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MINERALOGICAL STUDY OF KEMAMAN COASTAL SEDIMENTS OFF TERENGGANU, MALAYSIA

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Abstract: The study was conducted to determine the mineral contents and the textural classes of the Kemaman coastal sediments. The samples were collected using Smith Mc Intyre grab on board KL PAUS ship owned by the Fishery Department, Malaysia. The sediments were collected from 12 stations and were analysed for mineral contents and textural classes of sediments. The result of X-ray Diffraction (XRD) analysis showed that quartz component was the dominant mineral in most of the stations, while other minerals, such as feldspar, illite, kaolinite, montmorillonite, chlorite and vermiculite, were found to be in trace amounts. For the textural class, two textural classes of the sediments were identified as sand and sandy loam. Sand texture was mostly found in the nearshore area while sandy loam was found in the offshore area.

KEYWORDS: Mineralogy, minerals, sediment texture.

Introduction

A mineral is a naturally-occurring, inorganic solid with a definite chemical composition and a crystalline structure. A mineral can be identified by its physical properties, some of them being sufficient for full identification without equivocation. Minerals may be classified according to chemical composition and can be categorised by anion group (Aganon et al., 2004). Geological domains of Peninsular Malaysia in its northern part of the Eastern domain are dominated by Carboniferous and in the south by Permian. The older rocks are laid down in shallow-to-deep marine environments.

Beach sands are present in areas where there are no hard cliffs bordering the sea. Wide beach ridges can be found in the north of Terengganu and some around Kerteh and Chukai with well-sorted sand. Fluvial deposits are dominant in river valleys in Sungai Terengganu and its tributaries, Sungai Dungun and Sungai Kemaman. These areas are characterised by the presence of levees, cut-off meanders and abandoned channels. The sand deposits ranged between poorly-sorted silt sands to sandy silts (Antonina, 2001).

The objectives of the study are to determine the mineral contents in sediments of the study area, to determine the textural classes of the sediments, and to provide a scientific data for better management in the research area.

Materials and Methods

Study area and sampling

The district of Kemaman (Lat. 4º 14' N, Long. 103 º 25; E) is situated approximately 170 km south of Kuala Terengganu, Malaysia. It covers an area of 253,668 hectares of which 82,264 is used for agricultural activities (33.6%) and 107,074 hectares for forestry, industrial, housing and especially commercial purposes (42.2%). This area is surrounded with mangrove forests, metal industries and quarries, port for Marine departments and shipyards. Rainfall distribution is high and shows monthly variations (Malaysian Meteorological Service). High rainfall is recorded in November, December and January. These months fall in the northeast monsoon season while the months of February, June and July have least rainfall (southwest monsoon season). Tides are characterised as mixed semidiurnal mesotide with a mean range of 1.8m. Figure 1 shows the location of stations in the study area.

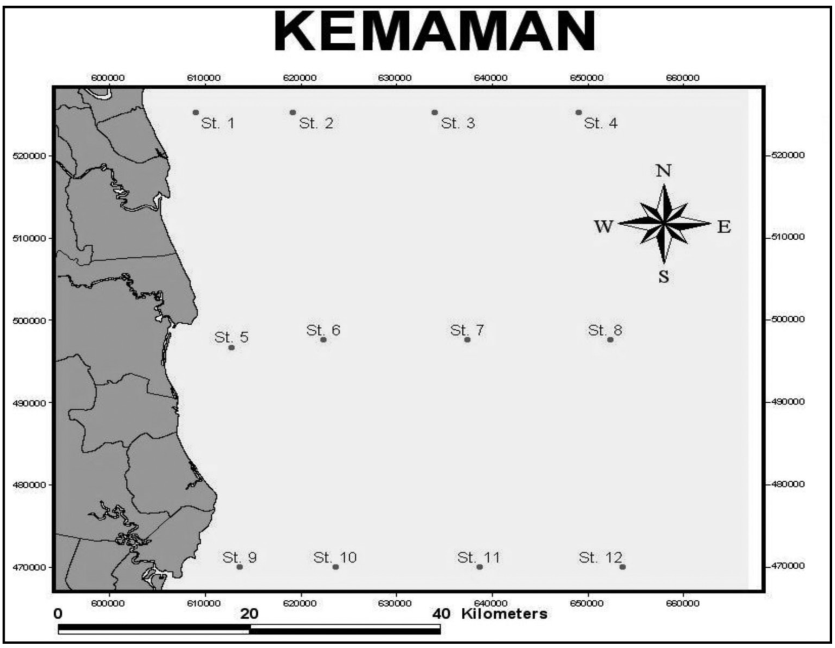

Figure 1: The location of the sampling stations in the study area

The samples were collected from twelve stations off the Kemaman coastal area which covers from Dungun to the Kemaman river. A Smith Mc Intyre Grab was used to collect the sediment samples. To ensure the coordinates of each station, Global Positioning System (GPS) was used. The samples were collected from the three assigned transects with four stations in each transect. The first transect was at the coastal area of Dungun river while the second and third transects were at the coastal areas of Kerteh Port and Kemaman River, respectively.

