Can you really infer permeability from magnetism…?

Advanced Downhole Petrophysics Ltd. (ADP) is a new company commercializing novel interpretation of a naturally occurring phenomenon, ***magnetic susceptibility*** in order to estimate both permeability and mineralogy in a passive, non-destructive environment.

Original research by Professor David Potter (recent recipient of the SCA's (Society of Core Analysts) Darcy Lifetime Achievement 2015 Award) and Dr. Arfan Ali, is the basis of the work currently undertaken by ADP.

One of ADP's first actions was to brand the technology: **MagPI™** (**Mag**netic **P**ermeability **I**ndicator) was born!

We are now delighted to offer the following services:

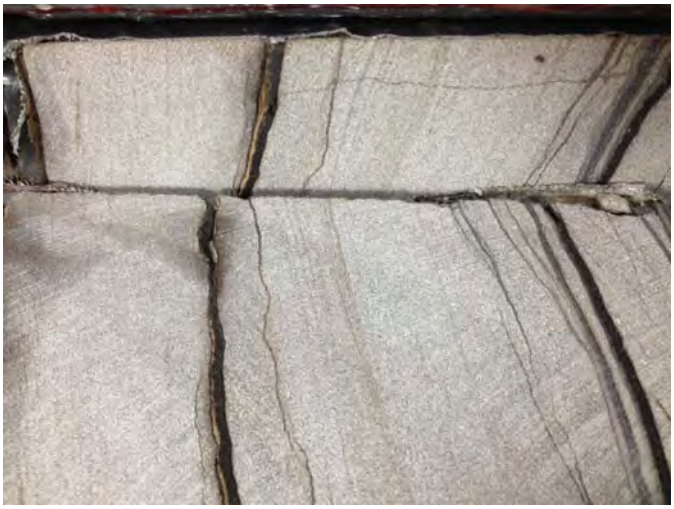
- Shore-based laboratory estimation of Permeability and Mineralogy on slabbed and plug cores in order to reduce, for example, multiple X-Ray Diffraction (XRD) measurements. MagPI™ measurements may be taken prior to core cleaning and processing to offer "quick-look" estimations (maybe months ahead of conventional techniques)

- Rig-based MagPI™ offers real-time drill-cuttings evaluation giving early indication of permeability and mineral content in order to better determine, for example, casing setting depths. It may also assist in thin-bed detection and potential identification of over or under-balanced zones which may be problematic in well control aspects of the drilling process

- For shore-based drill-cuttings disposal facilities MagPI™ offers a "quick-look" mineralogy quantification to help in the selection of most appropriate ultimate disposal methods

- Under development is ADP's downhole MagPI™ designed to integrate into existing logging suites in order to enhance conventional wire-line logging activities, again giving early estimations of permeability and mineralogy

Even highly deteriorated material can be assessed



"Thin beds"– measurement can be at 1-2 Cm. intervals

Magnetic Permeability Indicator

MagPI is a product of Advanced Downhole Petrophysics Ltd.

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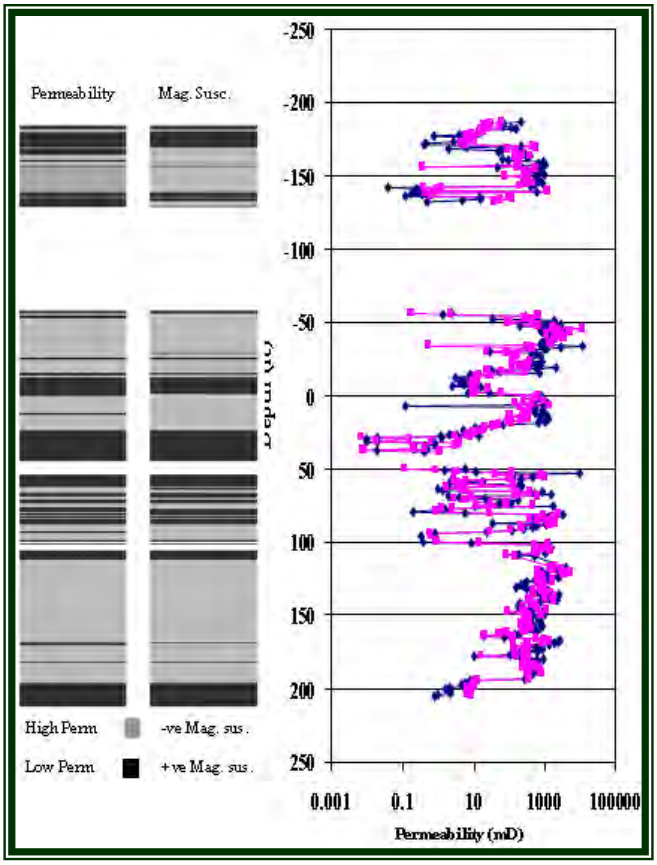


