

**GIS APPLICATION FOR MINERAL POTENTIAL MAPPING OF GOLD  
AND BASE METAL MINERALIZATION,  
IN PACITAN DISTRICT, EAST JAVA PROVINCE**

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***Abstract***

*The research area covers the administration of the Pacitan District, East Java Province. Geological data, such as lithological data, structural data, contour data and alteration, were used in analyses and making evidence maps. The geological data yield six evidence maps such as NE-SW lineament, NW-SE lineament, hostrock, heat source, kaolinite alteration and iron oxide alteration maps. Evidence maps were analyzed by weight of evidence methods to result in favorable maps, where the validity was tested using conditional independence (CI), the pairwise and overall tests. Then, the analyses produced a posterior probability map. Posterior probability map (mineral potential maps) was validated by checking field to determine the next exploration target zone cluster.*

*Posterior probability map (after validation) / favorable map predicted approximately 27,61% (389.83 km<sup>2</sup>) including the favorable zone and approximately 72,39% (1021,79 km<sup>2</sup>) including non favorable zones. Favorable zones are divided into three classes. The target areas were divided into five clusters areas of mineralized potential zone.*

**Keyword:** *GIS, weight of evidence, mineral potential mapping, Pacitan District*

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## 1 INTRODUCTION

GIS used as software to integrate multiple layers of geology data into a mineral potential maps, it help identify prospect for mineral exploration. This capability contributes to make GIS a very powerfull tool in mineral exploration (Harris et al., 2006).

The study area located in Pacitan district (Figure 1) is a hilly region with high and steep topography and only a few places that form the plains. Geologically, Pacitan had been known to have very large potential minerals, therefore it needs integrated efforts and sustainable management in order to be able to contribute optimally to local governments and communities. Metallic minerals that are considered to be economically important are gold and base metal.



Figure 1. East Java province map dan Pacitan district as study area which is shaded gray

## II RESEARCH METHODS

The principle of exploration models in this research divided into variables which being identifier where the minerals are located, such as lithology, geological structure and interpretation of satellite imagery. The outline of the research methodology comprises four phases (modification from Rojash, 2003) which consists of :

1. Determination of the model sediment deposits of gold and base metal mineralization (Corbet, 1996);
2. Data gathering and data entry to be used as a weighting variable;
3. Refinement, extraction and data integration and
4. Determination of the relation between the variables of geology, ASTER image analysis with the model deposits of gold and base metal mineralization; determinion of areas of potential and test validation.

### II.1. Evidence Data Preparation

In addition to lithological, structural, and satellite image data, other data required in further processing were hardcopy of geological map of Pacitan district, mineral deposit data compilation and alteration, which were obtained from mining

companies, as well as previous researches, then ASTER satellite image and altitude contour data.

## II.2 Data Processing

Data processing is using some softwares : satellite imagery processing softwares and geographic information system (GIS) that consist of ENVI 5, Arc.GIS 9.3, Map Info 10 Discover 12, Global Mapper 11 and Microsoft Excel 2010. The whole data were then converted into the local projection of Pacitan WGS 1984 with coordinate system of latitude and longitude (longlat) units of degrees, minutes and seconds.

### II.2.1. Geological Map Data Processing

The process began by scanning the whole geological map data. Then the geological map in image format (jpg) was digitized using Map Info 10 which was previously conducted by registration with the coordinate system of latitude and longitude coordinates (longlat) WGS 1984. After digitizing, then select these two lithological criteria i.e.: the host rock and intrusive rocks based on the general character of rocks those are closely linked to the presence of deposits or which are then used to determine the type of rock those were able act as the hostrock and intrusive rocks/heat source in the formation of mineralization. Results of these data processing is to perform evidence hostrock map and evidence heatsource map.

The geological structures which is exist in geological map is also digitized so that at the end it can be used as the consideration of *Data Elevation Model* (DEM) structure delineation.

