CLAY MINERAL STUDY OF MUD SAMPLES FROM SHASTRI ESTUARY, RATNAGIRI DISTRICT, MAHARASHTRA

Joshi S. B.* and Kulkarni D. D.**
*Department of Geology, WalchandCollege of Arts & Science, Solapur 413006
** School of Earth Science, Solapur University, Solapur

ABSTRACT

Shastri is one of the most prominent estuary of west coast of Maharashtra, originates near Prachitgad on the western scarp. The estuary shows development of inter-tidal mud flats in the lower and middle reaches. These mud samples contain verities of clay minerals. The present work deals with the study of clay minerals to understand the genesis and environment of deposition. The composition of clay depends mainly on chemical composition of parent minerals and physico-chemical environment in which alteration takes place. The clay mineral studies of representative mud samples from Shastri estuary carried out by XRD and IR spectroscopic analysis. It is seen from the XRD diffractograms and IR spectra that the minerals viz. kaolinite, goethite, illite, chlorite, muscovite, gibbsite and montmorillonite are present in order of abundance. The area of investigation constitute of basaltic lava flows capped by laterites. Presence of kaolinite in mudflats indicates that it might have been formed due to intense chemical weathering of plagioclase feldspars present in the basalts under tropical conditions and deposited in estuarine environment. The presence of kaolinite, gibbsite along with goethite indicate that they are the products of chemical weathering of pyroxenes present in the basalts. The presence of illite in the recent mud-flats suggests transitional environment. The abundance of montmorillonite clay mainly depends upon the hydraulic conditions of the estuarine environment and intense weathering of volcanic rocks of the study area. The presence of muscovite in the mud samples is less, which may be due to its flaky habit and relatively less specific gravity. It could have formed in the source region probably by the hydrothermal alteration of pyroxenes from the basalt. Muscovite can also be accounted due to long shore transport, being derived from the Pre-cambrian terrain, exposed in the southern part of the study area.

Key words: estuary, clay minerals, mud flats, basalt, transitional

INTRODUCTION:

An estuary represents one of the most complex environments and is a transitional ecotone at the confluence of rivers and sea. It is a semi-enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the open sea. The main factors, which determine the estuarine processes, are fresh water influx, waves and tides of sea and climatic conditions. These factors are more complex in case of tropical estuaries especially those, which are located geographically within the belt of monsoon influence (Bukhari and Nayak, 2000). The coastal rivers play important role in the carrying and distribution of the sediments especially in the form of inter-tidal mudflats at the mouth, than any other agents, released from uppermost parts of the earth crust. The intertidal mudflats are prominent sub-environments found on the fringe of estuaries and in low relief sheltered coastal environments (O' Brine, et. al. 2000). They are wide expanse of fine grained, soft sediments along the shore and generally consist of deposits of clay, silt, ooze, etc. (King C. A. M., 1972). Mudflats are developed where enough fine sediment are available and the wave action is not strong enough to disturb the sediments (Reineck and Singh, 1980). The characters of the mudflats are considerably modified during journey in terms of mineralogy, texture and chemistry. The present work has been carried in relation with these aspects of the Shastri estuary.

AREA OF INVESTIGATION AND GEOLOGY:

The area selected for the study is a Shastri River Basin (SRB), a part of western coast of India from Maharashtra state. It lies between lat. 16 ^{0}, 57' N; long. 73 ^{0},15 'E and lat. 17^{0}, 30' N; long. 73^{0}, 50' E (Fig. 1). River Shastri originates in the Western Ghat section. In the study area, Deccan basalt lava flows belonging to Ambenali and Poladpur formations of Wai sub-group are exposed (Mitchell and Cox, 1991). According to the literature brought out by GSI (2001), these lava flows belong to Diveghat and Purandargarh formations. They are mainly exposed along river valleys, valley sides and near shore. Most of the basaltic flows are capped by laterite. The Quaternary sediments are exposed along the banks of Shastri river and its tributaries (Fig. 2).

