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OBSERVATORIES, PROGRAM IN THE BRITISH ISLES

History

In his survey of magnetic observatories that have operated in the British Isles, Robinson (1982) lists 18 locations, including 11 in England, 4 in Scotland, 2 in the Republic of Ireland, and 1 on the island of Jersey. The earliest two observatories were both constructed in 1838: in the grounds of Trinity College, Dublin; and in Greenwich Park, London, where an astronomical observatory had been established following a warrant issued by King Charles II in 1675. The earliest known measurement of magnetic declination at Greenwich is that made by John Flamsteed in 1680, and declination measurements were made there regularly from 1816, to assist in the calibration of ships' compasses. The initial program of observations at Dublin and Greenwich consisted of two-hourly measurements. Both observatories, along with that at Makerstoun in Scotland, participated in the Göttingen Magnetic Union (1836–1841), which promoted simultaneous measurements at cooperating observatories, and certain days were designated "term days" when observations were made every 5 min. A British artillery officer, Edward Sabine, was a chief protagonist of the efforts by the Göttingen Magnetic Union to establish a global network of observatories, and through this, several observatories were set up by the British in its colonies at the time (see *Gauss, Carl Friedrich*; *Humbolt, Alexander von*; *Sabine, Edward*; and *Geomagnetism, history of*).

The laborious nature of meteorological and magnetic observations stimulated a drive to develop automatic recording devices, and Charles Brooke designed the photographic magnetographs that were brought into operation in Greenwich in 1847 (Brooke, 1847). Francis Ronalds, working at Kew Observatory, which had been built at Richmond, London, for King George III to observe the transit of Venus in 1769, also produced a photographic magnetograph at around the same time as Brooke's. Ronalds' instrument was later redesigned by John Welsh to produce the Kew-pattern magnetograph that was subsequently installed in many observatories around the world (Stewart, 1859). The instrumental developments by Brooke and Ronalds established the standard technique employed for magnetic observatory recording worldwide for more than a century (see *Instrumentation, history of*).

Observations at Dublin Observatory were short-lived, continuing only until 1850. A meteorological observatory was established on Valentia Island, Kerry, in 1867 and regular absolute magnetic observations commenced there in 1888. The observatory was moved to the mainland, close to the town of Cahirciveen, in 1892, but kept the name Valentia Observatory. Continuous recording instruments were first installed in 1953. Met Éireann, the Irish meteorological service, now runs the observatory.

Geomagnetic measurements in London were to become impossible because of electrification of the railway and tramway systems. Kew Observatory suffered disturbances from about 1900 and with compensation from the tramway company responsible, Eskdalemuir Observatory, in the Southern Uplands of Scotland, was built. Eskdalemuir was selected as one of very few places in Great Britain that was more than 10 miles from the then extensive rail network. Construction work at Eskdalemuir started in 1904 and a full program of magnetic observations began in 1908. Later, the geomagnetic work carried out at Greenwich was similarly affected and was transferred to Abinger Observatory, on Leith Hill, London, in 1924. Observations were made there until April 1957 when, once more, disturbances from electrified railways reached intolerable levels. A transfer of operations was planned and a magnetic observatory was constructed close to the village of Hartland, Devon. Hartland Observatory opened in 1957, in time for the observatory to participate in the International Geophysical Year (IGY). Overlapping measurements were made at the times of the Greenwich–Abinger and the Abinger–Hartland moves, establishing site differences and enabling the records from the three observatories to be combined.

Lerwick Observatory in the Shetland Isles was established as a meteorological station in 1919 and geomagnetic measurements began there in 1922. Lerwick, Eskdalemuir, and Hartland are the three magnetic observatories in operation in the UK in 2005. They are run by the British Geological Survey (BGS), a component body of the Natural Environment Research Council. Lerwick and Eskdalemuir continue to have roles as meteorological stations, and seismological equipment is operated at all the observatories.

Observatory operations in 2005

The main objective of a magnetic observatory is to record geomagnetic field variations continuously, over the long term, at a stable location, and to maintain the accuracy required to produce data of the quality needed for studies of the slow changes of the main geomagnetic field generated in the Earth's core, the secular variation. The combination of magnetographs, based on suspended magnet instruments and photographic recording, supported by regular absolute observations, enabled the UK observatories to achieve this objective over many decades. However, the observatory operations were labor-intensive, both in running the magnetographs and in processing the analog photographic recordings. By the 1970s, technical developments in fluxgate and proton precession magnetometers gave an alternative set of observatory instruments, and advances in digital data acquisition and computing presented new opportunities for observatory automation. The BGS began a development program, and automatic digital systems were adopted as the observatory standard recording equipment at the three UK observatories on January 1, 1983 (see *Geomagnetic secular variation*; *Observatories, instrumentation*).

