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Characterization of the sand of Brahmaputra river of Bangladesh

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Abstract

The aim of this paper is to study on the mineralogy, morphology, magnetic property and composition of the sand of Brahmaputra River, Bangladesh. The sand has been collected from randomly selected seven places and separated by High Intensity Rolling Magnetic Separator into three fractions, viz. magnetic, para-magnetic and non-magnetic parts. The identifications of the valuable heavy minerals existing in these fractions have been performed. The valuable heavy minerals in the separated fractions have been counted under reflected and polarizing microscope and it is found that the magnetic fraction contains ilmenite, magnetite and garnet. The major grain size fraction of the magnetic fraction is 125 - 250 μm (57.18%). Zircon, rutile, xenotime, monazite, sillimanite etc. have been counted in other two fractions. X-ray Diffraction (XRD), X-ray Fluorescence (XRF) and Isodynamic Separator have been applied for mineral assessment and to quantify the relative proportion of mineral species.

Key words: Brahmaputra, Magnetite, Sediment, Ilmenite, Rutile

Introduction

The Brahmaputra River originating in Tibet and flowing through Tibet and the north-eastern part of India enters Bangladesh in Nagaswari Thana of Kurigram District (Fig. 1). The system is a very large scale sand bed braided river (Coleman, 1969) of a 15 km width with individual channels of 2-3 km wide. His bed level has an elevation of 7-20m above the sea level (Rahman 1972). The River carries 7.35-8.00×10^8 ton of sediment every year. The sediment contains large quantity of sandy materials, which are generally laid down on the bed of the river, forming sand bars. The thickness of sand deposits up to gravel bed is 44 m (Umitsu 1991). Alluvial sediments contain both light and heavy minerals in many countries of the world in the coastal areas as well as in land areas. For economic exploitation of mineral sands, it is necessary to identify the minerals present, quantify total reserves of sand deposits, determine the contents and quality of economic minerals, and find the market demands in the country and abroad. The main objective of this study is to work with the magnetic fraction because the concentration of the valuable heavy minerals (VHM) in the magnetic fraction is high and can be separated easily by magnetic separator. Keeping these points in mind, a field trip was made and some sediment samples were collected from the newly developed sand bars of the Brahmaputra basin to find out the percentage and morphology, mineralogy of valuable heavy minerals present together with the chemical compositions.

Materials and Methods

The samples seven in number are collected from 1 m depth and the locations are shown in Fig. 1. The samples have been separated at 60 rpm (magnetic fraction) and 140 rpm (paramagnetic fraction) speed by High Intensity Rolling Magnetic separator. Each sample (100 g) is sieved through a sieve shaker (US sieve 35, 60, 120, 230 and 325) after removing organic matter from the samples by washing several times with 1N HCl followed by distilled water. The visual identification of heavy minerals in the fractions was made by using a polarizing microscope and binocular microscope (under transmitted and reflected light). The every mineral countable in the sample (opaque: such as ilmenite and transparent: such as Zircon, Kyanite, etc.) were estimated by counting a minimum of 200 grains by the ribbon method as described by Mange and Maurer (1991). The mineralogical studies of heavy fractions were also carried out by the Powder XRD

