Pre-Tertiary Buried Hills Assessment Unit 31270102

Geologic Summary
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Assessment Unit Summary
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Pre-Tertiary Buried Hills Assessment Unit 31270102
Bohaiwan Basin Geologic Province 3127
DESCRIPTION: The assessment unit is characterized by oil and gas fields trapped in buried hills (fault blocks) that largely consist of upper Proterozoic and lower Paleozoic marine carbonate reservoirs. Fields are confined to six sub-basins of extensional origin (Bozhong, Huanghua, Liaohe, Linqing/Dongpu, Jiyang, Jizhong), each having one or more pod(s) of active Eocene source rocks. The Bozhong sub-basin is located in offshore Bohai Bay whereas the Jizhong, Linqing/Dongpu, and most of the Jiyang sub-basins are located onshore. The Huanghua and Liaohe sub-basins have large offshore parts. The giant Renqui field is located in the Jizhong sub-basin. Gas-bearing, pre-Tertiary buried hills sourced by Carboniferous and Permian coalbeds are not included in this assessment unit.

SOURCE ROCKS: Source rocks are deep-water lacustrine shale and mudstone of Eocene and Oligocene age that are draped over the buried hills. The dominant source rock is the upper Eocene part of the Shahejie Formation (Members 3). Additional source rocks are the lower Eocene part of the Shahejie Formation (Member 4), Oligocene part of Shahejie Formation (Member 1), and Eocene Kongdian Formation (Member 2). The thickness of Member 3 of the Shahejie Formation is approximately 1,000 m in each sub-basin and its total organic carbon (TOC) values range from about 1 to 4.5. Oil-source rock correlations clearly demonstrate that oil in the buried hills was derived from adjoining lacustrine shale and mudstone.

MATURATION: The Shahejie Formation (Member 3) has been mature with respect to oil generation since about the middle Oligocene/early Miocene. Member 3 is largely immature with respect to gas generation. In contrast, the Shahejie (Member 4) and Kongdian (Member 2) Formations have been mature with respect to gas generation since about the middle Miocene. The Shahejie Formation (Member 1) is immature with respect to oil and gas generation in most sub-basins. A relatively high geothermal gradient of about 32 to 36°C/km accompanied oil and gas generation.

MIGRATION: Only very local lateral migration of oil and gas occurred in the sub-basins and it was confined to the pods of mature source rocks. Oil and gas migrated directly into buried hills from adjoining and overlying Tertiary lacustrine source rocks. Some migration of oil and gas followed unconformities and normal faults. A limited number of burial/uplift/generation scenarios are critical for the charging and preservation of the buried-hill accumulations.

RESERVOIR ROCK: The best reservoir rocks are shallow marine dolomite and limestone beds of Proterozoic, Cambrian, and Ordovician age that have been exposed to long periods of subaerial weathering, erosion, and karst processes. Solution-enlarged fractures, vugs, and cavities are common features in the better reservoirs. These dolomite and limestone reservoirs occupy the Proterozoic Wumishan Formation and numerous formations of Cambrian and Ordovician age. Local reservoirs consist of Archean crystalline basement, Proterozoic/lower Paleozoic sandstone beds, and Mesozoic volcanic rock and sandstone.
TRAPS AND SEALS: The major traps are buried hills (fault blocks) of extensional origin overlain by seals and source rocks of Tertiary lacustrine shale and mudstone such as the widespread Member 3 of the Eocene Shahejie Formation.

REFERENCES:
Pre-Tertiary Buried Hills
Assessment Unit - 31270102

EXPLANATION

- Hydrography
- Shoreline
- Geologic province code and boundary
- Country boundary
- Gas field centerpoint
- Oil field centerpoint

Projection: Robinson. Central meridian: 0
SEVENTH APPROXIMATION
NEW MILLENNIUM WORLD PETROLEUM ASSESSMENT
DATA FORM FOR CONVENTIONAL ASSESSMENT UNITS

Date:………………………….. 4/28/99
Assessment Geologist:…….. R.T. Ryder
Region:…………………….. Asia Pacific
Province:………………….. Bohaiwan Basin
Priority or Boutique……….. Priority
Total Petroleum System…….. Shahejie-Shahejie/Guantao/Wumishan
Assessment Unit:…………… Pre-Tertiary Buried Hills

* Notes from Assessor MMS growth factor.

