Delineating Basin in Atambua, West Timor with Novel Gravity Data

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Abstract. Atambua, West Timor has a complex-geological structure. However, the subsurface-geological model based on geophysical data is still limited there or imaging of Timor Island is only available at crustal-mantle scale whose spare spatial resolution. Therefore, this paper aims to map basement configuration in Atambua as well as to delineate its basin and lineament. This study used ground data gravity acquired by Scintrex CG-5, proceed with standard procedure processing, and interpreted it with geology data. The results of the research are the boundary of the basin from the Atambua basin indicated by -26 to -52 mGal and the Central basin whose gravity anomaly of -16 to -52 mGal, exhibiting a trend of lineament that is Southwest–Northeast, and configuration of basement topography namely undulating basement. Basement high dominating Northern–Northwestern and Eastern–Southeastern while lower basement located in the middle area from North to South zone. On the other side average thickness of the sedimentary layer from paraautochthon in the line AA', line BB', and line CC' are 3, 3, and 4 Kilometers respectively implying the possibility to generate hydrocarbon.

Keywords: *2.5D modeling; Atambua; basin; basement; gravity; Timor*

1 Introduction

Atambua City is part of West Timor or Nusa Tenggara Timur (NTT) province, Indonesia separated from Timor Leste which both areas located at Timor Island. Audley-Charles in [1], Charlton in [2], Harris and Long in [3], Sawyer in [4], and Villeneuve, *et.al* in [5] have reported the complex-geological surface of Timor Island. However, the subsurface-geological model based on geophysical data is still limited in Atambua and surrounding it.

Porritt, *et.al* in [6] and Zhang and Miller in [7] have imaged Timor Island with ambient noise tomography at crustal-mantle scale and also it had spare spatial resolution. Gravity study is widely used to map the geometry and features of sedimentary basins as worked by Li, *at.al* in [8] and Abdullayev, *at.al* in [9]. Therefore, this paper aims to map basement configuration in Atambua and surround it as well as to delineate its sub-basin and lineament. Wijanarko, *et.al* in

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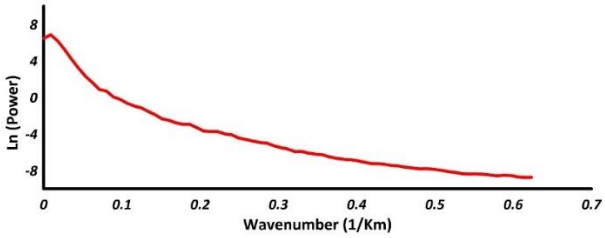
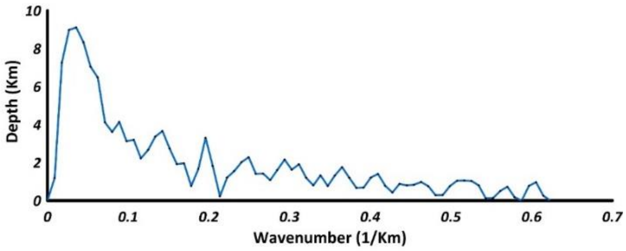
[10] state that one important phase in hydrocarbon prospecting is an estimation of basement depth and the gravity method is of particular interest for mapping basement topography.



(a)



(b)

Figure 1 signal-spectrum analysis of gravity anomaly, (a) plotting amplitude vs wavenumber, and (b) graph depth vs wavenumber.

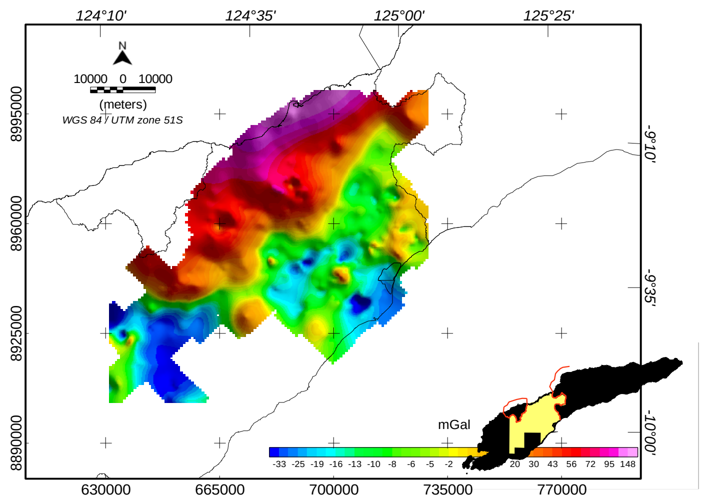


Figure 2 Completed Bouguer Anomaly (CBA) map.

