Geomorphology and iron sand potential at coastal sediment morphology, Kebumen Regency

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Abstract. Geomorphology is a landform that extends on the surface of the earth as a result of interactions between endogenous and exogenous processes. Landform classification based on morphometry, morphogenesis, and morphoarengement. Kebumen has attractive geological diversity. The potential of iron sand spread out as beach sand deposits. This research conducted to map landforms, including south coast region and analyze the distribution of iron sand sediment. The study used DEMNAS image analysis, a 1: 20,000 scale with Arc-GIS software. Variables analysis includes elevation, aspect, roughness, hill shade, river pattern, and hill roughness accompanied by a field survey. Resistivity survey on old beach deposits morphology (2 locations) and young beach deposits (2 locations) to obtain data on the potential of iron sand. Measurement using OYO Model 2, McOHM Resitivimeter, Schlumberger configuration, and geophysical modelling using Res-2Din software. The landform in Kebumen consists of 33 units as structural, denudational, dissolving, fluvial, and coastal landforms. The Coastal Sediment landscape consists of 3 units, in the form of young coastal sediment, old coastal sediment, and fluvio marine sediment. The potential of iron sand is founded in young coastal sediment (M5) is about 764,77 Ha, and old coastal sediment (M4) about 590,84 Ha. Mineral compositions are olivine, pyroxene, hornblende, biotite, and impurities as quartz, plagioclase, orthoclase, rutile and calcite minerals. Coastal sand sediment in the Old Sediment is found 30-60 m depth with overburden up to 4 m. The potential of beach sand about 406,686,300 m3 similar with 1,037,050,065 tons, total Fe estimated about 629,696,799 tons.

Keywords: Kebumen, geomorphology, coastal sand deposit, iron sand, potential

1 Introduction

1.1 Background Study

Geomorphology defines as the science that describes landforms and processes that affect their formation and investigates the interrelationships between landforms and processes in spatial order [1]. Geomorphology is a science of landforms, especially about nature, origin, the process of development, and material composition [2]. It is talks about landforms that carve the earth's surface, emphasizing the way it is formed and the context of its environment which are studied by emphasizing the process of formation and development in the future, and its context with the environment [3, 4]. The underlying bedrock and structure will have a profound influence on the landform (e.g. structural hill, granitic residual hill etc.) [5].

The landform is the physical appearance of our earth as a result of geomorphological processes that work on the surface of the earth due to the influence of endogenous or exogenous forces or a combination of both. It is a result of geomorphological processes which is influenced by lithological conditions, geological structures and the length of geomorphological processes.

Geomorphology map is a precise and systematic picture of landforms and other related phenomena. It can be divided into standard maps for general purposes and thematic maps for specific purposes. The contents for general purposes include all aspects such as landform units, lithology, topography, flow patterns, geomorphological processes, and age/chronology [6]. Landforms can be used as characteristic units by having similarities that are influenced by topographic factors and geological structures and exogenous processes [7]. The study of landforms at the same time can represent the condition of slopes, drainage, and soil in general [8].

According to [9], landforms are land surface configurations produced by natural processes. Landforms are morphologies and land surface characteristics as a result of interactions between physical processes and crustal movements with the geology of the earth's surface layers [10]. [8] believes that land characteristics are very important in interpreting land use, as well as landforms, whose existence is influenced by topographic factors and geological structures and exogenous processes.

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Landforms can be used as land characteristics that have similarities in each unit. Information from this approach contains a set of variables that affect each type of land use, so homogeneity of land use will be obtained in terms of land characteristics [11]. There is a pattern of gradation in an environment, and the higher elevation is correlated with a decrease in temperature and the addition of rainfall so that there are differences in community and population [12].

The land analysis classification system developed by ITC [1], is used for surveys of various scientific disciplines; various levels of detail; allow clear differences between homogeneous units by using aerial imagery/photographs to minimize sampling in the field, and allows (Table 1) for generalizations.

Table 1. Geomorphology classification base on slope and elevation [1].

Unit	Slope (%)	Elevation (m)
Plain	0-2	< 5
Undulating	3-7	5-50
Undulating-Rolling	8-13	25-75
Rolling	14-20	50-200
Rolling-Hilly	21-55	200-500
Hilly	56-140	500-1000
Mountainious	>140 %	>10000

The geomorphological classification refer to the formation of morphology caused by geological processes, both endogenous and exogenous; the shape of the earth landscape divides into 9 main classes, namely 1. Folds Mountains, 2. Plateau Mountains, 3. Fault Mountains, 4. Volcano Mountains, 5. Karst Mountains, 6. River and Lake Plains, 7 Coastal Plain, Delta and Sea, 8. Desert, 9. Glacial [13].

