PETROGENESIS AND ASSOCIATED HYDROTHERMAL ALTERATION OF ABANGKOMBA SEAMOUNT, FLORES SEA, EAST NUSA TENGGARA*)

By :

Rosana, M.F.[1], Sarmili, L.[2], Bagio, I.,[3] Taufik, M[4]

1. Department of Geology, Padjadjaran University, Bandung
rosanamf@yahoo.com
2. Marine Geological Institute (MGI), Bandung
3. PT. ANEKA TAMBANG TBK, Jakarta
4.

Summary

The Abangkomba seamount is located in the southernmost part of the “Neo-volcanic Komba-ridge” of submarine volcanic structures in the Flores Sea, East Nusa Tenggara. The collected dreged samples are dominated by igneous volcanic rocks, volcaniclastics, and pumice. The rocks vary from fresh to highly altered, the fresh are abundance in biotite and feldspar, and the latter are increasingly impregnated with sulfides, mostly pyrite.and rarely chalcopyrite and pyrrhotite. Chemical compositions indicating the samples are potassium-rich belong to shoshonite series. TAS diagram shows the samples mostly ranging between trachybasalt and trachyandesite, corresponding to increasing SiO2 and alkali contents. The Abangkomba seamount had undergone lower- grade differentiation with partial melting and associated with extensional structure. The altered samples of Abangkomba indicating three alteration zone, characterized by dominated alteration mineral: a) sub-prophylitic zone is marked by chlorite-carbonate-illite-pyrophyllite, b) phyllic zone is characterized by carbonate-sericite-illite, c) argillic zone consist of carbonate-smectite. Significant metals contents of Au-Ag and Cu-Zn shows from chemical analysis. Increasing of illite contents is corresponding to increasing in Au, this indicating that mineralization at Abangkomba is formed at near-neutral fluids environment, as also indicating by the occurrences of calcite minerals. The chemistry and mineralogy of altered rocks strongly resembles to the type of epithermal low sulfidation.

Keywords : Seamount, Abang Komba, Petrogenesis, Hydrothermal

INTRODUCTION

The Research team of join Indonesia-Gemany (BANDAMIN III) using research vessel BARUNA JAWA VIII, has focused on the area in transition zone in the vicinity of the well known Komba-Batu Tara- volcano. This area is located in the back arc region-eastern edge of sunda arc-north of Lomblen island, to reveal such unknown structural propagation and collecting new samples especially beneath the sea surface of the newly called *neo volcanic ridge* (NVR) prolonged southward from the Komba volcano (Sarmili and Halbach, 2001).

The highly propagation of extensional structure as a results of subduction reversal in the area of Australia-Banda arc collision are providing abundant conduit for hydrothermal emanation, this hypothesis is an obvious guidance for prospecting the metal deposit in the research area, which is also suspected has structural influence from the collision event. The NVR striking southeastward from the Komba volcano and directly connected to the island of Lomblen and Alor, in the eastern part of flores basin in the back arc region (Fig. 1). It is consists of three other Seamount, named by the BANDAMIN researcher as, from closest to Komba-Batu Tara- volcano; are Barunakomba, Abangkomba, and Ibukomba.

The NVR are tectonically belong to the transitional zone. The distinct tectonic feature was the extensional structure develop in the back arc region directing NW-SE (Katili, 1989; Prasetyo, 1985). The striking of the NVR, which is also NW-SE is likely representing this feature since the active volcano of Komba are have a magmatic source by the conduit/plumbing system generated by this extensional structure. The result of the intense hydro acoustic survey in the Abangkomba seamount and adjacent, is also identified the NW-SE striking extensional structure (Fig. 2) which is seems being the part of earlier mentioned tectonic feature. This NW-SE structure was cut by the later structural development which can be seen by the topographic expression as a feature of pull-apart basin. We proposed the younger structural development is caused by the right lateral regional scale fault, which is also being the boundary of arc to back arc region, as proposed by Mc. Caffrey (1988) (Fig. 1). The smaller scale of normal faults was also identified in the northern flank of the Abangkomba seamount, cross-cut each other, and prospective area of hydrothermal interest (Fig. 2 and 3).