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2 Materials and Methods

The research used gravity data acquired by PPPTMGB "LEMIGAS" through August–December 2015 in Atambua, West Timor, and its surrounding areas. Elevation data consist of Differential Global Positioning System (DGPS) measurements and Digital Elevation Model (DEM) from satellite imagery. The geological data used to support interpretation was obtained from the publications and surface geological data acquired by PPPTMGB "LEMIGAS". The distribution of gravity data appeared in Figure 3.

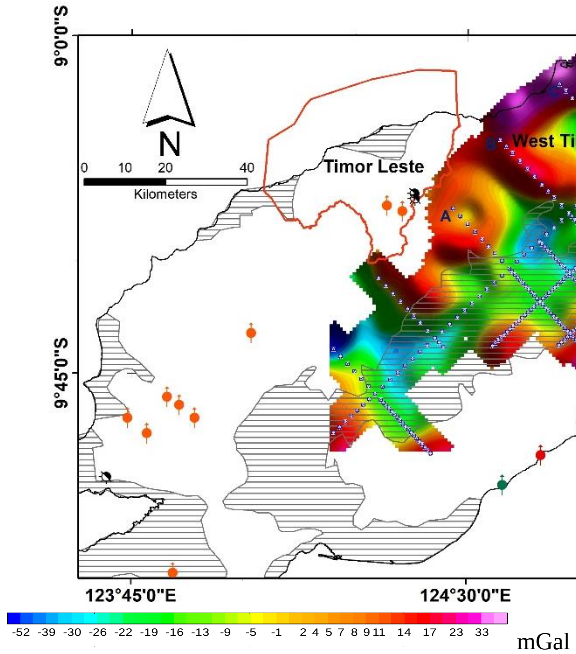

Figure 3 esidual anomaly map overlay with black hatch representing the boundary of syn and post-orogenic basin defined by Charlton in [2].

Observed gravity data has been carried out with Scintrex CG-5. There were 900 acquisition points distributed along Atambua, West Timor, and its surrounding. Distance between data point around 1 to 3 Kilometers and interval of gravity-line was about 10 Kilometers. Gravity data processing has been done with a standard workflow. It began from drift correction, removing tidal effect, corrections of latitude, free-air, Bouguer, and terrain, then it continued with signal enhancement to obtain residual anomaly, the procedure given by Telford, *et.al* in [11].

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The results of gravity processing are presented in Figure 1, Figure 2, and Figure 3 exhibiting signal spectrum analysis, Complete Bouguer Anomaly (CBA) map, and residual gravity anomaly map. The spectrums are expressed by a graph of the depth and amplitude (energy) versus the wavenumber. Signal analysis was used to separate regional and residual gravity anomalies. The bandpass filter was used for the separation of the anomaly with a cut-off of wave numbers 0.1 and 0.01 or wavelengths of 10 Km and 100 Km. The results of the bandpass filter analysis are agreed with the output pattern of the Butterworth filter using a central filter with a wavenumber of 0.01 or a wavelength of 100 Km and a filtering degree 8 (not shown). Gravity data processing was used to extract the value of the gravitational field into information about the subsurface density distribution with 2.5D gravity forward modeling (Figure 4, Figure 5, and Figure 6). Gravity anomaly map and modeling were performed by using the Geosoft Oasis Montaj software package.

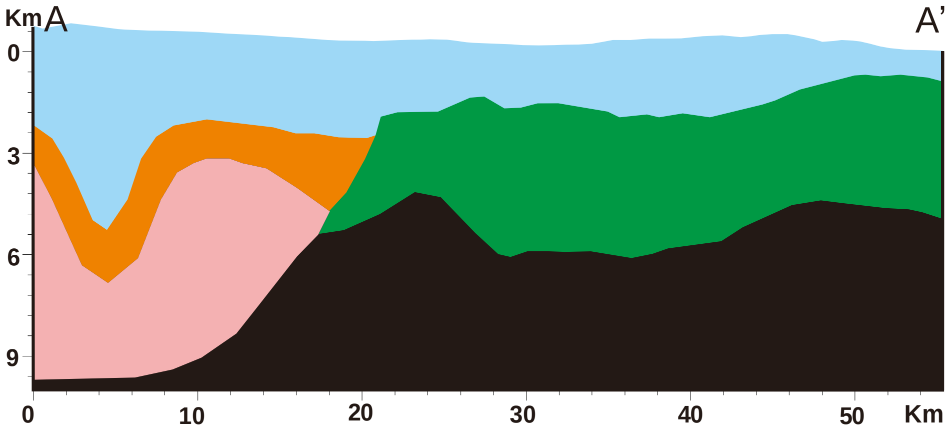

Figure 4 forward modeling line AA' of gravity refers to Figure 3. Simplification of the subsurface model. Color legend: Australian basement (black), Banda terrane (light pink), Allochthonous (orange), Paraautochthons (green), and grouping of Bobonaro mélange, Banda nappe, Australian nappe, and Viqueque sequence.