CHARACTERISTICS OF ASSESSMENT UNIT

Oil (<20,000 cfg/bo overall) or Gas (>20,000 cfg/bo overall):… Oil
What is the minimum field size?………. 5 mmboe grown (>1mmboe)
(the smallest field that has potential to be added to reserves in the next 30 years)
Number of discovered fields exceeding minimum size:……..
Established (>13 fields) X Frontier (1-13 fields) Hypothetical (no fields)
Median size (grown) of discovered oil fields (mmboe):
1st 3rd 174 2nd 3rd 32 3rd 3rd 60
Median size (grown) of discovered gas fields (bcfg):
1st 3rd 3593 2nd 3rd 3rd 3rd

Assessment-Unit Probabilities:
Attribute Probability of occurrence (0-1.0)
1. CHARGE: Adequate petroleum charge for an undiscovered field > minimum size……………… 1.0
2. ROCKS: Adequate reservoirs, traps, and seals for an undiscovered field > minimum size…… 1.0
3. TIMING OF GEOLOGIC EVENTS: Favorable timing for an undiscovered field > minimum size 1.0

Assessment-Unit GEOLOGIC Probability (Product of 1, 2, and 3):……………… 1.0

4. ACCESSIBILITY: Adequate location to allow exploration for an undiscovered field
> minimum size………………………………………………………………………………… 1.0

UNDISCOVERED FIELDS

Number of Undiscovered Fields: How many undiscovered fields exist that are > minimum size?:
(uncertainty of fixed but unknown values)
Oil fields:……………………………min. no. (>0) 10 median no. 30 max no. 70
Gas fields:……………………………min. no. (>0) 2 median no. 15 max no. 40

Size of Undiscovered Fields: What are the anticipated sizes (grown) of the above fields?:
(variations in the sizes of undiscovered fields)
Oil in oil fields (mmbo):……..min. size 5 median size 40 max. size 1000
Gas in gas fields (bcfg):……..min. size 30 median size 80 max. size 3000
### AVERAGE RATIOS FOR UNDISCOVERED FIELDS, TO ASSESS COPRODUCTS
(uncertainty of fixed but unknown values)

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<thead>
<tr>
<th></th>
<th>minimum</th>
<th>median</th>
<th>maximum</th>
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<tr>
<td>Gas/oil ratio (cfg/bo)</td>
<td>350</td>
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<td>NGL/gas ratio (bngl/mmcf)</td>
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<td>90</td>
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<tr>
<td><strong>Gas fields:</strong></td>
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<tr>
<td>Liquids/gas ratio (bngl/mmcf)</td>
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<td>66</td>
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<tr>
<td>Oil/gas ratio (bo/mmcf)</td>
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</table>

### SELECTED ANCILLARY DATA FOR UNDISCOVERED FIELDS
(variations in the properties of undiscovered fields)

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<th>maximum</th>
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<td><strong>Oil Fields:</strong></td>
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<tr>
<td>API gravity (degrees)</td>
<td>20</td>
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<td>50</td>
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<td>Sulfur content of oil (%)</td>
<td>0.05</td>
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<td>Drilling Depth (m)</td>
<td>1000</td>
<td>3000</td>
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<td>Depth (m) of water (if applicable)</td>
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<td>40</td>
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<td><strong>Gas Fields:</strong></td>
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<tr>
<td>Inert gas content (%)</td>
<td>0.5</td>
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<td>CO₂ content (%)</td>
<td>0.1</td>
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<td>Hydrogen-sulfide content (%)</td>
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<td>Depth (m) of water (if applicable)</td>
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Pre-Tertiary Buried Hills, AU 31270102
Undiscovered Field-Size Distribution

Minimum field size: 5 MMBO
Mean number of undiscovered fields: 65.7
Pre-Tertiary Buried Hills, AU 31270102
Undiscovered Field-Size Distribution

Minimum field size: 30 BCFG
Mean number of undiscovered fields: 16.4

GAS-FIELD SIZE (BCFG)

UNDISCOVERED GAS FIELDS (No.)