UK EARTHQUAKE MONITORING 1989/90

BGS Seismic Monitoring and Information Service

First Annual Report

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UK Earthquake Monitoring 1989/90

BGS Seismic Monitoring and Information Service

First Annual Report

C W A Browitt

UK Seismic Monitoring and Information Service

Year One Report to Customer Group: April 1990

Cover photo

Solar-powered earthquake-monitoring station in the North-west Highlands of Scotland

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Edinburgh British Geological Survey 1991

BRITISH GEOLOGICAL SURVEY

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The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as its basic research projects. It also undertakes programmes of British technical aid in geology in developing countries as arranged by the Overseas Development Administration.

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UK SEISMIC MONITORING AND INFORMATION SERVICE
YEAR ONE REPORT TO CUSTOMER GROUP: APRIL 1990

1. Executive Summary

Since 1969, the British Geological Survey (BGS) has been monitoring earthquakes in the UK from a number of observation points determined by specific scientific and customer requirements. As a result, there has been no purpose-orientated background seismic monitoring network to provide a complete, objective database for understanding seismic events and for hazard assessment. Increasing interest in the assessment of earthquake risk by public and commercial organisations engaged in planning, construction and industrial plant operation, has led the Department of the Environment, together with BGS's parent body, the Natural Environment Research Council, to coordinate the provision of information on current seismic events and to establish an historical database and archive. Other sponsors, listed in Annex A, are contributing to the project.

In the first year of the project, the most significant progress has been the installation of networks of seismic monitoring instruments around the north Irish Sea (6 stations, including 2 in Northern Ireland) and in SE England (5 stations). These filled 2 of the most obvious deficiencies in coverage. Instrumentation development has resulted in a computer-based data acquisition system capable of being interrogated remotely from the BGS Office in Edinburgh by telephone, thereby improving response time and accuracy in determining the cause of a felt seismic event. This new technology will be used to upgrade existing networks as funding permits, with Cornwall as the first priority.

Almost every week, seismic events are reported to be felt somewhere in the UK. A number of these prove to be sonic booms or are otherwise spurious but a large proportion are natural or mining-induced earthquakes often felt at intensities which cause concern and, occasionally, some damage. During the year to April, 1990, the more significant of the natural events occurred in North Wales, the Doncaster/Sheffield area, Staffordshire, Cleveland, north of Glasgow, Glen Lyon, Colonsay and Shropshire. Mining-related activity has taken place in the Midlothian and Fife/Clackmannan coalfields and activity which is probably coal-mining related resulted in over 60 events being felt in the Thoresby area in Nottinghamshire.

The Shropshire earthquake of 2 April 1990, centred near Bishop's Castle, was one of the largest British earthquakes this century with a Richter magnitude of 5.1. It was felt over most of England and Wales and in southern Scotland and eastern Ireland with minor damage being sustained in Shrewsbury, Wrexham and villages near the epicentre.

Information on seismic events has been made available at a number of levels and timescales. Within 1 to 24 hours, members of the Customer group have received notification of the occurrence of felt events together with initial details which have been amplified as more data became available. Preliminary monthly bulletins of all events recorded have been issued 2 to 3 months in arrears and the revised annual bulletin, with epicentre and station maps, is scheduled for publication later in 1990.

To facilitate Customer group access to information following a larger earthquake (eg Bishop's Castle), when the telephones becomes busy with calls, a computer bulletin board has been established. Password holders can gain access to its information independently of the local telephone system.

An important aim of the project, to establish a national database and archive of UK earthquake information, has made relatively slow progress owing to a shortage of suitable accommodation in the BGS Edinburgh Office. However, plans for a purpose-built storage and inspection area have been drawn up and work should start during 1990. The facility will have the capability of accommodating historical textual archives and seismograms together with modern analogue and digital tapes.

2. Introduction

2.1 History of monitoring: 1969-1988

The British Geological Survey (BGS) started to monitor earthquakes in 1969 using a network of modern instruments linked to Edinburgh by radio from sites up to 70 km away (LOWNET). Figure 1, shows the detection capability of this network for the UK and demonstrates its limitations for earthquakes which are felt in England and Wales (almost all earthquakes above magnitude 2.5 and many smaller ones are felt). The situation was improved in 1976 when seismograph stations sponsored by the Department of the Enviroment were installed near Stoke-on-Trent, Leeds, Leicester and Hereford. Also in the mid 1970s, BGS started monitoring around Kyle of Lochalsh in response to felt earthquakes in the area. Between 1979 and 1981 other stations, sponsored by the Department of Energy, were installed in Shetland, NE Scotland and East Anglia to monitor the North Sea oilfields and in Devon and Cornwall to monitor the Hot Dry Rock geothermal project. Following the magnitude 5.4 (ML) Lleyn earthquake in 1984, BGS installed an aftershock monitoring network which was later supported, in a modified form, by Nuclear Electric plc. In a joint project between BGS and Renfrew District Council a network was established in the west of the Scottish Midland Valley in 1983 centred on the Thomas Coates Observatory in Paisley which, early in this century, had operated a Milne seismograph. The San Francisco earthquake of 1906 was recorded here. In Jersey, the Meteorological Office, the New Waterworks Company and BGS installed a monitoring network in 1981. Whilst the data is used for monitoring earthquakes off the south and south west coasts of England, this network is treated as being outside the present UK monitoring service project.

As a result of these responses to specific requirements in the period 1969 to 1988, the BGS seismograph network in late 1988 was non uniform in coverage (Fig 2). In addition to those stations operated by BGS, data was available from dense networks around Hinkley and Dungeness power stations, operated by Nuclear Electric, and from a distributed network of 8 stations in England and Wales, operated by MOD. The former are event-triggered, rather than continuous, and are designed to be inward-looking. The MOD stations are low frequency and designed for looking at large distant seismic events from sources outside the UK. Therefore, whilst data from these are useful they only contribute to a limited extent to the National monitoring effort.

2.2 Background to the project

Following its support of a number of earthquake studies in the 1970s and 1980s and recognising the similar work being sponsored by other agencies, the Department of the Environment concluded that there would be benefit in coordinating these activities in order to improve seismic risk assessments throughout the United Kingdom. Consequently, potential customers for seismic investigations were invited to form a group to consider the various requirements and to develop a strategy.

Following discussion within this group, the Department commissioned Dr R D Adams of the International Seismological Centre, Newbury, Berkshire to provide an independant expert view on seismic investigation requirements in Great Britain. His report and recommendations on the need for seismic monitoring drew attention to conspicuous gaps in existing coverage, notably in South East England and Northern Ireland. A specification of the necessary work was prepared and it was agreed that the Global Seismology Unit of the British Geological Survey was an appropriate contractor to carry out the work because of its existing structure and capabilities and the facilities it already had in place.

A number of organisations then secured approval to support the improved service financially (listed at Annex A). Whilst the total contributions fall short of those needed to secure comprehensive monitoring coverage, it was felt that the costs of the service, once established, would be offset partly by revenue and that other organisations might become interested in contributing. Initial approaches have now been made to a number of other interests. In addition, some other organisations have agreed to contribute by providing data from their own monitoring equipment or by providing other facilities. All categories of supporters of the project listed in Annex A are referred to as the Customer group.

3. Programme objectives

3.1 Long-term

The overall objectives of the service are:

(i) To provide a database for seismic risk assessment using existing information together with that obtained from a uniform distribution of modern seismographic stations throughout the UK landmass. A mobile network of seismograph stations would be used for specific investigations of seismic sources to supplement the background network.

(ii) Using that network, to provide near-immediate preliminary responses to seismic vibrations reported to have been heard or felt.

These objectives and a strategy to meet them were described more fully in a proposal from BGS dated December 1987. The higher the density of seismograph stations in the network, the more accurate will be the response and the database. In discussion with the customer group, a 70 km average spacing of stations (Fig 3) was agreed as a cost-effective way of achieving the main goals although it was recognised that some parameters (eg depths of focus and focal mechanisms) would not be well-determined.

3.2 Short-term

In 1988, the Customer group agreed to a reduced initial phase of development of the monitoring network to fit the limited funds likely to become available in the first 3 years. In this strategy, the following sacrifices were made:

(i) The mobile network would not be specifically supported.

(ii) The 70 km-spacing of stations would not cover the whole country. Advantage would be taken, where possible, of site- specific networks operated for other purposes and of existing recorders with spare channel capacity to add individual stations. Priority for new networks would be in the south east of England and around the north Irish Sea. This modified coverage by the background network is shown in Figure 4.

(iii) Upgrading of the analogue stations to digital recording and direct access to remote networks (from Edinburgh) using computer or telephone links would be reduced to an opportunistic phased level as resources became available.

The establishing of a "user-friendly" database and archive of seismicity was to be retained as a high priority element of the project.

4. Development of the monitoring network

4.1 Station distribution

By the end of 1989 the coverage proposed (Fig 4) was achieved except for seven stations: one each in W Scotland, SW Wales, Exmoor, E Devon, W Midlands, Lincolnshire and E Anglia. The prospects of installing half of these in 1990, however, are good. Figure 5 shows the actual position in December, 1989. In particular, new networks were installed in SE England (5 stations) and around the north Irish Sea (6 stations, including 2 in Northern Ireland). In NW England a dense network, commissioned by Scottish Nuclear/Nuclear Electric, was installed and operational in August 1989 and data is available for publication. Its future, of course, is not assured and this condition also applies to the Nuclear Electric-sponsored stations in NW Wales. The earthquake detection capability of the network for relatively noisy background conditions is shown in Figure 6.

As anticipated at the outset of the project, the Department of Energy closed its ten-year North Sea monitoring operation in June 1989. This means that the Shetland, NE Scotland and E Anglia networks are not supported. The Department of Energy has, however, agreed that it will donate the equipment to the project and those networks have, for the present, been left in place in the hope of achieving an expansion in the Customer group contribution which would provide the necessary resources to avoid a break in monitoring. On the positive side, the Department of Energy, which also funds the SW England network for the HDR geothermal project, has confirmed support for those stations until September 1991. It seems likely that some background monitoring might continue to be supported after that date.

4.2 Progress with instrumentation

Whilst the initial implementation of the strategy to upgrade the monitoring network has had to be limited, there has been some progress with instrument development towards the longer term goals. In collaboration with Bergen University, a computer-based data acquisition system is being developed to provide digital data acquisition in Edinburgh from remote sensors anywhere in the country that can be reached by public telephone or computer networks. It has the potential advantage of streamlining analysis procedure but does not provide the continuous recording of the existing FM analogue systems. Up to three of these systems will be installed in 1990 but they will not be able to function to full potential until 16-bit digital transmission from all of the stations in each network can be provided.

Seismograph stations in any part of England SE of Nottingham suffer from relatively high vibration noise levels owing to the surface geological conditions. Partly with support from the Scottish Nuclear/Nuclear Electric which has similar conditions at its NW England site, borehole sensors have been constructed and are under trial. If successful, they could be used in the south east to overcome the noise problems.

5. Seismic activity in Year 1

5.1 Earthquakes located for 1989

Details of all earthquakes and sonic booms detected by the network are provided in the BGS bulletin for 1989 which is scheduled for publication later in 1990. A map of the 370 seismic events located is reproduced here as Figure 7 and a catalogue of those with magnitudes of 2.0 or greater is listed in Annex B.

5.2 Significant events

Highlights of the seismic activity during 1989 and to the end of the first year of the project (April 1990) are given below:

(i) In the south west, 17 earthquakes were located with magnitudes up to 2.4 ML. Most were offshore and include one earthquake 7 km east of St Martins in the Scilly Isles.

(ii) In the southern North Sea, 3 earthquakes occurred in October and December with magnitudes between 2.0 and 3.2 ML.

(iii) In North Wales, seismicity continued to be dominated by aftershocks of the 1984 Lleyn peninsula earthquake with their characteristic depths of 20-25 km. Magnitudes ranged up to 2.1 ML which, although small, are occasionally reported to be felt by people (eg 18 January 1990).

(iv) In Nottinghamshire, over 60 felt events have occurred in the Thoresby area in the period September 1989 to January 1990. They show some characteristics of events induced by coalmining.

(v) The Doncaster and Sheffield area was affected by a magnitude 3.0 ML earthquake on 8 February 1990 (Fig 8). A questionnaire survey yielded approximately 300 replies; most from Sheffield city, but the event was also felt in the Doncaster, Rotherham, Barnsley and Thorne areas of south Yorkshire. There was minor damage including cracks in internal plaster walls, pictures fallen from walls and broken panes in a greenhouse which indicates a maximum intensity of shaking of V MSK.

