THE POSSIBILITY OF HYDROCARBON TRAP AND ITS POTENTIAL IN THE NORTH BONE BASIN, BASED ON GEOLOGICAL AND GEOPHYSICAL DATA

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ABSTRACT

Based on the analysis of geological and geophysical data, it can be informed that investigated area is the sedimentary Bone basin formed since the beginning of the Tertiary age and developed through Paleogen to the Neogene. The basin is defined as a fore-arc basin underlain unconformable by pre-Tertiary basement rocks comprising metamorphics, volcanics, meta-sediments (the Laitimojong and Pompangeo Complexes). The hydrocarbon occurrence in Bone Basin showed by gas seeps in the surface are located in Pongko and Malangke villages. Some hydrocarbon traps such as structures and stratigraphy are shown in the seismic profiles. Abundant coarse clastic and limestone deposits such as the fluviodeltaic of Toraja and Lamasi Formations may plays as good reservoir in the basin. claystone within the Lamasi Formation and shale within the Toraja Formation predicted as petroleum source rocks in the area. The seals in the basin considered as the existence of numerous claystone and siltstone horizons within the Bone Bone Formation that is also indicated by the drilling results.

Keywords : sedimentary basin, hydrocarbon potential, trap, Bone Basin

SARI

Berdasarkan analisis data geologi dan geofisika dapat diinformasikan bahwa daerah penelitian merupakan cekungan sedimen Bone yang terbentuk sejak Kala Paleogen hingga Neogen. Cekungan tersebut merupakan cekungan busur depan dan dialasi oleh batuan Pra-Tersier dari Formasi Latimojong dan Formasi Pompangeo yang terdiri dari batuan gunung api, batuan ubahan dan batuan meta sediment. Keterdapatan Hidrokarbon di Cekungan Bone ditunjukkan oleh rembesan gas di daerah Pongko dan Kampung Malangke. Analisis lintasan seismik menunjukkan bahwa bentuk perangkap hidrokarbon di daerah tersebut adalah perangkap struktur dan perangkap stratigrafi yang ditunjukkan pada penampang seismik. Batuan sedimen klastik dan batuan karbonat dari Formasi Toraja dan Formasi Lamasi dapat berfungsi sebagai batuan reservoir hidrokarbon di cekungan tersebut. Batulempung pada Formasi Lamasi dan serpih di dalam Formasi Toraja diduga merupakan batuan sumber minyak di daerah tersebut. Data bor menunjukkan bahwa di cekungan tersebut didapatkan batuan klastik halus dari Formasi Bone Bone yang dapat berfungsi sebagai penutup dari sistem perangkap hidrokarbon di daerah ini.

Kate kunci : cekungan sedimen, potensi hidrokarbon, perangkap, Cekungan Bone

INTRODUCTION AND METHODOLOGY

The Bone Basin is situated in South and Southeast Sulawesi Provinces which covers the area of more than 61,670 square kilometers (Widijono *et al*., 2004; Patra Nusa Data, 2004) and occupies almost all areas of Bone Gulf. The Bone Basin is known to have oil resources for speculative of original in place is 682.40 MMBO, for speculative recovery is 170.60 MMBO. The gas resources of original in place for hypothetic is 3.210 Tcf, for speculative is 0.50 Tcf. The gas of recovery resources for hypothetic is 2.299 Tcf, and for speculative is 0.40 Tcf (Patra Nusa Data, 2004).

The investigated area is shown in Figure 1, located at coordinates of Longitude120°10'E to 120°54'E and Latitude 02°35'S to 03°36'S. The onshore area covers almost the whole of Masamba flat-plain offshore occupying some parts of the Northwestern area of Bone Gulf. The main data sources consists of compilation the geological map of North Bone Gulf and its surrounding (Sudjatmiko *et al.*, 1992, Rusmana, *et al*., 1993, Ratman *et al*., 1993), Bouguer anomaly map of the North Bone Gulf amd Surrounding (Sobari. *et al*., 1996, Sobari. *et al*., 2006), nine (9) lines refraction seismic records of about 447.3 line kilometers with a single well offshore data of BBA-1X with the penetration depth of 10,521 feet (Pertamina, 1972).

This well is located at geographic coordinates of 120°36'04"E and 02°53'13"S with the water depth of 155 feet. Based on a brief review and interpretation on the gravity and seismic reflection data, it believes that the well has not penetrated the lower Tertiary successions. Factually, those data were collected by Gulf Oil Company in 1971 that were old enough for present evaluations.

The occurrence of some leads, such as gas seepages in Pongko and Malangke Villages, gas discovery in Sengkang Block, oil and gas discovery in Tomori Block, the present of closures indicated that the the Bone Basin may contain a significant potential of hydrocarbon resources.

TECTONIC SETTING

The Indonesian Archipelago consists of an island arc system, typical of the western Pasific. This island arc system encloses shallow shelf sea areas, which show large tectonic-physiographic features the well-known Sunda Shelf and Sahul Shelf. The first belongs to the continent of Asia, and the later to that of Australia, while in between such as the Bone Basin is probably oceanic fore arc basin deeps.

Based on the geological point of view, the Bone Basin is situated in between south and southeast arms of Sulawesi, interpreted as a composite basin, with its origin as a subduction complex and suture between Sundaland and Gondwana-derived micro-continents, which subsequently evolved as a submerged intra-mountain basin. The basin was a typically sedimentary basin that has been formed in the Early Tertiary, and was developed through the Neogene time. Geological history of the basin was in a fore-arc setting, as a result of westward subduction complex (Silver and Rangin, 1991) which was developed to the east of Western Sulawesi (Figure 2).

The basin is underlain unconformably by the pre-Tertiary basement rocks comprising of metamorphics, volcanics, meta-sediments (Latimojong and Pompangeo complexes). Sedimentation process in the basin was commenced by deposition of Toraja Formation in the west arm, followed by Lamasi Formation and ended by deposition of Bone-Bone Formation.

Tectonic history of this Bone Basin has been summarized firstly by Audley Charles *et.al* (1972), and Hall *et al*. (2001) in conjunction with the plate tectonic reconstructions of Eastern Indonesia and the

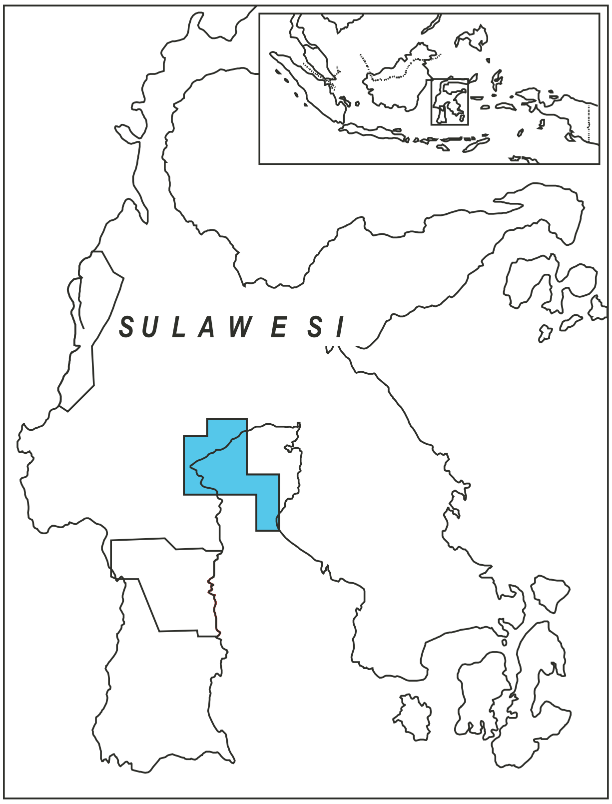

Figure 1. Locations of investigated area.

emplacement of Eastern arm of Sulawesi by the end of the Miocene.

