The Formation of Submarine Baruna Komba Ridge on Northeast Flores Waters in relation to low anomaly of marine magnetism

Formasi Punggungan Bawah Laut Baruna Komba di Timurlaut Perairan Flores, Kaitannya dengan Anomali Rendah Kemagnitan Laut

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ABSTRACT: There are three submarine ridges found on northeast of Flores waters. One of them is Baruna Komba submarine ridge found on south of Komba (Batutara) Volcano. Two others are Abang and Ibu Komba volcanoes located more to the southeast of the Baruna Komba. The position of the Baruna Komba situated more closely to the active Komba volcano and it is considered that the formation of Baruna Komba ridge is younger than the Abang and Ibu Komba volcanoes. The Baruna Komba also interpreted before as a magmatic volcano. Data from marine magnetism shows that there is a low or negative anomaly on Baruna Komba ridge whereas on Abang and Ibu Komba ridges, they are high and positive anomalies. These data indicate that the Baruna Komba ridge is not a volcanic ridge but it is a submarine ridge formed by a volcanic detritus or non magnetized sedimentation. The low anomaly around these submarine ridges gives northwest to southeast lineation and we interpreted also as a big fault on the west side of these ridges. On the other hand, the Abang and the Ibu Komba ridges are closely related to submarine magmatic volcanoes.

Keywords : The Baruna Komba, magmatic volcano, volcanic detritus, Northeast Flores Waters.

ABSTRAK : *Di perairan sebelah timur laut pulau Flores ditemukan tiga bukit bawah laut. Salah satunya adalah Baruna Komba sebagai bukit bawah laut yang ditemukan di selatan gunung api Komba. Dua bukit lainnya adalah Abang dan Ibu Komba di sebelah tenggara Baruna Komba. Posisi Baruna Komba terletak lebih dekat dengan gunung api Komba yang masih aktif sehingga ditafsirkan sebagai bukit bawah laut termuda dibandingkan gunung api bawah laut Abang dan Ibu Komba. Baruna Komba ditafsirkan sebelumnya sebagai gunung api juga. Dari data magnetik kelautan menunjukkan bahwa adanya anomali negatif atau rendah di atas Baruna Komba, sedangkan di atas Abang dan Ibu Komba menunjukkan anomali positif atau tinggi. Data magnetik ini menandakan bahwa bukit bawah laut Baruna Komba bukan sebagai gunung api tetapi terbentuk oleh material seperti lava, breksi gunung api dan lahar yang terendapkan sewaktu letusan gunung api Komba. Sebaliknya, bukit bawah laut Abang dan Ibu Komba dapat ditafsirkan sebagai gunung api bawah laut yang bersifat magmatik.*

Kata Kunci : *Baruna Komba, gunung api bersifat magmatik, endapan vulkanik, perairan timur laut Flores.*

INTRODUCTION

The study of marine geomagnetic has been done by using Research Vessel of Geomarine III. It was done during five days, starts from 8th to 13th of October 2010 on northeast Flores Island or surroundings Batutara (Komba) volcano waters. The shiptrack are about 750 km long and dominantly in east-west direction to cut the submarine ridges almost perpendicularly.

Data of marine geomagnetic from this cruise is based on field observed magnetic values those are mixed with earth regional magnetic and geological body-caused anomaly values. This field values have been corrected by IGRF correction, one of them from data position of point coordinate (after fieldwork) and also from daily correction and end up with total magnetic intensity from body-caused anomaly values.

The study area is situated on Northeast of East Nusa Tenggara Province in between 123º 18' 16'' - 123º 57' 39'' E and 07º 40' 57'' - 08º 04' 01'' S (Figure 1). The area is divided into three different submarine ridges, on the most northern part is situated the Komba (Batutara) active volcano as volcano island with its elevation of 400 meters above sea level. To its southeast, those are Baruna, Abang and Ibu Komba (Sarmili L. et.al., 2003 and 2004).

They have different in their own morphologies, such as, the Ibu Komba is situated in the longest

