LANDFORM APPROACH FOR MINING SITE EVALUATION IN GALUR SUB DISTRICT, KULON PROGO REGENCY, YOGYAKARTA SPECIAL PROVINCE

By
Suratman Woroeprojo

Department of Physical Geography, Faculty of Geography, Gadjah Mada University, Yogyakarta, Indonesia

ABSTRACT

The objectives of the study are (a) to determine the potency and characteristics of mineral deposits (b) to evaluate the land suitability for mining purposes based on landform unit approach in the Galur Sub district Kulon Progo Regency, Yogyakarta Special Province. Landform classification and mapping have been done using aerial photo interpretation. The landform units were used as sample areas to determine the mineral characteristics and the landform description. The characteristics of the minerals include physical characteristics such as grain size and chemical composition. Stratified random sampling is used in the selection of sand samples. Sand deposit is calculated by the extent of area x thickness x specific weight. The volcanic sands in the study area are potentially suitable for mining exploitation especially in the river terraces and river sand bar. Clay loam soils in the natural levee and alluvial plain are moderately potential, while sand deposit along the sand dunes are not suitable site for mining exploitation.

Keywords: landform, mineral deposit and potency, land suitability for mining

INTRODUCTION

Geomorphological studies emphasizing on palaeogeomorphological aspects are commonly carried out in the framework of mineral exploration (Verspagen '83). Palaeorelief and or terrain configuration are sometimes related to mineral deposits, in fact mineral deposits, may be associated with: (a) actual relief forms, resulting from present geomorphological processes, (b) relic relief forms, (c) burial relief forms covered by more recent deposits, (d) fossil relief forms. Fluvial work and marine activities are always dynamic processes affected by climatic fluctuation. Sand deposits along the river terraces, beach ridges and sand dunes are potential
used for constructional purposes are abundant but the distribution is uneven. Due to their uneven distribution and the large demand, the exploitation of surficial materials sometimes causes negative environmental problems. In the Gahar Sub district the mineral deposits are distributed in the fluvial landforms and marine aeolian landforms. The potency and characterization of the mineral deposits are important to be examined, while mining activities in this area increasing rapidly in some places.

**OBJECTIVE OF THE STUDY**

Objectives of the study are (a) to determine the potency and characterization of mineral deposits (b) to evaluate the land suitability to mining purposes based on landform units approach.

**METHOD**

Landform classification was done based on genetic-landscape approach. Aerial photo interpretation was done intensively to identify and delineate the landform units of the study area. Some materials used in the research are: aerial photograph at scale 1:30,000, topographical map at scale 1:25,000, geological map at scale 1:100,000 and spatial map at scale 1:50,000. Field data to be collected in each landform unit includes landform type, land function, land use, natural hazard, while samples collection are taken for grain size analysis and chemical composition analysis. Stratified random sampling is used in the selection of sand samples. Sand deposit is calculated by the extent of area x thickness x specific weight. The field data and laboratory data are presented in a table and map in order to determine the suitable area for mining activities. The matching method is used in the land suitability classification for mining purposes.

**DESCRIPTION OF THE STUDY AREA**

The Gahar sub district is located in the southeastern part of Kulon Progo Regency Yogyakarta Special Province, about 20 km south west of Yogyakarta city (see Figure 1). The area is about 32.91 km² and divided into 7 villages. The study area has a humid tropical monsoon climate. The monsoon character of the climate is reflected by a pronounced dry season which normally lasts from June to October and wet season prevailing from November to April. The annual rainfall recorded in the study area is about 2494 mm and the mean annual temperature is about 28 °C. (Sarzmaman et al., 1995). A brief description of the various lithological types and their relation to landform is given below.

1. Alluvial and colluvial deposits (recent) consist of clay, silt, sand and gravel. These lithological types are occupying the alluvial plain, infilled valley bottom and natural levee.
2. Eolian-marine deposit consists of sand deposits of reworking volcanic materials are distributed along the coast (sand dunes and beach ridges).

3. Volcanic material deposit consists of sands and gravels are deposited along river terraces of Progo River.

Geomorphologically, the study area is dominated by fluvial and eolian-marine landforms, which characterized by low topography and flat to gently slope.

