

ART. XVI. – *Historical Earthquakes in Northwest England*  
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### Introduction

RECENT reappraisals of British earthquakes have highlighted the fact that northwest England is one of the more active areas in the country.<sup>1</sup> Tentative attempts have also been made to associate earthquakes in Lancashire with some of the main faults in this heavily-faulted region.<sup>2</sup> Such studies rely chiefly on the record of events in the 19th and 20th centuries, which are relatively well documented. Earthquakes before 1800 have not been examined in comparable detail since the now dated work of Davison, either individually (with a few exceptions) or in their regional context.<sup>3</sup> In the investigation that follows, emphasis is placed on those cultural and geographical factors that have determined the survival (or absence) of information and which need to be taken into account when assessing the data at our disposal.

### Aspects of Historical Geography

The area under consideration lies west of the Pennines and incorporates what used to be Flintshire, Cheshire, Lancashire, West Yorkshire, Cumberland and Westmorland (Fig. 1). Until at least the end of the 14th century, this area was underpopulated with respect to the rest of England and contained few places of political, religious or commercial importance in comparison with the numerous towns, fairs and pilgrimage centres in the south and east. It is from such centres that earthquake data could be expected to survive. No earthquakes in the northwest have in fact been reported before the 17th century, although information is available for some shocks in north Derbyshire and south Yorkshire which may have been felt in the area.

During the 17th century, there was a marked increase in population, particularly in Lancashire; and as elsewhere, sources for the study of local history become fuller. This is reflected in the fact that four earthquakes are recorded in letters and diaries of the period. None of these shocks can however be completely identified and others must be missing from the record. Communications with the south, where information had a better chance of being reported, remained poor.<sup>4</sup> Not only was news of the northwest thus of limited currency on the national level; even locally, circumstances were not conducive to the rapid dissemination of information. At the end of the century, Celia Fiennes frequently remarked on her slow progress through the region compared with her rate of travel elsewhere.<sup>5</sup>

In the course of the 18th century, this picture altered dramatically, with Lancashire undergoing the greatest rate of population increase in the country, at around 190%; by 1801, Lancashire was second in population density only to London.<sup>6</sup> Such concentrations of people undoubtedly influence the reporting of earthquakes, for not only is there a greater number of potential observers, but also the busy urban environment facilitates the dissemination and accumulation of information. In contrast with the manufacturing

towns of Lancashire and West Yorkshire, however, the rest of the northwest was still thinly populated, nor was the Lake District the fashionable seasonal resort it was to become during the Romantic Revival.<sup>7</sup>

### Sources of information

Reports of early earthquakes are most commonly found in local antiquarian and historical works, diaries and private correspondence, parish registers and, in the 18th century, provincial newspapers.<sup>8</sup> Papers were published, sometimes only briefly, in Chester, Halifax, Kendal, Liverpool, Manchester, Middlewich, Preston, Warrington and Whitehaven, from as early as the 1720s. A fairly close coverage of events in south Lancashire is preserved at least from mid-century. In addition, long-established newspapers in the more prolific centres such as Derby, Leeds, Newcastle, Sheffield and York, round the periphery of the area of interest (see Fig. 1), attracted correspondence from all over northern England. Further information may be obtained from the national London press. Reference is made here to the London papers only when they provide accounts not found in the regional press.

While the newspapers give rise to a great improvement in the coverage of events in England, some drawbacks should be noted briefly. A report may be published from several places, but perhaps only containing the experiences of one person (the correspondent) rather than the whole community, so that the overall strength of the shock in that place may be hard to judge. Such accounts, in the form of letters, are normally repeated verbatim in several different papers; the accumulation of press reports can therefore often yield only a disappointing volume of hard information. The copying of reports in different papers at weekly intervals can also lead to uncertainty as to the correct date of the original report. Such problems are nevertheless small beside the overall value of 18th century newspapers for both positive and negative evidence of earthquake occurrence.

The increased prominence and populousness of the northwest, improvements in communications and the greater volume and variety of source material all combine to make the record of earthquakes more complete and detailed than had previously been the case. Awareness of the population distribution in the area, and of the character of the sources available, plays an important part in assessing the information at our disposal, allowing each case to be interpreted in its geographical and cultural context.

### Earthquakes in the 17th century

As noted above, four earthquakes are recorded in the 17th century. On 18 March 1613, an "exceeding great earthquake" occurred at Nantwich between 7 and 8 a.m. The shock was felt in Flint and Denbighshire and parts of Shropshire, but not as far south as Ludlow. In Nantwich, it seemed to come from the east and to last for three minutes.<sup>9</sup> Another earthquake was noted at Nantwich around 4 a.m. on 1 January 1635, without further details.<sup>10</sup> On the morning of 2 May 1672 the Rev. Thomas Jolly, living at Wymondhouses on the northwest side of Pendle Hill in Lancashire, was disturbed by a shock which he "heard and felt" on his bed.<sup>11</sup> None of these shocks can be fully identified. A more significant earthquake occurred on 11 April 1650, at about 5 p.m. In

the counties of Cumberland and Westmorland, "we had a general earthquake; the people were so frightened therewith, that they forsook their houses, and some houses were so shaken, that the chimnies fell down".<sup>12</sup> The author of this account was writing in Penrith, which may have been the scene of the damage. The shock was possibly felt as far as Glasgow, about 170 km away: Robert Baillie mentions that he felt an earthquake one afternoon, five or six years before the shock of 17 August 1656.<sup>13</sup> If this assumption is correct, the 1650 earthquake may have been as large as the 1786 event (see below). Tentative locations of these earthquakes are given in Fig. 1 and Table 1.

### Earthquakes in the 18th century

#### *1738 December 30*

The first earthquake so far identified in the 18th century occurred between 7 and 8 a.m. on 30 December 1738, affecting several towns near Huddersfield in the West Riding of Yorkshire (Fig. 2). A letter reproduced in several newspapers states that the shock was widely noticed in "hills, woods, rivers and towns" while indoors, pots, plates and other utensils rattled and rolled out of their places, and people in bed were afraid of being tumbled out; the inhabitants of the area were struck with "inexpressible horror".<sup>14</sup> The shaking may thus have reached Intensity V (MSK) in some places, but there is no clear indication of how widespread were the strongest effects. An independent account from Mirfield indicates that the shock was not felt by everyone.<sup>15</sup> It is clear that with such slender evidence, any assessment of the Intensity and extent of the earthquake must be very tentative.

Some negative evidence can be inferred to limit the area affected. Arthur Jessop of Totties near Holmfirth notes in his diary under 2 January 1739 that he heard of the shock in Halifax "market place"; but it is clear that he did not feel it himself.<sup>16</sup> The fact that the *Leeds Mercury* and the *Lancashire Journal* (a Manchester paper) do not refer to the event, while not conclusive in view of the limited amount of local news they carried, does at least suggest that the shock was not strong enough to attract much attention in these busy centres of population. It therefore seems reasonable to confine the earthquake to the area outlined on Fig. 2, which has a radius of about 15 km.

#### *1750 April 2*

The northwest was not exempted from the unusual sequence of earthquakes that occurred throughout England in the course of 1750, starting with the shocks in London on 8 February and 8 March. These were widely reported in the newspapers and captured the imagination of the public as well as the interest of the "philosophers".<sup>17</sup> Letters and diaries of this period are full of references to earthquakes and many doubtful reports arise from the susceptibilities of the time. Reports of a shock in West-Chester (i.e. Chester) on 18 March seem to have been a hoax.<sup>18</sup> In reporting the genuine earthquake that followed on 2 April, a letter from Chester starts by confessing that "the Accounts of an Earthquake here on the 18th past were premature . . .".<sup>19</sup> From Chester also derived a highly colourful and exaggerated account of the earthquake, which claimed that 12 houses, part of the town hall and more than 100 chimneys were thrown down, causing several injuries and one fatality. This was published in various London papers,

which later carried denials of the report and even noted that "in some parts of Chester it was not felt at all".<sup>20</sup> Another account (see note 19) states that "some old houses" were thrown down in Liverpool, which again is not substantiated in other reports. One more sober letter does however observe that the shock in Liverpool "alarmed the Inhabitants pretty much, but did little Damage";<sup>21</sup> an ampler account, by the same author, says that the shock in Liverpool "was not so sensible as at some other Places", and refers only to trifling "damage" such as a china jar and a marble slab falling and being smashed.<sup>22</sup>

Despite these conflicts in the sources, a reasonable picture of the extent and severity of the earthquake emerges.<sup>23</sup> The shock occurred at about 10 p.m. and was felt at its maximum extent from Lancaster in the north to Conover near Shrewsbury in the south, and from Flintshire in the west to Stockport in the east (Fig. 3). Details from the Shrewsbury area indicate that "many people felt a small shock".<sup>24</sup> No details of the earthquake have been found from the area between Wigan (where Davison locates the event) and Lancaster, where the shock must similarly have been felt at low intensities. The shock in Flintshire moved one correspondent's bed a little way on its casters and shook him up and down several times.<sup>25</sup> Wrexham, Altrincham and Stockport are said to have experienced the earthquake, without details (see note 22); in Manchester it was slight, and felt only by those in upper rooms, who were moved up and down in their beds, according to the sole report available.<sup>26</sup>

Within this area, the shock was "severely felt" in Warrington<sup>27</sup> and "smart" in Northwich;<sup>28</sup> the latter account says it was felt in the centre of Cheshire but not in Chester itself, the opposite extreme to the exaggerated statements noted above. The best description says the earthquake there was sensibly felt by all or most of the inhabitants; a few bricks fell from a chimney in Forest Street and several house-bells were rung. A sentry at the castle was shaken off his seat and the inhabitants of the town were terribly alarmed. The shock was felt some miles around, particularly at Barnhill, where the houses were greatly shaken.<sup>29</sup> This suggests Intensities in the range IV-V between Chester and Barnhill. A similar level of intensity may also have been experienced in Liverpool.

On this basis, the 1750 earthquake should be centred just north of Chester, the strongest shaking occurring within a radius of approximately 25 km around. The full extent of the felt area of the shock is not well defined, but may have a radius of about 55 km (Fig. 3).

### 1753 June 8

Parts of the same region were again disturbed by an earthquake only three years later. *Harrop's Manchester Mercury* makes the significant comment: "such an extraordinary event cannot be remembered to have happened here before . . . (and it caused) . . . great consternation".<sup>30</sup> This is implicit confirmation of the feebleness of the 1750 shock in Manchester.

Details of the earthquake suggest it was relatively severe and widely felt, although its correct location remains ambiguous. The shock occurred sometime between 11.15 and 11.40 p.m. on Friday 8 June 1753.<sup>31</sup> The reports from Manchester already noted state that several parts of the town were alarmed (particularly at the upper end of Market

Street Lane); a great many people were awakened by the shaking of their beds, which lasted about a minute. It was also felt in the adjacent villages, more strongly at Radcliffe and Oldham, where beds were lifted up and houses violently agitated. The shock was also reported from Halifax and Cheshire: at Knutsford the shaking lasted about twenty seconds. It was also strong in the neighbouring villages of Tabley, Tatton, Rostherne, Mobberly, Toft and Peover, greatly alarming the inhabitants but doing no damage.<sup>32</sup> A useful independent perspective on this report is provided by a letter written later from Peover, which makes it clear the intensity at Peover should not be assessed higher than IV.<sup>33</sup>

The shock appears to have been stronger to the north, at Skipton, where it was felt "all over the town and neighbourhood", at about 11.30 p.m., not only by those in bed but also by people indoors who were still up and by people in the street. Some moveable objects, such as deal planks, were thrown down.<sup>34</sup> This implies Intensity V at Skipton, which may be near the epicentre of the earthquake. On this basis, the shock may be comparable with that of 1768 and other later events (see below). Unfortunately the distribution of places mentioned is clearly asymmetrical with respect to Skipton (see Fig. 4) and no information has been found for areas to the north, east or west. Neither the *Newcastle Journal* nor the *York Courant* have any local details of the shock, and no copies of papers from Leeds or Preston have been traced. The limit of the shock to the south appears better defined, by the absence of references in the Chester press to the shock being felt in that town.<sup>35</sup>

In view of the relatively sparse population in the uplands north of Skipton, such a lack of information is not surprising. The absence of news in the press partly reflects the poor survival rate of papers and partly, the character of the provincial press at this time. Nevertheless, larger events in the next two decades are more widely publicised and it seems reasonable to conclude that the shock was not felt significant distances outside the tentative area suggested on Fig. 4, which has a radius of about 50 km.