SAMPLE COLLECTION:

River Shastri is about 72 km. in length and originates in the Western Ghat section, flows for about 72 kms and meets Arabian sea. The inter-tidal mud-flats are prominent in the lower and middle reaches of the river. While, poorly developed sediments are present in the upper reaches of the basin. In order to carry out the mineralogical studies, the representative core samples from the mudflats, up to 10 cm depth were collected from six different localities, covering lower, middle and upper reaches of the estuary (Fig. 3). The samples collected by using PVC pipe during the low tide time. Two core samples of mud collected near the mouth representing lower reach of the estuary at Tavsal and Saitvada. Another two samples were collected from the middle part of the estuary in the vicinity of confluence points of the tributaries at Agarnaral and Phungus and other remaining two core samples were collected from the upper reaches of river, which is far away from the mouth, at Sangmeshwar and Phansavane.

METHODOLOGY:

Pipette analysis: The analysis of sediment containing significant fines (< 63 mm) is satisfactorily achieved by the use of the pipette method (Krumbein and Pettijohn, 1938; Folk, 1974). The mud samples were treated with 1: 10 HCl for twenty-four hours to remove the carbonates. Then thoroughly washed with distilled water and sun dried for few days. The dried sample was weighed to about 10 gm and taken in a 1000 ml. glass beaker, which was filled up with distilled water along with 15 % H_2O_2 to remove organic matter, without disturbing the sample, which is settled at bottom for about 24 hrs. Clay has cohesive properties and hence it forms aggregates when saturated, therefore 10 ml of known concentration (44 gm/100 ml) sodium hexa-meta-phosphate solution was added as a dispersant.

Clay Mineral Studies: Using a pipette 100 ml of solution prepared for mud size analysis was withdrawn from the top 20 cm depth of cylinder and taken in a dry petridish, containing the glass slide for clay mineral studies. The fraction so obtained in a petridish was allowed to air dry. Thin film of clay minerals on the glass slide was used for X.R.D. studies and the clay minerals extracted from the petridish were subjected to I.R. Spectroscopy.

X-Ray Diffraction Studies: Clay mineral fraction obtained from mud flats were examined for their identification with the help of XRD techniques. The studies were carried out on a Phillip – 1710 X- ray diffractometer. The instrument was operated at 35 Kv and 20 MA using Cu – Ni radiations. The diffractogram was scanned within a range from 5^0 to 60^0 with a step width 0.02. The scanning speed was maintained at 2^0 per minute. The diffractograms for each sample were obtained and then analyzed to identify clay mineral assemblage.

For the identification of clay minerals from the Shastri estuary, six samples of mud flats have been analyzed. The identification was carried out with the help of a ‘d’ spacing and 2 θ values, by searching and comparing with the standard values as has been given in the J. C. P. D. S. (1974, a and b). The interpretation of X-ray diffractograms has been carried out and described in the following paragraphs. The X-ray diffractograms of representative mud samples have been shown in Fig. 4a, 4b and 4c. From the diffractograms it has been inferred that ‘d’ spacing values 7.15 A^0, 7.12 A^0, 4.86 A^0, 3.57 A^0, 3.56 A^0, 2.73 A^0, 2.54 A^0, 2.31 A^0, 2.25 A^0, 1.99 A^0, 1.91 A^0, 1.61 A^0, 1.49 A^0, 1.48 A^0, 1.46 A^0, indicate presence of kaolinite. The goethite has been inferred due to 1.37 A^0, 1.36 A^0, 1.34 A^0, 1.31 A^0, 1.22 A^0 and 1.19 A^0 ‘d’ spacing. The ‘d’ spacing values 7.20 A^0, 4.85 A^0, 2.83 A^0 and 2.05 A^0 indicate presence of chlorite while illite has been inferred from the ‘d’ spacing values 10.30 A^0, 10.01 A^0, 3.34 A^0, 3.14 A^0, 2.86 A^0, 2.61 A^0, 2.00 A^0. From the values of ‘d’ spacing 9.97 A^0, 5.01 A^0, 4.98 A^0, 3.34 A^0 and 3.22 A^0 the presence of muscovite is inferred. Gibbsite has been inferred from the 4.84 A^0, 3.18 A^0, 2.19 A^0, 2.00 A^0 'd' spacing values. Similarly, montmorillonite has been inferred from 7.11 A^0, 6.05 A^0 and 3.02 A^0 'd' spacing values. The clay mineral assemblage so inferred from X-ray studies have been presented in the table 1. The mud samples from the Shastri estuary represent kaolinite, goethite, illite, chlorite, muscovite, gibbsite and montmorillonite as clay mineral assemblage in order of abundance.

