P 395

Recent Advances in Rotary Sidewall Coring: Applications in Formation Evaluation and Beyond

*Chandramani Shrivastava and Koushik Sikdar**

Summary

Sidewall cores are integral part of formation evaluation, often providing the ground-truth about the sub-surface and used to calibrate the well-log response. Percussion coring has been around and in use for many decades, primarily for their ease of operation and cost-benefits. However, rotary cores are better suited for any petrophysical properties calculations, though with complex operations and cost-constraints. Recent advances in sidewall coring has eased the operations and also ensured bigger volume of rocks for most of the analysis performed on the conventional cores. The latest generation of rotary sidewall coring technology lends itself to address various challenges in formation evaluation and beyond; in completion planning and stimulation design.

Keywords: *Sidewall Core, Advanced Core Analysis, Core Plugs, Petrophysics*

Introduction

Core data remains the "ground truth" even though various high resolution sophisticated well log measurements are available to characterize the sub-surface. Acquiring the conventional drill-core has its own inherent challenges associated with recovery and cost constraints. The drill-core remains the gold standard for all types of core analysis; i) conventional core analysis, ii) routine core analysis, and iii) special core analysis.

With technology advances in high-resolution seismic data acquisition, processing and interpretation, understanding the larger geology picture in sub-surface is getting easier. And, coupled with high resolution borehole images the finer-scale geological understanding can be developed. Integrating the data on these two scales-apart measurements is reducing the dependence on core-data for sedimentary structures and depositional environment interpretation. Furthermore sidewall cores also provide effective method for obtaining geological data (Collier, 1989). For petrophysical and reservoir properties analysis in lab to cover the wide spectrum of routine to advanced core analysis, a decent volume and size of rock is needed that traditionally is derived from the drill-core in the form of plugs. There always have been discussions if sidewall cores can actually be recovered with good integrity and enough volume for the advanced analysis.

Recent advances in sidewall coring have ensured that most of the analysis performed on conventional core can actually be done with the latest generation of rotary sidewall cores.

Sidewall Coring

Sidewall coring has been around since many decades, the cores providing the "real rock" from the subsurface for lab analysis. Koepf (1961) presented a detailed account of how sidewall core analysis adds to formation evaluation. Fens (1998) discussed that contrary to core that is usually only taken over the reservoir interval, sidewall cores are taken in reservoir sections as well as in the cap-rock and source rock samples for age-dating and to evaluate cap-rock sealing capacity and source-rock potential.

In early days the main objectives of sidewall coring used to be grain-size, mineralogy, biostratigraphy etc. With complex reservoirs coming to development, a lot more

Schlumberger Nigeria Ltd., Lagos
cshrivastva@slb.com

analysis was needed to be performed on the "rock samples". However, the conventional drill-cores are always expensive to acquire and recovery could be adversely affected in heterogeneous formations many time. Moreover, there are always issues with the depth-control and often log measurements are used to tie the core to correct depth. Sidewall coring is done with excellent depth control and the zones of interest can be selected precisely with prior run logs. Over the last few years, many practices have been developed which greatly increase the utility of the sidewall cores (Arora, 2011).

The two main types of sidewall coring are:

- **Percussion coring**: when a hollow bullet is fired in the formation to retrieve the rock-sample.
- **Rotary coring:** when a rotary drill-bit conveyed on wireline or pipe retrieves the rock-sample after drill-and-severe.

There are advantages and disadvantages associated with the two technologies. Percussion coring impacts the rock (Webster, 1959) and may adversely affect the properties like porosity and permeability; whereas the rotary coring is better suited for such analysis and many more. However, rotary coring traditionally has been avoided in unconsolidated formation due to low recovery. And, rotary coring is operationally complex and expensive compare to the percussion coring.

Applications of Rotary Sidewall Coring

Sidewall coring applications are numerous; from conventional to unconventional reservoirs. The common geological applications are related with seal-integrity and total organic content (TOC), lithology, mineralogy (thin section, XRD, SEM), biostratigraphy, grain size and density analysis etc. petrophysical applications vary from calibrating the log response to porosity, permeably, saturation, NMR, capillary pressures, fluid type. Also, stimulation and completion planning is based on the sidewall core analysis.