During Early Tertiary or older, a westward subduction complex was probably developed to the east of Western Sulawesi and Bone Basin was in a fore arc setting. Then in the Middle Miocene a collision event occurred between micro-continents and the Early Tertiary accretionary complex. This collision resulted in eastwards obduction of the accretionary complex (Simandjuntak, 1992) on to the micro-continents (Figure 3)

During Late Miocene micro-continents moved to the west, and collided against and was partly subducted beneath the Western Sulawesi. It generated a compressional force that was propagated to a major back-thrust system westwards and fold belt as shown in Kalosi and Majene. From two colliding plates, then were locked up during the Pliocene and continued plate convergence was accommodated by strike-slip movements along the Walanae, Palu-Koro and other faults.

In the southern part of Bone Basin, westerly movement of the micro-continents did not reach the collision stage with Western Sulawesi. Instead, Southeast Sulawesi was rotated eastwards resulting

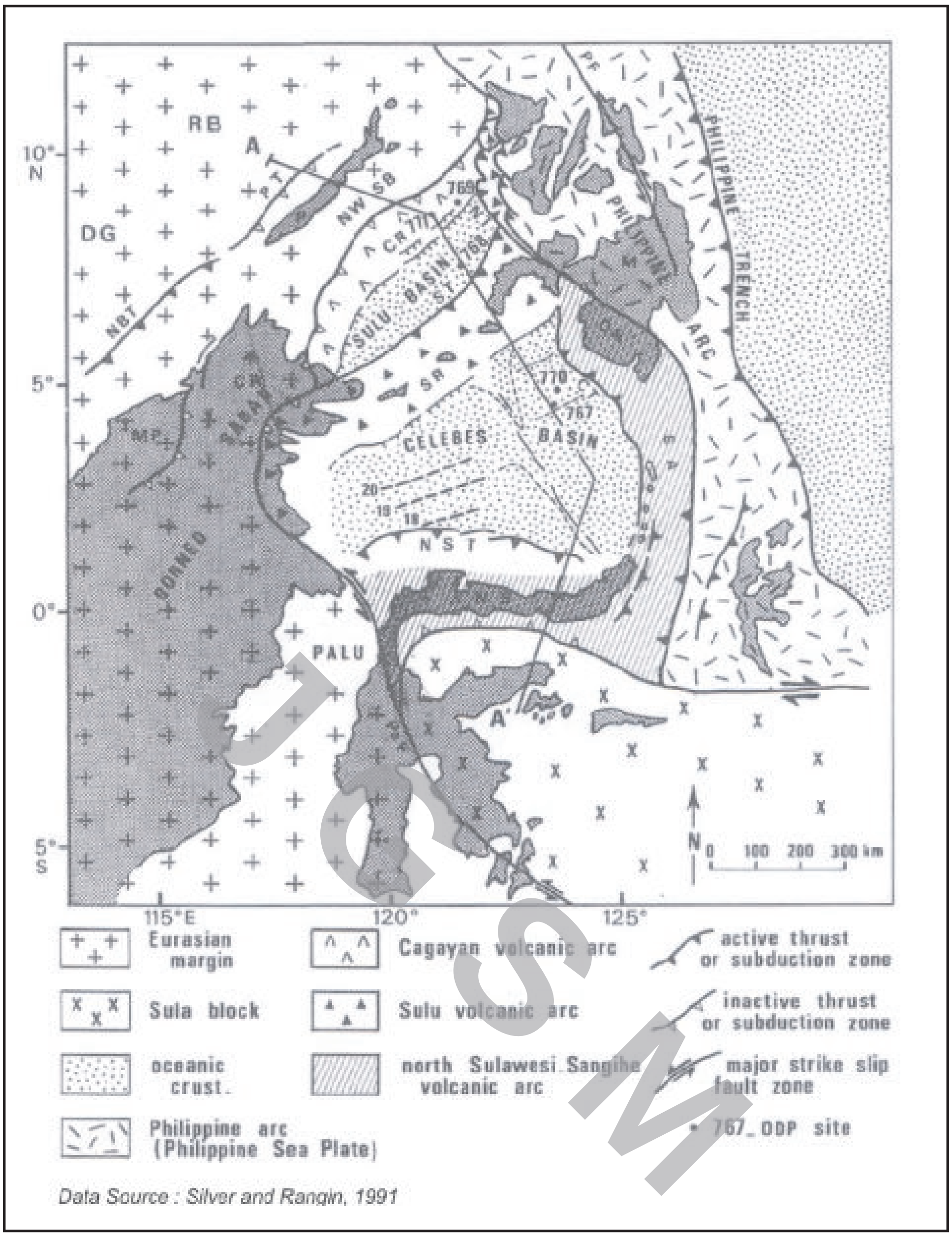

Figure 2. Regional tektonic setting of Sulawesi (Silver and Rangin, 1991)

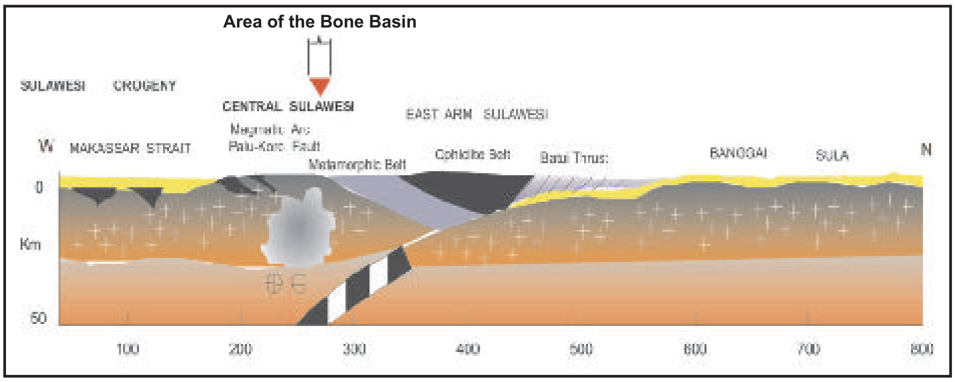

Figure 3. Tectonic cross-section of Sulawesi Neogene orogeny (Simanjuntak, 1992).

in a major extensional fault cutting along the middle of the Bone Basin. In other words, the sedimentary basins can be divided into two parts, namely pre-emplacement and post-emplacement of the eastern arm. Both events have very important implication to the lithology and structure of the basin in conjunction with the existing of hydrocarbon trap.

Stratigraphy

The stratigraphy of the onshore Bone Basin can be divided into two geological groups, *i.e*. Western Province of Sulawesi and Eastern Province of Sulawesi. The border of these provinces (Bachri, 2006) is very close to Masamba. Western Sulawesi Province is to the west of Masamba, whilst to the east belong to the Eastern Sulawesi Province.

Stratigraphy of the western Bone Basin consist of Midle - Late Eocene Latimojong Formation, Late Eocene Toraja Formation, Late Oligocene - Early Miocene Lamasi Formation, Mio - Pliocene Bone Bone Formation and Quaternary Alluvium.

