British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Communicating uncertainty in geomagnetic field estimates provided by the BGS to aid directional drilling

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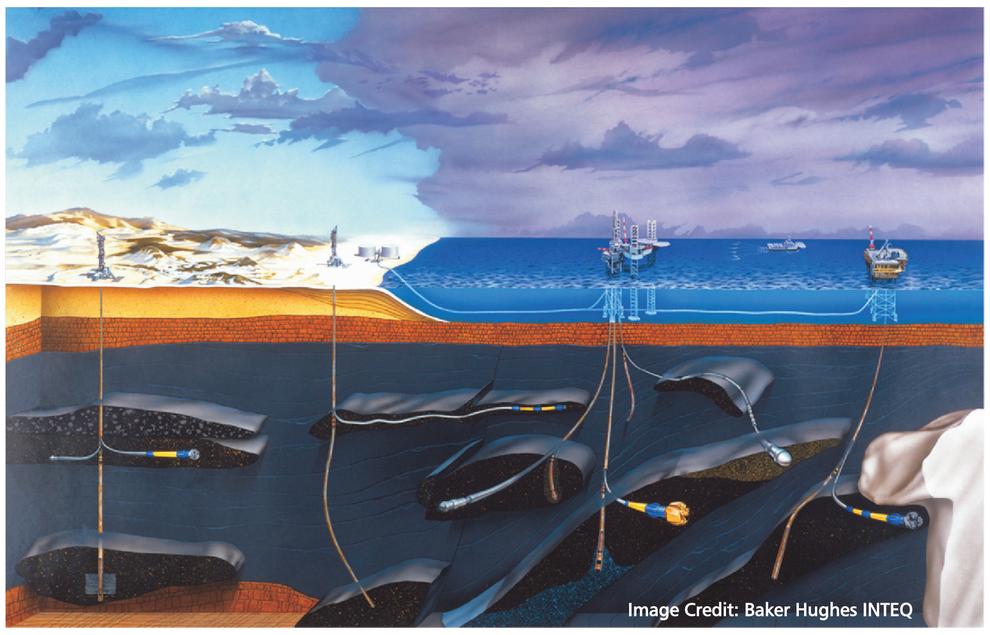
Summary

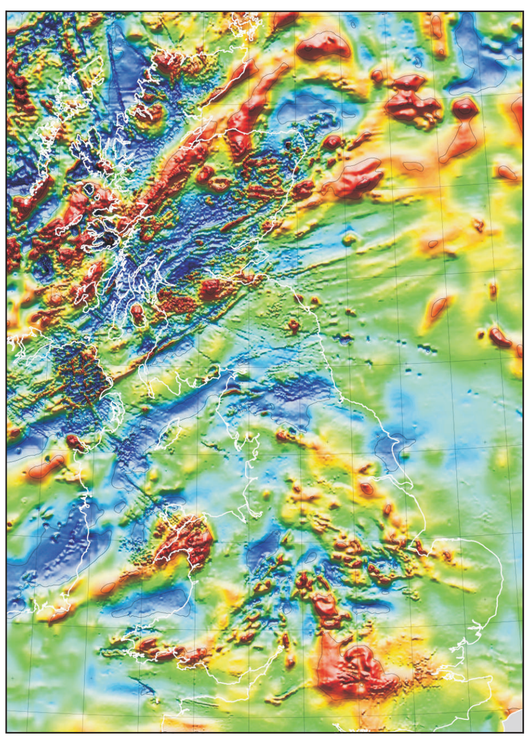
Navigating underground when drilling for oil and gas has become more challenging as companies try to hit smaller targets in reservoirs already congested with existing wells. One widely used method is Measurement While Drilling (MWD) using magnetic survey tools to direct the drill head. The provision of accurate geomagnetic field values with verifiable estimates of uncertainty is of utmost importance as the estimates help mitigate the risk of collision or missing a target.