#### 1755 November 17

Late in November 1755 the first details of the catastrophic Lisbon earthquake were beginning to appear in the English newspapers. Just over a fortnight after this disaster, but before the full impact of the news had stimulated a general public interest, a strong but apparently localized shock was reported from the parish of Irton, near Whitehaven in Cumbria. The only account of the event so far identified has little prominence in the press, being reported in identical terms in one Newcastle and two London papers.<sup>36</sup> The account originates in a letter from Whitehaven, which was developing rapidly at this period, but there is no suggestion that the shock itself was felt there.<sup>37</sup> Local sources of information are scarce for the rest of this part of Cumberland, and the full extent of the shock cannot be identified, though seemingly negative evidence from Whitehaven suggests its radius did not exceed 20 km.

The epicentral area must have been near Irton, where a violent shock was experienced around 7 p.m. (see Fig. 1). "Several farmhouses in that parish and neighbourhood were very much shook and torn by it" and at Irton Hall, the old tower shook so much that "furniture tumbled about the floor, to the great terror of the family". This suggests that at least Intensity VI was experienced around Irton. Further information about this shock would be of great interest.

*1757 May 17*

At about 3 p.m. on Tuesday 17 May 1757 a “small” shock of earthquake was reported from Ripponden; the tremor lasted about two seconds and was followed by a noise like thunder at a distance. It is said to have been felt for several miles around. The account concludes with the statement that “This is the fourth Shock which has happened here within the Memory of Man”.<sup>38</sup> This refers implicitly to the earthquakes of 1738 and 1753 already described, but the other event is not certain. It is convenient to suppose that the earthquake of 1750 is meant, which was possibly felt as Ripponden at low intensity (see Fig. 3). If not, an unidentified shock may be involved, although the longer memories may have recalled the earthquake of 7 October 1690, which was probably felt in the area.<sup>39</sup>

This solitary newspaper account of the event is confirmed and supplemented by John Wesley, who was preaching in the area affected. At Heptonstall, near Hebden Bridge, he was told of the earthquake the previous afternoon, felt by many people in several places five or six miles around. People indoors “heard their pewter and glass clatter”, and many of those in the fields felt the ground “shake under their feet”. The following day, Wesley learnt that the shock had been strongly felt by many people at Bingley and as far as the neighbourhood of Preston.<sup>40</sup>

The area affected thus has a radius of about 25 km (see Fig. 5); the absence of local information in the papers from Manchester and Leeds suggests it was not felt in these cities. It is also implied in Wesley’s journal that he was not aware of the earthquake before reaching Heptonstall, and since he was in Halifax on the day of the shock, the tremor there cannot have attracted general attention. This argues for the earthquake being felt at Intensities below IV at the margins of the area outlined on Fig. 5.

*1768 January 18*

The *Manchester Mercury*<sup>41</sup> carries a letter from Mold (Flintshire) describing an earthquake there at around 2 a.m., which alarmed “all except the very sound sleepers” in the town and neighbourhood (Fig. 1). The author states that the shock seemed to be horizontal and to move towards the southeast. The only damage reported was to a coal pit at Leeswold, where about twelve yards of the side of the pit were thrown down and some part of the roof. The shock may have been the result, rather than the cause, of the pit collapse. The date of the newspaper, 2 February 1768, is sometimes taken to be the date of the earthquake in Manchester,<sup>42</sup> but there is no evidence of this.

*1768 May 15*

Many northern newspapers report a much larger earthquake that was “perceiv’d in most parts of Yorkshire & Westmorland”<sup>43</sup> at about 4.15 p.m. on Sunday 15 May 1768. It was felt on both sides of the Pennines, to the north of the area previously affected in 1753 (see Fig. 6).

Davison’s account of the earthquake includes Manchester within the felt area, on the authority of Mallet, but this is clearly incorrect.<sup>44</sup> The Manchester paper makes no reference to the shock being felt there, but on the contrary prints a report from Newcastle that at Middleton near Lanchester (*sic.*) field walls were observed “very sensibly to move”, household furnishings were strongly shaken and the flagstones in one house

heaved.<sup>45</sup> Lanchester is near Durham: the paper prints other reports from Staindrop and elsewhere in this district. There remains the problem of identifying Middleton correctly, for although there are many places of this name in the area affected, none of them are particularly close to Lanchester.<sup>46</sup> The nearest is Middleton in Teesdale, which may be the place intended, but the issue is of minor importance, since it does not affect either the epicentral location or the felt area of the earthquake, beyond excluding Manchester.

The location of the earthquake is again problematic, since there is little evidence of high intensity shaking. At Kendal, the shock lasted about ten seconds and was preceded by a loud rumbling noise. At the church, glass was "shivered from the windows" and many people (especially women) left the service in alarm. The shock was felt throughout the whole town and the adjacent area, but no other damage was done than "terrifying and alarming the inhabitants". The river at Kendal was reported to be much agitated, and the shock there was thought to have moved from east to west.<sup>47</sup> To the east of Kendal, the shock was described as "smart" throughout the neighbourhood of Leyburn, where the tremor was thought to have passed from west to east, which may indicate an epicentre approximately between there and Kendal. Some further indications of this are contained in the statement that "many places in Swaledale" experienced the shock.<sup>48</sup>

North of this area, the earthquake was reportedly slight at Darlington, and "sensibly felt" as two slight shocks at Newcastle, which must have been near the limit of the felt area;<sup>49</sup> to the northwest, George Williamson, curate of Arthuret, noted the shock in his diary, but without details.<sup>50</sup> No evidence has been found that the shock was felt in Carlisle or Whitehaven, though this is not unlikely.

In the south of the affected area, the shock was reported from Ingleton to Otley, and in the area northwest of Leeds, but not apparently in Leeds itself. Some walls were said to have been thrown down near Malham.<sup>51</sup> A letter from Malham, reproduced in several papers, says the shock occurred at about 5 p.m. and lasted about a minute; it was also felt in the moors around the village and at Skipton, Keighley and elsewhere.<sup>52</sup> The shock was also reported to have been felt in "several parts" of the city of York.<sup>53</sup>

The area thus defined is reasonably coherent, and is centred north of Swaledale, with a radius of about 80 km, corresponding to the radius of perceptibility of the shock at Intensity III. This is suggested by the fact that the tremor was described as "slight" at Beetham, Newcastle and elsewhere on the margin of the affected area. Even though it clearly attracted fairly widespread attention, this may be because it occurred at a quiet time on a Sunday afternoon, when people would be sensitive to such an event. A location based on the maximum reported Intensities would put the epicentre southwest of the position shown in Fig. 6.

#### *1771 August 24*

A tremor was felt in the Congleton-Astbury area at 4 a.m. according to a report in papers from Chester and Derby, copied in various London newspapers.<sup>54</sup> At Astbury, several people in bed were shaken, along with other things in each house. The tremor is thought to have lasted about three seconds. At Congleton it was described as a "small" earthquake, which did no damage. It was reported to have been felt about twelve miles (19 km) away. These accounts are confirmed by a personal memorandum which notes

that a "very smart Shock of an Earthquake" was felt at Newcastle (under Lyme), 15 km to the south, at about 4.30 in the morning.<sup>55</sup> No newspapers are available from Shrewsbury at this date to indicate whether the shock was more widely felt in this direction. To the north, the Manchester papers give no local information about the event.<sup>56</sup> The earthquake should have a felt radius of about 10 km and may have been centred near Stoke on Trent (see Fig. 1).

#### 1777 September 14

The most celebrated earthquake in this period occurred in 1777, and attracted more attention than any other in the region, not so much because of its size or severity, as because of where it happened, i.e. in the heavily populated region of what is now Greater Manchester. Reports of the earthquake are available from about 70 places throughout the area from Ravensglass in the north, to York and Gainsborough in the east and Birmingham and Nottinghamshire in the south, an area approximately 230 by 140 km at its greatest extent (see Fig. 7). The event has been described at length elsewhere,<sup>57</sup> so that only main outlines need be reviewed here.

The strongest effects of the shock were noticed at Manchester, where "several chimneys" fell down (the city must have had over 4,000 houses at this time); in Altrincham, where "some chimneys shattered" and at Knutsford, where bricks fell from chimneys.<sup>58</sup> Maximum Intensities may thus have reached VI, but other accounts suggest that the shocks were generally experienced in Manchester at Intensities IV to V.

The earthquake occurred at about 11 a.m. on Sunday morning, when many of the inhabitants were at worship. A considerable panic developed to get out of the churches in Manchester, and during the crush people were trampled and lost items of clothing. Bells tolled in the Collegiate Church and at St. Mary's, and people from all over town rushed into the streets. The inhabitants who were at home were as much alarmed as those in Church, with furniture shifted and windows and doors thrown open. Several references however indicate that it was not generally felt out of doors.<sup>59</sup>

Comparable effects were experienced outside Manchester; at Bingley, Bowden, Chorley, Gargrave, Kirkham, Lymm and Warrington people ran out of churches and meeting houses in the greatest consternation and at Skipton the shock greatly alarmed most of the town.<sup>60</sup> The shock was less severe in Leeds and further to the northeast, at York, it was referred to as slight.<sup>61</sup> To the extreme northwest of the area affected, the shock was recorded by William Hutton at Beetham<sup>62</sup> and in a letter from Ravensglass, where the shock seemed to travel from northwest to southeast (*sic.*). There is no evidence to suggest that the shock was felt as far north as Whitehaven.<sup>63</sup>

Nearer Manchester the earthquake was unevenly experienced; one contemporary states that it was slight at Blackburn and not felt to the west, at Liverpool or Chester, though other reports mention slight effects in both cities.<sup>64</sup>

To the south and east, the earthquake was reported throughout Staffordshire and Derbyshire, but there is no indication in the Birmingham or Coventry papers that the shock was felt in those cities.<sup>65</sup> In Derbyshire, the earthquake was strong near the High Peak and reports were received of some damage to the underground drains ("soughs") in the leadmines.<sup>66</sup> The furthest place mentioned in this direction is Loughborough, where again the inhabitants were disturbed at church, indicating that similar experiences were had throughout the affected area.

To the east, the earthquake was noticed in Sheffield and as far as Gainsborough, where it greatly alarmed the town and neighbourhood.<sup>67</sup> The shock was similarly widely felt in the villages round Nottingham.<sup>68</sup>

Various pamphlets produced after the earthquake explore both the scientific and cautionary aspects of the event, opinions being divided almost equally between the theory that it was caused by electricity, and that it was sent as a warning from God. The Manchester populace tended to the latter view, and a minor revolution in church attendance was reported.<sup>69</sup>

The epicentre of the earthquake should be sought in the region between Manchester and Altrincham, on the basis of the damage caused there. The other places mentioned as affected are asymmetrically distributed with respect to this location however, and it is particularly noticeable that few reports come from the west and southwest (see Fig. 7). While other epicentral locations north or east of Manchester might seem preferable, there is no indication of damage from these areas. The average radius of perceptibility of the shock at Intensity IV should be about 85 km.