(vi) In Staffordshire, magnitude 2.4 and 2.8 ML events were strongly felt in 1990 on 26 February and 4 March, respectively (Fig 9). The latter was felt over a diameter of some 30 km and yielded over 600 responses to a survey in the local newspaper. It has some similarity to an event in July 1980 which was also widely felt and which did not appear to be related to present-day coalmining. This is significant since coalmining-induced seismicity has been proven for some sequences of events in the general area in the past.

(vii) In Loftus, Boulby and Easington, near Middlesbrough, an earthquake was felt on 5 September. The epicentre of the event, which had a magnitude of 2.4 ML, was located near a large, active potash mine at Boulby and the records showed some characteristics of a mining-induced earthquake. However, a mining-induced origin could not be confirmed because of the distance of the event from the nearest seismograph stations (more than 80 km).

(viii) In Midlothian, the closure of the Bilston Glen colliery in June 1989 resulted in a decline of events which have been a feature of the area for many years. In the Fife/Clackmannan coalfield activity has remained steady with an event of magnitude 1.3 ML felt strongly on 11 August 1989.

(xi) North of Glagow in the Milngavie/Blanefield area, an earthquake with magnitude 2.2 ML was felt widely on 6 January 1990. Although the intensity (IV MSK) was below damaging level, it caused much concern as it affected a densely populated area.

(x) In the Glen Lyon - Loch Rannoch area, an earthquake with magnitude 2.5 ML was felt with intensities up to IV MSK on 9 January 1990. Its epicentre was in the mountainous region between the two areas.

(xi) Near the island of Colonsay, a magnitude 3.0 ML earthquake occurred on 26 January 1990. It was felt on Colonsay (IV MSK) and Iona (II MSK) but caused little concern.

(xii) In the North Sea, some 30 earthquakes have been located west of the fourth meridian in or near to the British sector. The largest, with a magnitude of 4.0 ML had an epicentre 140 km NE of the Shetland Islands.

(xiii) Throughout the country, many 'seismic' events have been reported to be felt like small earthquakes which, on analysis, proved to be sonic booms. These are easily discriminated from seismic events (earthquakes or explosions) when instrumental records are available (Fig 10). Examples came from Whitby, Isle of Man, Belfast, Anglesey, Inverbervie, Stonehaven, Norfolk and Swansea.

5.3 The Bishop's Castle earthquake

With a Richter magnitude of 5.1, the earthquake of 2 April 1990 was one of the largest British earthquakes this century. The epicentre is near the village of Clun, in Shropshire, approximately 7 km SSW of Bishop's Castle, and its focal parameters are:

Grid East:	329.7 $\pm$ 1.0 km
Grid North:	282.4 $\pm$ 1.0 km
Depth:	14.3 $\pm$ 4.7 km
Time:	13.46 and 34.20 sec GMT
Magnitude:	5.1 ML

Most of the high sensitivity seismic stations in Britain were saturated by the amplitude of the ground motion but eight low gain vertical seismometer recordings were available to calculate the Richter local magnitude.

The earthquake was felt over a large area from Ayrshire in the north to Cornwall in the south, Kent in the east, and Dublin in the west. Damage was minor and limited to the epicentral area, north to Wrexham and especially Shrewsbury, which suffered most. It included cracks in chimneys, falls of parts of chimneys, cracks in plaster and falls of small amounts of plaster. The British Geological Survey carried out a macroseismic survey after the mainshock which yielded over 6,000 responses, and, as a result, has assessed the epicentral (and maximum intensity) as VI MSK.

While this earthquake does not have any direct precedent, so far as is known, it is comparable to other earthquakes in the general Herefordshire area, notably those of 6 Oct 1863, 27 Dec 1896 and 15 Aug 1926, which had Richter magnitudes of 5.2, 5.2 and 4.8, respectively. The epicentre of the 1926 event was near Tenbury Wells, about 40 km SE of the epicentre of the Bishop's Castle earthquake. There have also been small events in the Clun area, notably the 15 Apr 1984 Newtown earthquake (3.2 ML) and the 31 May 1882 Knighton and 27 Dec 1768 Presteigne earthquakes. These last two had small magnitudes (based on felt areas) but appear to have caused relatively high intensities of up to V and VII MSK, respectively.

Following the mainshock, a dense network of 11 stations was installed around the epicentre in order to detect possible aftershocks with station positions chosen to optimise the location accuracy and focal mechanism determinations. In the six weeks following the mainshock, only six aftershocks were detected with the largest magnitude, 1.5 ML, occurring the day after the mainshock. The local network, however, has provided improved control over aftershock location, with a corresponding reduction of the hypocentral errors to ± 0.4 km in epicentre and to ± 0.2 km in depth for the best cases.

This small number of aftershocks contrasts with that for similar magnitude events in intraplate environments, worldwide, and especially when compared with the 19 July 1984 (5.4 ML) earthquake on the Lleyn Peninsula when 20 events per week with magnitudes greater than 1.0 ML occurred in the first 4 weeks. This lack of a substantial aftershock sequence at Bishop's Castle suggests a relatively high stress drop which is consistent with the markedly higher frequency content of the mainshock when compared to that of the Lleyn event.

A focal mechanism obtained for the mainshock shows a dominance of strike-slip faulting with a component of thrust on either a N or WSW striking fault plane. The focal planes dip steeply west and SSE, respectively.

One aftershock, on 17 April with a magnitude of 0.7 ML, has also yielded a mechanism with focal planes similar in strike to the mainshock but with dips in the opposite sense and a dominant thrust component. The maximum compressive stress directions determined for both events are NW-SE.

In the absence of other evidence, the two possible focal planes defined by an earthquake mechanism analysis cannot be separated into the fault plane and the orthogonal auxiliary plane. Despite the small number of aftershocks, the accuracy of location provided by the dense local network of monitoring stations has permitted these few events to identify the N-S plane as that of the causative fault.

The surface structure of the area is dominated by the NE striking Welsh Borderland Fault System and no surface feature has characteristics that are compatible with either plane of the mainshock mechanism. There is, therefore, no surface expression of the causative fault of the mid-crustal Bishop's Castle seismicity which is consistent with the usual situation for intraplate earthquakes.

5.4 Global earthquakes

Although aimed at monitoring the UK, the network detects events from Europe and throughout the world. Data is supplied to the International seismological community. This is important because monitoring agencies elsewhere reciprocate by providing records of British earthquakes. In particular, exchange takes place with:

(i) International Seismological Centre, Newbury, England (ISC)

(ii) National Earthquake Information Centre, Denver, Colorado (NEIC)

(iii) European & Mediterranean Seismological Commission, Strasbourg (CSEM)

The largest global earthquake for over 10 years occurred on 23 May in the Macquarie Island region, south west of New Zealand. With a magnitude of 8.2 Ms, it just exceeded the Mexico City earthquake in 1985 which caused approximately 10,000 fatalities. By contrast, the Macquarie event, with its epicentre in a remote oceanic region, caused little concern and no Media interest. It was felt only on Macquarie and Campbell Islands with a maximum intensity of V MM (below damaging).

The most publicised earthquake, which also resulted in many enquiries to BGS from the Public and Media, was the 18 October Loma Prieta (initially called San Francisco) earthquake which caused damage in San Francisco and the Santa Cruz/Hollister area of California. With a magnitude of 7.1 ML it was slightly larger than the Armenia earthquake of December 1988 which caused 25,000 deaths. The Loma Prieta earthquake, however, caused only 62 fatalities as a result of the higher degree of earthquake preparedness California. Nevertheless, this rupture of a 40 km section of the San Andreas fault resulted in over 3,000 injuries, 12,000 homeless and $6 billion of damage.

The Newcastle, Australia, earthquake which occurred north of Sydney on 27 December 1989 caused 11 deaths. With a magnitude of only 5.5 Mb it is of a size which can occur infrequently in Britain. The buildings in this part of Australia were designed and constructed without provision for earthquake shaking as there is little evidence of such events in the history of the area. Seismograms were recorded on the UK network (Fig 11) from seismic waves which travelled through the Earth's core. The pulses shown are from two such waves, each reflected at the surface near the epicentre making the four in total. The time intervals between the first and second and the third and fourth pulses enable us to estimate the depth of the earthquake as 10 km, approximately.

In East Germany, on 13 March 1989, a strong mining-induced earthquake occurred and was felt in West Germany, parts of France, Czechoslovakia, Switzerland and Austria. In the epicentral area, 80% of buildings were damaged by the event which is believed to be the result of a rockburst or pillar collapse following blasting at the Ernst Thaelmann mine near Merkers. The event had a magnitude of 5.4 Mb (4.7 Ms) and was, therefore, similar in size to the Newcastle, Australia, earthquake.

6. Archives

6.1 Identification and cataloguing

Although work has been hindered by a shortage of adequate accommodation, a certain amount of progress has been made. An inventory of current holdings has been made preparatory to formulating a new system of classification and cataloguing. The software and hardware requirements necessary for implementing this have been identified and are being purchased. Advice has been received in the management of the archives from the curators of comparable collections (BAS and Met Office) and we continue to liaise with the archivists of the Scottish Record Office.

Work continues in identifying the location of other archival seismological materials. For example:

Aberdeen: An important collection currently being maintained by the University of Aberdeen but which may be transferred to Edinburgh at some date in the future.

Eskdalemuir: A small holding of materials which is supervised by BGS.

Durham: An important collection which will continue to be administered by Durham University for the forseeable future.

London: The Milne Library is looked after by the Science Museum.

Barnwood: The Nuclear Electric has a large collection of photocopies of material gathered in the course of seismic hazard studies over the past eight years.

Newport: The Isle of Wight Record Office has a small collection of material saved from the blaze at Shide Observatory in 1913.

Paisley: This observatory is still active.

Other observatories: It now seems certain that the collections associated with Stonyhurst and Oxford have been destroyed.

6.2 Storage and inspection facilities

The problem of space appears to be close to resolution with a plan to create purpose-designed archive and inspection offices in Murchison House, Edinburgh for which plans are currently being drafted by the architects.

7. Dissemination of results

7.1 Near-immediate response

Nominated members of the Customer group have been programmed into the BGS fax so that seismic event alerts can be transmitted (normally within 1 to 24 hours) with minimal operator input. In the year April 1989 to March 1990 some 27 such alerts have been issued (examples in Annex C).

A bulletin board has been established on a captive process on the VAX computer in Murchison House. Any authorised user can log in to it from a remote terminal in the UK, or further afield, and can access 'help' information, two data fields and one message field.

(a) One data field contains the past three months of seismic readings, earthquake parameters and comments. These are constantly under revision at this stage with new information being added (particularly for the most recent weeks) as it arrives and is processed in Edinburgh. At present, this data file is updated on a weekly basis.

(b) The second data field contains information on recent significant earthquakes in the UK and overseas. For the UK, the initial entry is similar to the event alert information sent by fax but it can be readily updated throughout the day or week as more information becomes available.

(c) The third field permits anyone accessing the system to leave a message the presence of which will be automatically flagged when key analysts in Murchison House log on to the computer for any purpose.

Anyone who accesses the bulletin board, whether a message is left or not, is automatically registered.

In addition to these ways of distributing early results, information is also disseminated in response to telephone calls, telex, fax and written enquiries and in response to the media. Where appropriate, charges are made for the provision of both raw and interpreted data.

7.2 Medium term response

Within three months of the end of a recording period of one month, preliminary bulletins of event parameters and raw data have been issued to nominated members of the Customer group. It is anticipated that the delay will be cut to two months during 1990 but it does not seem to be practical, at this stage, to reduce this to one month without sacrificing completeness.

The earlier intention to provide dial-up computer access to the previous 12 months of data has not been implemented. It could readily be achieved by using the existing bulletin board facility or by establishing a second bulletin board with more restricted access to protect the value of the data. In the future, there is a prospect of providing access to an optical disk containing up to 10 years of past data, including seismograms, if the need were accepted.

7.3 Longer term response

It is proposed to publish the annual bulletin of revised earthquake parameters for 1989 by July 1990. As in previous years, the volume will also contain small scale maps of cumulative seismicity since 1969.

On request, data will be made available to Customer group members on computer tapes in a format to be agreed.

