Overview of Indian Sedimentary Basins and Blocks-on-Offer (under OALP II)
Presentation outline

- Indian Sedimentary Basins
- Hydrocarbon Resource Reassessment Study
- Contract Areas-on-Offer
- Summary
Indian Sedimentary Basins

Basin category

- A new 3-tier category for 26 basins
- A simplified approach to present the Category based on the instances of ‘discovery’ and ‘commerciality’, closely in line with PRMS ideology

- **Category I**: 7 basins which are commercially producing from established petroleum resources ("RESERVES")
- **Category II**: 5 basins which have established petroleum resources but are yet to produce commercially ("CONTINGENT RESOURCES")
- **Category III**: 14 basins which have prognosticated resources but still to be discovered ("PROSPECTIVE RESOURCES")
Indian Sedimentary Basins

Basins under category

- **Category I**
  - Krishna-Godavari(KG), Mumbai Offshore, Assam Shelf, Rajasthan, Cauvery, Assam-Arakan Fold Belt and Cambay

- **Category II**
  - Saurashtra, Kutch, Vindhyan, Mahanadi and Andaman

- **Category III**
  - Kerala-Konkan, Bengal-Purnea, Ganga-Punjab, Pranhita-Godavari(PG), Satpura-South Rewa-Damodar, Himalyan Foreland, Chattisgarh, Narmada, Spiti-Zanskar, Deccan Syneclide, Cuddapah, Karewa, Bhima-Kaladgi, and Bastar
Overview of the study

- During 2017, hydrocarbon resource reassessment study was carried out for all 26 basins
- **Assessment done for conventional reservoirs only**
- Reviewed by international domain-experts and Indian basin-experts
- Assessed 13 basins with adequate datasets through “Petroleum System Modeling”
  - 9 basins (Assam Shelf, Cambay, Rajasthan, Mumbai, Krishna-Godavari, Cauvery, Mahanadi, Bengal-Purnea and Kerala-Konkan) : entire area
  - 4 basins (Assam Arakan, Andaman, Kutch and Saurashtra) : part area
- **Identified a total of 177 Plays**
  - 87 in Tertiary, 53 in Mesozoic and 37 Pre-Mesozoic
- **Identified new plays**
  - Mesozoic reservoirs in 14 basins
  - Basement fractures in many new discoveries
Hydrocarbon Resource Reassessment Study

Results of the study

- Last assessment done in 1995-96 for 15 sedimentary basins:
  - Inplace assessed: 28,085 MMTOE (210 BBBLOE)
- Current assessment done across Onland, Shallow Water and Deep Water
  - Inplace Reassessed: 41,872 MMTOE (315 BBBLOE)
    - Discovered: 12,076 MMTOE (85 BBBLOE)
    - Undiscovered: 29,796 MMTOE (230 BBBLOE)
- Increase of total hydrocarbon estimate: 49.1%
- Reassessment at hydrocarbon play level
- A complete geoscientific database with easy-to-use subsurface models, maps and reports
Hydrocarbon Resource Reassessment Study

Results Compared

1995-96 study
- Carried out for 15 basins
- Areal Yield method used for all basins
- Assessment at basin level
- Deepwater areas excluded and assessed separately
- Limited tools and less data sets

2015-17 study
- All 26 basins re-assessed
- 13 basins/basin areas with good data sets were assessed using improved tools. Rest with Areal Yield
- Assessment at play level
- Deepwater areas included and assessed with basins
- New tools and expanded datasets
Contract Areas-on-Offer

Basin-wise Hydrocarbon Resources

<table>
<thead>
<tr>
<th>Basins</th>
<th>Established</th>
<th>Undiscovered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Krishna-Godavari</td>
<td>1,977</td>
<td>7,578</td>
</tr>
<tr>
<td>Cambay</td>
<td>1,800</td>
<td>786</td>
</tr>
<tr>
<td>Cauvery</td>
<td>292</td>
<td>1,672</td>
</tr>
<tr>
<td>Kutch</td>
<td>71</td>
<td>827</td>
</tr>
<tr>
<td>Rajasthan-Jaisalmer</td>
<td>94</td>
<td>803</td>
</tr>
<tr>
<td>Mahanadi</td>
<td>77</td>
<td>574</td>
</tr>
<tr>
<td>Andaman</td>
<td>2</td>
<td>369</td>
</tr>
</tbody>
</table>