The Latimojong Formation consist of phylite, shale, chert and marble. The thickness of this formation is more than 1000 meters. The Latimojong Formation probably unconformable overlain by the Toraja Formation. The Toraja Formation, consists of shale, marly shale, limestone, coal, quartz sandstone and conglomerate. The thickness of Toraja Formation is more than 1000 meters. The Toraja Formation probably unconformable overlain by the Lamasi Formation. The Lamasi Formation consist of basaltic lava and volcanic breccia. All of these three formations are unconformable overlain by Cellebes Molasse type sediments of the Mio-Pliocene Bone-Bone Formation. The Bone Bone Formation consist of alternating of sandstone and claystone. The thickness of this formation is 1000 meters. The Kambuno Granite of Pliocene in age may had intruded all the older rock formations. Stratigraphy of the onshore eastern Bone Basin basically is more simples than to the west. The basement of this area is composed of Mesozoic rocks comprising serpentinite, meta-limestone and metamorphic rocks of Pompangeo Complex (schist, gneiss, phyllite, slate and quartzite). The basement is uncorformable overlain by the Mio-Pliocene of Bone-Bone Formation and the Quaternary alluvium. Stratigraphic and Tectonic frameworks offshore the Bone Basin are still poorly understood due to limited publications data. Stratigraphy of the basin is available mostly from the BBA-1X of a single offshore exploration well located at 120°36'04"E and 02°53'13"S with the water depth of 155 feet which reached the penetration depth of 10,521 feet. Based on this well data the Gulf Oil Co (Cater *et al*., 1972). has summarized the stratigraphy of the basin as follows :

1. Zone N.22-N.23 at the depth of 240 ft - 480 ft from the age of Pleistocene to Recent with the lithology consists of interbedded clays and sands.
2. Zone upper N.19-N.22 at the depth from 480 ft to 2220 ft from Pleistocene to Lower Pliocene age with the lithology consists of interbedded clays and sands with some traces of lignite.
3. Zone N.17 - Lowermost N.19 at the depth of 2220 ft - 5340 ft from Lowermost Pliocene to Upper Miocene with the lithology consists of interbedded clays and sands with occasional lignite and probably some conglomerates (5255 ft - 5289 ft).
4. Zone N.15-N.16 at the depth of 5340 ft - 5640 ft from Middle - Upper Miocene with the lithology consists of clays and claystone are very dominant in this zone.
5. Zone N.14 from the depth of 5640 ft - 6360 ft from Middle Miocene age with lithology consists of claystone with a little interbedded sandstone. Some claystones are very silty.
6. Zone Upper N.13 at the depth of 6360 ft - 9060 ft Middle Miocene age with the lithology consists of claystone frequently silty or sandy interbedded with sandstone and some siltstone.
7. Zone Lower N.13 at the depth of 9060 ft - 10,524 ft from the Middle Miocene age with the lithology consists of sandstone become and are interbedded with claystone ans occasionally siltstone, some claystones are very sandy, some sandstone below 10,000 ft are conglomeratic containing pebbles of quartz.

However the correlation to the known formations on shore is very difficult because of several factors. In fact correlation of a single well data of BBA-1X, and logging as well as paleontological results are very difficult to be correlated with the specific reflector of seismic records. This is one of the reason that the location of the BBA-1X of a single well is on the chaotic fracture zone. The stratigraphic succession intersected by the well does not represent the true stratigraphic succession of the Bone Basin, especially below unconformity surface at about 1.6 seconds (See interpreted line seismic 312). In addition correlation of specific horizons among the lines is very difficult due to poor quality of some records.

The Toraja Formation is one of the most important formation in the area, because of its extensive distribution especially in the west, with thickness is not less than 1000 meters and, the depositional environment from fluvio-deltaic to bathyal condition (Bahri, 2006). The presence of very thick shale has paid attention for the possibilities of the occurrence of oil source rock. Furthermore this formation might has not developed to the east of Sulawesi. In Sengkang Block and Tomori, the brown shale of Toraja Formation plays as source rock hidrocarbon. The chart of stratigraphic correlation for onshore and offshore of the northern Bone Basin can be seen in Figure 4.

Geophysical Data

The most recently additional data on the basin (onshore part) is gravity data collected by the Geological Research and Development Centre (now Geological Survey Institute) which conducted the systematic regional mapping in the Sulawesi areas of scale 1:250,000. However, the data is very regional having the spacing of about 10 km and may contribute of some informations to the basin evaluation assessment. From this map can be seen several structural lineament (Figure 5).

Mean while integrated gravity and surface geology interpretations give the ideas of a new model tectonic as can be seen as Figure 6. From this model, can be predict that the basement of the West Bone Basin is Sundaland and the East Bone Basin is Pompangeo complexes. From this model it can also been seen that the sediment thickness of West Bone Basin reached 4000 meters and in the East Bone Basin reached 2500 meters.

The seismic reflection records consists of about 2000 line kilometers with the record length between four (4) and five (5) seconds but all were in the form of single volt unmigrated time section data. The data is available through the PT. Patra Nusa Data which is subsidiary of the PT. Pertamina.

Quality of the record could be considered poor or low quality such as noise is very dominant in almost every line, some multiples also still exist and disturbing much records. The original digital data is not available which is become a great handicap as we could not reprocesses the data with the current processing technology, that probably could improve the quality of the records.

However, from those seismic reflection data records indicate the existence of very large structural closures and traps on the isopach map (Isochrone map) as shown in Figure 13.

Result of interpretation on 5 (five) lines seismic (Figure 7) show some subsurface geological informations. These informations are explained as follow :

Line 12

The line 12 seismic section located at west onhore Northern Bone Basin (Figure 8).The length one this seismic line about 34.8 km l the interpretation result of this seismic section explained as follow:

- The depth of the top of the Lamasi Formation is located in 1.8 TWT/sec or 800 meters.
- The depth of the Toraja Formation is located in 3.2 TWT/sec or 1600 meters.
- The depth of the Latimojong Formation is located in from 3 TWT/sec to 3.4 TWT/sec or 1500 m to the 1700 m.

Kambuno granit intruded the Latimojong, Toraja and the Lamasi Formations. This seismic section also shows that the Latimojong and the Toraja Formations have been faulted.

Line G.

The line G seismic section located in the west onshore Northern Bone Basin , which is in east north east - west northwest direction (Figure 9). The long of this section is about 59 km. This section shows some informations that are explained as follows :

The basement is the Latimojong Formation whereas the depth of the top of this formation is from 1.2 to 4 twt/sec or 600 to 2000 m. This formation overlain by the Toraja Formation. The top of Toraja Formation is in 3 twt/sec or 500 to 1500 m. Carbonate build up maybe develop in this formation. The Toraja Formation overlained by the Lamasi Formation. The depth of top of the Lamasi Formation is in 0.2 twt/sec to 1. 1 twt/sec or 100 m to 500 mter. This seismic line also give information that the basement has been faulted.

