Exploration Opportunities in the Middle East

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Finding Petroleum Middle East Forum
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Agenda

What defines the Middle East?

Regional Considerations

Exploration Frontiers

Conclusions

Grateful acknowledgement of support from:
Middle East Geography

<table>
<thead>
<tr>
<th>OPEC Countries</th>
<th>Non-OPEC Countries</th>
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<tbody>
<tr>
<td>Iraq</td>
<td>Yemen</td>
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<td>Iran</td>
<td>Oman</td>
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<td>Saudi Arabia</td>
<td>Jordan</td>
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<td>Kuwait</td>
<td>Syria</td>
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<tr>
<td>UAE</td>
<td>Lebanon</td>
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<td>Qatar</td>
<td>Israel</td>
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Proven Reserves (mmbbl)

- Saudi Arabia: 266,455
- Iran: 158,400
- Iraq: 142,503
- Kuwait: 101,500
- UAE: 97,800
- Qatar: 25,244
- Oman: 5,373
- Yemen: 3,000
- Bahrain: 125
- Israel: 13
- Jordan: 1
- Syria: 2,500

Source: EIA 2017

Map credit: Westwood Global Energy Group 2017
The Middle East is the Largest Petroleum Province in the World

*BP Statistical Review of World Energy, 2016*

The Middle East in 2015 –

**OIL**
47% of the world’s reserves and 33% of world production

R/P 73 years (world average 50 years)

**GAS**
43% of the world’s reserves and 17% of world production

R/P 130 years

Exploration has been very successful – why?

Why the Middle East Fields May Produce Oil Forever (*Mahfoud and Beck, Offshore, Jan 1995*)
**Middle East – Regional Setting**

### Palaeozoic
- Early Palaeozoic - Arabia stable subsiding passive margin
- Hercynian orogen and uplift from Devonian
- Permian rifting, deposition of the Khuff formation

### Mesozoic
- Mesozoic formation of structural highs and lows
- Regional extension from breakup of Gondwana, rifting along Zagros belt
- Middle Jurassic - Early Cretaceous inversion (central Arabian arch)

### Cenozoic
- Mid Tertiary formation of Zagros foreland basin
- Continued rifting and subsidence

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**Source:** REP2017, adapted from multiple sources

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Middle East – Why is There So Much Oil and Gas?

- Tethys Setting

- Long-lived extensive passive margin through Palaeozoic-Mesozoic, overlain by Tertiary Zagros Foldbelt
- Multiple petroleum systems with excellent source rocks and reservoirs, mainly carbonates
- Evaporites provide major regional seals, fold belt detachments and structures
- Large structures – regional arches inherited from Hercynian, salt-related structures and Zagros folds

- Source and Reservoirs

Mid Cretaceous - Oligocene
Early Cretaceous
Late Jurassic
Mid Jurassic

Palaeozoic

MAJOR PETROLEUM SYSTEMS

Source: GeoExPro 2015
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Iraq - Kurdistan

**Discovered Volumes 2008 - 2017**

- **Iraq Kurdistan Gross Wells by Play Type & Result, 2008 - 2017**

  - Gas Discovery
  - Oil & Gas Discovery
  - Oil Discovery
  - Dry Hole

- **Iraq Kurdistan Gross Wells by Play Type & Commerciality, 2008-2017**

  - Commercial
  - Non-Commercial
  - Dry Hole

**Commercial Success Rate 32%**

Source: REP 2017

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**Exploration history, last 10 - 12 years**

- **Volume discovered/produced**
- **Key discoveries/major plays**
- **Challenges**
  - Fractured reservoirs
  - Oil export and sales
  - Payments
- **Remaining opportunities**

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Discovered Volumes:

<table>
<thead>
<tr>
<th>Year</th>
<th>Volume discovered/produced</th>
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<tr>
<td>2008-2017</td>
<td>3274 mmbce (Oil) 2157 mmbce (Gas)</td>
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Source: REP 2017, adapted from Western Zagros February 2017 map

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Iraq – Kurdistan Challenges

Challenges
- Fractured reservoirs – write downs
- Oil export and sales / Payments

Remaining opportunities
- Tertiary reservoirs - better matrix poroperm, located in south where gas more predominant

Taq Taq - Downgrades
- 2015 Genel Taq Taq downgrade from 683 – 356mmbbl
- 2017 downgrade to 267mmbbl
- 9 years after first oil!