#### *1780 December 9*

In marked contrast with the previous earthquake, a shock of comparable size only three years later is very poorly documented in contemporary sources. As it occurred in the north Pennines, in the region previously affected in 1768, the absence of detail clearly reflects the sparse population of the district and other factors that served to lessen the impact of the shock in comparison with the 1777 earthquake. Numerous reports are available, but they tend to be repetitive and only a dozen places are mentioned with any details (see Fig. 8).

The earthquake occurred around 4.30 p.m. on a Saturday afternoon, which may partly account for its relatively low impact. The strongest effects reported were at Redmire and Leyburn, where it was felt upstairs and down with a heaving motion and a cracking of the timbers of the houses. A barrel of gin was thrown from a shelf, and in several houses "things not firmly supported were thrown down".<sup>70</sup> This suggests maximum Intensities around V in this neighbourhood. There is no reason to equate this with the epicentral Intensity, except that the places where felt reports are given are fairly uniformly distributed about these Wensleydale villages (see Fig. 8). The shock at Redmire is thought to have come from the west.

To the east, a report of the effects in an upper room at Yarm indicate Intensities less than IV. In Newcastle, where it was market day, many were unaware of the shock. Those indoors noticed the rattling of windows and furniture for about two seconds. Some people ran out of their houses in alarm. The shock was also reported from Morpeth and Warkworth to the north.<sup>71</sup> The only other report in the north comes from Whitehaven where the shock was described as slight, though consisting of three or four tremors.<sup>72</sup>

To the west, the shock was reported in the Beetham parish registers as affecting the whole country around, more generally so than that of 1768.<sup>73</sup> This is confirmed by an account from Burton, where a slight tremor and noise lasted as long as "one might deliberately count 12 or 14".<sup>74</sup> At Malham the shock was strongly felt and caused great consternation, but it was only slight at Leeds.<sup>75</sup> In York, the shock was felt by several people in different parts of the city and in the neighbouring villages,<sup>76</sup> but again clearly at Intensities not exceeding IV.

The main problem concerning the assessment of this earthquake is how far south it was felt. At Chester a slight shock of short duration was reported,<sup>77</sup> and near Holywell two shocks were felt, the second "very violent".<sup>78</sup> It remains significant that no reports are available from the Manchester area that showed itself so sensitive to the earthquake only three years before. The shock is not mentioned in the one surviving Manchester paper for this date. A Liverpool paper mentions the shock in Chester and elsewhere, but not in Liverpool itself.<sup>79</sup> Clearly the earthquake was not generally perceived in this area; the tremors affecting Chester and Holywell must have been very slight. These reports may therefore be assessed at Intensity III in an area where the shock was not otherwise felt.

It is difficult to outline even an approximate felt area (Fig. 8). Excluding Holywell and Chester, the area affected has a radius of about 90 km, with a notional epicentre about 30 km from Redmire. Intensities within this area, which is probably an underestimate for isoseismal III, do not seem to have been generally as high as IV. Greater confidence is not possible when data are so sparse, but despite its remote location, further information could have been expected had the shock been stronger.

#### *1786 August 11*

The largest and most damaging of all the earthquakes reported in the north of England during the 18th century occurred in western parts of Cumberland at around 2.15 a.m. on 11 August 1786.<sup>80</sup> Isolated reports suggest that it was felt as far away as Aberdeen, Belfast, Dublin and Chatham.<sup>81</sup> Accounts are available from over 60 places, which in contrast with the earthquake of 1777 illustrates the strength of the shock rather than the density of population of the area affected, although Whitehaven itself was a flourishing town at this period, and two or three others between Carlisle and Lancaster had populations greater than 2,500.<sup>82</sup> The earthquake has recently been the subject of a detailed investigation,<sup>83</sup> to which the following account is supplementary.

The epicentral area of the earthquake seems to be clearly marked by accounts of damage from Egremont, where several chimneys and part of the ruins of the castle collapsed, Workington, where the quay was a little damaged, and Whitehaven, where one chimney was thrown down in Tangier Street and three people in different parts of the town were thrown off their feet. One of them was "considerably hurt". The shock in Whitehaven was thought to have travelled from the southeast.<sup>84</sup> A report in the *Daily Universal Register* (now the *Times*) of 28 August, that several chimneys fell at Cockermouth is not supported by local sources, nor is the same paper's report that the quay at Whitehaven suffered similar damage to that occurring at Workington. Later reports from Whitehaven state that during the earthquake several thousand tons of rock were brought down from the Pillar (2927 feet, 890 m) near the head of Ennerdale Water,<sup>85</sup> and it is also stated that a substantial landslide occurred on the slopes of the Red Pike (2479 feet, 754 m), revealing extensive iron deposits.<sup>86</sup> These indications of the epicentral area are reinforced by the account of a strong aftershock on 6 July 1787, reported at Penrith, Threlkeld and Keswick. Falls of precarious rock were noted from the sides of Helvellyn (3113 feet, 949 m) by shepherds and travellers, not associated until afterwards with the shock that morning.<sup>87</sup>

The highest Intensities experienced in this area must have been between VI and VII

(MSK). Other reports give further hints of the damage, which may however merely be rumours; according to a letter from Kirkcudbright, speaking of Whitehaven, it was said that "the walls of several houses were split and the people that were in their beds thrown out, and some of them much bruised".<sup>88</sup> In the Bootle Parish Registers it is noted that the only damage was "throwing down some wall fences, and displacing a few slates from houses", perhaps referring to Bootle itself, where the shock was thought to have come from the northeast.<sup>89</sup> At Barrow, near the Isle of Walney, a house was reported to have been cracked from top to bottom by the shock.<sup>90</sup> "Some old walls" are also reported to have been thrown down in the neighbourhood of Penrith, Appleby and Brough.<sup>91</sup>

These and other reports indicate that the earthquake was strongly felt throughout western Cumberland and neighbouring areas of Scotland. In Dumfries, great numbers felt the shock and many were awakened;<sup>92</sup> in Gilsland, all those asleep were awoken, furniture was reported to have been violently shaken and some lamps were extinguished;<sup>93</sup> while further south in Cartmel and Cark, almost everyone was awakened and much alarm was caused.<sup>94</sup> In Carlisle, those who were awake or out of doors estimated the shock to last four or five seconds and many others were woken.<sup>95</sup> Intensities in this area must thus have been around V; it is interesting to note that within this general area, the shock was apparently not felt in the mining community at Aulstone-Moor (= Alston?), in the South Tyne valley.<sup>96</sup>

Outside Cumbria, the earthquake was not widely reported. The time of day of the shock is relevant to this observation, because to be experienced and reported, an earthquake in the middle of the night has to be sufficiently strong to arouse sleepers, i.e. at least Intensity IV. A more compelling reason than low Intensity for the lack of data outside Cumberland and Westmorland is the sparsity of population in the Pennine valleys. The shock was feebly felt in Newcastle<sup>97</sup> and by isolated individuals in the towns of the Tweed valley between Jedburgh and Berwick, where, interestingly, it was thought to have been a local shock from the west or northwest.<sup>98</sup> Papers from York, Leeds and Manchester mention the earthquake, but with no indications that it was felt in any of those centres (despite some statements that York and Manchester were affected). A follow-up report of the earthquake in the *Cumberland Pacquet* (23 August), describing the effects of the shock of Belle Isle on Windermere, specifically mentions that the tremor was not felt at Liverpool, Chester or Shrewsbury, nor barely felt south of Preston. In Glasgow and Edinburgh to the north, isolated reports from a few people who were awake at the time<sup>99</sup> indicate that the shock was not generally experienced.

Fig. 9 therefore illustrates the approximate area over which the earthquake was felt at Intensities around IV or greater, which has a radius of around 130 km. The area of stronger shaking (V) has a radius of about 65 km. Maximum Intensities of VI-VII occurred within the hatched area, with a radius of about 12 km round the macroseismic epicentre.

### 1787 July 6

As already mentioned, the earthquake of 11 August 1786 was followed by another shock in part of the same area nearly a year later, reported from Penrith, Threlkeld and Keswick along with "several places in the neighbourhood of the mountains".<sup>100</sup> The aspect of the shock which caused most comment in the papers was the fall of rocks

“which have long seemed tottering” from the steep sides of Helvellyn, both on the day of the earthquake and on 9 July. The fallen rocks were noted later in the day but shepherds had experienced the trembling of the mountain and there seems every reason to suppose that the rockfalls were triggered by the earthquake.<sup>101</sup> There is a notable delay in reports of this event being published in the papers, news from these relatively remote areas not commanding immediate attention. The radius of the area affected by the shock should not have exceeded 10 km; there is no indication that it was felt in Whitehaven (see Fig. 9).

### 1795 July 17

A distinct shock is reported to have affected Bowden, Manchester, Bolton and other places at about 3.30 a.m.<sup>102</sup> At one household in Bowden a servant was sent out to enquire as to the cause of the shock but returned none the wiser; only then was an earthquake thought to have occurred. The effects of the shock in Bolton and Manchester have not yet been verified.<sup>103</sup> The area affected is small, with a radius of around 10 km centred near Manchester (see Fig. 1).

## Conclusions

Table 1 lists the earthquakes discussed, with their assessed Intensities, felt areas and location.<sup>104</sup> The location quality is indicated and is clearly best in the case of small shocks and those associated with damage. The events are plotted on Fig. 1, according to their size, those with a radius of isoseismal IV greater than 40 km being defined as large.

TABLE 1 – Earthquakes in Northwest England before 1800

DATE	TIME	°N – °W	q	r <sub>4</sub>	r <sub>3</sub>	I <sub>max.</sub>
1613 Mar. 18	0730	53·1 – 3·0	C	30		V?
1635 Jan. 1	0400	53·1 – 2·5	C			V?
1650 Apr. 11	1700	54·6 – 2·8	C		170?	VI
1672 May 2	a.m.	53·9 – 2·3	B?			IV?
1738 Dec. 30	0730	53·7 – 1·8	A	15		V
1750 Apr. 2	2200	53·2 – 2·8	B	25	55	V
1753 Jun. 8	2330	53·8 – 2·0	C	50		V
1755 Nov. 17	1900	54·4 – 3·4	A			VI
1757 May 17	1500	53·8 – 2·1	B	24		IV
1768 Jan. 18	0200	53·1 – 3·1	A			IV-V
1768 May 15	1615	54·5 – 2·0	C		80	V
1771 Aug. 24	0415	53·1 – 2·2	A	11		IV
1777 Sep. 14	1100	53·4 – 2·3	B	85		VI
1780 Dec. 9	1630	54·5 – 2·1	C		90	V
1786 Aug. 11	0215	54·5 – 3·5	B	130		VI-VII
1787 Jul. 6	a.m.	54·6 – 3·0	A	10		IV
1795 Jul. 17	0330	53·5 – 2·3	A	11		IV

q is the quality of the location, A = within 5 km, B = within 10 km, C = worse than 10 km accuracy. r<sub>4</sub> and r<sub>3</sub> are the radii of areas within isoseismals IV and III respectively. I<sub>max.</sub> is the maximum Intensity reported or inferred.

Apart from the early events, for which data are insufficient, those of 1753, 1768 and 1780 cannot be located accurately, largely because they occurred in sparsely populated regions of the Pennines. For similar reasons, assessment of the areas affected at different Intensities is also difficult for these events: no isoseismal IV can be drawn for either the 1768 or 1780 earthquakes and the isoseismal III in both cases is probably an underestimate.