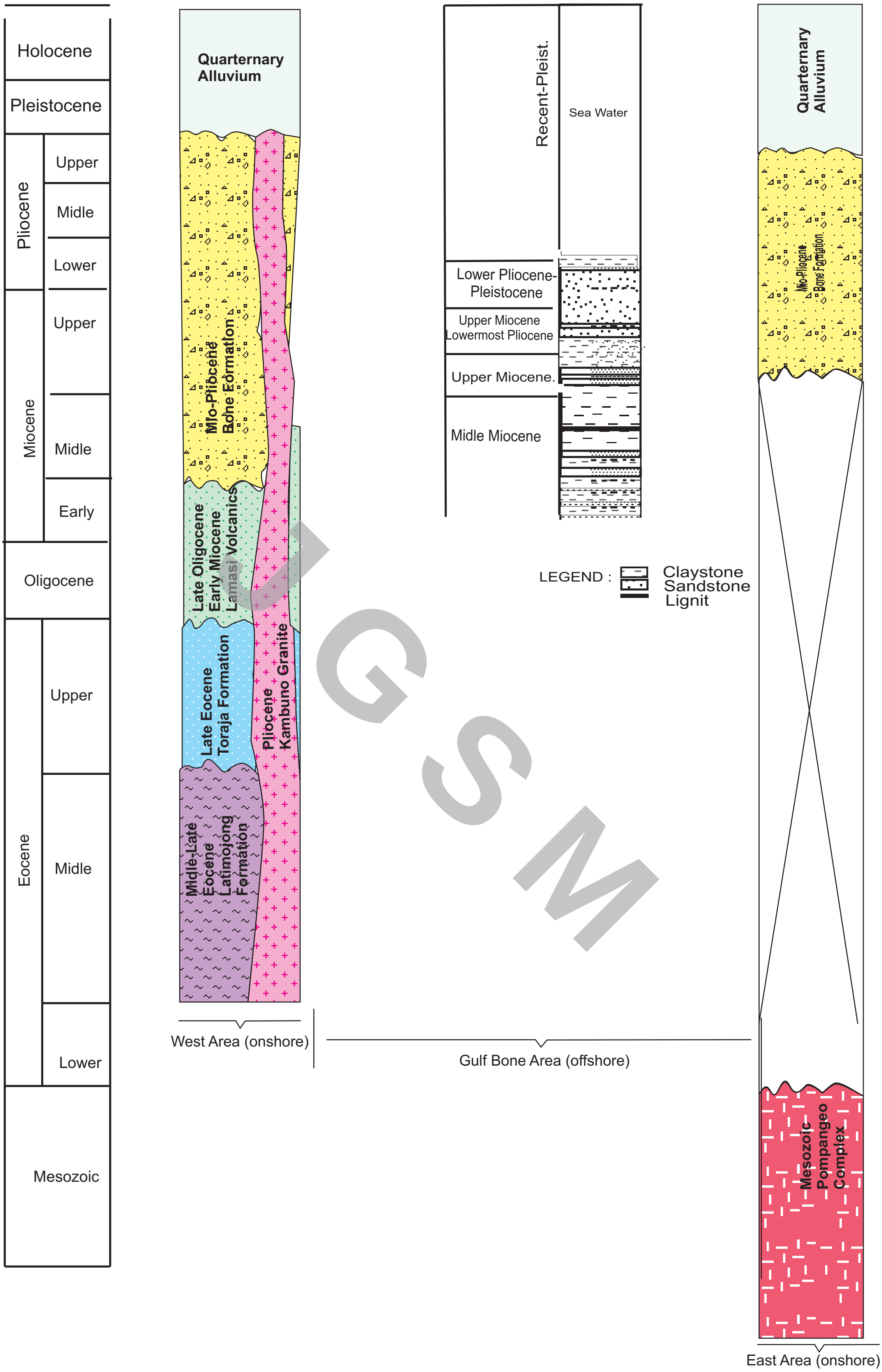

Figure 4. Stratigraphic correlation western onshore, offshore and eastern onshore north Bone basin.

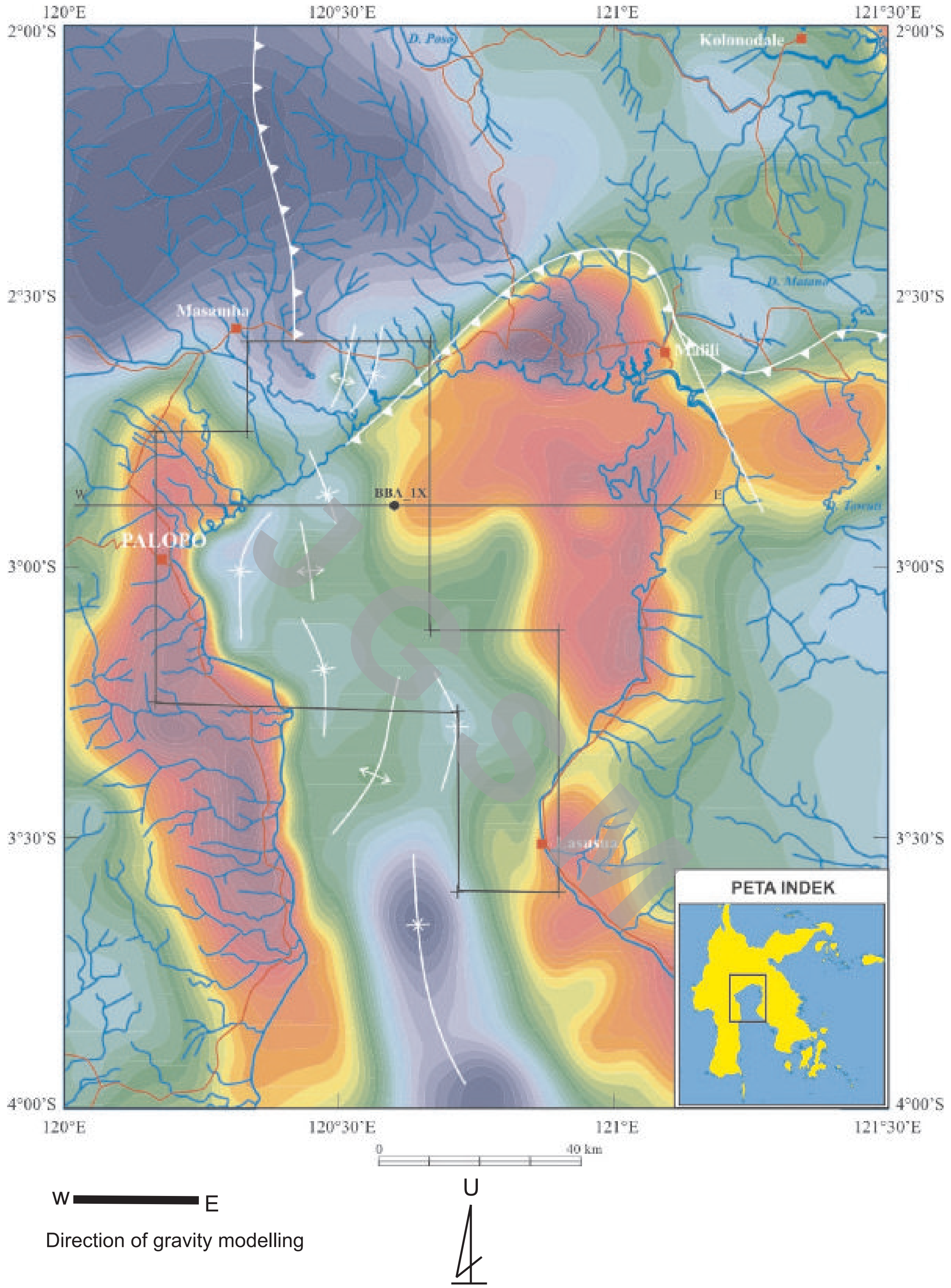

Figure 5. Bouguer anomaly images for structures interpretation.