8. Programme for 1990/91

During the year, the project team will continue to detect, locate and understand natural seismicity and man-made events in and around the UK and to supply timely information to the Customer group. In addition, it will make progress towards the longer-term objectives of the project, to provide a 'user-friendly' database and archive of UK seismicity and a digital network of seismometers with an average spacing of 70 km throughout the country. The level of progress is partly dependent on the resources available through the Customer group including the Natural Environment Research Council. Anticipated advances are:

(i) Installation of new seismograph stations recording at existing centres, in W Scotland, SW Wales, E Devon and W Midlands.

(ii) Upgrading the Cornwall network to digital recording and dial-up access from Edinburgh, and planning a second upgrade to take place in 1991.

(iii) Dissemination of information on the Bulletin Board and its means of access to the Customer group.

(iv) Commissioning of an optical disk storage system for seismograms recorded on the network. Back-up copies of these disks will be made and retained at Keyworth to guard against any catastrophic event at Murchison House (eg fire).

(v) Initiating, at least, building work at Murchison House to provide purpose-built archive and inspection facilities for historical (pre 1970's) and modern earthquake records. Cataloguing existing BGS holdings will continue, in the mean-time, in temporary facilities.

(vi) A watching brief will be kept on known archives of UK information held by other organisations. BGS will endeavour to obtain agreement to transfer seismograms written on the Mainka instrument in Jersey to Edinburgh for cataloguing and safe-keeping. They occupy a small volume.

Acknowledgements

We particularly wish to thank the Customer group (listed in Annex A) for their participation, financial support, and data and equipment input to the project. Outside this group, modern data has been made freely available by Leeds University and historical data by a number of organisations and libraries which will be catalogued at a future date. Station operators and landowners through the UK have made an important contribution and the technical and scientific staff in BGS (listed in Annex D) have been at the sharp end of the operation. The work is supported by the Natural Environment Research Council and is published with the approval of the Director of the British Geological Survey (NERC).

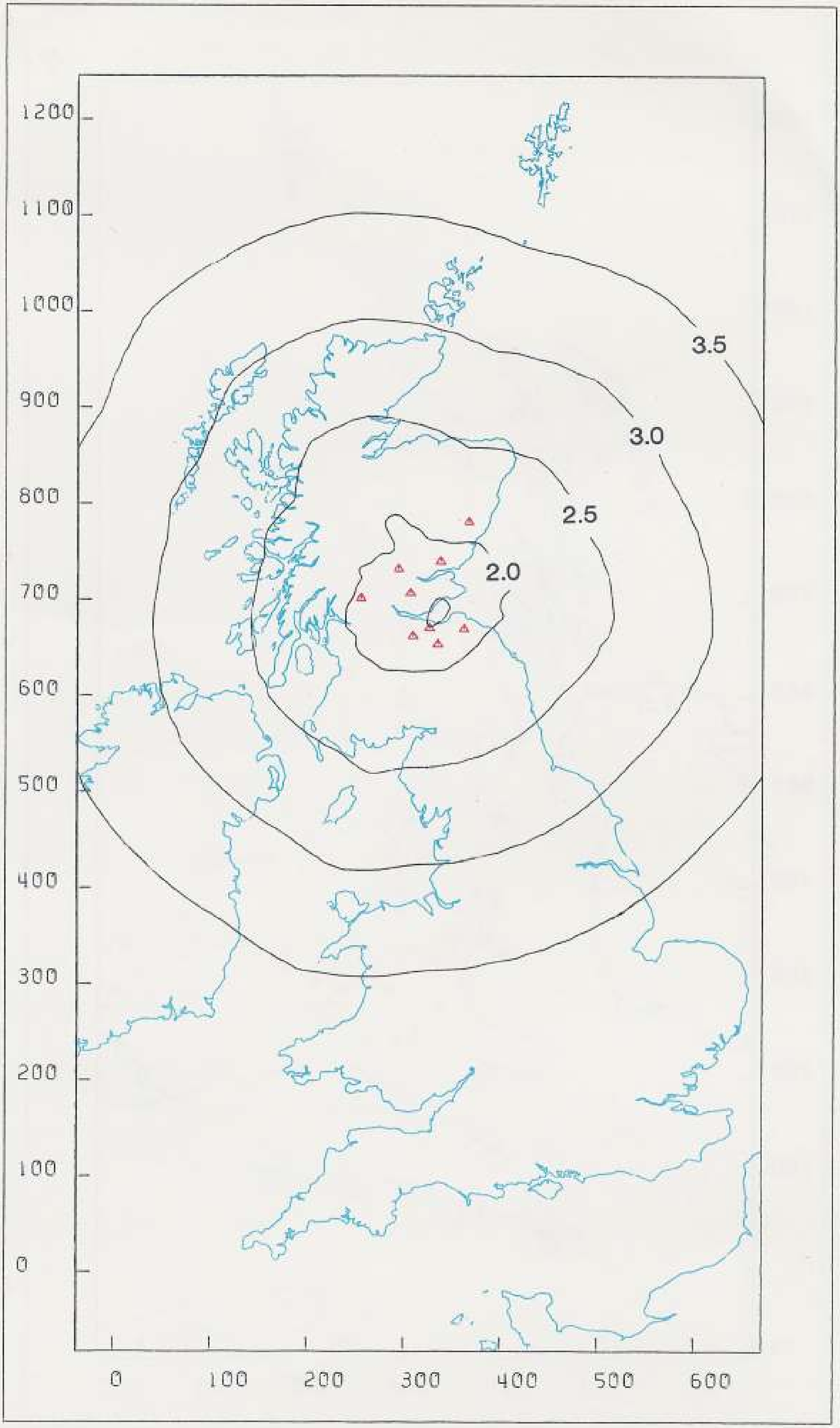

Figure 1. Detection capability of the Lowlands seismograph network. Contours show the magnitude of an earthquake which would be detected by 5 stations of the network in the presence of background noise of 20 nanometers at 10Hz.

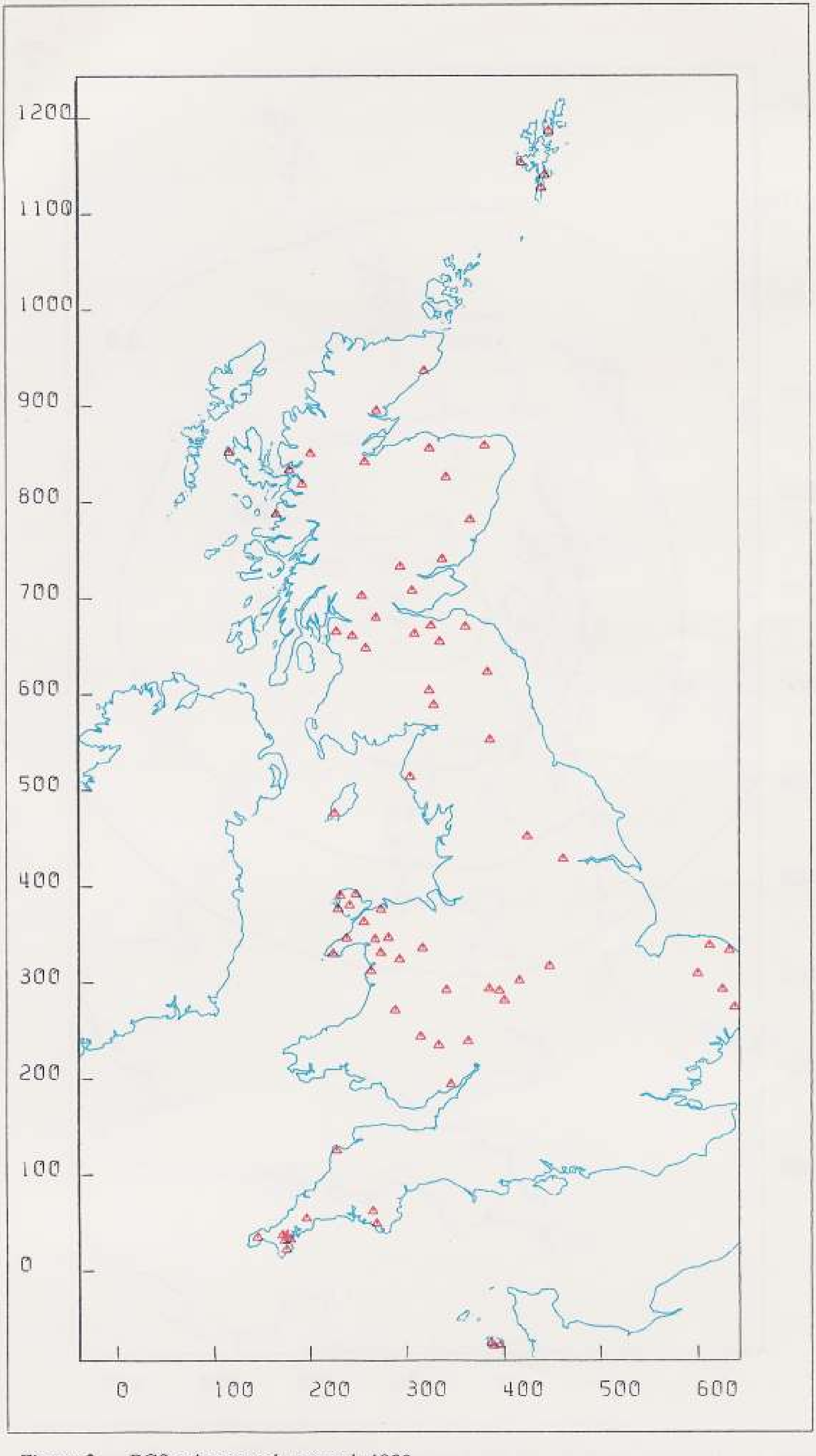

Figure 2. BGS seismograph network 1988.

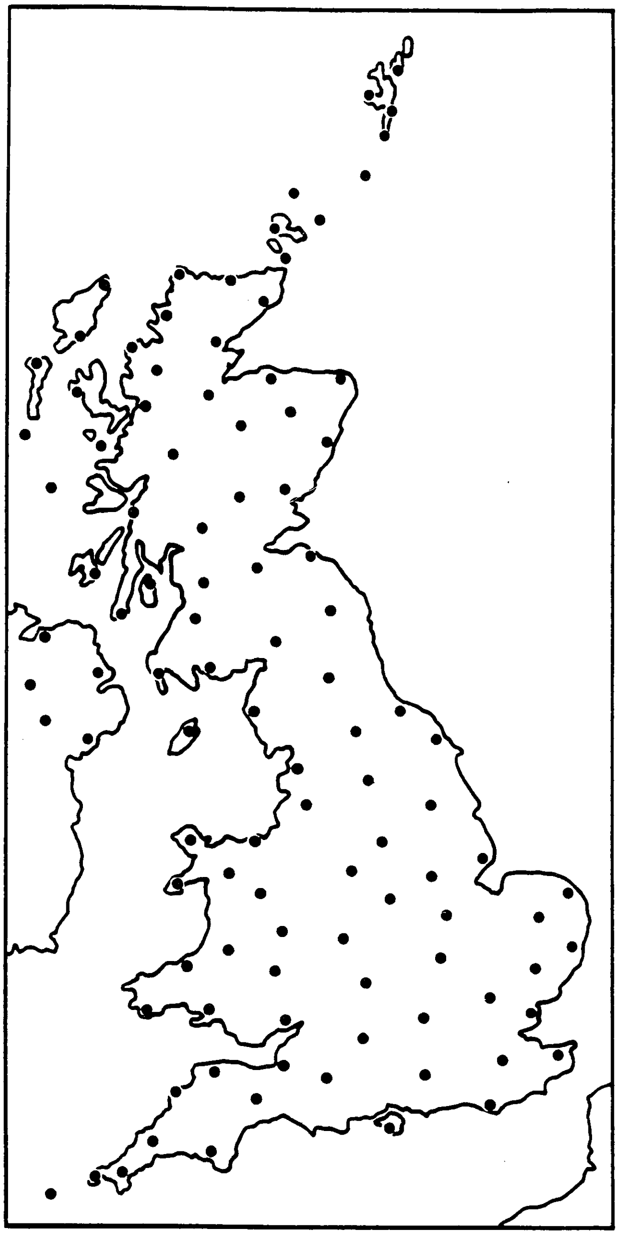

Figure 3. Proposed UK background seismic monitoring network with an average station spacing of 70 km.