### II.2.2. Aster Satellite Image Data Processing

#### A. Pre-Processing

Pre-processing is proceeding before the level 1B image further processing, this stage is intended to eliminate the damage caused by sensor effects and atmospheric effects maximally, then register the image into a precise map projection (Gozzard, 2006) which includes the Crosstalk correction, Radiance calibration, Orbital parameters correction, East-west offset of SWIR bands, Layer stacking, Dark pixel correction, image mosaicking, masking Cloud.

#### B. Processing

Stages of image processing includes:

##### a. Cropping image

Cropping image is the image cutting process in order to reduce the overbroad study area, based on administrative boundaries of Pacitan district, East Java Province. Image cutting process using ENVI 5 or with ArcGIS 9.3 by condition both files will be cut have the same datum and projection.

##### b. Normalized Difference Vegetation Index (NDVI)

Before mapping the surface mineral distribution, it has to begin by identifying the density of vegetation by Normalized Difference Vegetation

Index (NDVI) method. Vegetation density mapping aims to identify the characteristics of land cover, and as an early indication of the presence of mineral deposits through vegetation (Rojas, 2003). NDVI normalization calculation is obtained by using visible wavelength bands (red) (band 2; 0.63 to 0.69 m) and near infrared (band 3; 0.76 to 0.86 m).

Normalization before vegetation density calculation aims to that NDVI which has a negative value (-) and water bodies would not be included to the calculation. NDVI calculation according to Kalinowski and Oliver, 2004 are :  $NDVI = (NIR - Red \text{ Band Band}) / (NIR + Red \text{ Band Band}) = (3 - \text{Band Band } 2) / (3 + \text{Band Band } 2)$ .

Near infra red Band and Red Band are albedo value in the range of wave lengths of 3 and 2 on the ASTER image. NDVI value obtained from the above formula ranges from -1.0 to 1.0.

c. Defoliant Methods

Image processing for mapping the mineral surface in vegetated areas consist of three stages. The first stage using defoliant methods to improve the spectral response of surface minerals, which is based on the response of spectral minerals reflectance. Second, the sample extraction area (training area) as the reference pixel containing mineral surface alteration. Third, supervised classification by determined the threshold limit of the processed image, in order to obtain a map of surface mineral alteration distribution.

The next stage is to extract the training sample area that has been known to either containing or not a deposit of gold and base metals to be integrated into alteration distribution processed output produced before proceeding the further classification process. Supervised classification process is performed by using the maximum likelihood method (Richards, 1999, in Carranza and Hale, 2000).

Accuracy rate calculation of identified minerals alteration using formula by comparing the number of alteration distribution points of training data point be in mutual accord to the pixel position of the ASTER image alteration results, divided by total number of points which have available alteration information on the training point. The level of *overall classification* or *overall performance class* can be calculated by summing total number of pixels that are classified and dividing by the number of pixels that will be tested.  $Overall \text{ Classification} = (\text{number of convenient alteration pixels}) / (\text{Total alteration sample})$ .

### II.2.3 Contour Data Processing

Contour data used to identify geological structures and patterns of lineament that exist in the study area. Contour data process began by cropping convenient to the administration of Pacitan district, then made into a digital map elevation model (DEM) using software Global Mapper 11 or ArcGIS 9.3, afterwards proceed it in to hillshade form so that the contrasts area can be more visible. The image later can be processed to extract the appearance of lineament pattern in study area.

The process of delineation of geological structure performed manually (on screen) by dragging a line on the areas that are considered to have certain characteristics, by changing the solar radiance direction on the angle of radiation 315°, 0°, 45°, 90°, 135°, 180°, 225°, 270°, and then the whole map is combined into one (fusion). Results of structure derived from former geological map which is combined with map of Hillshade DEM, eventually it can be determined the confirmed alignment as the new geological structure and lineament as the results of the manual on the hillshade DEM map.

Lineament and geological structure which are obtained from delineation result created the influence area/buffer in order that it can be identified how far the relation between the presence of a mineral deposit as well as geological structure.