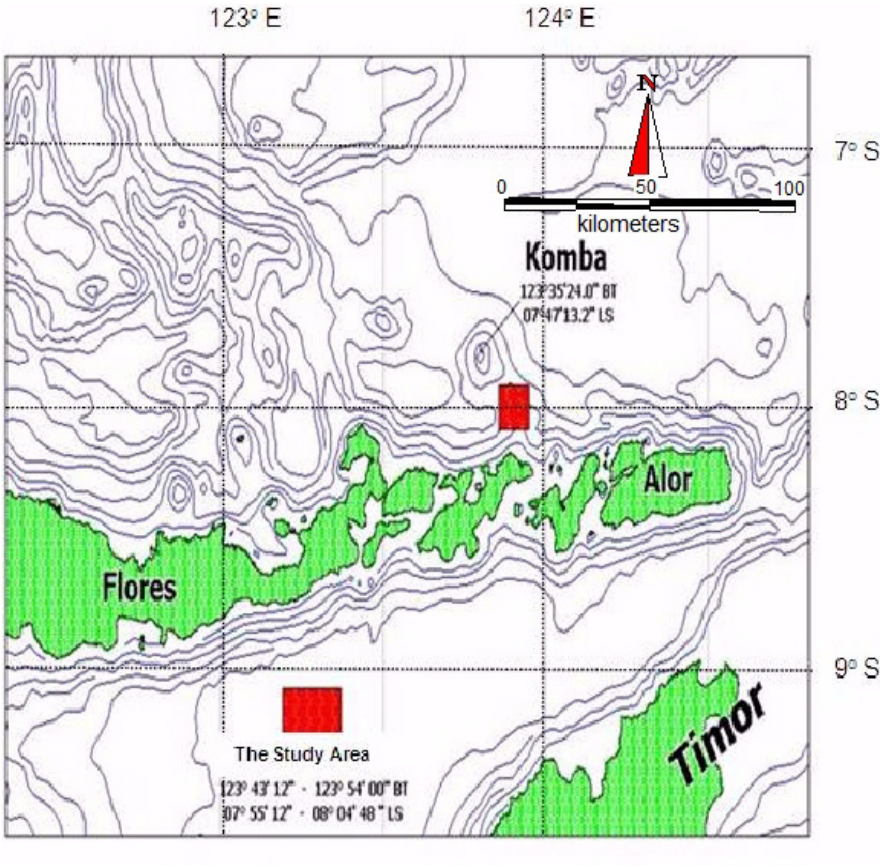

Figure 1. Location Map of Komba Ridges

distance from the Komba volcano and it has a flat on top the ridge. The Ibu Komba indicates submarine erosion is higher than the other ridges. The other two submarine ridges show the cone shape on top of the ridge, those are indicate the erosion is lower compare to Ibu Komba. The erosion level can indicate the age of the ridge itself, the higher the erosion the older the age. These three submarine ridges are known as the submarine Komba ridges.

These submarine ridges are non active submarine volcanoes in which located on transition of volcanic arc between Sunda Arc and Banda Arc (Hamilton, 1979). In other words, these submarine ridges belong to inner volcanic arc and close to active volcanic arc that has been deformed by tectonic evolution and produced a pull apart structures (Halbach, et. al; 2003). Next, these structures were become a place of an intrusion of hydrothermal fluid to obtain hydrothermal mineralization.

METHODS

Marine magnetometer is used in order to know the variation of total magnetic intensities in the study area. These magnetic values will give rock's susceptibilities which described undirectly what kind of rocks, their relationship and the existence of geoloical structures.

The equipment of marine magnetometer consists of Sea Spy Hardware and Sea Link Software. The magnetometer censor is towed 170 meter behind the R/V Geomarine III. This work is done at the same time with bathymetry and seismic reflection lines. It is due to Sea Link can receive the actual position of GPS, the marine magnetometer has been synchronized with GPS data position of Trimble DSM 132. The interval measurement is one second at detail observation less than one gamma.

The marine magnetometer measurement will be related to the magnetic anomalies in Komba Volcano waters and its surroundings. The Komba volcano is one of active volcanoes in East Nusa Tenggara presently and their magnetic anomalies will be compared to others submarine ridges/volcanoes, like, Baruna, Abang and Ibu Komba. Their high magnetic anomalies will be interpreted as volcano which have magmatic underneath.

Measuring the depth of the sea in this investigation is to obtain the basic morphology of the seabed bathymetry map. Depth data taken simultaneously at the time of seismic and magnetic track. With the acquisition of more depth data will facilitate the withdrawal of the sea depth contour.

Echosounder used is the Sub-bottom Profiler and Bathy 2010 echosounder Reson 420.

Multichannel seismic equipment used in this study consists of major equipment such as 4 airgun with a volume of 150 cu in each airgun, fitted jackets and arranged side by side (parallel cluster). In the operational field activities airgun array was withdrawn 40 meters behind the ship, and the distance to the streamer behind airgun is 110 meters. During the survey two airgun operated by blasting 25 meter intervals, given the limited ability of seismic magnitude compressor about 190 SCFM in providing for the needs of high-pressure air to the airgun. Active streamer towed behind the ship at about 150 meters from the stern. Along streamer installed three Digibird Ion 5010 on the front end, middle and back streamer, which is used as a streamer depth control. During the survey Digibird position is monitored by the Positioning Control System (PCS) with software DigiCourse at the Geophysical Laboratory Geomarin III and sought to remain at a depth of 5-7 meters from the sea level. The position of depth streamer is depend on noise conditions, if it is too shallow or close to sea level noise wavelength would cover the signal reflected from the seabed.

Conversely, if too deep, the sensitivity of the streamer will be reduced due to high hydrostatic pressure, or is automatically turned off when the depth exceeds 30 meters.

The purpose of measurement is to get the value of magnetization of P. Komba (G. Komba) area which is an active volcano, with the purpose to provide information about the geological picture of the area in relation to the presence of G. Komba, G. Baruna Komba, G, Abang Komba , and Ibu Komba Volcanoes.