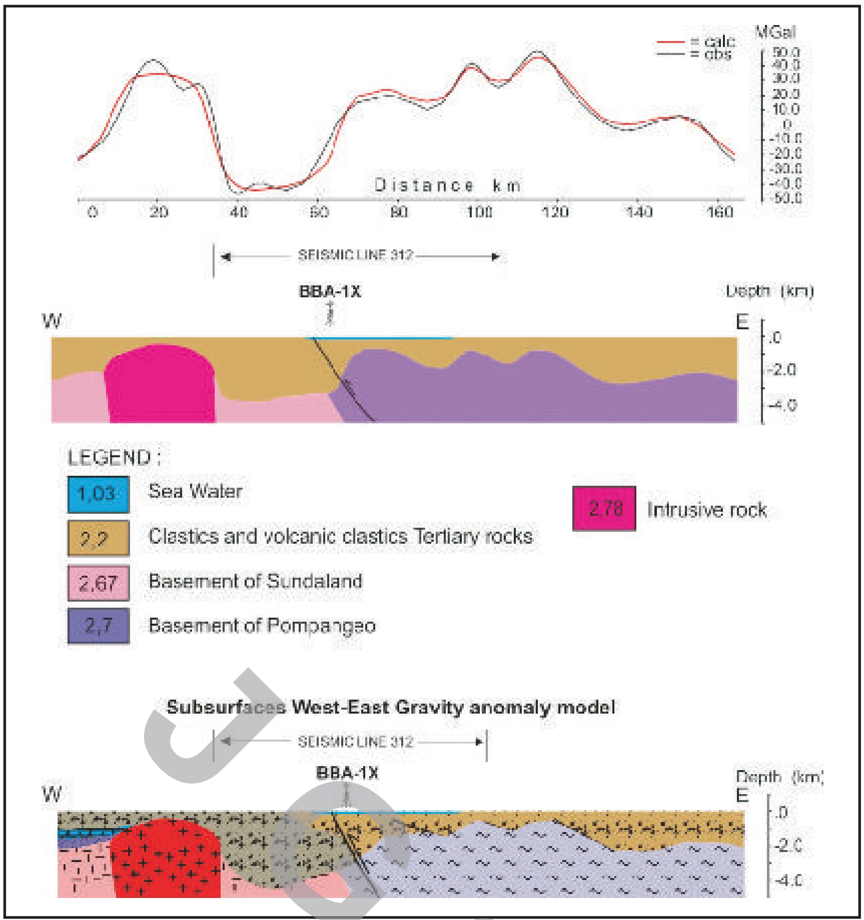

Figure 6. Geological cross-section model based on gravity Data

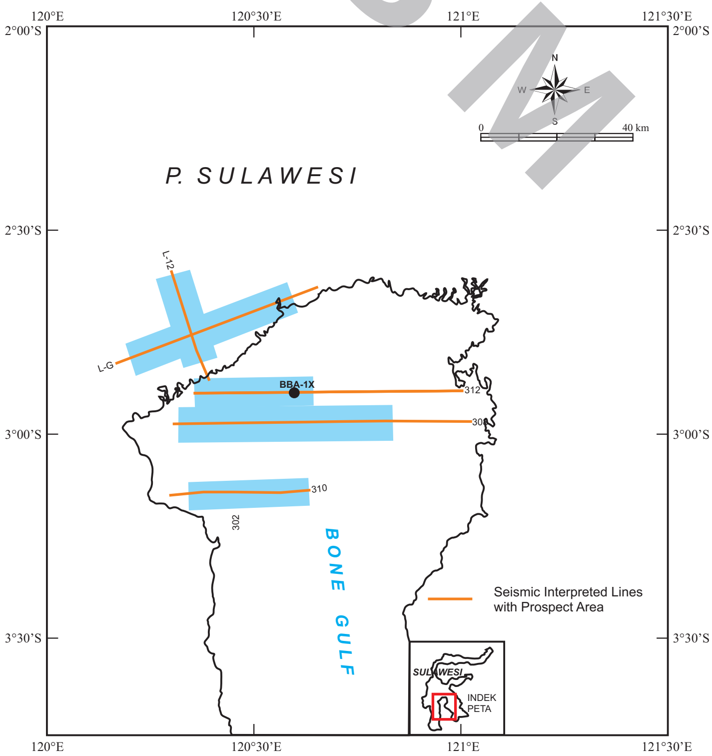

Figure 7. Line of Seismic Section in Northern Bone basin.

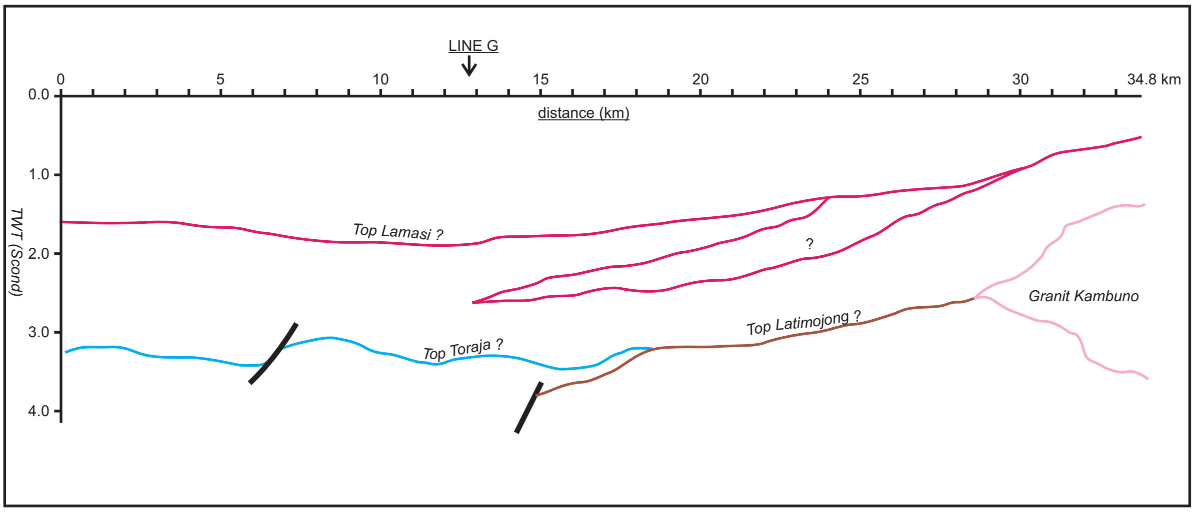

Figure 8. Interpretation seismic section line 12.

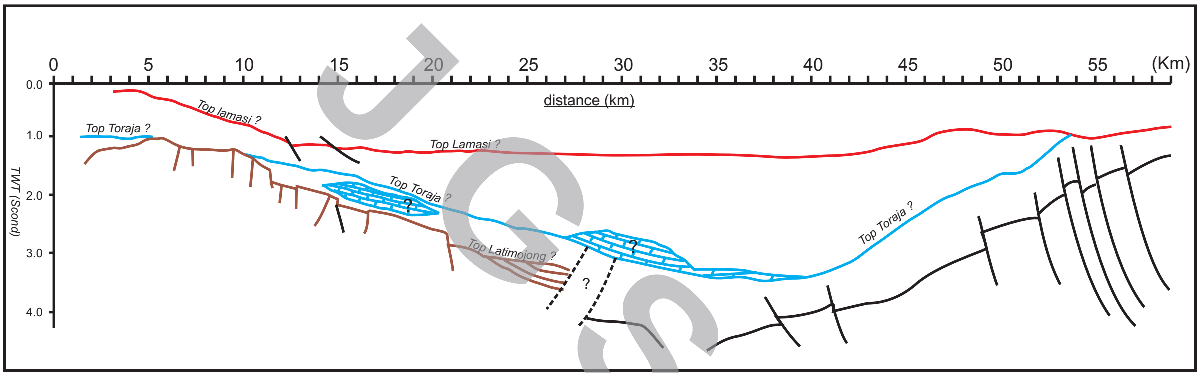

Figure 9. Interpretation seismic section line 12 G.

