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INSIDE THIS ISSUE

Reducing foot print by obtaining Lab-Ready Core plug samples in Offshore

Coring provides the only means of obtaining high quality samples for the direct measurement of rock and its reservoir properties. Cores provide both geological & engineering information and are essential to understanding the nature of the pore system in the potential reservoir unit. The knowledge gained from cores enhances our ability to predict reservoir performance and devise completion strategies to maximize hydrocarbon recovery.

Sidewall Coring: Sidewall coring systems have been developed to obtain core samples after a well has been drilled and logged. The tools can be precisely positioned in zones of interest using gamma logs and extract cores. The advantages of this coring system are speed, low cost, and the ability to sample zones of interest with precision after open hole logs have been acquired. Percussion sidewall coring tools puncture the formation using hollow, retrievable, cylindrical bullets 1 in. wide by 1.75 in. long powered by explosives. The impact of the percussion core barrels alters the formation by shattering harder rock or compressing softer sediments, thereby reducing the quantitative value of the sidewall core analysis data.

Analysis	Parameters derived	Plug size
Petrophysical studies	Porosity, Permeability, a, m, n	1”dia / 1-3” length
Geomechanical studies	Vp, Vs, Tri-axial studies etc	1”dia / 2” length
NMR Studies	T2 Cut-off	1”dia / 1-3” length
XRD analysis	Elemental analysis	5-10 grams

Mechanical/Rotary Side Wall Coring: The rotary, or mechanical sidewall coring tool, was developed to recover sidewall core samples without the shattering impact of the percussion system. Suitable for hard to friable rock, the rotary sidewall corer uses a diamond-tipped drill to cut individual plugs from the sidewall. The major advantage of the rotary sidewall coring system is that it produces samples suitable for quantitative core analysis.

In Western Offshore basin, PCOR rotary side wall coring job was carried out recently in a few wells. In one such well, the core samples were recovered from the Basement Section and quality of core samples were good and deemed fit for lab studies. Since the formation/lithology sampled was hard rock basement, normal percussion side wall coring method have limitations in returning quality cores. Another highlight of the core samples retrieved from PCOR tool is that the samples, by virtue of having 1 inch diameter can be used directly in place of conventional core plugs for triaxial studies to derive rock mechanical properties.

Tool Name	Service Provider	Core Specifications
PowerCOR sidewall coring tool (PCOR)	Baker Hughes	Core diameter: 1 in, Core length: 1.8 in
Mechanical Sidewall Coring Tool (MSCT)	Schlumberger	Core diameter: 0.92 in, Core length: 2 in
Rotary Side wall Coring Tool (RSCT)	Halliburton	Core diameter: 0.93 in, Core length: 1.75 in

Core retrieved from PCOR job in Mumbai offshore

Differential Acoustic measurement Spectroscopy (DARS) – Opening up New R & D Avenues

Authors: Surbhi Mundra, Parmanand, Sanjeev Lakhera, Vinod Kumar, Yogesh Bahukhandi - CEWELL, ONGC

In order to guide seismic interpretations with regard to reservoir prediction and fluid identification, it is important to understand the frequency dependence of the elastic properties of fluid-filled rocks. Further for carrying out 3D Geomechanical studies using seismic volumes a correlation between dynamic & static mechanical properties is required.

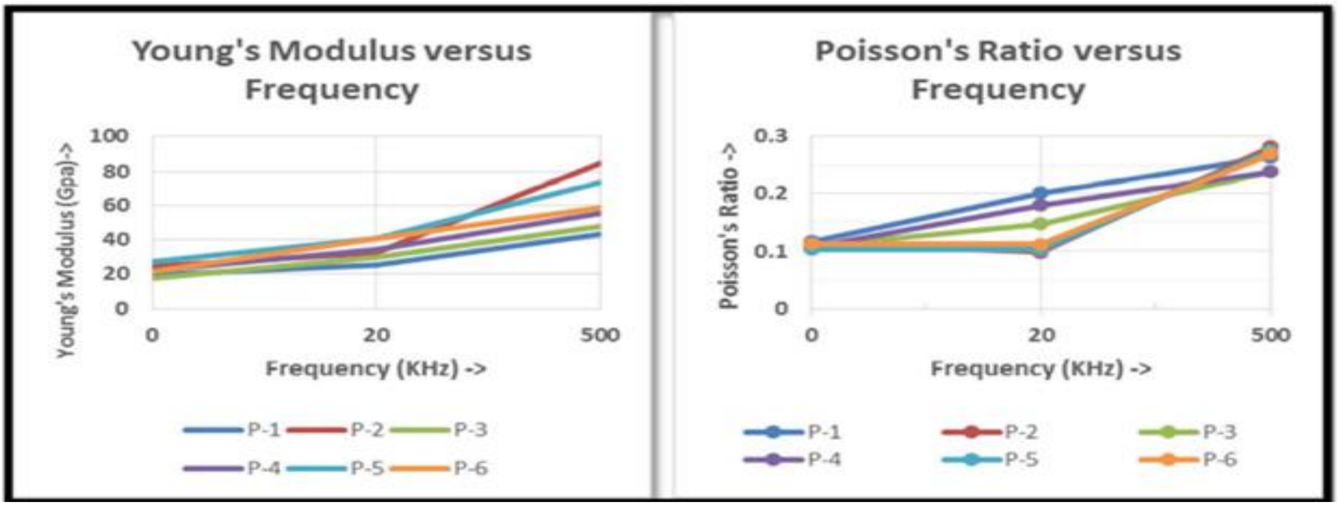
However, their practical use is limited because of the lack of systematic experimental validation and calibration at seismic frequencies. In fact, experimental measurements on well-characterized rock samples are carried out mostly at ultrasonic frequencies. A good amount of research is underway to understand the frequency dependent estimation of elastic & mechanical properties of rocks and their applications. A typical constraint to derive elastic/ mechanical properties on plug sized samples is the wavelength of the acoustic signal used should be of the order of the size of the samples. That is the reason frequencies in the range of 100 -500 Khz are generally used.