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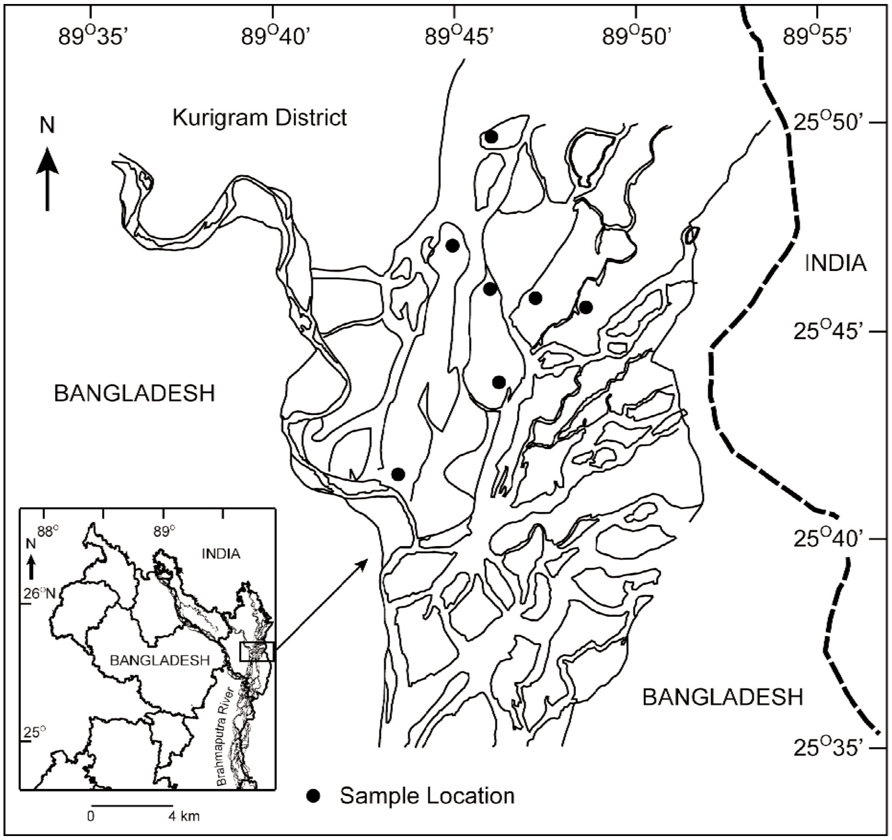

Fig. 1: Location map of the investigated area

analysis and the elemental compositions of heavy fractions were determined by the XRF analysis.

For XRD analysis, a Philips PANalytical X'Pert Pro MPD (PW3040) automated powder diffractometer equipped with a Cu-Kα radiation source operated at 40 KV-30 mA was used. The selected scan range was 10-80^o with a step size of 0.020^o and counting time of 0.50 s. The digital data were interpreted by auto matching with the data available in 'X'Pert High Score Plus' software of the XRD system used.

The elemental compositions were determined by X-ray fluorescence (XRF) Spectrometric method using Rigaku ZSX Primus XRF machine equipped with an end window 4 KW RH - Anode X-ray tube operated at 40 KV - 60 mA for heavy elements and 30 KV - 100 mA for light elements. A standard procedure was followed to make sample for XRF analysis (Goto and Tatsumi 1994, 1996).

Results and Discussion

Magnetic separation

Seven samples on magnetic separation by High Intensity Rolling Magnetic Separator show that the amount of magnetic fraction varies from 6.63% to 18.86%; whereas, the amount of para-magnetic fraction varies from 7.95% to 16.17% (Table I). The grain size distribution shows that the predominant (57.18%) size is in the rank of 125 - 250 µm in the magnetic fraction. Similarly, 60.37% and 64.5% of para-magnetic and non-magnetic fractions, respectively, have the grain size of above range (Table II). It is noticed that mag-

Table I: The percentages of magnetic, para-magnetic and non-magnetic fractions which are separated by High Intensity Rolling Magnetic Separator

Sample No.	Magnetic part (%)	Para-Magnetic part (%)	Non-Magnetic part (%)
1	10.53	10.52	78.95
2	6.63	7.95	85.42
3	13.49	11.73	74.78
4	9.96	10.72	79.32
5	12.50	12.50	75.00
6	11.76	10.59	77.65
7	18.86	16.17	64.97
Average	11.96	11.45	76.58

netite is assembled mainly in 45 - 63 µm sized fraction; whereas, ilmenite is assembled mainly in 63 - 250 µm sized fractions of magnetic part.