RESULTS

Bathymetric (sounding) surveys conducted along with the line overall is more than 875.5 km. Lines which are trending West - East is 447 km, North - South is104 km, Southeast - Northwest is153 km, and Southwest - Northeast 171.5 km. All these lines are in total length of 875.5 km (Figure 2). In detail, some liness like line 1, 6 and 24 were over the Baruna Komba submarine ridge can be explained as follows:

- Line L-1 trending northwest-southeast mapped the bathymetry along the 87 kms. This track is the longest which passes the peak of the submarine ridge. Data from the previous line was deliberately taken to identify the changes of submarine ridges. From the previous, bathymetric data derived from Halbach et al. (2003), Sarmili et al. (2003 and 2004). This line has passed through the submarine ridges of Ibu Komba, Abang Komba and Baruna Komba (Figure 3) even up to the slopes of volcanoes that rise to the surface of Komba volcano. Morphological changes can be found on the slopes of the Komba volcano which showed morphologic mound / small hills which are thought to be the product of Komba eruption in 2007 or before.
- Line L-6 is an east-west line direction passed through the slopes of the Komba volcano along 59 km. Morphology was bumpy and allegedly in the formation of a mound of material Komba eruption that erupted in 2007 or before. The culmination of an undulated morphology is having a depth of approximately 500 m to 900 m and on the line is formed the deepest ocean depth more than 3500 m.
- Line L-24 has a direction from northeast to southwest along the 47 km. This line starts from a depth of 3500 m to 1500 m. Running through the southern slope of the Komba volcano of 1500 meter depth. The line is just to re-track the trajectory of the previous line with different directions in which the purpose is to determine the material distribution result of volcanic eruptions Komba 2007 or before. It turns out the volcano slope indeed shed more material to the south. Line ends at the southwestern tip at a depth of 3500 m deep basin.

Seismic Reflection

During the 5 day seismic reflection works in the Bandamin II Expedition, we have as many as 15 lines if compared to bathymetric map (25 lines), with a total length of the line is 763.5 km. These lines are east-west trending (447 km), northwest-southeast (153 km) north-south (104 km) and northeast-southwest (171.5 km).

The seismic reflection lines those cut formerly the submarine ridge of Baruna Komba are 1, 6 and 24 lines, the details are as follows:

Line 1 (BDMN 01) has a length of about 87 km (Figure 4), which begins from the southeast. This passage was passed through the Baruna, Abang and Ibu Komba submarine ridges. In between the two peaks is punctuated by a zone of sediment-filled depression.

The passage was started from Ibu Komba submarine ridge of a dome-shaped morphology which marks the abrasion rate is higher than the Abang Komba submarine ridge on its northwest. The Ibu Komba submarine ridge also has bumpy peaks and has a depth deeper than the other submarine ridges. If it continues towards the northwest, we will discover the Abang Komba submarine ridge who has a conical peak which is higher than the Ibu Komba.

More to the northwest after crossing a rather broad depression filled with sediments, we obtained the Baruna Komba submarine ridge who is also a cone-

