwich	51.27	1.34	F

Table 46 - Data for the earthquake of 1 May 1580

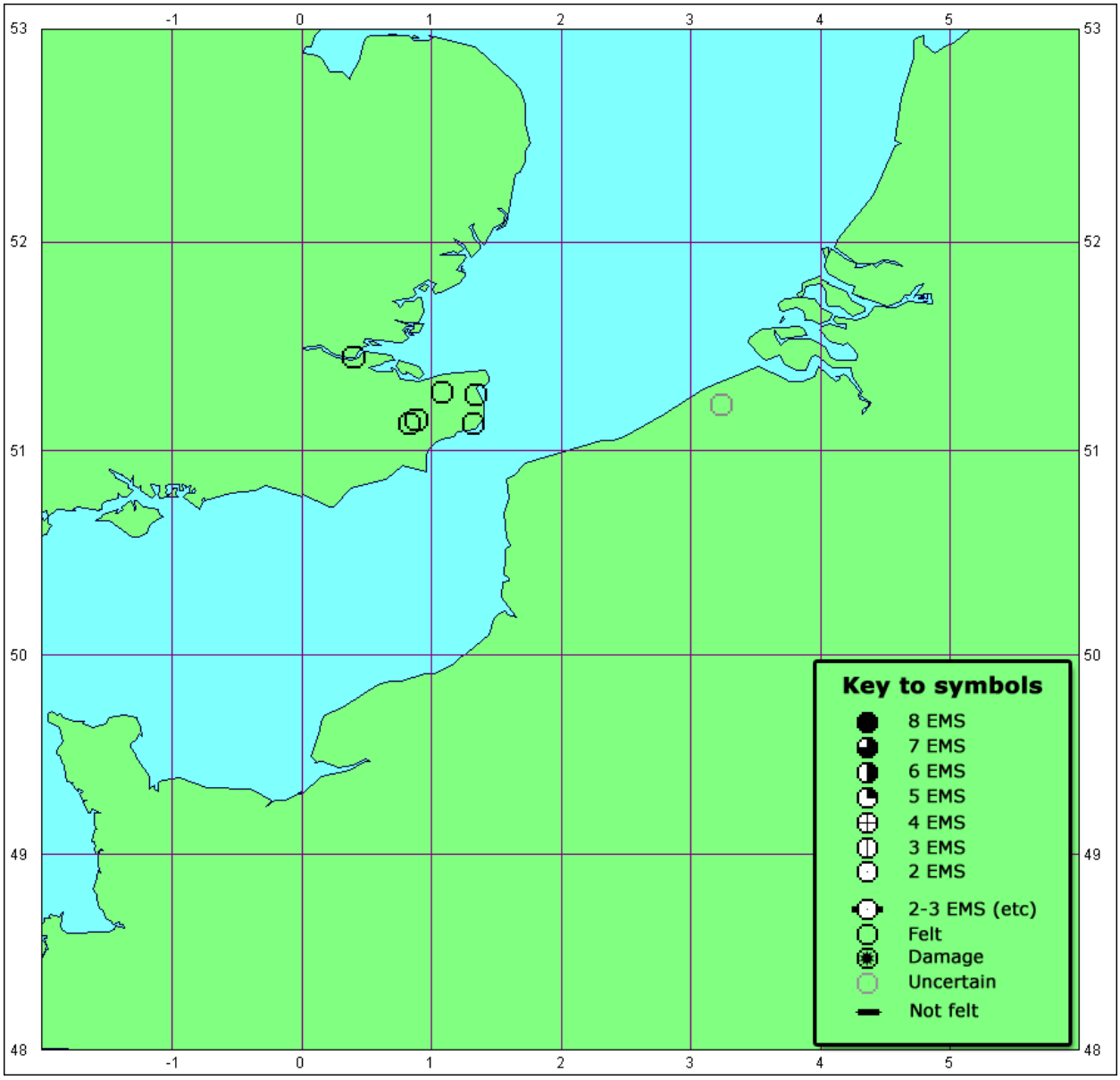

Figure 45 -The earthquake of 1 May 1580

3.98 11 APRIL 1586 IRELAND

This event is mentioned by Short (1749), and only in the table; no earlier source has been found. It must be considered very doubtful – assuming the date to be correct, it may well have been

some form of landslip. The Annals of the Four Masters record that 1586 was a wet year in Ireland, but mentions no earthquake (McDonald 2002).

