Measuring Ireland's Earthquakes

The Dublin Institute for Advanced Studies Regional Seismic Network

The Dublin Institute for Advanced Studies operates a digital short period network of permanent seismic recording stations in Ireland. The DNET network consists of the stations DLF, DCN, DMUB and are located in the eastern part of the country. The broadband station DSB (in association with GFZ Potsdam, Germany) is located south of Dublin in the Dublin mountains.

In the past in the south east of the country there was also a network of permanent short period digital recorders, ENET, comprising the stations ECB, ECP, and ETA. This network is currently not in operation. The station VAL in the south west of the country is operated by the Irish Meteorological Service and was part of the international WWSSN

DNET has been in operation since 1978 and ENET started in 1981 (it was closed down in 1999). DNET has been updated and enhanced over the years but is currently in great need of a significant injection of capital if we are to be able to work in line with our other European partners.

Currently there is a proposal for funding to expand and upgrade the network before the Government. Ireland is unique among its major European partners in that it is the only EU country that does not have a nationally funded regional seismic network.

The DIAS network is a continuously recording system, 365 days a year. It records all seismic events, local, regional and teleseismic (i.e. from all over the world from Kamchatcka in Siberia to San Francisco, and from Africa, Indonesia and Australia. Data are recorded on disks, which are then retrieved every fortnight.

It is also sensitive enough to register the shock waves associated with local quarry blasts above a certain threshold throughout Ireland, to locate them very accurately and use the data for further study of the deep structure of the earth. The seismic signature associated with a quarry blast is quite different from that associated with an earthquake whither it is a local, regional or teleseismic event. Controlled sources have been studied in order to calibrate the network which is also being used for structural studies of the earths crust.

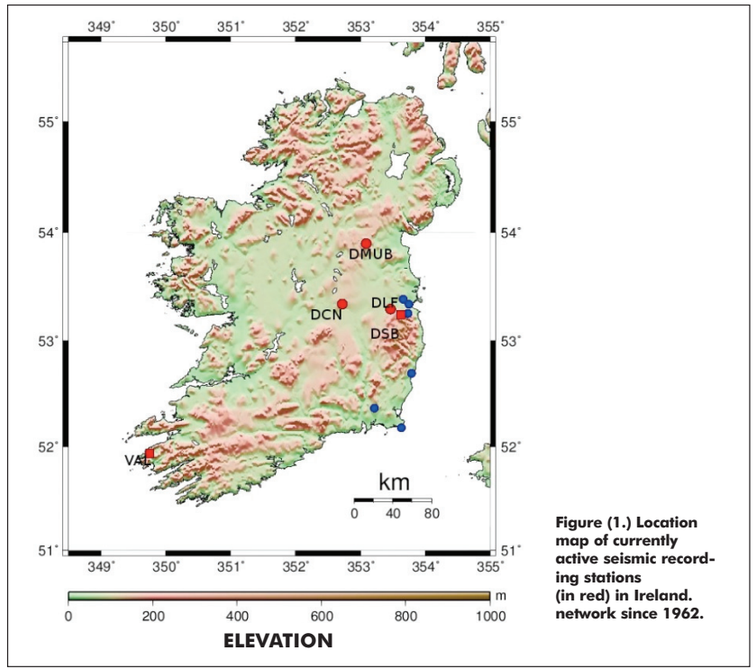
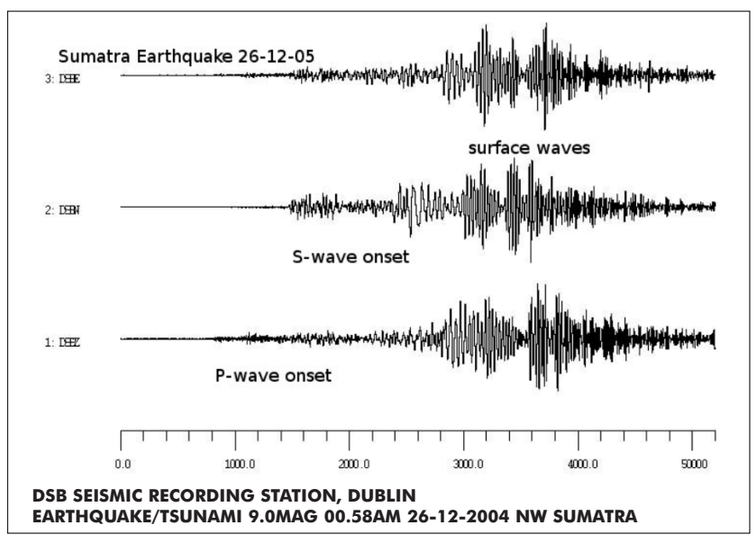


Figure (1.) Location map of currently active seismic recording stations (in red) in Ireland. network since 1962.