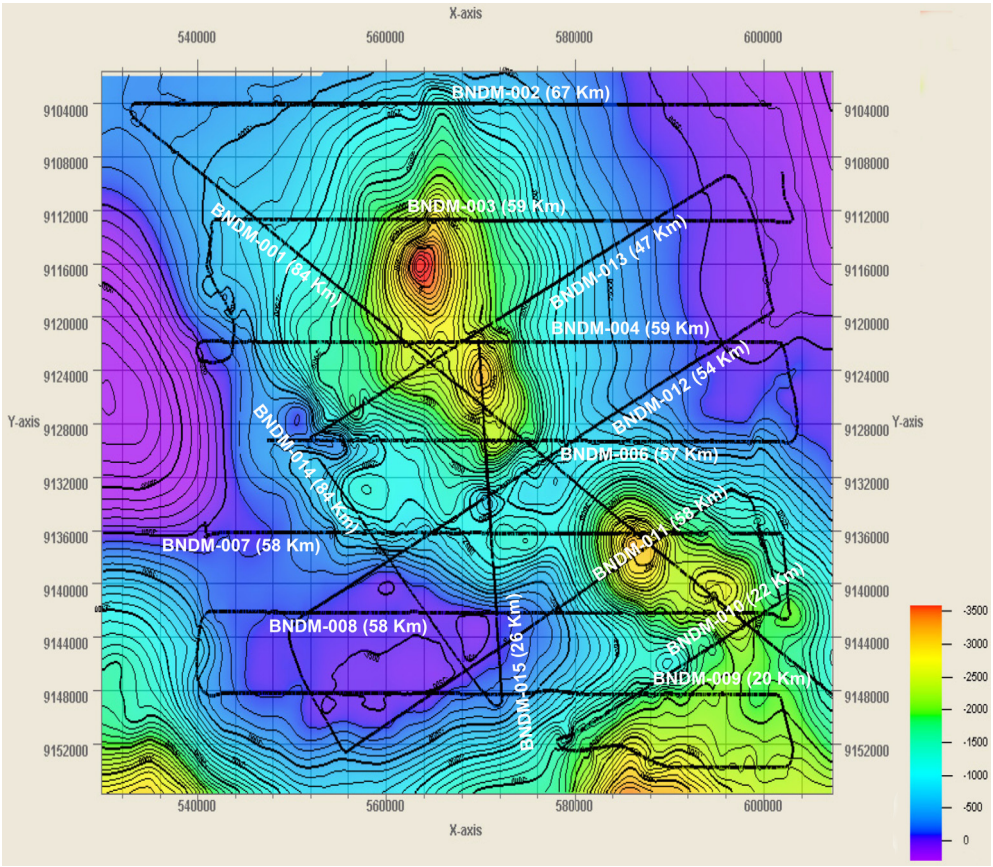

Figure 2. Bathymetric Map with 25 lines of different directions

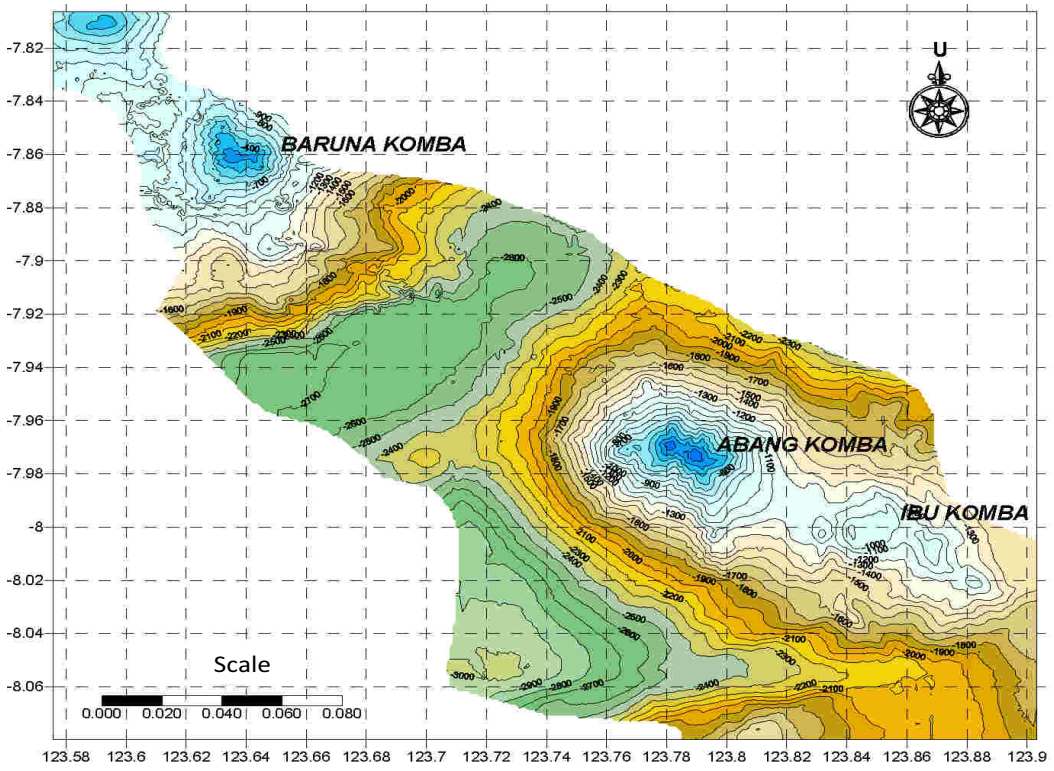

Figure 3. Bathymetric map of Baruna, Abang dan Ibu Komba ridges (Sarmili et al., 2009)

