Ellenburger Coalesced-Collapsed Paleocave Reservoir Model Based on Outcrop, Core, and GPR Data

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Outline

• Present study area
• Show megascale paleocave collapse features
• Map of paleocave facies
• Reservoir model
**Cave-System Evolution**

**Phase 1:** Modern cave system

**Phase 2:** Multiple near-surface cave systems developed at composite unconformity

**Phase 3:** Coalesced, collapsed-paleocave system

**Unconformity**

**Active cave systems**

**Composite unconformity**

**Suprastratal deformation**

**Exploration Targets**

- Active cave systems
- Relict cave systems

Long-term exposure

Burial and collapse

100 to >1000 m

Suprastratal deformation
**GPR Facies**

**Undisturbed host rock**

**Disturbed host rock**

**Coarser-clast dominated brecciated rock**

**Finer-clast dominated brecciated rock**

10 meters ~32 feet

Blocks or slabs
Collapsed Paleocavern

- Modern surface karst
- Disturbed host rock
- Chaotic breccia cave fill
- Collapsed cave ceiling

~ 40 ft (~12 m)
Collapsed Paleocavern

Collapsed cave ceiling
Collapsed Paleocavern

Collapsed cavern

Disturbed host rock

Legend:
- Undisturbed host rock
- Disturbed host rock
- Brecciated paleocave facies
Paleocave Facies

3-meter slice

Breccia
Disturbed
Undisturbed
Breccia
Disturbed
Breccia

crackle breccia fractures

Loucks (1999)
Paleocave Facies
Extended Study Area

Dean Word Quarry
“PIT”

Cave-Facies 1
Cave-Facies 2
Cave-Facies 3
Cave-Facies 4
Cave-Facies 5
Undisturbed Host Rock
Disturbed Host Rock
Collapsed Ceiling and Wall Rock
Coarse-Breccia Cave Passage Fill
Fine-Breccia Cave Passage Fill

~3 mile
Well & Facies Control

10-20 ft

20-30 ft

30-40 ft

10,000 ft

20,000 ft
Stochastic Facies Modeling
Sequential Indicator Simulation

Well Controls 41
GPR Facies 3

Model Dimensions
10,000 ft x 20,000 ft x 250 ft
200x400x12 (50 ft x 50 ft x 20-30 ft )
1.5 M cells

Simulation Parameters

<table>
<thead>
<tr>
<th>Facies</th>
<th>Ranges (ft)</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Major</td>
<td>Minor</td>
</tr>
<tr>
<td>Collapsed</td>
<td>1,000-5,000</td>
<td>700-3,500</td>
</tr>
<tr>
<td>Disturbed</td>
<td>1,000-5,000</td>
<td>1,000-5,000</td>
</tr>
<tr>
<td>Undisturbed</td>
<td>200-1,000</td>
<td>100-500</td>
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</tbody>
</table>
Stochastic Facies Model
Sequential Indicator Simulation

10,000 ft
20,000 ft
250 ft

10-20 ft
20-30 ft
30-40 ft

Collapsed
Undisturbed
Disturbed
Stochastic Facies Model

Sequential Indicator Simulation

10,000 ft

20,000 ft

250 ft

Collapsed
Undisturbed
Disturbed

Stochastic Facies Model
Sequential Indicator Simulation
Sequential Indicator Simulation

Effect of Correlation Length of Collapsed Facies

R=1,000 ft 2,000 ft 3,000 ft 5,000 ft

Collapsed Undisturbed Disturbed

10,000 ft 20,000 ft

Collapsed  Disturbed  Undisturbed
Effect of Correlation Length of Undisturbed Facies
Sequential Indicator Simulation

Sequential Indicator Simulation

Effect of Correlation Length of Undisturbed Facies
Sequential Indicator Simulation

10,000 ft
20,000 ft

R=200 ft 300 ft 500 ft 1,000 ft

Collapsed Undisturbed Disturbed

10,000 ft
20,000 ft

R=200 ft 300 ft 500 ft 1,000 ft

Collapsed Undisturbed Disturbed
Multi-Step Facies Modeling
Sequential Indicator Simulation

(1) 10,000 ft
Single Step
(2) Collapsed + Disturbed
(3) Disturbed + Undisturbed
(4) Combined

Collapsed  Disturbed  Undisturbed

20,000 ft
Facies in 10-20 Ft Interval

<table>
<thead>
<tr>
<th>Single-Step Model</th>
<th>Multi-Step Model</th>
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<td>Template</td>
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<tr>
<td>Modeled</td>
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</tr>
</tbody>
</table>

- Green: Collapsed
- Blue: Disturbed
- Yellow: Undisturbed
Facies in 20-30 Ft Interval

Single-Step Model

Template

Modeled

Multi-Step Model

Template

Modeled

Legend:
- Green: Collapsed
- Blue: Disturbed
- Yellow: Undisturbed
### Facies in 30-40 Ft Interval

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Legend:
- **Green**: Collapsed
- **Blue**: Disturbed
- **Yellow**: Undisturbed
Summary

• Megascale paleocave collapse features were mapped using outcrop, core and GPR data
• Paleocave facies include collapsed (brecciated), disturbed (fractured), and undisturbed rocks
• Paleocave facies are patchy and can be modeled by stochastic simulation
• Paleocave reservoirs show strong heterogeneity