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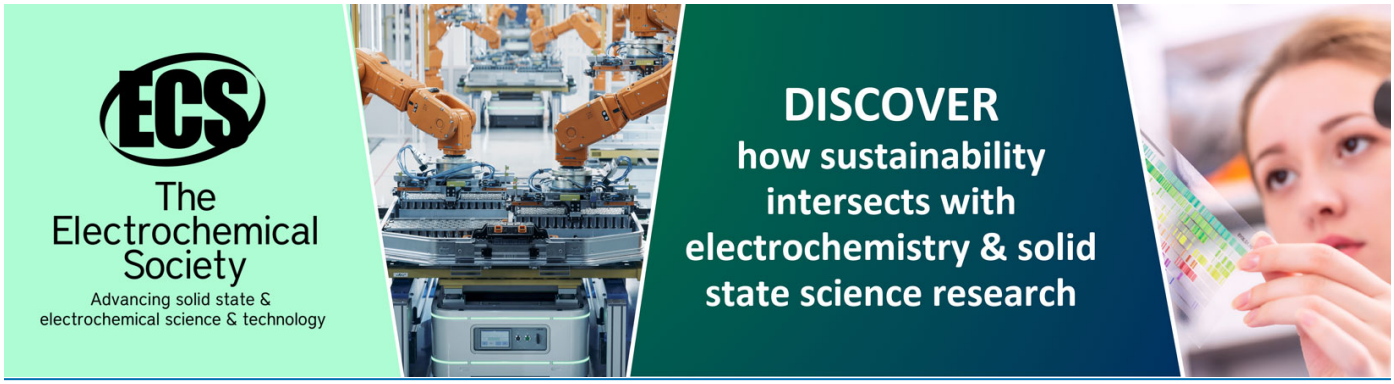

Sedimentation process in Kuala Gigieng Coast, Aceh Besar based on magnetic and gravity surveys

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Abstract. The study of the sedimentation process in coastal can be used to investigate historical settlements and paleo disaster in the area. We have conducted magnetic and gravity survey to model the sedimentation process in Kuala Gigieng area, Aceh Besar, one of the important harbors during the Aceh Sultanate in 16th. The magnetic and gravity methods are able to map structures based on magnetic susceptibility and density distribution below the surface, respectively. The total magnetic field data were measured by the magnetic method, while the gravity method measured gravitational acceleration data. The data were acquired in an area of 1858 x 725 m2 with stations spacing between 70 -100 meters in grid. The standard magnetic and gravity correction was applied to the data, so that the total magnetic field anomaly and Bouguer anomaly are obtained which reflect the conditions the subsurface. The anomaly map obtained shows the pattern of maximum and minimum values, which the patterns were the same as the topography of the measurement area. To get a clearer sediment model, gravity data has been carried out 2D forward modeling with cross sections cutting from coast to land. The 2D model illustrates the existence of 3 layers in the measurement area, sequentially consisting of alluvial and clay, sandstone, and tuff sandstone sediments. The alluvial deposits in the first layer form a repetitive pattern from the land side to the coast; the pattern was formed by coastal activity. The sequence of sediment layers shows the age of the sediment, with the oldest layers formed far from the coast and the youngest layers formed near the coast.

1. Introduction

Aceh Besar is a province located on the tip of Sumatra. Aceh Besar coast is an area dominated by alluvial deposits. Alluvial deposits have a thickness of 80 meters below the surface in the region, which has been a dense settlement since the beginning of the first millennium [1]. In the 16th century, the waters of Aceh Besar were a strategic location for trade routes located between the Indian Ocean and the Malacca Strait. The area is a port for ships from Sri Lanka, India [2], and Portugal [3]. Based on this history, one of the port locations is in the Kuala Gigieng area, Aceh Besar, which has undergone a sedimentation process [4]. Studies of the process can be carried out to investigate historic settlements and paleo disasters using geophysical methods. Geophysical methods that are popularly used in sedimentation studies are magnetic and gravitational methods that can be used to find the geological structure of the subsurface area [5], [6],[7]. This method can be used on a regional scale to

a small scale near the surface. The total magnetic field is a representation of subsurface susceptibility values. The gravity method measures the acceleration of gravity above the surface. Gravity is a representation of subsurface density [8], the methods are also used in case of mapping the ancient buried structure in the subsurface[9].

