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SOME OBSERVATION ON THE MINERALOGY AND CHEMISTRY OF THE PLEISTOCENE ALLUVIUM FROM MIRPURE AREA, DACCA

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A preliminary study of the Pleistocene alluvium from Mirpure area, Dacca has been carried out with respect to its texture, mineralogy and chemistry. The clay falls in the category of "loam" with none of the sand, silt and clay fractions generally exceeding 50%. Chemically the clay may be termed as sublateritic markedly enriched in alumina and iron oxide and deficient in lime and magnesia. The mineralogical study of the coarse fraction separated from the clay indicates the presence of, besides other light minerals, clear grains of labradorite and bytownite. Heavy minerals consists of sillimanite, zircon, kyanite, topaz, tourmaline, staurolite and rutile in order of decreasing abundance. The suite of heavy minerals suggests a mixed perentage.

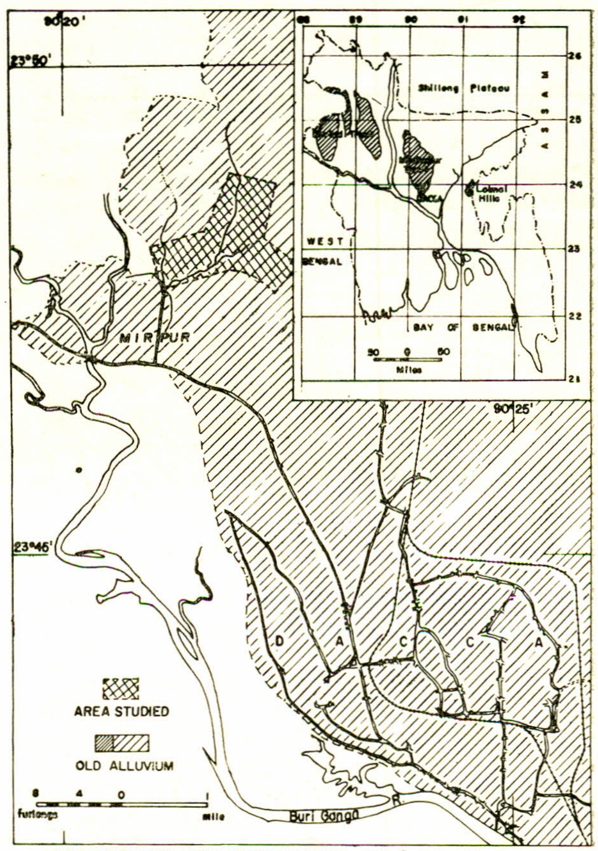
On the basis of mineralogical study it is suggested that the 'old alluvium' of Mirpure has been largely derived from igneous and metamorphic source rocks. Further, it is suggested that the sediments have been deposited under subareal condition most probably fluviatile.

The alluvial flat in East Pakistan is generally separated into two distinct physiographic units. One is the so called 'old alluvium' and the other is the new alluvium deposited by the intricate river system of East Pakistan during the Recent. The 'old alluvium' stands out prominently as physiographically elevated unit and is supposed to have been deposited during the Pleistocene epoch the material of which has been deprived from the north.[1]

Besides several smaller outcrops, there are two large tracts predominantly covered by 'old alluvium'—Barind and the Modhupur jungle Fig. 1. The Barind covers an area of 2500 sq miles and lies between Ganges and Barhamputra forming the northwestern part of East Pakistan. The Modhupur tract covers an area of 1600 sq miles between Meghna and Barhamputra rivers extending from Dacca in the south to Jamalpur in the Mymensingh district in the north. The tract stretches for about 70 miles along northsouth while its extent along east-west is only about 35 miles.[2] Its present elevated position attaining a maximum height of 100′ above sea-level along the western margin with respect to the surrounding alluvial flat of the Recent is considered to be due to 'enechelon faulting'.[3] The Modhupur jungle gradually slopes down towards east to be overlapped by the alluvium of the Recent.

Paucity of literature on the subject indicates that the 'old alluvium in general has been given very little attention by geologists. Such inadequate published literature as exist point towards the necessity of a more detailed investigation than has hitherto been carried out.

The present preliminary investigation has therefore been undertaken to determine quantitatively the mechanical and chemical composition of the old alluvium. Further, the coarse fraction separated from the alluvium has been studied for its mineral content, texture and relative abundance.



MAP SHOWING THE DISTRIBUTION OF 'OLD ALLUVIUM" IN EAST PAKISTAN, AND THE AREA STUDIED

Material and Method

Six samples of the 'old alluvium' were collected from freshly excavated areas in Mirpure, 10 miles north of Dacca which constitutes the southern part of the Modhupur tract. These samples were collected by scrapping the face of fresh exposures from top, to bottom usually representing 3 to 5 feet in length so that a representative sample was obtained for the particular exposure. Samples were spaced atleast ¼ mile apart.

