Global Oil & Gas Exploration Situation and Implication

CNPC RIPED
December, 2019
Background

Why did: for CNPC overseas business (91 Projects in 35 countries)

What deliver: Petroleum resources distribution
Exploration situation
Long-term tendency

Information Covered: Global 2018 exploration events

Value added: for CNPC
for IOC/NOC/Independents
for Stakeholders
for Services
......
I. Global Oil and Gas Exploration Situation

II. Global 2018 Key Exploration Discoveries Overview

III. Implication for Future Global Oil and Gas Exploration
Global 2018 Oil and Gas Exploration Situation

**Exploration Investment**
Lower in general, **but** slightly increase share in upstream

**Exploration Activities**
Less Exploration workload, **but** drilled wells increased

**Exploration Discoveries**
Depressed newly conventional O&G discoveries, **but** 6 features identified
Global 2018 Oil and Gas Exploration Situation

**Exploration Investment**

2018: **USD 43.4 billion**
Percentage of total: 12%, YoY **↑2.3%**

2016-2018: Low level

Global annual oil and gas exploration investment by year
Global 2018 Oil and Gas Exploration Situation

Exploration Activities

Less workload on gravity, magnetic survey & 2D seismic maintained for two consecutive years

- Gravity & magnetic survey: 20,000 km, ↓78.5% YoY
- 2D seismic: 76,000 km, ↓9% YoY
- Target basins: Bas-Congo & Benin (West Africa), Natal Trough (South Africa), Kofoli (Sri Lanka), North Atlantic (Canada), Paneba (Brazil)
- Survey lines: 5,000 km+
- Offshore 2D seismic / Total 2D seismic: ≥80%, 7th consecutive years

Global gravity & magnetic exploration workload by year

Global 2D seismic exploration workload by year
Global 2018 Oil and Gas Exploration Situation

Exploration Activities

3D seismic acquisition slightly dropped in 2018

- Global 3D Seismic
  - Regions: Andaman Sea (Malaysia), Côte d'Ivoire, (North Sea), Moore (Norway), North Atlantic (Canada), Australia-Bonapart (Indonesia), Senegal, Tarfaya (Morocco)
  - Acreage: >10,000 km²
  - Total length: 296,000 km², by 5.4% (YoY)
  - Offshore 3D seismic / total: 88%

Global 3D seismic exploration by year

- Proportion of 3D seismic offshore
- 3D seismic (10,000 km²)
Exploration well drilling dramatically increased in 2018

- **2018 Drilling Wells Review**
  - Total exploration & appraisal: **1,657, ↑14.7% YoY**
  - Offshore drilling: **406**
  - Offshore drilling/Annual total: **25% YoY**

- **Offshore Drilling Regions:**
  - North Sea Basin, Bohai Bay Basin, Mumbai Basin,
  - Deep-water Gulf of Mexico Basin

- **Onshore Drilling Regions:**
  - Siberia Basin, Oman Basin, Australia’s Erromanga Basin

**Exploration and appraisal wells by sector / by year**

- **Basins with more than 5 offshore wells**
- **Basins with more than 15 onshore wells**
Stable exploration drilling, similar success rate between offshore and onshore

Global 2018 Exploration Drilling Review

- Total wells drilling
  - Exploration: 838
  - Percentage of total: 51%
  - Drilling Region: Eromanga Basin, Indus Basin, Abu Gharadig Basin (Egypt), North Sea Basin, Oman Basin, etc.

- Total offshore drilling
  - Exploration: 237
  - Percentage of total: 58.4%

- Success Rate: Onshore ≈ Offshore
Continuously depressed newly conventional O&G discoveries, but 5 features identified

Global 2018 Conventional O&G Discovery Review

- Discovery
  Conventional O&G fields: **263, 3% YoY**

- The newly added recoverable reserves
  Total O&G: **1.1 BToE, 27% YoY**
  Oil: **510 MMT**, Gas: **699.7 BCM**

Global recoverable reserves from newly conventional oil and gas discoveries by year
20 large- and medium-scale oil and gas fields were major contributors to global newly added reserves