Left: Comparison of the sign of the raw magnetic susceptibility signal and the main permeability zones (N. Sea oil well). Net -ve magnetic susceptibility (grey shading) correlates with high permeability clean sand reservoir intervals. Net +ve susceptibility (black shading) correlates with lower permeability muddy sand or shale intervals

Right: The variation with depth of the magnetically derived predicted permeability (pink) and the measured horizontal plug air permeability (blue)

Advantages of Magnetics & Comparisons with Traditional Core Analysis Techniques:

- Rapid: Measurements can be made in a few seconds, so readings from conventional core plugs (a few hundred) from 1 or 2 wells can be obtained in just one day, rather than days or weeks currently required by other techniques. Estimates of key petrophysical parameters can be obtained quickly allowing important field development decisions to be made at a much earlier stage (well before the conventional core analysis data becomes available)
- Improved permeability prediction: The technique does not rely on any correlation with porosity and has shown better correlations with permeability than NMR measurements in similar samples in shoreface reservoirs
- Higher resolution than current conventional laboratory core analysis measurements (such as core gamma ray)
- Quicker than XRD: can use larger sample volumes, and can identify ferrimagnetic components beyond the detection of XRD
- Flexible: Works on variety of media (probe on slabbed core, conventional plug, and / or whole core). The techniques work even on fractured core plugs
- Portability: Measurements can be made almost anywhere including laboratory and on or offshore wellsites
- No extra offshore preparation of the core sample is required
- Can measure cleaned or uncleaned samples (reducing preparation time). The techniques can also quantify the effect of sample cleaning (e.g. removal of clays)
- Non-destructive, environmentally friendly: It is not necessary to cut core plugs (particularly useful for unconsolidated core)
- Rapid anisotropic measurements are possible on individual core plugs
- Potential for downhole measurements

Frequently Asked Questions

Q What is MagPI?

A MagPI™ is a range of tools and services that Advanced Downhole Petrophysics Ltd has developed to offer an innovative method of reservoir evaluation to the oil and gas industry. This includes prediction of permeability and other key petrophysical parameters including clay content. We also offer a number of services on drill cuttings (see our products section of the website).

Q What is the operating principle of MagPI?

A The principle which our MagPI™ range of tools is based on is a novel method that exploits a physical phenomenon called magnetic susceptibility.

Q What is magnetic susceptibility?

A Magnetic susceptibility is the degree that a material (formation rock samples in our case) is magnetized after its exposure to a magnetic field. Various matrix and clay minerals have characteristic magnetic susceptibility signatures. The measured magnetic susceptibility helps in the determination and quantification of these minerals in reservoir rock samples.

Q How is magnetic susceptibility related with permeability and other important parameters?

A After years of research, Professor David Potter who is one of the Scientific Advisers to our team, has proven and demonstrated method of converting magnetic susceptibility measurements of rocks into mineral content which shows a strong correlation with permeability and other important petrophysical parameters.

Q Why is MagPI more competitive than other techniques available in the market?

A MagPI™ provides rapid, cost-effective and non-destructive measurements to the client. This enables improved decision-making by cutting the risk, time and cost of developing O&G reservoirs.

Q Where can it be applied?

A There are three versions (existing & planned) of MagPI™ with different applications:

i. A portable shore-based laboratory tool providing the option of performing measurements of cores and cuttings sent from the well-site.

ii. A portable rig tool offering the option of performing measurements of drill cuttings in real time when wells are being drilled.

iii. A downhole tool that will have increased accuracy and functionality while offering real-time measurements.

