Geology and Tectonic Evolution of Bird Head Region Papua, Indonesia: Implication for Hydrocarbon Exploration in the Eastern Indonesia*

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Abstract

The Bird Head Region is located in the western part of Papua Island and is one the most geological complex regions in the eastern part of Indonesia. This region is known as one of the most hydrocarbon prolific areas in Indonesia. Two major oil and gas producing basins were discovered in the region namely the Salawati and Bintuni Basins. Numerous work and publications have been done in the area to ramification geologic history of the region. However, the geology and structural evolution of the region are poorly known due to limited data over the region, particularly in relation to hydrocarbon distribution. In addition, several recent results of exploration drilling have generated major disappointment for continuity of future exploration in the region. One of the main problems is related to the origin and tectonic evolution of the Bird Head Region. This paper is presenting results of the ongoing study in ramification of the problems using tectono-straigaphy approach generated from integrated fieldwork and subsurface data evaluation (2D seismic and well data).

There are several different published proposed models of the origin of the Bird Head Region. However, most of the models were not supported by enough subsurface data. Understanding stratigraphy from various different locations within the region and detail structural evolution is one of the most important tasks in solving the origin of Bird Head. Our newly proposed model generated from conducting numerous 2D and 3D palinspatic reconstructions from several different locations in the regions using integrated surface and subsurface geological information. It is clear that deformation of the region varies from area to area indicating that the region experienced several translations and rotations during their history. Using structural reconstructions we developed several
representative paleogeographies of the region showing distribution of Jurassic and Tertiary reservoirs including their petroleum system. Hopefully, our new model can help in locating new exploration target areas.

**Selected References**


GEOLOGY AND TECTONIC EVOLUTION OF BIRD HEAD REGION PAPUA, INDONESIA: IMPLICATIONS FOR HYDROCARBON EXPLORATION IN THE EASTERN INDONESIA

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• Eastern Indonesia is tectonically and structurally extremely complex, comprising slivers of continental blocks, arc fragments and trapped ocean basins.

• Many potential petroleum basins are recognized; however geologically poorly understood.

• Origin of Bird Head? (Micro-continent)

• The origin peculiar triangular deep embayment of the Cendrawasih Bay (Basin) are still growing debate.

TECTONIC EVOLUTION - PALEOGEOGRAPHY
Tectonic Map of New Guinea

EXPLANATION
- Ophiolites and ultramafic rocks
- Approximate limit of underthrust Australian continental crust
- Exposed continental basement
- Inactive deformation front
- Slow convergence (< 2 cm/yr)
- Rapid convergence (> 2 cm/yr)
- Active spreading oceanic ridge
- Active strike-slip fault zone
- Inactive strike-slip fault zone
- Relative plate motion vector with respect to the Australian plate

Sapiie (1998)
Banda area complete Bouguer anomaly on-shore, height correction anomaly off-shore, mGals. 3D image sunlit from the NW at 45 degrees.
REGIONAL GEOLOGY AND HC OCCURRENCES

- **Abadi Field**: >7 Tcf gas
- **Bintuni**: ~14 Tcf gas
- **Salawati**: ~300 MMBO
- **Oesil**: ~14 MMBO
- **Abadi Field**: >7 Tcf gas
TECTONIC EVOLUTION OF BIRD HEAD REGION

(A) Translation Model 1

(B) Translation Model 2

(C) Rotational Model 1 (clockwise)

(D) Rotational Model 2 (counter clockwise)

(E) Combination Model

- Paleozoic Structure
- Mesozoic Structure
- Cenozoic Structure
- Australian
- Outcropped Continent Basement
- Pacific
- City
- Relative Plate Motion

Sapiie, et. al. (2009)
SUBSURFACE DATABASE OF BIRD HEAD REGION
Regional Correlations

- Pliocene Sequence
- Miocene Sequence
- Oligocene Sequence
- Cretaceous Sequence
- Late Jurassic Sequence
- Early – Middle Jurassic Sequence
- Triassic Sequence
DEFORMATION OF BIRD HEAD REGION
SALAWATI – MISOOL DEFORMATION