Line 310

The line 310 seismic section located in southern part offshore Northern Bone Basin , which is in west - east direction, reaches about 42 km in long (Figure 10). Based on interpretation this seismic section several informations can explained as follow :

The basement is the Latimojong Formation whereas the depth of the top of this formation is from 1.5 to 3.2 t wt/sec or 750 to 1600 m. The Latimojong Formation overlain by the Toraja Formation. The top of the Toraja Formation lay in 0.5 to 2.5 twt/sec or 250 to 1250 m. The Toraja Formation overlained by the Lamasi Formation. The depth of the Lamasi Formation is 1twt/sec to 1.21 twt/sec or 500 m to 600 meter. This seismic line also give information that the basement, the Toraja Formation and Lamasi Formation have faulted.

Line 308

The line 308 seismic section located in middle part offshore North Bone Basin. , which is in west-east direction, reaches about 70 km in long (Figure 11). Based on interpretation this seismic section several informations can explained as follow:

The basement is the Latimojong Formation whereas this formation represented West Sulawesi geological terrain and ophiolite where represented the East Sulawesi geological terrain. The depth of the top of the Latimojong Formation 2 from to 4 t wt/sec or 1000 to 2000 m. Latimojong Formation overlain by the Toraja Formation. The top of Toraja Formation is in 1 to 2 twt/sec or 500 to 1000 m. The Toraja Formation overlain by the Lamasi Formation. The depth of the Lamasi Formation is in 1.2 twt/sec to 1.4 twt/sec or 600 m to 700 meter.

The depth of the top of the ophiolite complexes is from 1.0 to 3.0 4 t wt/sec or 500 to 1500 m. The ophiolite complexes overlained by the pre Tertiary Pompangeo complexes which is the top of these complexes is from 1.0 to 1.5 twt/sec or 500 m to 750 meter. The Pompangeo complexes overlain by the Matano Formation. The top of the Matano Formation is in 1 to 1.3 twt/sec or 500 to 650 m.

This seismic line also give information that all of these formations had folded and faulted.

Line 312

The line 312 seismic section located in the northern part offshore of the Northern Bone Basin which is in west -east direction, reaches about 80 km (Figure 12) in a long. Based on interpretation this seismic section several informations are explained as follows:

The basement is the Latimojong Formation whereas this formation represented the West Sulawesi geological terrain and ophiolite where represenred the East Sulawesi geological terrain. The depth of the top of the Latimojong Formation from 3 to 3.8 t wt/sec or 1500 to 1900m. The Latimojong Formation overlain by the Toraja Formation. The top of the Toraja Formation is in 1.5 to 2.2 twt/sec or 750 to 1100 m. The Toraja Formation overlain by the Lamasi Formation. The depth of the Lamasi Formation is 1.2twt/sec to 1.4 twt/sec or 600 m to 700 meter.

The depth of the top of Ophiolite complexes is from 3.0 to 3.14 t wt/sec or 1500 to 1550 m. The ophiolite complexes overlained by the pre Tertiery Pompangeo complexes which is the top of these complexes from 0.75 to 2.0 twt/sec or 350 m to 1000 meter. The Pompangeo complexes overlain by the Matano Formation. The top of the Matano Formation is in 1 twt/sec or 500 m.

This seismic line also give information that all of these formations had been folded and faulted.

This structural was interpreted as the basement uplift that it was estimated and interpreted at about 5000 feet which leaded the Gulf Oil Co to drill the BBA-1X to test the closure. The result was very different in which the hole abandoned at about 10,500 feet in the succession of sandstones and siltstones beds from the Middle Miocene age and no basement had been penetrated so far.

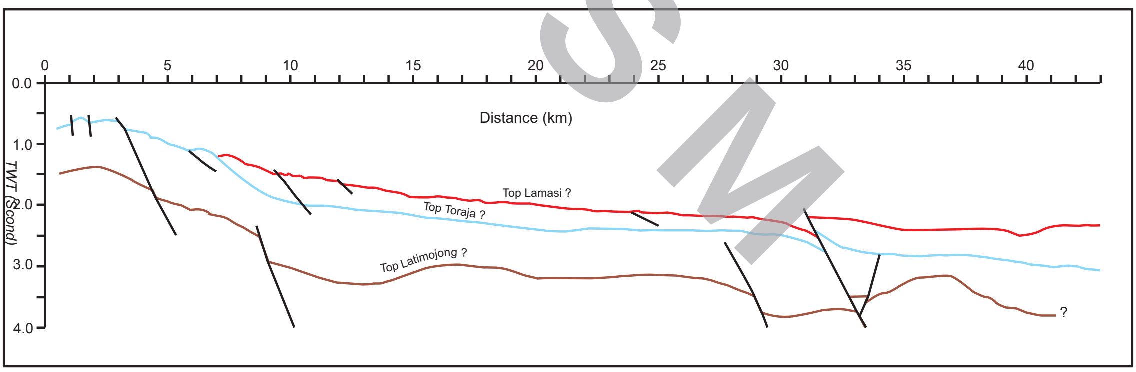

Figure 10. Seismic section interpretation Line 310.

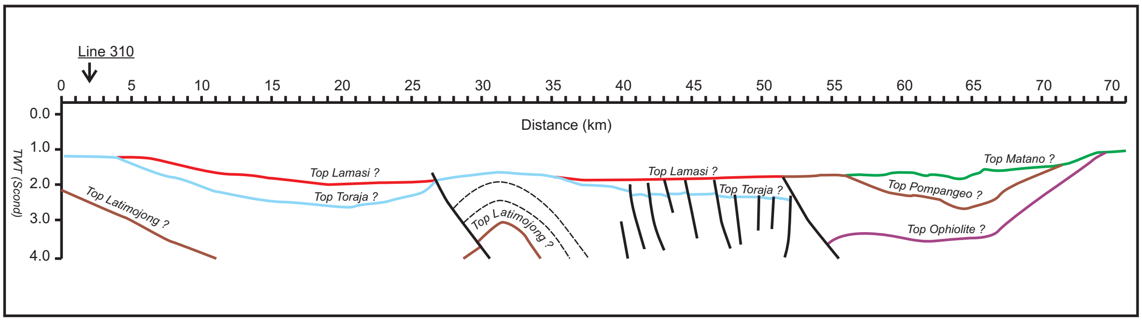

Figure 11. Seismic section interpretation Line 308.