Soils in the study area are young soils consist of Regosols, Aluvial and Cambisols. The land-use in the study area is strongly affected by human activities such as wetland rice, settlement, homestead gardens and bare land. Wetland rice is distributed over the alluvial plain, while settlement and homestead gardens are distributed along the natural levee and old beach ridges.

Figure 1. Map of the Study Area
RESULTS AND DISCUSSIONS

1) Landform Unit

The landform of the study area can be classified based on genetic landscape approach. According to the main geomorphological-photo interpretation scale 1 : 30,000 there are three main origins of landform. These landforms are fluvial, marine, and eolian.

Alluvial plain

Alluvial plain is developed by fluvial processes such as surface overland flow, inundation and flooding. The material is mostly clay. The terrain is characterized by flat topography and frequently flooded in the wet season. The local farmers use the land for rice and dry mixed cultivation.

Natural levee and river terraces

These landform units are located along the river Prago and Galur. From field observation show, that natural levee is now used for settlements and homestead garden. The materials are derived from river deposition processes of Prago River. The clay loam soils of natural levees is exploited for local livestock industry. In the river terraces, the local people develop the land for agriculture and mining. Flooding and river water erosion are the common processes, therefore the activities of the local people depend on the climate.

Reach ridges and in active sand dunes

The sand materials of in active sand dunes cover the old beach ridges. The material is mostly fine to medium grained sand. Wind erosion and deposition processes are not active, because of the distance from coastline and good land use or vegetation cover. Field observation show the terrain is smooth undulating to flat. The landform units are intensively used for cultivation and settlements.

Active sand dunes

The sand dunes are dominated by irregular and or the longitudinal type. They are formed by eolian processes along the coast. Sand materials are derived from the reworking processes by marine and eolian activities. Undulating relief with flat slope, sparse vegetation and barrenland are easily determined both in the field and from aerial photograph.

Less active sand dunes

The wind processes is less active, and land surface is mostly covered by natural vegetation or partly cultivated by local people. Therefore, sand material are not easily transported by wind. Field observations show that terrain is undulating and flat slope.
2) Mineral Potency

Sand deposits in the study area derive from Merapi, Merbabu, Slamaling volcano and Kulonprogo mountains (Surutman, et al., 1993). The volcanic sand of Merapi Volcano are transported by fluvial processes of Progo river especially during the wet season. The fluvio volcanic processes are still active; therefore, the dominant deposit is characterized by sand. The sand units and their properties are presented in Table 1 and the distribution of pumice minerals are presented in Figure 2. Based on the landform unit, the mineral potency are explained.

1. Sand deposits of Ringin (R1 3/1)

In general, sand unit of Ringin consist of coarse sand, and very coarse gravelly. The percentage of coarse to very coarse gravelly is about 50%, while the chemical composition S₂O₃ (54.23%) and Al₂O₃ (16.67%) are dominantly occurred. Tonseage deposit is about 1,104,000 ton, while static deposit is estimated about 480,000 m³. Table 1 shows that the total exploitation is about 9690 ton/year, therefore the predicted time for mining activities is about 114 years.

2. Sand deposits of Pulog (P1 3)

The sand unit of Pulog consist of gravelly sand which dominated by medium to coarse sand (>75%) while the chemical composition slightly different from sand unit of Ringin. Tonseage deposit is about 138,000 ton while static deposit is estimated about 60,300 m³. Table 1 shows that the total exploitation is about 28890 ton/year, therefore the estimated time for mining activities is about 4 years.

3. Sand deposits of Nepi (N1 2/2)

In general, the sand unit Nepi consist of gravelly sand. According to grain size analysis, the percentage of medium sand is about 3%, while the chemical composition slightly different from sand unit of Ringin (see Table 1). Tonseage deposit is about 391,000 ton, while static deposit is estimated about 170,000 m³. According to Table 1 can be explained that the total exploitation is about 28890 ton/year, therefore the predicted time for mining activities is about 13 years.