The alluvium as seen in the field is unconsolidated and massive. Plasticity increases with water content and it becomes very hard and stiff when dried. The colour of the alluvium is reddish brown in the upper horizon but with depth gradually becomes light brown and even mottled. The uniform intense coloration near the surface is obviously due to oxidation of iron into ferric state. Varying quantities of limonitic concretions of 1 mm to 2 mm in size are found associated with the clay.

Laboratory investigation of the alluvium has involved (i) size analysis by hydrometer method after necessary dispersion, (ii) separation of coarse fraction lying between .074 mm to .246 mm by seiving, (iii) heavy mineral separation by centrifuging after treatment with dilute hydrochloric acid to remove the iron coating from the surface of the grains, (iv) microscopic determination of minerals and their relative abundance and (v) chemical analysis of three of the samples. The results obtained have been presented and discussed in the following paragraphs.

Table 1.—Result of Mechanical Analysis of the Pleistocene Alluvium from Mirpur, Dacca.

	S1	S2	S3	S4	S5	S6
Clay %	37	37	35	40	40	29
Silt %	14	12	19	17	17	30
Sand %	49	51	46	43	43	41
Total	100	100	100	100	100	100

Table 2.—Result of Chemical Analysis of the Pleistocence Alluvium from Mirpur, Dacca.

	S1	S2	S3
SiO_2	40.50	40.56	44.03
Al_2O_3	29.39	26.86	27.32
Fe_2O_3(a)	12.01	11.98	12.58
CaO	0.50	0.40	0.50
MgO	1.51	1.09	1.00
Na_2O+K_2O	3.80	6.71	4.29
TiO_2	0.08	0.43	0.29
P_2O_5	1.02	1.23	1.50
CO_2	0.49	0.45	0.51
H_2O(b)	10.59	10.67	7.99

Note :(a) Total iron (b) Total water

Results

Mechanical Analysis.—The results of the mechanical composition of six samples of the alluvium have been represented on a triangular classification scheme proposed by Shepard.[9] The alluvium falls under the catagory of clayey sand and can be termed as "loam" according to Robinson's classification scheme.[10] A prominent feature of the old alluvium is fairly low content of silt in relation to those of sand and clay (Table 1, Fig. 2).

Chemical Analysis.—Three samples of the alluvium have been chemically analysed by gravimetric method (Table 2). A plot of the major oxides is shown on a triangular diagram[11] (Fig. 3). For the sake of comparison with the 'old alluvium' major oxides for average shale as well as for average igneous rock,[12] the kind of material which may reasonably be assumed to have provided the source rock for the alluvium, have also been plotted in the same diagram.

Mineralogy.—The mineralogical studies include the examination of heavy and light fractions of all the six samples. The coarse fractions lying between .074 mm to .246 mm were studied for the heavy and light minerals present.

Heavy Minerals.—The amount of heavy minerals present is very low and ranges between .70% to 2.80% by weight of the coarse fractions of the size .074 mm to .246 mm. The relative abundance of the heavy minerals present, calculated on the basis of a total count of 1367 grains, has been given

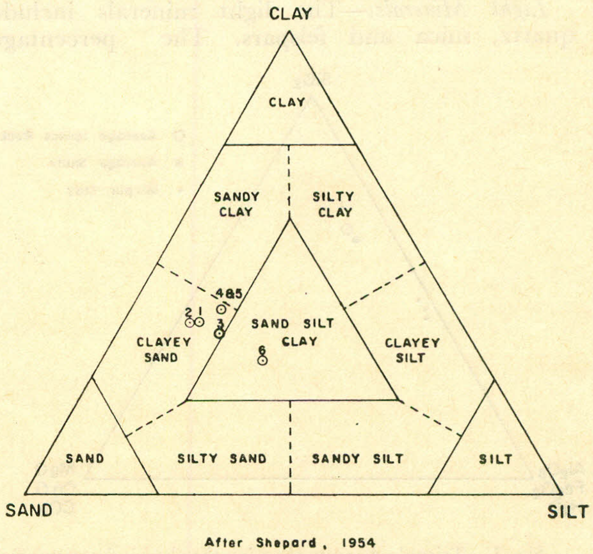


Fig. 2.—Triangle diagram showing the mechanical composition of the Pleistocene alluvium from Mirpur area, Dacca. (o^1 indicates the sample with its composition).

in Table 3. Of the heavy minerals, opaques (magnetite, ilmenite, limonite) constitute considerable proportion amounting to 31.7% by volume. Among the nonopaques, sillimanite is the most abundant mineral (12.72%) followed by zircon (11.99%), topaz, kyanite and tourmaline. Garnet and hornblende are present in notably low quantity (Table 3).

