Paleozoic Hydrocarbon Habitat in the Arabian Plate

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Outline

- Paleozoic tectonics
- Paleozoic stratigraphy
- Hercynian deformation
- Hydrocarbon Systems
- Summary
Main Tectonic Elements of the Arabian Plate

- Alpine suture
- Hercynian mobile zones
- N. Iran suture
- Fold-thrust belt
- Volcanic arc
- Ophiolite
- Infracambrian salt basin
- Precambrian Shield
- Tertiary Basalt
- Palmyra Inversion zone
- Stable platform
- Mesozoic Graben
- Red Sea
- Arabian Sea
- Caspian
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Structure
Top
Crystaline
Basement

Arabian
Shield

Depth (Km)
- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
> 14

200 km
Stratigraphy of Northern Arabian Plate

Hercynian Orogeny

Periglacial

Marine Sands

Marine Carbonates

Continental Clastics

Gas
Oil
Source Rock
Coal
Stratigraphy of Southern Arabian Plate

- **Continental Clastics**
- **Marine Sands**
- **Marine shales**
- **Glacial**
- **Carbonates and Evaporites**
- **Glacial Deposits**
- **Shallow Marine Clastics and Carbonates**

**PALEOZOIC**
- **MZ**
- **PP**
- **CC**
- **DD**
- **SS**
- **OO**
- **CE**

**North**
- SW JORDAN
- SAUDI ARABIA
- OMAN
- South

**Hercynian Orogeny**

**Gas** • **Oil** • **Source Rock**
Infracambrian Salt Basin in Rub’ al Khali Basin, Southern Saudi Arabia

TWT

0.0
1.0
2.0
3.0
4.0

50 km

Crystalline Basement

t. Cretaceous

b. Silurian

b. Cambrian

t. Permian

b. Silurian

H. Jurassic

b. Cambrian

Infracambrian Salt Basin in Rub’ al Khali Basin, Southern Saudi Arabia

TWT

0.0
1.0
2.0
3.0
4.0

50 km

Crystalline Basement

T. Cretaceous

b. Silurian

b. Cambrian

t. Permian

t. Jurassic

Salt
Middle Cambrian Environments of Deposition
Cambrian Siq Sandstone (Nabatean Tomb, NW Saudi Arabia)
Late Cambrian Environments of Deposition

- Continental clastics & shallow marine clastics
- Continental clastics
- Marine sands
- Marine shales

Map showing distribution of geological environments during the Late Cambrian period.
Middle Ordovician Environments of Deposition
(Hanadir maximum flood)
Upper Ordovician Sarah Formation
Filling Tunnel Valley, NW Saudi Arabia
Upper Ordovician Sarah Formation
Filling Tunnel Valley, NW Saudi Arabia
Early Silurian Environments of Deposition

- Marine shales
- Marine carbonates
- Continental clastics & volcanics

Source Rocks

Indian Ocean

Red Sea

Caspian

500 km
Devonian Environments of Deposition

- Deltaic & shallow marine sands
- Marine clastics & carbonates
- Devonian mobile belt
- Marine shales
- Deltaic & shallow marine sands
- Continental clastics?
Devonian Jauf & Jubah Formations
Northern Saudi Arabia
Upper Carboniferous (Post-Hercynian) Khalata Tillite, South Oman
Early Permian Environments of Deposition

- Marine Sands
- Marine Carbonates
- Continental Clastics

Map showing the distribution of different depositional environments during the Early Permian period.
Late Permian Environments of Deposition

- Shallow marine carbonates
- Deep Marine carbonates
- Shelf edge carbonates
- Shallow marine carbonates
- Continental Clastics
- Evaporites
- Mixed
- Arabian Sea
- Caspian
- 200 km scale
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Longitudinal Section – Oman Basins (Hercynian Inversion)
Hercynian Erosion
(Permian - base Silurian Isopach)

Silurian completely eroded
Hercynian Mega Structures
Southwest Ghawar Flank

Time Structure

Coherency

Base Silurian
Southwest Ghawar Flank

Time Structure

Coherency

Permian

Base Silurian
Ghawar: Permian Khuff Structure
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Silurian Hydrocarbon System

High Relief
Hercynian Structures

- Triassic shale (regional seal)
- Late Permian evapo-carbonates (Khuff)
- Permo-Carboniferous sandstone (Unayzah)
- Hercynian Unconformity
- Devonian sandstone (Jauf)
- Silurian shale (source rock)
- Cambro-Ordovician clastics
- Precambrian basement
Silurian Hydrocarbon System

High Relief Hercynian Structures

Low Relief Hercynian Structures

- Triassic shale
- Khuff
- Unayzah
- Hercynian Unconformity
- Devonian
- Silurian shale
- Basement
Truncation Traps Along the Flanks of High Relief Hercynian Structure: Mazalij
Precambrian HC System: Haima Gas Plays in Oman

- Tertiary
- Mesozoic
- Existing oil fields
- Permo-Carboniferous
- Ordovician / Cambrian Clastics
- $\Phi$ 8-10%
- $K$ 1-2 mD
- PC - Salt

Scale:
- 2 km
- 5 km
Precambrian Oil Plays
South Oman Salt Basin
Summary

- Multi-company collaboration has significantly improved our understanding of the Paleozoic in the Arabian Plate.
- The Carboniferous Hercynian orogeny was the key to shaping the Paleozoic hydrocarbon habitat.
- Two styles of Hercynian deformation:
  - Regional sags & swells
  - Basement horsts
- Two independent hydrocarbon systems: Precambrian and Silurian.
- Silurian has high potential: USGS estimates it generated 808 TCF and 37 billion barrels of conventional resources.
- Key challenges to Paleozoic exploration are seismic imaging and predicting reservoir quality.