Many thematic solutions addressing the following challenges have seen detailed applications of the sidewall cores. Koepf saw its application in low-resistivity pays way back in 1961, when he cautioned that sidewall sample would show whether the changes indicated by the electrical logs in high-resistivity zones are due to reduction in porosity or in the presence of hydrocarbon. Morphy (1985) used the sidewall sample thin sections to evaluate the completion potential of low resistivity reservoirs, discrimination between bioturbated and clay-free zones. Shade (1992) noted that clay mineral mobilization, fluid sensitivity and iron/ acid susceptibility can be significantly reduced with proper planning if authigenic chlorite and kaolinite occurring as pore lining and filling materials as seen from sidewall samples are factored in. Lyne (2006) presented an account of the sidewall sample importance in calibrating NMR response in heavy oil. Henry (1996) showed how heavy oil asset management can be improved with biomarker variability in sidewall cores and produced oils. Laubach (1999) integrated image logs and rotary cores for natural fracture analysis in Appalachian basin. Completion design and gravel pack design have been helped with the grain-size variability (Himes, 1986) and rock competence (Britt, 2004). Determination of mechanical rock properties is important for reservoir compaction, borehole stability, formation control and hydraulic fracturing.

Various tests are being performed on rotary cores in shale reservoirs, such as desorption isotherms, tight rock analysis, rock-mechanics, geochemistry, XRD, SEM, acid solubility etc. (Vasilache, 2008).

Although the ability to perform routine core analysis (RCAL) measurements on sidewall core samples improved significantly with the introduction of the first rotary sidewall coring tools in the 1980s, significant limitations remain related to the relatively small size of the sample. Among other challenges, measurement uncertainty is higher compared with core plugs, and in heterogeneous formations the smaller volume of rock is expected to be intrinsically less representative of bulk reservoir properties. Many special core analysis (SCAL) and rock mechanics methods are not considered to give valid results or cannot be performed owing to insufficient volume of core material (Laronga, 2011).

Large Format Sidewall Coring

The Large-Format sidewall core (SWC) provides over 4 times the rock volume compared to the conventional rotary SWC (Figure-1).

Figure 1: Comparison of the large-format SWC (1.5”x3”) with conventional rotary SWC (~1”x2”)

Its volume (1.5” diameter and 3” length) is similar to the core plugs that are taken from the bottom hole core for analysis. This provides adequate size for advanced analysis like relative permeability, triaxial Geomechanics, wettability, NMR calibration etc.

Dynamic control on Weight-On-Bit (WOB) is deployed in the latest generation rotary sidewall coring technology. It enables changing the drilling parameters in real time for every coring depth to honor the rock-strength and borehole conditions. Also, rocks of extremely different rock-mechanical properties can be cored in a single descent of the tool downhole (Figure-2); from Unconfined Compressive Strength (UCS) of a few hundreds to more than tens of thousands psi.

Figure 2: Large-format SWC subsampled on three axes for geomechanical testing (Ref: Laronga, 2011).

Comparative analysis of the large-format rotary cores and conventional rotary cores is presented in Figure-3; where V. GOOD is what can be achieved on bottom hole core.