METHODS

The research are aimed to obtain a more detailed study in a frontier area, by the use of hydroacoustic survey resulting in the bathymetry of observed area and shallow penetrating single beam echosounder to gain regional structural propagation. The samples were collected by dredging tools which was included within the BARUNA JAYA VIII reseach vessel. The dredging activities are yielding 72 rocks samples from 87 times dredging with 15 empty samples. The dredging tools are operating within depth of -200 m to nearly -1000m in the very exact location of Abangkomba seamount.

Petrography and mineragrafi analyses were applied to identify the rocks type and metal mineral contents. Altered rocks are analized for clay mineral alteration and metal content. The clay mineral are examined trough PIMA. Selected samples were analyzed for chemical compositions of whole rocks and metal contents.

RESULTS

Dredged samples are mostly consist of volcanogenic material; pumice, volcaniclastic, igneous volcanic rocks, and some are hydrothermal rocks. It is interesting that the rock from one vicinity of the Abangkomba seamount are ranging froms basaltic to dacitic at specimen description. Whole sample are uniformly shows the appearance of significant hydrous mineral of amphibole and biotite from fine grain to coarsest of 1,5 cm. This phenomena are present in every rock type either basaltic, andesitic, or dacitic. Pumice are quite abundant and have a basaltic-andesitic to andesitic-dacitic in composition, with biotite presence which is coarse grained and very clear, the pumice are also texturally very scorious as a sign of rapid degass, and locate at shalower level at about -200m to -400m in average. It is unquestionable that this pumice are of the pyroclatic flow type deposites, where better forming condition is at shallower level than -200m (Cas and Wright, 1984), thus the questionable is the rapid uplift which always been proposed as tectonic impact of the Banda arc-Australian collision?or the rise of global sea level by ice age melt is faster than the uplift?

Another sign of volcanic activities are the presence of vocaniclastic rocks such as ash tuff, lapili and breccia, but only in andesitic and andesitic-dacitic in composition. The later composition are shows intens alteration, accompany by the presence of milimeter scale of veinlets, vuggy quartz in mm to cm scale, and disseminated sulphide.

The igneous volcanic rocks show much wider range from a truly basaltic colour, andesitic-basaltic, and andestic-dasitic. Like the volcaniclastic the intens alteration is happen to andesitic-dasitic composition, biotite and amphibole are also present in every rocks type with few are very coarse, but the vesicular are absent in the andesitic-dacitic type. Those major chemical analysys are comprise the name of trachybasalt and trachyandesite for the used of TAS diagram by Le Bas et al. (1985) meanwhile all samples falls into the shoshonite field in the potassium against silica diagram by Peccerilo and Taylor (1976).

Since the existence of extensional and normal fault are reported of being propagated and cut each other in the area by Sarmili and Halbach (2002), it is reasonable to have an expectaction of mineralization to be found. There is indication of this, which are seems to corroborate such process, found in the collected samples, obviously in the andesitic-dacitic type.

Moderate to strongly altered rock are analised further for clay mineral, alteration mineral and metal content. The clay mineral are examined trough PIMA, by the result we gain such clay of; illite, pyrophyllite, smectite, and paragonite. The dominating alteration assemblage discovered by PIMA are illite, illite-gypsum, smectite, and smectite-gypsum, eventough theres another mineral variation such paragonite, jarosite, and muscovite.

Combining the petrographical and PIMA anlysed data, alteration zone can be divided as follows:

1. Chlorite-carbonate-illite-pyrophyllite
2. Carbonate-sericite-illite
3. Carbonate-smectite

Chlorite-carbonate-illite-pyrophyllite zone are occupy about 85% of coverage area (Fig. 4). This zone is dominated by chlorite, carbonate, illite, pyrophillite, secondary quartz, cerisite, gypsum, jarosite, and paragonit that estimated to be formed at temperature of 240^0-300^0 C, in a neutral to nearly neutral condition (pH 5-6).

Carbonate-cerisite-illite zone are located in the northern are of the Abangkomba seamount, asociated with Andesitic-dasitic rock type near the crosscut normal fault. The assemblage are carbonate, cerisite (muscovite), illite, gypsum. Estimation forming temperature; 250^0-300^0 C, in pH 4-6 This condition are suspected as a impact of fluid mixing with a more acidic host rock, thus chlorite are absent and serisite become more abundant.