The marked angularity of the grains is the conspicuous textural feature although subrounded to perfectly rounded grains are also observed. Zircon, for example, can be found as perfectly euhedral crystal to well rounded grains. Tourmaline appears as perfectly angular prismatic grains to those with snubbed edges and corners. Both the green and red varieties of tourmaline are present, the former being far more abundant. Kyanite occurs as cleavage fragments and elongated prismatic grains showing step like features and exhibits remarkable angularity. Sillimanite is another mineral which occurs as colourless prismatic grains often showing radial structure. Garnet occurs as colourless stout angular to subangular grains often showing pitted surface and conchoidal fracture. Staurolite and topaz are also found to occur as stout angular to subangular grains with conchoidal fracture; the former being slightly pleochroic. Hornblende is found as pale green coloured grains often with jagged ends. Rutile is found in two forms—well formed prismatic grains showing marked angularity and striations and rounded and anhedral grains, the later being more frequent (Figs 4 and 5).

Light Minerals.—The light minerals include quartz, mica and felspars. The percentage abundance of these minerals has not been worked out mainly due to the difficulties involved in distinguishing between orthoclase felspars and quartz and also between untwinned plagioclase and

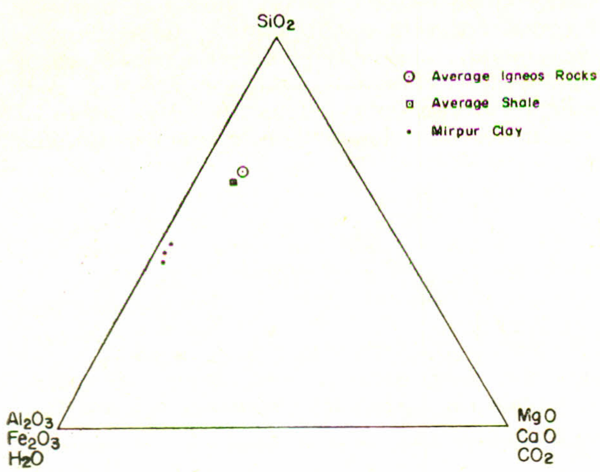


Fig. 3.—Triangle diagram showing the chemical composition of the Pleistocene alluvium from Mirpure area, Dacca. Composition for average shale and average igneous rock has also been plotted for comparision.

TABLE 3.—RELATIVE PERCENTAGE ABUNDANCE OF HEAVY MINERALS FOUND IN THE PLEISTOCENE ALLUVIUM FROM MIRPUR, DACCA.

Minerals	Percent
Zircon	11.99
Tourmaline	8.26
Kyanite	8.85
Garnet	1.38
Topaz	8.48
Staurolite	5.48
Sillimonite	12.72
Rutile	2.19
Hornblende	1.02
Opaques	31.72
Unidentified	7.82

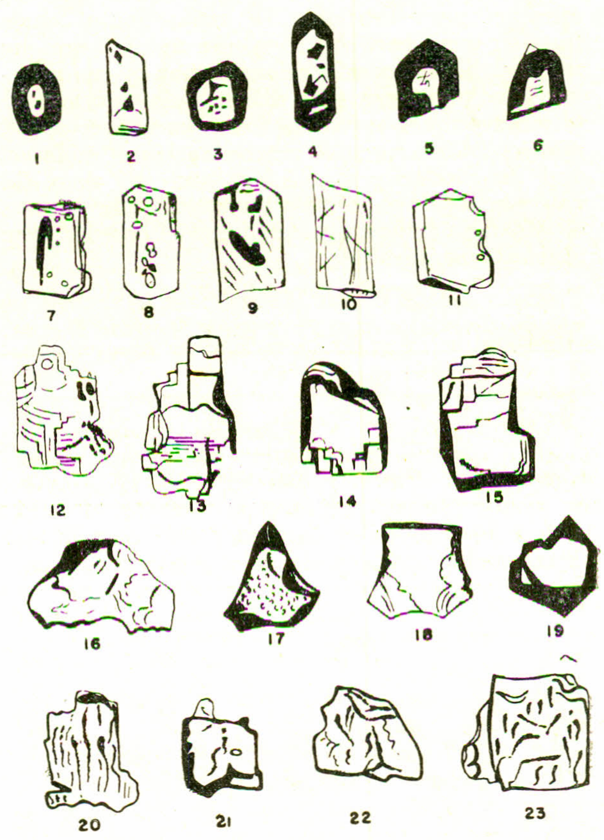


Fig. 4.—Sketches of minerals showing their textural features. 1—6 zircon (note inclusion and overgrowth), 7-11 tourmaline (note probable liquid inclusion represented by open circles), 12-15 kayanite, 16-19 garnet, 20-23 topaz, grain size—.246mm to .074 mm.

