UNIQUE MINERALOGY OF OIL SHALE FROM THE PICEANCE BASIN, COLORADO

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Introduction

• Recent events have once again made oil shale an attractive potential resource.

• One of the largest deposits, estimated at well over 700 billion barrels, is situated in the western United States in the Piceance Basin of western Colorado.

• The distinct mineralogy of these rocks represents their unique conditions of deposition and subsequent diagenetic alteration.

• Work is again being conducted to determine if oil can be extracted in an economic and environmentally friendly fashion (requires in-situ methods).
Oil Shale Sample Collection

Fresh and weathered oil shale samples were collected from the Mahogany Zone and the R-8 zone.
Oil Shale Samples

• Analyzed various Piceance Basin outcrop samples using XRD, SEM and TGA-MS.

• Samples analyzed consist of kerogen-rich materials that are representative of the Mahogany zone of the Green River Formation.
Piceance Basin Oil Shale Mineralogy

- **Clays**
  - Smectite (Expandable Clay) 0 – 25 wt%
  - Illite / Mica (Non-Expandable) 0 – 20 wt%

- **Carbonates**
  - Calcite - CaCO₃ 0 – 15 wt%
  - Siderite - FeCO₃ 0 – 3 wt%
  - Dolomite / Ankerite – Ca(Fe,Mg)(CO₃)₂ 0 – 45 wt%

- **Analcime (Na-Zeolite)** 0 – 20 wt%
- **Dawsonite - NaAl(CO₃)(OH)₂** 0 – 20 wt%
- **Kerogen (amorphous)** 0 – 45 wt%
- **Pyrite - FeS₂** 0 – 3 wt%
- **Gypsum - CaSO₄ • 2H₂O** 0 – 1 wt%
- **Quartz, Feldspar, and other detritus**
• Buddingtonite, (analogous to an ammonium version of K-feldspar) is also present and indicates an authigenic origin forming simultaneously with the maturation of the organic materials.

• Dawsonite \([\text{NaAl(CO}_3\text{)(OH)}_2]\), is unusual, as it is extremely rare in nature but very abundant in the Piceance Basin.

• Analcime observed in significant quantities in these samples, (especially as nodules and clasts that appear along bedding).

• Nahcolite (\(\text{NaHCO}_3\)), forms economic deposits deeper in the basin.
Expandable Clay in Oil Shale
Sample A03

- Determine the orientation of clay in the rock.
- Determine expansion of the clay as a solid in the rock.

- Analyzed solid chunk of outcrop sample A03.
  - 24% Smectite, 20% Illite, 1% Kaolinite
  - 20% Kerogen, 20% quartz, 10% Dolomite
  - Plus Analcime, Dawsonite, Feldspar, Pyrite, Gypsum

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Smectite Structural States

0 water layer

1 water layer

2 water layers

- Interlayer Cation
- Water Molecule
A03 Expansion with RH

![Graph showing %RH and Temperature over time with peaks and steps.](image)
Expandable Clay in Sample A03

• Distinct orientation / foliation of the clay particles
  • Will produce preferential parting planes
  • Fluid and gas flow expected to be facilitated along bedding planes (between layers of cards rather then through them).

• Readily expands/contracts with varying Water Vapor Pressure
  • Went from ~11.5 to ~14.5 angstroms.
  • Wet – dry cycles may be able to facilitate creation of pathways.
Outcrop Sample (Stop 3)
Outcrop Sample (Stop 3): Sample Preparation

- Slice 11 Top
- Slice 12
- Slice 13
- Red Spot
- Coating
- Slice 01
- Slice 02
- Slice 03
- Slice 04
- Slice 05
- Slice 06
- Slice 07
- Slice 08
- Slice 09
- Slice 10
- Slice 11
Inorganic Rock-forming Minerals vs. Kerogen

![Graph showing the distribution of inorganic rock-forming minerals and kerogen in a sample.](image-url)
Pyrite vs. Kerogen

![Pyrite vs. Kerogen Graph](image)
Outcrop Sample (Stop 3)

Nodule: Mainly Analcime & Albite

Disturbed Zone: Mainly Analcime & Albite

Altered Exterior: Mainly Ankerite/Dolomite
Alteration Processes
Summary of Results

- Mineralogy and kerogen content highly variable between layers.
- No strong trends in kerogen to mineral content.
- Weathered and intrusive zones are:
  - Poor in Kerogen content
  - Enriched in albite and analcime
  - Devoid of pyrite
  - Intrusive Zones = reduced carbonate content
  - Weathered Exterior = Increased Ankerite content
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