Carbonate-smectite zone located more to the southern part and associated with andesite and pumice, the present mineral assembalge are carbonate, smectite and gypsum. This zone estimated to be formed at temperature of 20^0-140^0 C, in pH 4-6.

The direct relation of Abangkomba with Komba-Batu Tara- volcano, has bring the histories of the later volcano become important to be reviewed. Tough Abangkomba has also shows an explosion histories, the composition of the rock is different. The shoshonitic composition of basaltic or basaltic-andesitic reflect the advance evolution of the Abngkomba seamount. Furthermore, the Abangkomba seamount compositions show less evolved magmatic compositions than the Komba volcano, it is interesting to see the relation of magma generation, and these indicated both volcanos in directly connected ridges. Hence, we can identify, how does the structural propagation in the back arc and the later subducted material affected the plumbing system of Komba volcano relatively to Abangkomba seamount. Here we suspected that the *Neo Volcanic Ridges* is formed by the NW-SE back arc sructural propagation from post Australia-Banda arc collisional process, thereby a significant difference in age between this two volcanos are indicated.

The mineralogy shows that Abangkomba seamount is have strong characteristic of an arc melt composition, by the absence of olivine and the presence of orthopyroxene and plagioclase, when the presence of abundant biotite reflect how the potassium enrichment come after in the late stage differentiation. The alteration characteristic is also affected by the smaller cross-cut normal fault in the northern flank of Abngkomba seamount, since strongly altered rocks are cames from the adjacent area.

CONCLUSIONS

The rocks of Abangkomba are composed mainly of basaltic or basaltic-andesitic (shohonitic) reflect the advance evolution of the Abangkomba seamount. TAS diagram shows the samples mostly ranging between trachybasalt and trachyandesite, corresponding to increasing SiO2 and alkali contents. The Abangkomba seamount had undergone lower-grade differentiation with partial melting and associated with extensional structure.

The altered samples of Abangkomba indicating three alteration zone, characterized by dominated alteration mineral: a) chlorite-carbonate-illite-pyrophyllite zone, b) carbonate-sericite-illite zone, and c) carbonate-smectite zone. The mineralogy shows an arc melt composition, which indicated by the absence of olivine and the presence of orthopyroxene and plagioclase, when the presence of abundant biotite reflect how the potassium enrichment come after in the late stage differentiation.

The chemistry and mineralogy of altered rocks strongly resembles to the type of epithermal low sulfidation. The alteration characteristic is also affected by the smaller cross-cut normal fault in the northern flank of Abngkomba seamount, since strongly altered rocks are cames from the adjacent area.

Acknowledgments

Thanks to all Baruna Jaya VIII crews for the nice cruise, Prof. Marlina A. Elburg, had nobly provide her time for the enriching e-discussion and to A. Khrisna Wardhana for sincerely helped searching and collecting refferences.

Refferences

Abbot, M.J. and Chamalaun, F.H., 1976. *Geochronology of Some Banda Arc Volcanics*. Pusat Penelitian dan Pengembangan Geologi. Special Publication..

Bronlow, H. Arthur, 1996. *Geochemistry*. Prentice Hall, Upper Saddle River, New Jersey.

Cas, R.A.F. and Wright, J.V., 1988. *Volcanic Succesions, Modern and Ancient, A geological approach to processes, products and Successions.* Chapman and Hall publishers, 2-6 Boundary low, London SE1 8HN, UK.

Claproth, Richard, 1989. *Magmatic Affinities of Volcanic Rocks From Ungaran, Central Java*. The volcanological survey of Indonesia. Majalah IAGI, Geologi Indonesia, special edition of "60 tahun J.A. Katili". Vol 12. no 1. IAGI.

Corbett, G.J. and Leach, T.M. 1995. *Southwest Pacific Rim Gold/Copper System: Structure, Alteration, and Mineralization*. A workshop presented for the Society of Exploration Geochemists at Townsville, Australia.

Cox, K.G., Bell, J.D., Pankhurst, R.J., 1979. *The Interpretation of Igneous Rocks.* George Allen & Unwin LTD 40 Museum street, London WCIA 1LU publishers.