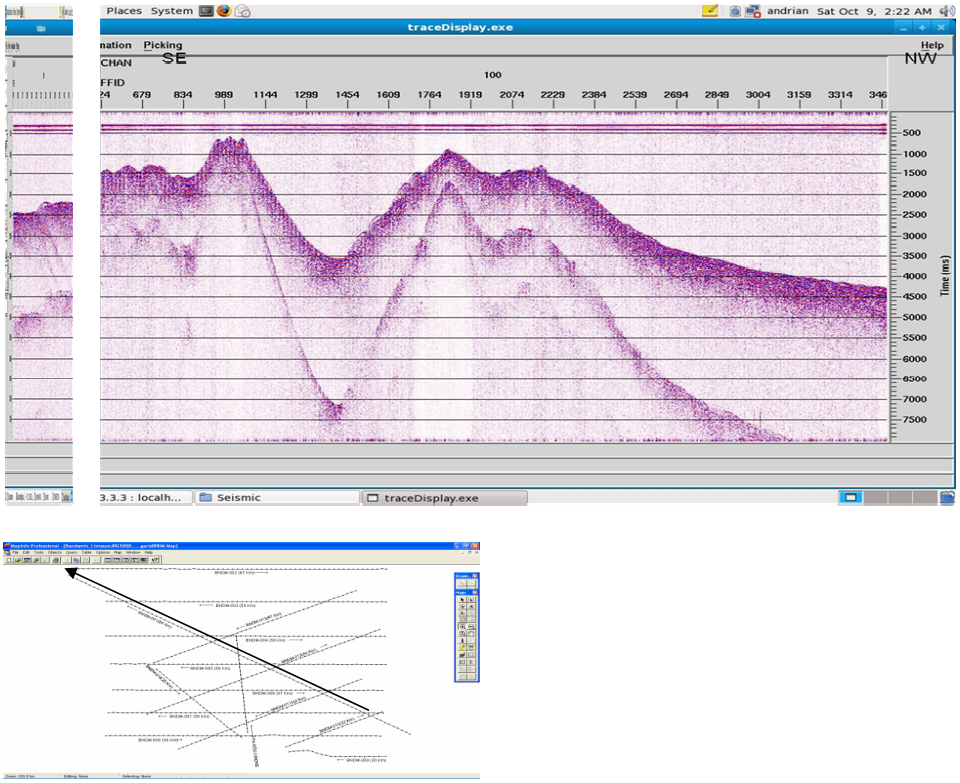

Figure 4. Line 1 (BDMN 01) that passed the Baruna, Abang and IbuKomba submarine ridges

shaped peak. On Baruna Komba slopes, we found many new sediment deposition is interpreted as volcanic eruptions result from Komba volcano eruption on its northwest. From cross section of seismic reflection, on the slopes of the Baruna Komba, we saw a material's deposit, especially on its southeast which one day will be an avalanche of material toward the deeper basin.

Running toward the northwest after passing the Baruna Komba submarine ridge, there are submarine hills that are part of the slope Komba volcano and rise up to the surface. This seismic reflection line was more towards southern slopes where the steeper slope does not look obvious.

Further to the north or northwest of Komba volcano, there is no other submarine ridge. The morphology of the deeper parts showed the horizontal morphology. More to the northwest end of the track 1 is no longer obtained sediment yield from Komba volcanic eruption which erupted in 2007 or even nowaday's.

Line 6 (BNDM 06) is the seismic reflection line which has direction from west to east along the 59 km. Morphologically, this location is a submarine ridge has a wavy top. This location is very close to the southern part of Komba volcano. On western slopes was obtained avalanches and sediment whereas in the eastern slopes the avalanche can not be found.

Sediment deposition is expected as a volcanic lava or volcanoclastic originated from eruption of Komba volcano in 2007.

Likewise, the undulated peaks on Baruna Komba consist of sludge lava flowing from the slopes of Komba volcano in the north. The interpretation of sesmic reflection are found many faults near the summit of this submarine ridge. Toward the eastern part, on a fairly steep slope, there is a layer of fine sediments characterized by parallel seismic reflector.

This is a Baruna Komba submarine ridge (Sarmili, et al., 2003 and 2004), which is one of the submarine ridges in Komba waters.

Line 24 (BNDM 24) is trending from northeast to southwest along the 47 km (Figure 7). The line is close to the Komba volcano that is an island and active volcano.

Line starts from the deepest part of the bathymetry and at cross sections of seismic reflection, there is a parallel reflector pattern indicates a very fine sediment with the layer is not clearly obvious. Toward the middle section, appears a quite high submarine ridge Baruna Komba that is located in the southeast of the Komba volcano. It seems that a lot of new sediments were deposited on the top of the slope, especially in its western slopes. The Baruna Komba submarine ridge appearance is questionable whether this is indeed the

magmatic volcano or simply as part of the volcanoclastic deposit or as an avalanche of old caldera Komba?.

Data processing on board magnetometer is done by editing raw data by adjusting the magnetic values soared too high or too low to be an average, and then create profile of each line based on marine magnetic observations.

Anomalies of magnetic field observations are varies with a minimum price of around 43,800 nT and a maximum of about 44,700 nT.

There are only three lines of marine magnetic lines which are passed the Baruna, Abang and Ibu Komba submarine ridges, those are lines 1, 6 and 24.

Existing line 1 is diagonally with this 84 km long trending NW-SE (N300oE). In general, the gradient profile based on observation looks likely to continue up with a minimum around 43,875 nT, a maximum of about 44,650 nT.

In profile of line 1, the intensity of the magnetic observations anomalies seen higher than normal anomalies especially in the horizontal axis from 555,000 up to 570,000, those are, on Komba and Baruna Komba volcanoes, and reached the highest anomaly in the horizontal axis of 580,000 to 600,000, especially on Abang Komba and Ibu Komba submarine ridges.

Profile of line 1, is decline at the end of the line with intensities of the magnetic observations anomalies relatively high at the beginning of the line. In other words, the intensity of the magnetic observations is higher in Abang and Ibu Komba submarine ridges.