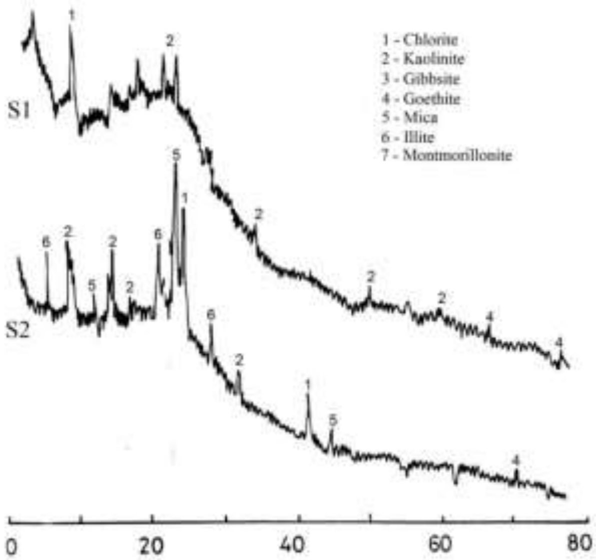


Fig. 4 a: X-Ray Diffractograms of Mud Samples from lower reach of Shastri Estuary

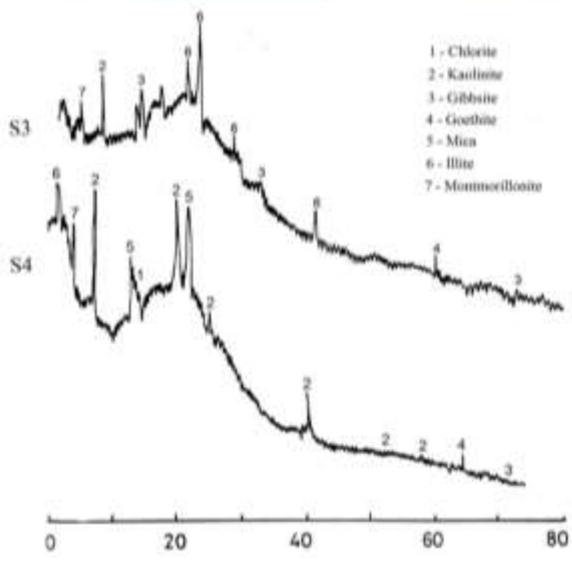


Fig.4 b: X-Ray Diffractograms of Mud Samples from middle reach of Shastri Estuary

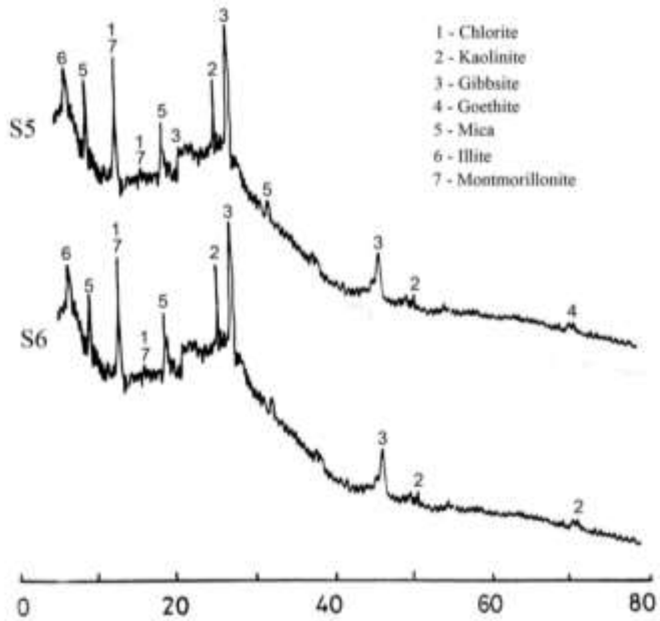


Fig.4 c: X-Ray Diffractograms of Mud Samples from upper reach of Shastri Estuary

Table 1 : Semi-Quantitative Abundances of Clay Minerals from X-Ray Studies of Mudflat Samples from Shastri Estuary

Sample No.	Kaolinite	Goethite	Chlorite	Illite	Muscovite	Gibbsite	Montmorillonite
S-1	71.62	3.13	25.25	-	-	-	-
S-2	22.47	2.02	19.63	31.41	24.47	-	-
S-3	15.66	3.18	-	59.71	-	17.54	3.91
S-4	50.29	1.79	6.81	9.11	29.36	2.64	-
S-5	10.23	1.73	23.16	18.22	22.22	3.77	20.67
S-6	9.99	-	23.24	18.25	22.20	5.72	20.60
Mean	30.04	1.98	19.62	27.34	24.56	7.42	15.06