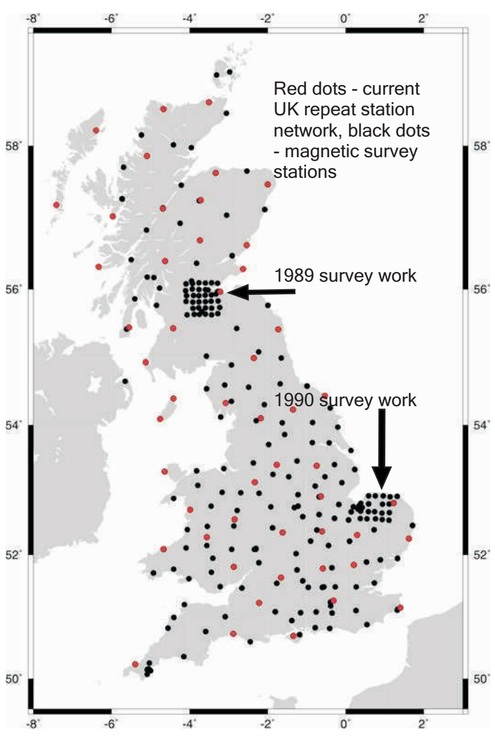


The BGS offers three options to the oil industry depending on accuracy required: the basic option is to use estimates of the geomagnetic field from the annually updated **BGS Global Geomagnetic Model (BGGM)**; the second and more accurate option, **In-Field Referencing (IFR)**, includes estimates of the local crustal magnetic field; the third and most accurate option, **Interpolation In-Field Referencing (IIFR)**, includes estimates of the rapidly time-varying magnetic field at the oil field. The estimates of uncertainty in the geomagnetic field values supplied under each of these options are almost as important as the values themselves because they are incorporated into company software which derives positional error ellipsoids along the well-path. We describe work done over several years on the derivation and communication of geomagnetic field uncertainty for the oil industry.

Validation of IFR transformation technique

Field work involving geomagnetic observations at 55 sites over 2 different anomalies in 1989/90. This work (a) provided demonstration of the method to transform aeromagnetic scalar data (picture below left) into vector estimates on the ground, and (b) contributed to estimates of uncertainty for IFR data.

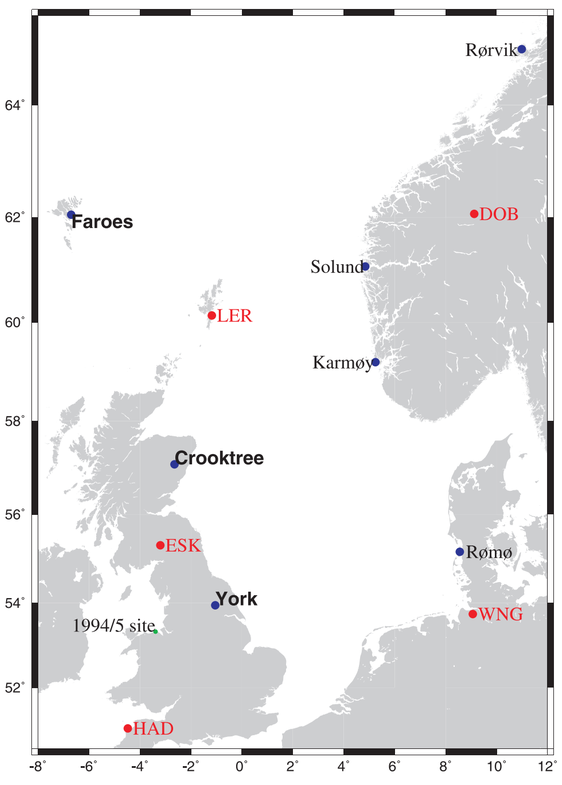




Validation of IIFR technique

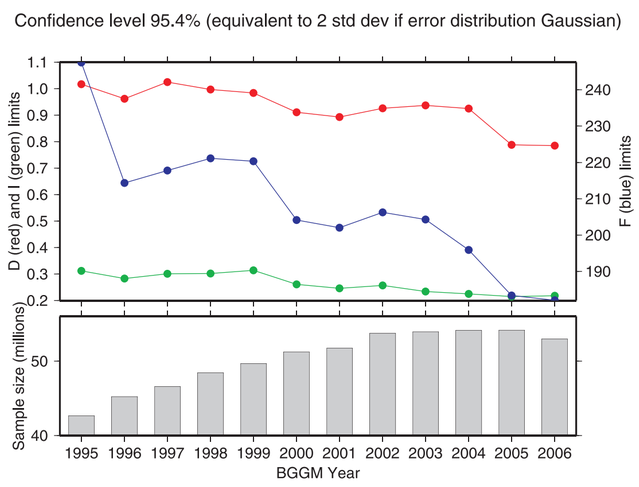
In 1994/5 a monitoring station was set up in North Wales and 4 months of continuous observations were collected. This work (a) demonstrated IIFR - variations at Eskdalemuir and Hartland observatories were combined, compared with those measured at the station, and applied to aid directional drilling in Liverpool Bay, and (b) contributed to estimates of uncertainty for IIFR data.