Line 6 of marine magnetometer is 59 km length of East-West trending, located on south of Komba volcano with anomaly variations of magnetic observations about 43,810 nT to 44,230 nT. In general, all lines show the intensity of the magnetic gradient profile is relatively flat observation. The profile shows a fluctuating magnetic intensity observations that relatively greater fluctuation in the horizontal axis 555 000 to 575 000 or in the Komba volcano and Baruna Komba submarine ridge. At horizontal axis of 580,000 to 600,000 or in the east of Baruna Komba submarine ridge, the intensity of the magnetic fluctuations appear smaller. Of particular interest in this line is the anomaly which declined sharply, especially in the horizontal axis between 56,000 and 57,000 those are at anomaly about 43 820 nT. It can be interpreted that the rock has a very low intensity magnetic likely are not related to volcanic magma or perhaps as a rock avalanche material resulting from Komba volcanic eruption and deposited on this location.

Line 24 is a marine magnetic line extends about 45 km and trending from northeast to southwest. This line cut between Baruna Komba submarine ridge and Komba volcano. There are interesting point that is from the horizontal axis between 565,000 to 570,000 has an intensity of about 43,850 nT anomalies, the magnetic anomalies is just above the sediment laharik Komba volcano result of volcanic eruptions. Anomaly to the southwest landscape shows the average anomalies of around 44 080 are owned by the sedimentary basins that lie quite extensive.

DISCUSSION

From the depth of data across the entire study area, this area has a generally formed of morphology submarine ridges trending northwest - southeast. The submarine ridges consist of submarine ridges of Ibu Komba at the southeastern and Abang Komba in the west sea, and in the end at the western end of Baruna Komba. Of the three submarine ridges, the depths of the sea starting from a hundred meters as a peak up to three thousand meters of their legs.

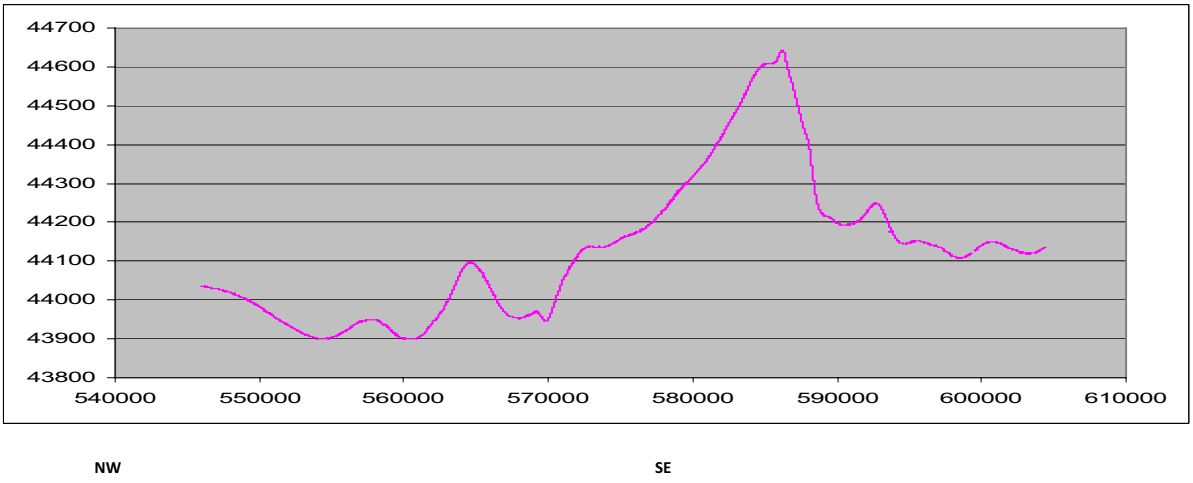

Figure 5. Line 1 is a profile of Northwest – Southeast marine magnetometer

These submarine ridges range are surrounded by a deep-sea that is why submarine ridges become very prominent morphologies.

Morphologically these submarine ridges are trending northwest - southeast and they have a length of about 20 km from the south Recent volcanic arc.

These ridges are between northern emergence of Komba (Batutara) volcano and to the south is the island volcanic arc of East Nusa Tenggara.

The west and eastern boundary between these submarine ridges are characterized by both plains morphology that are common as deep sea sedimentary basins where they have over than 2800 meters depth. The sedimentation basin at the top is usually filled by younger sediments.

Seismic reflection data across the entire study area has been already interpreted, even so marine magnetic data.

From the seismic reflection profile shows that there are three submarine ridges, starting from the southeast to the northwest. From the southeast, Ibu Komba and Abang Komba submarine ridges, both can be distinguished from the form in which the submarine ridge morphology Abang Komba more conical shape than others. From the peak shape, it can be predicted that Ibu Komba submarine ridge is much more mature from the level of erosion.

Data of marine magnetometer, the two submarine ridges show high magnetic anomalies (Figure 5). This magnetic data indicate the content of iron in metallic elements, which also means that the element of metal can only be produced in rocks those have magnetic rocks. Rocks found in the study area are intermediate to basic igneous rocks (Halbach et al; 2003). These rocks are closely related to the magma source beneath them. It can be interpreted that the two submarine ridges of Abang Komba and Ibu Komba are related to magmatic volcanic source.