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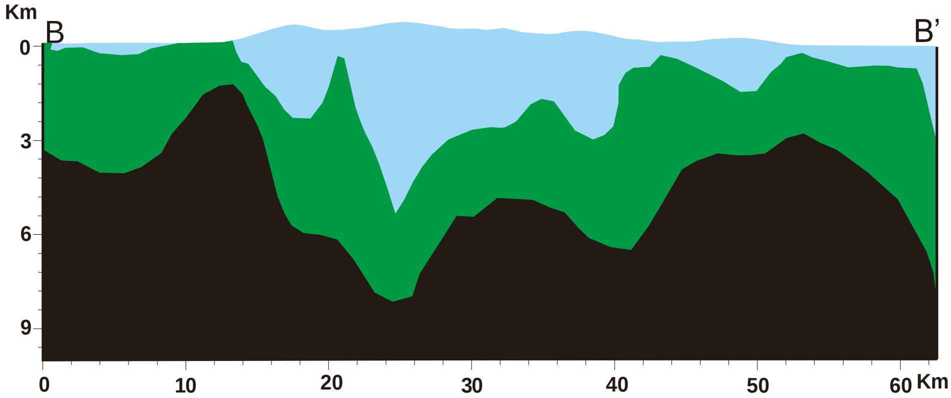

Figure 5 forward modeling line BB' of gravity refers to Figure 3. Simplification of the subsurface model. Color legend: Australian basement (black), Paraautochthons (green), and grouping of Bobonaro mélange, Banda nappe, Australian nappe, and Viqueque sequence.

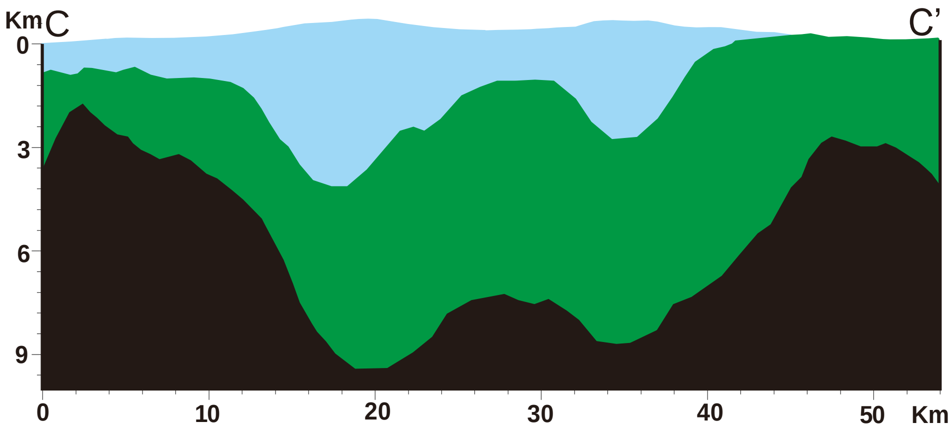

Figure 6 forward modeling line CC' of gravity refers to Figure 3. Simplification of the subsurface model. Color legend: Australian basement (black), Paraautochthons (green), and grouping of Bobonaro mélange, Banda nappe, Australian nappe, and Viqueque sequence.

3 Result and Discussion

Analysis of subsurface geology in terms of delineating basement configuration lineaments, and basin in Atambua and its surrounding areas based on gravity data and surface geological data. Based on the CBA map in Figure 2, a large high gravity anomaly is located in the Northern–Northwestern of the research area. The range value of the high gravity anomaly is about 43–148 mGal of the total amount between -33 to 148 mGal. The high gravity anomaly indicates a relatively

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shallower crust in the Northern–Northwestern zone compared with Central and Southern areas. It is agreeing with the ambient noise tomography from Porritt, *et.al* in [6] and Zhang and Miller in [7]. On the other hand, low gravity anomaly whose value -5 to -33 mGal commonly situated in Central area toward Southern–Southeastern zone. The low gravity anomaly is supposed to thick-crust of Australian continental. Positive gravity gradient from Northwest (NW) to Southeast (SE) in West Timor is frequently found in Timor Leste (East Timor), it given by Chamalaun et al in [12].

Separating local or residual gravity anomaly from the regional used signal spectrum analysis in Figure 1 and it obtained residual gravity map revealed by Figure 3. Generally, the depth of the basement exhibited by signal spectrum analysis is around 2.8–8.8 Kilometers. The range value of residual anomaly is about -52 to 33 mGal. The residual map represents a shallower anomaly compared to the CBA map. Based on analysis of the residual map, there are two basins in the research area. The first one is located in the middle-Northern zone indicated by -26 to -52 mGal coincide with bright blue to dark blue. The second basin occupies the middle of the Central part toward Southwestern whose gravity anomaly of -16 to -52 mGal indicated by green to dark blue. The first basin namely the Atambua basin and the second basin is Central Basin.