#### II.2.4. Training Point Mineral Deposits / *Known Deposits*

Preced by compile entire data of mineralization potential deposit, selected which have association with gold and base metals, then registered to map Pacitan in the form of map info table / shapefile that can be integrated with other data. The data used is then divided into two parts, the first is used as a model for the deposit and the rest is used as a validation point.

Beside the mineral deposit data, the selection of data against training point which is associated with alteration of kaolinite, iron oxide alteration, as well as non rock alteration. Then proceed *thresholding* to the point of each hydrothermal alteration maps, both kaolinite and iron oxide alteration. This method later called as supervised classification. The data used to clarify the distribution of hydrothermal alteration resulting from the processing of ASTER image.

#### II.2.5 Spatial Data Processing

Evidence map which had been produced later proceed in buffer due to the presence of mineral deposits, the optimal distance selected by condition of deposit presence > 70%. Data analysis was conducted using weight of evidence (WOfE), to gain information about how much weight and relevance of each geological variable (evidence map) to the presence of mineral deposits in the form of a matrix comparison. Analysis sequence methods of weight of evidence in the study area (modified from Schmitt, 2010) :

- 1) Determine the criteria for the model, i.e. the mineralization deposits Gold and Base Metal Mineralization in the Circum-Pacific (Corbet and Leach, 1996).
- 2) Geological data processing such as lithologic, structure, alteration, contour data into a map of evidence.
- 3) Determine the number and percentage of deposits that are known precisely by predicted in the model, i.e. the number of occurrences located within the favorable zone, at least > 70% of the mineral deposits which are known to be acceptable.
- 4) Evidence maps analyzed by software ArcGIS /MapInfo in determining the reclassification boundary and those had been reclassified earlier in the form of binary values 1, and 0 is no prospect prospects.

- 5) Each evidence map should be tested such as *pairwise* test and *overall test of conditional of independence* (CI).
- 6) Weight (weight) is calculated, and the reclassification of the evidence map combined to produce favorability map using raster operations calculator.
- 7) Determine the percentage of the area including to favorable zones (areas with posterior probability greater than the prior probability), it is acceptable if the area percentage of favorable zones at least about 25%, and by determining the number and percentage of knowing deposits which is precisely predicted in the model.
- 8) Favorable maps (posterior probability map) reclassified into multiclass map, divided into three classes, i.e. high potential, intermediate potential and low potential. Then conducted to the field validation (field checking) randomly against the posterior map.
- 9) Determination of the target of cluster further exploration area.

### II.3 Type Of Data

The data used in this study is a semi-detail geological map of all sub-districts of Pacitan, ASTER image of Pacitan and surrounding areas, Pacitan contour data, alteration assay data and non alteration, presence of metal mineralized deposits compiled by local mining companies and from the Department of Mineral and Energy of Pacitan District Government.

## III. EVIDENCE MAP DESIGNATION AND WEIGHT OF EVIDENCE (WOFE) MODELING

Evidence map is the result of the evidence data processing. Whole data converted into digital format. The selected data should be important and relevant to this study such as the lithological, structural, hydrothermal alteration map refers to the study of literature and the earlier research.

### III.1. Lithology

The most important information related to the geological map is lithological data and age of the individual rock units. Lithology data are taken from semi-detail geological maps of study area by scale of 1 : 25,000 (Widiasmoro, 2003) which divides the study area into several lithologies, generally dominated by volcanic clastic rocks Oligo-Miocene age. Lithological data has great potential for gold and base metal deposits modelling in the study area. Based on the general characteristics of metallic mineral deposits on other prospects and in the study area, it divided into two criterias, namely the host rock lithology / host rock (Figure 2) and rock heat source / heat source (Figure 3).



Figure 2. Hostrock evidence map of study area

The hostrock of Pacitan district, the rock metal mineralization is preserved in polymic breccias unit, volcanic sandstone unit, microdiorit unit, the lava flow breccias unit and andesite-dacite unit (Widiasmoro, 2003), these potential unit contain Cu, Pb, Zn, Ag elements, (Figure III.1), yet the units are considered as non parent rock (non hostrock).

