XL-Rock
Large-volume rotary sidewall coring service
Retrieving up to fifty 1.5-in-OD by 2.5-in-long sidewall core samples from a single descent into a well, the XL-Rock* large-volume rotary sidewall coring service closes the gap between core plugs from continuous conventional core and wireline-conveyed rotary sidewall cores. These large-volume core samples deliver a rock volume equivalent to conventional core plugs, matching the industry’s standard sample size for most special core analysis (SCAL) measurements and enabling key answers in less time and at lower cost than conventional coring.

Uncovering the secrets of your reservoir, core by core

APPLICATIONS
- Geomechanics
- Relative permeability
- Mineralogy: x-ray diffraction, scanning electron microscope, isotopes
- Petrographic description
- Source rock and oil characterization
- Log calibration: grain density, resistivity $m$ and $n$ exponents, nuclear magnetic resonance (NMR) $T_2$ cutoff, mineralogy and total organic carbon (TOC), and geomechanical properties to acoustic logs
- Grain-size analysis
- Reservoir storage capacity
- Reservoir flow capacity
- Capillary pressure characteristics

BENEFITS
- Reduced cost and time by retrieving 1.5-in-diameter core plugs that support same analysis as plugs from conventional whole core
- Efficient sampling across a wide range of lithology with real-time control of variable weight-on-bit
- Improved safety with larger working loads at surface from combinability with the Schlumberger electrically controlled release device (ECRD)
- Safer conveyance on drillpipe through combinability with a tension-compression sub and the TLC* tough logging conditions system

FEATURES
- Operations in environments up to 30,000 psi and 350 degF
- Retrieval of up to fifty 1.5-in-OD core samples per run
- Borehole size from 7.5 to 19 in
- More than 3 times the rock volume of standard 0.92-in-diameter cores
- Exclusive access to TerraTek* Fast Track Geomechanics* full-anisotropic rotary sidewall core characterization with calibration to logs
The large volume and dimensions of the XL-Rock sidewall cores support full analytical characterization that was previously reserved for conventional core samples. To provide maximum information in the minimum amount of time, TerraTek Fast Track Geomechanics full-anisotropic rotary sidewall core characterization is reserved exclusively for operators with XL-Rock cores. Fast Track Geomechanics analysis delivers a timely evaluation of mechanical properties and completion quality assessment for tight shales. Conventional geomechanical testing and analysis require conventionally coring the well and take a much longer time to return results that are crucial for completion decision making.

Fast Track Geomechanics analysis of rotary sidewall plugs (RSWPs) begins with heterogeneous rock analysis (HRA) conducted within 2 h of receiving wireline well logs. HRA objectively identifies the diagenetic rock facies (rock classes) in the logged section. From this assessment, the most efficient sampling that obtains the maximum representation of variability in physical properties can be planned. Once the core points are selected for sampling, large-volume sidewall cores are drilled with the XL-Rock tool. The collected core samples are shipped to a Schlumberger laboratory where TerraTek services are performed on RSWPs. The data are analyzed and propagated to provide answers important to completion design.

The dedicated Fast Track Geomechanics workflow makes it possible for a typical sampling of five diagenetic facies, each at a separate depth, to be fully evaluated for static and dynamic anisotropic elastic properties with the analysis completed in 2 weeks. The workflow incorporates integrated sample preparation and handling, exclusive access to testing systems, and semiautomated data processing and integration. The XL-Rock large-volume cores make it possible to extract sufficient material for complete analysis of reservoir quality, equivalent to the analysis of plugs taken from whole conventional core.

Large-volume XL-Rock sidewall cores recover a sufficient volume of rock to extract three triaxial minicores for full analysis of completion quality, which previously required samples taken from conventional core.