Table II: The grain size distribution among the magnetic, para-magnetic and non-magnetic fractions

Grain size ranges µm	Magnetic part (%)	Para-Magnetic part (%)	Non-Magnetic part (%)
250-500	13.63	13.70	10.02
125-250	57.18	60.37	64.5
63-125	24.29	23.33	20.45
45-63	3.55	1.85	3.75
Pan	1.33	0.74	1.25

Grain counting by microscope

The binocular and polarizing microscopes are used to identify the valuable minerals in the magnetic, para-magnetic and non-magnetic fractions. Ilmenite (5.95%), garnet (8.84%) and magnetite (4.65%) are identified in the magnetic fraction. Ilmenite (3.60%) and garnet (2.74%) are also identified in the para-magnetic fraction associated with monazite (1.35%), zircon (0.34%), chlorite (2.59%) and kyanite (5.22%). The grains of ilmenite and garnet that are found in the para-magnetic fractions are usually weathered and

Table III: The percentages of minerals in the magnetic, para-magnetic and non-magnetic parts

Mineral Name	Magnetic Part	Para-Magnetic Part	Non-Magnetic Part
Chlorite	0	2.59	0
Garnet	8.84	2.74	0
Ilmenite	5.95	3.6	0
Kyanite	0	5.22	0
Magnetite	4.65	0	0
Monazite	0	1.35	0.28
Rutile	0	0	1.36
Sillimanite	0	0	3.1
Xenotime	0	0	1.95
Zircon	0	0.34	1.42
Quartz	0	31.01	72.24
Feldspar	2.21	5.27	5.76
Mica (Muscovite + Biotite)	31.01	14.02	5.89
Hornblende	12.72	13.2	2.45
Pyroxene	16.28	11.25	0
Olivine	7.34	2.48	0
Hematite	5.23	0	0
Others	5.77	6.93	5.55
Total	100	100	100

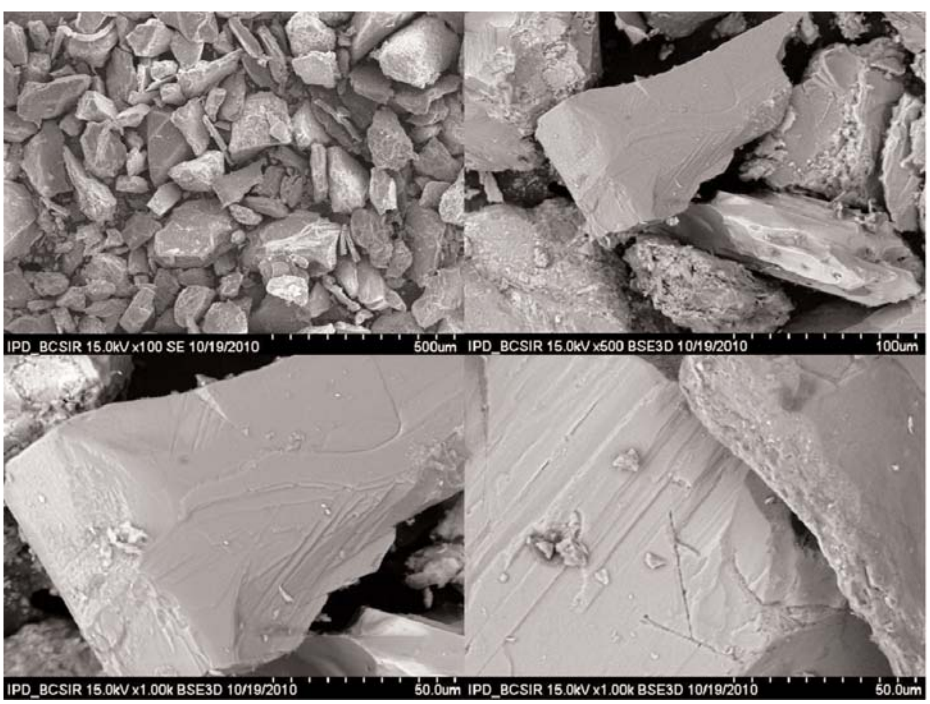

Fig. 2: SEM Photographs of Magnetite. The grains are mostly inclusions free

altered. Because of weathering and alteration these grains have lost Fe and become less magnetic. The opaque mineral, magnetite can be separated by a hand magnet and usually concentrates in the magnetic fraction. The other non-magnetic valuable minerals, viz. zircon (1.42%), rutile (1.36%), xenotime (1.95%) and sillimanite (3.10%) are identified in