While the lithological unit which has role as heat source in the mineralization process are dacite intrusions, andesite, pyroxene andesite, granodiorite, and microdiorit (Figure III.2).

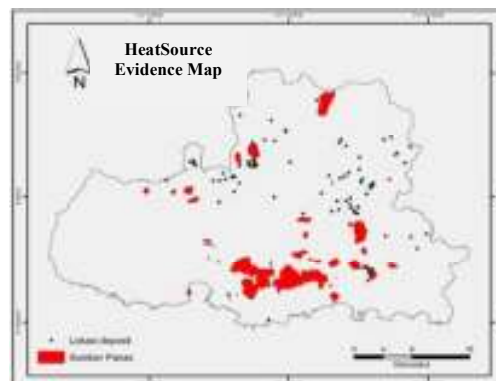


Figure 3. Heat source evidence map of study area

### III.2. Geological Structure

Analysis of geological structure and lineament are used to find the link between the presence of geological structures in the study area with mineral deposits, as well as determine the direction of the the most influential structure in the formation of mineral deposits.

In addition to the processing of digital elevation model maps are also conducted to support the information of geological structures. Further processing with manual methods/on screen to create a Hillshade map using lighting effects at the inclination of 135°, 180°, 225°, 270°, 315°, 0°, 45°, 90°. Selection of this angle is intended to perform shading effects that show indications of alignment

due to the structure, especially to find the general direction of the dominant structure in the study area. the result of hillshade map performs the best image effects at the inclination  $315^\circ$ ,  $0^\circ$ ,  $45^\circ$  and  $90^\circ$  (Figure 4), then four different angles of inclination combined (fusion) into one hillshade map (Figure 5).

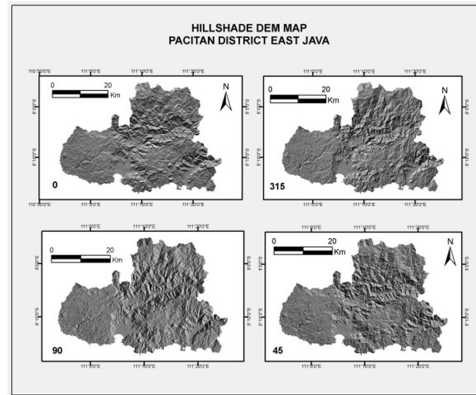


Figure 4. Hillshade DEM map with inclination  $315^\circ$ ,  $0^\circ$ ,  $45^\circ$ ,  $90^\circ$

Structure delineation map further broadly classified into two general directions, that is NE-SW lineament and NW-SE lineament.

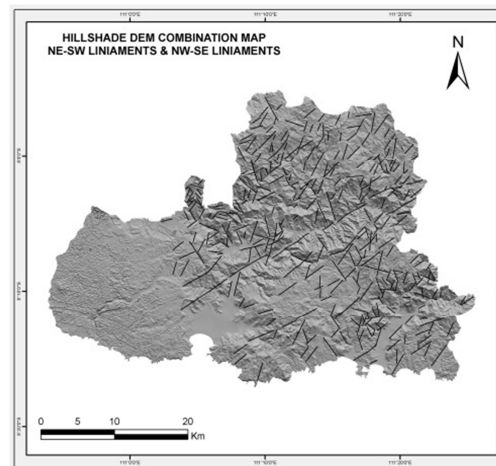


Figure 5. Combination map of hillshade DEM with inclination  $315^\circ$ ,  $0^\circ$ ,  $45^\circ$ ,  $90^\circ$  and lineament of manual delineation/on screen

### III.3 Hydrothermal alteration

Hydrothermal alteration in the study area is obtained by processing information from ASTER image. ASTER imagery application usage in study area is to gain the information types of kaolinite alteration / clay and iron oxide (limonite) by using the method of defoliant (modification Rojas, 2003).