Infrared Spectroscopic Studies: The clay mineral fractions obtained from the representative samples have also subjected to I. R. spectroscopic studies. The I. R. spectra for the clay minerals obtained on a Perkin-Elmer model 783 Infra Red spectrophotometer. For this purpose, the samples were mixed with KBr to form pellets following the method suggested by Vander Marel and Beutelspacher (1976). I. R. spectrum for each mud sample were obtained in the frequency range of 400 to 4000 cm^{-1} (Fig .5a, 5b and 5c). The spectra have been interpretated for clay mineral content by comparing with the standards given by Vander Marel and

Beutespacher (1976). The clay mineral assemblage so inferred from I.R. has been presented in the Table 2. From the IR spectra, it is seen that the mud samples show the presence of kaolinite, goethite, gibbsite, illite, muscovite, chlorite and montmorillonite minerals.

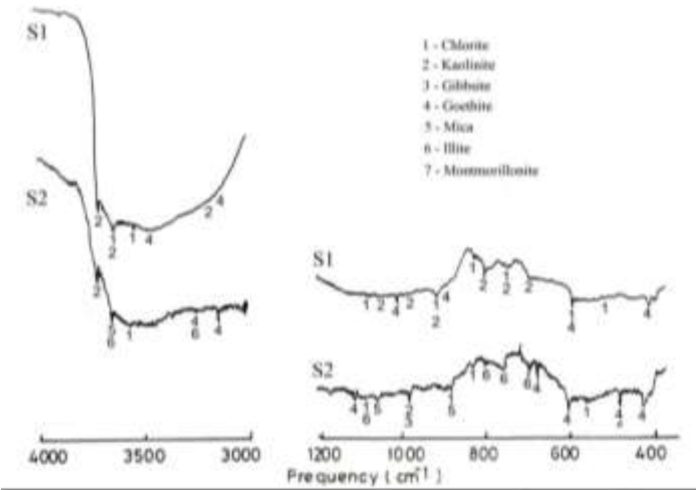


Fig. 5a: Infra-Red Spectra of Mud Samples from Lower Reach of Shastri Estuary

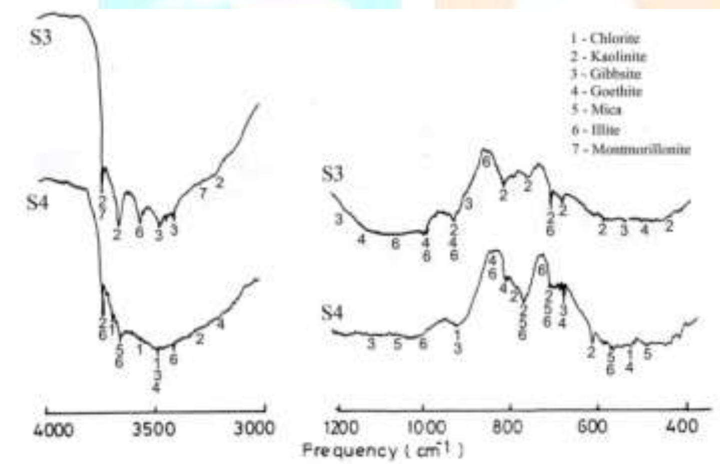


Fig. 5b: Infra-Red Spectra of Mud Samples from Middle Reach of Shastri Estuary

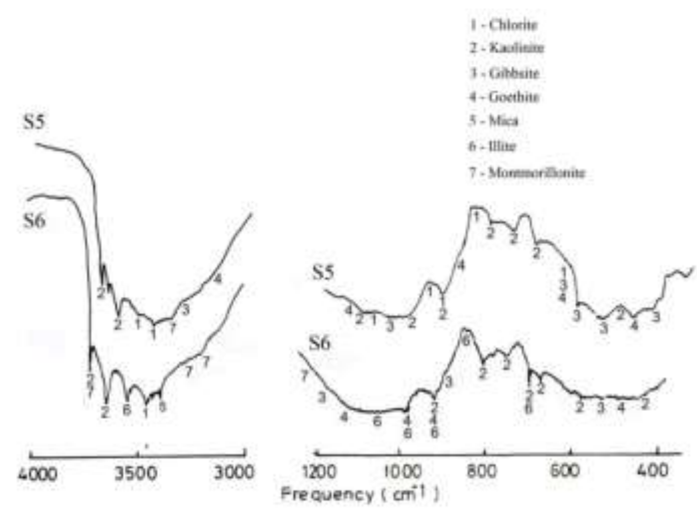


Fig. 5c: Infra-Red Spectra of Mud Samples from Upper Reach of Shastri Estuary

Table 2: Clay Mineral Assemblages As Interred from X.R.D. & I.R. Mudflat Samples from Studies for Shastri Estuary

