Geological Industry in Indiana

Petroleum, coal, and stone

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Objectives

1. Types of geological industry in Indiana
2. Stone industry
3. Hydrocarbons and formation of oil and gas
4. Trenton gas field and its history
5. Rise and fall of gas and oil resources

Upcoming Quizzes

1. Friday, April 5: Silurian associated with Field trip 1
2. Wednesday, April 17: Mississippian associated with Field trip 2
Industrial and commercial geological resources in Indiana

Limestone and dolomite
- Dimension stone (Indiana building stone), crushed stone ("aggregate"), agricultural lime, filtering (sulfur dioxide scrubbing in coal-fired power plants), lime for steel production

Sandstone
- Architectural building and landscaping

Clay and shale
- Cement, brick, concrete blocks, tiles, animal feed, plastics, adhesives, paint

Gypsum
- Plaster and drywall

Peat
- Soil improvement, potting soils, golf courses, earthworm culture

Sand and gravel (aggregates)
- Concrete, fill, asphalt, filtration, road construction, snow and ice control, molding in foundries, glass, golf courses, sandblasting

Coal
- Electric power plants, industrial plant power, coke manufacture.

Oil and natural gas
- Heating, automobiles, other transportation, plastics, etc.
<table>
<thead>
<tr>
<th>Commodity</th>
<th>Number of Operations</th>
<th>Number of Companies</th>
<th>National Rank (Production)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>4</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Cement, portland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cement, masonry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay and shale, common</td>
<td>11</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Crushed stone, limestone and dolomite</td>
<td>90</td>
<td>36</td>
<td>12</td>
</tr>
<tr>
<td>Dimension limestone</td>
<td>19</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>Dimension sandstone</td>
<td>5</td>
<td>5</td>
<td>NA</td>
</tr>
<tr>
<td>Gypsum</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Lime</td>
<td>2</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Peat</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Sand and gravel, construction</td>
<td>177</td>
<td>108</td>
<td>12</td>
</tr>
<tr>
<td>Sand, industrial</td>
<td>1</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Slag</td>
<td>17</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>332</td>
<td>172</td>
<td>XX</td>
</tr>
</tbody>
</table>

2. Data withheld by the U.S. Geological Survey. Indiana usually ranks in the top 5 states.
3. Includes all geologic formations. Those producing from the Salem Formation total 11 companies with 14 quarries.
4. Does not include sand and gravel operations producing only pit run material.
5. Not a sum of this column. Some companies produce more than one commodity.
Value of Indiana mineral and fuel production (2005)

IN 2005 (thousands) - $1,705,296

- Coal ($901,465)
- Clay and Shale ($9,800)
- Portland Cement ($217,000)
- Other ($134,004)
- Sand and Gravel ($118,000)
- Crude Oil and Natural Gas ($115,027)
- Dimension Limestone ($45,000)
- Crushed Stone ($265,000)

Includes: ball clay, gem stones, gypsum, industrial sand, lime, masonry cement, and peat.
Stone Industry

• Indiana Limestone (dimension stone) comes mostly from Salem Limestone in Monroe and Lawrence counties

• 2.7 million cubic feet of Indiana Limestone is quarried each year

• 12 million cubic feet quarried in 1929

• First quarry was at Stinesville, opened in 1827

• Hunters Quarries (junction of 37 and the Bypass) were the center of Indiana Limestone production, along with Oolitic and Bedford

• Used for bridges, tunnels, buildings, railbeds. (Empire State Building, Pentagon, Washington National Cathedral, Yankee Stadium, 35 of 50 state capitols)

Abandoned stone quarries
Hydrocarbons

<table>
<thead>
<tr>
<th>Hydrocarbon</th>
<th>Number of Carbon(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>1</td>
</tr>
<tr>
<td>Ethane</td>
<td>2</td>
</tr>
<tr>
<td>Propane</td>
<td>3</td>
</tr>
<tr>
<td>Butane</td>
<td>4</td>
</tr>
<tr>
<td>Pentane</td>
<td>5</td>
</tr>
<tr>
<td>Hexane</td>
<td>6</td>
</tr>
<tr>
<td>Heptane</td>
<td>7</td>
</tr>
<tr>
<td>Octane</td>
<td>8</td>
</tr>
<tr>
<td>Nonane</td>
<td>9</td>
</tr>
<tr>
<td>Decane</td>
<td>10</td>
</tr>
</tbody>
</table>

**Gases**

Methane (CH$_4$)

**Liquids**
Plants and carbon

Cellulose: \((C_6H_{10}O_5)_n\)
Lignin: \(C_9H_{10}O_2, C_{10}H_{12}O_3, C_{11}H_{14}O_4\)
Formation of petroleum

- **Source rocks** are fine-grained sediments rich in organic matter
- Source rocks contain 1%-10% organic carbon by weight, mostly “kerogen” (which is normally insoluble organic matter)
- Organics normally derived from algae, bacteria, and land plants
- When source rock is heated sufficiently kerogen breaks down into oil or gas
- **oil window** ca. 60–160°C, **gas window** ca. 150–200°C
- Organic rich rocks that have not been heated to 100°C are **potential source rocks**, those that have been heated above 100°C are **actual source rocks**
Petroleum reservoirs
Source > migration > reservoir