Analysis	Std Rotary	Large-Format Rotary
Storage Capacity	GOOD	V. GOOD
Flow Capacity	GOOD	V. GOOD
Grain Density	GOOD	V. GOOD
Evaluate productive potential (saturation)	GOOD	V. GOOD
Capillary pressure characteristics	GOOD	V. GOOD
Electrical properties	FAIR	GOOD
Acoustic velocity characteristics	FAIR	GOOD
NMR T2 and T2 critical	FAIR	GOOD
Continuous Section Log Calibrations	POOR	FAIR
Mechanical Properties	FAIR	GOOD
Pore Volume Compressibility	FAIR	GOOD
End Point Relative Permeability	FAIR	GOOD
Core Wettability	FAIR	GOOD
Water Sensitivity, Critical Velocity	FAIR	GOOD
Mineralogical Information, XRD, SEM, Isotope	V. GOOD	V. GOOD
Petrographic Description	V. GOOD	V. GOOD
Environment of Deposition	FAIR	GOOD
Seal Studies and Breakthrough Pressure	FAIR	GOOD
Fracture Analysis	POOR	FAIR
Determination of Contacts	FAIR	GOOD
Source Rock and Oil Characterization	GOOD	V. GOOD
Bio stratigraphic Correlation	FAIR	GOOD
Grain Size Analysis	GOOD	V. GOOD

Figure 3: Large-format SWC advantages

Conclusion

Rotary sidewall cores have their established role in formation evaluation program. However, some advanced applications analysis still needed a plug from the drill-core to reduce uncertainty. Recent advances in sidewall coring have ensured that the optimal volume is available with large format sidewall cores for most of the advanced and special core analysis with better operational efficiency while reducing the reliance on drill-cores. Also, the completion and stimulation designs derive a great deal of information from the large-format sidewall cores.

Acknowledgement

Authors are grateful to the management of Schlumberger for their support and approval to present this work. They also acknowledge their colleagues at Schlumberger and various operating companies for the fruitful discussions.

References

Arora, A.J., Bihani, A.D., Padalkar, C.M., Punase, A.D., Patwardhan, S.D.; 2011, "Sidewall Coring: Advanced In-situ Freeze-Core Technique"; IPTC-14669

Britt, L.L., Smith, M.B., Haddad, Z., Reese, J., Kelly, P.; 2004, "Rotary Sidewall Cores: A Cost Effective Means of Determining Young's Modulus"; SPE-90861

Collier, H; 1989, "Petrographic Analysis of Thin Sections of Cuttings and Sidewall Cores: An Effective method for Obtaining Geologic Data"; AAPG Southwest Section-1989; San Angelo, Texas.

Fens, T.W., Kraaijveld, M.A., Riepe, L., Visser, R.; 1998, "Archie's Dream: Petrophysics from Sidewall Samples and Cuttings"; SCA-9805

Himes, R.E., Ruiz Jr, S.J.; 1986, "New Sidewall Core Analysis Techniques Improve Gravel Pack Design"; SPE-14813

Koepf, E.H., Granberry, R.J.; 1961, "The Use of Sidewall Core Analysis in Formation Evaluation"; Journal of Petroleum technology; Vol 13, No 5

Laronga, R., Tevis, C., Kaiser, B., Lake, P., Fargo, D.; 2011, "Field test Results of a New-Generation Large-Bore Rotary Coring Tool"; SPWLA 52nd Annual Logging Symposium-2011; Colorado, USA

Laubach, S.E., Doherty, E.; 1999, "Oriented Drilled Sidewall Cores for Natural Fracture Evaluation"; SPE-56801

Lyne, A.M., Riva, A., Gossenberg, P.; 2006, "Early Detection of Biodegraded Oil Using NMR Downhole Logs and Hydrocarbon GC-MS Analysis of Sidewall Cores"; MEOS-2006; Baharain

Morphy III, P.H., Thomson, U.; 1985, "Using Sidewall Sample Thin Sections to Evaluate the Completion Potential of Low Resistivity Pleistocene Sands, Offshore Lousiana"; SPE-14273

Shade, M.E., Hanse, D.K.T.; 1992, "Drilled Sidewall Cores Aid in Interpretation of the Tertiary Wasatch Formation, natural Buttes Field, Utah"; 1992 Utah geological Association Guidebook 20.

Vasilache, M.A.; 2008, "Shale Analysis Using Rotary Sidewall Samples"; AAPG Annual Convention, San Antonio, Texas

Webster, G.M., Dawsongrove, G.E.; 1959, "The Alteration of Rock Properties by Percussion Sidewall Coring"; SPE-1159-G