#### III.3.1. Kaolinite alteration (clay)

Band ratio 1: 2 and 5: 6 based on the spectral can detect the mineral kaolinite and vegetation. Vegetation was detected with a ratio of 1: 2 and kaolinite with ratio of 5: 6 (Table 1). Based on the results of principal component analysis on two ratios bands above, it appears that the DPC 2 can be used to see



indications of the distribution of the mineral kaolinite, where in PC 2 the existence of the mineral kaolinite and vegetation objects can be distinguished. Mineral kaolinite in the image has a bright hue (Figure 6).

Table 1. Directed Principal Component Analysis of the ratio band ASTER imagery to detect mineral kaolinite with defoliant method

Principal Component	Eigen vector	
	Band 1:Band 2	Band 5:Band6
DPC 1	0.99926	0.03848
DPC 2	<b>-0.03848</b>	<b>0.99926</b>

To gain sample between the regions containing and not containing mineralization extracted from training point of the territory that had been known associated with kaolinite alteration, trainingpoint derived from compiled data of the mining company. The statistical method used is the supervised classification with maximum likelihood approach (Rojash, 2003).

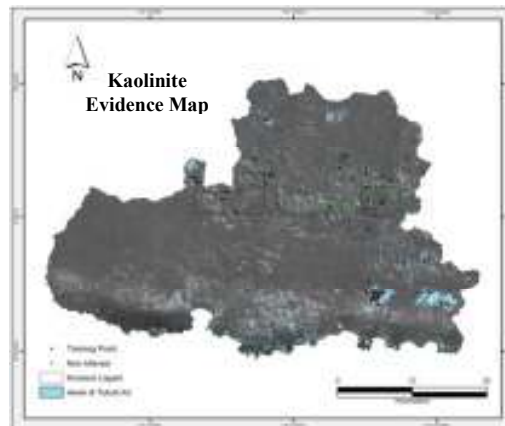


Figure 6. Kaolinit alteration zone using defoliant method, kaolinit alteration identified from bright pixel

The principle of the *maximum likelihood* method is to find the parameter values that provide the greatest possibility (likelihood) to gain the observed data as an estimator. The further tresholding process is to change the gray image into a binary image (red and white) in order it can be separated between containing area of kaolinite alteration and no kaolinite alteration (Figure 7)



Figure 7. Kaolinit alteration zone after *threshhold* processing. The rectangular line is concenssion area belong to local companies

### III.3.1. Iron oxide alteration

Band ratio 1: 2 and 3: 4 based on spectral value can detect minerals iron oxide (limonite / hematite) and vegetation. Vegetation was detected with a ratio of 1: 2 and iron oxide with a ratio of 3: 4 (Table 2). DPC 2 can be used to see an indication of the distribution of iron oxide minerals, by PC 2 the presence of iron oxide minerals and vegetation objects can be distinguished. Iron oxide minerals in the image has bright hue (Figure 8). Afterwards the same processing method as in the kaolinite alteration proceeding, to separate the pixels which indicated iron oxide alteration and non iron oxide alteration.

Table 2. *Directed Principal Component* analysis of ASTER image band ratio to identify iron oxide mineral (limonite/hematite) using *defoliant* method

Principal Component	Eigen vector	
	Band 1:Band 2	Band 3:Band4
DPC 1	0.00896	0.99996
DPC 2	<b>0.99996</b>	<b>-0.00896</b>

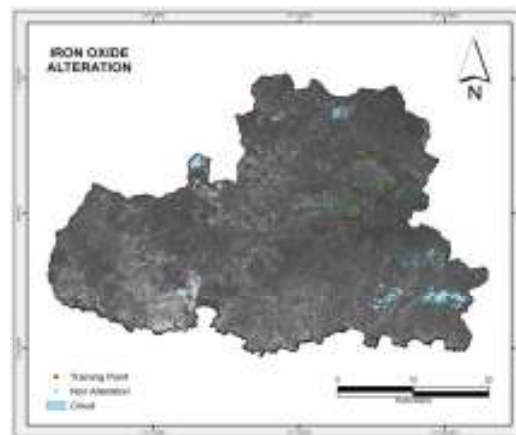


Figure 8. Iron oxide alteration zone using *defoliant* method. Iron oxide alteration identified from bright pixel