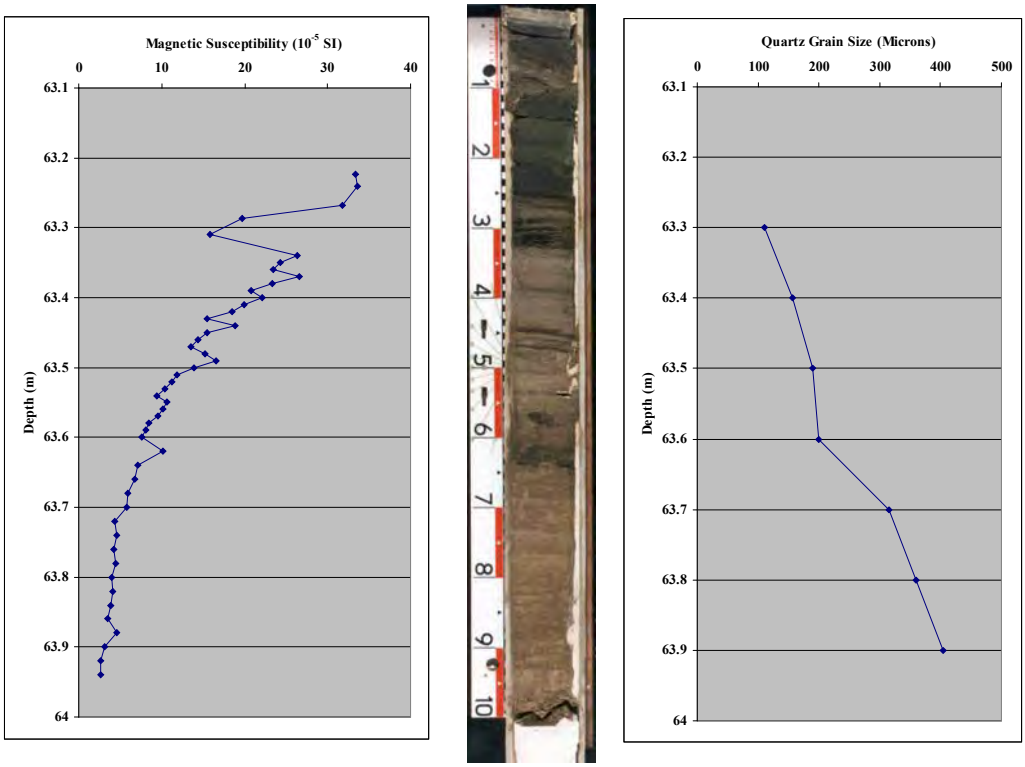
Q How does this compare with Nuclear Magnetic Resonance?

A Nuclear Magnetic Resonance (NMR) is currently the main downhole technique used to measure rock porosity and from this estimate permeability. Because NMR uses a correlation with measured porosity to estimate permeability it increases the uncertainty and hence error margin of assessments. Certain reservoir characteristics can also mask the actual permeability of a formation rock, such as the build-up of clays. In situations like this, where there is not a correlation between these two variables, this technique (and others) may give misleading indicators, potentially causing economic reservoirs to be overlooked and uneconomic ones to be developed. Magnetic susceptibility removes this ambiguity.

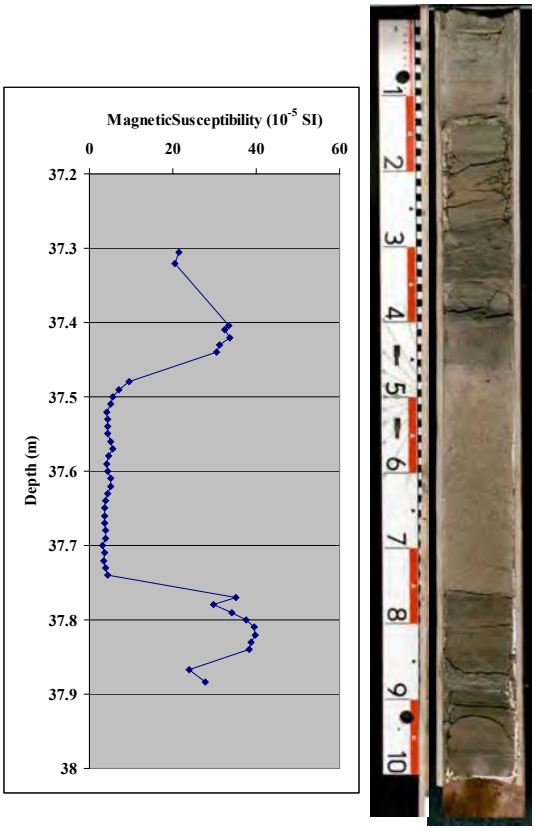
Q Does MagPI require nuclear sources to operate?

A No! - MagPI™ is a nuclear-free and environmentally friendly service product that makes it even more attractive in terms of health and safety regulations.

Magnetic Probe on Unconsolidated Core
(Rapid & Non-Destructive)



Above left: Probe magnetic susceptibility versus depth on a "graded" turbidite sand unit. Other conventional core analysis techniques are unable to pick up these subtle variations in clay content. **Above right:** Laser particle size analysis showed that the quartz grain size trend was the mirror image of the clay content profile.



Left: Probe magnetic susceptibility versus depth on a "uniform" turbidite sand. The relatively clean homogeneous sand interval is easily distinguished from the more clay rich intervals above and below the sand.

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