Sample No.	X.R.D.	I.R.
S-1	Kaolinite, Goethite, Chlorite	Kaolinite, Goethite, Chlorite
S-2	Kaolinite, Goethite, Chlorite, Illite, Muscovite	Kaolinite, Goethite, Chlorite, Illite, Muscovite
S-3	Kaolinite, Goethite, Illite, Gibbsite, Montmorillonite	Kaolinite, Goethite, Illite, Gibbsite, Montmorillonite
S-4	Kaolinite, Goethite, Illite, Muscovite, Gibbsite	Kaolinite, Goethite, Illite, Muscovite, Gibbsite.
S-5	Kaolinite, Goethite, Chlorite, Muscovite, Gibbsite, Montmorillonite	Kaolinite, Goethite, Chlorite, Muscovite, Gibbsite, Montmorillonite
S-6	Kaolinite, Chlorite, Illite, Muscovite, Gibbsite, Montmorillonite	Kaolinite, Chlorite, Illite, Muscovite, Gibbsite, Montmorillonite

Discussion and Conclusion :

From the above discussion, it has been observed that the mud flat samples from Shastri River Basin, show the presence of variety of clay minerals. The area constitute of basaltic lava flows capped by laterites. The mineralogical studies of mud samples have been carried out to understand the genesis and environment of deposition. Clay minerals are the products of chemical weathering. The presence of particular clay mineral in the mud gives an approximate indication of the degree and extent of chemical weathering of the host rock and climatic conditions. In the present case, the host rock is basalt and the study area falls under the humid and sub-tropical conditions. The process of lateritization involves leaching of most of the oxides from pyroxenes and feldspars. This process of leaching takes place by percolating solutions and is responsible for the formation of clay minerals in the residual deposit. The primary environment in the area is one in which the clay minerals are formed. It is followed by subsequent transportation of these clay minerals from laterites through lithomarge clay to the mud flats and their deposition along the banks of estuarine mouth and hinterland zones, representing the secondary environment.

From the analysis, it has been observed that kaolinite mineral is more dominant amongst the other clay minerals. According to Biscay (1965), the formation of kaolinite and its presence in the mudflats indicates that it might have been formed due to intense chemical weathering of plagioclase feldspars present in the basalts under tropical conditions. It is formed from the basaltic soils developed under heavy rainfall, good drainage and acidic water. In marine environment, kaolinite concentrates near the shore and therefore, it is a good indicator of paleo-geography (Keller, 1962). Presence of kaolinite in the mudflat samples indicate that it has been deposited under estuarine environment (Pandit, S. J. 1992).

The gibbsite mineral is found to be associated with kaolinite in all samples. Presence of gibbsite in the mud-flats indicates that it is formed by breaking away the feldspars present in the basalt (Khanadal and Devraju 1987). Formation of gibbsite can also be resulted due to chemical weathering of kaolinite. With the increasing degree of leaching, kaolinite gets transferred to gibbsite by a hydrolysis processes (Jackson, 1959). The presence of kaolinite, gibbsite along with goethite indicate that they are the products of chemical weathering of pyroxenes present in the basalts. Sahastrabudhe (1989) has reported such assemblages of minerals in laterites of West Coast, Maharashtra.

According to Velde (1968), it can be said that when the sediments containing Kaolinite, subjected to subsequent diagenesis during burial, gives rise to illite + chlorite. In the present case, illite and chlorite might have formed due to the diagenesis of kaolinite. Keller (1970), observed that when fluvial system discharges kaolinite into ocean, it probably begins to dissolve under the influence of marine environment to give rise to illite. The presence of illite in the recent mud-flats from transitional environment, like present one have also been reported by Pandian and Sukhtankar (1991). In the present area, gibbsite on transformation gives rise to chlorite. Thus the presence of chlorite in mud-flats can be formed either due to diagenetic alteration of kaolinite or that of gibbsite.