Elburg, M.A., van Bergen, M.J., and Foden, J.D., 2004. *Subducted upper and lower continental crust contributes to magmatism in the collision sector of the Sunda-Banda arc, Indonesia*. Geological Society of America, v 32, no. 1; p. 41-44.

Gillespie, M.R., and Styles, M.T., 1999. *BGS Rock Classification Scheme, Volume 1, Classification of Igneous Rocks.* British Geological survey research report, (2nd edition), RR 99-06, keyworth, Nottingham NG12 5GG UK.

Guilbert, J.M. and Park, C.F. 1986. *The Geology Of Ore Deposits*. W. H. Freeman and Company, New York.

Hall, R., 2002. *Cenozoic geological and plate tectonic evolution of SE Asia and the SW Pasific: Computer-based reconstructions, model and animations*. J Asian Earth sci. 20, 353-431.

Hamilton, W., 1979. *Tectonics of The Indonesian Region*. Pusat penelitian dan Pengembangan Geologi. Publikasi Khusus.

Katili, J.A., 1989. *Review of Past and Present Geotectonic concepts of Eastern Indonesia.* Netherlands Journal of sea research. Direktorat Volkanologi Indonesia., R.K.551.24., kat., r., c.1.

McCaffrey, Robert., 1988. *Active Tectonics of The Eastern Sunda Arcs.* Journal of Geophysical research, vol. 93, no B12, pages 15, 163-15, 182, December 10, 1988.

Paripurno, Eko T., 2005. *Analisis Segmentasi Kerapatan Gunungapi di Indonesia.* Majalah Geologi Indonesia, vol. 20, No. 3, Agustus 2005; 129-138.

Prasetyo, Hardi, 1985. *Marine Geology and Tectonic Development of The Banda Sea Region Eastern Indonesia*. Pusat penelitian dan Pengembangan Geologi Kelautan. Special publication.

Robertson, S., 1999. *BGS Rock classification Scheme, Volume 2, Classification of Metamorphic rocks*. British Geological Survey, Keyworth, Nottingham NG12 5GG UK.

Sarmili, L., and Halbach, P., 2001. *Bandamin I, Cruise Report, Indonesia-German Join Research*. Pusat Penelitian dan Pengembangan geologi Kelautan. Special publication.

Sjarifudin, M.Z, 1989. *Petrokimia Batuan Kompleks Anak Ranakah, flores, Nusa Tenggara Timur.* Majalah IAGI, Geologi Indonesia, edisi 60 tahun J.A. Katili. Vol 12. no 1. IAGI.

van Bergen, M.J., Vroon, P.Z., Varekamp, J.C., and Poorter, R.P.E., 1992. *The Origin of*

The Potassic Rock Suite from Batu Tara Volcano (East Sunda Arc Indonesia). Lithos, 28 (1992) 261-282. Elsevier science publishers B.V., Amsterdam.

Varekamp, J.C., Van Bergen, M.J., Vroon, P.Z., Poorter, R.P.E., Wirakusumah, A.D., Erfan, R.D., Suharyono, K., and Sriwana, T., 1989. *Volcanism and Tectonics in The Eastern Sunda Arc, Indonesia.* Netherlands Journal of sea research, 24 (2/3): 313-322.

Wilson, Marjorie, 1989. *Igneous Petrogenesis, A Global Tectonic Approach*. Unwin Hyman Inc. London.

