Space Weather Services for the Offshore Drilling Industry

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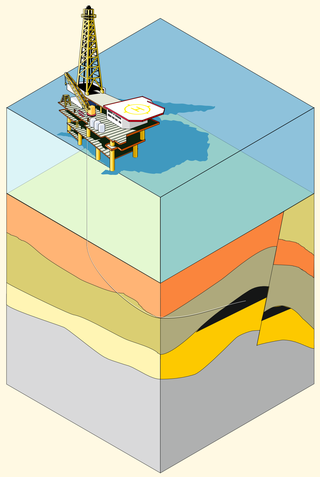
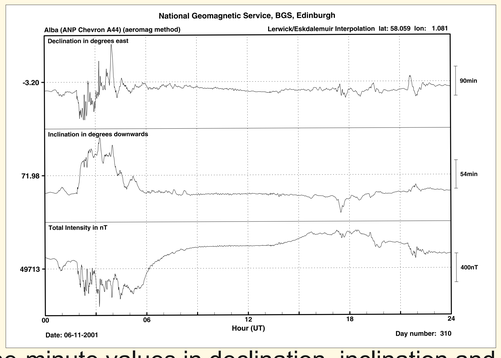
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

ESTEC Space Weather Workshop 17-19 December 2001

The requirement to extract the maximum amount of oil from reservoirs while continually striving to reduce drilling costs has led to the development of the technique of directional drilling over the last few decades. The oil industry now has the capability to drill dozens of wells from a single platform in many different directions, extending typically to 5km horizontally. The world record for extended reach drilling is in excess of 11km. The size of the geological targets requires an accuracy in direction of the order of 0.1 degrees in navigating the well-bore. Surveys of this accuracy can be made using gyroscopic instruments, but these require drilling to stop for the duration of the survey, which may be some hours. When the cost of the rig hire is taken into account it makes these surveys expensive to conduct. A cheaper method is to use magnetic survey instruments in a non-magnetic part of the drill string near the drill bit. These can make measurements while drilling, but the accuracy is limited by the accuracy with which the direction of the Earth's magnetic field is known. In the North Sea this may typically change by up to 0.2 degrees throughout the day, and during magnetic storms deviations of the order of a few degrees may be experienced. The British Geological Survey has developed the technique of Interpolated In-Field Referencing (IIFR) to remove this source of error by using data from its magnetic observatories. Data are required by the well-bore surveyors in near-real time when decisions have to be made about steering the well. The benefit to the oil industry of using IIFR derives from the fact that an accuracy similar to that achieved with gyroscopic survey tools can be achieved with magnetic survey tools. This means that wells can be drilled with fewer or no gyro surveys, greatly reducing the costs associated with navigating the well-bore. Additionally there are fewer risks to drilling operations than when running gyroscopic tools because the long pauses in drilling required by the gyro surveys may lead to the drill string getting stuck in the hole. As a space weather service, IIFR can be characterized primarily as a near real-time monitoring service. Forecasting does not play, and is not likely to play, a significant role because no decisions are made affecting drilling operations based on a space weather forecast. IIFR has been applied in more than 30 offshore oilfields around the UK, and has been applied in other high latitude oilfields offshore Canada and the USA. It is unlikely that the benefits would be significant at geomagnetic latitudes much lower than the North Sea.

The offshore oil industry use magnetic data in borehole surveying as a cheaper alternative to using gyroscopic survey tools. The technique known as Interpolated In-Field Referencing (IIFR) has been jointly developed by BGS and Sperry-Sun Drilling Services to give accurate one-minute magnetic values at the oil well locations, enabling the technique of measurement-while-drilling (MWD) to be used.