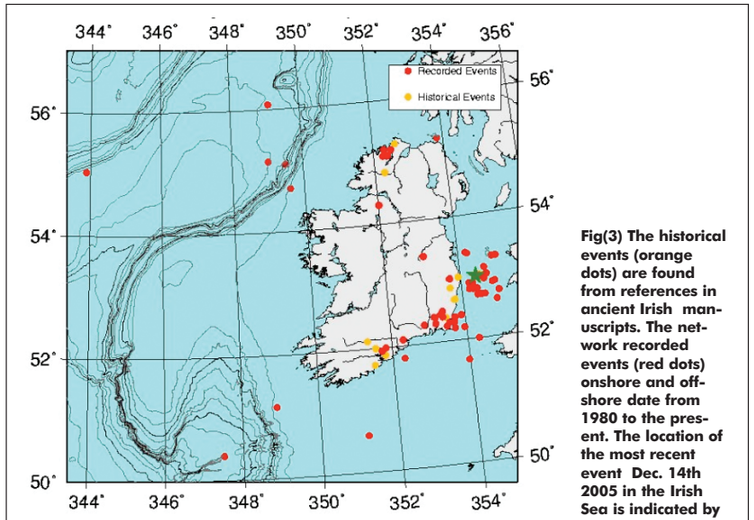
THE ANATOMY OF A SEISMOGRAM

Fig (2) is the seismogram of the devastating Sumatra Event of Dec 2005 recorded by our station DSB in the Dublin Mountains and is a good example to use to explain the nature of the different seismic waves associated with each seismic event.

A seismogram is a record of an earthquake and is made up of P-waves, S-waves and surface waves. The P-wave, or primary compressional wave is the first phase observed on the seismograms followed by the slower S-wave, or shear wave, then the surface waves. Identifying the first P-onset and the first S-onset and measuring the difference in their arrival time determines the distance of the earthquake from the seismometer. The three seismograms in Fig (2) represent the shock wave recorded at one location (in this case DSB) by each of three sensors at right angles to each other and labelled Z (vertical component), N (horizontal component in N-S direction) and E (horizontal component in E-W direction).



DSB SEISMIC RECORDING STATION, DUBLIN
EARTHQUAKE/TSUNAMI 9.0MAG 00.58AM 26-12-2004 NW SUMATRA



IRISH EARTHQUAKES (1980 - 2006)

Fig(3) The historical events (orange dots) are found from references in ancient Irish manuscripts. The network recorded events (red dots) onshore and offshore date from 1980 to the present. The location of the most recent event Dec. 14th 2005 in the Irish Sea is indicated by a green star.

Typical wave velocities for Ireland are P-waves 4-8 km/sec, S-waves 2-5 km/sec and surface waves 1.8-4.5 km/sec. The arrival times of the P and S waves at different seismic stations are used to determine the location of the earthquake. These waves travel away from the seismic source at velocities characteristic of the rocks they are passing through. The epicentre and depth of the earthquake focus are determined using several P and S-readings using a triangulation process. Surface waves are seen on shallow local earthquakes (<5km) but not on deeper ones. They are prominent on broadband stations for world earthquakes. In engineering terms it is the S-wave component that poses the greatest threat to structures for a typical seismic event.

.

SEISMICITY IN IRELAND

Contrary to popular belief, instrumentally recorded seismic events do occur each year in and around the island of Ireland and are recorded by our seismic network. There are 2 distinct areas of seismic activity around Ireland. The main seismic activity is in the southeast of the country and the neighbouring Irish Sea. These events are thought to be associated with major structural features originating from the Caledonian tectonic phases. This was a major episode of granite emplacement and geological structural activity more than 400 million years ago. The roughly NE-SW trend of the events reflect a similar fabric to the deep underlying Caledonian controls in this region. The tectonically complex region of the central Irish Sea is reflected in the very strong gravity gradients portraying a similar Caledonian orientation.

The second area is in the northwest of Ireland. The seismicity recorded here is in part due to the extension into Donegal of part of the large complex Scottish Highlands fault systems. Both networks are thus optimally sited to record any seismicity in these areas. There appears to be a complete absence of recorded events in the intervening area even though it includes major structural features.

The most notable features about Irish seismicity are the low magnitude, in general, of the events ~0.5-2.0 magnitude on the Richter Scale, however magnitudes as great as 5.4Ml have been recorded. They are deep events usually 10-20km deep, and occur either in the northwest, the southeast or in the Irish Sea.

LOCAL EVENTS RECORDED BY THE DIAS SEISMIC NETWORK

The pattern of instrumentally located events and the historical records of reported events show the same distribution. Fig (3)

Two terms that are important in talking about earthquakes are intensity and magnitude.