For the sake of comparison, Fig. 10 plots earthquakes in the northwest after 1800,

TABLE 2 – Earthquakes in Northwest England after 1800

DATE	TIME	'6	'5	'4	'3	'2
1835 Aug. 20	0333		22	55	100	
1843 Mar. 17	0055		42	99	155	
1869 Mar. 15	1806	(5)	(16)	30 (27)	70	120
1871 Mar. 17	2305		37	87	132	
1901 Jul. 9	1623	(6)	(15)	(27)	80 ?	
1915 Oct. 2	0315				70 ?	
1933 Jan. 14	0830	(14)	21 (25)	60 (100)	102	149
1944 Dec. 30	0136	7	27	79	139	226
1970 Aug. 9	2009			40 (65)	80 (110)	131
1972 Mar. 7	0652		11	24	56	
1979 Dec. 26	0355	(11)	(27)	(110)		

The largest events reported in the area after 1800. Radii of perceptibility are derived directly from the Principia Mechanica study (1982) with alternative values (in brackets) taken from the Soil Mechanics study (1982).

again distinguished as large or small, superimposed on the early events. Table 2 lists the largest of these earthquakes with their radii of perceptibility. Direct comparison should await a re-evaluation of the later earthquakes consistent with the present investigation, but on the basis of existing studies it is clear that the 1768 and 1780 earthquakes should be comparable with those of 17 March 1871, 14 January 1933 and 9 August 1970, of which the latter was the smallest.

This paper has sought to present the material that exists for a detailed appraisal of the long-term seismicity of the region. Instrumental data on recent events will not only add more precise information on levels and location of activity, but will help to calibrate the relatively full record of the past 300 years.

## Notes and References

- <sup>1</sup> Principia Mechanica Ltd., *British earthquakes: an assessment for CEGB, BNFL, SSEB*, report no. 115/82 (London, 1982).
- <sup>2</sup> G. R. J. Browning & A. W. B. Jacob, 'Preliminary study of the north of England earthquake of 9 August, 1970', *Nature* 228 (1970), 835-7; R. C. Lilwall & G. Riddle, 'Earth tremor near Todmorden of March 7, 1972', *Nature* 244 (1973), 113-4.
- <sup>3</sup> C. Davison, *A history of British earthquakes* (Cambridge, 1924). Individual events have been studied by Soil Mechanics Ltd., *Re-assessment of UK seismicity data for CEGB*, report no. 7984 (1982) and C. Melville, 'The Manchester earthquake of 14 September 1777: a reappraisal of contemporary reports', *Disasters* 9/iii (1985), 197-205
- <sup>4</sup> The route map of Britain made by J. Ogilby, *Britannia* (London, 1675) indicates that the network thinned out considerably north of an imaginary line from York to Exeter.

- <sup>5</sup> J. Hillaby (ed.), *The journeys of Celia Fiennes* (London, 1983).
- <sup>6</sup> H. C. Priŕice, 'England circa 1800' in H. C. Darby (ed.), *A new historical geography of England after 1600* (Cambridge, 1976), 89-164.
- <sup>7</sup> Daniel Defoe, *A tour through the whole island of Great Britain*, ed. P. Rogers (Harmondsworth, 1979), 550, described Westmorland c. 1725 as "eminent only for being the wildest, most barren and frightful of any that I have passed over in England, or even in Wales itself". Whitehaven, Penrith and Carlisle were the most flourishing towns that he visited in Cumberland.
- <sup>8</sup> C. P. Melville, 'The geography and intensity of earthquakes in Britain – the eighteenth century', in *Earthquake engineering in Britain* (London, 1985), 7-23, discusses some of the sources available.
- <sup>9</sup> P. Roberts, *Y Cwita Cyfarwydd*, ed. D. R. Thomas (London, 1883), 40; J. Hall, *A history of the town and parish of Nantwich* (Nantwich, 1883), 119; Wilbraham family diary, Chester R.O. DDX 210/1, fol. 13 recto. This was taken as "a sure signe that the cominge of Christ is at hand, and even at the Dores".
- <sup>10</sup> Hall, *op. cit.*, 134; Wilbraham family diary, fol. 19 recto.
- <sup>11</sup> H. Fishwick (ed.), 'Notebook of the Rev. Thomas Jolly', *Chetham Soc.* 33 (1894), 8.
- <sup>12</sup> *Strange Newes from the North* (London, 1650).
- <sup>13</sup> Robert Baillie, *Letters and journals . . . 1637 to the year 1662 . . . etc.* (Edinburgh, 1775), ii, 411-2.
- <sup>14</sup> *Adam's Weekly Courant*, 17-24 Jan., *Derby Mercury*, 18 January 1739. The letter notes that earthquakes in that part of the world are very rare, but more likely to occur in such "mountaineous Countries, which abound with Mines of Coal &c." than in more level regions.
- <sup>15</sup> The vicar of Mirfield described it as a "sudden and violent earthquake" at Mirfield and neighbourhood, and noted that he felt the earthquake at Kirklees, where he perceived his "bed to rock and the chamber to shake", so that he expected the whole house to fall. He was startled and woke his brother, who was with him, "but he felt nothing of it"; Diary of J. Ismay, Wakefield Co.R.O., D1/192.
- <sup>16</sup> C. E. Whiting (ed.), 'Diary of Arthur Jessop', *Yorks. Arch. Soc., Record Series*, 117 (1951), 43.
- <sup>17</sup> T. D. Kendrick, *The Lisbon earthquake* (London, 1956); G. S. Rousseau, 'The London earthquakes of 1750', *Journal of World History*, IX/3 (1968), 436-451. A special supplementary volume of the *Philosophical Transactions*, XLVI/497 (1750), 601-750 was produced to cover the communications received.
- <sup>18</sup> *Derby Mercury*, 6 April 1750.
- <sup>19</sup> *Leeds Mercury, York Courant*, 10 April 1750.
- <sup>20</sup> See the *Whitehall Evening Post*, no. 648, 5-7 April 1750 and the denial in no. 652, 10 days later. The *Sherborne Mercury*, 9 April, notes that it had received a letter from Chester, signed F. Battersby, with several particulars "which we hope are not true; however, as we know not the writer, we don't chuse to copy his letter".
- <sup>21</sup> *Derby Mercury*, 20 April 1750.
- <sup>22</sup> Rev. J. Seddon to J. Philpot, 10 May 1750, in *Phil. Trans.* (1750), 695-8. The details about the strange light in the sky confirm the common authorship of the two accounts, but the dimensions given of the area of the earthquake differ.
- <sup>23</sup> See also the investigation of this earthquake by Soil Mechanics Ltd. *op. cit.*, vol. 3.
- <sup>24</sup> A. M. Leighton to Mrs Letitia Barnston, dated "The Abbey" (i.e. Abbey Foregate, Shrewsbury), 7 April 1750, in Shropshire Co.R.O., 1536/Box 5. The writer did not herself feel the shock, "being asleep at the time".
- <sup>25</sup> T. Pennant to R. Holford, from Downing near Holywell, 2 April 1750, in *Phil. Trans.* (1750), 687.
- <sup>26</sup> Published in the *Derby Mercury*, among other papers. I have not traced any surviving Manchester newspaper for this period.
- <sup>27</sup> *Northampton Mercury*, 16 April 1750.
- <sup>28</sup> *Leeds Mercury*, 17 April 1750.
- <sup>29</sup> *Phil. Trans.* (1750), 683. Similar details are noted in the letter from Chester already referred to, see the *Leeds Mercury*, 10 April. A heap of pit-coal was shaken down into a yard. "The Discourse all Yesterday was, how People were differently affected the Night before."
- <sup>30</sup> *Harrop's Manchester Mercury*, 12 June 1753.
- <sup>31</sup> *Gentleman's Magazine* (1753), 295, prints a letter from Manchester dated 25 June, describing the shock as occurring on the 22nd (a fortnight late). The same letter is found in several earlier newspapers, and in fact says the shock occurred "on Friday night last". With the widespread practice of copying reports from one paper to another, usually at weekly intervals, the date of the original account frequently became obscured.

- E. Baines, *History of the County Palatine and the Duchy of Lancaster* (Manchester, 1836), ii, 302 and Davison, 219 both give this incorrect date.
- <sup>32</sup> *Read's Weekly Journal*, 23 June 1753; the report says that some hundreds stayed up all night praying for the deliverance, and that it was thought to be a punishment for the current attempts to naturalize the Jews!
- <sup>33</sup> Simon Mills to John Grimston, letter dated Peover, 4 August 1753, in Humberside Co. R.O., DDGR 42/3. He says "according to accounts of persons in this place there was an earthquake felt some months ago, but this is all the knowlege I have of it for my sleep was not disturbed by it".
- <sup>34</sup> *York Courant*, 12 June, *Newcastle Journal*, 16 June 1753, among other papers.
- <sup>35</sup> *Adam's Weekly Courant*, 19 June 1753 prints only the letter from Skipton; no copy of the previous issue has however been traced. No reference is made in the extracts from the *Leeds Mercury* published by the Thoresby Society.
- <sup>36</sup> *Public Advertiser*, 26 November, *Read's Weekly Journal*, 29 November, *Newcastle Journal*, 6 December 1755; the latter misprints the date as 15 Nov.
- <sup>37</sup> J. E. Williams, 'Whitehaven in the Eighteenth Century', *Econ. Hist. Rev.* 2nd series, VIII (1955-6), 393-404. The classical catalogues, such as Perrey and Mallet, are in some confusion here and mention Whitehaven as affected by the shock.
- <sup>38</sup> *Whitworth's Manchester Advertiser*, 31 May; *Leeds Intelligencer*, 31 May 1757 (see the extract in *Thoresby Soc. Misc.* vol. 4 (1895), 241, where the earthquake is misdated 26 May). The shock is not mentioned in Harrop's *Manchester Mercury*, which has very little local news at this period.
- <sup>39</sup> For which see C. P. Melville, 'The seismicity of England: four early earthquakes in western Britain', *Boll. di Geofisica Teorica ed Applicata*, XXV/97 (March 1983), 69-71.
- <sup>40</sup> *The Works of John Wesley*, ed. 1872 (reprinted Michigan N.D.), The Journal, vol. ii, 407-8.
- <sup>41</sup> *Harrop's Manchester Mercury*, 2 February 1768.
- <sup>42</sup> For example, W. E. A. Axon, *The annals of Manchester* (Manchester, 1886), 98, presumably confused with the next event.
- <sup>43</sup> L. Tufnell, 'Environmental observations by the Rev. William Hutton of Beetham, Cumbria', CW2, lxxxiii, 146.
- <sup>44</sup> Davison, 223 calls it an earthquake of "unknown epicentre" and uses no contemporary sources.
- <sup>45</sup> *Harrop's Manchester Mercury*, 31 May 1768. The account is probably reproduced from the *Newcastle Chronicle* of 21 May. The Liverpool papers similarly have no local details to suggest that the shock was felt in that city.
- <sup>46</sup> The possibility remains that Lanchester is a mistake for Lancaster, which is mentioned by other Newcastle papers that do not refer to Lanchester (e.g. *Newcastle Courant*, 21 May; *Newcastle Journal*, 28 May; see also *Leeds Intelligencer*, 24 May 1768). There is a place called Middleton to the southwest of Lancaster. Such a mistake seems on the whole unlikely and there is every reason to suppose that both Lanchester and Lancaster were affected.
- <sup>47</sup> *Liverpool General Advertiser*, 20 May; *Newcastle Chronicle*, 21 May; *Harrop's Manchester Mercury*, 24 May 1768. J. F. Curwen, *Kirkbie-Kendall* (Kendal, 1900), 217 puts the shock in May 1767.
- <sup>48</sup> *Newcastle Chronicle* and *Newcastle Journal*, 28 May 1768.
- <sup>49</sup> *Newcastle Chronicle* and *Newcastle Journal*, 21 May 1768. In one instance, two gentlemen of the town were taking tea with four ladies, when the women all "shewed great surprize, and were much alarmed with an unusual motion of the room, and their seats. Neither the gentleman nor myself perceived so much of it, being at that time much engaged in discourse".
- <sup>50</sup> Diary of the Rev. G. Williamson, Cumbria R.O., DX/I24. It is unfortunate that no Whitehaven paper was produced at this date.
- <sup>51</sup> *Leeds Intelligencer*, 24 May 1768.
- <sup>52</sup> *Derby Mercury*, 27 May 1768, in addition to many of the papers already cited. "Occurrences of this kind are the more frightful in this Country because they so very seldom happen, and as it abounds so much in Hills and solid Rocks" was the opinion of the correspondent.
- <sup>53</sup> *York Courant*, 24 May; *Newcastle Chronicle*, 28 May 1768.
- <sup>54</sup> *Adam's Weekly Courant*, 3 September, see also the *Leeds Intelligencer*, 10 September 1771, the Gentleman's Magazine, 41 (1771), 422, and other London papers. *Drewry's Derby Mercury*, 6 September 1771, has the only account to mention Congleton rather than Astbury.
- <sup>55</sup> Personal memo. among the Fenton family papers, in Staffordshire R.O., D(W) 1788/V/92.