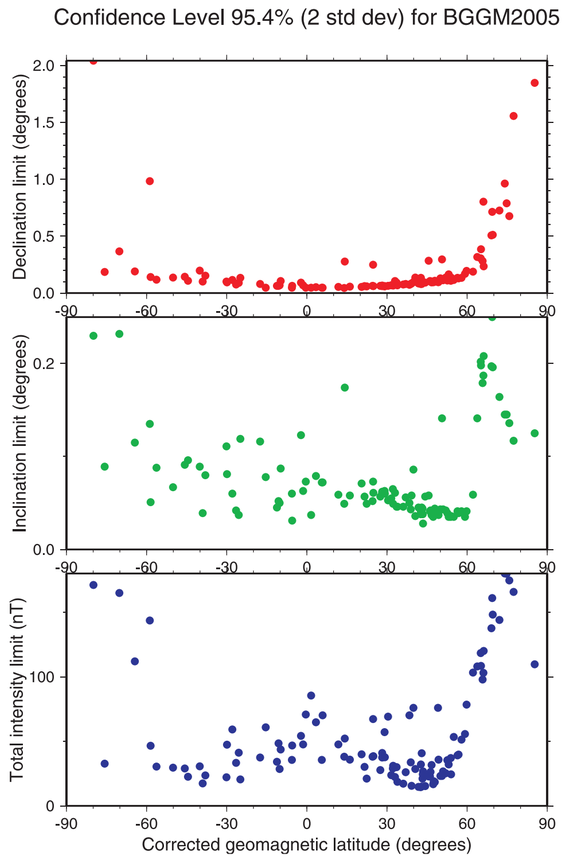
Recently a more detailed study was done using data from all available observatories (red) and variation stations (blue) around the North Sea. This work allowed us to quantify the increase of uncertainties in the IIFR technique with latitude.



Assessment of BGGM uncertainty

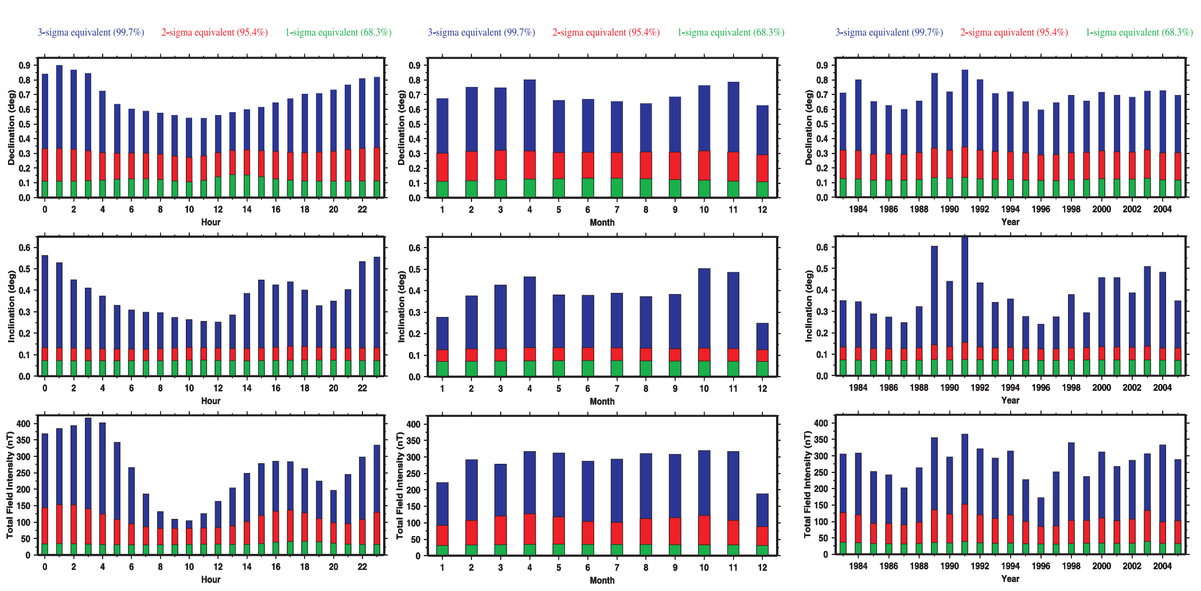
In 2008 the accuracy of the annual BGGMs is being reassessed by comparing with extensive data collections which simulate global MWD magnetic data. The downward trend with time in the limits (left) is due to modern satellite magnetic data and the improvements in the models they have allowed. The uncertainties increase with latitude (right), particularly for oil fields under the auroral zones.





Assessment of IFR uncertainty

IFR includes estimates of the main field and crustal field. IFR values at a given location therefore have uncertainties which vary with time. Whilst the minute-to-minute variations are not predictable there are patterns over the long term for daily, annual and solar cycle time-scales (see below). These plots also demonstrate that geomagnetic field variations do not follow a normal or Gaussian error distribution.



Communications with oil industry

Over the years we have established ourselves as world leaders in the application of geomagnetism in the oil industry. Communication of the science and the services that we provide has been through various joint and individual client meetings and by telephone and email. There are also written communications in the form of BGS Commissioned Reports and papers published in industry and scientific journals.