Based on the explanation above, we have applied the gravity and magnetic methods for near surface modelling.This study aims to identify alluvial deposits in the Kuala Gigieng region, Aceh Besar. The magnetic data interpreted qualitatively, and gravity data were modelled using 2D forward modelling. The model can explain the pattern of sedimentation.

2. Research Methods

The study was conducted in the Kuala Gigieng area, Aceh Besar (Figure.1). The area covered 1.82 km x 0.73 km. The data were collected at 120 stations. The distance between stations varied from 90 m to 120 m. The data were collected using Proton Precession Magnetometer and Scintrex CG-5 Autograv Gravitymeter for the magnetic and gravity methods respectifelly.

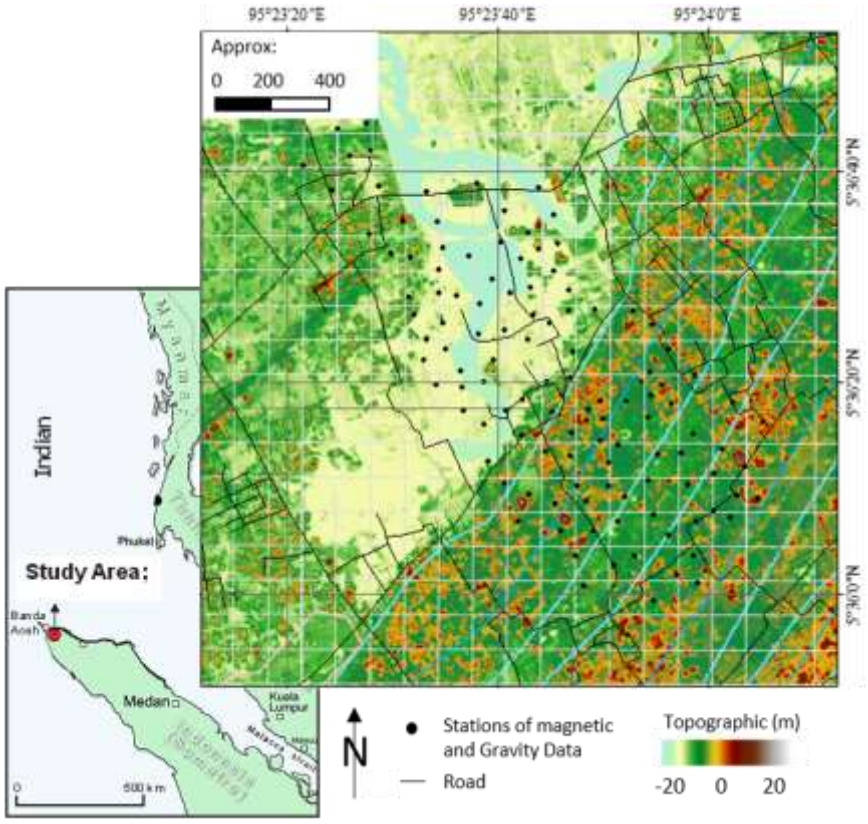

Figure 1. Location map of the study area.

Before interpretation, the measured data were corrected using standard methods. The IGRF (International Geodetic Reference Field) and diurnal correction were applied to the measured total magnetic field data. The corrected data were enhanced using pseudo-gravitation and reduction to the poles for better interpretation [10]. This transformation convert the magnetic dipole field to the monopole. In gravity data, tides, drift, latitude, free air, Bouguer correction, and terrain corrections were applied to measured data. After the corrected data were modelled using forward modelling code [12].