Methodology like DARS i.e., Differential Acoustic measurement Spectroscopy have been developed to investigate the acoustic properties of samples in the lower frequency range. This new laboratory measurement technique examines the change in resonant frequencies of a cavity perturbed by the introduction of a small test sample. The resonant frequency shift between the empty and sample-loaded cavity is used to estimate the acoustic properties of the loaded sample. This new Technology is in the R&D phase and is expected to be used widely in future to get more accurate low frequency measurement.

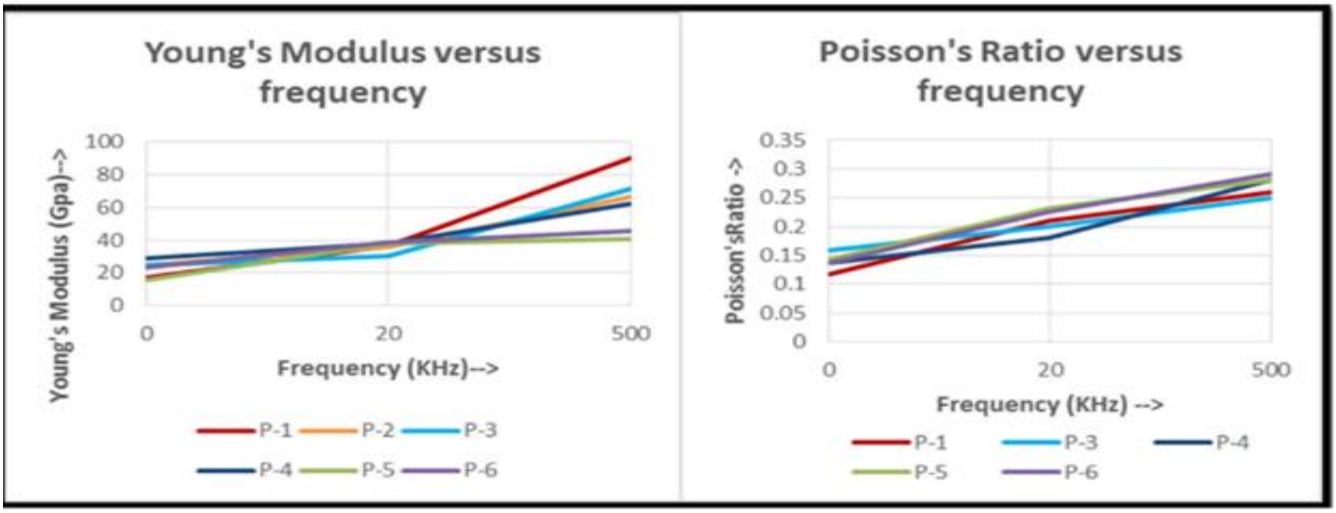
To get a feel of the issues and challenges it was decided to foray into this field with the help of existing equipment/ Lab setups at different institutes of ONGC. Mechanical properties at ultrasonic frequencies (500 KHz) and Triaxial Tests (Static Properties) were tested on same/ adjacent samples from tight reservoirs in Mandapeta (Mandapeta Fm.) & Malleswaram (Nandigama Fm.)fields. 85 plugs from these formations were subjected to Triaxial/ Vp-Vs measurements. Vp-Vs measurements & Static Mechanical Properties were measured at different confining pressures. Going further, this data was compared with the log derived values at those depths.