### III.3.3. Distribution Validation Of Hydrothermal Alteration Map

Testing towards the accuracy of distribution maps of the hydrothermal alteration minerals known on the ASTER image processing should be validated, coordinate position (pixel) with exploration result data and mapping field data. This is useful in determining the percentage of accuracy of the resulting alteration maps.

If the alteration pixels of the analysis of image processing has higher value than to threshold, it can be known to be consistent and whereas if it is below the threshold value is known to be an error factor. Alteration validation by the above method produces a total accuracy rate of 82.5% of hydrothermal alteration (Table 3).

Table 3. Hydrothermal alteration accuracy rate of validation result by *training point* data of companies compilation

Alteration	Threshold Value	Information	Number	Overall Accuracy (%)
Kaolinit	3.615759	All sample	20	85
		Match training point	17	
		Not match training point	3	
Iron oxide	2.074133	All sample	20	80
		Match training point	16	
		Not match training point	4	
			<b>Total Overall Accuracy</b>	<b>82.5%</b>

### III.4. VEGETATION INDEX

Vegetation density analysis proceed using NDVI index, which is function of NIR with VNIR  $((TM3-TM2) / (TM3 + TM2))$ . After obtained the value of the data above, NDVI has a value range of -1 to 1 (Figure 9). Then the distribution of vegetation is proceed using data validation land cover map of Bakosurtanal 2002 and observations in the field.

Based on the results of the processing, the density of the vegetation of study area are divided into five classes, the body of water, such as a river, lake or marsh tidal, it has pixel values -1 and -0.5978 occupies an area of 4.72% or 65.10 km<sup>2</sup>. Wet and dry rice field has a pixel values - 0.5978 up to 21.98% -0.2707 occupies an area of 302.63 km<sup>2</sup>. Soil/field has pixel values -0.2707 to -0.00124 39.36% occupies an area of 542.11 km<sup>2</sup>, grove has pixel values up to 0.3552 - 0.00124 occupies an area of 26.47% 364.58 km<sup>2</sup>, while forests covered by huge trees and dense vegetation has a pixel values of 0.3552 to 1% 7:46 occupies an area of 102.72 km<sup>2</sup> (Figure 10)

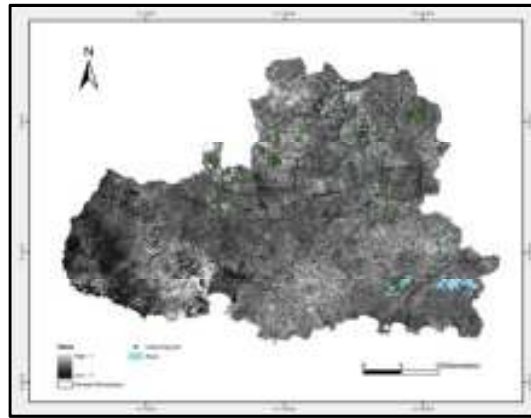


Figure 9. NDVI of study area

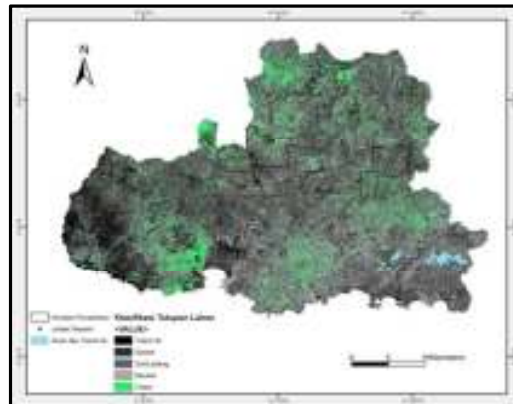


Figure 10. Land cover classification of study area

### III.5 SPATIAL ASSOCIATION OF DEPOSIT MINERAL WITH EVIDENCE MAPS

Data of evidence map used in predicting the distribution of gold and base metal mineralization in the study area consist of six evidence maps, there are NE-SW direction lineament, NW-SE direction lineament, host rock, intrusive rocks/heat source, kaolinite alteration, and iron oxide alteration.