Unrisked Inplace in OALP II Basins

Inplace, MMTOE
Total 14 blocks
- Distributed into 7 sedimentary basins
- Mahanadi has most number of blocks (5)

5 blocks from Category I basins
9 blocks from Category II

- Mahanadi, 5
- Cauvery, 1
- Cambay, 2
- Kutch, 2
- Andaman, 2
- Andaman
- Rajasthan, 1
- Krishna Godavari, 1
- **Total area 29,233 sq km**
- Mahanadi, Andaman, and Kutch have maximum acreage.
- 8 blocks in Onland (13,733 sq km, 47% of total offering)
- 5 blocks in Shallow Water (13986 sq km, 48%)
- 1 block in Ultra Deep Water (1514 sq km, 5%)
Krishna-Godavari Basin

- Total block on offer: 1
- Cumulative area: 1,514 sq km

**Prognosticated Resources** (In-place MMTOE)

<table>
<thead>
<tr>
<th>Play-wise Resource</th>
<th>Discovered</th>
<th>Undiscovered</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pliocene Play</td>
<td>1,798</td>
<td></td>
<td>1,798</td>
</tr>
<tr>
<td>Miocene Play</td>
<td></td>
<td>1,201</td>
<td>1,201</td>
</tr>
<tr>
<td>Eocene Play</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Paleocene Play</td>
<td>316</td>
<td></td>
<td>316</td>
</tr>
<tr>
<td>Late Cretaceous Play</td>
<td>571</td>
<td></td>
<td>571</td>
</tr>
<tr>
<td>Early Cretaceous Play</td>
<td>807</td>
<td></td>
<td>807</td>
</tr>
<tr>
<td>Late Jurassic Play</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triassic Play</td>
<td>1,482</td>
<td></td>
<td>1,482</td>
</tr>
<tr>
<td>Permian</td>
<td>75</td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>Basement</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

- Total block-on-offer: 1
- Cumulative area: 1,514 sq km
KG-UDWHP-2018/1

- Analogous to discoveries in shallow biogenic and deeper thermogenic plays
- Channelized system within Pleistocene, Pliocene and Miocene plays
- Target Depth: 4800 m.
- Approximate Area 1,514 Sq. Km.
- Datasets: 2D/3D seismic, 2 wells
Krishna-Godavari Basin

KG Onland Paleozoic

- Oil @ 3k+ BOPD
- Gas @ 300k+ SCMD
- Choke: 40/64"
- Formation: Godavari Clay (Plio-Pleistocene)
- Depth: ~2,900m

KG Deep Water

- Oil @ 3k+ BOPD
- Gas @ 25k+ SCMD
- Choke: 16/64"
- Formation: Kommugudem (Permo-Triassic)
- Depth: ~3,300m
Cauvery Basin

- **Total block-on-offer:** 1
- **Cumulative area:** 474 sq km

### Prognosticated Resources (In-place MMTOE)

<table>
<thead>
<tr>
<th></th>
<th>Discovered</th>
<th>Undiscovered</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>292</td>
<td>1,672</td>
<td>1,964</td>
</tr>
</tbody>
</table>

### Play-wise Resource

- **Miocene:** 0
- **Oligocene:** 0
- **Paleocene- Eocene:** 13
- **Maastrichian- Campanian:** 4
- **Santonian:** 4
- **Turonian- Cenomanian:** 28
- **Early Cretaceous:** 4
- **Jurassic:** 0
- **Basement:** 21

Total: 1,893 Million Tonnes Oil-Equivalent
Cauvery Basin

CY-ONHP-2018/1

- Analogous to oil discovery Bhuvanagiri Formation (Upper Cretaceous)
- Plays expected in Basement, Cretaceous, Paleocene
- Basement undrilled, producing in other area
- Target Depth for wells: 2,000 m.
- Area: 474 Sq. Km.
- Datasets: 2D/3D seismic and 4 wells
Cauvery Basin