Total magnetic field data were carried out by pseudo gravitation and reduction to the poles. The pseudo-gravitation transformation was used to determine the subsurface by calculating the

magnetization value against the apparent density value. The value used is 100 kg / m^3 per A / m [11]. Transformation to polar reduction transforms lateral anomalies into symmetrical anomalies. This transformation was done using Oasis Montaj software. The results of the transformation were then carried out with qualitative interpretations. The standard gravity data correction results are complete Bouguer anomalies. The data were then eliminated by regional effects. The results of the removal of effects are complete residual Bouguer anomalies. Then this value was modeled using a forward model method to obtain subsurface structures [12].

3. Results and Discussions

In this study, the field data obtained was then corrected to get the transformation map that had been reduced to poles (RTP) (Figure. 2) and pseudo-gravitation (Figure. 3). Pseudo-gravitation transformation are carried out to facilitate quantitative analysis. The maximum value of the contour pattern are yellow to red (0.05 - 0.3 pseudo mGal). The minimum value for the contour pattern are blue to purple (-0.15 - -0.4 pseudo mGal). This result indicates that the anomaly is a regional anomaly. The regional anomaly can be used as a basis for determining the location of anomalies.

Actually, RTP and pseudo-gravitation map have the same pattern. Both results show maximum and minimum anomalies by eliminating local anomalies as can be seen from Figure. 2 and Figure. 3 [10]. Both of these transformations have eliminated the effects of magnetic dipoles to be monopole.

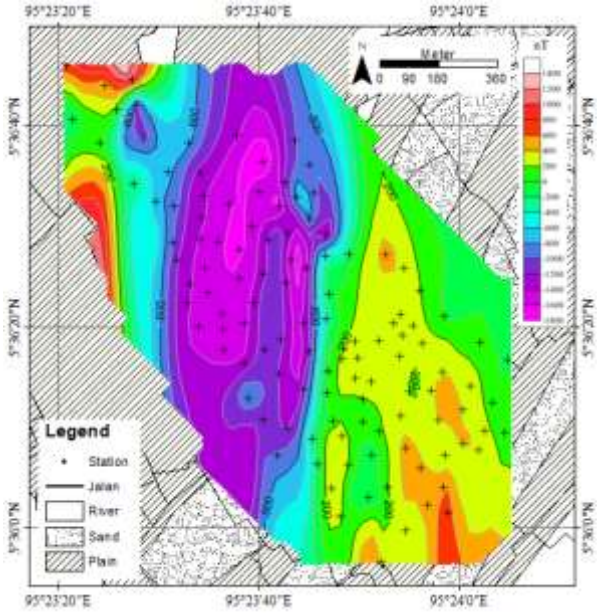

Figure 2. Reduce to pole magnetic fieldmap of the study.

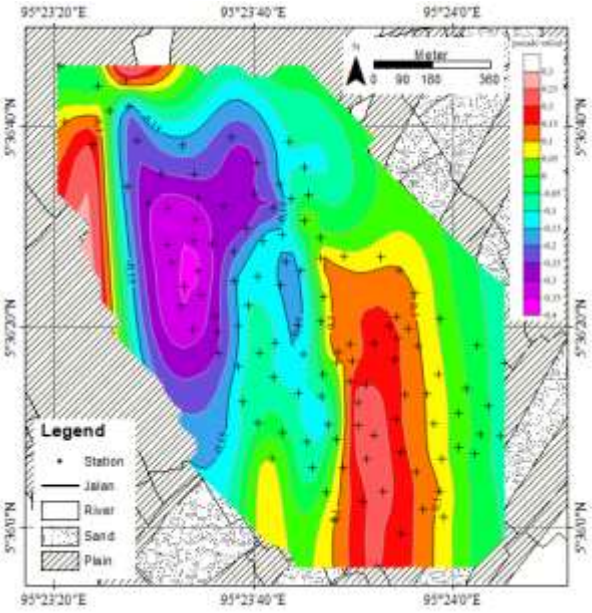

Figure 3. Transform Pseudo-gravitation magnetic field map of the study.

