Experienced specialists providing consulting services worldwide

Coalbed Methane Consulting Services
Schlumberger is a world leader in coalbed methane (CBM) engineering and geosciences. Schlumberger Data & Consulting Services (DCS) specialists have experience in more than 65 coal basins worldwide enabling us to answer such questions as:

- Will long-life CBM reserves strengthen a portfolio?
- Where are the best CBM reservoirs found?
- What are the characteristics of these reservoirs?
- What makes an optimal CBM field development plan?
- Are there any special considerations in drilling and completing CBM wells?
Schlumberger DCS specialists have demonstrated technical leadership by publishing more than 100 technical papers and presenting more than 50 short courses and seminars on coalbed methane. In addition, we have developed special tools for CBM reservoirs—a proprietary production analysis and forecasting model in ProCADE® well analysis software and a proprietary 3D CBM template model in ECLIPSE® reservoir simulation software. This simulator models desorption and diffusion, considers dual porosity, handles variable reservoir properties, and includes features for coal mine applications. ECLIPSE uses a modified Warren and Root dual porosity model and includes all of the required routines and models for CBM calculations and predictions. In addition, ECLIPSE has the capability to model enhanced coalbed methane (ECBM) production via CO₂ flooding and geologic sequestration of CO₂ in deep coalbeds.
Applications, benefits, and services

**BENEFITS**
Our consultants work closely with you to ensure that project results are consistent with your business strategy. To do this, DCS relies on our experienced CBM team—skilled geoscientists, engineers, economists, and others—to design solutions to meet your needs. DCS has the specialists and technology to lower your operating costs and improve efficiency.

**APPLICATIONS**
- Exploration
- Development
- Drilling and completions
- Production
- Reserves and economics
- Integrated reservoir studies
- Mine degasification

**BENEFITS**
- Optimized drilling prospects
- Enhanced completions
- Increased reserves
- Reduced investment and operating costs
- Improved reservoir understanding and performance

**CBM SERVICES**

**Geosciences**
- Basin assessment and fairway delineation
- Exploration target selection
- Resource mapping and assessment
- Prospect evaluation

**Field and Laboratory Evaluation**
- Gas content and storage capacity
- Coal characterization

**Engineering**
- Drilling and completion optimization
- Well test design and analysis
- Hydraulic fracturing optimization
- Field supervision and QC
- Production analysis
- CBM reservoir simulation

**Economics and Strategic Studies**
- Reserves assessment
- Acquisition/divestiture facilitation
- Independent evaluation/appraisal
INTEGRATED CBM MODEL

The ideal prospecting methodology begins with an integrated model of the coalbeds. Using the whole-earth platform of our Petrel® seismic-to-simulation software, Schlumberger specialists first develop an integrated model of the regional geologic and hydrologic settings of coalbeds in the basin. Then we assess any existing production performance, along with historical mining, drilling, completion, and operation practices.

Next, well performance is integrated with an understanding of the regional geologic and hydrologic settings to identify controls on production and establish production domains. The CBM potential of the production domains is then forecast using special simulators designed to model the unique properties of CBM reservoirs.

The key considerations in prospecting for CBM reserves are

- regional structure and stratigraphy
- coal occurrences—net and total thickness
- reservoir characteristics, including coal rank and permeability
- hydrology of the coal reservoirs
- gas content and origin
- gas resource estimates
- reservoir dynamics, including storage and flow features
- gas resource evaluation
- drilling and completion practices
- operations—production and handling of gas and water
- best completion practices
- well spacing and other factors controlling production rates
- production domains
- type-curve models with economics
- production forecasts by area.

Proprietary CBM reservoir simulators model coal’s unique characteristics and properties.

Production trend maps, similar to this Black Warrior basin study, identify production fairways and sweet spots.