- Reserves of newly discovered O&G fields
  - > 500 MMbbl: 3
  - 100-500 MMbbl: 17

- Recoverable reserves
  - 710 MToE, 65% of the total
    - Oil: 300MMt
    - Gas: 492 BCM

- 18 Offshore fields
  - Recoverable reserves: 647 MToE
  - Offshore: 91% of the total

Global newly discovered oil and gas fields with reserves greater than 100 Mboe in 2018

<table>
<thead>
<tr>
<th>Oil and Gas Field</th>
<th>Country</th>
<th>Basin</th>
<th>Basin Type</th>
<th>Operator</th>
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</table>
Natural Gas, Offshore and Middle-Shallow reservoirs dominated the new discoveries

- **Natural Gas**
  Newly added reserves: **699.7 BCM**
  **53.2%** of the total

- **Offshore**
  Newly discovered O&G fields: **85**
  Newly added reserves: **860 MToE, 79%** of the total

- **Middle-shallow reservoirs**
  **84.4%** of the total new discoveries
  Deep reservoirs: slightly increased
  Ultra-deep reservoirs: slightly declined
Global 2018 Oil and Gas Exploration Situation

Passive continental margin basins still dominated in new oil and gas exploration discoveries

- **Passive continental margin basins: 67%**
  - Mid-Atlantic Guyana Basin, Eastern Mediterranean Basin, Bas-Congo Basin (West Africa), Roebuck Basin (Australia), Voring Basin (Norway) and deep-water Gulf of Mexico Basin

- **Rift basins: 16%**  
  - **Foreland basins: 13%**
Major contributions from mature basins, New territories were attractive for discoveries

- **Recoverable reserves**
  - Mature basins: 72
  - Contribution: 680 MToE, 62.6% of the total
    - Basins: West Siberian Basin (Russia), Bas-Congo Basin (West Africa), Voring Basin (Norway)

- **New territories were attractive**
  - 11 basins, e.g. Guyana Basin, Eratosthenes Basin (Eastern Mediterranean), Roebuck Basin (Australia)
  - Recoverable reserves: 410 MToE, 37.4% of the total
I. Global Oil and Gas Exploration Situation

II. Global 2018 Key Exploration Discoveries Overview

III. Implication for Future Global Oil and Gas Exploration
Global 2018 Key Exploration Discoveries Overview

- Eratosthenes Basin, Eastern Mediterranean: Organic reefs
- Guyana, South America: Deep water
- Arctic South Kara Sea, Russia: North-Obskoye large gas field
- Donner Halten Sub-basin in Voring Basin, Norway: Largest discovery (20 Years)
- Roebuck Sub-basin, North West Shelf, Australia: Largest oil field discovery (40 Years)
Global 2018 Key Exploration Discoveries Overview
Case 1-Calypso Gas Field

Organic reefs continuously to be the significant exploration target in Eratosthenes Basin, Eastern Mediterranean — Calypso Gas Field

- **Eastern Mediterranean Waters**
  - 3 basins, 282,000 km²
  - Passive continental margin basins
  - Formed at northern margin of Gondwana

- **Exploration History**
  - At early stage: Oligocene-Miocene delta sand body in onshore-shallow waters of the Nile Delta
  - Since 1999: Deep-water delta front (Shell, Noble Energy)
  - 2009: Breakthroughs were made in Levant Basin
  - Since 2015, Deep organic reefs in Eratosthenes Basin (Eni)

- **Current Status**
  - NG accumulated recoverable reserves: 3.8 TCM

2P Reserves of petroliferous basins in Eastern Mediterranean by Year

- Exploration in shallow waters mainly in Nile Delta
- Deep & ultra deep waters exploration stage
- Miocene turbidite sand body
- Cretaceous - Miocene Reef
- Tamar, 285 BCM, first discovered with ultra-deep water E3-N1 sandstone
- Zohr, 850 BCM, first discovered with K-N1 reef limestone
Organic reefs continuously to be the significant exploration target in Eratosthenes Basin, Eastern Mediterranean — Calypso Gas Field