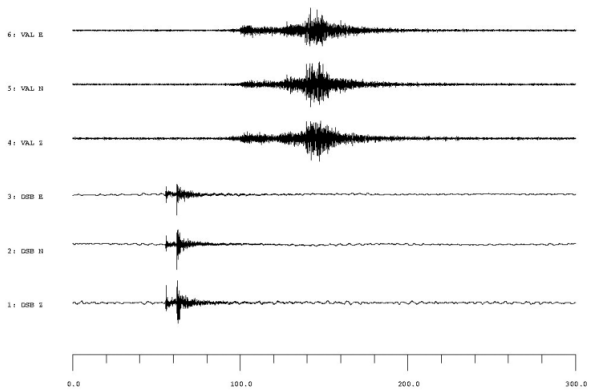
The intensity of an earthquake is a measure of ground shaking estimated from its observed effects, especially damage caused by the event. For each earthquake, the intensity varies from place to place; usually it is greatest close to the epicentre of the earthquake, dying off with increasing distance from there. These felt effects are then compiled into macroseismic maps showing lines of equal intensity (isoseismals). The intensity scale (using Roman numerals) varies from 1 – not felt (detected by instruments only) to XII Catastrophic – everything destroyed. This scale is based on the European Macroseismic Scale (EMS) and is a modified version of a similar scale designed by the Italian seismologist, Mercalli.

Magnitude is a measure of the size of an earthquake and the magnitude scale is logarithmic. It is related to the amount of seismic energy released into the Earth's crust (a magnitude 6 earthquake will move the ground 10 times more than a magnitude 5 event and releases 32 times the energy). Peak acceleration or peak velocity are read from the seismograms. Due to attenuation, different values of peak ground acceleration and peak ground velocity will be obtained from seismograms recorded at different distances from the earthquakes focus. Short period instruments are designed to record local earthquakes and are used to calculate local magnitude (ML) but designated Ml (i.e. L lowercase). The magnitude scale is known as the Richter Scale.

The most recent damaging earthquake in Ireland recorded by the DIAS network was on July 19th 1984. This was a deep crustal event of magnitude 5.4Ml whose epicentre was off the Lleyn Peninsula of NW Wales. This was felt widely in Britain and on the east coast of Ireland and caused some structural damage to houses on the east coast of Ireland.

The most recent earthquake felt by some people on the east coast occurred at 03:30am on Wednesday, December 14th 2005. It as felt by people from Roundwood in Wicklow as far north as Portmarnock in Co. Dublin. It measured 2.8 Ml magnitude and the epicentre was in the Irish Sea not far from the location of the January 1951 (recorded by the British Geological Survey – no Irish stations were recording at this time.) event of magnitude 4.8 Ml.

Most of the world's large earthquakes



DSB (DUBLIN MOUNTAINS) AND VAL (VALENTIA, CO KERRY) RECORDINGS OF EARTHQUAKE OF WICKLOW HEAD. TIME: 03:30 ON 14-DEC-2005, MAG, 2.8, DEPTH 10.00KM

Biography

Thomas Blake is Experimental Officer in the Geophysics Section of the School of Cosmic Physics in the Dublin Institute for Advanced Studies. Originally from Golden, in County Tipperary, his career path was strongly influenced by his father's (Daniel Blake) association with Gortdrum copper mines near Tipperary town where he worked as Purchasing Officer. Thomas has a B.A. Mod. Natural Science (Geology) from Trinity College and an M.Sc. in Geophysics from NUI, Galway. He has worked in Ireland, France and Africa as a Uranium prospecting geologist. Subsequently he worked with BP Ireland as a seismic data analyst. He joined DIAS in 1984 and has been involved in many international reflection and refraction seismic experiments in Europe, America and Africa. Currently he is responsible for the maintenance, upgrading and development of the DIAS Regional Seismic Network. For further information he can be contacted via email tb@cp.dias.ie

occur at plate boundaries. The greatest stresses do occur in these regions and these are large enough to generate faulting. In quieter zones, like the relatively passive continental margin in which Ireland lies, the stresses are less but they still do exist. They may not be great enough to produce new faults but can be enough to cause movement on faults that already exist. Because stress can be concentrated by structural features, quite large events sometimes happen a long way away from plate margins. In such intra-plate surroundings the attenuation of seismic waves may be low and the affected areas can be very large. For example, events in the Eastern United States (also on a passive continental margin similar to Ireland) affect much larger areas than similar sized ones in the more active Western U.S.A.

A final point to note is that the depth of the earthquake focus is important. The December event was about 10km below the surface so no one could be less that about 10km from the source. This reduced the maximum intensity felt by people. Had it been close to the surface there would probably have been more significant felt reports and possible structural damage. While most of the earthquakes in this part of the world are at mid-crustal depths (about 15kms below the surface), some are not.

The recent announcement that UNESCO is to locate an early tsunami warning system in the NE Atlantic is very welcome. Ireland will seek inclusion in this programme with the intention of securing the development and expansion of the existing DIAS seismic network to increase the number of recording stations and to equip this facility with state of the art technology on a par with our other European colleagues. The resultant transmission of data in real time will ensure continuous monitoring for potentially threatening events and thereby enable us to design rapid automatic alerts for the relevant authorities.

For more information, contact
Mr Tom Blake, Experimental Officer
School of Cosmic Physics
Dublin Institute for Advanced Studies
5 Merrion Square, Dublin 2
+353 1 6621333

[Technical note regarding our hardware.]
DNET, ENET and VAL use Earth Data PR2400 and PR6-24 Portable Field data recorders with Guralp and Wilmore seismometers as sensors. DSB is a Quanterra Q680 VBB data acquisition system and has a Streckeisen-STS2 seismometer.