A Geologic Primer of the Energy-rich Piceance Basin, Western Colorado

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Garfield County Energy Advisory Board
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Summary of Presentation

1. Geologic Time and Changing Landscapes
2. Piceance Basin Geometry
3. Energy Resources
4. Groundwater Resources
Geologic Time

EARTH’S AGE ~4.5 Billion Years!
1 million years = 12,500 lifetimes (80 year span)

1 billion years = 12,500,000 lifetimes

Age of the Earth ~4.5 billion years = 56,250,000 lifetimes

Considerable amount of time for landscapes to change!
Miocene ~10 million years ago
Eocene ~40 million years ago
Late Cretaceous ~70 million years ago
Late Jurassic ~150 million years ago
Late Triassic ~210 million years ago
Late Pennsylvanian ~310 million years ago
Late Devonian ~360 million years ago
Silurian ~440 million years ago
Ordovician ~490 million years ago
Early Cambrian ~520 million years ago
Changing Landscapes
Major Events in Colorado

~1.7 Billion years ago
Continental Accretion, Volcanic Activity

~320 to 250 Million years ago
Ancestral Rocky Mountains

~125 to 70 Million years ago
Cretaceous Interior Seaway

~70 to 50 Million years ago
Laramide Mountain Building

~30 Million years ago to present
Regional uplift, volcanism, and erosion
Cretaceous Interior Seaway

~125 Million Years


Colorado

Cretaceous Interior Seaway
~120 to ~65 Million Years

Cretaceous Interior Seaway
Cretaceous Interior Seaway Coastal Environments

- Open Marine
- Shoreline
- Coastal Plain
Sedimentary Rock Record of the Seaway

Late Jurassic, before flooding by the Seaway

Older Rocks
(Morrison Fm, Cutler Fm., Leadville Limestone, etc.)
Sedimentary Rock Record of the Seaway

Dakota Group

Coastal sediments as seaway came in

Older Rocks

(Morrison Fm, Cutler Fm., Leadville Limestone, etc.)
Mancos Group (Pierre Shale to the east)

Marine mud, limestone, off-shore sands

Niobrara Formation

Calcarious shale and limestone
~75 Million Years

- Large delta system encroached into the seaway across NW Colorado
Mesaverde Group

Shoreline and delta sands, coastal plain mud, peat, sand, river sands

• Sediments were deposited along beaches and near-shore swamps along the migrating shoreline

• Sea-level fluctuated back and forth across Colorado

• Eventually retreated east
Mesaverde Group,
Coal Canyon
~70 to ~50 Million Years

Fragmentation of the region into series of block uplifts separated by deep basins

Laramide Mountain Building Event
Wasatch Formation (Fort Union Formation)
Non-marine river deposited sand, overbank mud and peat.
~50 Million Years

- Deep basin development accommodating large restricted lakes.

Ron Blakey, Northern Arizona University (http://jan.ucc.nau.edu/~rcb7/)
Green River Formation
Lake deposited mud, limestone, evaporites
Uinta Formation

Stream-deposited sand and gravel
~30 to ~10 Million years

- Regional uplift
- Volcanism
- Erosion

PICEANCE BASIN
Widespread volcanic flows
Including Grand Mesa complex
Continued uplift and deep incision by modern stream systems

Limited volcanism (Dotsero ~ 4,150 years ago)
Basin Geometry
Piceance Basin Diagrammatic Cross-Sections

Generalized West-East Cross Section through the North Part of the Piceance Structural Basin
(Modified from Tweto, 1983)

Generalized West-East Cross Section through the South Part of the Piceance Structural Basin
(Modified from Tweto, 1983)
Primary Basin Structural Features

- Bound by uplifts
- Internally complex, with smaller folds and numerous faults

Grand Junction
Grand Mesa
Rifle

Red color is below sea level
Gopher’s View

View from below the surface
Energy Resources
Coal!
Stratigraphic Occurrence of Coal!
Oil and Gas!
Oil and Gas Wells in the Piceance Basin Region

Legend
- COGCC Oil and Gas Wells as of 9/21/03
- Urban Areas
- Major rivers
- Mesaverde Outline
- Lower Mesaverde Outcrop
- Undifferentiated Mesaverde Outcrop

COLORADO GEOLOGICAL SURVEY
Oil and Gas Reservoirs

Mancos Group

Mesaverde Group

Niobrara Fm

Source coals and shales

Porous Sands

Wasatch Fm.

