Hydrocarbon Exploration in Morocco: Conventional & Unconventional

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Key Aspects

• Political and economic stability;
• Economic policy of integration at regional and international levels;
• Growing and developing infrastructure projects;
• Energy policy based on developing partner’s activities in the petroleum research;
• Favorable and attractive hydrocarbon’s terms.
Exploration History

Seismic acquired between 1961 et 2012

Total of 2D Seismic 202 731 Km
Total of 3D Seismic 28 719 Km²

Beginning of 3D seismic acquisition
Exploration History

Evolution of wells numbers between 1950 and 2012

309 exploration wells drilled between 1950 and 2012 (36 in Offshore)
Exploration Status

Open acreage, permits and reconnaissance licences map

Open acreage

- 06 blocks offshore
- 05 blocks onshore

Under negotiation

- 04 blocks offshore
- 09 blocks onshore

PA & RL

- 31 Petroleum Agreements offshore and onshore
- 08 Reconnaissance Licenses (6 onshore and 2 offshore)
Objectives ranging from Precambrian to Neogene in five major geological domains:

- The Anti Atlas and Saharian domain (Paleozoic objectives)
- The Costal Meseta domain (Paleozoic, Triassic and Jurassic objectives)
- The Atlasic domain (Triassic and Jurassic objectives)
- The Atlantic passive margin (Jurassic, Cretaceous and Tertiary objectives)
- The Rif domain (Mesozoic and Tertiary objectives)
Objectives ranging from Paleozoic to Neogene in four main provinces

- Alpine thrust and fold belt province (Cretaceous and Tertiary objectives)
- Paleozoic and Triassic Province
- Mobile salt province (Jurassic, Cretaceous and Tertiary objectives)
- Platform Province (Jurassic and Cretaceous objectives)
Petroleum Systems: Source Rocks

Paleozoic Source Rocks (Silurian, Devonian & Carboniferous)

ACCUMULATIONS
- Tendrara Gas Field (High Plateaux)
- Meskala, Kechoula, Jeer, Ndark and Zelten Gaz fields (Essaouira)

WELLS AND OUTCROPS
- Tadla Basin TOC up to 12.12%
- Doukkala Basin TOC up to 5%
- Anti Atlas TOC up to 12.1%
- Ouarzazate TOC up to 11%
- Boudenib Basin TOC up to 3.2%
- Zag basin TOC up to 1.89% and OD-1 Oil and Gas shows.
Petroleum Systems: Source Rocks

Jurassic Source Rocks

Lower & Middle Jurassic
- Sidi Fili oil field: TOC up to 5.5%
- Rif and Middle Atlas oil seeps (TOC up to 3.4%)
- GTE-1 oil shows?
- MO-8 Light oil
- DSDP-547 up to 8.9 %TOC & 48.5 mg/g S2
- TanTan-1 well up to 2.5 % TOC; 800 HI
- Souss basin (EGA-1 TOC up to 2.74%)
- Fuerteventura black shale

Upper Jurassic
- Sidi Rhalem oil field
- TKM well: Oxfordian shale up to 4.3 % TOC
- DSDP-547 up to 1.9 %TOC
- IFNI-1 up to 3.36 % TOC
- Fuerteventura Island: 80m Oxfordian black shale
Petroleum Systems: Source Rocks

Cretaceous Source Rocks

**Aptian-Albian:**
- Locally developed thin “bituminous shales” onshore in the Rif and western High Atlas
- DSDP 544: TOC to 4.5%
- BTS-1: tested minor trace of oil; TOC 2-4% and a HI of 280-340
- DSDP 370/416: TOC to 6.2% & S₂ to 31 mg/g
- MarCan-1: TOC to 2.4% & S₂ to 8.9 mg/g 82% type II and 18% type III
- 40 m organic rich black shale crops out in Fuerteventura
- DSDP-369 up to 3%

**Cenomanian-Turonian:**
- Tarfaya oil shale quarry, the source rock interval is 50 m thick, with a TOC of 2-19%
- AGM-2 3.5% TOC, 574 HI
- Amber-1 well 26 m thick section Turonian interval 12.5% to 15.9% TOC
- RAK-1 well encountered organic rich laminae.
Petroleum Systems: Reservoir Rocks

Paleozoice Reservoir Rocks

- Cambrian and Ordovician shallow marine sandstones;
- Devonian Platform carbonates with Coral reef and patch reefs;
- Upper Devonian and Carboniferous turbidite sandstones.
Triassic Reservoir Rocks