Iron sand is a metal mineral resource that is produced from the weathering and transportation of iron-containing rocks. On the southern coast of Kebumen, the potential for iron sand is spread over 39.16 km length, as young coastal sediment. Magnetic minerals are more common in the East (Mirit) than the West (Puring). Optimal acquisition of magnetic minerals in the East is obtained at grain sizes +120 # to -120 # with a magnetic intensity of 200 G (66.46% to 81.47% by weight). Optimal magnetic mineral acquisition in the west can be at a rough size (+ 35 #) with a magnetic intensity of 1000 G (59.05% by weight). The total Fe content of magnetic minerals is opposite to SiO_2, while TiO_2 follows the total Fe pattern. The highest total east Fe (56, 57%) was obtained at grain size + 120 # with a magnetic intensity of 200 G, while the western part (60.72%) at size -120 # with a magnetic intensity of 200 G, but the percentage of magnetic minerals was only 34 - 39% by weight [14].

1.2 Regional geology

Kebumen Regency is an area that has interesting geological condition, because the diversity of rocks formation and age from the Cretaceous to Quaternary

According [15] the stratigraphy of Kebumen and surrounding areas includes the Luk Ulo Melange Complex (Ktm), Karangsambung Formation (Teok), Totogan Formation (Tomt), Gabon Formation (Tomg), Waturanda Formation (Tmw), Penosogan Formation (Tmp), Kalipucang Formation (Tmk), Members of the Halang Formation Breccias (Tmpb), Halang Formation (Tmph), Peniron Formation (Tpp), Coastal Deposits (Qac) and Alluvial Deposits (Qa) as shown in Figure 1.

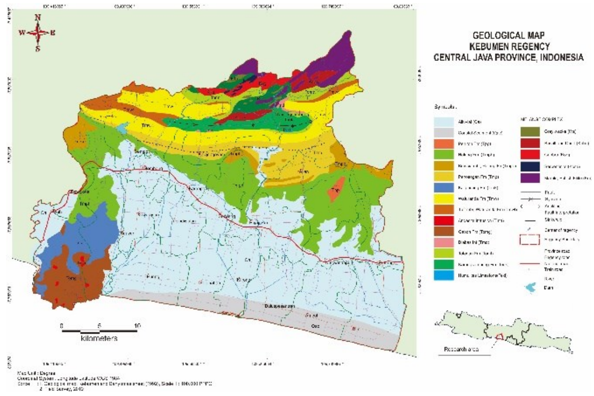

Fig. 1. Geological map of a research area

1.3 The Urgent of study

The geological condition of Kebumen Regency is very complex, but geomorphological mapping based on elevation, aspect, roughness, hill shade, river pattern, and hill roughness variables have never been done. Iron sand is a metal mineral that is still much needed for the steel industry. In Purworejo Regency, coastal deposits are divided into old and young beaches, both of which have the iron sand potential [16]. Meanwhile, the existence of coastal sediments in Kebumen Regency has not been carried out research on the distribution of the existence of these types of coastal sediments. This research was conducted to map the landscape in Kebumen District and analyze the potential distribution of iron sand sediment resources based on field observations and geoelectrical resistivity.

2 Methodology

This research was conducted through DEMNAS image analysis, a 1: 20,000 scale using Arc-GIS soft ware. Variables analyzed include elevation, aspect, roughness, hill shade, river pattern, and hill roughness. The results of the analysis are then overlaid to get a geomorphological map. The results of the GIS analysis are then carried out a field survey for correction and taking pictures. The landform classification is based on a combination of morphological classification by [1] and [13]. Iron sand data was carried out through geo-electric surveys using the OYO Model 2 Mc OHM Resistivity meter, Schlumberger configuration in Mirit District (2 locations), and Ambal District (2 locations). Geophysical modelling using Res-2Dvif software. The research flow chart can be seen in Figure 2.