Yefbie Fm.
Seismic Interpretation of Cendrawasih Bay – *Baseline Issue?*

- Tied to O-1 well for Pliocene – Pleistocene
- Divided into two major sequences
- Angular unconformity relationship

Sapiie, et al. (2007)
Seismic Interpretation of Cendrawasih Bay

Cendrawasih Bay  Waipona

- Three Deformation Styles:
  - Early normal faults
  - Late Miocene (?) Thrust-Folds system
  - Younger thin-skinned Thrust-Folds system

Sapiie, et al. (2007)
SORONG FAULT ZONE (SFZ)

REGIONAL STRUCTURES - 3D VIEW – continental vs. oceanic basement?

Sapiie, et al. (2007)
PALINSOMATIC RECONSTRUCTIONS – BALANCING CROSS-SECTION

Total Strain = 3.89% (shortening)
Total Strain Distribution at Bird's Head Area

<table>
<thead>
<tr>
<th></th>
<th>West Misool</th>
<th>Seram</th>
<th>East Seram</th>
<th>NW Salawati</th>
<th>Cendrawasih Bay</th>
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<tbody>
<tr>
<td>Triassic-Early Jurassic</td>
<td>0.2</td>
<td>0.34</td>
<td>1.17</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Early-Late Jurassic</td>
<td>0.67</td>
<td>0.25</td>
<td>0.15</td>
<td>0</td>
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<tr>
<td>Late Jurassic-Cretaceous</td>
<td>0</td>
<td>0.19</td>
<td>0.15</td>
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<tr>
<td>Cretaceous-Early Oligocene</td>
<td>0.21</td>
<td>0.07</td>
<td>0.19</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Early Oligocene-Miocene</td>
<td>0</td>
<td>0.19</td>
<td>0.15</td>
<td>0.8</td>
<td>-9.27</td>
</tr>
<tr>
<td>Miocene-Early Pliocene</td>
<td>-1.22</td>
<td>-0.96</td>
<td>-0.75</td>
<td>-12.28</td>
<td>-4.97</td>
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<tr>
<td>Early Pliocene-Present</td>
<td>-7.09</td>
<td>-13.98</td>
<td>-0.75</td>
<td>-2.37</td>
<td>-0.98</td>
</tr>
</tbody>
</table>
DEFORMATION PATTERN AND FAULT STYLE


Sapiie, et al. (2012)
STRAIN ANALYSIS BIRD REGION – STRIKE SLIP DEFORMATION

Lowell (1985)
BIRD HEAD RECONSTRUCTIONS

RECENT

- Australian Plate
- Pacific Plate
- Paleozoic Basement
- Rock
- Mesozoic Graben
- Paleozoic Graben
- Thrust Fault
- Strike-Slip Fault
CONCLUSIONS OF BIRDHEAD REGIONS

• BIRD HEAD REGION IS VERY COMPLEX STRUCTURES AND KINEMATICS AT PRESENT-DAY IT MOVING AS PART OF GREAT PACIFIC PLATES.

• DEFORMATION WITHIN CENDRAWASIH, SALAWATI AND SERAM BASINS IS CONTROLLED BY ACTIVITY OF SORONG FAULT ZONE.

• COMPLEX GEOMETRY OF SORONG FAULT ZONE CONTROLLED BY PRE-EXISTING FAULT SUCH AS LEFT OR RIGHT-STEPPING CAUSED LOCAL ASYMMETRY DEFORMATION PATTERN RESULTED IN SHORTENING AND EXTENSION WITHIN CENDRAWASIH BAY AND SURROUNDING BIRD HEAD REGION.

• SIMPLE SHEAR MECHANISM INVOLVING RIGID BODY with TRANSLATION AND ROTATION AS THE MAIN MECHANISM
SPECIAL THANKS TO:

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