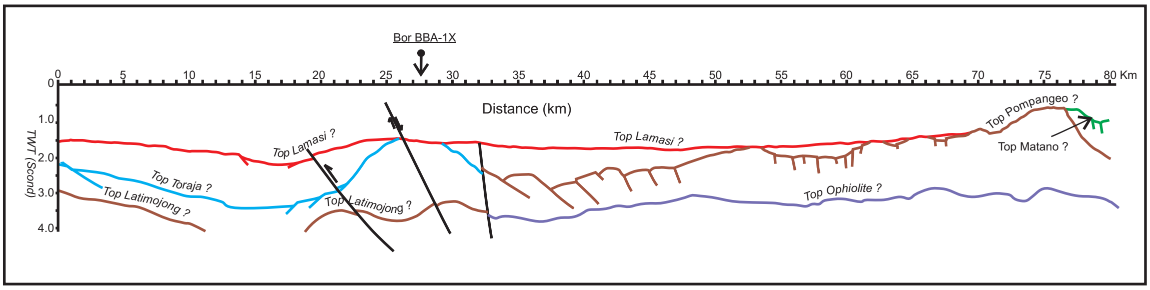

Figure 12. Seismic section interpretation Line 312.

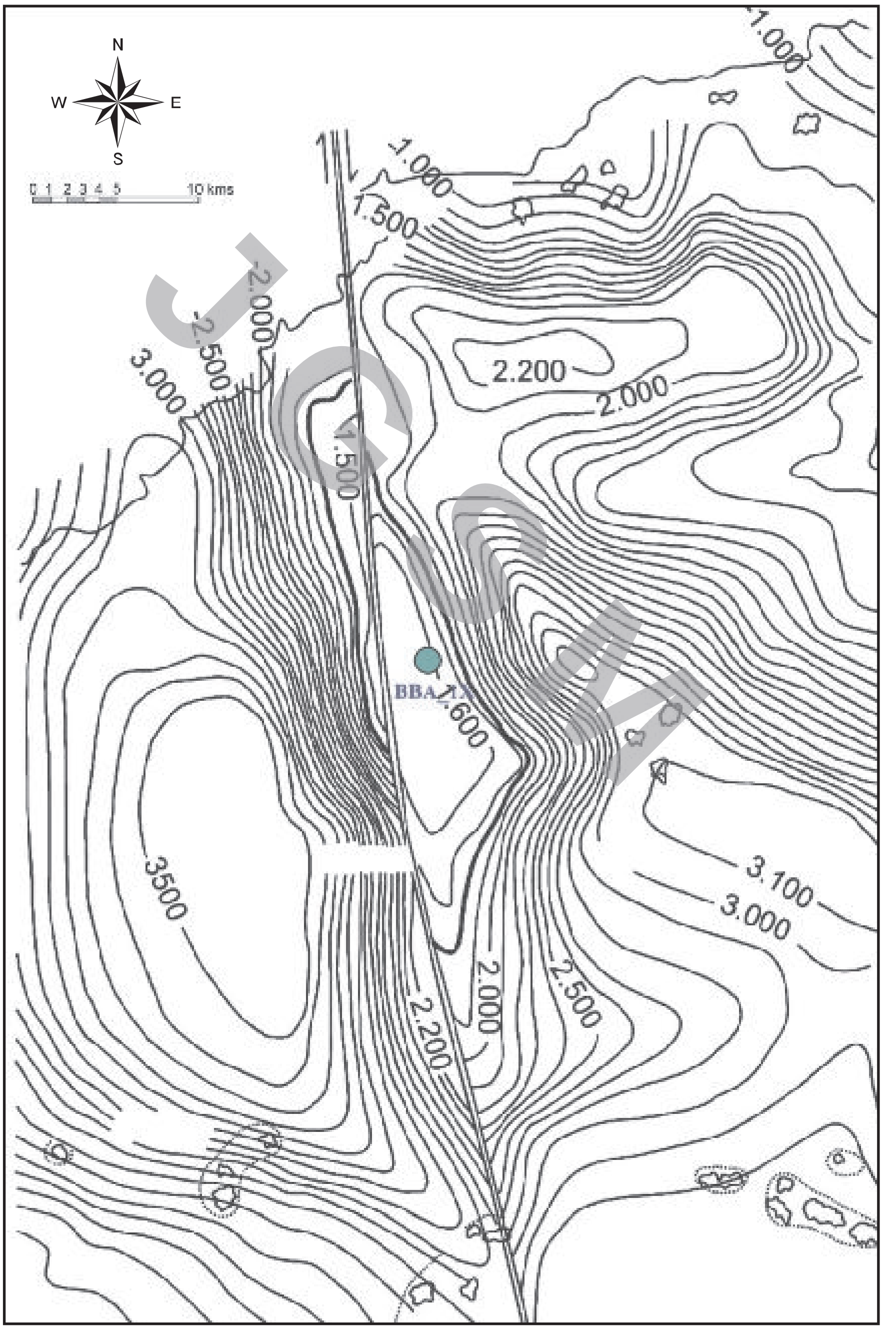

Figure 13. Closure map of the Northern Bone Basin.

Hydrocarbon Closure and Its Potential

For an accumulation of hydrocarbons to be recoveriable, the underlying geology must be favorable to form closure structures. This favorable geology depends on the presence of source and reservoir rock, the depth and the time of burial, and the presence of migration routes or geological traps or reservoirs. A hydrocarbon reservoir is permeable rock that has been geologically sealed at the correct time to form a "trap". The presence of migration routes affects the depth and location of an oil or gas reservoir. Coal bed is found in the Toraja Formation which serve as both the source and reservoir for the gas.

There are no papers or documents yet that explain the hydrocarbon potential in the Bone Basin. Although there are some indications of gas seeps in the surface which located in Pongko and Malangke villages (previously mention), it might be gas of biogenic origin or thermogenic origin, but here is no study yet to conclude their types. The reason of the Gulf Oil Company to stop drilling of well BBA-1X with the depth of 10,500 feet eventhough there is no basement had been encountered.

Hydrocarbon generation, migration, and entrapment in the Bone Basin might have take place during and post the Plio-Pleistocene compression phase of post collision event. A significant increase in heating rate is believed to have occurred during this period resulting in oil generation. Migration pathways between older source rocks (the Toraja Formation) and reservoirs are faults and anticlines formed or reactivated during the Pleistocene. The reservoir rocks are expected to be the clastics and carbonate rocks of the Toraja Formation and the volcanic clastics of the Lamasi Formation. This period is also characterized by the formation of structural traps. The majority of oils within the basin might be derived from fluvio-deltaic and marine shale source rocks.

Oil field distribution is mainly fault-controlled migration directions out of the generating oil source rocks and suspected shale and claystone facies. The migration directions are based on lateral up-dip occurring within the sandstone or carbonate rocks of the Toraja Formation and the volcanic clastics of the Lamasi Formation.

The seals that are regarded as a regional seal for hydrocarbon which may be trapped in the fine-grained rocks of the Toraja itself and the Lamasi Formation as well as the Bone-Bone Formation.

The structural trappings occurred in the area that is related to the high-angle thrust faults. Faults formed or reactivated during post Plio-Pleistocene that have acted as migration pathways between older source rocks and younger reservoirs, since the majority of structural traps were formed during this period.

The BBA-1X well indicated that many sandstones horizons in the basin have high to very high porosities some as high as 30 percent, with permeability (liquid) in the order of several hundred millidarcys. Therefore, it can be concluded that the reservoir is not a problem within the Bone Basin. On the other hand the drilling results also indicate that up to the depth of more than 10,000 feet in which the well had not encountered/intersected the rock horizons which could be considered as potential to be a source rock layer.