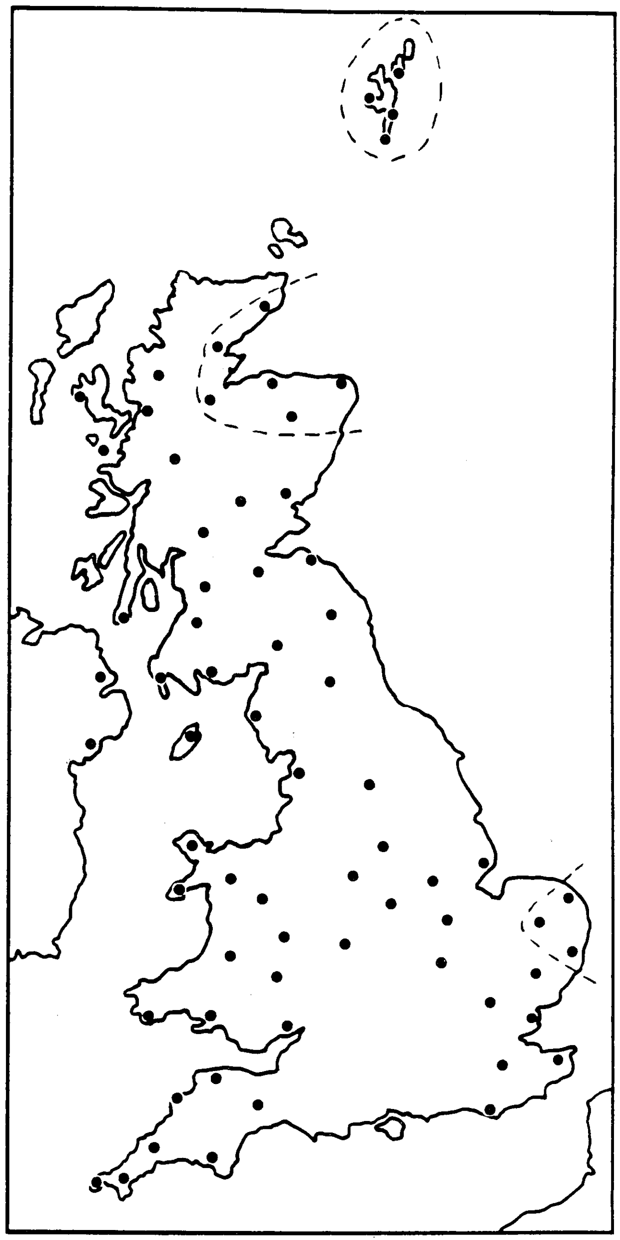

Figure 4. Proposed UK seismograph network for 1990. Dashed lines enclose stations for which support is not yet secure.

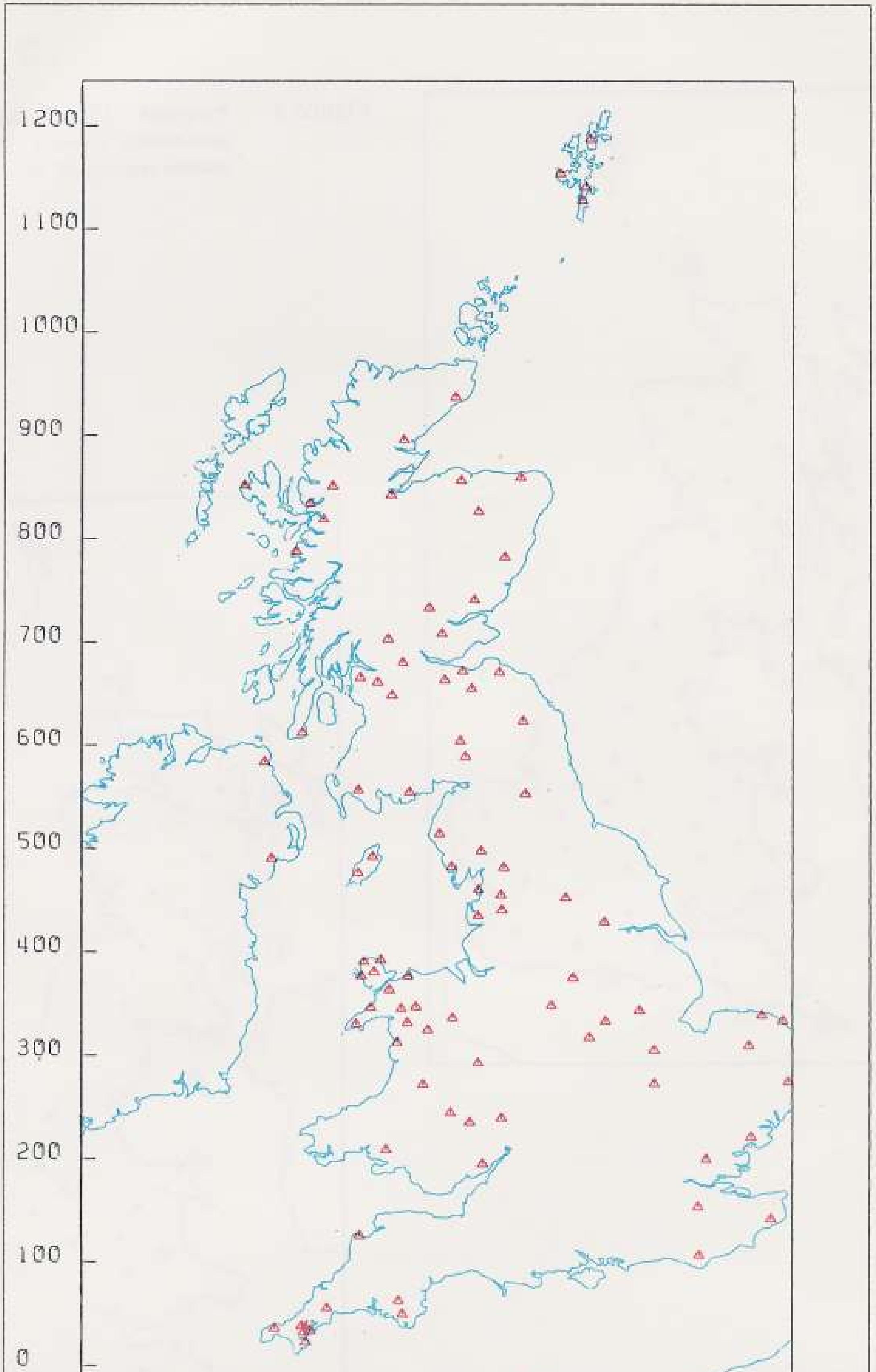

Figure 5. BGS seismograph network operational in December 1989.

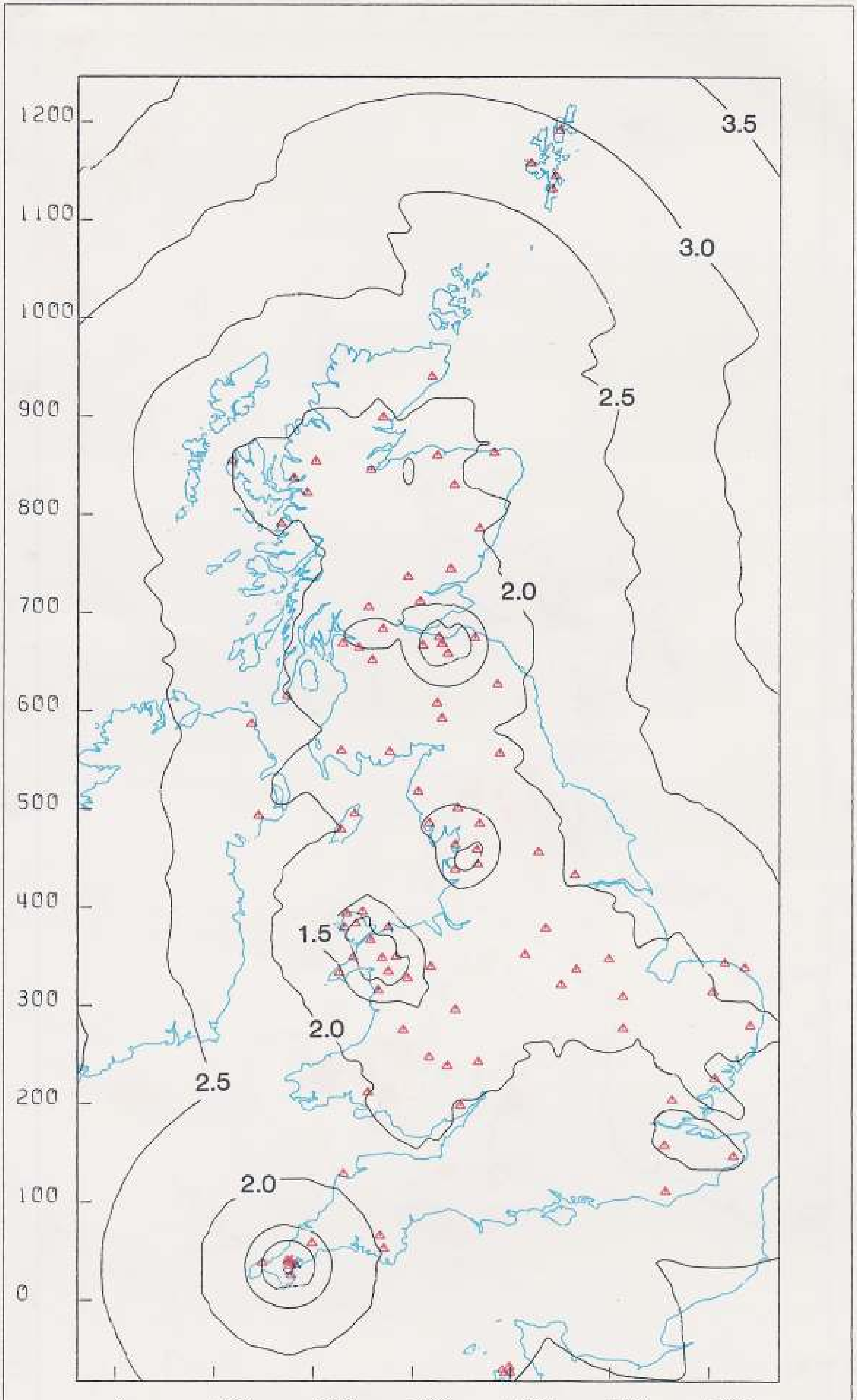

Figure 6. Earthquake identification capability. Contour values are Richter local magnitude (ML) for 20 nanometer noise and S-wave amplitudes twice that at the fifth nearest station.