New data & understanding on hydrocarbon accumulation

- 2012: 2D seismic reprocessed (Eni) likely organic reefs in Cretaceous-Miocene system
- 2014, Shorouk Block (Egypt), Eni: 100% participant
- 2015, Refined characterization of organic reefs with new 3D seismic data
- Aug. 2015, Well Zohr-1: Discovery of giant organic reefs gas field
  Area: 100 km², Gas column: 654m, Reserves: 850 BCM
- 2017, Offshore Concession (blocks 6/8/10) Bidding (Cyprus) -- Eni, Exxon Mobil
- 2018, Calypso Gas Field (Blk 6) -- Eni
  Area: 72 km², Reserves: 100 BCM
- 2019, Glaucus Gas Field (Blk 10) -- Exxon Mobile
  Area: 100 km², Reserves: 130 BCM

Current Status of Cyprus Waters

- Calypso 1
  100 BCM
- Glaucus 1
  130 BCM
- Zohr

2D seismic in the bidding package (time profile)

2D seismic reprocessed by Eni (depth profile)
Deep water exploration continuously to be the significant exploration target in Guyana, South America

- **Guyana Basin**
  - Early Cretaceous passive continental margin
  - Area: 230,000 km²

- **Before 2007**
  - Onshore exploration
  - No significant discovery

- **2013**
  - Offshore seismic exploration

- **2015-2017**
  - 5 large-scale O&G fields, e.g. Liza
  - Upper Cretaceous Turbidite Sandstone
  - By Exxon Mobil

**Stratigraphic Chart - Guyana Basin**

**Oil and gas reserves discovered in Guyana Basin by year**

**Guyana Basin**

- **Oil**: 720 MMT
- **Gas**: 190 Mtoe

**Accumulatively discovered reserves (100 Mtoe)**

- **Oil**: 2015, 2018, 2019
- **Gas**: 2015, 2018, 2019
Deep water exploration continuously to be the significant exploration target in Guyana, South America

**5 Newly Discovered Oil Fields, 2 Types of Hydrocarbon Accumulation**

- **Blk Stabroek**
  - 13 O&G fields
  - Accumulated recoverable reserves: 910 MToE
- **2018**
  - Location: SE of Blk Stabroek
  - Drilling: 3 wells (Pacora 1, Longtail 1, Pluma 1)
  - Discovery: Cretaceous
  - 3 oil fields, Total reserves: 137 MMt
  - Newly added reserves: 226 MToE

- **J3-K1 Carbonate (Well Ranger-1)**
  - Location: Northern part of Blk Stabroek
  - Area: 36 km², Reservoir thickness: 70m
  - Reserves: 50.54 MMt

- **Eocene-Miocene turbidite sand (Well Hammerhead 1)**
  - Area: 51 km², Reserves: 38.59 MMt
Global 2018 Key Exploration Discoveries Overview

Case 2- Guyana Basin

Deep water exploration continuously to be the significant exploration target in Guyana, South America

**Jubilee**: Cote d’Ivoire Basin (West Africa) → Upper Cretaceous turbidite sandstone accumulation (Guyana Basin)

Guyana Basin → Fausto Amazon Basin, Liberia Basin, Cote d’Ivoire Basin

Oil and gas fields in middle and south coast of the Atlantic Ocean
North-Obskoye large gas field was discovered in Arctic South Kara Sea, Russia

The South Kara Sea: Extension of West Siberian Basin to the Arctic waters
Exploration area: 769,000 km²

- 1960-1980’s Onshore giant gas condensate fields
- After: Stagnant exploration
- 2014: Pobeda (Victory) giant oil field (Rosneft & Exxon)
- 2018: North-Obskoye giant gas field (Novatek)
  - 2 Gas fields -- Dinkov & Nyarmeyskoye (Gazprom)
- By the end of 2018, total NG reserves -- 6.3 TCM