The gravity values in the study area are divided into two parts, the highest gravitational value (≥ 66.5 mGal) and the smallest gravitational value (≤ 66.4 mGal). Bouguer gravity map in the study area (Figure. 4) shows the highest value (≥66.5 mGal, which is an area represented by blue) along the settlement area. The smallest gravitational values are (≤66.4 mGal, i.e. the area represented by red) rivers and dikes.

The residual gravity map (Figure. 5) shows the highest gravitational area around the housing area. A high value indicates something below the surface. This value includes residual data because there are still influenced by regional effects. The residual anomalies obtained indicate high gravity values in the housing area. Residual data shows that something close to the surface. Profileis selected in the

research area. This profile extends from the southeast-northwest direction (Figure. 6). From this profile, 2D models are made of subsurface structures.

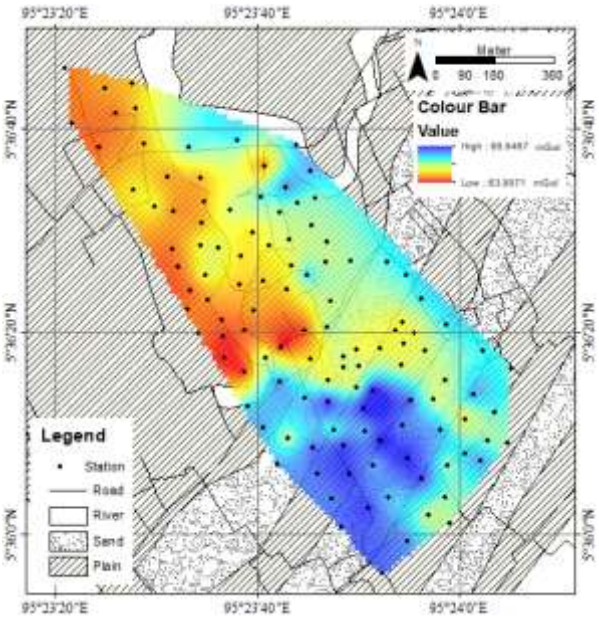

Figure 4. Bouguer gravity map of the study area.

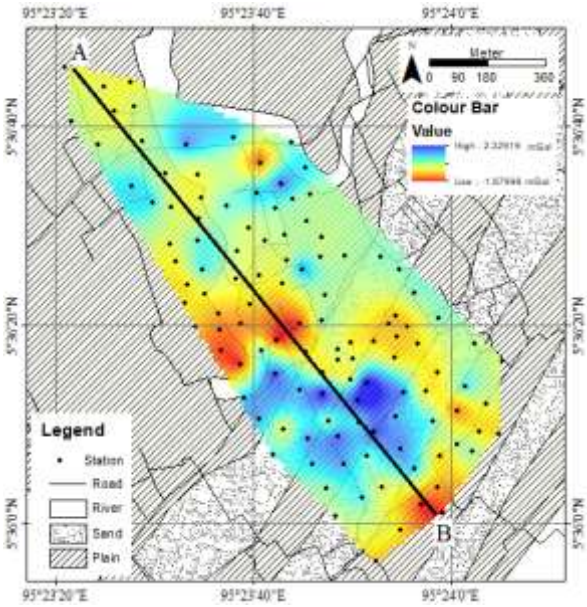

Figure 5. Residual gravity map of the study area with profile.

Based on information on the geological map of the study area (Figure. 6), it shows that the study area is dominated by a quarter of a rock (gravel, sand, and mud) [12]. Based on the geological model of the study area from the A-B cross section (Figure. 7), there are 3 layers. The first layer are alluvium sand ($\rho = 1.66\ gr/cm^3$) and clay stone ($\rho = 2.07\ gr/cm^3$). The second layer is sandstone($\rho = 2.11\ gr/cm^3$). The third layer is sand($\rho = 2.18\ gr/cm^3$).