Stratigraphy of the BBA-1X well is not represented the stratigraphy of the Bone Basin in general, as we stated above that the location of the BBA-1X is in the chaotic fracture zone of the Palu - Koro Fault, besides that the well is still far to reach the basement. Thus, it is considered that the equivalent of the Toraja Formation exposed on land might served as potential source rock as well as reservoir. Besides the existences of the equivalent of Taraja Formation, the source rocks could also be developed, locally as the sediment deposited farther away from the source, *i.e* as sedimentation moved to the deeper part of the basin.

The seals in the basin could be provided by the existence of numerous claystone and siltstone horizons as indicated by the drilling results. Of course not as high as productive basin in other part of Indonesia such as Central, South Sumatera, and Kutai Basins. Therefore the Bone Basin is farvorable potential to contain hydrocarbons. The petroleum potentiality of the basin might be considered as a low to moderate level.

CONCLUSIONS

Preliminary evaluation of the Bone Basin is based on the main data of 5(five) lines seismic and a single well data interpretations. Subsidiary data supports are geology, gravity and other publication literatures. The result of the hydrocarbon potentiality can be concluded as follows :

- The Bone Basin contains Tertiary sedimentary and volcanic clastic rocks underlain by various pre-Tertiary rocks comprising metamorphic, meta-sediment, volcanic and igneous rocks. The total thickness of the basin filled sediment ranges from approximately 2000 meters to about 5000 meters depth. Seismic data record shows that the basin may have hydrocarbon potential ranging from medium to low level.
- First drilling exploration for hydrocarbon purposes have been done by the Gulf Oil Co. This off-shore drilling a single well of the BBA-1X indicates the depth penetration of 10,521 feet, that the well had not encountered the Latimojong Basement Formation. This well was situated exactly on the top of anticlinal structural closure, but the result was dry as noted by company, and also no hydrocarbon indication.
- Some kinds of highstand system tract of hydrocarbon plays are erosional trucation and probably channel deposits, which can be recognized on the lines G and 312. Hard evaluation of the existing seismic record also reveal many fault planes interpretation also can be obtained on the lines of 312, G, etc).

The future exploration plays within the Bone Basin area will be directed to the pre collision sediments (middle Miocene) in the western part of the basin, *i.e* west of the big active Palu - Koro Fault.

As the only anticlinal structural *trap* recognized on the existing seismic records had been tested with the BBA-1X well, the result was dry. So for the future the plays will be stressed to exploit the possibility of stratigraphic traps. Such as Lowstand and transgressive stratigraphic sequences as pinch-out or basement onlap, some are recognized on the old records (*e.i.* line G). Some kinds of highstand system tract such as erosional truncation (as recognized on line 312 and line G) and probably channels deposits.

Carefully evaluation on the existing seismic records (very difficult) also reveal many (interpreted) fault planes (line G and also line 312), which could act as structural traps . The possibility of this kind of traps would be evaluated as well.

With the exploration plays is more directed for stratigraphic traps, and in order to conduct seismic stratigraphic analysis more precisely we require much better seismic records. In this relation our first activity in the future is to conduct about 2000 line km high resolution multi folds seismic reflection survey using more powerful seismic sources. The survey will cover offshore as well as onshore part of the Bone Basin.

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REFERENCES

Audley-Charles, M.G., Carter, D.J. and. Milsom, J.S., 1972. *Tectonic Development of Eastern Indonesia in Relation to Gondwanaland Dispersal, Nature Physical Science* vol 23 , p. 36-39

Bachri, S., 2006. Stratigraphic correlation North Bone Basin. PSG, (unpublished)

Cater, M.C.,. Scrutton, M.E. and Tidey, G.L., 1972. The Micropaleontology and Stratigraphy of The Indonesia Gulf Oil Company BBA-1X Well, Gulf of Bone Sulawesi. Perta,mina. (Unpublished)

Grainge, A.M. and Davies, K. G. , 1983. Reef Exploration in the East Sengkang Basin, Sulawesi. *Proceedings Indonesian Petroleum Association Twelth Annulal Convention*.

Hall, R., 2001. *Cenozoic Reconstructions of SE Asia and the SW Pasific Changing patterns of land and sea*. SE Asia Research Group Departmen of Geology , Royal Holloway University of London. Swets and Zeilinger Publishers , 126, pp, 35-56

Mubroto,B., Briden,J.C., McClelland.E., Hall. R., 1994. *Paleomagnetism of the Balantak ophiolite, Sulawesi*. Earth and planetary science letter 125 (1994) 193-209 p.

Patra Nusa Data, 2004, Oil Resources in Tertiary Sedimentary Basins of Indonesia(Unpublished)

Pertamina, 1972, BBA-1X Final Report Exploratory Well Off-shore, South Sulawesi. Production Sharing Contract. (Unpublished)

Ratman, N. dan Atmawinata, S., 1993. *Geological Map of The Mamuju Quadrangle, Sulawesi, scale 1:250.000.* Geological Research and Development Centre. Bandung.

Rusmana, E., Sukido,.Sukarna. D.,.Haryono,E. dan Simanjuntak, T.O., 1993, *Geological Map of The Lasusua-Kendari Quadrangles, Sulawesi Scale 1:250.000.* Geological Research and Development Centre. Bandung.

Simanjuntak, T.O., 1992. Tectonic Development of Indonesian Archipelago and Its Bearing on the Occurance of Energy Resources. *Bull. Gol. Res. Dev. Centre* 2-23 p.

-------------------., 1986. Sedimentology and tectonics of the collision complex in the eastern arm of Sulawesi, Indonesia. Unpubl, Phd.Thesis, RHBNC Univ. of London, 371 p.

------------------., Rusmana, E., Surono., Supandjono, J.B., 1991. *Geological Map of Malili Quadrangle, Sulawesi. scale 1:250.000*. Geological Research and Development Centre, Bandung.

------------------.,. Rusmana, E., Surono, and Supanjono, B., 1992. *Geological Map of The Malili Quadrangle, South Sulawesi. scale 1:250.000*. Geological Research and Development Centre. Bandung..

Sobari, I., Siagian, H., Mirnanda, E. and Subagio., 2006. *Bouguer Anomali Map of the Malili Quadrangle, Sulawesi. scale 1:250.000*. Geological Survey Institut. (In-preparation).

-----------------., and Eddy Mirnanda, 1996. *Bouguer Anomaly Map of the Majene and Western Part of Palopo Quadrangles. Scale 1:250.000*, Sulawesi.

Sudarmono, 1999. Tectonic and stratigraphic evolution of Bone basin, Abstract of *Proceed. Of the geology of Indonesia*, book 50th anniversary memorial seminar outhored by RW. Van Bammelen.

Sudjatmiko, D., Bachri, S. dan Sukido, 1992. *Geological Map of Majene and Western Part of Palopo Quadrangles, Sulawesi. Scale 1:250.000*, Geological Research and Development Centre. Bandung.

Sukamto,R., and Simanjuntak, T.O., 1983. Tectonic Relationship between Geologic Provinces of Western Sulawesi, Eastern Sulawesi and Banggai-Sula in the light of Sedimentological aspects. *Geol. Res. Dev. Centre Bull*, 1-12 p.

Widijono, B.S., Simanjuntak, T.O., Panggabean, H., Panjaitan, S., Hutubessy, S., Syarif, N. Simamora,W.H., Siagian, H.P., Hayat, D.Z., 2004. *Peta cekungan sedimen Indonesia bagian timur. Berdasarkan anomali gayaberat. Sekala 1:2000.000*. Program Pemetaan & Penelitian Dasar, Kelompok Geofisika.

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