4. Sand deposits Jati (J1 1/1)

Sand unit of Jati located near the sand unit of Nepi consist of gravelly sand. The percentage of gravelly is decrease about 10% than sand unit of Nepi and Pulog, while the silt content increase about 0.4%. The chemical composition of this sand unit is slightly different such as T₂O₅ (0.13%). Tonseage deposit is about 828,000 ton and the static deposits is estimated about 360,000 m³. Table 1 shows that the total exploitation is about 275240 ton/ year, therefore the predicted time for mining activities is about 3 years.

5. Sand deposits Jonggrangsan (Jn 1/1)

Sand unit of Jonggrangsan is located in the south of sand unit of Jati, consist of medium sand, the local people mentioned the sand unit Jonggrangsan as “pasir brehih”,
because of the gravelly content is little than the other sand unit in the study area. The chemical composition such as Fe₂O₃ decreases 1.21% and MgO 0.69%. The tonnage deposit of sand unit Jongrangsan is 1,242,000 ton, while static deposit is estimated about 540,000 m³. According to Table 1, it can be explained that the total exploitation is about 24,980 ton/year, therefore the predicted time for mining activities is about 42 years.

6. Sand deposits of Sobinan (Sa 3/1)
Sand unit of Sobinan is located near the mouth of Peong River. The sand composition is dominated by fine to coarse sand and classified as iron sand (Fe₂O₃=17.5%). Fluvio-marine processes influence the sand occurrence. Total tonnage deposit is about 1,495,000 ton, while static deposit is estimated about 6,590,000 m³.

7. Clay deposits of Gural (Gu 1/1)
Clay unit of Gural is located in alluvial plain and natural levees. The soil texture is very fine as clay loam. The local people use the soils for break industries. The tonnage deposit is about 8,396,000 ton, while the static deposit is estimated about 39,528,000 m³.

Land suitability site for mining exploitation.

Land classification for mining purposes can be determined according to landform unit approach. Land characteristics are selected in relation to the objectives of the study, such as mineral potential, area function, natural risk and land use. The rating of each land characteristics are used as a method in the construction of the criteria to determine land classification for mining exploitation (see Table 2).

<table>
<thead>
<tr>
<th>Sand Deposits Location</th>
<th>Com- position</th>
<th>Grain size</th>
<th>Area (ha)</th>
<th>Thickness (m)</th>
<th>Deposit (m³)</th>
<th>Tonnage (ton)</th>
<th>Time/year</th>
<th>Mining Production (ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hwajeong</td>
<td>Anhydrite sand</td>
<td>Course sand</td>
<td>24</td>
<td>2</td>
<td>480000</td>
<td>1,104</td>
<td>13.5</td>
<td>5660 114.2</td>
</tr>
<tr>
<td>Polu</td>
<td>Anhydrite sand</td>
<td>Course sand</td>
<td>12</td>
<td>8.5</td>
<td>69000</td>
<td>13</td>
<td>100.5</td>
<td>19900 47</td>
</tr>
<tr>
<td>Yangi</td>
<td>Anhydrite sand</td>
<td>Course sand</td>
<td>27</td>
<td>1</td>
<td>370000</td>
<td>39</td>
<td>100.5</td>
<td>299000 33.4</td>
</tr>
<tr>
<td>Jili</td>
<td>Anhydrite sand</td>
<td>Course sand</td>
<td>19</td>
<td>2</td>
<td>240000</td>
<td>38</td>
<td>100.5</td>
<td>238000 33.5</td>
</tr>
<tr>
<td>Jongrangsan</td>
<td>Anhydrite sand</td>
<td>Course sand</td>
<td>27</td>
<td>1</td>
<td>540000</td>
<td>2</td>
<td>103.5</td>
<td>20000 43.8</td>
</tr>
<tr>
<td>Suhak</td>
<td>Anhydrite sand</td>
<td>Course sand</td>
<td>27</td>
<td>1</td>
<td>540000</td>
<td>2</td>
<td>103.5</td>
<td>20000 43.8</td>
</tr>
</tbody>
</table>