Schlumberger Services

<table>
<thead>
<tr>
<th>Geophysics</th>
<th>Seismic interpretation</th>
<th>Seismic modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geology</td>
<td>Depositional stratigraphy</td>
<td>Burial history/source</td>
</tr>
<tr>
<td></td>
<td>Geostatistics</td>
<td>Sedimentology</td>
</tr>
<tr>
<td>Drilling engineering</td>
<td>Unconventional drilling</td>
<td>Well design</td>
</tr>
<tr>
<td></td>
<td>Geomechanics</td>
<td></td>
</tr>
<tr>
<td>Formation evaluation</td>
<td>Well log analysis</td>
<td>Core analysis</td>
</tr>
<tr>
<td></td>
<td>Well test analysis</td>
<td>Production analysis</td>
</tr>
<tr>
<td>Reservoir engineering</td>
<td>Simulation</td>
<td>Reserve evaluation</td>
</tr>
<tr>
<td></td>
<td>Fluid properties</td>
<td></td>
</tr>
<tr>
<td>Production engineering</td>
<td>Well completions</td>
<td>Workovers</td>
</tr>
<tr>
<td></td>
<td>Stimulation</td>
<td>Artificial lift</td>
</tr>
<tr>
<td>Reservoir risk and economics</td>
<td>Project economics</td>
<td>Technical risk</td>
</tr>
<tr>
<td></td>
<td>Operational risk</td>
<td></td>
</tr>
<tr>
<td>Solutions</td>
<td>Develop innovative and collaborative processes that create value for clients and Schlumberger</td>
<td></td>
</tr>
</tbody>
</table>
**TerraTek Geomechanics Laboratory Center of Excellence** provides crews on wellsite locations for operators taking core. Services offered at the wellsite include field desorption analysis on whole core, cuttings, or sidewall samples. Desorption canisters are used to seal coal samples once core is received at the surface. Additionally, wellsite services include gas sampling during desorption and preservation of remaining whole core samples for further reservoir characterization in the laboratory.

Once received by the TerraTek laboratory, coal samples are subjected to a series of tests to determine gas in place, storage capacity, and other production parameters.

**GAS CONTENT AND STORAGE CAPACITY**

Long-term desorption tests determine gas in place and provide gas samples for compositional analysis. Sorption isotherms are subsequently conducted to measure the coal’s capacity to adsorb gas. When coupled with the canister desorption and reservoir pressure data, it will indicate if the coal is fully saturated with gas or, as is the case with some coalbed reservoirs, it is undersaturated and will require substantial pressure drawdown before significant gas can be desorbed and produced.

Other tests are performed on coals in the laboratory to determine quality and energy content. Such tests include ultimate and proximate analysis (moisture, ash, volatile matter, fixed carbon sulfur, Btu [British thermal unit], and chemical composition [C, H, N, O]), diffusion coefficients (single or multicomponent gases), and residual gas measurements using SPEX mill techniques.

**COAL CHARACTERIZATION**

TerraTek laboratory specialists perform many specialized tests in the laboratory that can further characterize coalbed reservoirs. These include coal petrology (fracture/cleat descriptions, vitrinite reflectance, and maceral composition), mechanical properties (e.g., for use in fracture stimulation design and to answer mechanical questions about the coals and intervening strata), as well as determinations of porosity, permeability, and saturation. TerraTek services provide detailed core descriptions and, on occasion, supply computerized tomography (CT) imaging as requested.

Together, the TerraTek field and laboratory coal services equip clients with accurate and dependable data required to develop coalbed methane properties.
accurate and dependable data

Desorption canisters used to seal coal samples.

Sorption isotherms measure the coal’s capacity to adsorb gas.

Geomechanics testing for mechanical properties.
WORLDWIDE EXPERIENCE

- More than 150 CBM projects completed
- Knowledge base of every coal basin in the US
- Experience from over 65 coal basins in 25 countries on 6 continents
- CBM client base exceeding 100
  - major production companies
  - large and small independents
  - national companies
  - mining operators
- More than 150 years’ combined experience

Schlumberger consulting specialists have completed more than 100 CBM projects and made geologic evaluations of 28 major coal basins worldwide (indicated in blue). Our project experience includes every major coal basin in the US.