- <sup>56</sup> *Prescott's Manchester Journal*, 7 September follows the account in *Adam's Weekly Courant*; *Harrop's Manchester Mercury* does not refer to the earthquake.
- <sup>57</sup> C. Melville, 'The Manchester earthquake' (1985), *op. cit.*
- <sup>58</sup> *London Chronicle*, 18 September, *General Evening Post*, 20 September, *Jopson's Coventry Mercury*, 22 September 1777.
- <sup>59</sup> Thomas Henry, 'An Account of the Earthquake which was felt at Manchester and other Places, on the 14th Day of September 1777', *Phil. Trans. R. Soc.*, 68 (1779), 221-31; *Harrop's Manchester Mercury*, 16 September; *Morning Post & Daily Advertiser*, 19 September 1777; similar accounts are in S. Hibbert, *History of the Foundations in Manchester*, ii (London, 1834), 160 and Baines, *op. cit.*, ii, 310.
- <sup>60</sup> See references in Melville, 'The Manchester earthquake' (1985).
- <sup>61</sup> *Leeds Intelligencer* and *Leeds Mercury*, 16 September; *York Courant*, 23 September 1777.
- <sup>62</sup> Quoted by Tufnell, *loc. cit.*
- <sup>63</sup> *Newcastle Courant*, 11 October; the letter from Ravenglass also reports 'shocks' experienced in nearby Holmrook, apparently as the result of a storm on 17 September. The *Cumberland Pacquet*, 23 September 1777, makes no local reference to the earthquake.
- <sup>64</sup> Letter from Rev. J. White to his sister, dated Blackburn, 28 September in Leicestershire R.O., DE 730/8(h). Compare with the *Liverpool General Advertiser*, 19 September and *Adam's Weekly Courant* (Chester) 16 September 1777.
- <sup>65</sup> Neither *Jopson's Coventry Mercury* nor *Aris's Birmingham Gazette* contain local details, although both report the earthquake.
- <sup>66</sup> *Drewry's Derby Mercury*, 19 September 1777.
- <sup>67</sup> Quaker Records, Sheffield Central Library, QR. 4. *Aris's Birmingham Gazette*, 22 September, *Westminster Journal*, 27 September 1777.
- <sup>68</sup> *Creswell's Nottingham Journal*, 20 September 1777; a poem was sent to the paper, starting "Britons! repent, whilst there a space is given".
- <sup>69</sup> See the discussion and references in Melville, 'The Manchester earthquake' (1985), *op. cit.*
- <sup>70</sup> *York Chronicle*, 16 December 1780.
- <sup>71</sup> *Newcastle Courant* and *Newcastle Chronicle*, 16 December 1780.
- <sup>72</sup> *Cumberland Pacquet*, 12 December 1780.
- <sup>73</sup> William Hutton in Tufnell, *loc. cit.*
- <sup>74</sup> *Jopson's Coventry Mercury*, 25 December 1780.
- <sup>75</sup> *Leeds Intelligencer* and *Leeds Mercury*, 12 December 1780.
- <sup>76</sup> *York Courant*, 12 December 1780.
- <sup>77</sup> *Adam's Weekly Courant*, 12 December 1780.
- <sup>78</sup> T. Pennant, in *Phil. Trans. R.S.* 71 (1781), 193. Pennant, writing immediately after the earthquake (and before he would have seen the local weekly papers), says he could not trace the shock, which he thought came from the northeast, any further than Holywell. His letter, read on 25 January 1781, is incorrectly dated 12 December 1781 (*sic.*) and refers to a shock "on Saturday last". This has led to the date being given as 8 December (i.e. the corresponding day in 1781) in some sources, see J. Hardy, 'On an earthquake among the Cheviot Hills; with notices of Border earthquakes', *History of the Berwickshire Naturalists' Club* VI (1869-72), 227. R. Mallet, 'On the facts of earthquake phenomena', *Brit. Assn. Adv. Sci.* (1853), 199, duplicates the event under 18 December. On the strength of Pennant's letter, Davison, *op. cit.*, 182 identifies this as a North Wales earthquake of "unknown epicentre".
- <sup>79</sup> *Williamson's Liverpool Advertiser*, 14 December 1780. The shock is not mentioned in the other Liverpool paper.
- <sup>80</sup> William Hutton notes it was the smartest earthquake since he was made vicar, see Tufnell, *loc. cit.*
- <sup>81</sup> Davison, 204 casts doubt on whether these reports can properly be associated with the earthquake, but as long as they are considered to be isolated notices from areas where the shock was not otherwise perceived, there is no reason to discount them. The shock in Chatham "a little past two" is mentioned in the *Universal Daily Register*, 24 August 1786, p. 2; this statement may indeed indicate an isolated Intensity II about 470 km from the epicentre. On the other hand, note the spurious report that the earthquake of 9 December 1780 was felt in London "the next day" between 11 and 12 o'clock (!), in *Newcastle Courant*, 23 December 1780.
- <sup>82</sup> See Williams, *op. cit.* and C. M. Law, 'Some notes on the urban population of England and Wales in the 18th century', *Local Historian* X/3 (1974).

- <sup>83</sup> Soil Mechanics Ltd., *op. cit.*
- <sup>84</sup> *Cumberland Pacquet*, 16 August 1786, p. 2.
- <sup>85</sup> Reports from Whitehaven dated 13 September, given in the *Scots Magazine* 48 (1786), 457, and in the *Leeds Mercury*, 19 September.
- <sup>86</sup> *Hull Advertiser*, 21 February 1818, p. 3.
- <sup>87</sup> *Cumberland Pacquet*, 25 July 1787.
- <sup>88</sup> *Caledonian Mercury*, 16 August 1786.
- <sup>89</sup> Thomas Smith, rector, Bootle Parish Register of Baptisms and Burials, 1767-1812. Smith remarks, "For so kind a warning, of his supreme power and yet so merciful a deliverance, Blessed be the name of the Lord".
- <sup>90</sup> *Westmorland Advertiser & Kendal Chronicle*, 15 November 1817, (I am grateful to Lance Tufnell for this reference).
- <sup>91</sup> *Cumberland Pacquet*, 16 August 1786. Samuel More also notes that the shock was sensibly felt by everyone in Penrith.
- <sup>92</sup> *Caledonian Mercury*, 19 August 1786.
- <sup>93</sup> *Caledonian Mercury*, 16 August 1786.
- <sup>94</sup> S. More, *Phil. Trans. R. Soc.* 77 (1787), 35-6.
- <sup>95</sup> W. Hutchinson, *The history of the county of Cumberland*, vol. 2, (Carlisle, 1794), 673-4.
- <sup>96</sup> S. More, *loc. cit.*
- <sup>97</sup> *Newcastle Chronicle and Newcastle Courant*, 12 August 1786.
- <sup>98</sup> Hardy, *op. cit.*, 228. Various reports from Kelso, Carham and Pinnacle-Hill are quoted in several papers, see also P. Brydone's account from Coldstream in *Phil. Trans. R. Soc.*, 77 (1787), 69-70.
- <sup>99</sup> See for example, *Caledonian Mercury*, 16 August 1786.
- <sup>100</sup> *Cumberland Pacquet and Newcastle Courant*, 25 July 1787.
- <sup>101</sup> *Cumberland Pacquet*, 18 July 1787.
- <sup>102</sup> *The Times*, 22 July 1795.
- <sup>103</sup> No reports have been found in *Gore's Liverpool General Advertiser* nor *Harrop's Manchester Mercury*.
- <sup>104</sup> Some differences in the location and felt area assessment may be noted from those in Melville, 'The geography and intensity of earthquakes in Britain', where the difficulties of assessing these parameters are discussed. Differences in location are within the margin of uncertainty indicated. The assessments in Table 1 reflect the most detailed investigation of the earthquakes in question.

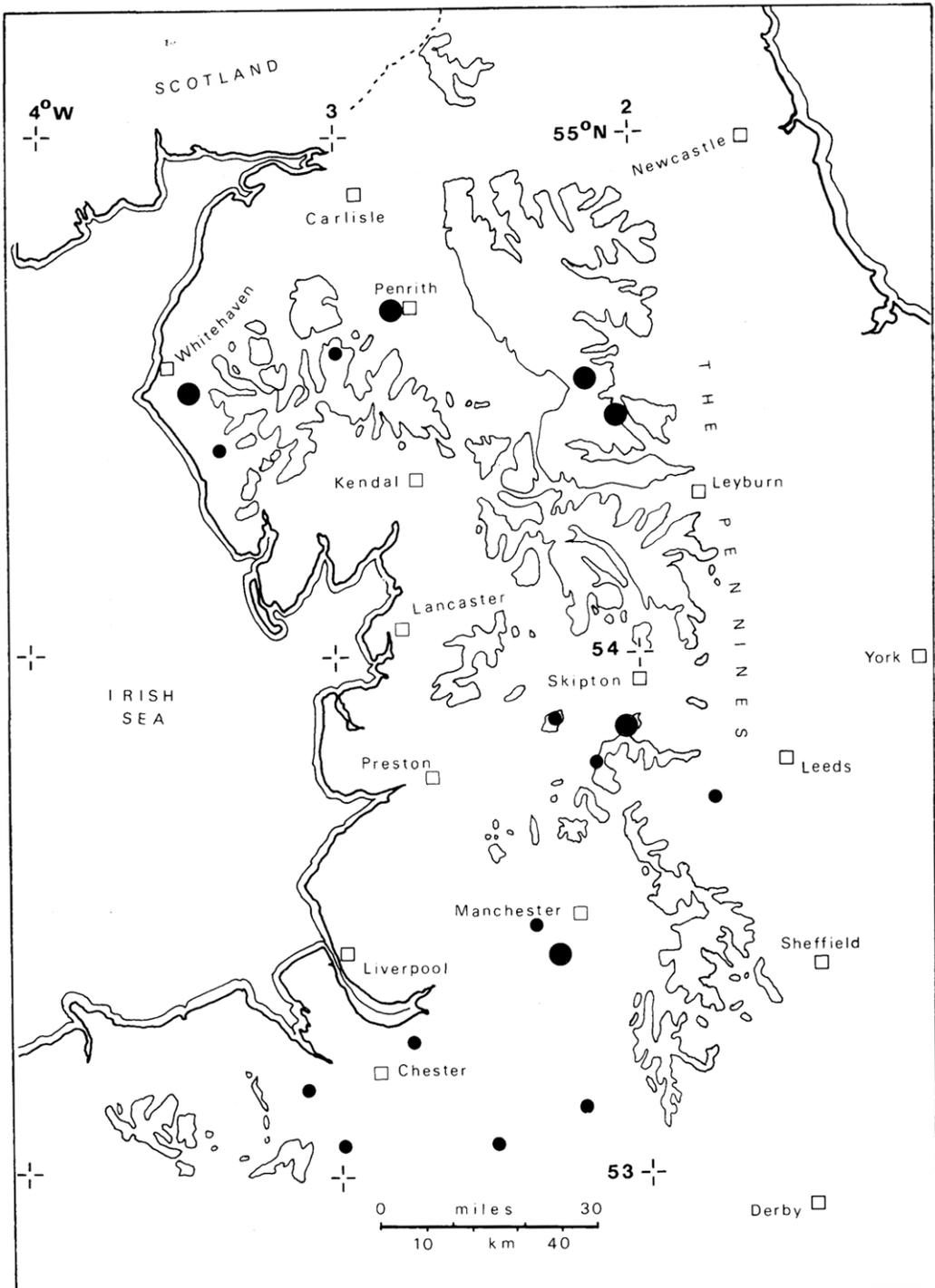


FIG. 1. - Northwest England; the study area is west of the Pennines. Earthquakes are marked by solid dots: large = those with radius of Intensity IV greater than 40 km, see Table 1. Land over 1200 feet is contoured.