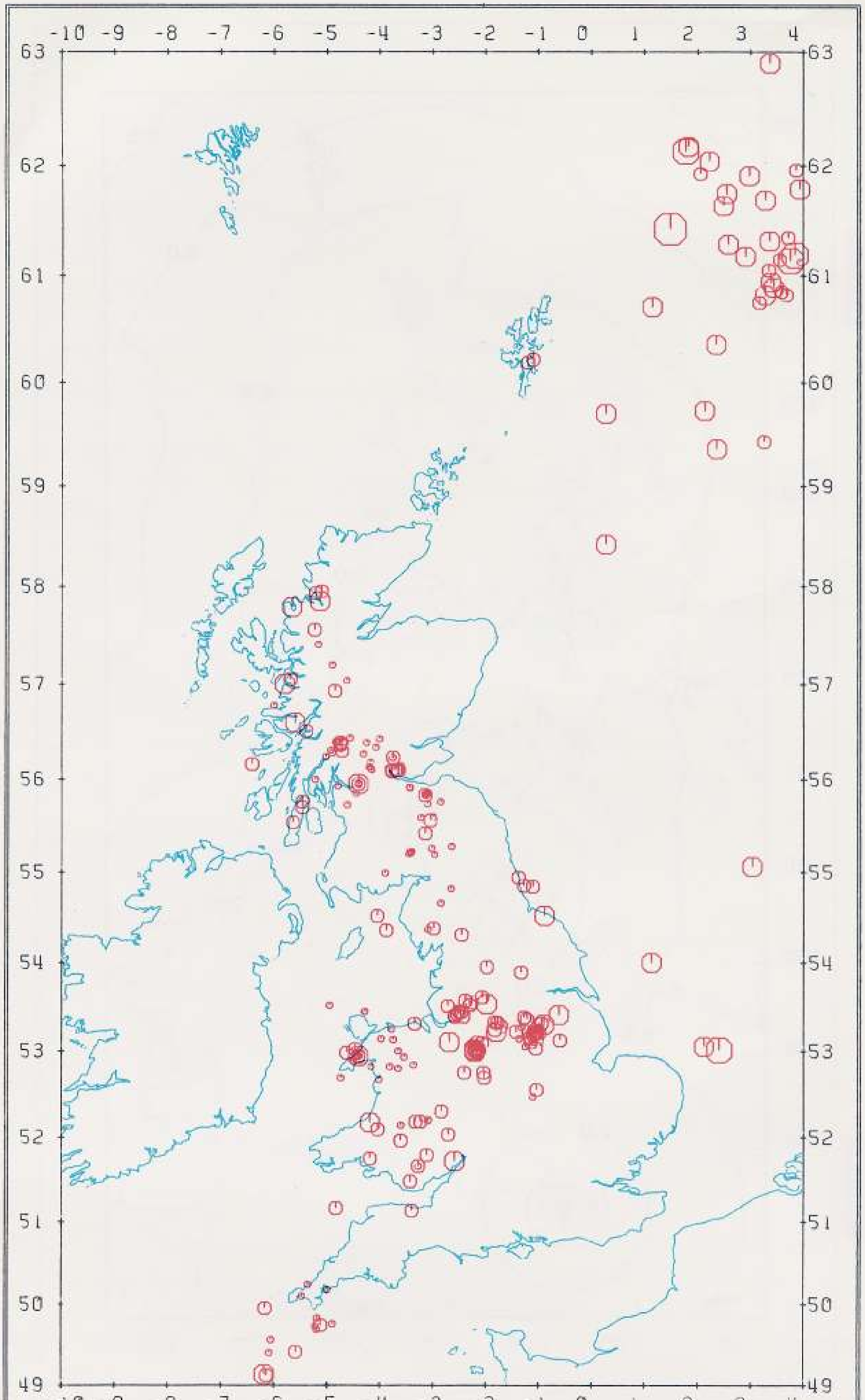

Figure 7. Epicentres of all UK earthquakes located in 1989.

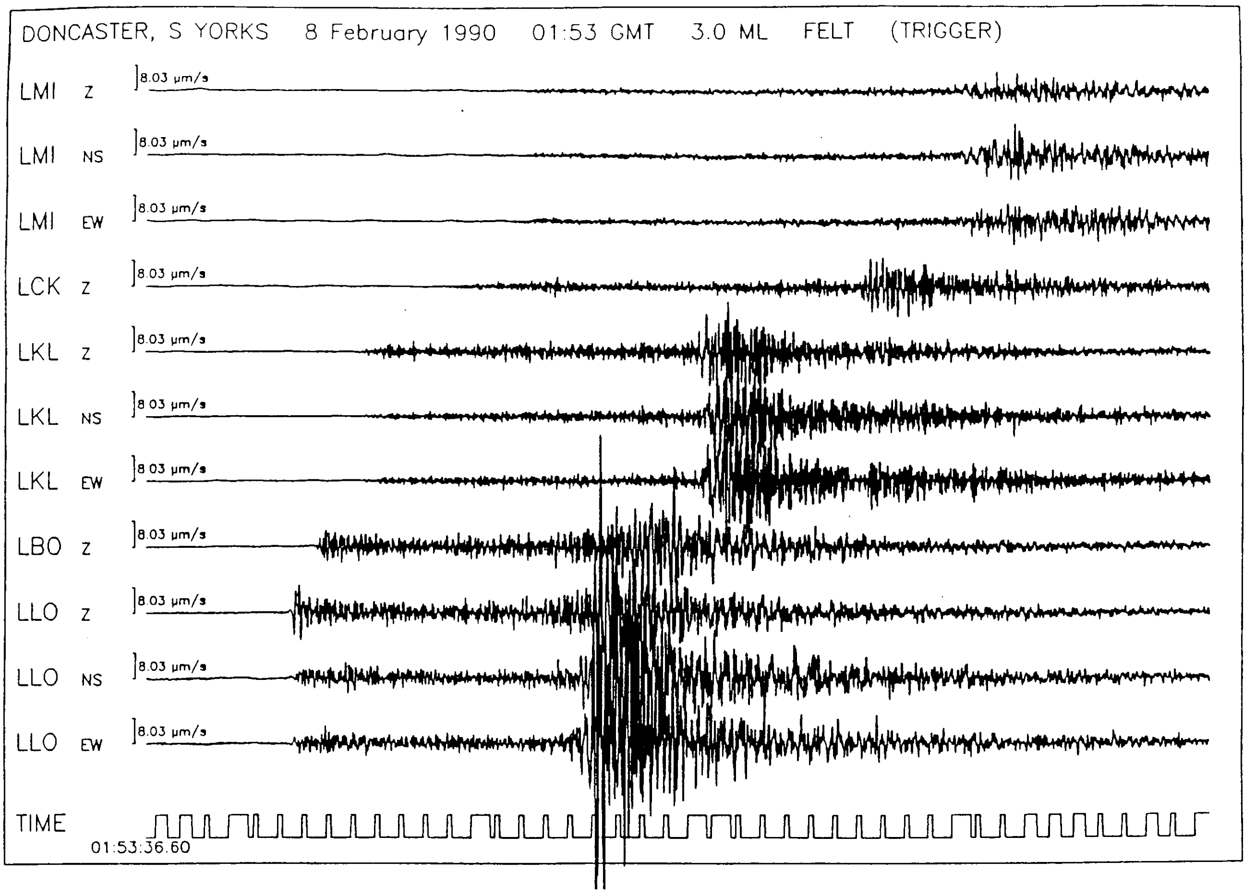

Figure 8. **Seismograms recorded in Lancashire from a magnitude 3.0 ML earthquake near Doncaster on 8 February 1990. It was felt in the Sheffield and Doncaster area. Three letter codes refer to stations listed in Annex E.**

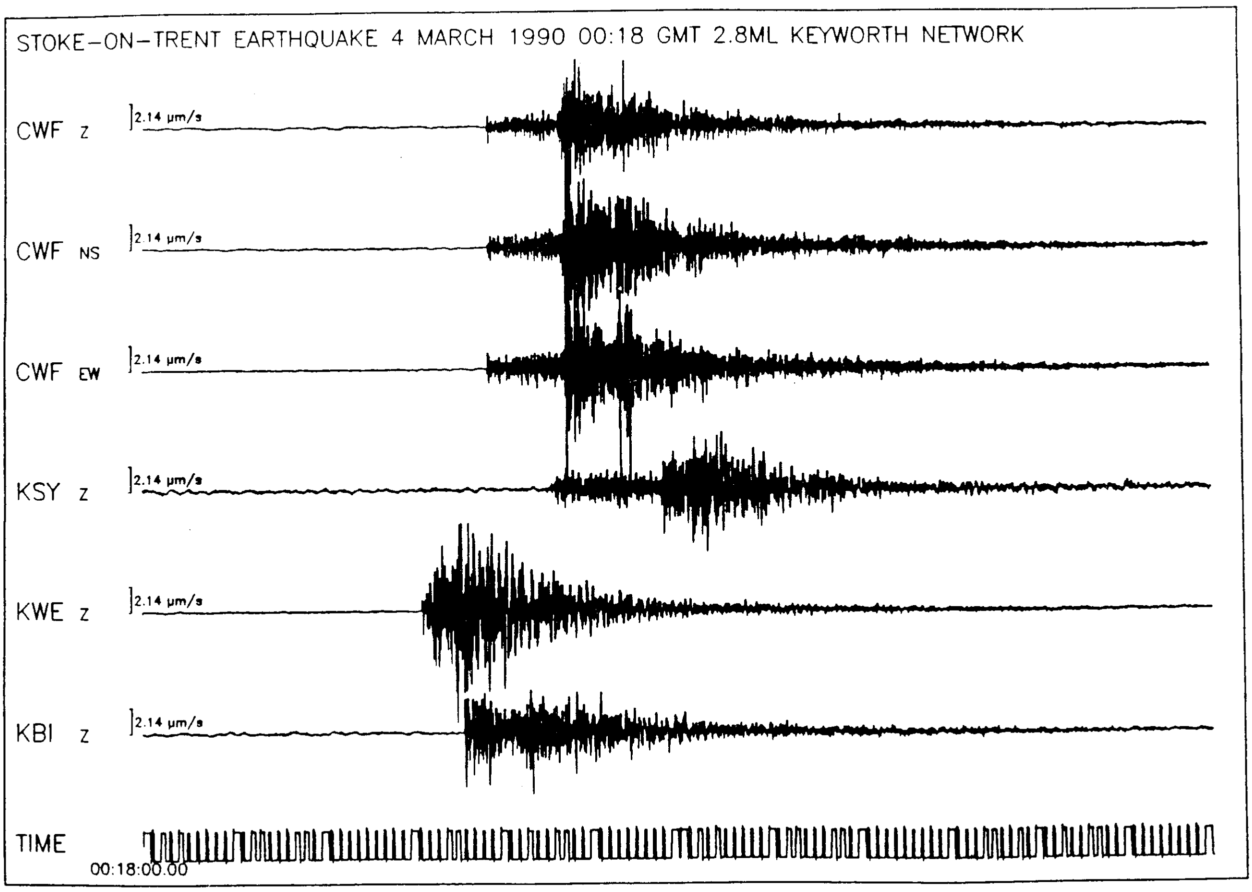

Figure 9. **Seismograms recorder in Leicestershire and Nottinghamshire from a magnitude 2.8 ML earthquake NE of Stoke on Trent on 4 March 1990 which was felt over a distance of some 30 km. Three letter codes refer to stations listed in Annex E.**

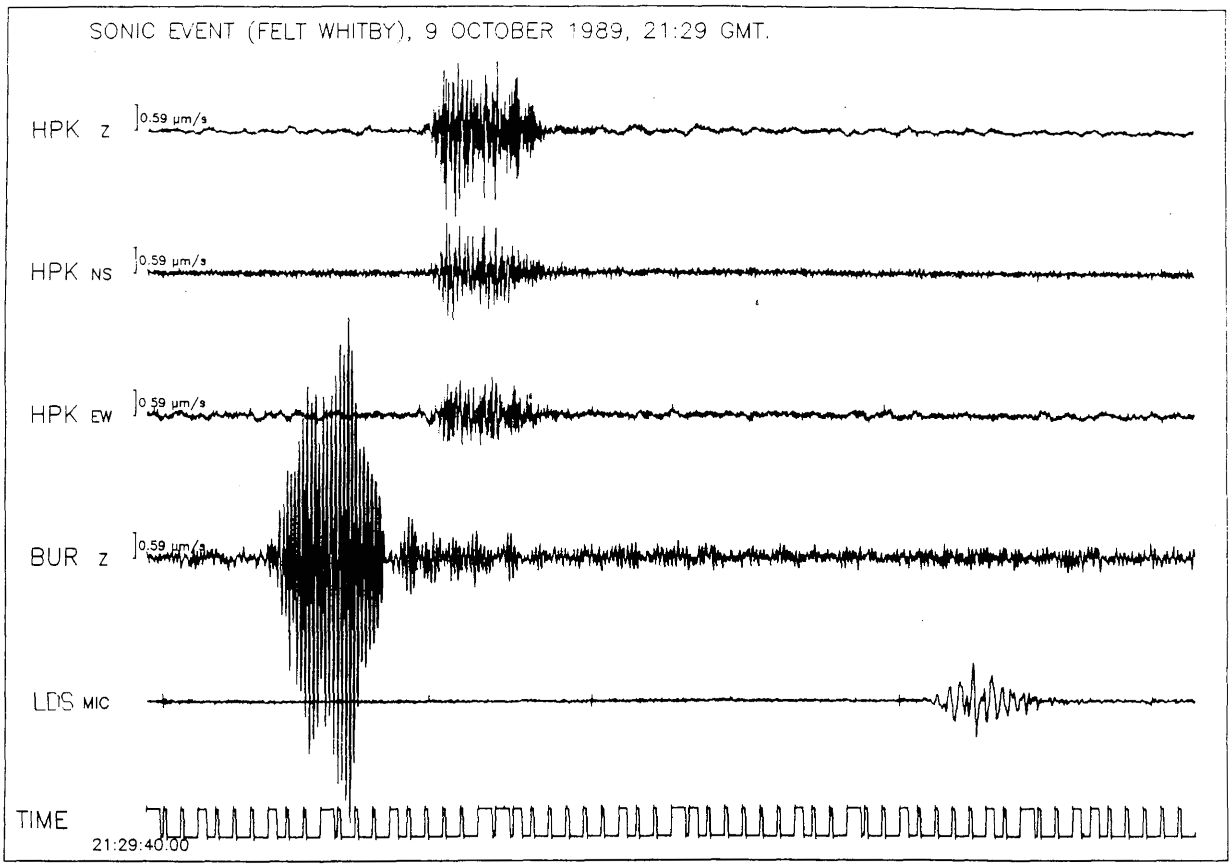

Figure 10. Seismograms recorded near Harrogate and Leeds from a sonic boom which was felt and heard in Whitby on 9 October, 1989. The top traces are from seismometers, the bottom one from a microphone. Three letter codes refer to stations listed in Annex E.