Mancos Group
New Drilling Technology

Horizontal Drilling

- Allows production from source beds and low permeability reservoir rocks
- Increases effective area of wellbore
- Increases chances of intersecting fractures or zones of higher permeability
New Drilling Technology

Fracturing

- Increases permeability around wellbore
“Other” Technology
(Rulison Project, 1969)
Coal-bearing interval
Coal Gas
Oil Shale
Stratigraphic Occurrence of Oil Shale

- Green River Formation
- Wasatch Fm.
- Mesaverde Group
- Mancos Group
Deposition of nahcolite, dawsonite, halite, and oil shale in Lake Uinta (fig. 12).
Mining
In-Situ Retort
Groundwater
Occurrence of Groundwater

- Alluvial Deposits
- Mesaverde Group
- Green River Fm
- Wasatch Fm.
- Mancos Group
- Bedrock Aquifers
Water Well Distribution

- Developing areas
- 90% less than 300 feet deep
- Very few more than 500 feet deep
- Depth is to where reliable water can be found!
**Bedrock Aquifers in the Basin**

<table>
<thead>
<tr>
<th>Era</th>
<th>System</th>
<th>Series</th>
<th>Stratigraphic Unit</th>
<th>Unit Thickness (feet)</th>
<th>Physical Description</th>
<th>Hydrogeologic Unit</th>
<th>Saturated Thickness (feet)</th>
<th>Hydrologic Characteristics</th>
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</thead>
<tbody>
<tr>
<td>Cenozoic</td>
<td></td>
<td></td>
<td>Uinta Formation</td>
<td>0–1,400</td>
<td>Silty sandstone; siltstone and marlstone</td>
<td>Upper Piceance Basis aquifer</td>
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<td></td>
<td>Eocene</td>
<td></td>
<td>Green River Formation</td>
<td>As much as 5,000</td>
<td>Parachute Creek Member kersgenous; dolomitic marlstone and shale 500–1,800</td>
<td>Mahogany confining unit</td>
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<td></td>
<td></td>
<td>Tertiary</td>
<td>Dinosaur Shale</td>
<td></td>
<td>Arvada Points Member shale; fine-grained sandstone and marlstone 0–1,820 ft</td>
<td>Lower Piceance Basis aquifer</td>
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<td></td>
<td></td>
<td>Wasatch Formation</td>
<td>About 5,000</td>
<td>Shale and tectonic sandstone</td>
<td>Fort Union aquifer</td>
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<td></td>
<td></td>
<td></td>
<td>Wasatch Formation</td>
<td>Averages 3,000 may be &gt;7,000</td>
<td>Fox Hills Sandstone, Lowis Shale, Williams Fork Formation, sandstone interbedded shale and coal</td>
<td>Mesaverde aquifer</td>
<td>&lt;500–2,000</td>
<td>Conductivity range &lt;92 to &gt;1.6 ft/day; yield 1 to 900 gpm; transmissivity 810–720 ft/day</td>
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<td></td>
<td>Mancos Shale</td>
<td>More than 7,000</td>
<td>Mainly shale but Frontier Sandstone may be local aquifer</td>
<td>Mancos confining unit</td>
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</tbody>
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**Colorado Geological Survey**
Groundwater and Energy Resources

- Almost all water wells are less than 500 feet deep
- Over 3,000 feet above top of Mesaverde Fm
- Over 5,000 feet above top of Cameo Coal Group in much of the basin
- Over 10,000 feet above top of Niobrara Fm in much of the basin
- Intervening strata are generally low in permeability
Groundwater and Oil Shale

- Not all Green River Fm water is potable
- High salinity in deepest part of the basin
Questions?

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