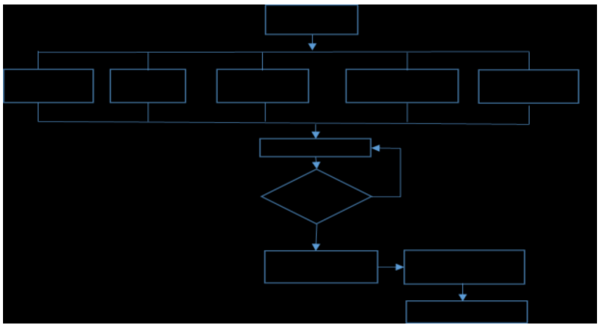

Fig. 2. Flow chart conducted this research

3 Results and Discussion

3.1. Geomorphology

Digital Elevation Model (DEM) data provided a fast and inexpensive way to extract geomorphic features indicated by topography, DEM successfully visualized the topography [17]. Based on the analysis of Demnas imagery, an elevation map, hill shade map, aspect map, roughness map, flow pattern map are produced, which are then overlaid into a tentative landform map. Based on the results of image analysis and field surveys, it was found 33 geomorphological map units (Table 2).

Based on the elevation analysis, it can be seen that the height of the study area starts from 0 m (on the south coast) to reach 900 m in Midangan Mts. The distribution of plains is in the southern part of the study area, with an area of around 49.5%. The distribution of height does not gradually rise towards the north but follows the patterns of developing structures (Figure 3.a.)

A hill shade is a grayscale 3D representation of the surface, with the sun's relative position taken into account for shading the image. This function uses the altitude and azimuth properties to specify the sun's position. Based on this analysis, the linear patterns of coastal deposition are seen more clearly as well as the alluvial fan pattern and fold structure that develops in the north. Mottled textures that develop in the southern part of the region can also be clearly observed (Figure 3.b.)

Aspect values indicate the direction of the physical slopes faces. We can classify aspects of directions based on the slope angle with a descriptive direction. An aspect raster output will typically result in several slope direction classes. Based on the aspect map, it can be clearly observed that the pattern of rock layers in the southern part of the Karangsambung tends to be trending west-east, but for the north, it is more towards the NNE-SSW pattern (Figure 3.c.)

Elevation map, hill shade map, aspect map, drainage pattern, and roughness are then overlaid to produce a landform map, which is then carried out a field survey to obtain a geomorphological map of this area (Figure 3.d.). Based on the geomorphological map, there are the structural landforms, denudational landforms, pediment landforms, karstic landforms, alluvial, and coastal sediment landforms.

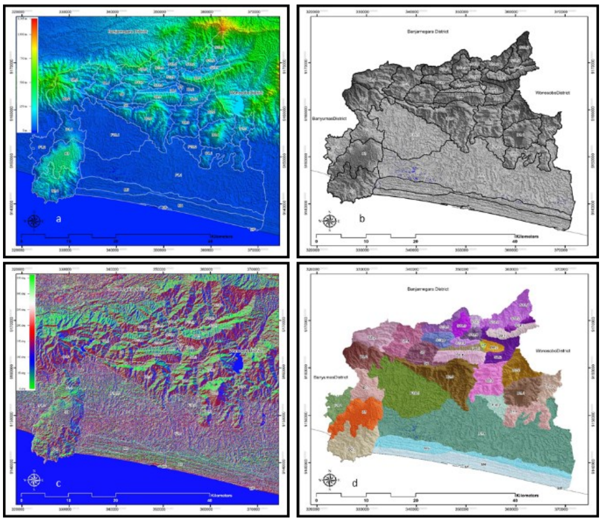

Fig. 3. **a)**. the Elevation map of the research area, **b)**. hillshide map, **c)**. aspeck map, and **d)**. geomorphological map

3.1.1. Structural landform

The structural landforms origin is composed of-rock layers series, both of which have been disturbed by pressure or those that have not been disturbed. This process involves the removal, settlement, and folding of the earth's crust to form geological structures of folds and faults. The main structure can be broken down into various forms based on the attitude of the rock layers and their slope. Landforms of structural origin generally have characteristics such as; dip and strike resistant rocks – non-resistance, the presence of a clear key horizon, the presence of joint, faults, and intrusive rock. In the study area, there are 15 geomorphological units in the form of hills with steep to moderate slopes. Structural landforms are often found in the northern part of the study area, especially in the Mélange complex, which is characterized by faults and joint alignment patterns. Anticlinal mountains/hills are found in Karangsambung which are composed of rigid and semi-plastic rocks, consisting of folded rocks, valleys located on the anticline peaks undergo erosion. Anticline peaks turn into valleys to form the morphology of the Amphitheater. This valley produced maximal erosion, and the Pediment landform is produced with avalanche material from steep walls around it (Figure 4)