- Gas @ 40k+ SCMD
- Choke: 5mm
- Formation: Kamalapuram (Eocene)
- Depth: ~1,500m

- Gas @ 35k+ SCMD
- Choke: 5mm
- Formation: Pre-Cambrian Basement
- Depth: ~1,700-2,200m
Kutch Basin

- Total blocks on offer: 2
- Cumulative area: 2,544 sq km

Prognosticated Resources (In-place MMTOE)

<table>
<thead>
<tr>
<th>Discovered</th>
<th>Un-discovered</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>827</td>
<td>898</td>
</tr>
</tbody>
</table>

Play-wise Resource (Offshore): 862 MMTOE

- Early Cretaceous Play
- Late Jurassic Play
- Mid Jurassic Upper Play
- Mid Jurassic Lower Play

Play-wise Resource (Onland): 36 MMTOE

- Mid Miocene Clastic
- Late Oligocene Clastic
- Early Eocene Clastic/Carbonate Play
- Paleocene Clastic/Carbonate Play
- Weathered Basalt
- Late Cretaceous Carbonate/Clastic Play
- Early Cretaceous Play
- Late Jurassic Play
- Mid Jurassic Upper Play
- Mid Jurassic Lower Play
Kutch Basin

GK-OSHP-2018/1

- Close to producing field, KD situated northerly
- Oilgo-Miocene strati-structural plays

- Target Depth for wells: 2,000 m.
- Area 1,732 Sq. Km.
- 2D seismic : Available

GK-OSHP-2018/2

- Close to producing field, KD situated northerly
- Oilgo-Miocene strati-structural plays
- Potential for Mesozoic

- Target Depth for wells: 2,000 m.
- Area 812 Sq. Km.
- 2D seismic : Available
Kutch Basin

- **Kutch Basin**
  - Gas @ 160k+ SCMD
  - Choke: 32/64"'
  - Formation: Chhasra (Mid. Miocene)
  - Depth: ~900m

- **EW**
  - Gas @ 45k+ to 190k+ SCMD
  - Choke: 32/64"
  - Formation: Jakhau (Early Eocene)
  - Depth: ~1,300 to 1,500m

- **ONLAND**
  - Gas discovery
  - Jhurio Formation (Jurassic)
  - Depth: ~2,500-2,600m

- **EMIO**
  - Gas @ 125k+ SCMD
  - Choke: 32/64"
  - Formation: Deccan Trap (Late Cretaceous)
  - Depth: ~1,450-1,500m
Cambay Basin

- Total blocks on offer: 2
- Cumulative area: 1,032 sq km

Prognosticated Resources (In-place MMTOE)

<table>
<thead>
<tr>
<th></th>
<th>Discovered</th>
<th>Undiscovered</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB-ONHP-2018/1</td>
<td>1,800</td>
<td>786</td>
<td>2,586</td>
</tr>
<tr>
<td>CB-ONHP-2018/2</td>
<td>0</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>

Play-wise Resource

- Oligo-Miocene: 1,273
- Late Eocene: 66
- Middle Eocene: 321
- Early Eocene: 512
- Late Paleocene: 388
- Early Paleocene: 0
- Cretaceous - Deccan Trap: 0

Million Tonnes Oil-Equivalent
Cambay Basin

**CB-ONHP-2018/1**
- Middle-Eocene Play: Close to producing Becharaji and Modhera fields from Kalol Formation
- Paleocene-Early Eocene Play: Leads from Modhera#2 well, Older Cambay Shale and Olpad Formation being secondary target
- Target Depth for wells: 1,500m.
- Area: 185 Sq. Km.
- 2D seismic: Available
- 3D seismic: Available

**CB-ONHP-2018/2**
- Eocene Play: Adjoining Baola Gas field, producing from Oolitic reservoirs
- Mesozoic Play: Seismic data indicative of thick Mesozoic sediments below the Deccan Trap section
- Target Depth for wells: 3,000m.
- Area: 847 Sq. Km.
- 2D seismic: Available
- 3D seismic: Available
Cambay Basin