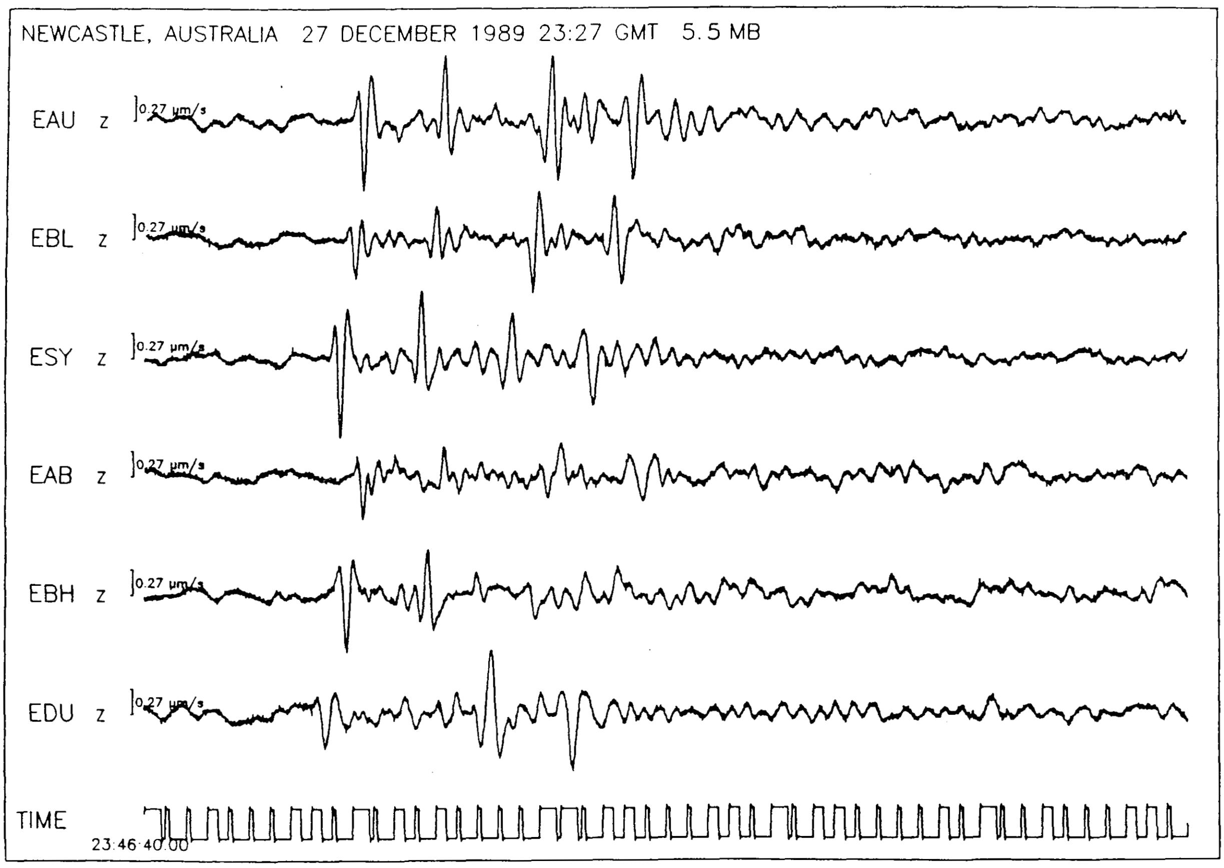

Figure 11. Seismograms recorded around Edinburgh, Scotland, from the magnitude 5.5 Mb Newcastle, Australia, earthquake of 27 December, 1989, which caused 11 deaths. Three letter codes refer to stations listed in Annex E.

CONTRIBUTORS TO THE PROJECT

Department of the Environment
British Nuclear Fuels plc
AEA Technology (formerly the UK Atomic Energy Authority)
Department of Economic Development (N Ireland)
Department of the Environment (N Ireland)
Nuclear Installations Inspectorate
Scottish Hydroelectric plc (formerly North of Scotland Hydro Electricity Board)
British Coal
Renfrew District Council
Natural Environment Research Council

Nuclear Electric plc (formerly CEGB)	Data
Scottish Nuclear plc (formerly SSEB)	Data
Ministry of Defence	Data
Department of Energy	Equipment

Customer Group Members (not contributing in Year One)

British Gas
Nirex
Building Research Establishment
Department of Trade and Industry
Health and Safety Executive
Scottish Development Department
Welsh Office
International Seismological Centre

EARTHQUAKES WITH MAGNITUDES $\geq$ 2.0 RECORDED IN THE UK AND OFFSHORE WATERS: 1989

EVENTS $\geq$2.0 ONSHORE UK

Date	HrMnSecs	Lat	Lon	KmE	KmN	Dep	Mag	Locality	Int	No	DM	Gap	RMS	ERH	ERZ	Q	SQD	Comments...
070189	141637.6	53.01	-2.19	387.6	346.3	3.3	2.1	STOKE-ON-TRENT,STAFFS		15	23	117	0.14	0.6	1.3	B	A*C	
040289	002817.1	53.32	-0.89	473.9	380.5	0.7	2.2	E.RETFORD,NOTTS		9	43	252	0.36	7.2	3.6	D	D*D	COALFIELD TYPE
230289	195826.2	52.19	-4.18	251.1	256.7	8.2	2.3	NEW QUAY,DYFED		31	56	147	0.26	0.6	1.6	C	B*D	
230289	195826.3	52.19	-4.17	251.9	256.5	7.8	2.3	NEWQUAY,DYFED		30	49	82	0.31	0.8	1.5	C	C*C	
280289	133831.5	57.87	-5.11	215.5	891.3	3.0	2.2	ULLAPOOL,HIGHLAND	2	16	43	181	0.29	1.4	2.2	C	B*D	FELT STRATHKANAIRD
010389	101937.9	55.97	-4.39	250.7	678.0	4.0	2.3	STRATHBLANE,S'CLYDE		21	19	130	0.07	0.2	0.6	B	A*C	
200489	115907.4	51.74	-2.57	360.4	204.6	2.7	2.1	LYDNEY,GLOUCESTERSHIRE		11	20	232	0.46	4.1	3.6	D	C*D	
200489	120839.6	53.55	-1.97	402.2	406.4	4.6	2.2	MOSSLEY,GT.MANCHESTER		11	50	206	0.09	2.8	1.6	D	C*D	
210489	223654.7	57.81	-5.64	183.9	886.1	17.8	2.1	POOLEWE,HIGHLAND		7	40	323	0.05	1.0	0.6	C	B*D	
230489	214353.8	53.43	-0.61	492.6	393.7	18.1	2.4	E OF GAINSBOROUGH,LINC		9	46	212	0.15	1.3	1.3	C	B*D	
020589	122740.7	53.03	-2.19	387.3	348.3	3.9	2.0	STOKE-ON-TRENT,STAFFS		16	23	153	0.14	0.8	1.5	B	A*C	
070589	231601.1	53.04	-2.20	386.8	348.6	3.2	2.0	STOKE-ON-TRENT,STAFFS		17	24	154	0.18	0.9	2.0	C	B*C	
100689	084121.9	53.03	-2.19	387.2	348.2	4.5	2.2	STOKE-ON-TRENT,STAFFS		21	24	138	0.19	0.7	1.5	C	B*C	
100689	092851.2	53.03	-2.18	387.8	348.4	5.3	2.0	STOKE-ON-TRENT,STAFFS		20	23	137	0.14	0.5	0.8	B	A*C	
110789	121331.3	56.62	-5.58	180.4	753.2	0.7	2.1	LOCHUISGE,MORVERN		10	37	202	0.34	5.0	3.7	D	C*D	
280789	135816.5	52.96	-4.39	239.4	342.9	24.1	2.1	LLEYN AFTERSHOCK		18	3	88	0.09	0.4	0.9	A	A*A	
040989	124814.7	53.24	-1.79	413.7	371.8	0.5	2.1	BUXTON,DERBYSHIRE		11	105	312	0.22	13.8	9.2	D	D*D	COALFIELD TYPE
050989	161323.7	54.54	-0.88	472.3	516.1	0.4	2.4	LOFTUS,CLEVELAND	4+	19	81	236	0.36	2.8	1.8	D	C*D	FELT EASINGTON,BOULBY
250989	102705.0	53.12	-2.67	355.3	357.9	7.2	2.0	RIDLEY,CHESHIRE		15	46	276	0.25	2.9	4.5	D	C*D	
221089	200043.0	57.02	-5.78	170.5	798.9	7.1	2.2	LOCH NEVIS		17	12	117	0.26	1.2	1.6	B	B*B	

EVENTS $\geq$2.0 NORTH SEA REGION

Date	HrMnSecs	Lat	Lon	KmE	KmN	Dep	Mag	Locality	Int	No	DM	Gap	RMS	ERH	ERZ	Q	SQD	Comments...
140289	204419.1	61.16	3.76			10.2	3.0	NORTHERN NORTH SEA		11	55	262	0.19	2.3	1.4	C	B*D	
280389	143030.6	58.44	0.28			5.0	2.8	PIPER ALPHA TOPPLE		16	178	163	0.36	2.1	411.7	D	C*D	PIPER ALPHA TOPPLING EXPLN
060489	103301.7	60.96	3.39			21.5	2.1	NORTHERN NORTH SEA		14	75	250	0.31	2.9	3.9	D	C*D	
100489	114308.5	59.38	2.37			1.0	2.3	NORTHERN NORTH SEA		14	165	291	0.35	12.1	13.3	D	D*D	
110489	083705.4	62.19	1.84			0.3	2.4	NORTHERN NORTH SEA		10	200	337	0.24	78.0	92.7	D	D*D	
120489	213005.5	61.93	2.99			0.5	2.1	NORTHERN NORTH SEA		8	135	319	0.68	11.5	4.9	D	D*D	
160489	092714.0	61.21	3.85			8.3	3.0	NORTHERN NORTH SEA		8	52	278	0.15	2.2	2.4	C	B*D	
180489	192839.0	60.38	2.36			1.0	2.0	NORTHERN NORTH SEA		8	156	298	0.93	40.6	45.5	D	D*D	
030589	054253.9	61.45	1.50			34.7	4.0	NORTHERN NORTH SEA		28	172	223	0.73	5.6	91.4	D	D*D	
120589	192626.2	59.75	2.14			15.0	2.3	NORTHERN NORTH SEA		10	186	296	0.81	34.2	44.6	D	D*D	
170589	124231.5	61.77	2.57			12.1	2.6	NORTHERN NORTH SEA		20	122	215	0.45	3.9	4.9	D	C*D	
170689	101440.1	60.91	3.44			19.2	2.1	NORTHERN NORTH SEA		21	73	176	0.30	2.4	2.1	C	B*D	
030789	152808.3	61.81	3.94			0.2	2.0	NORTHERN NORTH SEA		18	50	291	0.67	5.5	4.2	D	D*D	
020989	000847.9	61.20	2.92			16.5	2.0	NORTHERN NORTH SEA		8	101	326	0.21	4.4	2.2	D	C*D	
020989	001745.3	61.34	3.37			17.3	2.4	NORTHERN NORTH SEA		12	81	301	0.23	2.6	1.4	D	C*D	
110989	134502.7	62.92	3.37			10.0	2.5	NORTHERN NORTH SEA		15	151	337	0.46	9.7	8.2	D	D*D	
210989	134122.6	62.15	1.79			10.0	3.0	NORTHERN NORTH SEA		20	199	255	0.51	9.4	9.2	D	D*D	
031089	214930.2	61.31	2.60			10.0	2.0	NORTHERN NORTH SEA		10	120	307	0.50	7.0	5.8	D	D*D	
041089	234745.7	60.84	3.28			9.0	2.3	NORTHERN NORTH SEA		10	84	304	0.70	8.2	5.0	D	D*D	
091089	193426.5	53.03	2.42			0.0	3.2	SOUTHERN NORTH SEA		17	87	287	0.69	6.3	3.6	D	D*D	
271089	032452.3	61.66	2.51			1.0	2.3	NORTHERN NORTH SEA		16	138	228	0.86	9.1	6.4	D	D*D	