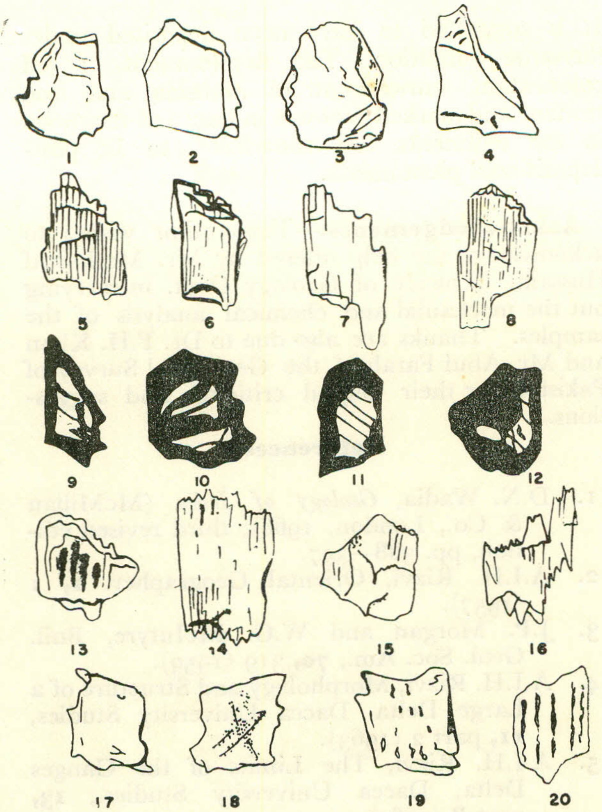


Fig. 5.—Sketches of minerals showing their textural features. 1-4 staurolite, 5-8 sillimanite, 9-12 rutile, 13-16 hornblende, 17 and 18 quartz, 19 and 20 plagioclase felspar, nicols not crossed (note surface pitting and channels developed due to solution and leaching). Grain size—.246 mm to .074 mm.

orthoclase in the grain slides leading to erraneous 'abundance' results.

Felspars, although being greatly subordinate to quartz commands special attention because of the large number of species occuring together. Among the potash felspars, orthoclase, microcline and perthite have been recognised. The plagioclase felspars include such species as oligoclise, andesine, laboradorite and bytownite as has been revealed by extinction angle measurements on a number of 011 cleavage fragments.

The felspars occur largely as subangular fragments. They usually show snubbed edges although occasionally fragments with marked angularity are seen. Felspars by and large have escaped complete alteration. In many cases particularly in orthoclase felspar, alteration is marked by turbid appearance in the central part of the grains. The plagioclase felspars although being generally less stable than potash felspars[13] are fairly fresh and show clear features such as little groves and channels on the surface that might have developed due to solution and leaching (Fig. 5, No. 19 and 20).

Among the light minerals quartz is the most abundant one and is found as angular to subangular grains. Many quartz grains have no inclusions while others show abundant inclusions of unidentified minerals of rounded to acicular habits. They show both normal and strained extinction. Neither outgrowth nor has secondary enlargement been noticed. Mica occurs as thin cleavage flakes of circular habits with jagged edges.

Discussion and Conclusion

Mechanical analysis of the clay reveals the presence of relatively high proportion of sand content which is not immediately apparent on megascopic examination. The relatively low quantity of silt in relation to the sand and clay fractions is a notable feature of the alluvium. Further, it appears that the general mechanical composition of the old alluvium is fairly uniform and so are its lithological characters. The apparent poor sorting as is indicated by the amount of sand-silt-clay admixture may be suggestive of a fluviatile condition of deposition of these sediments.

Chemical analysis of three samples of the old alluvium reveals two important features: (a) high content of alumina and iron and (b) low content of lime, magnesia and carbon dioxide. A plot of the major oxides on a triangular diagram (Fig. 3) clearly indicates an enrichment of alumina and iron in the alluvium as compared with those for average shale as well as for average igneous rock. Low content of soda, potash, lime and magnesia is considered to be due to solution and leaching of these metals from the clay under the present warm and humid climatic condition. Solution and leaching is also indicated by the development of minute solution channels on plagioclase felspars. A greater part of the chemical differenciation is considered to be a post-depositional feature and can be ascribed to warm and humid climatic condition where such processes as oxidation and leaching due to solution prevail. The present red colouration of the alluvium is also considered to be a later development due to the oxidation of iron into ferric state. The intensity of red colour has been found to decrease with depth on freshly excavated outcrops which also turn reddish brown on continued exposure.