- **Cambay Basin**
  - **Oil @ 2k+ BOPD**
  - **Choke: 32/64”**
  - **Formation: Ankleshwar/ Hazard (Mid.Eocene)**
  - **Depth: ~2,550m**

- **Miocene Basal Sands (MBS)**
  - **Oil discovery**
  - **Oil @ 200+ BOPD, 5mm bean**
  - **Southern part (Akholjuni area)**
  - **Depth: ~1,450m**

- **K-III/K-IV**
  - **Oil discovery**
  - **Oil @ 25+ BOPD, 12/64” bean**
  - **Eastern margin (Dehgam area)**
  - **Depth: ~1,250m**
Rajasthan sub-basin - Jaisalmer

- Total block-on-offer: 1
- Area: 417 sq km

**Prognosticated Resources (In-place MMTOE)**

<table>
<thead>
<tr>
<th></th>
<th>Discovered</th>
<th>Undiscovered</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>94</td>
<td>803</td>
<td>897</td>
</tr>
</tbody>
</table>

- **Eocene - Khuiala**: 178 MMTOE
- **Eocene - Bandha**: 285 MMTOE
- **Paleocene - Sanu**: 136 MMTOE
- **Mid Cretaceous - Goru**: 108 MMTOE
- **Early Cretaceous - Pariwar**: 53 MMTOE
- **Late Jurassic - B&B**: 117 MMTOE
- **Mid Jurassic - Jaisalmer**:
- **Early Jurassic - Lathi**:
- **Permo-Triassic - Bhuana**:

**Play-wise Resource**
Rajasthan sub-basin - Jaisalmer

RJ-ONHP-2018/1

- Cretaceous and Paleocene Play: Close to discovered fields of Chinnewala Tibba, Bakhri Tibba, Kharatar in the west and Ghotaru field in the north
- Prospects in Sanu, Lower Goru and Pariwar Formation
- Target Depth: 1,000m
- Area: 417 Sq. Km.
- 2D seismic: Available
Rajasthan sub-basin - Jaisalmer
Mahanadi Basin

- Total blocks on offer: 5
- Area: 13,634 sq km

### Prognosticated Resources (In-place MMTOE)

<table>
<thead>
<tr>
<th></th>
<th>Discovered</th>
<th>Undiscovered</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN-ONHP-2018/1</td>
<td>51</td>
<td>110</td>
<td>161</td>
</tr>
<tr>
<td>MN-ONHP-2018/2</td>
<td>3</td>
<td>83</td>
<td>86</td>
</tr>
<tr>
<td>MN-ONHP-2018/3</td>
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<td>80</td>
<td>127</td>
</tr>
<tr>
<td>MN-ONHP-2018/4</td>
<td>0</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>MN-OSHP-2018/1</td>
<td>150</td>
<td>300</td>
<td>450</td>
</tr>
</tbody>
</table>

- Total blocks-on-offer: 5
- Area: 13,634 sq km
Mahanadi Basin

MN-ONHP-2018/1

- Early Cretaceous Syn-rift Play: Lacustrine source rocks, reservoir rocks defined by alluvial fans and deltaic sediments and seal facies of intra-formational shales
- Neogene Play: Shallow biogenic gas evidenced from surface gas seepages
- Target Depth for wells: 1,900m.
- Area: 2,934 Sq. Km.
- 2D seismic: Available
Mahanadi Basin

MN-ONHP-2018/2

- Both Tertiary and Cretaceous play
- Tectonic trend of Mesozoic section analogous to the producing Basins to the south like Cauvery and Krishna-Godavari
- The well, MON-3 falling in proposed area has good quality source rock

- Target Depth for wells: 2,000m.
- Area 2,539 Sq. Km.
- 2D seismic: Available
Mahanadi Basin

MN-ONHP-2018/3

- Up-dip prospects,
- The well MON-2 falling near to proposed area has hydrocarbon shows in deeper Mesozoic prospect
- Seismic anomalies in Mesozoic