Analytical procedures:

The samples were analysed using two methods: (a) X-Ray Diffractometer (XRD) for silt and clay fractions and (b) hydrometer method for textural classes.

(a) X-Ray Diffractometer method:

The silt and clay fractions were analysed using the X-Ray Diffractometer (XRD) method. This method was employed as it only requires small amounts of material and is non-destructive. The samples were spread over the ceramic plate slowly by using a syringe. 1ml of magnesium chloride ($MgCl_2$) was dropped on the ceramic plate once it was dried. Then, 1ml of glycerol was added into the sample and left to dry on a horizontal surface to ensure distribution on the particles. The purpose of glycerol is to expand the mineral surface. Afterwards the samples were injected into the X-Ray Diffractometer. This was done for all the samples.

(b) Hydrometer method:

Texture is the stable property of soil, which is defined as the relative proportion of sand, silt, and clay or what is called soil separates. Knowing the values of percentage sand, silt, and clay in the sediments, the textural classes can be obtained. In this study, the textural classes of the sediments were determined using the United States Department of Agriculture (USDA) textural triangle. The USDA soil texture classes are sand, loamy sands, sandy loams, loam, silt loam, silt, sandy clay loam, silty clay loam, sandy clay, silty clay, and clay. Subclasses of sands are subdivided into coarse sand, sand, fine sand, and very fine sand. Subclasses of loamy sands and sandy loams that are based on sand size are named similarly (Brady, 1974). In this method, a bouyocous jar was used in settling the sediments for 40 seconds and, at 2 hours. 50 g of sediment was used and mixed with calgon solution in order to disperse the sediment into single particles that were then stirred for 15 minutes. After the analysis, calculation of % sand, silt and clay was done and knowing the % sand, silt and clay, the United States Department of Agriculture textural triangle was referred to for the texture.

Results and Discussion

Table 1 shows the mineral composition of silt and clay fractions in the study area. According to the results, quartz is the dominant mineral recorded in most of the stations. The minerals that were observed apparently in most of the stations are feldspar (Stations 1, 2, 4, 5, 10, 11 and 12) and illite (Stations 1, 4, 6 and 7). Illite, which is the dominant clay mineral in argillaceous rocks, forms by the weathering of silicates through the alteration of other clay minerals and during degradation of muscovite (Deer et al., 1966).

Results also showed that kaolinite is only present in trace amounts in most of the stations (Stations 2, 3, 10, 11 and 12). Other mineral which were present as trace minerals are montmorillonite (Stations 1, 2, 3, 4, 5, 6, 7, 8, 9, 11 and 12), vermiculite (Stations 2, 3, 6 and 7) and chlorite (Stations 1, 2, 3, 4, 5, 8, 9 and 10). Most soils contain a large percentage of quartz and feldspar, and the abundance of these minerals makes it difficult to determine other primary minerals (Kimpe, 1993).

According to the result (Table 2), there are two types of texture classes found in the study area which were determined using USDA textural triangle. The different textural classes are sand and sandy loam. The group of sand texture was found dominant in stations 2, 5, 6, 7, 9, 10 and 11 while sandy loam texture was found in stations 1, 3, 4, 8 and 12. The result also shows that the sandy loam texture were mostly found in the offshore area (Stations 1, 3, 4, 8 and 12) while the sand texture were found in the nearshore area (Stations 2, 5, 6, 7, 9, 10 and 11).