Mineral deposits (training point) is divided into two, the first is 61 sites (73.5%) as a model for the deposit and 22 sites (26.5%) used as validation of the deposit. One of the data driven modeling assumption is that every single pixel has only one deposit / training point (Schmitt, 2010) in the study area, one pixel represents a 30m x 30m in a probabilistic mapping of gold and base metal mineralization potential. Evidence map later validated by conditional independence testing.

Conditional independence test is divided into two, pairwise test (chi-square test) and overall test.

### III.5.1. Pairwise test/chi-square test

Results on the calculation of conditional independence over the pair of binary map evidence summarized in Table 4, with a degree of freedom 1 and the 98% confidence level, that the chi-square value of 5.412. From the 15 pairs of evidence binary map, only one pair which has relation/conditional dependence i.e a pair of evidence map of NE-SW lineament and evidence kaolinite map. If there is any relation between evidence binary map, based on the value of  $X^2$ , this map can still be combined into mineral potential map with previously overall test on the conditional independence (Carranza, 2002).

Table 4. *Chi square* value as *conditional independence* testing of six pairs of *evidence* binary map which is related to gold and basemetal presence

EVIDENCE MAPS	NW-SE	HOSTROCK	HEAT SOURCE	KAOLINIT	OKSIDA BESI
NE-SW	0,983	0.674	3.442	<b>6.684</b>	0.031
NW-SE		0.002	0.735	0.002	1.810
HOSTROCK			0.357	0.674	0.357
HEAT SOURCE				2.169	2.897
KAOLINIT					0.435

### III.5.2. Overall test

Overall conditional independence testing on the posterior probability maps are presented in Table 5. Whole map of evidence presented, so that resulting deposit predictions about 62.77 higher about 2.82% than the observable deposit model (61 deposit), so that the posterior probability map is acceptable and statistically valid (qualified prediction deposit <15%).

Table 5. Outline of *overall test conditional* result of posterior probability map

Probability value in map	Area (km <sup>2</sup> )	Deposit predicted
0,230775	116,70	26.93
0,059262	253,63	15.03
0,047907	135,27	6.48
0,015807	906,20	14.32
<b>Total</b>	<b>1412</b>	<b>62.77</b>

### III.5. Weight of Evidence Modelling

The ultimate buffer distance of cutoff values is selected by the presence of deposits which are more than 73.5%, studentized C and significant contrast, with 6 evidence maps, i.e. evidence map of NE-SW lineament, evidence map of NW-SE lineament, evidence map of hostrock, evidence map of heatsource, evidence map of kaolinite alteration and evidence map of iron oxide alteration. If the deposit models used 61 point location, large of study area is 1411.8 km<sup>2</sup>, then the value of the prior probability / prior probabilistic  $P\{D\} = 61 / 1412 = 0,043207$  and  $\log_e O\{D\} = -3,141747$ .

Favorability map of gold and basemetal potential which are used for validation of deposit model is divided into two zones, favorability zones and non

favorability, the posterior probability which has number above the prior probability ( $> 0,043207$ ) were classified as favorable zone, while the rest are included to the non zones favorable (Carranza, 2002). Favorable map for gold and base metal mineral potential can be seen in Figure 11.