### Gas Fields Discovered in South Kara Sea Area

<table>
<thead>
<tr>
<th>Gas field</th>
<th>Year of discovery</th>
<th>Oil (10,000 t)</th>
<th>Gas (100 MCM)</th>
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<tr>
<td>Obskoye Severnoye</td>
<td>2018</td>
<td>411</td>
<td>855</td>
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<tr>
<td>Im.V.A.Dinkova</td>
<td>2018</td>
<td>41</td>
<td>283</td>
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<td>Nyarmeyskoye</td>
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Oil and gas fields in Yamalo-Nenetskiy area
North-Obskoye large gas field was discovered in Arctic South Kara Sea, Russia

- 2011 North-Obskoye block (Novatek Concession)
- Oct, 2018 Well Drilling -- Obskaya North-1
  Discovery: lower Cretaceous Aptian
  Area: 1116.5 km², Thickness: 15m
  Recoverable reserves: 84.96 BCM

There are still a lot of untapped traps in the South Kara Sea waters. With the proceeding of the exploitation and production of Yamal project and Arctic project, the E&P potential in this area will be further unleashed.
Global 2018 Key Exploration Discoveries Overview
Case 4- Hades/Iris Gas Field

Discovery breakthrough over past 2 decades in Donner Halten Subbasin in Voring Basin, Norway

- The Voring Basin
  Passive continental margin basin
  Area: 148,000 km²

- 1980’s: Exploration initial stage
  Major target: Donna & Halten sub-basin
  Continuous discoveries

- Since 2000, Expanding Stage
  Deep & ultra deep waters to the west of the sub-basin

- Current
  Discovered O&G fields: 96
  Accumulated recoverable reserves: 1.53 BToE
  Oil dominated

Oil and gas fields in Voring Basin
Global 2018 Key Exploration Discoveries Overview

Case 4- Hades/Iris Gas Field

Discovery breakthrough over past 2 decades in Donner Halten Subbasin in Voring Basin, Norway

- **2001**
  - Morvin oil field, Onstream
  - 1st discovered by Equinor (Statoil)

- **2012**
  - Block 6506/11-10
  - 1st CA in Voring Basin of Norway
  - OMV, Austria (Operator)

- **April, 2018**
  - Discovery of Hades/Iris Gas Field
  - Location: 5 km NW to Morvin oil field
  - 2P reserves of 28.72 MToE.

- **Biggest Discovery (20 years)**
  - Condensate gas accumulation
  - Cretaceous & Jurassic
Largest oil field discovery over 4 decades in Roebuck Sub-basin, North West Shelf, Australia

- **Roebuck Sub-basin**
  - Passive continental margin basin
  - Northwestern Australian continental shelf
  - Area: 84,000 Km²
  - Prolific gas basins surrounding

- **North Carnarvon Basin**
  - Rich oil in shallow waters (J-K)
  - Rich gas in deep waters (T)

- **Browse Basin**
  - Rich oil in shallow waters (K)
  - Rich gas in deep waters (J)

Before 1980
- Drilling: 8 wells
- Discovery: Phoenix Gas Field

1980s’—2014
- No exploration discoveries

After 2014
- Discoveries: 3 O&G fields
- Total O&G recoverable reserves **77.96 MToE**
- Gas dominated

Major petrolierous basins in the northwestern Australian continental shelf

Reserves of discovered oil and gas fields in Roebuck Sub-basin by year
Largest oil field discovery over 4 decades in Roebuck Sub-basin, North West Shelf, Australia

Roebuck Sub-basin Exploration Review

- **2014 -- by Apache**
  - R&D: Phoenix south trap
  - Drilling: O&G discovery
  - Formation: Middle Triassic sandstone

- **2016 -- by Quadrant Energy**
  - Further exploration: Southwards
  - Discovery: Roc condensate reservoir
  - 2P recoverable reserves: 45.34 MToE

- **2018 -- by Quadrant Energy**
  - Discovery: Dorado light oil reservoir
  - Lithologic turbidite sandstone trap
  - The 3rd largest oil discovery in Western Australia
  - Significance to the exploration of NW Australian continental shelf
I. Global Oil and Gas Exploration Situation

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III. Implication for Future Global Oil and Gas Exploration
18 Exploration Targets will be the future hotspots, Offshore dominates