No mention is made here of a number of other events that are clearly non-seismic in origin at around the same period: 1 July 1583 and 13 July 1584 (Dorset); 4 August 1585 (Nottingham?); 1588 (Dorset) and 18 December 1596 (Kent), some of which are probably duplicates with wrong dates (Baker 1643, Short 1749, Montbéliard 1761, Perrey 1849, etc).

DOUBTFUL

3.99 23 JULY 1597 SCOTLAND

This earthquake was reportedly felt over the whole of the North of Scotland, but the only place for which any sort of effect is mentioned is Perth, on practically the edge of the felt area, where a man laying out counters on a board (possibly on his lap) had the counters thrown to the floor (Calderwood 1845). The only other settlement mentioned is the village of Cromarty (Balfour Paul 1897); otherwise only areas are mentioned (Atholl, Breadalbane, Kintail, Lennox, Mar and Ross). A contemporary account, believed by Balfour Paul (1897) to be the work of Robert Durie, who may have been in the Isle of Lewis at the time of the earthquake, describes “a great earthquake … such as never before was heard of within the memory of man” (Balfour Paul 1897). Another contemporary, James Melvill (1829) says that all the north parts of Scotland were made to tremble, but in a set of verses on the subject emphasises the north-west. He gives the time as between 8 and 9 in the morning.

There is a hint that this earthquake may also have been felt in Northern Ireland. A sequence of chance events preserved a piece of oral history that an earthquake was felt in Antrim around 1600 by Sir Hugh Clotworthy. Sir Thomas Molyneux, writing a letter to his brother in 1690 after an earthquake was felt in Dublin, states, “I was told by an old lady of 75 years of age that she remembers to have heard when she was young that Sir Hugh Clotworthy … perceived an earthquake at his house nigh the town of Antrim … long before she was born”. This letter survived and was published in a university magazine in the mid 19th century (Marsh, 1841).Only this stretched chain of happenstance preserves the information at all; a good illustration of the frailty of transmission of earthquake data at this period. The dating can only be guessed at, but given it was at least 75 years plus “a long time”, and given that Clotworthy only took up residence in Antrim in the 1590s, 1597 certainly fits.

There are no reports from Glasgow or Edinburgh; evidence from later earthquakes suggests that intensity from earthquakes in western Scotland tends to attenuate rapidly at the Highland Boundary Fault, as in the case of the 1880 Argyll and 1986 Oban earthquakes (Musson 1989b). The data for the 1597 earthquake bears a strong resemblance to the macroseismic field of the 1880 event, which was felt also in Northern Ireland (it was, in fact, the most perceptible earthquake in Northern Ireland on record; Musson et al. 1984). An epicentre in the Oban area and a magnitude around 5 Mw would fit the observations.

Place	*Latitude*	*Longitude*	*Intensity*
Antrim	54.70	-6.20	F?
Atholl	56.76	-3.85	F
Breadalbane	56.47	-4.32	F
Cromarty	57.68	-4.05	F
Kintail	57.22	-5.40	F
Lennox	56.19	-4.39	F
Lewis	58.33	-6.58	F?