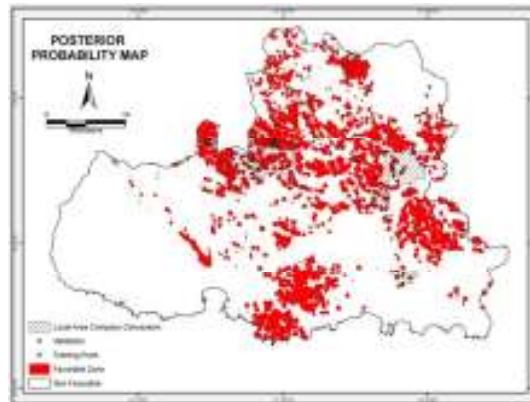


Figure 11. *Posterior (favorable)* probability map of mineralization potential of study area which is performed six *evidence* map

Based on Figure 11 indicated that 27.61% (389,83km<sup>2</sup>) area including to favorable zone and 72.39% (1021,79km<sup>2</sup>) area including to non zones favorable due to the presence of gold and base metal deposits. The presence of gold and base metal deposits in this map as much as 59 deposit or 96,72% in the favorable zone, and as much as 2 deposit or 3,28% on non-favorable zone than in the deposit model, while to validate the deposit of mineralization presence in non favorable zone 5 deposit is present (22,73%), while in the favorable zone as much as 17 deposit is present (77,27%), so that the validation test are statistically acceptable (qualified presence of deposit  $> 73,5\%$ ).

Favorable zones are divided into three classes, which has greater posterior probability value than the prior probability ( $> 0,043207$ ). Posterior probability value from 0,043207 to 0,047907 including to the class of low potential, probability value from 0,047907 to 0,059261 including to the medium potential and probability value 0,059261 to 0,230775321 belongs to the class of high potency. Referring to Figure 11 indicated that approximately 135,27 km<sup>2</sup> (9,58%) have a low potential, approximately 253,63 km<sup>2</sup> (17,97%) have intermediate potential, approximately 116,70 km<sup>2</sup> (8,27%) have high potential.

Occurrences of high potential mineralization is closely related to the host rock and geological structures both NW-SE direction and NE-SW direction lineament, this structure developed a flow of hot magma fluid which consequently create a trap container structure as potential ore deposit occurrences. While lithological unit which support the existence of high ore potential such as polymic breccia, volcanic sandstone, volcanic breccia and intrusive rocks from the Late Oligocene up to Miocene.



Figure III.11.

Multiclass posterior probability map and cluster area of potential gold and base metal mineralization in the research area

In high potential class perhaps have the most numerous metallic mineral deposits, medium potential medium has ranked second after the high potential and low potential in final rank is still possible has metal deposits there. Determination and distribution of the cluster area of mineralization conducted on an area that has the highest probability (the red zone).

Cluster areas of potential mineralization multiclass posterior probability map is divided into five zones, namely Zone 1, Zone 2, Zone 3, Zone 4 and Zone 5. Zone 1 is located in Arjosari Sub-district, Punung Sub-district and Nawangan Sub-district. Zone 2 include the Bandar Sub-district, Tulakan Sub-district, Tegalombo Sub-district, and Ngadirojo Sub-district. Zone 3 is in the northern part of the Nawangan Sub-district. Zone 4 is located at the east on the the Tegalombo Sub-district while Zone 5 is located in Kebonagung Sub-district, Tulakan Sub-district and Ngadirojo Sub-district.

#### IV. CONCLUSION

Potential mineral mapping using Geographic Information System (GIS) based on the weight of evidences method (WofE) is very useful in the analysis of potential occurrences of gold and base metal deposits in Pacitan, East Java Province. WofE method is also sensitive to the presence of the deposit amount and the large of study area, especially when there is a deposit model had been known (known deposits).

Favorable map predicted approximately 27,61% (389.83 km<sup>2</sup>) including the favorable zone and approximately 72,39% (1021,79 km<sup>2</sup>) including non favorable zones. Favorable zones are divided into three classes. The target areas were divided into five clusters areas of mineralized potential zone.

In further studies can be developed parameters of analysis data such as geomagnetic anomaly, geophysical anomaly, stream sediment, and using other prediction methods of mineral potential mapping and compared with the Weight of Evidence method (WofE).

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