### TerraTek Answer Products for XL-Rock Rotary Sidewall Core Samples
- Completion quality log (CQL)
- Continuous profile of static and dynamic Young’s modulus (vertical and horizontal)
- Continuous profile of static and dynamic Poisson’s ratio (vertical and horizontal)
- Continuous profile of compressional and shear wave velocities
- Continuous profile of minimum horizontal stress
Core analysis: The more material, the better

Wireline sidewall cores have a well-established role in formation evaluation. It is the physical measurements performed on these samples that provide control for key petrophysical parameters. Historically, the small size of sidewall cores has been a recognized constraint, permitting only a subset of the exhaustive information that is obtained from continuous whole core. But for reasons of operational efficiency, sidewall cores are often the only practical option in terms of time and cost.

Sample quality, and concurrently 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, but significant limitations remained related to the relatively small size of the samples. Although the MSCT* mechanical sidewall coring tool reliably acquired high-quality sidewall cores across a variety of lithologies, from hard, brittle igneous rocks to friable sandstones, carbonates, and shale plays, the standard sample size is a diameter of 0.92 in. Measurement uncertainty on these cores is high compared with that of core plugs from conventional core, which can be 3 to 4 times larger in volume. In heterogeneous formations the smaller volume of rock associated with sidewall cores is expected to be intrinsically less representative of bulk reservoir properties. At this sample size, many SCAL and rock mechanics methods are not considered to give valid results or cannot be performed because there is an insufficient volume of sidewall core material.

The innovative XL-Rock service breaks the sample size barrier for rotary sidewall cores, retrieving high-quality 1.5-in-OD by maximum 2.5-in-long sidewall core samples equivalent to standard laboratory core plugs. With this new coring capability, operators can fully characterize an extended reservoir interval in a single sidewall coring descent instead of multiple sidewall coring descents or multiple stands of whole-core retrieval.
XL-Rock diamond coring bit efficiently drills into a wide range of lithologies.
New electronics for expanded functionality and safety
XL-Rock large-volume rotary sidewall coring service is based on the reliable mechanical design of the MSCT tool and incorporates new ruggedized electronics to provide additional capabilities in retrieving the larger rock samples.

Operational risk is greatly reduced for XL-Rock service. At only 37 ft in length, the XL-Rock tool is the shortest rotary sidewall coring service in the market today. In addition, the shaft attached to the core bit has a special built-in safety feature to enable controlled release of the core bit if the bit becomes stuck in the formation. With limited tool length and integrated shaft-controlled release, XL-Rock service reduces fishing risk to the bare minimum.

The XL-Rock electronics are a complete redesign for compatibility with the latest Schlumberger telemetry systems, accessing features that were previously reserved for sophisticated logging toolstrings. The result is superior wellsite efficiency and core recovery. Engineers running the XL-Rock tool have real-time control of physical drilling parameters such as weight on bit and can adjust as needed to ensure that the tool is coring at the optimal settings for every core point.

The electronics also reduce operational risk through compatibility with the electrically controlled release device (ECRD), which greatly increases the amount of pull allowed on the wireline cable and reduces the chance of a stuck tool resulting fishing operation. Combinability with a tension-compression sub enables conveyance not just on wireline but also on drillpipe with the TLC tough logging conditions system.

Efficient, high-recovery sidewall core collection
Up to 50 samples can be collected by the XL-Rock tool in a single descent. At each core point, the tool is anchored and the coring bit assembly rotated from its transport position in the tool body to drill into the formation. Once the full length of the coring bit assembly has drilled into the formation, the assembly is canted upward to sever the end of the core, which is retained in the core bit by the core catcher ring as the assembly is retracted into the tool. Core markers separate each sidewall core sample stored in the tool for delivery to surface.

Reliability and range
The coring bit of the XL-Rock tool is powered by an in-house hydraulic motor for efficient sample recovery across a wide variety of rock types. When run in combination with Schlumberger engineered cables, the XL-Rock tool can be deployed on wireline cables as long as 40,000 ft.
An operator drilling a well in north central Pennsylvania wanted formation samples from a black shale targeted for unconventional gas. In this environment, large-volume rotary sidewall cores would be valuable for determining the basic composition, texture, and physical properties of the rock.