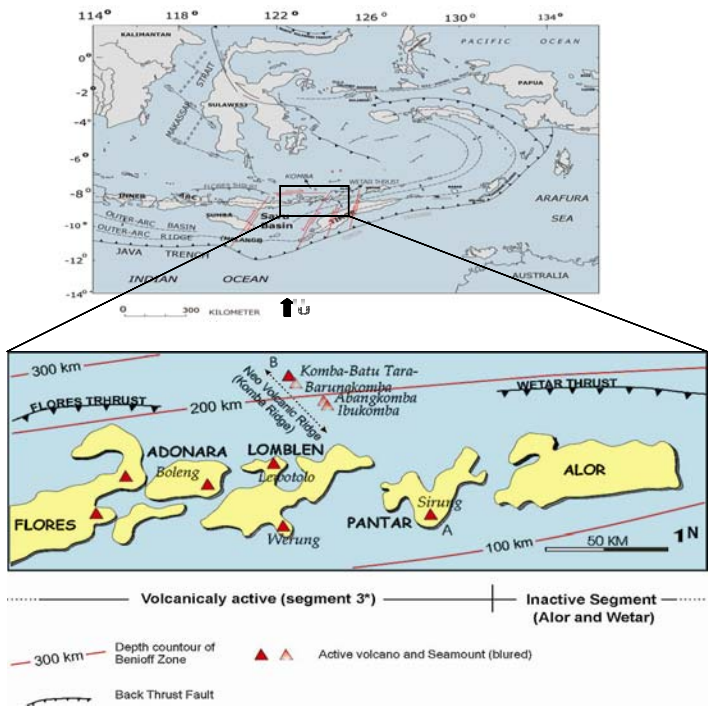

Figure 1. Location of NVR and tectonic of the region (Hamilton, 1979). Local tectonic (red coulored) of transcurrent fault by Mc. Caffrey (1988). Index map shows exact location of NVR (Abangkomba seamount), with Benioff Zone countour by Hamilton (1979).

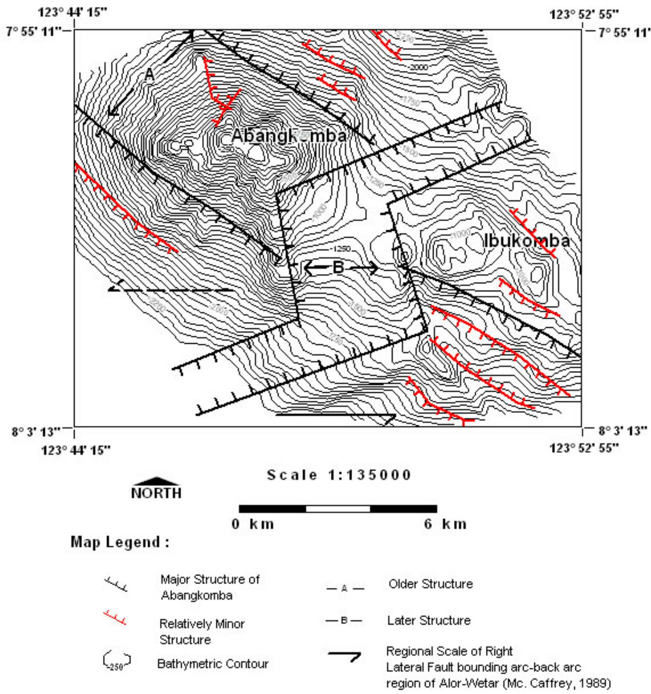

Figure 2. Tectonic map of NVR in the Abngkomba-Ibukomba area. Older Structure (A) are cutted by the later left-lateral extensional (B), resulting pull apart basin and displacement. Note also the smaler normal fault propagation in the northern flank cut each other as a hydrothermal prospective.