ANNEX B

F A X

BRITISH GEOLOGICAL SURVEY
MURCHISON HOUSE
WEST MAINS ROAD
EDINBURGH EH9 3LA

TEL: 031 667 1000
TLX: 727343 SEISED G
FAX: 031 667 1877 GSRG BGS

TO:

B R MARKER	- DOE	N J FULFORD	- BRITISH GAS
J COLLOFF	- BNFL	T JONES	- NIREX
A LORD	- BNFL	T A F WILLIS	- SSEB
C WILSON	- DED	P J FORD	- UKAEA
D J MALLARD	- CEGB	T M JOWITT	- BRITISH COAL
W P ASPINALL	- AA	F K GROSZMANN	- H&S EXEC
C BEAK	- HYDROBOARD	K D KANE	- DOE(NI)
R J STUBBS	- NII		
C PATCHETT	- NII	R T HAWORTH	- BGS, KEYWORTH
		M RAINES	- BGS, KEYWORTH

FROM: C W A BROWITT / D W REDMAYNE

DATE: 26 JANUARY 1990

TIME: 15.10

PAGES TO FOLLOWS: ONE

SEISMIC ALERT: COLONSAY / MULL - 26 JANUARY 1990

AN EARTHQUAKE OCCURRED IN THE MULL COLONSAY REGION TODAY WITH PROVISIONAL MAGNITUDE OF 3.0 ML. PRELIMINARY DETAILS ARE:

DATE: 26 JANUARY 1990

TIME: 13.42 GMT

GRID EAST: 127 KM E

GRID NORTH: 715 KM N

MAGNITUDE: 3.0 ML

INTENSITY: NO FELT REPORTS AT PRESENT

F A X

BRITISH GEOLOGICAL SURVEY
MURCHISON HOUSE
WEST MAINS ROAD
EDINBURGH EH9 3LA

TEL: 031 667 1000
TLX: 727343 SEISED G
FAX: 031 667 1877 GSRG BGS

TO:

B R MARKER	- DOE	N J FULFORD	- BRITISH GAS
J COLLOFF	- BNFL	T JONES	- NIREX
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C WILSON	- DED	P J FORD	- UKAEA
D J MALLARD	- CEGB	T M JOWITT	- BRITISH COAL
W P ASPINALL	- AA	F K GROSZMANN	- H&S EXEC
C BEAK	- HYDROBOARD	F D KANE	- DOE(NI)
R J STUBBS	- NII		
C PATCHETT	- NII	R T HAWORTH	- BGS, KEYWORTH
		M RAINES	- BGS, KEYWORTH

FROM: C W A BROWITT

DATE: 5.3.90

TIME: 10.45 onwards

PAGES TO FOLLOWS: NONE

SEISMIC ALERT - 4 MARCH 1990

AN EARTHQUAKE WAS REPORTED TO BE FELT WIDELY IN THE STOKE-ON-TRENT AREA EARLY ON SUNDAY 4 MARCH WITH MANY PEOPLE AWAKENED. PRELIMINARY DETAILS ARE AS FOLLOWS:

TIME: 00.18 GMT

DATE: 4 MARCH 1990

MAGNITUDE: 3.0 ML

INTENSITY: V MSK

A SMALLER EVENT (MAGNITUDE 2.3 ML) WAS FELT IN THE AREA AT 1309 ON MONDAY 26 FEBRUARY. THE NEAREST SEISMOGRAPH STATIONS SHOW SIGNALS WHICH HAVE SOME CHARACTERISTICS OF MINING-INDUCED EARTHQUAKES.

SUCH EVENTS HAVE BEEN COMMON IN THIS AREA IN RECENT YEARS WITH PARTICULARLY STRONG SEQUENCES IN THE MID 1970S AND EARLY 1980s.

A MACROSEISMIC SURVEY WILL BE CONDUCTED.

ANNEX C

BGS STAFF WITH INPUT TO THE PROJECT

Dr C W A Browitt

Mr P S Day

Mr C J Fyfe

Mr D D Gallowy

Mr D J Houliston

Mr N S Hunt

Mr J Laughlin

Mrs Y Liu

Miss A I McCluskie

Mr P C Marrow

Mr A Miller

Mr S N Morgan

Dr R M W Musson

Mr D L Petrie

Mr D W Redmayne

Mrs J A Richards

Mrs M E A Ritchie

Mr D A Stewart

Mrs R V Thomson

Mr T Turbitt

Mr W A Velzian

Miss A B Walker

Mr R M Young

GEOGRAPHICAL CO-ORDINATES OF BGS SEISMOGRAPH STATIONS ANNEX E

Code	Name	Lat	Lon	GrE (Kms)	GrN (Kms)	Ht (M)	Yrs Open	Comp	Agency
SHETLAND									
LRW	LERWICK	60.1360	-1.1779	445.66	1139.27	100	78-	4R	BGS
SAN	SANWICK	60.0176	-1.2386	442.44	1126.05	155	85-	1	BGS
WAL	WALLS	60.2576	-1.6133	421.40	1152.60	170	80-	1	BGS
YEL	YELL	60.5509	-1.0830	450.29	1185.55	200	79-	1	BGS
MORAY									
MCD	COLEBURN DISTIL	57.5827	-3.2541	325.02	855.41	280	81-	4R	BGS
MDO	DOCHFOUR	57.441	-4.363	258.17	841.43	366	81-	1	BGS
MFI	FISHRIE	57.6116	-2.2953	382.36	857.97	220	88-	1	BGS
MLA	LATHERON	58.305	-3.364	320.1	935.9	190	81-	1	BGS
MME	MEIKLE CAIRN	57.315	-2.965	341.9	825.3	455	81-	1	BGS
MVH	ACHVAICH	57.9232	-4.1816	270.8	894.7	198	84-	1	BGS
KYLE									
KAC	ACHNASHELLACH	57.4999	-5.2982	202.4	850.3	330	83-	1	BGS
KAR	ARISAIG	56.9175	-5.8302	166.9	787.2	225	83-	1	BGS
KPL	PLOCKTON	57.3391	-5.6527	180.21	833.50	36	86-	4R	BGS
KSB	SHIEL BRIDGE	57.2098	-5.4230	193.3	818.4	70	83-	1	BGS
KSK	SCOVAL	57.4653	-6.7020	118.1	851.4	250	89-	1	BGS
LOWNET									
EAB	ABERFOYLE	56.1881	-4.3400	254.80	701.95	250	69-	1R	BGS
EAU	AUCHINOON	55.8444	-3.4547	308.92	662.20	350	69-	1R	BGS
EBH	BLACK HILL	56.2481	-3.5081	306.56	707.19	375	69-	1R	BGS
EBL	BROAD LAW	55.7733	-3.0436	334.54	653.82	365	69-	1R	BGS
EDI	EDINBURGH	55.9233	-3.1861	325.89	670.66	125	69-	3R	BGS
EDR	DRUMTOCHTY	56.9189	-2.5392	367.18	780.96	388	89-	3R	BGS
EDU	DUNDEE	56.5475	-3.0142	337.65	739.95	275	69-	1R	BGS
ELO	LOGIEALMOND	56.4706	-3.7119	294.55	732.23	495	69-	1R	BGS
ESY	STONEYPATH	55.9177	-2.6144	361.60	669.56	328	81-	1R	BGS
PAISLEY									
PCA	CARROT	55.700	-4.255	258.3	647.5	305	83-	1	BGS
PCO	CORRIE	55.988	-4.097	269.0	679.3	274	83-	1	BGS
PGB	GLENIFFERBRAES	55.810	-4.478	244.5	660.5	200	84-	3	BGS
PMS	MUIRSHIEL	55.846	-4.744	228.2	664.8	351	83-	1	BGS
ESKDALEMUIR									
ESK	ESKDALEMUIR	55.3167	-3.2050	323.53	603.17	263	65-	3R	BGS
ECK	CAULDKAINE HILL	55.1812	-3.1271	328.23	588.02	337	81-	1R	BGS
XAL	ALLENDALE	54.8617	-2.2147	386.2	551.8	462	83-	1R	BGS
XDE	DENT	54.5058	-3.4897	303.5	513.3	291	83-	1R	BGS
XSO	SOURHOPE	55.4925	-2.2511	384.13	622.11	495	83-	1R	BGS
GALLOWAY AND N IRELAND									
GAL	GALLOWAY	54.8664	-4.7114	226.02	555.78	105	89-	3	BGS
GCD	CASTLE DOUGLAS	54.8638	-3.9417	275.39	553.84	189	89-	1	BGS
GCL	CUSHENDALL	55.076	-6.130	136.4	583.7	275	89-	1	BGS
GIM	N ISLE OF MAN	54.2923	-4.4670	239.45	491.34	366	89-	1	BGS
GMK	MULL OF KINTYRE	55.3459	-5.5936	172.18	611.65	160	89-	1	BGS
GMM	MTNS OF MOURNE	54.239	-5.951	142.6	489.8	140	89-	1	BGS

GEOGRAPHICAL CO-ORDINATES OF BGS SEISMOGRAPH STATIONS

Code	Name	Lat	Lon	GrE (Kms)	GrN (Kms)	Ht (M)	Yrs Open	Comp	Agency
LANCASHIRE									
LBO	BOWLAND	53.9790	-2.5728	362.44	453.83	320	89-	1	BGS
LBH	MORECOMBE B102	54.0324	-2.9058	340.68	460.0	-85	90-	1	BGS
LCK	CROOK	54.3595	-2.8715	343.37	496.36	200	89-	1	BGS
LKL	KIRKBY LONSDALE	54.2185	-2.5345	365.15	480.46	396	89-	3	BGS
LLO	LONGRIDGE	53.8503	-2.5598	363.18	439.51	247	89-	3	BGS
LLY	LYTHAM ST.ANNES	53.7976	-2.9069	340.27	433.88	33	89-	1	BGS
LMI	MILLOM	54.2206	-3.3070	314.79	481.35	140	89-	3	BGS
LMU	MORECAMBE MICPH	54.0250	-2.9051	340.71	459.18	5	89-	1	BGS
LEEDS									
HPK	HAVERAH PARK	53.9554	-1.6240	424.67	451.12	227	78-	4R	BGS
BUWY	BURN	53.7424	-1.0668	461.54	427.76	13	84-	1R	BGS
NORTH WALES									
WBR	BRONABER	52.8560	-3.8941	272.48	330.43	340	85-	1	BGS
WCB	CHURCH BAY	53.3782	-4.5465	230.63	389.86	135	85-	3	BGS
WFB	FAIRBOURNE	52.6830	-4.0378	262.26	311.46	325	85-	1	BGS
WFF	FFESTINIOG	52.9788	-3.9877	266.55	344.26	500	85-	2	BGS
WIM	ISLE OF MAN	54.1472	-4.6735	225.41	475.70	365	85-	1	BGS
WLC	LLYN CONWY	52.9956	-3.7788	280.63	345.76	440	85-	3	BGS
WLF	LLYNFAES	53.2893	-4.3966	240.26	379.63	65	85-	1	BGS
WME	MYNDD EILIAN	53.3966	-4.3034	246.86	391.36	130	85-	1	BGS
WPM	PENMAENMAWR	53.2583	-3.9049	272.94	375.19	350	85-	1	BGS
WST	STWLAN	52.975	-3.989	266.45	343.85	580	86-	1	BGS
WVR	VYRNWY	52.7974	-3.6051	291.79	323.44	580	85-	1	BGS
YRC	RHOSCOLYN	53.2506	-4.5741	228.28	375.74	24	84-	1	BGS
YRE	YR EIFL	52.9810	-4.4254	237.18	345.41	197	84-	3	BGS
YLL	LLANBERIS	53.1402	-4.1704	254.84	362.56	162	84-	1	BGS
YRH	RHIW	52.8335	-4.6289	222.93	329.5	300	84-	1	BGS
KEYWORTH									
CWF	CHARNWOOD FST	52.7382	-1.3071	446.78	315.88	185	75-	3R	BGS
KBI	BIRLEY GRANGE	53.2551	-1.5275	431.52	373.26	270	88-	1	BGS
KEY	KEYWORTH	52.8774	-1.0751	462.24	331.54	75	88-	1	BGS
KSY	SYSTON	52.9642	-0.5873	494.87	341.73	123	88-	1	BGS
KTG	TILBROOK GRANGE	52.3261	-0.4007	508.98	271.03	78	88-	1	BGS
KUF	UFFORD	52.6175	-0.3895	509.02	303.45	35	88-	1	BGS
KWE	WEAVER FARM	53.0165	-1.8412	410.65	346.62	330	88-	1	BGS
EAST ANGLIA									
ABA	BACONSTHORPE	52.8875	1.1471	611.7	336.9	13	82-	1	BGS
APA	PACKWAY	52.2999	1.4779	637.1	272.6	35	84-	1	BGS
AWH	WHINBURGH	52.6299	0.9512	599.70	307.70	60	80-	1R	BGS
AWI	WITTON	52.8324	1.4460	632.1	331.7	35	83-	1	BGS
HEREFORD									
SBD	BRYN DU	52.9055	-3.2588	315.35	335.01	497	80-	1	BGS
MCH	MICHAELCHURCH	51.9977	-2.9983	331.47	233.77	229	78-	4	BGS
HAE	ALDERS END	52.0376	-2.5475	362.45	237.88	224	82-	1	BGS
HCG	CRAIG GOCH	52.3224	-3.6567	287.1	270.7	511	80-	1R	BGS
HGH	GRAY HILL	51.6380	-2.8064	344.2	193.6	210	80-	1	BGS