Source: Laboratory analysis

Figure 2. Paddy sand Deposits in Gular-Sobinan-Kalam-Preg Regency

Table 1. Description of sand deposits in the study area

- The table shows the characteristics of sand deposits in the study area, including location, composition, grain size, area, thickness, deposit volume, tonnage, time required, and mining production.
- The deposits are categorized into different locations such as Hwajeong, Polu, Yangi, Jili, Jongrangsan, and Suhak.
- The deposits are characterized by their composition, such as anhydrite sand and course sand.
- The area, thickness, deposit volume, and tonnage vary significantly among the different deposits.
- The time required for mining activities ranges from 13.5 to 100.5 years, and the mining production also varies.

as mineral potential, area function, natural risk and land use. The rating of each land characteristics are used as a method in the construction of the criteria to determine land classification for mining exploitation (see Table 2).
Table 2. Criteria for Land Suitability for Mining Site

<table>
<thead>
<tr>
<th>Land characteristics</th>
<th>Land classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Minerals found (P)</td>
<td>Many</td>
</tr>
<tr>
<td></td>
<td>&gt; 500 ton</td>
</tr>
<tr>
<td>- quantity</td>
<td>good</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Area function (S)</td>
<td>Culmination</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural risk (N)</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Land use (L)</td>
<td>Dry field</td>
</tr>
<tr>
<td></td>
<td>bare land</td>
</tr>
</tbody>
</table>

Land suitability evaluation of each landscape unit can be done by matching the land characteristics of each landscape unit with the criteria of land classification for mining site. The result of the matching is presented in the Table 3.

Table 3. Suitability Classes for Mining Exploitation

<table>
<thead>
<tr>
<th>No.</th>
<th>Landform unit</th>
<th>Soil Density</th>
<th>Area function</th>
<th>Natural risk</th>
<th>Suitability Classes</th>
<th>Vol (ton)</th>
<th>Limitation factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aerial land</td>
<td>Sand, sand</td>
<td>Q1</td>
<td>K1</td>
<td>Q1</td>
<td>K3</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td>Dunes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Lowland land</td>
<td>Sand, sand</td>
<td>Q1</td>
<td>K1</td>
<td>Q1</td>
<td>K3</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>Dunes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>South slope</td>
<td>Sand, sand</td>
<td>Q1</td>
<td>K1</td>
<td>Q1</td>
<td>K3</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>escarpment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Alexander</td>
<td>Clay</td>
<td>Q1</td>
<td>K1</td>
<td>Q1</td>
<td>K1</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td>Plateau</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Natural land</td>
<td>Sand, clay</td>
<td>Q1</td>
<td>K1</td>
<td>Q1</td>
<td>K3</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Macro-areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>River flood</td>
<td>Sand</td>
<td>Q1</td>
<td>K1</td>
<td>Q1</td>
<td>K1</td>
<td>0.2</td>
</tr>
<tr>
<td>7</td>
<td>Sand Bar</td>
<td>Sand</td>
<td>Q1</td>
<td>K1</td>
<td>Q1</td>
<td>K3</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Source: matching between land characteristic and land classes for mining.

Exploration: Quantity Class
- Q1 = 1 - 500 ton
- Q2 = 500 - 1000 ton
- Q3 = > 1000 ton

Quality Class
- Q1 = good
- Q2 = moderate
- Q3 = poor

Matching symbols: K1, K2, K3

In the land suitability classification for mining exploitation purposes, three classes can be distinguished. In the purpose of this study, the matching between landform unit characteristics with the rating criteria for mining site selection is presented in Table 3 and Figure 3.
In the context of this study, the most potential landform units for sand and minerals exploitation are river bed and sand bar, while the landform unit for clay mineral exploitation is alluvial plain. In the natural levees, sand and clay minerals are not potential due to the occupation of this unit for settlements. The iron sands are potential in the active sand dunes and less active sand dunes, but these landform units are not potential for mining exploitation because of the restriction factor of the coastal area as a conservation zone. Sand mineral in the beach ridge and in active sand dunes are not potential for mining exploitation because of poor mineral qualities and high environmental risks (Figure 4).

CONCLUSIONS

Landform approach can be applied to the land evaluation for mining purposes. The geomorphological processes in the study area, dominated by the fluvial, marine, and aeolian processes. The mineral deposits are distributed according to the landform unit. The most potential area for sand mining purposes are the river bed and the sand bar, while the other landform units are not potential for mining purposes because of high environmental risk.

REFERENCES