Taq Taq Field Reserve Changes

Source: REP 2017

Key
- License Outline
- Pipeline (oil or gas)
- Oil Field
- Gas Field
- Key Field Discussed

Taq Taq Field Cross Section. Source: Mackertich and Samarrai 2015

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Iraq plans Offshore Oil and Gas Exploration

By John Lee.

Iraqi oil minister Jabar Ali al-Luaibi [Allibi] has directed the Iraqi Oil Exploration Company (OEC) to start exploring Iraq's coastal waters for new oil and gas reserves.

Addressing an OEC conference, the Minister also emphasised the need to focus on areas bordering neighbouring countries.
Iran – Zagros Fold Belt

- **Northwest: Lurestan Region**
  Extension of Kurdistan plays – Triassic & Jurassic reservoirs in NW, Cretaceous carbonates in SE

- **Central Area – Dezful Embayment**
  Undrilled structures, sub-thrust targets, stratigraphic plays

- **Southeast – Fars Region**
  Palaeozoic gas / Jurassic-Cretaceous oil

Source: REP2017, adapted from multiple sources

Iran – Offshore Persian Gulf

- Significant heavy oil and gas discoveries in last decade – Forroz, Madar, Ferdowsi
- Ongoing exploration by NIOC (1 rig)
- Most structures now drilled – remaining stratigraphic potential

Source: Global Geo Services AS website

- Persian Carpet 2D Seismic 2000 – 106,000 km in Persian Gulf (2*2 km grid) and Oman Sea
Iran – South Caspian Sea

- 2011 Sardar-e Jangal Discovery in 700m W.D. 500 mmb/5 tcf reserves?
- Sardar-e Jangal and 3 exploration blocks offered for international co-operation
- Likely multi-billion boe potential

Source: NIOC
Lebanon – First Licencing Round

- 5 Blocks offered for bidding in January 2017
- Bid submission September 2017
- Prequalifiers eliminate “small players”

Source: Lebanon Petroleum Administration 2015
Other Conventional and Unconventional Plays

- **Israel** – 24 offshore blocks offered in 1st Licensing Round Ministry report 6.6 bnbbls oil and >70 tcf to find

- **Yemen** – 2 out of 12 basins are producing oil and gas today

- **Proven Late Jurassic – Early Cretaceous petroleum system in 2 well-explored Mesozoic basins**

- **Less well-explored Jiza-Qamar Basin in east, Rub’ Al Khali and offshore Oligocene rifts**

- **Iran** – Interior basins: Oligo-Miocene source rocks

**Abu Dhabi** – Onshore Shale Potential

**Unconventional Plays**

- **Tight Gas**: Oman, Iraq, Syria
- **Qusaiba hot shale**, Saudi Arabia: 600 tcf
- **Jurassic and Cretaceous source rocks**: UAE
- **Upper Cretaceous Oil Shales**: Jordan
Conclusions

- The Middle East has a multitude of exploration opportunities in established and new plays and has barely started to tap its unconventional potential.

- The barriers to successful exploration are less technical and more political, commercial and related to insecurity in the region

- Major Exploration Themes
  - Go Deeper: The Palaeozoic petroleum system is underexplored
  - Look Harder: New seismic and new ideas will unlock new discoveries in the established plays, including stratigraphic traps
  - Test the Frontier Geography: Deepwater Mediterranean, South Caspian
  - Unconventional Potential: lots of source rocks and tight rock! But does it compete on cost?
Questions