GEOGRAPHICAL CO-ORDINATES OF BGS SEISMOGRAPH STATIONS

Code	Name	Lat	Lon	GrE (Kms)	GrN (Kms)	Ht (M)	Yrs Open	Comp	Agency
HLM	LONG MYND	52.5169	-2.8878	339.8	291.4	259	84-	1	BGS
HTR	TREWERN HILL	52.0790	-3.2697	313.0	243.1	329	82-	1	BGS
SOUTH EAST ENGLAND									
TFO	FOLKSTONE	51.1136	1.1406	619.8	139.6	188	89-	1	BGS
TEB	EASTBORNE	50.8188	0.1459	551.3	104.5	70	89-	1	BGS
TSA	SEVENOAKS	51.2427	0.1558	550.4	151.5	170	89-	1	BGS
TBW	BRENTWOOD	51.6549	0.2911	558.4	197.8	82	89-	1	BGS
TCR	COLCHESTER	51.8349	0.9215	601.2	219.2	40	89-	1	BGS
CORNWALL									
CCA	CARNMENELLIS	50.1864	-5.2277	169.62	36.87	213	81-	1	BGS
CBW	BUDOCK WATER	50.1482	-5.1144	177.52	32.29	98	81-	1	BGS
CCO	CONSTANTINE	50.1357	-5.1960	171.64	31.14	183	81-	1	BGS
CGH	GOONHILLY	50.0508	-5.1649	173.46	21.61	91	81-	1	BGS
CME	MENERDUE FARM	50.1760	-5.1903	172.23	35.60	178	82-	3	BGS
CPZ	PENZANCE	50.1560	-5.5835	144.06	34.65	198	81-	1	BGS
CR2	ROSEMANOWES 2	50.1669	-5.1687	173.7	34.5	152	81-	3	BGS
CRA	RAME	50.1648	-5.1921	172.06	34.36	198	82-	3	BGS
CRQ	ROSEMANOWES	50.1672	-5.1728	173.44	34.57	165	81-	3R	BGS
CSA	ST AUSTELL	50.3528	-4.8936	194.18	54.39	113	81-	1	BGS
CST	STITHIANS	50.1952	-5.1635	174.24	37.66	139	81-	1	BGS
CTR	TROLVIS QUARRY	50.1665	-5.1624	174.18	34.46	191	82-	3	BGS
DEVON									
DCO	COMBE FARM	50.3200	-3.8724	266.72	48.42	410	82-	1	BGS
DYA	YADSWORTHY	50.4352	-3.9309	262.89	61.33	280	82-	3	BGS
HTL	HARTLAND	50.9944	-4.4850	225.63	124.66	91	81-	3R	BGS
HSA	SWANSEA	51.7478	-4.1543	251.3	207.7	274	87-	1	BGS

Notes

1. The UK seismograph network is divided into a number of subnetworks, named Cornwall, Devon, etc, within which data is transmitted, principally by radio, from each seismometer station to a central recorder where it is registered against a common, accurate time standard.

2. From left to right the column headers stand for Latitude, Longitude, Easting, Northing, Height, Year station opened, number of seismometers at the station and the agency operating the station (in this list they are all BGS).

3. The 'R' against some station components indicates that station details have been registered with international agencies for data exchange purposes.

PROJECT PUBLICATIONS

BGS SEISMOLOGY REPORTS

1989

Report No.

WL/89/1	MacBeth, C.D. & Redmayne, D.W. Source study of local coalfield events using the modal synthesis of shear and surface waves.
WL/89/2	Walker, A.B. SW England Seismic Monitoring for the HDR Geothermal Programme 1987-1988.
WL/89/9	Turbitt, T. (Ed), Atkins, M.J., Galloway, D., Innes, I.M., Marrow, P.C., Richards, J.A., Redmayne, D.W., Ritchie, M.E.A., Simpson, B.A. Smith, A.D., and Walker, A.B. Bulletin of British Earthquakes 1987.
WL/89/11	Musson, R.M.W. Seismicity of Cornwall and Devon.
WL/89/14	Musson, R.M.W. The 1941 North Wales Earthquake Sequence.
WL/89/19	Musson, R.M.W. An unknown 18th century seismological manuscript.
WL/89/26	Simpson, B. Bulletin of North Sea Earthquakes 1988 - June 1989.
WL/89/28	Turbitt, T., Petrie, D.L. and Stewart, D.A. An improved North Sea Seismic Data Acquisition system at Statfjord A.
WL/89/37	Marrow, P.C. A brief note on earthquake recurrence statistics, with an example.
WL/89/39	Musson, R.M.W. Seismic hazard assessment for Fort William.

1990

WL/90/3	Turbitt, T. (ed.), Galloway, D.D., Hunt, N.S., Marrow, P.C., Musson, R.M.W., Redmayne, D.W., Richards, J.A., Ritchie, M.E.A., Simpson, B. and Walker, A.B. Bulletin of British earthquakes 1988.
WL/90/06	Musson, R.M.W. The Earl's Burn dam burst of 1839: An earthquake triggered dam failure in the UK?.
WL/90/10	Musson, R.M.W. The 3 July 1862 Thurso earthquake.
WL/90/11	Laughlin, J. and Velzian, W.A. A thermal array recorder for seismic event triggering systems.

In addition, eight confidential reports were prepared for commercial customers.

EXTERNAL PUBLICATIONS

Aspinall, W.P., Skipp, B.O. and Ritchie, M.E.A., 1990. Microtremor networks and seismic hazard assessment in the UK, *Quart.J.Eng.Geol.*, (in press).

Lindholm, C. and Marrow, P.C., 1989. Ocean Bottom Seismometers in the North Sea, a case history. Bulletin of the Seismological Society of America (in press).

MacBeth, C.D. and Redmayne, D.W., 1989. Source study of local coalfield events using the modal synthesis of shear and surface waves, *Geophys.J.Int.*, **99**, 155-172.

Miller, A., Richards, J.A., McCann, D.M., Browitt, C.W.A. and Jackson, P.D. 1989. Microseismic techniques for monitoring incipient hazardous collapse conditions above abandoned limestone mines, *Quart.J.Eng.Geol.*, **22**, 1-18.

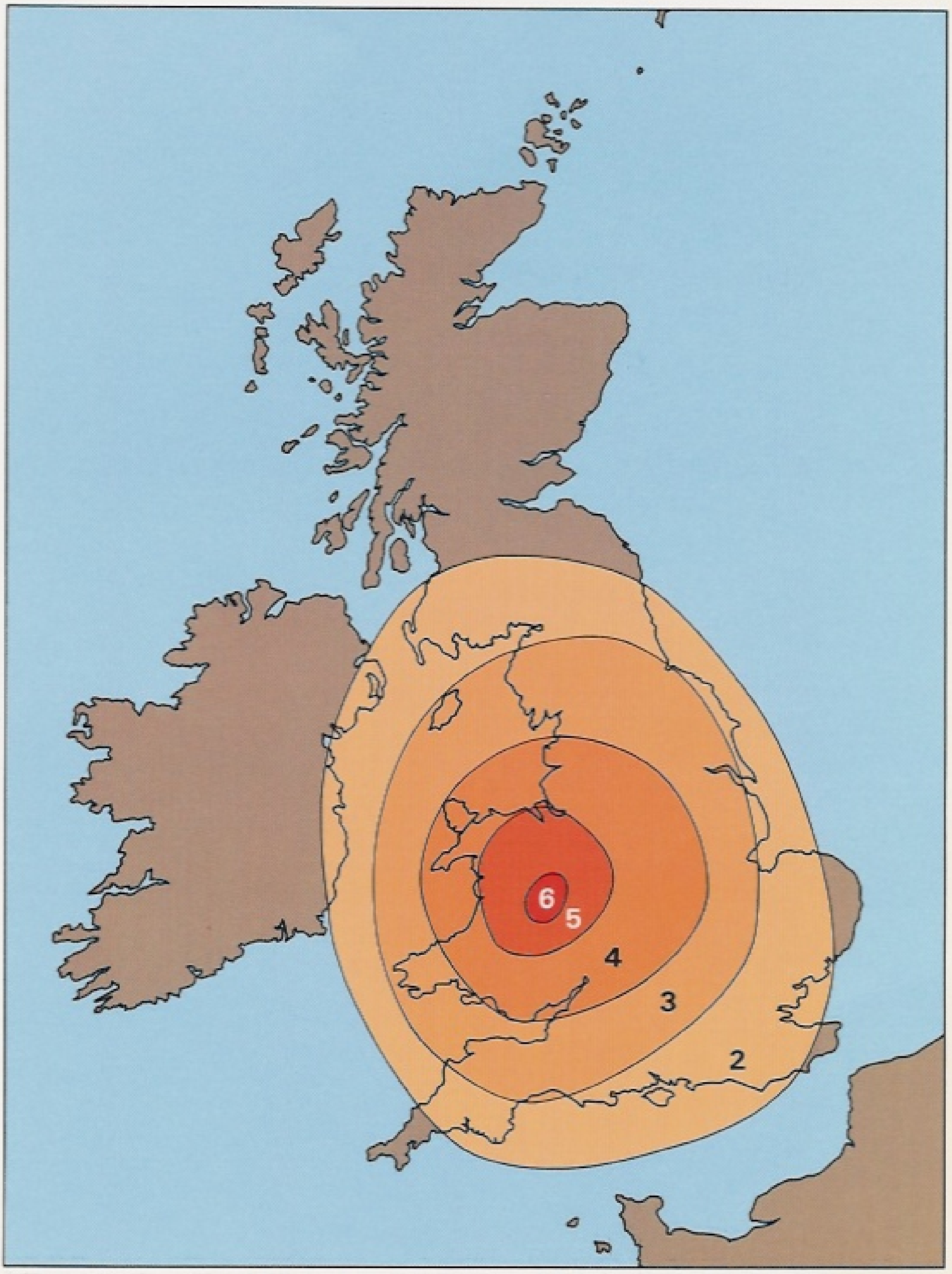
Musson, R.M.W., 1989. Accuracy of historical earthquake locations in Britain, *Geol. Mag.*, **126**, **6**, 685-689.

Redmayne, D.W. and Turbitt, T., 1989. Ground motion effects of the Lockerbie air crash impact. In: Proceedings of the United Kingdom Geophysical Assembly 1990, *Geophys.J.Int.* (in press).

Ritchie, M.E.A. and Walker, A.B., 1990. Fault-plane solutions from microearthquakes for North Wales and Cornwall and to the derivation of tectonic stress directions. In: Proceedings of the United Kingdom Geophysical Assembly 1990, *Geophys.J.Int.* (in press).

Turbitt, T., Browitt, C.W.A., 1989. Seismograph Networks of the United Kingdom: Present and Future. Proceedings of the Workshop on Seismic Networks and Rapid Digital Data Transmission and Exchange. Walferdange October 1989 (in press).

Natural Environment Research Council



Felt area of the magnitude 5.1 Bishop's Castle earthquake on 2 April 1990 with MSK intensity values