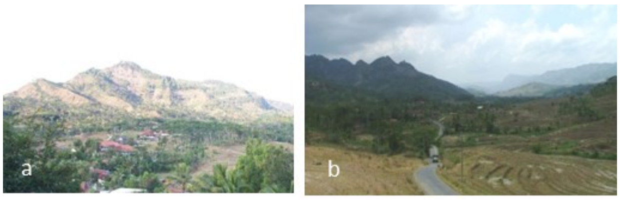

Fig. 4. The structural landforms; **a).**Synclinal ridges of Prahu Mts (S.9.1), **b).** Melange Steeply Hills unit, it is marked by fault blocks and dipping rock to the south (S.13.2), Structural Moderately Hills unit in the middle part (S.13.7), and Synclinal Steeply hills, in the south (S.9.1).

3.1.2. Denudasional landform

The denudation process is a process that tends to change the shape of the earth's surface called the process of nakedness. The main process is degradation in the form of weathering, which produces regolith and saprolite as well as erosion, transport, and mass movement processes. This process is common in hilly units with perishable and unstructured material. The degradation process causes aggradation on the slopes of the hilly legs producing colluvial deposits with mixed material (pediment). Sometimes denudational processes occur in the hills of structures with high weathering rates, so they are called structural denudational units.

The denudational process is strongly influenced by the type of material, slope, rainfall, temperature and sunlight, and relatively non-continuous flows. The characteristics are; the topography is rather rough to rough depending, relief slightly tilted to an oblique, irregular pattern, many dry valleys and slope erosion/back erosion, use of dry land or mixed gardens, and geomorphological processes always leave scars on hill slopes, and accumulation at the foot of the slope, as well as landslide appearances, are more common. In the study area, there were 9 (nine) denudational landforms in the form of steep to moderate hills with a strong to moderate erosion level and spread in the middle to the southeast of the study area (Table 2).

3.1.3. Karst landform

Karst is a German term derived from Slovenian (kras), which means rocky, arid land. According [18], karst as a field with typical hydrological conditions as a result of rock that dissolves easily and has well-developed secondary porosity on limestone or dolomite. It is easily distinguished from other landscapes such as the typical shape of a conical hill, a round hill (pepino hill), the remaining karst pole (tower karst) [2]. Karst does not only occur in carbonate rocky regions, but also occurs in other rocks that dissolve easily and have secondary porosity, such as gypsum and salt rocks. However, because carbonate rocks have the most extensive distribution, karst is often found in carbonate rocks [19].

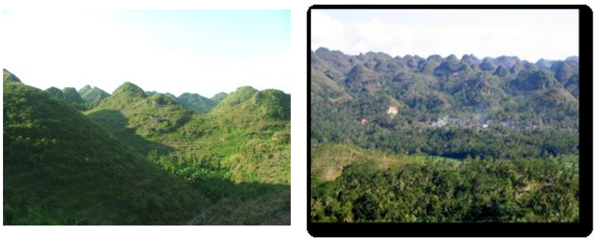

Fig. 5. Karst landforms (K.1) that form the cockpit hills with doline around it, take photographs from Tugu and Argopeni Vilage.

The Karst Landscape in the study area is characterized by landforms with mottled textures, composed of rounded hills spread between closed valleys of relatively uniform size. Relief is relatively rough with high topography and steep slope. River on the surface is not connected to each other, cut off, and entered into rocks (annular type) that form underground rivers. Red soil deposits at the bottom of the valley sometimes close and form ponds, such as the Blembem lake in Pakuran. The South Gombong karst landscape is in the form of small hills with valleys like inverted bowls that are spread evenly; this type of karst is called the Conical Hill Karst (Figure 5).

3.1.4. Fluvial landform

River landform (fluvial) is a result of the fluvial process. Basically, the flow of rivers is formed by the presence of water sources, both rain water, melting ice, or the appearance of springs, and the relief of the earth's surface. The fluvial process is a physical, and chemical process that results in changes in the shape of the earth's surface, which is caused by the action of surface water, whether it is water that flows in an integrated manner (rivers), or water that is not concentrated (sheet water). The fluvial process produces a unique landscape as a result of the behaviour of water flowing on the surface (Figure 6). This fluvial process varies in intensity. Fluvial landforms in the Karangsambung region are fertile and productive areas as a product of accumulate sedimentation due to periodic flooding [20, 21].