XL-Rock service was used to retrieve 1.5-in-diameter sidewall cores for a logging program consisting of 100 core points over the full openhole interval. Of the 100 samples attempted, 86 of the samples were brought to surface, achieving 96% core recovery. The core samples were drilled at an average of 5.3 min per core. The 1.5-in-diameter core samples had an average core length of more than 2 in end to end. The resulting sample volume was more than 300% of that retrievable by previous-generation rotary sidewall coring. The additional sample volume improved measurement precision by enabling analytical techniques such as tight rock analysis (TRA) to be conducted on a single sample instead of having to combine multiple small samples.

As has become standard practice with XL-Rock service, the operator followed XL-Rock sampling with FMI® fullbore formation microimager logging. XL-Rock coring leaves a 1.5-in-diameter hole in the borehole wall where the 1.5-in-diameter rock sample was extracted. These holes show up vividly on the high-resolution image acquired by the FMI tool, providing visual confirmation of the exact place on the borehole wall from which the core was taken. The core analysis program and subsequent integration with logs greatly benefit from the visual check of whether the samples taken are representative of the interval and from knowing their precise context with respect to the log measurements.

Based on the wealth of information delivered, XL-Rock service with a confirmatory FMI image has become an integral part of the standard exploration logging program for this operator.
In addition to recovering large-diameter samples, XL-Rock rotary sidewall coring operations have been conducted with consistently high recovery statistics and minimal average coring times in a variety of US shale reservoirs.

**PROVEN TRACK RECORD**

Core recovery statistics from four jobs in shale reservoirs.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Location</th>
<th>Total Cores Recovered</th>
<th>Core Recovery, %</th>
<th>Average Coring Time, min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job 1 Typical black shale</td>
<td>North central PA</td>
<td>96</td>
<td>96</td>
<td>5.3</td>
</tr>
<tr>
<td>Job 2 Fayetteville</td>
<td>Arkansas</td>
<td>89</td>
<td>97</td>
<td>5.6</td>
</tr>
<tr>
<td>Job 3 Bakken and Three Forks</td>
<td>Montana</td>
<td>50</td>
<td>100</td>
<td>9.2</td>
</tr>
<tr>
<td>Job 4 Monterey</td>
<td>California</td>
<td>49</td>
<td>96</td>
<td>5.1</td>
</tr>
</tbody>
</table>
## Measurement

<table>
<thead>
<tr>
<th>XL-Rock Tool</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sidewall core samples</td>
</tr>
<tr>
<td>Logging speed</td>
<td>Stationary avg. coring time: 3–8 min per sidewall core†</td>
</tr>
<tr>
<td>Range of measurement</td>
<td>Sidewall core size: 1.5-in diameter × 2.5-in long</td>
</tr>
<tr>
<td>Mud type or weight limitations</td>
<td>None</td>
</tr>
<tr>
<td>Special applications</td>
<td>Conveyance on wireline, drillpipe with the TLC tough logging conditions system, and coiled tubing</td>
</tr>
</tbody>
</table>

† Lithology dependent

## Mechanical

<table>
<thead>
<tr>
<th>XL-Rock Tool</th>
<th>Temperature rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>350 degF [177 degC]</td>
</tr>
<tr>
<td>Pressure rating</td>
<td>Standard: 25,000 psi [173 MPa]</td>
</tr>
<tr>
<td></td>
<td>High pressure: 30,000 psi [207 MPa]</td>
</tr>
<tr>
<td>Borehole size—min.</td>
<td>7.5 in [19.05 cm]</td>
</tr>
<tr>
<td>Borehole size—max.</td>
<td>19 in [49.53 cm]</td>
</tr>
<tr>
<td>Outside diameter</td>
<td>6.5 in [16.51 cm]</td>
</tr>
<tr>
<td>Length</td>
<td>37.0 ft [11.3 m]</td>
</tr>
<tr>
<td>Weight (in air)</td>
<td>970 lbf [440 kg]</td>
</tr>
<tr>
<td>Tension</td>
<td>22,900 lbf [101,860 N]</td>
</tr>
<tr>
<td>Compression</td>
<td>12,500 lbf [55,600 N]</td>
</tr>
</tbody>
</table>

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