FRONTIER EXPLORATION IN PAKISTAN

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- Pakistan Exploration & Production Outlook
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  - Low Velocity Zones in the core of anticline
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  - Stress Field Detector (SFD) Air Bourn Survey
  - Geological data to resolve steeply dipping dips on seismic
  - Geochemical surveys
  - Importance of analogues to explore new plays
- Take Home Message
Total Sedimentary Area: 827,268 Km2
Area under Exploration: 361,466 Km2
Exploration Licences: 179; Active Leases: 160
Active Exploration Companies:
- Operator: 30 (Foreign: 18 & Local: 12)
- Non Operator: 25 (Foreign: 20 & Local: 5)
Active Seismic Crews: 12; Active Rigs: 31
Wells Drilled (Since 1868):
- Exploratory: 957 (Success Ratio: 1 : 3)
- Discoveries: 329
- Appraisal & Dev: 1,281 (33 before 1947)
Avg. Daily Oil Production: 89,982 bbl/d (Dec, 2015)

<table>
<thead>
<tr>
<th>Reserves / Production (As of Dec, 2014)</th>
<th>Oil (MMBbl)</th>
<th>Gas (Tcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Recoverable</td>
<td>1,185.8</td>
<td>53.9</td>
</tr>
<tr>
<td>Cumulative Production</td>
<td>801.4</td>
<td>33.6</td>
</tr>
<tr>
<td>Balance Recoverable</td>
<td>384.4</td>
<td>20.2</td>
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</table>

Source: PPIS
GEOLOGICAL SETTING OF PAKISTAN
The above estimate is excluding Balochistan basin & offshore
Updates available as of 30 Oct 2015 for wells & 30 June 2015 for Reserves
EXPLORATION STATUS IN PAKISTAN

- Exploration wells: 980
- Discoveries: 350
- Success Ratio 1:3
- The total discovered reserves are around 61 tcfe (approximately 88% gas and 12% oil).
• Kharan Forearc Basin - Structure Plays

• Mud-diapirisim related traps play

• Deeper Plays with complex geological setting in Kirthar Foldbelt
REGIONAL SETTING – KIRTHAR FOLD BELT
FRONTIER EXPLORATION AREAS - MAKRAN

- Kharan Fore-arc Basin
- Sulaiman Fold belt
- Kirthar Fold belt
- Chagai Arc
- Afghan Block
- Punjab Platform
- Kirthar Fold belt
- Sind Platform
- Makran Accretionary Prism
- Arabian Plate Subduction Zone

Source: Geomap app

Khan et al., 2011
- Indus Offshore: Second largest delta/fan system, after Bengal Fan
- Water Depth 0 – 4500m
- Sediment Thickness 8 – 9 Km in Delta System
- Indus Delta system is analogous to other producing deltas
Offshore Indus developed off the passive continental margin of Pakistan-India approx. 60 Million Years ago.
A number of regional offshore evaluations conducted, Geology and HC potential yet to be unlocked

One of the last **unexplored**, **high prospectivity** basin in the world

or

A **low prospectivity** area, without commercial discoveries after 50 years of exploration?
USEFUL TOOLS & LESSON LEARNED
IMPLICATION OF CRUSHED ZONE WITH IN ANTICLINE

Structural Cross Section based on Surface Geology

Time (PSTM) Section

Depth (PSDM) Section

Axis of the Anticline
STRESS FIELD DETECTOR (SFD) IN FRONTIER AREAS

Concept

SFD Sensor Response

Seismic Profile

Trap development is shown on String and GengurII by the amplitude changes and a pronounced "closure" to the signal.
WIDE LINE SEISMIC DATA IN COMPLEX GEOLOGICAL SETTING

Conventional 2D Seismic Line

Wide Line

Ansari and Siddiqui, 2002
GEOLGICAL DATA TO RESOLVE STEEP DIPS ON SEISMIC

Geological Map

Well
Geochemical anomalies were ignored over valid structures

- Well failed

- Good tool to explore frontier areas

Samples analyzed for SSG = 601
Analogues:

- Kharan Basin of Pakistan is analogous to Salin Basin (Myanmar), Cook Inlet Basin (Alaska) and North Aleutian Basin (Alaska).

- Analogues help to identify new plays

Khan et al., 2011
TURBIDITES AT PASSIVE MARGINS – HUGE POTENTIAL

[Map showing geological features and sedimentary structures]

[Image of a mountain or cliff with geological features highlighted]

[Diagram illustrating channel lateral migration and sedimentary structures]

[Photo of a sedimentary structure with text overlay: 'Base of massive channel fill eroding distal levees']

[Photo of a sedimentary structure with text overlay: 'Massive channel fill eroding underlying levees']

[Photo of a sedimentary structure with text overlay: 'Detail of sandy levee with shale draping of beds made up of climbing ripples']

[Text overlay: 'Basal mudlast lag (cherty facies) overlain by coarse to very coarse grained sandstone']

[Text overlay: 'UPPER PAB - Upper Maastrichtian Highland s.s.']

[IFP-2005]
To explore geological complex frontier basins, artistic technologies are required.

Maximum tools should be utilized during prospect generation/evaluation in order to avoid surprises and not to miss the true potential.

Classical geological data is usually of low cost but always equally important like expensive tools.

Analogous are the key leads toward effective exploration of new areas.