Geomechanical testing with large rotary side-wall cores to reduce uncertainty of mechanical properties in the overburden

Ishtar Barranco
Chevron Australia Pty. Ltd.
250 St Georges Tce., Perth WA 6000
ishtar.barranco@chevron.com

Paul Hagin
Chevron Energy Technology Company
841 Chevron Way, Richmond, CA 94801
paul.hagin@chevron.com

SUMMARY

Understanding the strength of overburden rocks, and how they respond to changes in applied stress is essential for developing 3D mechanical earth models. Reliable prediction of the in-situ stress changes over time can only be undertaken with detailed knowledge of the overburden rock mechanical properties. Similarly, monitoring of surface deformation to interpret subsurface changes from fluids injection or production requires knowledge of overburden rock properties. Finally, rock mechanics tests of the overburden formation provide data to reduce the risk of wellbore instability problems for future drilling campaigns.

Acquiring conventional core through the overburden formations can be extremely costly. The XL-Rock tool allows the collection of side wall cores of sufficient size (1.5in x 2.5 in) to extract vertical sub-plugs for rock mechanics testing.

These samples can be used in cases where acquiring full core is not an option. Test results from conventional core have less uncertainty but XL-Rock samples have the following advantages:
1. Significantly lower acquisition cost than conventional coring.
2. Ability to take samples from widely separated formations, rather than just a relatively short continuous interval as is the case in conventional coring.
3. Sample selection can be closely targeted based on prior logging runs, to obtain samples from specific zones of interest.

This paper describes a case history, where, thirty-five XL-Rock samples were successfully acquired targeting overburden formations ranging in depth from 300-1600m. The samples were taken from different lithologies with a wide range of rock mechanical properties.

INTRODUCTION

The XL-Rock tool allows the collection of side wall cores of sufficient size (1.5in x 2.5 in) to extract vertical sub-plugs for rock mechanics testing (**Figure 1**). Use of the XL-Rock tool has a significant advantage over conventional core in that it can be undertaken after a logging suite, thus allowing specific points to be targeted from other logs such as images logs. This can help to improve sample recovery and allow the sampling different lithologies from a variety of widely separated formations, rather than just from a relatively short continuous interval as is the case in conventional coring.

Figure 1 – Standard rotary side-wall core sample (0.92’’x 2’’) compared with large rotary side-wall core sample (1.5’’ x 2.5’’)

XL-Rock therefore represents a potential method for collecting material to establish the required overburden rock mechanics data at a cost that is significantly less than would be needed to collect conventional core for each formation. The size of the samples is sufficient for RCA, SCAL and some Rock Mechanics testing (**Table 1**).

Test Type	Sample Size/ Orientation **	Number of samples required	Can XL Rock cores be used?
Hollow Cylinder Strength (HCS)	1.5” diameter, Horizontal	2 twins per interval	Possibly, depending on variability in sample diameter.
Confined Triaxial Compression	0.5” to 1.5” diameter, 0.75” diameter for shales, Vertical	3-5 twins per interval	Yes, 2-3 vertical sub-plugs can be cut from each core.
Brazilian Tensile Strength (BZT)	1.5” Diameter x 0.5” Length, Horizontal	1 or more per interval	Possibly, depending on variability in sample diameter.
Pore Volume Compressibility (PVC)	1.5” or 2.125” diameter, Vertical	1 or more per interval	No, core orientation is incorrect for this test.
Permeability as a function of stress	1.5” Diameter, Horizontal	1 or more per interval	Possibly, depending on variability in sample diameter.

Table 1- Geomechanical tests compatibility with XL-Rock samples

Development of reliable log-based correlations for rock mechanical properties is best achieved by collecting samples that have a variety of strengths and petrophysical properties. However, it should be recognised that there is a greater risk of non-recovery in weaker formations. This may require selection of more samples in weaker rocks to improve the likelihood of adequate recovery.

CASE HISTORY

In this case history, thirty-five XL-Rock samples were acquired, targeting various overburden lithologies form depths ranging between 400and 1600m below sea level.

Recording of sonic and image logs prior to XL-Rock acquisition reduced the recovery risk and optimised the sample selection **(Figure 2**). The sonic log was used to generate a quick-look UCS indicator to identify “weak zones” that could be below the 600-psi recommended recovery threshold.

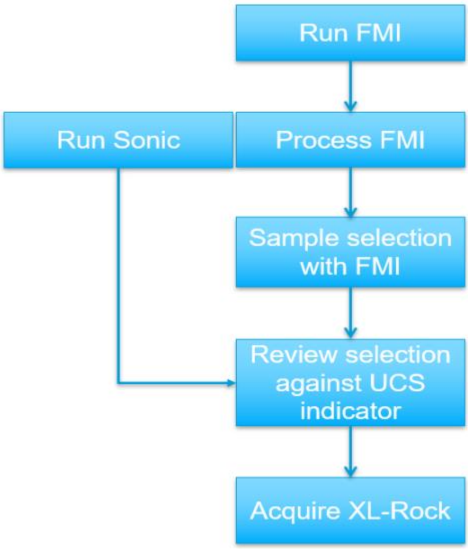

Figure 2 – Sample selection and XL-Rock acquisition workflow

The image logs were processed in real-time and used for selecting sample depths thus avoiding fractures and breakouts and allowing the identification of the different lithologies and sections that were homogeneous enough to acquire 5 XL-Rock samples in the same zone **(Figure 3).** It was determined that 5 XL-Rock samples per lithology provided sufficient plugs for all the geomechanical and other core analysis testing while keeping one back-up sample in case of poor recovery.