As a beginning into this vast field the following conclusions can be made :

- Keeping the trend values of Young's modulus and Poisson's ratio increase with frequency of measurement. The core derived dynamic Young's modulus (@500 KHz) is 2 - 5 times more than the static YME whereas the core derived dynamic PR (@500 KHz) is 2-2.5 times more than its static values for both the formations.
- At log frequency, there is huge dispersion in values of YME and PR. This is probably because of scale effect (Logs sample average values of about 2 ft. of formation). The dispersion is much more pronounced in case of Poisson's Ratio compared to Young's Modulus.
- Transforms between static and dynamic elastic constants (@ 500 KHz) are generated. This will help in calibrating mechanical/ geomechanical parameters measured from AVS measurements
- There is a defined trend in YME values which can be improved with more data points but no trend could be established for PR. This is in line with other published literature where dispersion in PR measured values have been found not to follow definitive trends.
- More experiments are planned to develop understanding in other geological/ depositional setups. Equipment facilitating Vp-Vs measurements at lower frequencies (like DARS) will also be explored to connect the missing link.

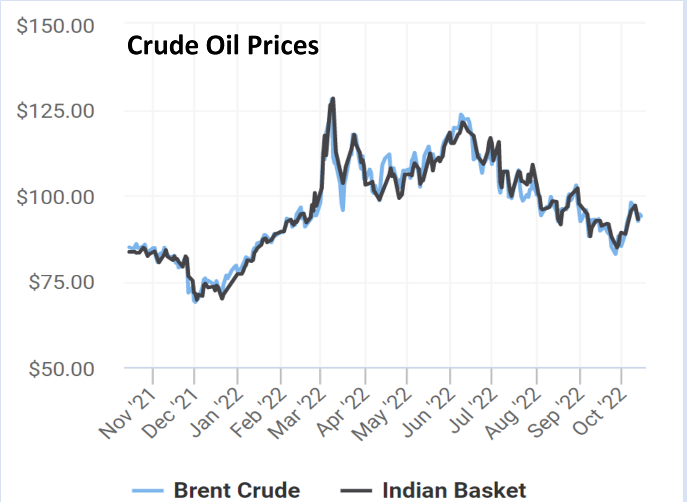


Variance of Youngs modulus and poissons ratio with frequency for mandapeta @ 3000 psi confining pressure

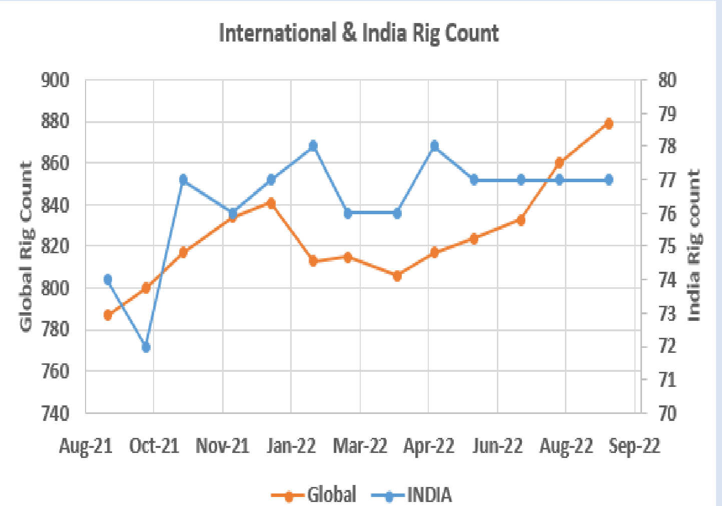


Variance of Youngs modulus and poissons ratio with frequency for malleswaram @ 3000 psi confining pressure

Zero freq(static values) refers to tria-axial measurement, 20 khz represent estimated values from log and and 500 khz represent values from AVS Equipment measurements



Courtesy: Oilprice.com

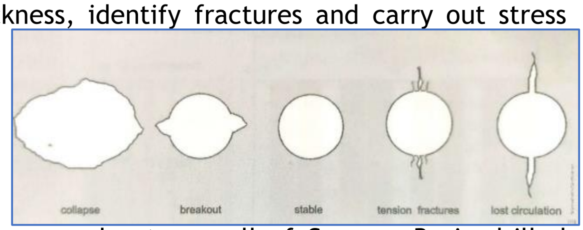


Courtesy: BakerHughes

Borehole Imaging provides Insights into Well Integrity, Borehole Stability & Stress Profiling

Authors: C S Sajith, ONGC Mumbai

Borehole imaging refers to acquiring and presenting images of the borehole wall using optical, acoustic, electrical measurements or a combination of these. Borehole images help in visualizing rather than guessing the subsurface reservoirs and are used to establish the presence of thin bed reservoirs, estimate the formation dips, describe the reservoir fabric, texture and secondary porosity, define the diagenetic and depositional facies, compute sand count and pay thickness, identify fractures and carry out stress profiling. The shape of the borehole provides very important insights about the stability of the well in general and the stress regime it is subjected to in particular.