Table 1: Mineral composition of silt and clay fractions in the study area

Station	*Quartz*	*Kaolinite*	*Illite*	*Montmorillonite*	*Chlorite*	*Vermiculite*	*Feldspar*
1	++	-	++	+	+	-	++
2	+++	+	+	+	+	+	++
3	+++	+	-	+	+	+	-
4	++	-	++	+	-	-	++
5	+++	-	-	+	+	-	++
6	+++	-	++	+	-	+	-
7	+++	-	++	+	-	+	-
8	+++	-	-	+	+	-	-
9	++	-	-	+	+	-	-
10	+	+	-	-	+	-	+
11	++	+	+	+	-	-	++
12	+++	+	+	+	-	-	++

Note:
(+++) = Dominant, (++) = Moderate, (+) = Trace, (-) = Not present

Table 2: Texture classes and percentage of clay, silt, and sand in the study area

Station	*Clay (%)*	*Silt (%)*	*Sand (%)*	*Texture class*
1	6.72	14	79.28	Sandy loam
2	6.72	6	87.28	Sand
3	6.72	10	83.28	Sandy loam
4	4.72	14	81.28	Sandy loam
5	4.72	0	95.28	Sand
6	4.72	8	87.28	Sand
7	4.72	6	89.28	Sand
8	6.72	8	85.28	Sandy loam
9	4.72	0	95.28	Sand
10	4.72	0	95.28	Sand
11	2.72	6	91.28	Sand
12	4.72	20	75.28	Sandy loam

The X-Ray Diffractometer was used to determine the clay minerals in sediments of the study area. The analysis showed that quartz is the most abundant mineral observed in every station. Quartz becomes the most common sedimentary mineral because of its high stability to physical and chemical weathering. Quartz is a common constituent of granite, sandstone, limestone, and many other igneous, sedimentary, and metamorphic rocks (Klein and Hurlbut, 1983).

Quartz is a type of clay mineral which commonly dominates the finer grades of sand as well as the silt separate. In addition, quartz is the main non-clay component. According to Antonina (2001), the dominance of quartz might be due to the weathering products of granite, which is the dominant rock found along coastal areas of East Coast of Peninsular Malaysia. These reasons might be the cause for the dominance of quartz in the area.

The result also showed that feldspar and illite occurred in less significant quantities in some stations. According to Aganon et al., (2004), feldspar is found in areas of rapid deposition on the source area. Feldspar is an aluminosillicates mineral containing appreciable quantities of potassium, sodium, and calcium. Upon chemical weathering, it forms clay minerals. Illite is a group of mica-like minerals in clay fraction and it formed as detrital clay minerals by fragmentation in physical weathering.

The other clay minerals, such as kaolinite (Stations 2, 3, 10, 11 and 12), montmorillonite (Stations 1, 2, 3, 4, 5, 6, 7, 8, 9, 11 and 12), chlorite (Stations 1, 2, 3, 5, 8, 9 and 10) and vermiculite (Stations 2, 3, 6 and 7), also occurred in trace amounts in most of the stations.The percentage of sand was high in those stations. Because of that, the occurrence of clay minerals in that area were slightly low. Isbell et al., (1980) stated that clay formation from sand and silt is generally limited. When the silt contents become less than 15%, this process is neglected. These might be the reasons for the lack of clay minerals present in these stations.Mostly coastal areas, such as Kemaman coastal area, are composed of quartz sand. If we take a close look at sand, we can see similar grains. Sand grains consist mainly of colourless quartz. Richard (1985) stated that quartz may go through several cycles of deposition, erosion and accumulation.

According to the result obtained, there were two major texture classes found in the study area: sand and sandy loam. Sand is not dominated by a particular size of sand particle. It contains 25% or more of very coarse, coarse, and medium sand (but less than 25% very coarse plus coarse sand), and less than 50% either fine sand or very fine sand. Sandy loams consist of soil materials containing somewhat less sand, and more silt plus clay, than loamy sands. As such, they possess characteristics which fall between the finer-textured sandy clay loam and the coarser-textured loamy sands. Many of the individual sand grains can still be seen and felt, but there is sufficient silt and/or clay to give coherence to the soil so that casts can be formed that will bear careful handling without breaking (Garrison, 1995).

The result also showed that most of the sandy loam texture occurred in offshore areas and the sand texture was found in nearshore areas. Seaward, water becomes deeper and more distance from a terrigenous source. Steidthman (1982) stated that, based upon water depth, the oceanic environment can be divided into shelf and deep ocean basin. Shelf sedimentation is strongly controlled by tides, waves and currents, but their influence decreases with depth. Shoreline turbulence prevents small particles from settling and transports them seaward where they are deposited in deeper water. It makes the particle size decrease seaward for recent sediments.

Conclusion

According to the observation in this study, quartz is the dominant mineral in every station which was determined by X-Ray Diffractometer (XRD). Minerals which also occurred in trace amounts are the clay minerals such as kaolinite, montmorillonite, illite, feldspar, chlorite and vermiculite. For the textures, it was observed that coarse texture (sand) was observed nearshore and fine texture (sandy loam) was observed offshore.

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