Mar	57.04	-3.07	F
Perth	56.39	-3.43	F
Ross	57.56	-4.59	F

Table 47 - Data for the earthquake of 23 July 1597

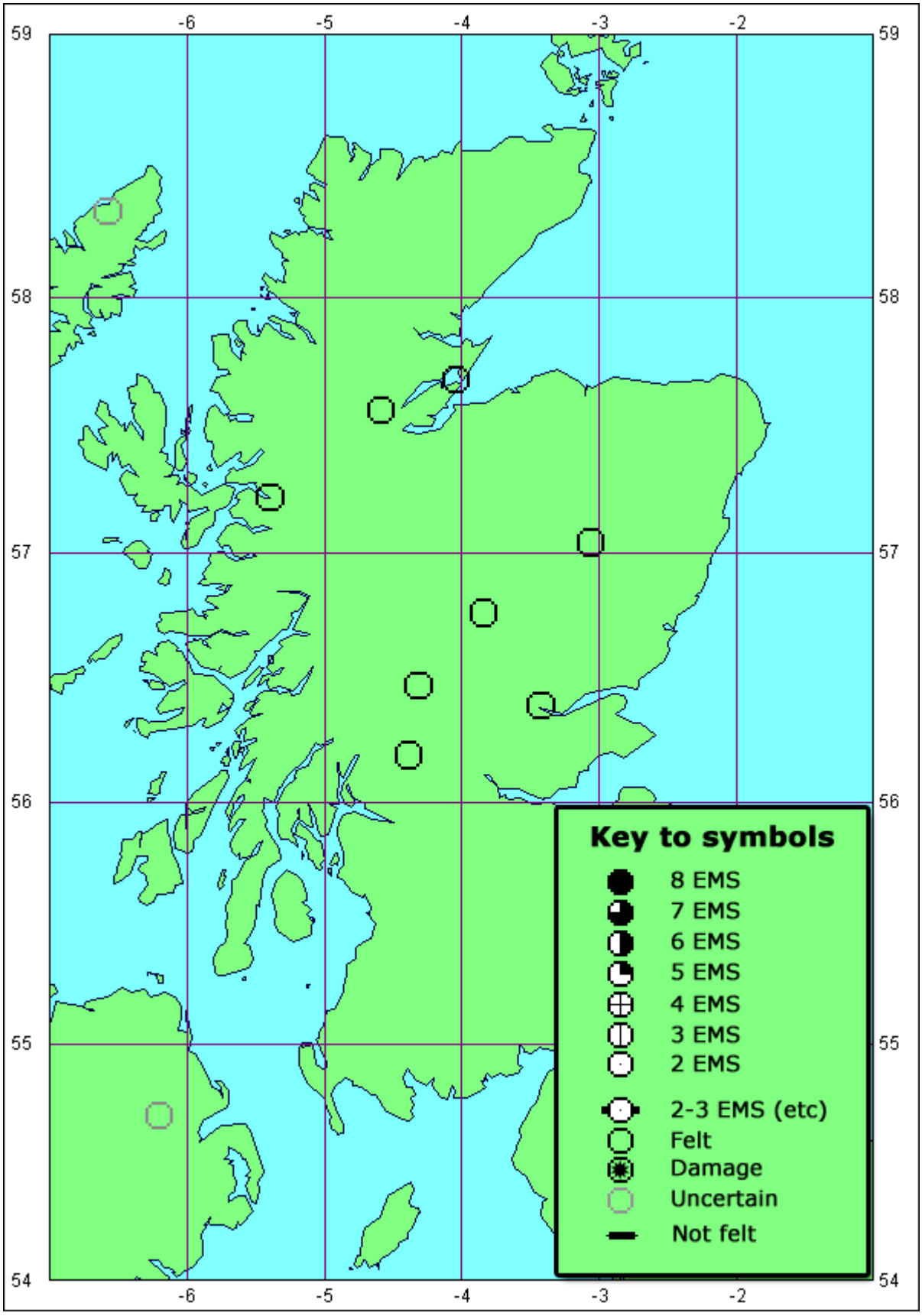

Figure 46 - The earthquake of 23 July 1597

3.100 1600 YORK

Described in Parsons and White (1830) as a very serious earthquake at York, and cited by Roper (1889) and Davison (1924), this is most likely a reference to the earthquake of 24 December 1601 (Ambraseys and Melville 1983).

MISDATED EARTHQUAKE

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