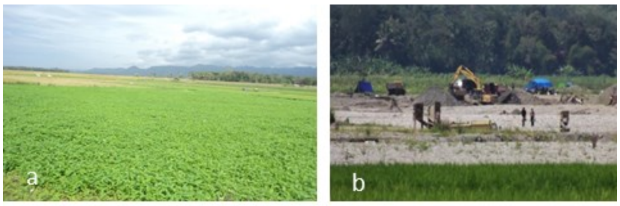

Fig. 6. **a)** Alluvial Plain, High overland flow (F.1.1) around the village of Sidomukti with background of the karst hills (K.1), **b)**. Luk Ulo Flood Plain (F.7), with many sand miners.

3.1.5. Coastal Sediment

Sanddune is part of the landform formed by the work of seawater (waves and currents), both constructive (sedimentary) and destructive (abrasion) processes and are found in coastal areas. Coastal areas are the confluence area between land and sea. The land is dry but sometimes submerged in water due to tides. Also still affected by strong sea winds and able to carry fine material, as well as saltwater permeation. While towards the sea covers parts of the sea that are still influenced by natural processes that occur on land, such as sedimentation and freshwater flow, as well as those caused by human activities such as deforestation and pollution [22].

The Coastal Plain landscape in the study area can be divided into Young Coastal Sediment (M.4) and Old Coastal Sediment (M5) and Fluvio-Marine Sediment (MF). The difference is based on river flow patterns, the shape of sandbanks, land conditions, and morphogenesis that control the formation of the landscape (Figure 7).

Table 2. Geomorphological unit at Kebumen Regency (Figure 3)