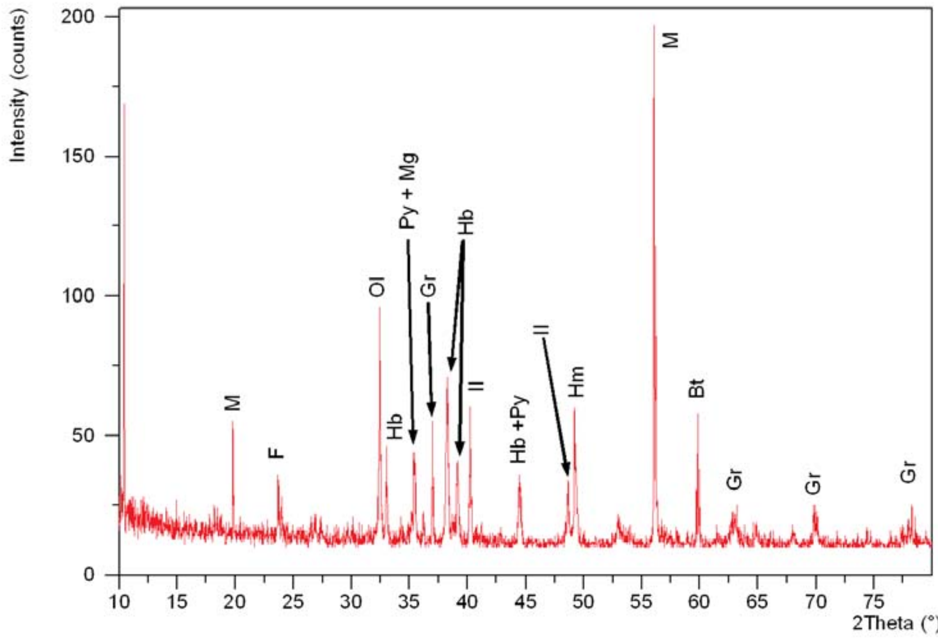

Fig. 3(a): XRD Pattern for the magnetic part of the sand of Brahmaputra river.
M = Muscovite, F = Feldspar, Ol = Olivine, Hb = Hornblende, Py = Pyroxene, Mg = Magnetite, Gr = Garnet, Il = Ilmenite, Hm = Hematite and Bt = Biotite