The more to the north, or rather to the northwest, there is Baruna Komba submarine ridge adjacent to the slopes of the Komba volcano as a volcanic island. Baruna Komba submarine ridge has a conical peak that also means that the erosion rate is still low. From a distance, the presence of the Komba volcanic is still active, the Baruna Komba is the youngest submarine ridge compared with Abang Komba and Ibu Komba.

Magnetic data that can be interpreted on the Baruna Komba submarine ridge has a low anomaly (Figures 6 and 7), which means that it is not having the nature of magnetism than other submarine ridges. That is, Baruna Komba submarine ridge has a negative anomaly, or interpreted that it does not have the elements associated with iron metal element of magnetization.

Another interpretation of Baruna Komba submarine ridge is not directly related to the magma beneath. This is differs from the Komba, Abang Komba and Ibu Komba. If the Baruna Komba submarine ridge is not associated with magma, it could be concluded that this seamount is an underwater volcanic rocks formed from avalanches result from a nearby Komba volcano.

Komba volcano is a volcanic island that is still active and its position is very close to the slope Baruna Komba submarine ridge. The crater of Komba volcano can be seen clearly from the south or southeast, and it is a split crater where the southern part of the crater has been lost and likely collapse into the sea below. The collapse materials are interpreted to be deposited as a mound of rock that formed the submarine ridge on its southeast.

CONCLUSIONS

Bathymetric mapping has been done along the 875.5 km's. Data obtained based on bathymetric lines in conjunction with the seismic reflection and marine magnetic lines.

The morphology of the seabed is despite already been mapped previously during studies conducted in the same area from 2001 to 2004. The results are broadly similar but there are differences, especially in the picture submarine morphology of the Baruna Komba. The presence of three submarine ridges that lined from the northwest to the southeast, those are Baruna Komba, Abang Komba and Ibu Komba submarine ridges.

The Baruna Komba submarine ridge is located next to a Komba volcano in which erupted in 2007. Eruptions Komba volcano is certainly gave an impact on the shape of a nearby of Baruna Komba.

From the bathymetric map looks a volcanic sediment accumulation in the form of loose sand deposits laharik and scattered around. The morphology of the Baruna Komba submarine ridge is clearly different from the previous bathymetry.

Absence of separate boundaries between Baruna Komba submarine ridge with Komba volcano due to this position has been covered by sediment laharik of the Komba volcano eruption in 2007 and is still ongoing small eruptions with throwing lapilli bombs and hot sand into the surrounding area.

The age of the submarine ridge is associated with a position close to or away from the Komba volcano as the youngest and still active volcano, in the form of a cone caldera indicates different levels of erosion. Seismic reflection data has been able to interpret the faults in which are strongly associated with the existing of Komba submarine ridges and surroundings.