No	Topography	Process	Erosion	Formation	Symbol	Geomorphology Unit	Area (Ha)
1	Moderatly Hills	Cuesta	Moderate Erosion	Waturanda-Karangsambung	S6	Cuesta Moderatly Hills , Moderate Erosion	198,363
2	Moderatly Hills	Structural-Denudational	Moderate Erosion	Waturanda-Tuffaceous member	S8.1	Structural-Denudational Moderate Hills, Moderate Erosion	322,503
3	Moderatly Hills	Structural-Denudational	Strong Erosion	Waturanda-Tuffaceous member	S8.2	Structural-Denudational Moderate Hills, Strong Erosion	313,273
4	Stepply Hills	Syncline	Weak Erosion	Totogan-Waturanda	S9.1	Synclinal Steeply Hills, Weak Erosion	155,047
5	Stepply Hills	Anticline	Weak Erosion	Waturanda	S9.2	Anticlinal Steeply Hills, Weak Erosion	246,778
6	Hills	Folding	Strong Erosion	Halang-Penosogan	S9.3	Folding Hills, Strong Erosion	376,277
7	Stepply Hills	Anticline	Moderate Erosion	Waturanda	S9.4	Anticlinal Steeply Hills, Moderate Erosion	212,089
8	Stepply Hills	Structural (Faulting/Jointing)	Strong Erosion	Mafic-ultramafic	S13.1	Melange Steeply Hills, Strong Erosion, Mafic	41,719
9	Stepply Hills	Structural (Faulting/Jointing)	Weak Erosion	Mafic-ultramafic, metamorphosis	S13.2	Melange Steeply Hills, Weak Erosion, Mafic	124,304
10	Hills	Structural (Faulting/Jointing)	Weak Erosion	Mafic-ultramafic, Totogan	S13.3	Melange Hills, Weak Erosion, Mafic-Totogan	127,616
11	Hills	Structural (Faulting/Jointing)	Strong Erosion	Basalt, Chert	S13.4	Melange Hills, Strong Erosion, Chert	72,119
12	Steeply Hills	Structural (Faulting/Jointing)	Weak Erosion	Mafic-ultramafic, Totogan	S13.5	Melange Steeply Hills, Weak Erosion, Mafic-Totogan	164,420
13	Moderatly Hills	Structural (Faulting/Jointing)	Strong Erosion	Metamorphisme	S13.6	Melange Moderatly Hills, Strong Erosion, Metamorphic	80,831
14	Moderatly Hills	Structural	Strong Erosion	Totogan	S13.7	Structural Moderatly Hills, Strong Erosion	60,452
15	Hills	Structural	Moderate Erosion	Waturanda-Totogan	S13.8	Structural Hills, Moderate Erosion	150,706
16	Moderatly Hills	Denudational	Strong Erosion	Halang	D1.1	Denudational Moderatly Hills, Strong Erosion, Totogan	274,543
17	Moderatly Hills	Denudational	Strong Erosion	Halang-breccia	D1.2	Denudational Moderatly Hills, Strong Erosion, Halang-Breccia	193,145
18	Steeply Hills	Denudational	Moderate Erosion	Gabon	D2.1	Denudational Steeply Hills, Moderat Erosion, Volcanic Gabon	496,696
19	Hills	Denudational	Moderate Erosion	Penosogan-breccia	D2.2	Denudational Hills, Moderate Erosion, Penosogan	293,926
20	Steeply Hills	Denudational	Moderate Erosion	Halang-Peniron	D2.3	Denudational Steeply Hills, Moderate Erosion, Halang	687,030
21	Steeply Hills	Denudational	Weak Erosion	Halang-Peniron	D3.1	Denudational Steeply Hills, Weak Erosion, Halang	349,335
22	Hills	Denudational	Weak Erosion	Halang- breccia	D3.2	Denudational Hills, Weak Erosion, Halang Breccia	346,146
23	Undulating-Rolling	Pediment	Weak Erosion	Karangsambung	D8.1	Pediment, Weak Erosion	80,372
24	Rolling	Pediment	Strong Erosion	Karangsambung	D8.2	Pediment, Strong Erosion	73,708
25	Hills	Karst	Dissolution	Kalipucang	K1	Karst Hills, Dissolution	493,998
26	Plain	Alluvial	High Overlandflow	Aluvial	F1.1	Alluvial Plain, high overlandflow	2982,079
27	Plain	Alluvial	Moderate overlandflow	Aluvial	F1.2	Alluvial Plain, Moderate overlandflow	204,816
28	Plain	Flood	Braided-channel	Aluvial	F7	Flood Plain	12,900
29	Flat- Undulating	Alluvial Fan	Strong Erosion	Aluvial	F16.1	Alluvial Fan, Strong Erosion	1101,623
30	Flat- Undulating	Alluvial Fan	Weak Erosion	Aluvial	F16.2	Alluvial Fan, Weak Erosion	146,737
31	Plain	Coastal	Strong Deflasion	Coastal Sediment 1	M4	Young Coastal Sediment	764,772
32	Plain	Coastal-Fluvial	Weak deflasion	Coastal Sediment 2	M5	Old Coastal Sediment	590,849
33	Plain	Fluvio-Marine	Abrasion-runoff	Coastal Sediment 3	MF	Fluvio-marine Sediment	16,813
						Total area (Ha)	11755,985

Fig. 7. a). Sanddune in the Young Coastal Sediment (M4), and swamp as The Fluvio-Marine (MF.1), b). The Fluvio-Marine (MF.1) that forms the Lembu Purwo lagoon at the S. Wawar estuary, Mirit

3.2. Potential of iron sand deposits

The beach deposits in Kebumen are in the form of young beach deposits (M.4) and old beach deposits (M.5). The young coastal sediment extends eastward, a distance of about 2.5 km in the East to 1km in the west,which is around 764.77 Ha. The Old Coastal Sediment (M.5) deposit is located north of the Young Coastal Sediment (M4), narrowing to the East with an area of about 1.5 km in the East to 3 km in the west with an area of about 590.84 Ha. Based on the mineralogical analysis, components that contain significant iron elements are magnetite and other iron oxides. The element iron is also contained in mafic minerals such as olivine, pyroxene, hornblenda and biotite, which are impurities but are magnetic and are often found in the presence of magnetite minerals. Other impurity minerals are silica, quartz, plagioclase, orthoclasts, rutile, and calcite. Magnetite minerals are mainly present in very fine sizes at fractions above +100 mesh. Most of the magnetite is contained as inclusion/bound in crystalline mafic minerals such as pyroxene, so that when captured with magnets it still contains a lot of impurities.