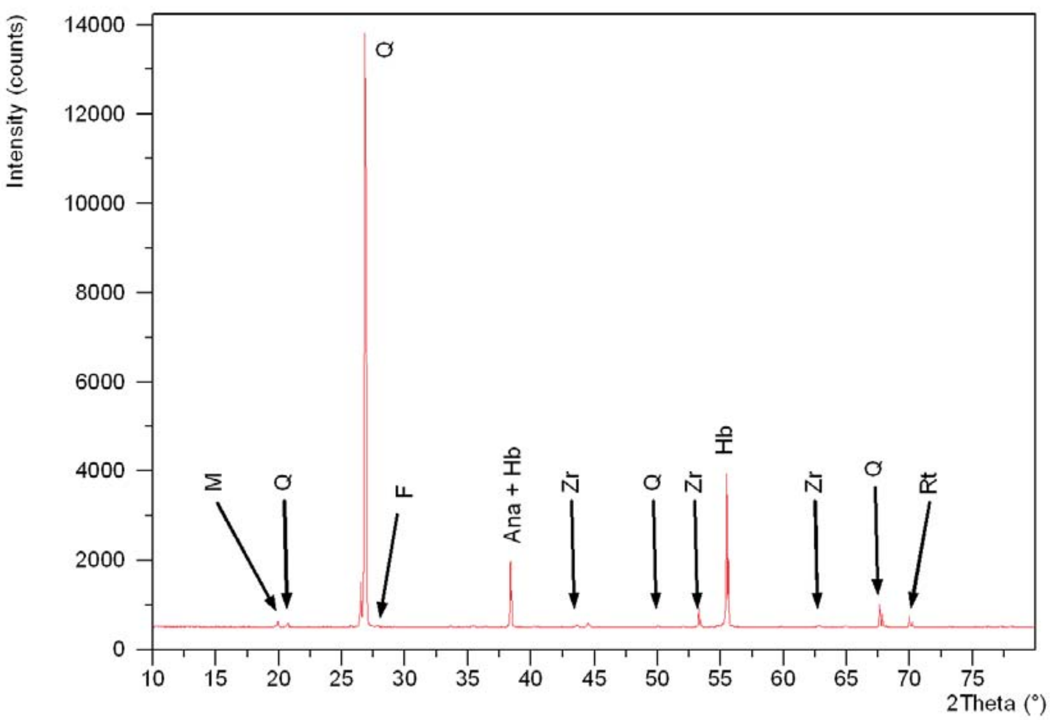

Fig. 3(b): XRD Pattern for the para-magnetic part of the sand of Brahmaputra river
F = Feldspar, Ol = Olivine, Hb = Hornblende, Py = Pyroxene, Gr = Garnet, Il = Ilmenite, Bt = Biotite, Q = Quartz, Mon = Monazite and Kya = Kyanite

the non-magnetic fraction (Table III). The SEM photograph of the magnetite grain shows that it is mostly fresh, unaltered and inclusion free (Fig. 2).

Phase identification

There are a large number of different minerals present, many of which have overlapping peaks, making identification challenging by XRD method. XRD analysis of the non-magnetic part reveals that the solids are predominately quartz (intensity counts is high in contrast with other phases and also other fractions) with a significant number of minor phases of feldspar, zircon, mica, hornblende, rutile, anatase (Fig. 3a). The XRD method of phase identification is consistent with microscopic study and as well as XRF analysis. The XRD pattern of para-magnetic part identifies mainly the phases of quartz, feldspar, hornblende, monazite, olivine, ilmenite, biotite, kyanite and garnet (Fig. 3b). The maximum intensity of the magnetic part predominantly shows muscovite along with magnetite, ilmenite, biotite, garnet, olivine, pyroxene, hornblende and hematite (Fig. 3c).

Elemental analysis

The elemental composition of three fractions reflects the overall chemistry of minerals contained in the fractions.Such information is useful to identifying fractions of mineralogi-

Table IV: The chemical composition of the magnetic, para-magnetic and non-magnetic parts

Element	Sample Name		
	Magnetic Part (Wt%)	Para-Magnetic Part (Wt%)	Non-Magnetic Part (Wt%)
Na_2O	0.249	1.29	2.196
MgO	12.01	4.222	0.284
Al_2O_3	16.92	14.919	8.039
SiO_2	39.132	62.14	76.954
P_2O_5	0.076	0.227	0.161
K_2O	4.946	3.495	2.289
CaO	1.682	1.68	1.177
TiO_2	2.368	0.795	0.151
Fe_2O_3	21.604	6.874	0.409
V	0.0281	0.0095	0.0004
Mn	0.3087	0.0808	0.0072
Rb	0.0309	0.0177	0.01
Sr	0.0002	0.0091	0.0117
Zr	0.0157	0.0644	0.0274
Ba	0.0615	0.0423	0.0229
Th	-	0.0052	0.0038
Hf	0.0003	0.0003	0.0003
Sc	0.0042	0.0014	-
U	0.0001	0.0002	0.0002
	99.44	95.87	91.74