- **Current hotspots:** E turbidite sand (Gulf of Mexico), K-E turbidite sand & carbonate rocks (Guyana), Subsalt carbonate rocks (South Atlantic), K basin floor fan (Senegal), E turbidite sands (East African waters), J-K rift (North Sea & Barents Sea), K-E reefs (Eastern Mediterranean), Zagros-Middle Arab J-E, foreland K-E (PNG)

- **Future hotspots:** J-K rift in Argentine waters, E turbidite sands (Columbia), K-turbidite sands (east coast of the United States), K-delta sands (north slope of Alaska), J-K sandstone (Greenland), J-K (Kara Sea of the Russian Arctic), Miocene sands (far northeast Sahalin), N sands (the Bay of Bengal-Andaman Sea), K-E sands (Somalia, East Africa)
Offshore has already been the global major conventional O&G exploration target area

- **In the past 10 years**
  - Offshore conventional newly added reserves
  - Newly discoveries reserves: 70%+
  - Offshore large-Medium O&G fields / Total: 80%+

- **In the past 5 years**
  - Licensed Blocks acreage: 4.76 Mln Km²
  - Offshore percentage: 51%

### Features summary for newly licensed onshore assets
- Basin Margin
- Re-tapping on highly explored target
- Complex geological settings
- Severe operating environment

**Implication for Future Global Oil and Gas Exploration**

1. Offshore Dominates Exploration Hotspots

**Graphs:**
- Recoverable reserve distribution by sector (2010-2018)
- Total proportion of offshore oil reserves
- Licensed block area (10,000 km²)
- Blocks licensed by sector (2014-2018)
Implication for Future Global Oil and Gas Exploration

Implication 1- Offshore Dominates Exploration Hotspots

Offshore has already been the global major conventional O&G exploration target area

- 2D & 3D Seismic
  - Offshore of the total: 70-95%
  - Far greater than Onshore

- Exploration success rate
  - Onshore: 38-60%
  - Offshore: 40-55%

Onshore and offshore exploration success rates by year

Onshore and offshore 2D seismic by year

Onshore and offshore 3D seismic by year

Implication 1:
Offshore Dominates Exploration Hotspots
Implication for Future Global Oil and Gas Exploration

Implication 2- Strengthening Independent Exploration

Strengthening independent exploration will be the fundamental for IOC sustainable development

Seven Majors are willing to increase reserves through sustained exploration investment

- Independent Exploration Investment
  - Annual average: USD 2.3 bln
  - Percentage of the upstream total: 11%

- Independent Reserves Increasement after 2014
  - Annual average newly added equity recoverable reserves: 77 MToE
  - Accounting for 43% of the newly added SEC reserves

Annual average exploration investment and percentage of upstream total from 2014-2018 by Majors

Annual average increase & percentage of independent exploration reserves from 2014-2018 by Majors

Implication for Future Global Oil and Gas Exploration

Implication 2- Strengthening Independent Exploration

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Annual average exploration investment and percentage of upstream total from 2014-2018 by Majors

Annual average increase & percentage of independent exploration reserves from 2014-2018 by Majors
Seven Majors actively participated in the exploration asset bids to ensure sustainable development

- By the end of 2018, average concession license / Major
  - Exploration blocks: 1068
  - Percentage of total blocks: 75%

- In past 5 years, annual average concession access / Major
  - Total exploration blocks: 67
  - Deep water blocks: 45, 67% of the total

Total Exploration Blocks License hold within Majors by the end of 2018

Exploration Blocks License hold within Majors in recent 5 years by sector
Implication for Future Global Oil and Gas Exploration

Implication 3- Scientific Farsightedness for Exploration Leading Position

Only by deploying exploration in frontier areas in advance, can a company take the lead in global O&G exploration

- IOC's Exploration Strategy

  **Active in the potential regions:** Eastern Mediterranean, Guyana, Brazil's pre-salt, East Africa

- Blocks operated by Eni in the Eastern Mediterranean
- Blocks operated by Exxon in the Guyana Basin
Implication for Future Global Oil and Gas Exploration
Implication 3- Scientific Farsightedness for Exploration Leading Position