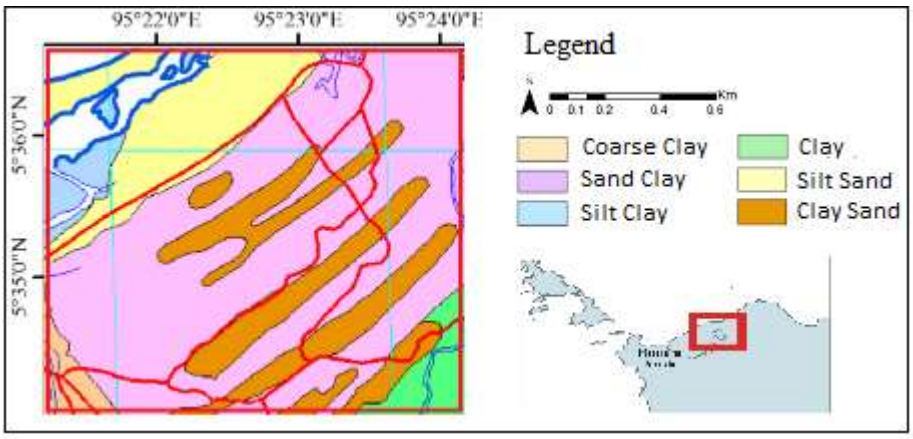

Figure 6. Geological map of the study area [13].

The research location is in the coastal deposition area. From 2D modeling, the precipitate formed are a horizontal layer. This deposit piles vertically. These sediment deposits accumulate vertically. The

wavy pattern on the model are caused by coastal erosion. Corrugated basins are formed due to wind movements. Wind causes weak parts to be carried away by water.

The topography of the study area is a delta plain which is the sedimentation process that happen along Krueng Aceh. The oldest layer is sandstone at a depth of 375 meters. Sandstone deposits occur over a relatively long period of time. Erosion effect is rellatively small because it is far from the beach. Then, there is a layer of sandstone deposited by passive alluvium and clay which are formed repeatedly and form a wave pattern.

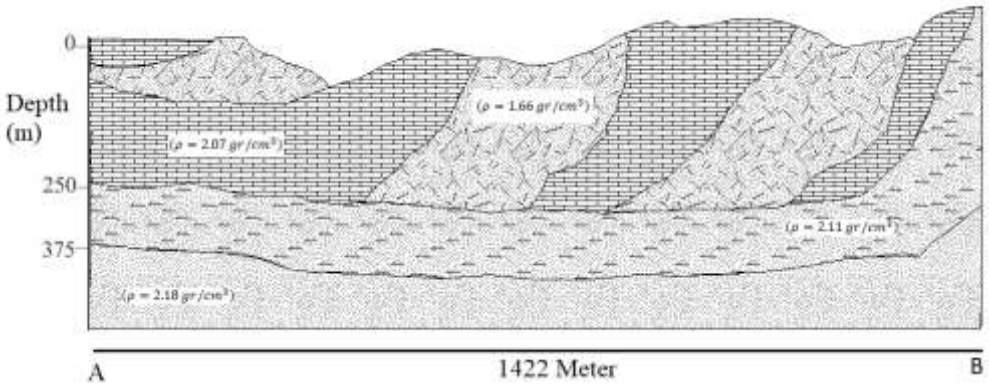

Figure7. Geological model for profile.

4. Conclusion

The maximum value of pseudogravitation anomaly map is 0.05 to 0.3 pseudo mGal and the minimum value is 0.15 to 0.4 pseudo mGal. On the RTP map, the maximum value is 200 nT to 600 nT and the minimum value is -600 nT to 1800 nT. The results of qualitative interpretations show a correlation with geological information in the study sites that have alluvial deposits in several locations. At the deposition sites, there are changes in the high and low contour patterns that show topographic changes (alluvial deposits) and down (alluvial erosion).

In the 2D model, it was found that the zone of alluvium deposits was at a depth of 0-350 meter with 2 types of deposits consisting of sand alluvium layers in the first layer and clay and sandstone in the second layer. It is also found that the oldest layer at 375 meter is sandstone. Sandstone is covered by the alluvium layer and clay stone at deposited repeatedly.

Acknowledgements

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