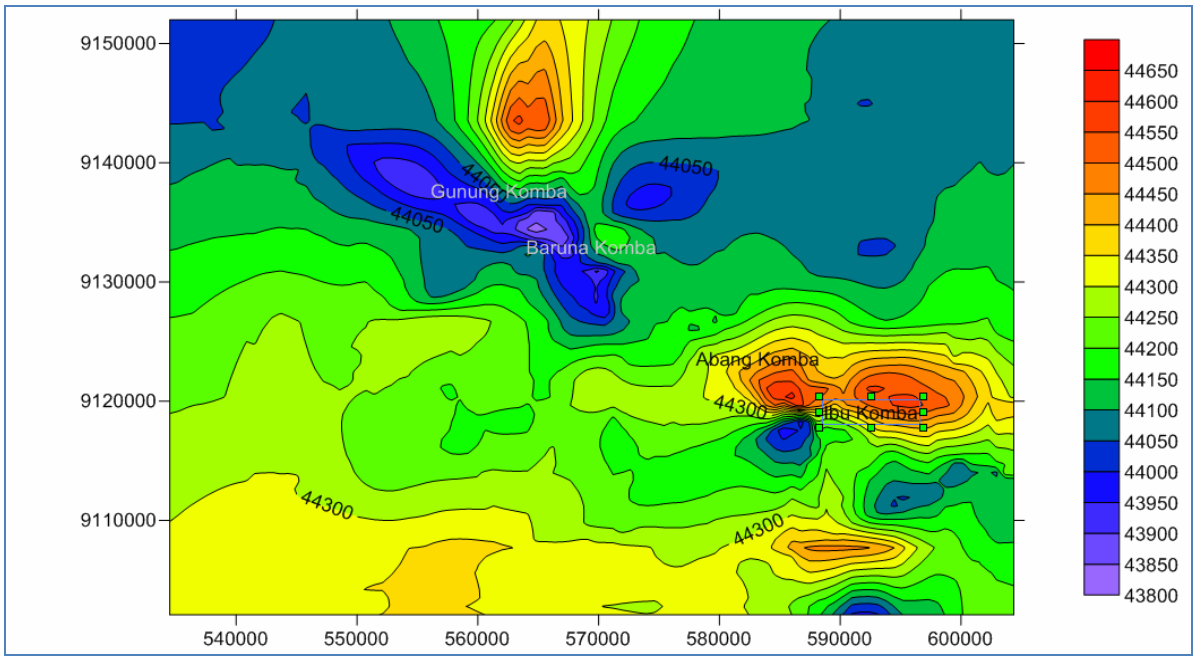

Figure 6. Marine Magnetic anomalies map on submarine Komba Ridges

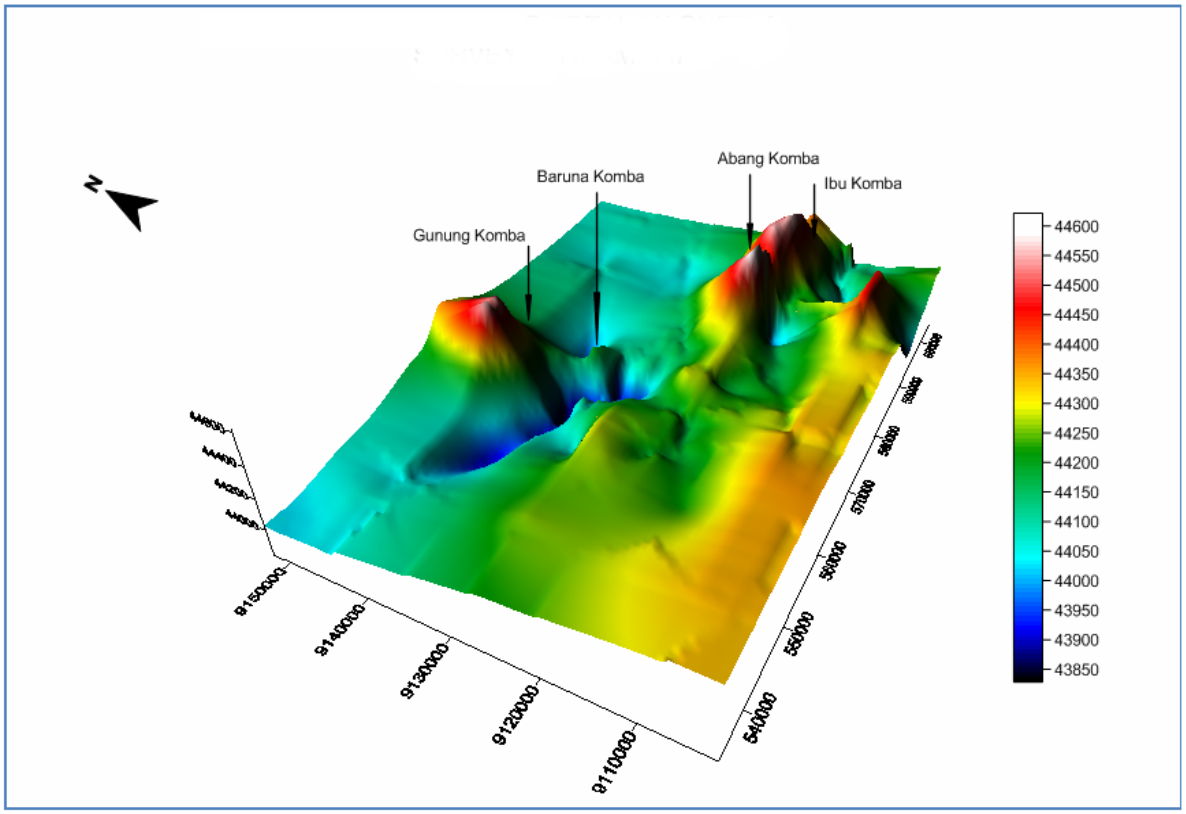

Figure 7.Marine Magnetic Map in 3D where Baruna Komba shows a negative anomalies

Seismic data indicate that the Komba volcano and all submarine ridges surrounding are clearly visible out of the cracks were caused by the fault or deep faults.

Marine magnetic anomaly data shows high anomalies over Abang Komba and Ibu Komba submarine ridges. The existence of a high anomaly can only be explained that the existing of submarine ridge is directly related to rock mass which content of high iron metal elements. These rocks are also closely related to the source of magma underneath the volcanic.

Magnetic anomalies over the Baruna Komba submarine ridge turns negative or very small, this indicates that the seamount does not contain elements of rock with high or non ferrous metals associated or not associated with magma source underneath.

In conclusion, the Baruna Komba submarine ridge is not correlated with magma but it is thought to be a deposition of volcanic clastics landslide in the nearby the slope of Komba volcano

Marine magnetic line can only be crossed on its slopes of Komba volcano, it shows such a high anomaly like on Abang and Ibu Komba submarine ridges. It is interpreted that Komba volcano has magma source rocks containing a high metal elements.

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