The magnetic minerals in coarse and fine fractions have a tendency to spread more eastward, in contrast to the distribution patterns of non-magnetic minerals such as quartz, plagioclase, calcite, K-fedspar, zircon which tend to multiply westward. Magnetite minerals are present as connective and loose minerals with opposite distribution patterns. Connected magnetite minerals are associated with olivine, pyroxine, horblenda, and biotite. In the fine fraction, the content of the magnetite connective and other mineral associations containing iron reached 37.41%, while the loose magnetite mineral was around 16.73% [23].

Magnetic separation analysis was carried out on coarse fraction (35 #), the moderate fraction (60 #), and fine fraction (120 #) with magnetic intensities of 200, 1000, and 3000 Gauss. More magnetic minerals are found in the East with 66.46% by weight, total Fe content of 56.57% obtained from magnetic separation at + 120 # with an intensity of 200 G. Whereas in the western part, the percentage of magnetic minerals is 34.39 % weight, total Fe content of 60.72% in magnetic separations of size -120 # with an intensity of 200 G [14].

Getting subsurface information, geo-electric measurements with the Schlumberger configuration are performed; 2 (two) locations which are in Mirit sub-district (eastern part) and 2 (two) locations in Ambal (western part). The results of the modeling of geoelectric measurements can be seen in Figure 8.

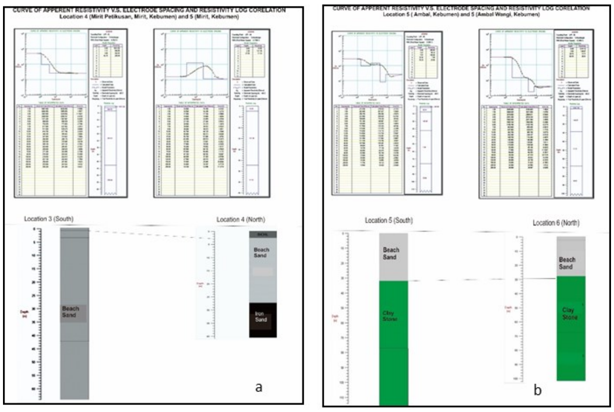

Fig. 8. **a)**. resistivity sounding analysis on the east young coastal sediment (points 3) and old coastal sediment (point 4), Mirit, **b)**. resistivity sounding analysis on the west young coastal sediment (point 5) and old coastal sediment (6), Ambal.

Based on the geoelectric analysis, old coastal sand deposits 3 km from the coastline are found iron sand thickness about 60 m in the East and 30 m in the west. With the assumption of a minimum thickness of an iron sand 30 m, a large area 1,355,621 Ha, so that the potential volume of iron sand is 406,686,300 m^3. Iron sand has a range of Bj 2.55 gr/cm^3, hence the potential for iron sand is 1,037,050,065 tons. The lowest total Fe content was 60.72% [12], so that the estimated total Fe potential of the study area reached 629,696,799 tons. To get iron sand in the old coastal plain area, Over Burden must be excavated for about 4 m and then get the iron sand content.

4 Conclusion and Recomendation

Based on DEMNAS image analysis and field observations, the landform units in Kebumen district are divided into 33 units, in the form of structural, denudational, solubility, fluvial and coastal landform. Structural landforms are mostly distributed in the north in the form of folds, fault, joints, and a combination of structures with a denudational process of 15 units. Denudational landscapes are scattered in the central and southeastern regions of the 9 unit. The Dissolving landscape in the form of karst hills (K1) is produced from the limestone dissolution process in the Kalipucang Formation. Alluvial deposits consist of 5 units of landform as a Flood Plain, Alluvial Fan, and Alluvial Plain, which are spread up to 49.5%. The Coastal Sediment landscape consists of 3 units, comprising young coastal deposits, old coastal deposits and Fluvio marine sediment.

Potential iron sand is found in Young Coastal Sediment (M.4), covering an area of 764.77 Ha and Old Coastal Sediment (M.5) covering an area of 590.84 Ha. Mineral compositions are olivine, pyroxene, hornblende, and biotite. Mineral impurities are silica, quartz, plagioclase, orthoclast, rutile and calcite. Coastal sand deposits in the Old Coastal Sediment (M.5) are found to be 30 m depth in the west and 60 m in the East with soil cover up to 4 m. The potential of beach sand is 406,686,300 m^3 or identical to 1,037,050,065 tons. With the lowest total Fe content of 60.72%, the total Fe content in iron sand is estimated to reach 629,696,799 tons.

It is recommended to geo-electric research and detailed drilling to obtain the amount of iron sand reserves in the old and young coastal deposits.

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