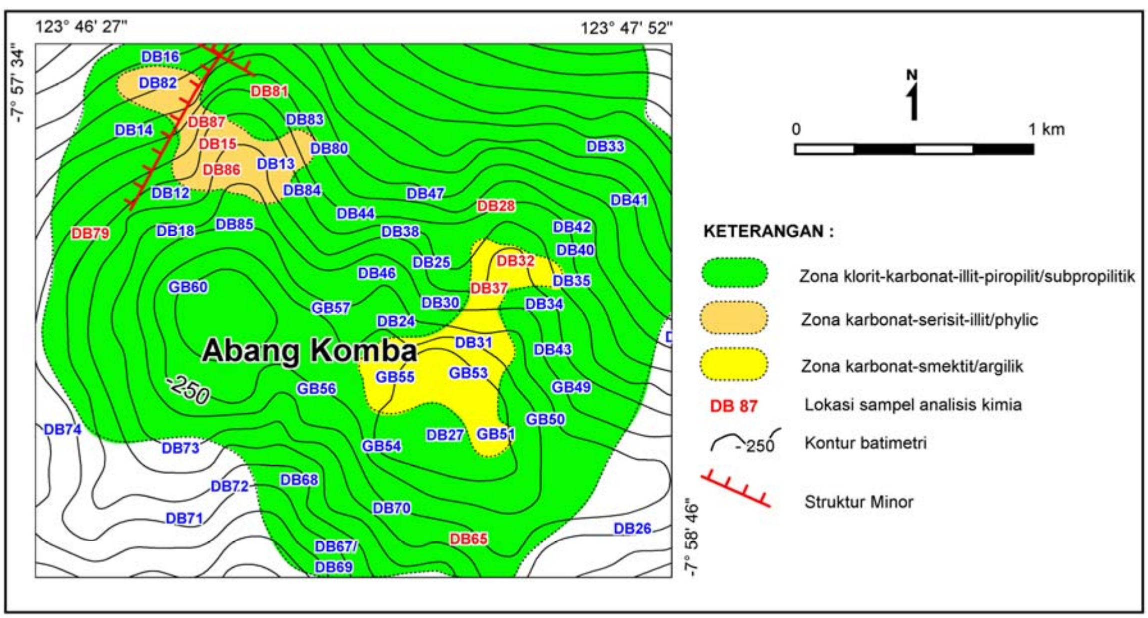

Figure 3. Type of alteration zonation, and sample locations for petrography, mineragraphy, PIMA and Assay of Abangkomba seamount.

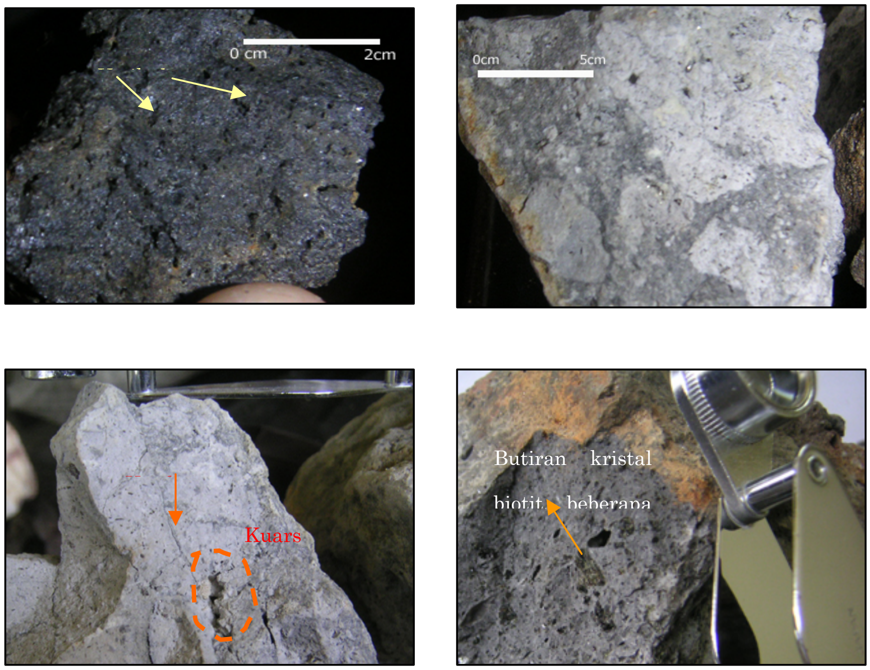

Figure 4. Specimen of dredged rocks. Basaltic with vesicular (a), volcaniclastic (b), moderately altered dacitic-andesitic (c), and Andesitic with coarse grained biotite.

