Advanced Downhole Petrophysics Ltd

Magnetic susceptibility measurements on Drill Cuttings from well: xxx-yyy-z

Job Report for: UK O&G Operator
Requested by: Petrophysics Manager
Service Order Number:

Date: September 2014

Contents

1. Introduction & Executive Summary

The job proposal responds to an initiative by a significant UK O&G Operator and assigns to Advanced Downhole Petrophysics Ltd, 11 Duddingston Park, Edinburgh, EH15 1JN, for the provision of magnetic susceptibility measurements on drill cuttings.

A total of 157 bags of wet drill cuttings were provided for the analysis. The bags constitute the interval from 5600 ft – 14560 ft AH BDF. A total of 421 measurements were performed on drill cuttings from all the bags.

A set of LWD log data has been provided by client Operating Company and which forms the basis of this analysis and report.

Executive Summary & Comments

The magnetic susceptibility results correlate particularly well with the gamma ray log. Interestingly the correlation is the opposite way round to what we normally see, and this gives us additional information that should be of interest to the Client. Normally a low gamma ray signal (e.g., in a clean sandstone interval) would give a low or negative magnetic susceptibility due to diamagnetic quartz, whereas a high gamma ray signal (e.g., in shale) would give a higher magnetic susceptibility signal due to paramagnetic clays etc. In the present study many of the low gamma ray intervals correspond to higher magnetic susceptibility (the yellow shaded intervals on both of these plots from 7,800 – 14,500 ft). The magnetic susceptibility tells us straightaway that there are paramagnetic and / or ferrimagnetic minerals present in those intervals in addition to the main matrix mineral. We have seen examples of this in other studies - these additional high magnetic susceptibility minerals can, for example, be due to the strongly paramagnetic mineral such as siderite, or due to the ferrimagnetic mineral magnetite. Such high magnetic susceptibility minerals can affect the downhole NMR results and so it is important to be able to identify them. Some of these higher magnetic susceptibility minerals (especially paramagnetic clays) can affect the permeability. Our magnetic susceptibility study on drill cuttings provides a very rapid means of indicating the presence of such high magnetic susceptibility minerals over large intervals.

2. Comparison between Magnetic Susceptibility and LWD Log Data

In the attached composite log, the mass magnetic susceptibility profile is shown in the first track.

The magnetic susceptibility data was measured on drill cuttings acquired in 12.25" and 8.5" hole sections. The remaining tracks show the LWD data (including GR, NUE, DEN, RES) acquired in these two hole sections. The LWD data was supplied by the client and is plotted against the mass magnetic susceptibility data to look for correlations between mass magnetic susceptibility and conventional logs.

In the overburden section (c. 5400 – 7800 ft MD), the mass magnetic susceptibility data shows a relatively low and uniform response which is consistent with the gamma ray and resistivity logs. There is an anomaly in the mass magnetic susceptibility data at c. 7300 ft MD and which is also consistent with the anomalously high gamma ray response at the same depth.

In the second section (c. 7800 – 9500 ft MD), there appears to be some hydrocarbon bearing sands (low GR and high RES responses). Again, these sands are picked up by the relatively high readings in the magnetic susceptibility profile.

The third section (c. 9500 – 10,900 ft MD) is a shaley interval which once again shows a relatively low and uniform mass magnetic susceptibility data.

The long horizontal reservoir section (c. 10,900 – 13,900 ft MD) consists of a number of sand and shale intervals. Once again, the mass magnetic susceptibility data beautifully characterizes between the sand and shale intervals and which is consistent with the rest of the LWD logs.

3. Conclusions

- The mass magnetic susceptibility profile shows distinct responses in the sand and shale intervals, i.e. a relatively low mass magnetic susceptibility response in the shale intervals and a relatively higher mass magnetic susceptibility response in the sand zones.
- The mass magnetic susceptibility data shows good correlation with Gamma ray and Neu/Den logs, i.e. mass magnetic susceptibility has distinct responses in the gas bearing sands versus shales.
- Due to the rapidity of measurements, a large volume of mass magnetic susceptibility data can be acquired at wellsite on drill cuttings. This would help identifying lithological changes, i.e. as we drill through overburden into the reservoir sands (or even picking up shales within the reservoir sands).
- Due to time constraints, on average, approximately 3 measurements were performed per bag of drill cuttings. We can perform a larger number of measurements (higher resolution) in order to provide more insights within individual bags.
- The wellsite magnetic susceptibility data on drill cuttings would also help support mud logs and biostrat data.
- We can quantify minerals (for simple mixtures) if quantitative mineralogical information is available at representative intervals.
- We can also make permeability predictions if some calibration data is available.
- The high resolution mass magnetic susceptibility measurements can also be acquired on extracted core samples for prediction of various petrophysical parameters including permeability, clay content and mineralogy quantifications.

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Sand - Shale (ND)

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ROBB

1.95 g/cm3 2.95

ROBB_DH

1.95 g/cm3 2.95

Sand - Shale (GR)

Sand - Shale (GR)

GR

0 gAPI 150

TNPH

45 pu -15

P40H

0.2 ohm.m 2000

TVD

Reference (ft) 1:5000

Mass Mag Susc

1 10000

GR

0 gAPI 150

TNPH

45 pu -15

P40H

0.2 ohm.m 2000

TVD

6000

7000

8000

9000

10000

11000

12000

13000

14000

5950

6389

6765

7058

7312

7567

7820

8037

8169

8208

8196

8187

8151

8098

8039

7993

7985

8079

8284