Since 1983, technology has continued to develop, bringing significant improvements to magnetometer performance and data acquisition and communications. The latest generation systems used at the UK observatories were commissioned on January 1, 2003, again based on the combination of fluxgate and proton precession magnetometers. The fluxgate magnetometer output is sampled once per second and the data are transmitted to the BGS offices in Edinburgh within minutes. A fluxgate–theodolite combination is used to make regular (manual) absolute measurements of magnetic declination and inclination, with the proton magnetometer providing absolute values of total field strength.

Instruments similar to those at the UK observatories are used at Valentia Observatory. Efforts to improve the global coverage of observatories continue and to this end observatories were set up by the BGS on Ascension Island and at Port Stanley in the Falklands Islands in 1992 and 1994, respectively.

Uses of the observatory data

In 2005, the combination of data from magnetic survey satellites, such as Ørsted and CHAMP, and observatories worldwide, is providing a rich resource for research into core processes. The data also bring practical benefits through their use in the production of global and national magnetic field models and charts used for navigation. Here, observatory data are of great importance because of the information they give on the secular variation, providing the basis for estimation of future values of the geomagnetic field at a given location (see *Ørsted*; *CHAMP*; *Main field maps*; *Main field modeling*; and *IGRF, International Geomagnetic Reference Field*).

Observatories also provide data on the relatively rapidly varying magnetic fields of ionospheric and magnetospheric origin. These "disturbance fields," indicative of "space weather" conditions, are characterized by various geomagnetic activity indices (Mayaud, 1980). Each of the UK observatories has provided data for the computation of the Kp-index since its creation in 1932. Data from the Greenwich–Abinger–Hartland series, together with data from Australian observatories, have been used to construct the aa-index, which extends from 1868, providing valuable information on long-term changes in solar–terrestrial interactions. (Both the Kp- and the aa-indices are computed for 3-h intervals.) When space weather conditions are such that a major geomagnetic disturbance, a magnetic storm, is in progress, operations in space and on the ground can be at risk. Global geomagnetic activity indices, such as Kp, are used widely as measures of disturbance. Satellite management, assessment of propagation conditions for radio and GPS signals, and geophysical surveying are examples of applications where indices are used (see *Storms and substorms, magnetic* and *Geomagnetic hazards*).

By collecting l-s samples, the UK observatories are producing data useful for research into external magnetic fields. Data at this time resolution are required for, and are applied to, modeling geomagnetically induced currents, which is of interest to the electricity distribution industry. A further modern-day application, important to hydrocarbons production around the UK, is the use of accurate magnetic reference data to correct wellbore survey measurements acquired using magnetic survey tools. Data from the UK magnetic observatories are used in the analysis of data collected in measurement-while-drilling operations, and this application demands the rapid access to the data that the UK observatory operations provide. This application has resulted in observatories being set up on Sable Island, offshore Nova Scotia, and at Prudhoe Bay in northern Alaska by Halliburton with the assistance of the BGS.

Outlook

Lerwick, Eskdalemuir, Hartland, Valentia, Ascension, and Port Stanley are all INTERMAGNET observatories and hence are members of a coordinated global monitoring network operating to high modern standards (see *Observatories, INTERMAGNET*). This echoes the participation of observatories in the British Isles and Empire in the Göttingen Magnetic Union. These observatories are providing data for scientific research, for global data products, and are also finding local applications for the data they produce. The scientific and "real world" demands for the data are as strong today as at any time in the past.

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Bibliography

Brooke, C., 1847. Description of apparatus for automatic registration of magnetometers and other meteorological instruments by photography. *Philosophical Transactions of the Royal Society of London*, **137**: 69–77.

Mayaud, P.N., 1980. *Derivation, Meaning and Use of Geomagnetic Indices.* American Geophysical Union, Geophysical Monograph 22. Washington, DC:American Geophysical Union.

Robinson, P.R., 1982. Geomagnetic observatories in the British Isles. *Vistas in Astronomy*, **26**: 347–367.

Stewart, B., 1859. An account of the construction of the self-recording magnetographs at present in operation at the Kew Observatory. *British Association Report 1859*, pp. 200–228.

Cross-references

CHAMP
Gauss, Carl Friedrich (1777–1855)
Geomagnetic Hazards
Geomagnetic Secular Variation
Geomagnetism, History of
Humbolt, Alexander von (1759–1859)
IGRF, International Geomagnetic Reference Field
Instrumentation, History of
Magnetometers, Laboratory
Main Field Maps
Main Field Modeling
Observatories, Instrumentation
Observatories, INTERMAGNET
Ørsted
Sabine, Edward (1788–1883)
Storms and Substorms, Magnetic