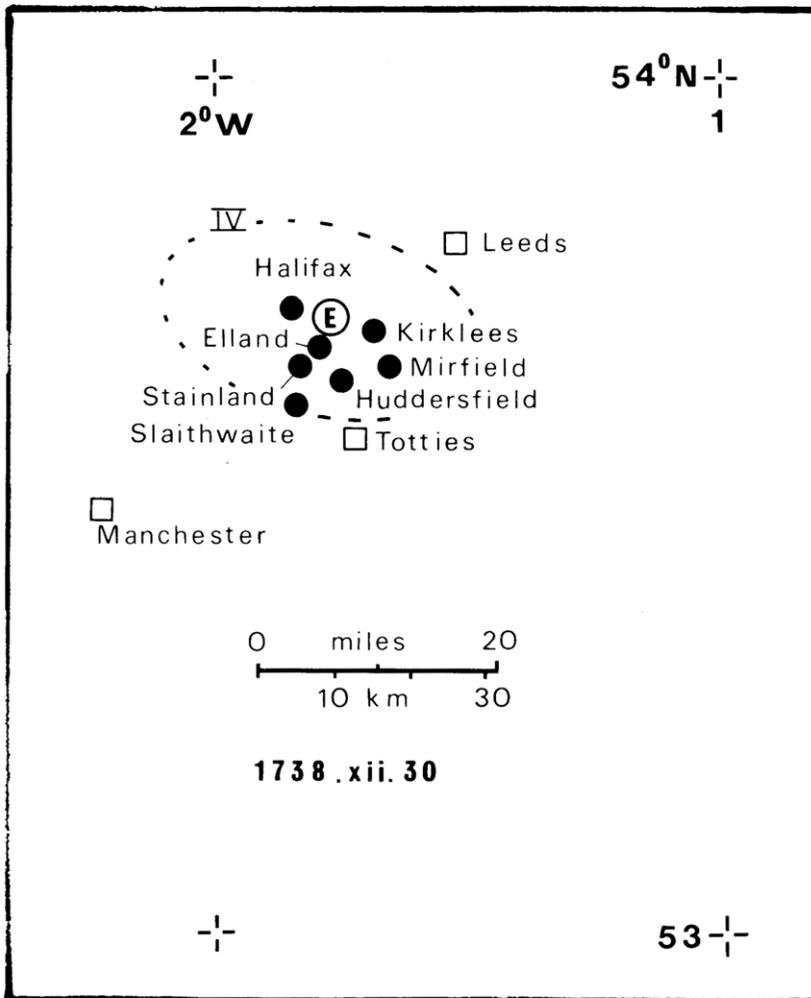


FIG. 2. - The earthquake of 30 December 1738. Solid dots = places affected at Intensities III-IV. Open squares = places where the shock was not reported. E marks the epicentre. The dashed isoseismal line encloses the area experiencing the Intensity indicated.

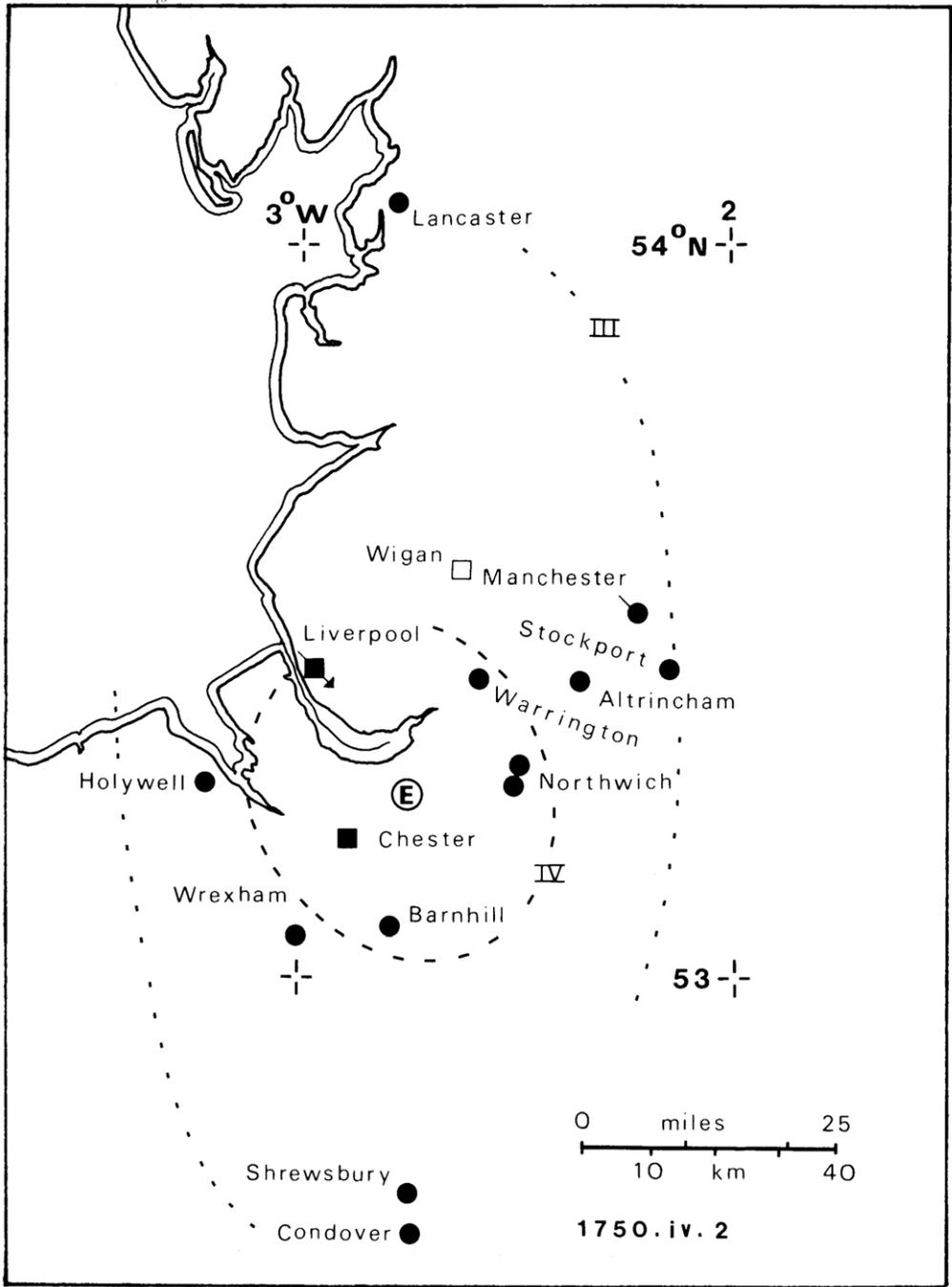


FIG. 3. - The earthquake of 2 April 1750. Solid squares = places affected at Intensities IV-V. Arrow indicates the observed direction of motion of the shock. Other symbols as in Fig. 2.

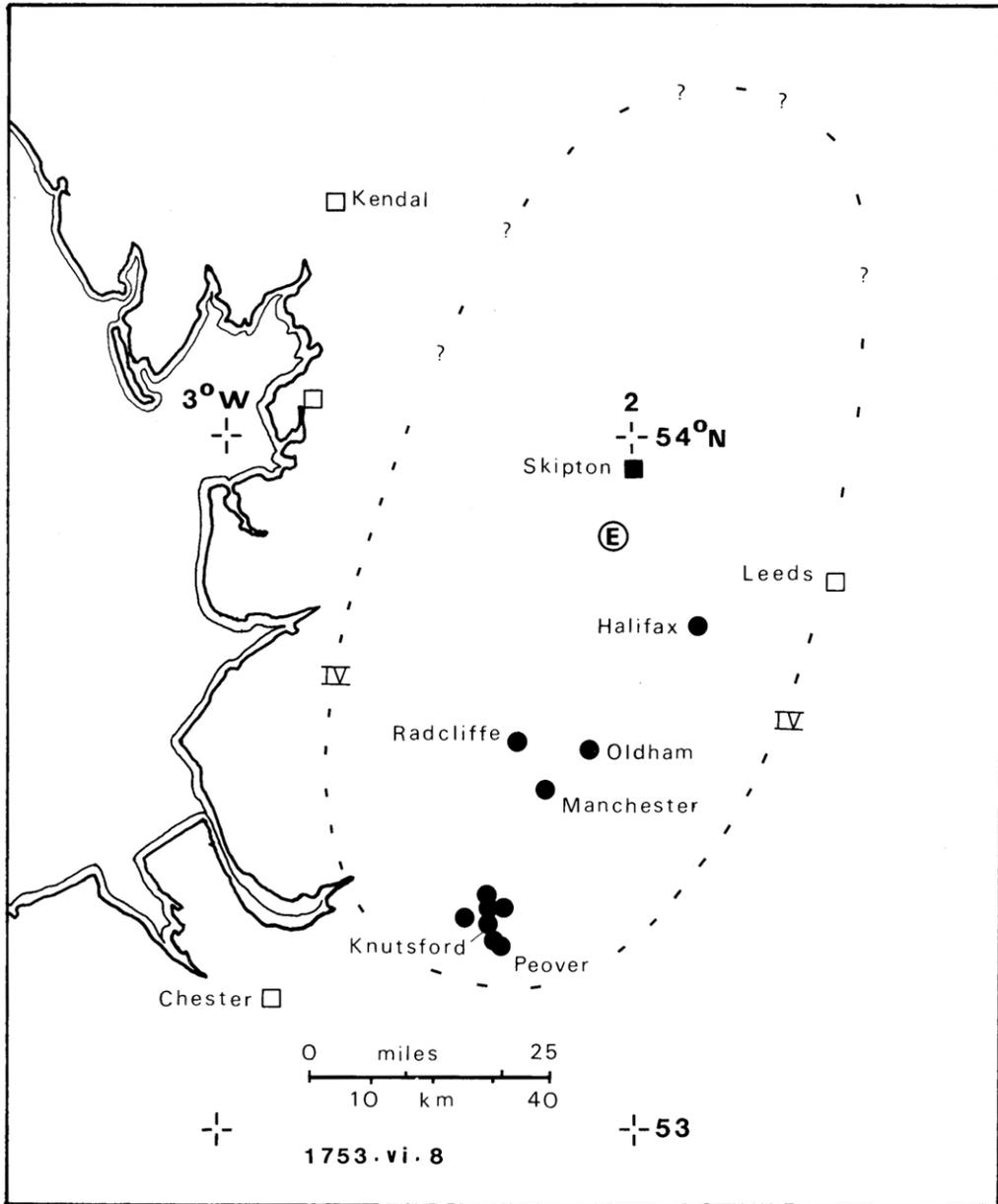


FIG. 4. - The earthquake of 8 June 1753. Symbols as in previous figures.