- Four potential reservoir intervals have been identified: porosity range between 10% & 16% and thickness between 10 & 200 m
- The outcropping T4 and T6 sandstone formations in the Argana valley and their lateral equivalents in the Meskala field;
- The Lower Liassic sandstones of the zelten field
- The Permian sandstones of Doukkala and Essaouira basins

Facies distribution at Upper Triassic
Petroleum Systems: Reservoir Rocks

Jurassic Reservoir Rocks

- Siliciclastic sediments derived from Paleozoic hinterland (metasediments and granites);
- Platform carbonates with coral reefs and shallow marine sandstones.

Cretaceous Reservoir Rocks

- Lower Cretaceous fluvio-deltaic systems, deltaic and/or fan apron sandstones & turbidite fans;
- Lower Cretaceous platform carbonates;
- Lower Cretaceous clastics were encountered onshore and have not yet been penetrated offshore.
- Upper Cretaceous turbidite sandstones of the Lowstand System Tracks.

Tertiary Reservoir Rocks

- Incised slope canyon sands (Lower Tertiary);
- Turbidite sandstones.
Play Concepts

• Paleozoic folded and faulted plays (Devonian reefs and Ordovician sandstones)
• Triassic alluvial & fluvial tilted blocks ;
• Folded and faulted Mesozoic plays;
• Subthrust Mesozoic plays;
• Tertiary foreland & foredeep turbidite sandstones;
• Well Developed Toe-Thrust Trend;
• Extensive Sub-Salt Potential;
• Salt related structures;
• Reef build ups structures;
• Platform Carbonates.
Conventional Hydrocarbon Resources

Offshore Basins

Example of play concepts: Lower Cretaceous lead in Offshore (Boujdour block)

- Traps: Stratigraphic (Amalgamated Channels)
- Reservoirs: Lower Cretaceous sandstones
- Source rocks: Aptian and Jurassic
- Seals: Tertiary & Upper Cretaceous marl and shale

Development of deltaic systems within the Lower Cretaceous

Area of channels

Amalgamated channels

Top Hauterivian

Top Albian

1061-BJ2

1314-BJ2

ONHym

GLOBAL APPR

PROSPECT AND PROPERTY EXPO
Conventional Hydrocarbon Resources

Onshore Basins

Example of play concepts: Tertiary lead in Onshore (Asilah block)

- Traps: Faulted anticline structures
- Reservoirs: Cretaceous & Tertiary turbidites
- Source rocks: Cenomanian-Turonian Shale
- Seals: Tertiary shale

Areal closure: 8.1 Km²
Recoverable oil (MMBBLs): 43.4 Mbbls

Line 09-ASL-11, through the Friska-1 Lead

Line 08-ASL-05, imbricated and folded Miocene play concept

TWT structure map at Miocene

Friska - 1 Lead
Unconventional Hydrocarbons: Oil Shale

- Oil-shale deposits have been identified at ten localities in Morocco (map), the most important of which are Upper Cretaceous. The two deposits that have been explored most extensively are the Timahdit and the Tarfaya deposits;

- Morocco has important oil reserves contained in the oil shales (approximately 50 billion barrels, just in Timahdit & Tarfaya).
Unconventional Hydrocarbons: Shale Gas

- First geological and geochemical appraisal of the Paleozoic depositional systems;
- Other basins worth a deep exploration work;
- The Mesozoic and Tertiary sediments have a good potential and should be considered for future shale gas development plans.
Unconventional Hydrocarbons: Shale Gas

Paleozoic system

Three potential formation intervals:

- Carboniferous TOC 1-2 %;
- Devonian TOC 1-5.3 %;
- Silurian TOC 1-12 %;
Summary

- Moroccan sedimentary basins, both onshore and offshore, remain under-explored;
- Exploration drilling activity, although limited, and outcrops have proven the presence of viable petroleum systems;
- New 3D seismic data have permitted to increase the rate of success and to delineate new prospects and play concepts ranging in age from Paleozoic to Tertiary, and of different types;
- In terms of unconventional hydrocarbons, Moroccan basins are believed to have a good potential and worth a deep exploration work.

Future exploration orientations

- Reevaluation and upgrade of the previously identified prospects and leads to go ahead for drilling;
- Intensive exploration programs to prove the unconventional hydrocarbon potential of the Moroccan basins.