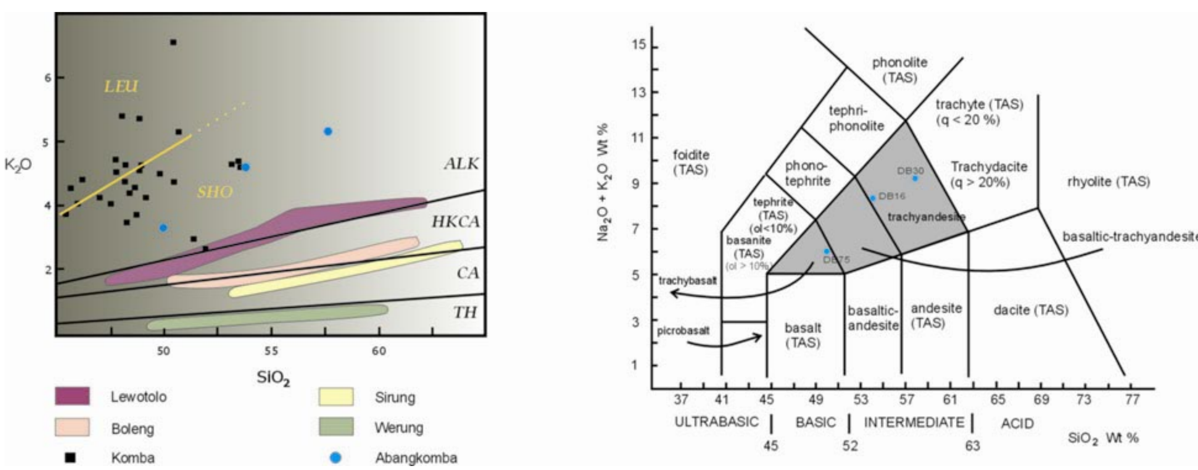

Figure 5. Major element plot of Abangkomba relatif to other volcano in the Alor-Pantar area. Left diagram data are from van Bergen (1992), yellow line are from Peccerilo (1976). Rigt diagram are geochemical clasification of Le Bas et al (1985).

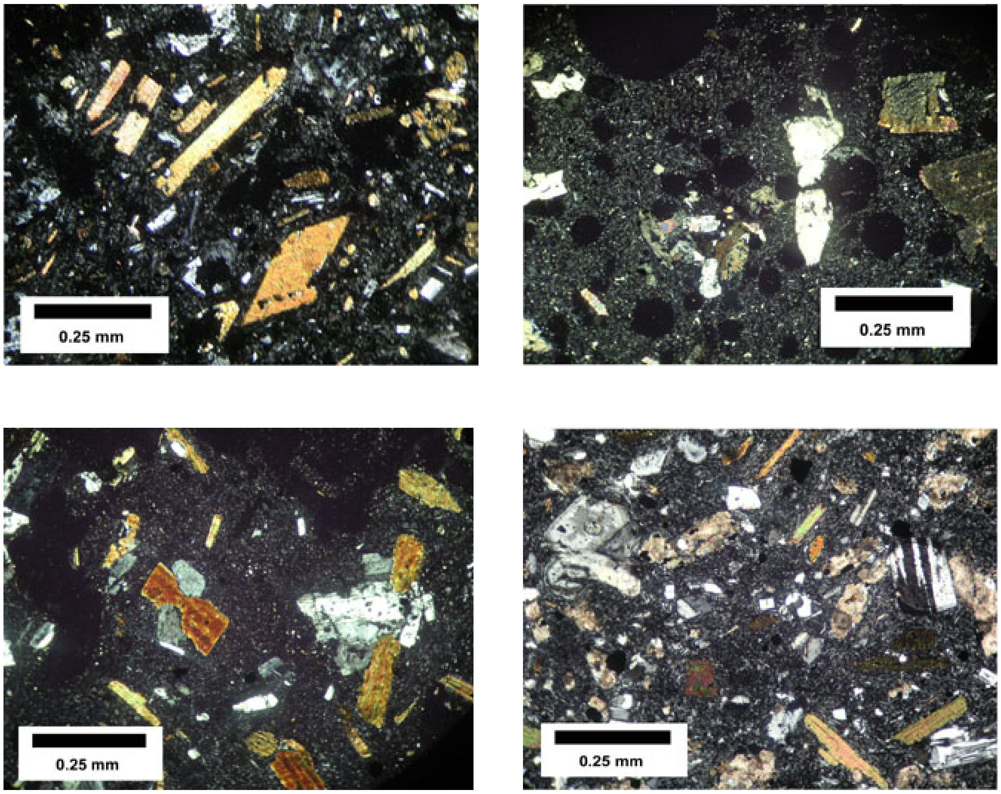

Figure 6. Petrographic of selected samples. **Biotite** andesite shows flow of phenocryst of pseudoamphibole biotite and other biotite (a), Vesicular basalt with lack of felsic mineral and absent of olivine (b), Brown amphibole and biotite locked by the later crystal of plagioclase, inside the **Biotite** andesite (c), and coarser groundmass of the dacitic-andesitic, with plagioclase break down into carbonate. Quickly cooled biotite shows by its acicular shape crystal