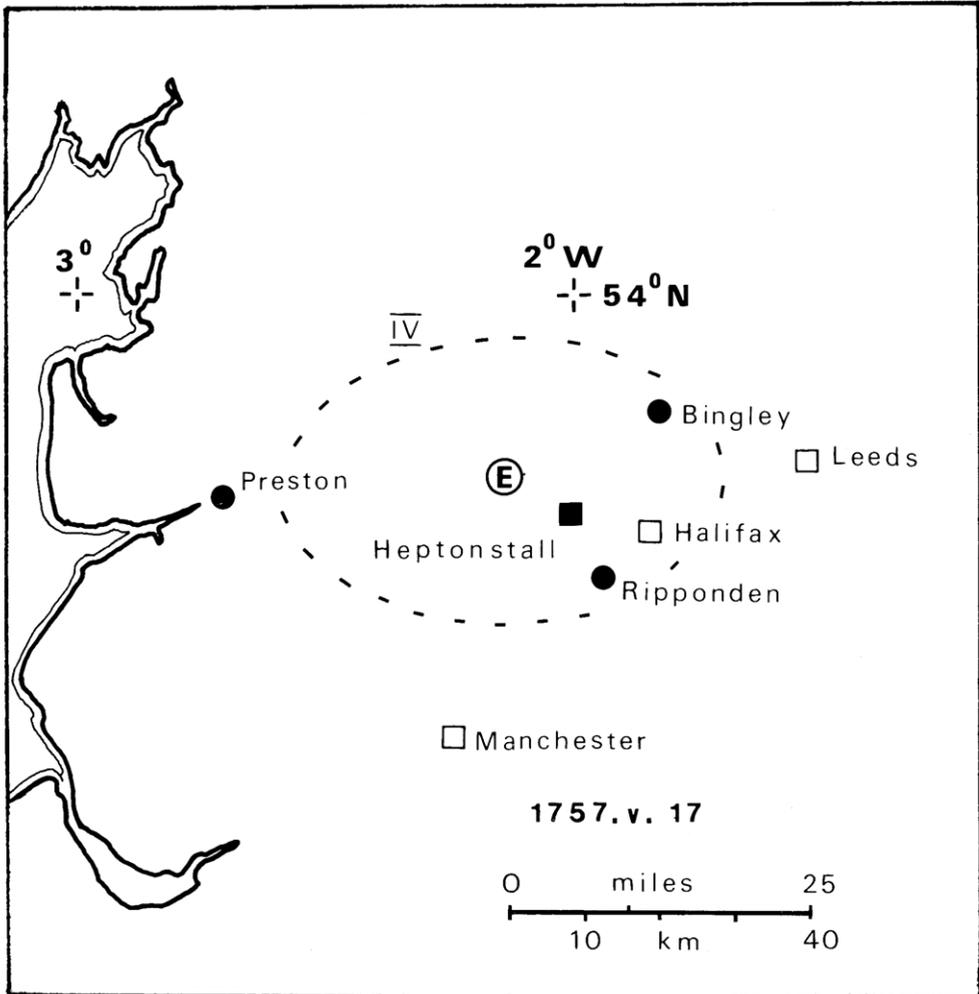


FIG. 5. – The earthquake of 17 May 1757. Symbols as in previous figures.

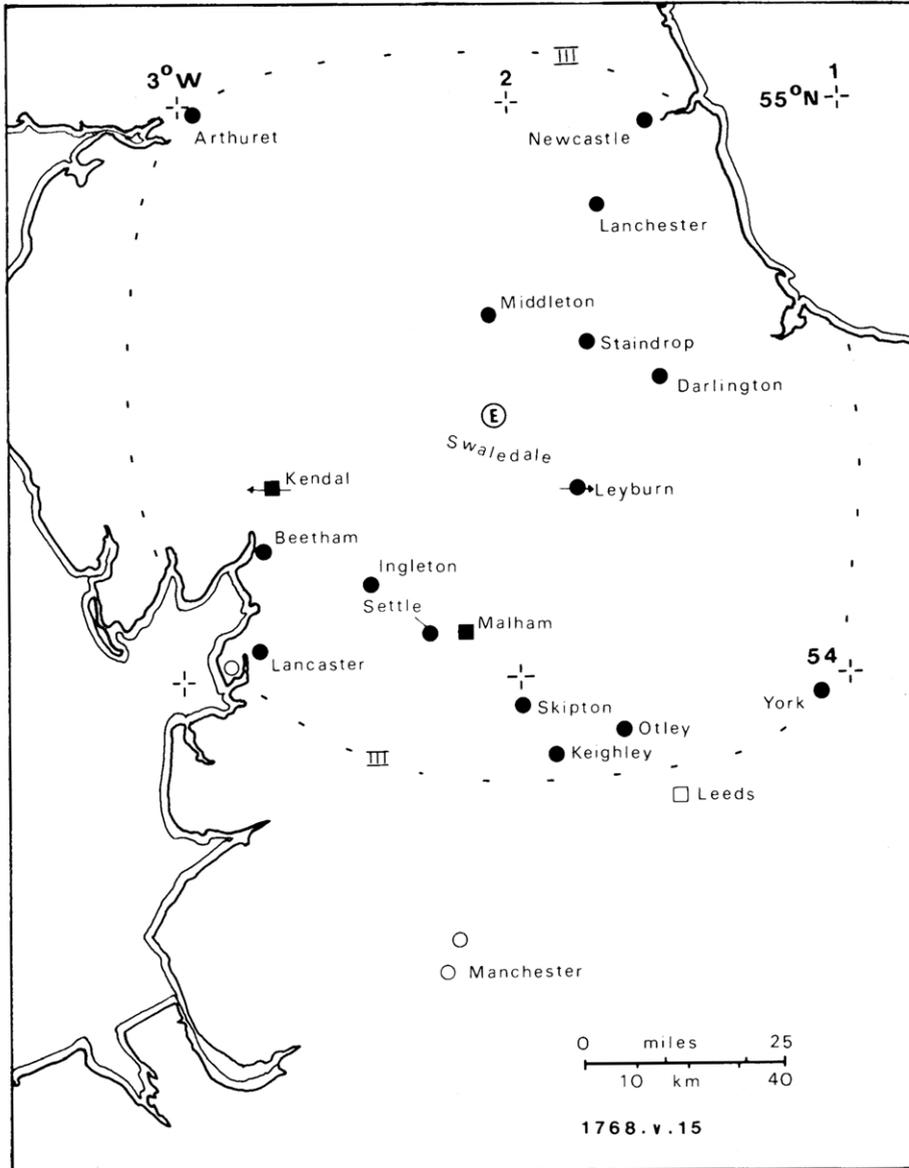


FIG. 6. – The earthquake of 15 May 1768. Open circles indicate places alleged to have felt the shock and some alternative locations for Middleton. Other symbols as in previous figures.

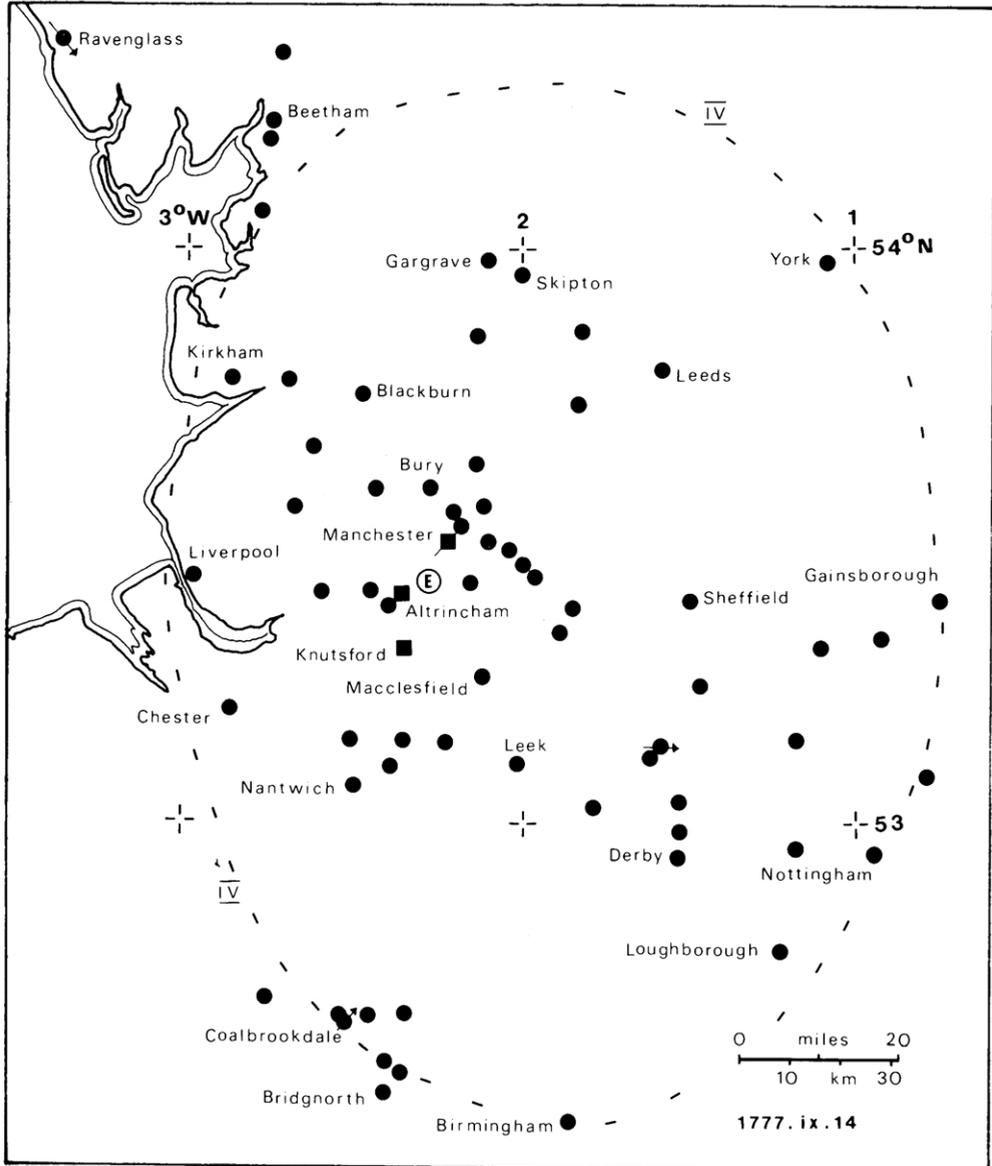


FIG. 7. - The earthquake of 14 September 1777. Symbols as in previous figures.