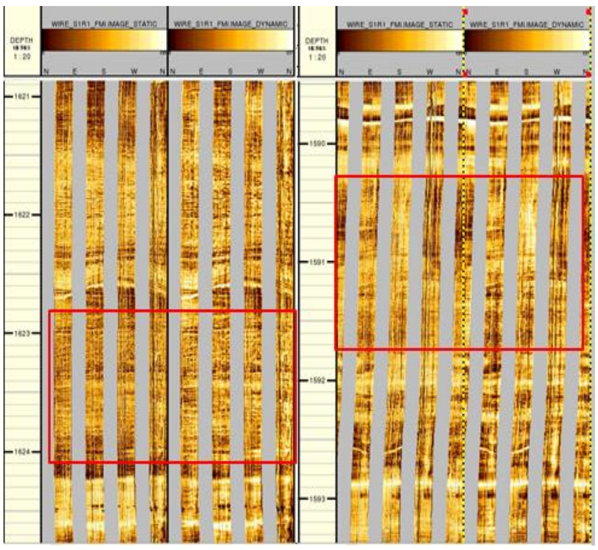

Figure 3 – Images logs were used to identify the best zones for the XL-Rock acquisition

This acquisition strategy provided excellent results. 35 XL-Rock samples were successful recovered with lengths of at least 2.5” **(Figure 4)**. Only three samples had cracks which prevented them from being used for geomechanics testing.

Figure 4 – XL-Rock samples in the barrel compared with standard rotary side wall core.

The samples acquired were used for Triaxial Compression (TXC) test using mini-plugs in different directions (vertical, horizontal, inclined) **(Figure 5).**

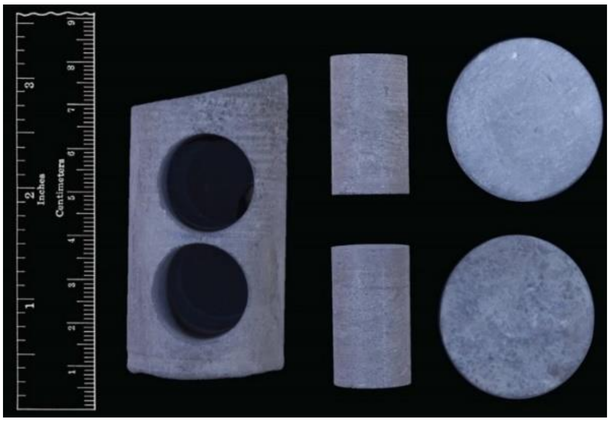

Figure 5 – XL-Rock core after plugging: showing two vertical ¾” diameter sub-plugs

Some samples were also used for Pore Volume Compressibility test (PVC). The PVC test is normally performed in vertical plugs and requires plugs of 1.2’’x 2.125’’. This test can’t be performed using mini-plugs, it requires the whole XL-Rock sample which is horizontal. Therefore, the PVC test was only performed in homogeneous sand samples where the horizontal and vertical geomechanical properties were considered isotropic.

The tests successfully provided valid data for Triaxial Compressive Strength **(Figure 6),** Young’s modulus, P and S wave velocities, dynamic Young’s modulus, dynamic and static Poisson’s ratio and permeability as a function of effective stress. Unconfined compressive strength and Hollow Cylinder Strength (HCS) were not measured on any of the samples as part of this testing program but can be considered in cases where completion design and sanding prediction applications are required.

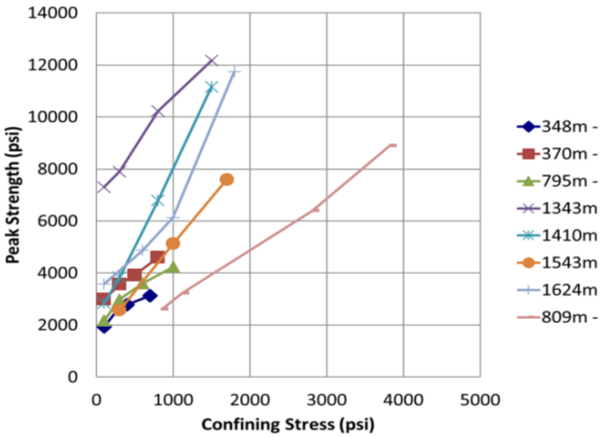

Figure 6 - Triaxial Compressive Strength Results as a function of confining stress. Samples are tested over a range of stresses associated with in situ conditions.

CONCLUSIONS

This case study successfully demonstrated that large rotary side-wall cores are a feasible option for obtaining samples for geomechanical testing, and that XL-Rock sampling programs can provide useful geomechanical data in sections which would not normally be cored. This is particularly the case in overburden sections in which the hole size can often be too large for cost-effective conventional coring.

Furthermore, this method provides the following advantages:

- Significantly lower acquisition cost relative to conventional coring.
- Ability to take samples from widely separated formations, rather than just from a relatively short continuous interval as is the case in conventional coring.
- Samples can be taken after a logging suite allowing to select rocks samples with different petrophysical properties using logs such as sonic, density or images logs.