Story on Stabroek Block of Guyana

<table>
<thead>
<tr>
<th>Year</th>
<th>Project</th>
<th>Oil (t)</th>
<th>Gas (100 MCM)</th>
<th>Total reserves (10,000 toe)</th>
<th>Series</th>
<th>Reservoir</th>
<th>Lithology</th>
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<tbody>
<tr>
<td>2015</td>
<td>Liza</td>
<td>25753</td>
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<tr>
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<td>9623</td>
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<td>Sandstone</td>
</tr>
</tbody>
</table>

1999-2007

- Exxon: 100% Participant
- Exxon & Mobil merged
- No reported exploration activities

2008-2014

- Exxon: start exploration
- Feb. 2009
  - Shell: 25% Participant
  - Exxon: 75% Participant
- Jul. 2012
  - Shell: 50% Participant
  - Exxon: 50% Participant
- 2013 –Exploration activities
  - 3D seismic: 2,350 km²
  - Impacted by territorial sea disputes
- 2014 –Exploration activities
  - Shell: withdraw (unknown reasons)
  - Hess: 30% Participant
  - Nexen: 25% Participant
  - Exxon: 45% Participant

2015-2019

- May 2015 Exxon
  - 1st O&G discovery
  - Well Liza-1, offshore Stabroek Block
- 2017-2018
  - Discoveries: Payara, Snoek, Liza Deep, Turbot, Longtail, Ranger, Pacora, Hammerhead, Pluma
- 2019
  - Shell: seeking for the opportunities
Implication for Future Global Oil and Gas Exploration

Implication 3- Scientific Farsightedness for Exploration Leading Position

- Short term exploration potential
  - Argentine waters, Cuba, Somalia, the Russian Arctic, Greenland

- 2019 Brand new exploration region
  - Argentine waters
    - 18 Blocks were awarded to 13 oil companies
      - Equinor: 7 Blocks

- No Chinese oil companies involved

<table>
<thead>
<tr>
<th>Block</th>
<th>Operator</th>
<th>Partner</th>
<th>Signature fee ($10,000)</th>
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<tbody>
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<td>MLO-124</td>
<td>Eni</td>
<td>Mitsui, Tecpetrol</td>
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<tr>
<td>MLO-121</td>
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<tr>
<td>CAN-108</td>
<td>Equinor</td>
<td>/</td>
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<td>CAN-114</td>
<td>Equinor</td>
<td>/</td>
<td>4717</td>
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<tr>
<td>AUS-105</td>
<td>Equinor</td>
<td>/</td>
<td>1520</td>
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<td>/</td>
<td>2287</td>
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<td>Shell</td>
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<tr>
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<td>Shell</td>
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<td>BP</td>
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<tr>
<td>CAN-113</td>
<td>Total</td>
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<td>MLO-123</td>
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</tbody>
</table>

Bidding results in Argentine waters, 2019
Implication for Future Global Oil and Gas Exploration

Implication 4- Data Sharing and R&D

- Multi-client seismic data base
  Acquisition: Spectrum, CGG, ION, BGP
- IOCs’ Actions
  Annual budget & planning
  R&D for bidding
- Resource host countries regulation
  Data base purchase before tendering
  2-3 times of the data base prices after awards

Utilization of multi-client seismic data base and enhancing the research for long term successful exploration

<table>
<thead>
<tr>
<th>Company type</th>
<th>Min. ($10,000)</th>
<th>Max. ($10,000)</th>
<th>Avg. ($10,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOC</td>
<td>650</td>
<td>5500</td>
<td>2650</td>
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<tr>
<td>NOC</td>
<td>560</td>
<td>3000</td>
<td>1500</td>
</tr>
<tr>
<td>Independents</td>
<td>300</td>
<td>3800</td>
<td>1020</td>
</tr>
</tbody>
</table>

Annual expenses for purchase of multi-client seismic data by company type
(Data collected from 2017 & 2018)

(Source: tendering information, seismic data inquiry, etc.)
Thanks!