Montmorillonite is another clay mineral present in the samples of mud-flats. It also shows its genesis in the primary environment like that of kaolinite, from laterite and lithomarge clay. This clay might have transported through the major stream at the time of deposition. Montmorillonite is formed due to intense chemical weathering of volcanic material (Keller, 1970). As stated by Kenett (1982), the formation of montmorillonite is from the Deccan basaltic flows or from laterites. Grim (1968), has pointed out that the abundance of montmorillonite mainly depends upon the hydraulic conditions of the estuarine environment and intense weathering of volcanic rocks of the study area. In the present investigation, more percentage of kaolinite as compared to montmorillonite could be due to the estuarine environment of deposition. The estuarine conditions may favour the deposition of kaolinite and keep the montmorillonite in suspension, which later on, directly transported to the place where the marine conditions are favourable.

The presence of muscovite in the mud samples is less. Due to its flaky habit and relatively less specific gravity, muscovite can easily migrate through medium of water. It could have been formed in the source region probably by the hydrothermal alteration of pyroxenes from the basalt. The presence of muscovite can also be accounted due to long shore transport, being derived from the Pre-cambrian terrain, which is exposed in the southern part of the study area.

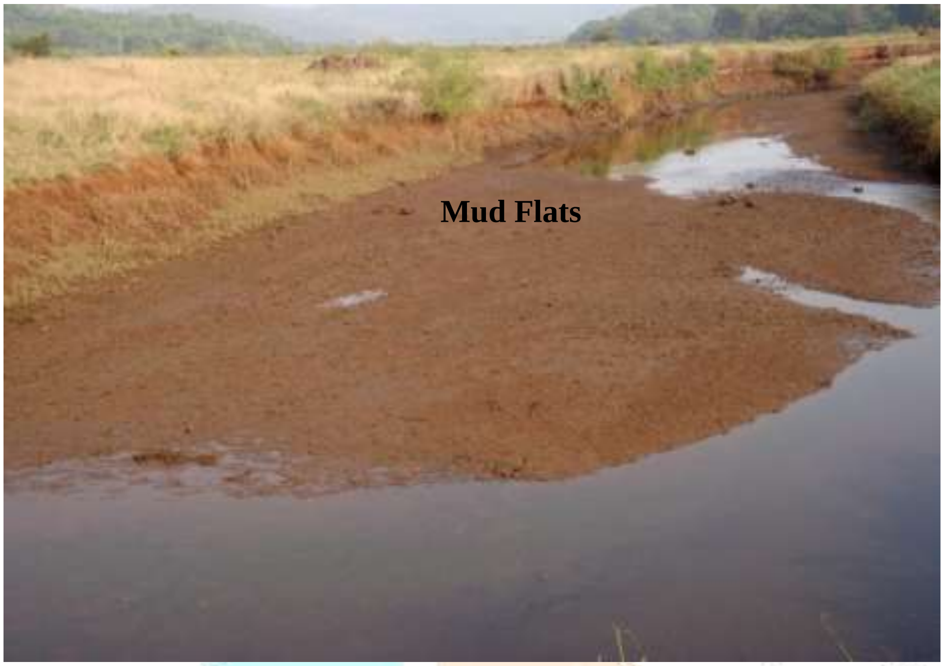
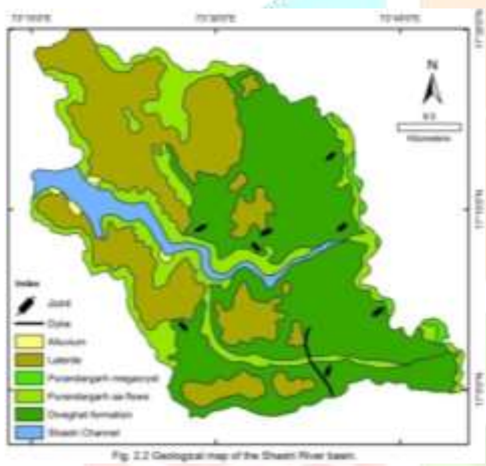


Plate 1: Development of the Mud Flats Exposed Along the Shastri River, (Location – Phungus)

Fig. 1 Area of Investigation (Google)

Fig. 3 Sample Location



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