The geometry of the basin is defined by a residual map slightly different from the basin proposed by Charlton in [2]. The Atambua basin here has a bigger geometry than what Charlton in [2] determined from surface syn and post-orogenic rocks. It is possible due to surface geological data does not reveal the continuity of syn and post-orogenic sediment vertically. On other hand, the Central basin has smaller geometry in comparison with the basin defined by Charlton in [2]. The difference is located around the East shoreline, surrounding Besikama, where high gravity anomaly from the residual map probable indicates basement high or another tight rock which can be determined by surface data previously.

The lineaments that exist here have trends, in general, Southwest (SW)–Northeast (NE). Those lineaments are depicted by CBA and residual map. Trending of lineament expects to correlate to structural geology in West Timor. They are also perpendicular with gravity lines for modeling in Figure 3. There are three cross-sections for 2.5D gravity forward modeling, i.e. line AA', line BB', and line CC'.

Line AA' is presented in Figure 4. It has a length of about 55 Kilometers with trending Southeast (SE)–Northwest (NW). Error-misfit obtained from modeling in the line AA' is 2.04 indicating a small error of modeling. This paper has simplified the geological modeling by concatenating all outcropping rocks into one layer i.e. blue. Sedimentary layers deposited before pre-breakup Australia from Gondwana are also simplified by grouping Permian or older Jurassic rocks

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into one layer indicated by green which is called paraautochthon. Based on modeling in Figure 6, the average thickness of the paraautochthon is about 3 Kilometers. The lowest layer is the basement exhibited by black as Australian basement and bright pink as Banda terrane. The sedimentary layer overlying Banda terrane is allochthonous depicted by orange.

Line BB' exhibited in Figure 7 whose length is about 62.5 Kilometers and the error-misfit is 1.65. The northwestern part of line BB' comprises of allochthonous and Bobonaro mélange represented in modeling with blue. Next to the east is the volcanic basic of Maubisse formation surrounded by Aitutu formation which both members of paraautochthon indicated by green. Toward to east again is the Bobonaro mélange and Viqueque sequence revealed in the model with blue. The paraautochthon in the line BB' has an average thickness of 3 Kilometers. The lowest layer is the basement depicted by black as an Australian basement dominating this area. The configuration of basement topography is rough here.

Line CC' is depicted in Figure 8 whose length is about 54 Kilometers and the error-misfit is 2,66. The upper part of line CC' mostly constituted of allochthonous, nappe paraautochthon, and Bobonaro mélange represented in modeling with blue. Next to the east is paraautochthon indicated by green. The paraautochthon in line CC' has an average thickness of 4 Kilometers. That thickness possibly could generate hydrocarbon, refer to sedimentary rocks in the pre-breakup unconformity, especially Aitutu formation. The Aitutu formation has proven to generate hydrocarbon and could expel oil and gas as stated by Shaylendra, *et.al* in [14]. The lowest layer is the basement depicted by black as an Australian basement dominating this area. Configuration of basement topography in the line CC' relatively similar with line BB' that is relatively undulating. Although line BB' is rougher than line CC' slightly.

4 Conclusion

Acquisition, processing, and analysis of novel gravity data have been carried out in Atambua and its surrounding, West Timor, Indonesia which produces CBA and residual anomaly maps. The CBA maps have revealed high gravity anomaly whose value are about 43–148 mGal indicates a relatively shallower crust in the Northern–Northwestern. Low gravity zone is supposed to thick-crust of Australian continental situated in Central area toward Southern–Southeastern whose value -5 to -33 mGal and Southern areas. The residual map exhibits basin in middle-Northern zone indicated by -26 to -52 mGal and basin occupies the middle of the Central part toward Southwestern whose gravity anomaly of -16 to -52 mGal. The first basin namely the Atambua basin and the second basin is Central Basin. The geometry of the basin is defined by a residual map slightly different from the basin proposed by Charlton in [2]. The CBA and residual

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anomaly map also exhibit a trend of lineament that is Southwest–Northeast. Moreover, modeling of subsurface geology admits configuration of basement topography namely undulating basement. Basement high dominating Northern–Northwestern and Eastern–Southeastern particularly around shoreline while lower basement, in general, located in the middle area from North to South zone. On the other side average thickness of the sedimentary layer from paraautochthon in the line AA', line BB', and line CC' are 3, 3, and 4 Kilometers respectively. That thickness possibly could generate hydrocarbon, refer to sedimentary rocks in the pre-breakup unconformity, especially Aitutu formation because it has proven to generate hydrocarbon and could expel oil and gas.

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Acknowledgment

Many thanks to Research and Development Centre for Oil and Gas Technology "LEMIGAS" who have given permission to publish this article and the Ministry of Energy and Mineral Resources awarding scholarship for the author to study at ITB.

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