- Target Depth for wells: 4,500 m.
- Area: 3,138 Sq. Km.
- 2D seismic: Available (+NSP)

Seismic section across the Block
Mahanadi Basin

MN-ONHP-2018/4

- The well MON-4 falls in the proposed area
- Tertiary and Cretaceous plays are primary targets
- Tectonic trend of Mesozoic section analogous to the producing Basins to the south like Cauvery and Krishna-Godavari

- Target Depth for wells: 5,500 m.
- Area: 3,197 Sq. Km.
- 2D seismic: Available (+NSP)

Seismic section across the Block
Mahanadi Basin

MN-OSHP-2018/1

- Located adjacent to PSC blocks
- Tertiary plays are primary targets
- Basin analogy: The well MSW-2, MSW-3 had gas indications. The well MDW-10 has mixed gas in Paleogene fan
- Biogenic gas discovery from Miocene slope fans in the offset block

- Target Depth for wells: 3,000m.
- Area: 1,825 Sq. Km.
- 2D/3D seismic: Available
- Wells: 2 wells in the Block and 4 nearby wells

Seismic section across the Block
Andaman Basin

- **Total blocks on offer:** 2
- **Area:** 9,616 sq km

### Prognosticated Resources (In-place MMTOE)

<table>
<thead>
<tr>
<th></th>
<th>Discovered</th>
<th>Undiscovered</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>369</td>
<td>371</td>
</tr>
</tbody>
</table>

- **Total blocks-on-offer:** 2
- **Area:** 9,616 sq km

### Play-wise Resource (East Andaman)

- **Mid Miocene:** 41
- **Early Miocene:** 29
- **Oligocene:** 235
- **Eocene:** 54

**Million Tonnes Oil-Equivalent**
Andaman Basin

AN-OSHP 2018/1:

- Shallow water Block, water depth 5-110m, located in outer Fore-arc setting of East Andaman
- 2D seismic lines available
- Proposed area part of the AN-1 structure where the first drilled well flowed gas from Middle Miocene Limestone
- Mid Miocene Carbonate Play and Paleocene-Eocene Clastic play are potential targets
- Leads from mud volcanics with hydrocarbon presence (fluorescence)
- Source rock has Type II Kerogen
- Anticline adjacent to mud volcanoes and presence of large slope strata are favourable target areas

- Target Depth for wells: 2,600m
- Area: 3,669 Sq. Km.
Andaman Basin

AN-OSHP 2018/2:
- Shallow water Block, water depth 50-400, located within the Accretionary Prism in the west of Andaman Islands
- Paleocene-Eocene clastic play
- Leads from mud volcanics with hydrocarbon presence (fluorescence)
- Source rock has Type II Kerogen
- Anticline adjacent to mud volcanoes and presence of large slope strata are favourable target areas
- Target Depth for wells: 2,450m.
- Area: 5,947 Sq. Km.
Brief of Contract Areas

– Contract Blocks-on-offer: 14
– Total area on offer: 29,233sq km
– Individual area size: 185 to 5,947 sq km
– The Shallowest Target Depth at 1,000 m
– The deepest Target Depth at 5,500 m
– Wells, seismic, well reports and petroleum resource reports
Opportunities to OALP bidders

– Contract areas are largely pre-assessed by prospective bidders
  – Information on block-level prospectivity outlined by originator through due diligence report
  – Basin-specific Technical Booklets will be available for constituent contract areas

– NDR has already set up the data rooms
  – Industry-standard interpretation software with full G&G functionality are available for basic interpretation

– Continued chance of access to NDR for more/missed-out data
  – NDR is updated with new data continuously
  – Basin-specific information on hydrocarbon resource reports are now available

– NCR (“National Core Repository”) is currently conceptualized
  – Access to Cores/ Drill-cuttings/ Fluid samples is now available from across basins from NOC’s Core Labs, now declared National Asset
Welcome to an opportunity ..
of exploring the ‘undiscovered’ potential of hydrocarbons, both conventional and un-conventional under two contract formats.. with attractive fiscal and contractual terms ..