APPLICATION OF MAGNETICS FOR OIL AND GAS

INTODUCTION

Magnetic methods have been used in the oil and gas exploration since 1920s but, for the most of that period, only to investigate major fault zones and map basement rocks however, recent advances imply that now, under favorable conditions (and especially in combination with other geophysical and geochemical methods), magnetic techniques can play a bigger role in locating oil and gas fields.

Structure associated anomalies related to magnetic fault blocks

In the Mesozoic and Cenozoic eras, the rigid basement of the north china basin underwent strong and widespread fault blocking. The basement uplifts produced lateral magnetization contrast and in some cases the faulting could be associated with magnetization contrast with the basement. Thus, possible oil and gas traps correlate with gravity and magnetic anomalies.

The Niutuozhen anomaly is a typical basement block anomaly. A corresponding gravity high is situated on the steep gradient slope between the positive and negative peaks. The offset between the gravity and magnetic anomalies is caused by the oblique magnetization of the source. The core of the uplift is mainly Precambrian magnetic crystalline basement rocks, which are overlain by Paleozoic carbonates.

Structure associated anomalies related to volcanic rocks

The aero magnetic map of the giant Daqing Dome (the largest oil field in china) has many local highs (amplitudes often 40-50nT). The depth of the sources is 3-5km. A well with depth of 4188m encountered upper Jurassic magnetic andesite and basalt with thickness up to 104m, which produce a local magnetic high.

The northern Dagang area consists of a fault block composed of Paleozoic limestone and Mesozoic volcanic. The northeast trending positive magnetic anomaly has an amplitude of 7-25nT. A well penetrated, at 1638m, Mesozoic basalt, which had a thickness of several tens of meters. Since the basalt layers occur along a fold-axis controlled by a major fault, the related anomalies coincide well with the Dagang structure itself.

Structure associated anomalies related to magnetic sedimentary formations

In the south part of the south Peten basin in southern Belize, the main exploration target is the Coban formation of cretaceous age. This is a prolific producer in neighboring Guatemala.

High frequency magnetic anomalies, not expected in this area due to the great depth to the basement (3000-6000m), were recorded. A previous interpretation of the data attributes these anomalies to igneous sills and dikes, but their pervasive occurrence over a large area and their consistent wavelengths suggested folded magnetic sedimentary beds.

It was established that indeed there was a highly magnetic bed in the lower Eocene Toledo formation near the top of the sedimentary section.

The monkey river well drilled in 1979 and with a total depth of 3507ft, in the eastern part of the area showed that the magnetic interval had a thickness of 490m and that susceptibility averaged 220 * 10^-6 units. Petrographic analysis of the grains showed that a large percentage was andesite, a rock common in volcanic flows that generally contains several percent magnetites. A comparison of the final residual map with seismic data, especially in the offshore portion, revealed that the residual magnetic highs correspond very closely to seismic highs. The target cretaceous beds lie 200-400m below the magnetic Toledo formation, so there is generally a small (but predictable) horizontal offset between the residual magnetic highs and the structure of economic interest.

Direct detection of oil and gas

The use of magnetic methods for direct or semi direct location of oil and gas is based on the detection of diagenetic magnetite, caused by hydrocarbon seepage. The presence of magnetic bodies over oil and gas accumulations has been established for many producing areas. Some of these bodies are shallow (less than 1000ft;some are rather deep (greater than 3000ft).

D.F Saunders and S.A Terry reviewed some of the theories concerning the formation of this diagenetic magnetite in “onshore exploration using the new geochemistry and geomorphology”. According to these authors, hematite in the sediments overlying petroleum accumulations is converted to magnetite by chemical reduction due to hydrogen sulfide formed by sulfate reducing bacteria in the presence of hydrocarbon gases. Hydrogen sulfide can be generated in shallow reservoirs by alteration that results from the introduction of anaerobic bacteria by descending meteoric waters. The bacteria selected their food from the hydrocarbons and deliver oxygen by the reduction of sulfate ions in the invading waters.

Another possibility is that reduced iron in solution combines with hematite and water to form magnetite, and a third possibility is that ferrous iron produce at some depth may migrate upward into an oxidizing zone. Slow oxidation may directly produce magnetite.

The conversion of nonmagnetic hematite to magnetite creates anomalous “ripples” on the aeromagnetic total field record, which can be readily identified in the data processing. Its longer wavelength and its higher amplitude recognize the diagenetic magnetic signal. The very long basement effects and very short cultural sources were removed or highly suppressed by data processing.

Seepage Activity

This refers to the relative rate of hydrocarbon seepage. There are two distinct end members of seepage activity:

Active seepage: the term seepage refers to areas where subsurface hydrocarbons seep in large concentrations into shallow sediments and soils and into the overlying water column. Active seeps often display acoustic anomalies on conventional or high-resolution seismic profiles. Active seepage occurs in basins now actively generating hydrocarbons or that contain excellent migration pathways. these seeps are easily detected by most sampling techniques.

Passive seepage: areas where subsurface hydrocarbons are not actively seeping are said to be passive seepage. Such seeps usually contain low molecular weight hydrocarbons and volatile high molecular weight hydrocarbons above background levels. Acoustic anomalies may be present, but water column anomalies are rare. Anomalies levels of hydrocarbon seepage may be detectable near major leak points or below the zone of maximum disturbance (near surface zone of variable depth and thickness in which sedimentary and biological processes alter or destroy volatile hydrocarbons.

Anomalies relate to traps

An assumption is that the anomaly at the surface can be related reliably to a petroleum accumulation at depth. The success with which this can be on is greatest in area of relatively simple geology and becomes increasingly difficult as the geology becomes more complex. The geochemical or microbial anomaly at the surface represent the end of a petroleum migration pathway, a pathway that can range from short distance vertical migration at one end of the spectrum to long distance lateral migration at the other extreme. Relationships between surface geochemical anomalies and subsurface accumulations can be complex; proper interpretation requires integrating seepage data with geological, geophysical, and hydrologic data. Understanding geology and, hence, petroleum dynamics - is the key to using seepage data in exploration.

References: www.ask.com
www.google.com