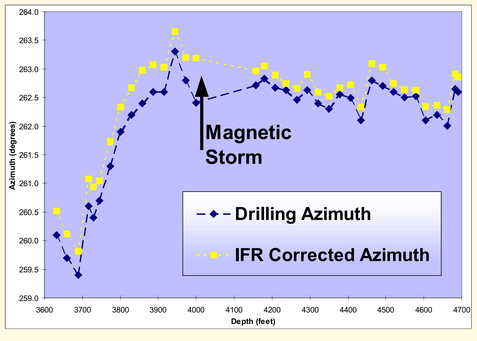


One-minute values in declination, inclination and total field are derived for all oil wells using the IIFR technique. Data for the wells currently drilling are made available to bore-hole surveyors throughout the day in close to real-time - updates are available every 10 minutes. An example of a complete day of data is shown in the magnetogram above

The geomagnetic field can be expressed as the vector sum of the contributions from three main sources: the main field generated in the Earth's core, the crustal field from the local rocks and a combined disturbance field from various currents flowing in the upper atmosphere and magnetosphere, which also induce electrical currents in the sea and ground.

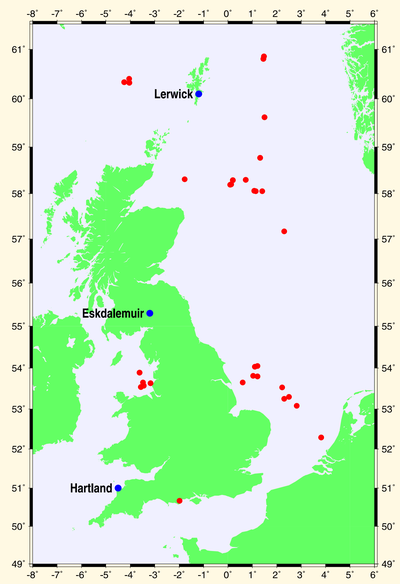
The IIFR technique must consider all three of these sources. The main field can be estimated at the drilling location using a spherical harmonic model, which includes the secular variation element. Detailed crustal field anomalies are obtained from aeromagnetic and marine surveys of the oil field areas. These two sources are not influenced by space weather effects and are not considered further here.

The disturbance or external field contributions are combined together and estimated for the location of the oil well using data from the three UK magnetic observatories, which are located as shown on the map.



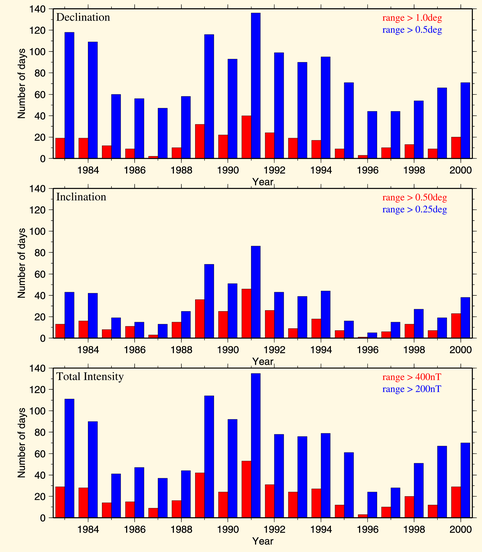
Right: The effect of correcting the measured (drilling) azimuth for the effects of a magnetic storm.

Locations of oil fields where external field variations have been used to improve drilling accuracy.



In directional drilling magnetic declination (the angle between true and magnetic north) is required to convert the survey measurements to the geographic reference frame. Additionally the total field intensity and inclination (the angle the field direction makes with the horizontal plane) are required for algorithms which remove interference from the drill string. The levels of accuracy required are **0.1 degrees** in declination, **0.05 degrees** in inclination and **50 nT** in total field intensity. The plot below gives an indication of why the external field should be accounted for when drilling wells at UK latitudes.

Frequency of magnetic disturbances at Lerwick observatory



Below : A geological cross section along the world's longest extended-reach well drilled at Wytch Farm (approximately to scale). The oil reserves extend many kilometers offshore beneath Poole Bay on the southern coast of England. The application of IIFR in MWD surveys has contributed to this world record. (Picture courtesy of Anadrill Schlumberger)