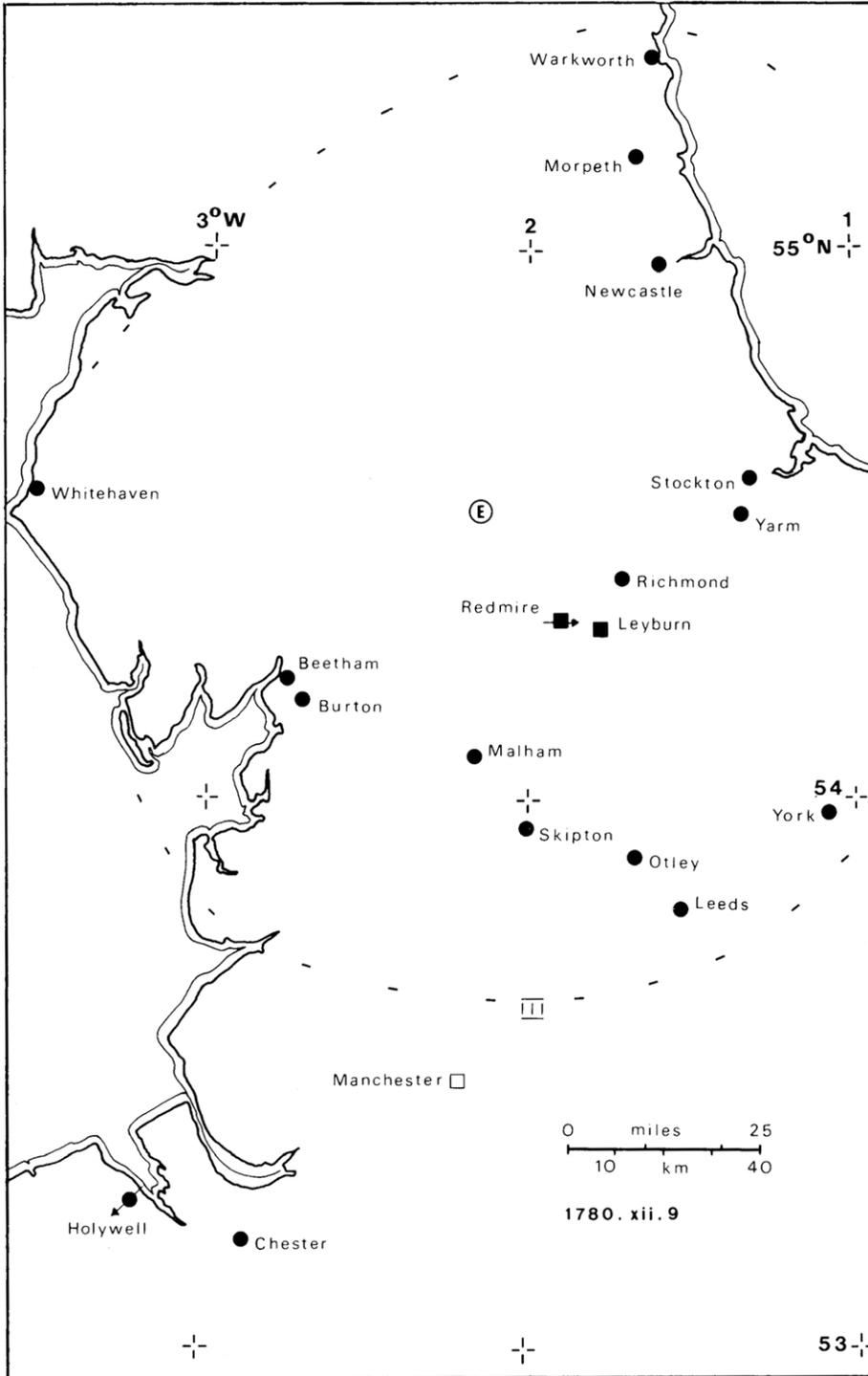


FIG. 8. – The earthquake of 9 December 1780. Symbols as in previous figures.

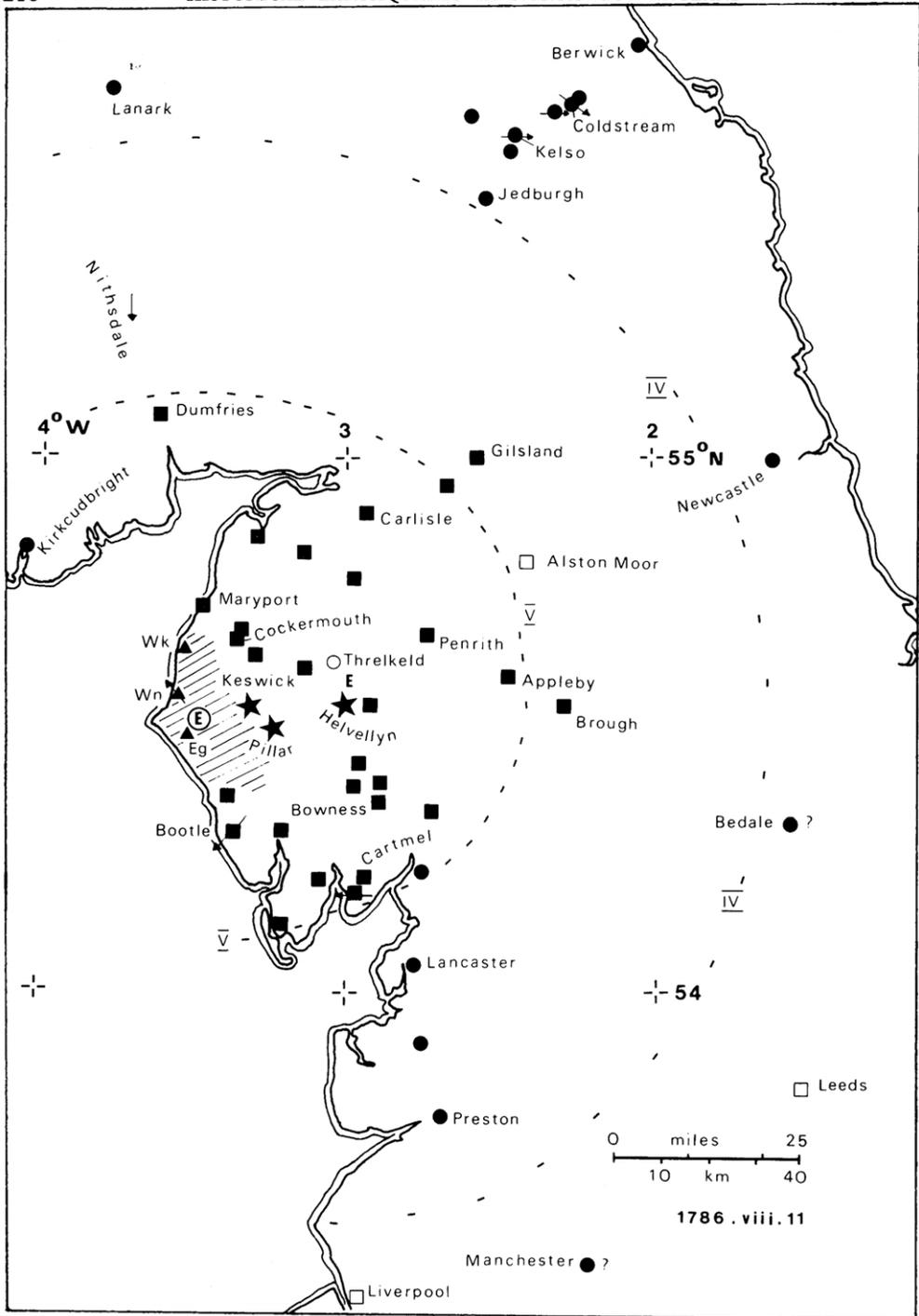


FIG. 9. - The earthquake of 11 August 1786. Solid triangles = places affected at Intensity V-VI or more; solid stars = mountains where rockfalls were reported. Threlkeld (open circle) is mentioned in connection with the shock of 6 July 1787, located nearby. Hatchings mark the area of strongest shaking. Other symbols as in previous figures.

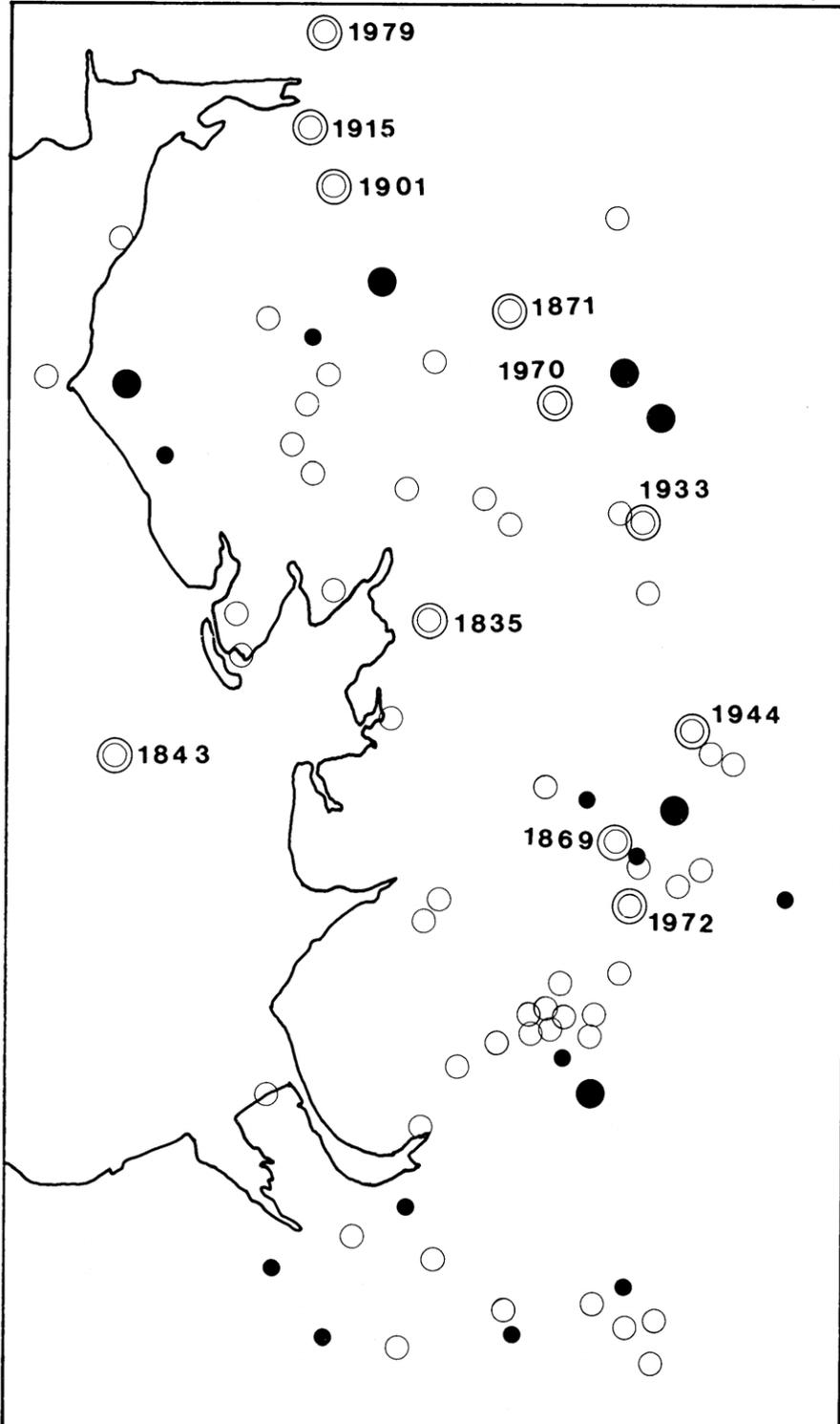


FIG. 10. - The seismicity of northwest England. Open circles = events after 1800, taken from Principia Mechanica Ltd., *op. cit.*, Fig. 1.1.2. The largest of these earthquakes are marked with a double circle and dated, see Table 2 for details. Solid dots = earthquakes before 1800 investigated in this paper. These data have not been unified and direct comparisons might be misleading.