Fe_2O_3 = Total iron oxide

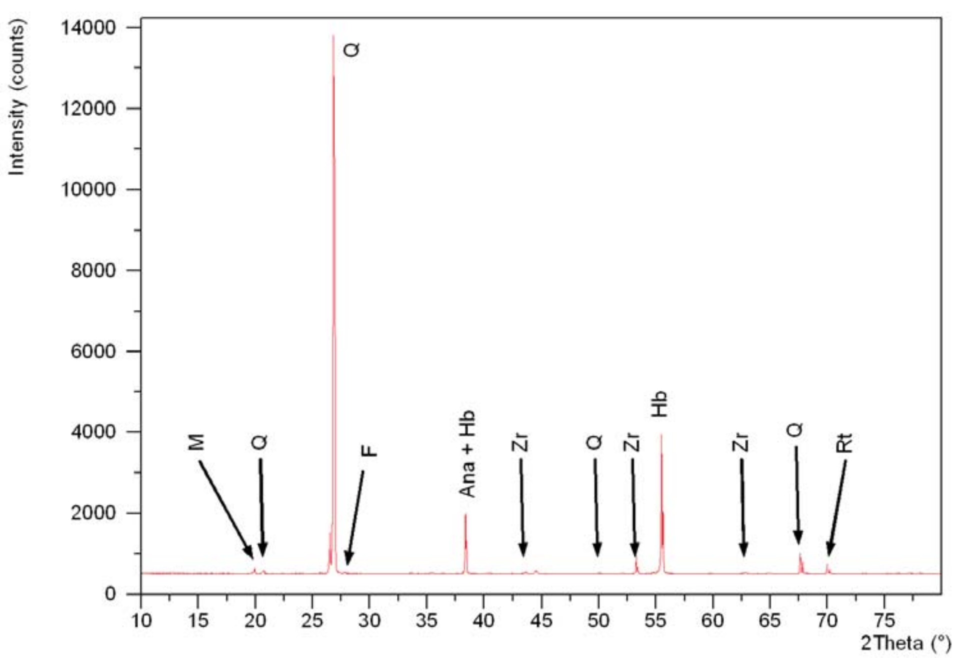

Fig. 3(c): XRD Pattern for the non-magnetic part of the sand of Brahmaputra river

M = Muscovite, F = Feldspar, Hb = Hornblende, Q = Quartz, Ana = Anatase, Zr = Zircon and Rt = Rutile cal interest. The elemental composition of the fractions determined by XRF analysis is given in Table IV. From this study it is observed that the marked enrichment of iron oxide (21.604%) and titanium oxide (2.368%) together with inclusion of lesser amount of silicon oxide (39.132%) occur in the magnetic part than in other two parts.

Conclusions

The present study shows the magnetic properties of the sand of Brahmaputra River and identifies it as a source of Fe and Ti bearing minerals magnetite and ilmenite which are economically valuable and huge demand in the international market. The Al, K, Mg, Si bearing minerals (e.g. olivine, pyroxene, hornblende, mica etc.) can not be separated easily by physical separation method and are less economically valuable in contrast with magnetite and ilmenite through physical separation. It is found that the magnetic fraction is important because the concentration of valuable minerals in it is high and can be separated easily from other two fractions. The concentration of valuable heavy minerals in the sand of the Brahmaputra river is remarkable. The heavy minerals ilmenite (5.95%), garnet (8.84%), magnetite (4.65%) are enriched in the magnetic fraction while zircon (1.42%), rutile (1.36%) are enriched in the non-magnetic fraction. On the basis of the minerals ilmenite and magnetite as main products and other minerals zircon, rutile, garnet, sillimanite etc. may be bi-product; a mine and a mineral separation plant can be developed in the Nagaswari Thana of Kurigram district where the Brahmaputra river enters Bangladesh. For this purpose, a comprehensive study is required to assess the reserve estimation and have to setup a pilot plant before establishing a mine and mineral separation plant.

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