Carbonates, coals, and shales are typical source rocks
Sandstones and limestones are typical carriers
Shales and mudstones are typical impermeable caps above reservoirs
Conodont alteration index (CAI)

Indiana conodonts: Carl Rexroad, Indiana Geological Survey

<table>
<thead>
<tr>
<th>CAI</th>
<th>Naturally altered conodonts from field samples (Rheinisches Schiefergebirge and Montagne Noire)</th>
<th>Temperature range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><img src="image1.png" alt="Image of conodonts with CAI 1 alteration index" /></td>
<td>&lt; 50°-80°C</td>
</tr>
<tr>
<td>2</td>
<td><img src="image2.png" alt="Image of conodonts with CAI 2 alteration index" /></td>
<td>60°-140°C</td>
</tr>
<tr>
<td>3</td>
<td><img src="image3.png" alt="Image of conodonts with CAI 3 alteration index" /></td>
<td>110°-200°C</td>
</tr>
<tr>
<td>4</td>
<td><img src="image4.png" alt="Image of conodonts with CAI 4 alteration index" /></td>
<td>190°-300°C</td>
</tr>
<tr>
<td>5</td>
<td><img src="image5.png" alt="Image of conodonts with CAI 5 alteration index" /></td>
<td>300°-480°C</td>
</tr>
<tr>
<td>6</td>
<td><img src="image6.png" alt="Image of conodonts with CAI 6 alteration index" /></td>
<td>360°-550°C</td>
</tr>
</tbody>
</table>

Indiana’s oil and gas fields

Figure 23. Map of Indiana showing oil and gas fields. From Indiana Geol. Survey Bull. 42-N,
Trenton Gas Field: 1890-1910
Trenton, Blackford County (SW of Fort Wayne, NE of Indianapolis)

• Petroleum industry took off in 1850s in Pennsylvania. Petroleum oil replaced whale oil for lighting and lubricants
• Well in Eaton drilled for coal struck natural gas, producing flame 2 feet high that burned for 10 years
• Wells at Findlay hit natural gas in subsurface Trenton Limestone (Ordovician)
• Oil hit at Lima, Ohio 1885 struck oil and started boom
• By 1888 some wells producing 1000 barrels a day, first refineries and pipelines built in 1880s and 1890s
• Natural gas used for lighting and power to local industry, or simply burned off
• Peak production in 1900 (11 million barrels), dropped to 2 million by 1910
• Largest producer of natural gas in the world

Shooting a well with nitroglycerin, 1890, Jay County
Shooting the well

Figure 12. “Shooting the well.” This was often a gala event during the Trenton boom. Here a sizable crowd watches the shooting of Black & Haskell’s No. 1 Callihan gas well near Bryant, Jay County, ca. 1890. Note the nitroglycerin wagon in the center foreground.

Hospital Hill, Peru, Indiana
Promotional literature from Hartford, Ind.

Flambeaux and waste natural gas

- In 1887 IGS found that most wells were open, allowing gas to escape 24 hours a day
- In 1898 US Supreme Court upheld state anti-waste laws, allowing the state to move in and cap wells

History of Indiana Oil Production

(Figure 28. Oil production in Indiana, 1889-1979. Modified from Indiana Geol. Survey Bull. 42-N, fig. 18.)

Employment in geological industry in Indiana

<table>
<thead>
<tr>
<th>Commodity Type</th>
<th>Employment</th>
<th>Total Employee Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Minerals</td>
<td>3,628</td>
<td>7,477,953</td>
</tr>
<tr>
<td>Coal</td>
<td>2,788</td>
<td>6,888,402</td>
</tr>
<tr>
<td>Oil and Natural Gas</td>
<td>236</td>
<td>NA</td>
</tr>
</tbody>
</table>

Source of data: U.S. Mine Safety and Health Administration and Indiana Department of Workforce Development. All data are for 2005 with the exception of Oil and Natural Gas which are for 2003. Data include office workers.
History of Oil & Gas Discovery versus demand

(Longwell, 2002. The future of the oil and gas industry: past approaches, new challenges. World Energy, 5(3).) Longwell was Director and Executive VP of Exxon Mobil
The scale of oil use, production, and reserves

Petroleum consumption today: 84,077,000 barrels per day
(BP estimate, 2009)
Cost of oil today: $96 / barrel
(27 March 2013, 12:47 am)

Alaskan National Wildlife Refuge Reserves

Estimated recoverable crude: 5,700,000,000 to 16,000,000,000 barrels
(USGS estimates)
Total worth: $547 billion to $1.5 trillion
(at today’s price)
Current global oil consumption (2012): 88 million barrels per day
Total extension of world oil consumption: 64 to 181 days
(2 to 6 months)
Think gas is expensive now? Just wait.
You’ve heard it before, but this time it’s for real:
We’re at the beginning of the end of cheap oil.