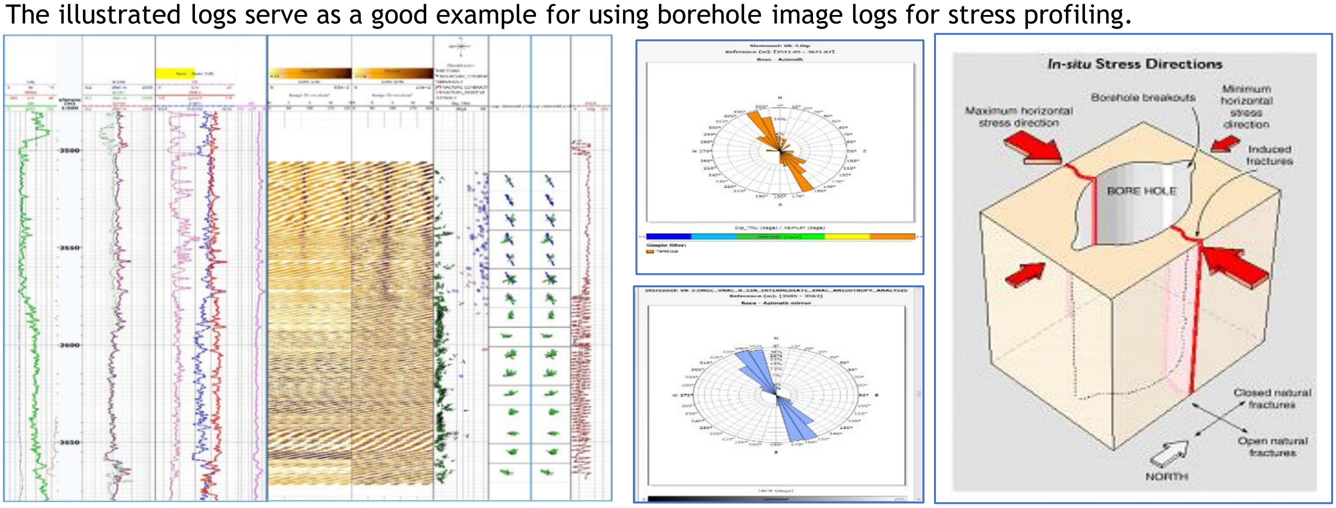


Borehole profiles and well stability

Microresistivity electrical imaging log data was acquired in an exploratory well of Cauvery Basin drilled with an objective to explore the deep synrift sequences. After lowering the 9 ⅝" casing, the borehole was subjected to shoe strengthening process a few times as pressure drop was observed during shoe integrity tests (SIT). Further a leak off test (LOT) was carried out wherein the formation leaked at 820psi surface pressure, EMW: 1.71 (Formation breakdown pressure: 1340 psi, EMW: 1.82 and Fracture closure pressure: 780 psi, EMW: 1.70, volume pumped: 450 Liters and Volume returned: 450 Liters). The well encountered approximately 70m of arenaceous facies followed by 80m of shaly facies in the subsequently drilled 8 ½" section of the borehole. After drilling through the shale, upon penetrating the objective synrift sequence, well became active with mud belching observed at well mouth. The mud weight was increased step by step to control the activity following which a loss-gain situation prevailed. Once the well was conditioned for nil dynamic loss and nil reduction in mud weight, open hole logs were acquired. The acquired logs bore tell-tale signatures of the formation breakdown that lead to mud loss giving insights to the prevalent stress regimes of the area.

The image log was clearly indicating the developed tensile fractures all along the top sandstone portion of 8 ½" section. The increased mud weight intended to control the activity in the objective formation resulted in formation breakdown leading to a loss in circulation. The tensile fractures that propagate along the maximum horizontal stress direction (SHmax) were captured by the image logs. The SHmax direction of NNW-SSE was further corroborated by the fast shear azimuth (FSA) derived from cross dipole logs as well.

The illustrated logs serve as a good example for using borehole image logs for stress profiling.



Log motif showing Image logs with tensile fractures in NNW-SSE direction corroborated by Dipole sonic derived fast shear azimuth

For contributing Articles for Upcoming Bulletins may please contact
Mail id: sajith_cs@ongc.co.in
Ph No: 9445005818

SPWLA INDIA Chapter
President: Shri Manoj Kumar Tewari,
Chief Logging Services, ONGC Mumbai
Mail: spwla.india@gmail.com
Website: www.spwlaindia.org