The suite of heavy minerals present in the 'old alluvium' includes in order of abundance, sillimanite, zircon, topaz, kyanite, tourmaline, garnet and hornblende. Apart from hornblende all the minerals are chemically stable. Hornblende is however present in notably low quantity. The heavy minerals present indicate a mixed parentage for the 'old alluvium.' The association of sillimanite, kyanite and garnet or a garnet-staurolite-kyanite suite is well known as indicator of metamorphic sources.[13] Therefore the presence of such minerals as kyanite, sillimanite, garnet and staurolite along with quartz showing undulose extinction in the old alluvium is suggestive of its derivation from a metamorphic province. The occurrence of euhedral zircon, rutile, tourmaline, microcline and perthite in the sediments indicates an igneous source rock. A sedimentary source is also indicated by occasional presence of rounded zircon and quartz grains.

Among the light minerals, presence of calcic plagioclase like labradorite and bytownite is particularly significant. These felspars are very susceptible to chemical decay.[14] Inspite of their highly unstable nature they have been found to be fairly fresh and angular. While the presence of the calcic plagioclases indicates a source of basic igneous rocks, it also suggests a rather short distance of transportation.

From a priliminary study such as this covering a small area it is not possible to say much about the condition of deposition of these sediments. The material of the 'old alluvium' can however be suggested to have been derived predominantly from igneous and metamorphic source rocks. It is also suggested that atleast partially the 'old alluvium' represents glacial rewash sediments transported from the north as is indicated by the presence of particularly fresh plagioclase felspars. The climatic condition during the time of deposition of these sediments may not have been as warm and humid as it is now. Remarkable angularity of both the light and heavy minerals and relatively poor sorting suggest a short distance transportation and deposition under subarial condition—probably fluviatile. This is corroborated by the occurrence of gravels as recorded in many of the boreholes drilled in the old alluvium of Modhupure and Barind tracts by East Pakistan WAPDA in connection with underground water investigation.[15] Further, in none of the boreholes so far drilled presence of any fossil but for some partially decomposed wood has been reported.

In conclusion it may be said that the 'old alluvium' of Mirpur has been derived largely from igneous and metamorphic source rocks. It is suggested to have been deposited under fluviatile condition. The development of red colouration, enrichment of alumina and iron content and marked decrease in lime and magnesia in the sediments are considered to be post-depositional phenomena.

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References

1. D.N. Wadia, *Geology of India* (McMillan & Co., London, 1966), third revised edition, pp. 388—397.
2. A.I.H. Rizvi, Oriental Geographer, **1**, 1 (1957).
3. J.P. Morgan and W.G. McIntyre, Bull. Geol. Soc. Am., **70**, 319 (1959).
4. A.I.H. Rizvi, Morphology and Structure of a Large Delta, Dacca University Studies, **11**, part 2 (1963).
5. A.I.H. Rizvi, The Limits of the Ganges Delta, Dacca University Studies., **13**, part B (1964).
6. H. Brammer, An Outline of the Geology and Geography of East Pakistan in relation to soil development, Pakistan J. Soil Sci., **1**, 1 (1964).
7. M. Qudrat-i-Khuda, M.A. Biswas and A.K. Basak, Scientific Researches, **1**, 105 (1964).
8. M.A. Biswas and S. J. Ahmad, Scientific Researches, **1**, 184 (1964).
9. F.P. Shepard, *Nomenclature Bassed on Sand-Silt-Clay Ratio 1954.* (Harper and Row, 1957) second edition, p. 24.
10. Robinson's *In Sedimentary Rocks* (Harper and Row 1957), second edition, p. 24.
11. F. J. Pettijohn, *Sedimentary Rocks* (Harper and Row 1957), second edition, p. 106.
12. F.W. Clarks, The Data of Geochemistry, Geol. Survey of Am. Bull., 770 (fifth edition), pp. 34 (1959).
13. H.B. Milner, *Sedimentary Petrology* (Thomas Murby & Co., 1940, third edition, p. 499.
14. B. Mason, *Principles of Geochemistry* (John Wiley & Sons, 1956). pp. 132.
15. Directorate of Hydrogeology, E.P. WAPDA Groundwater Investigation in East Pakistan (1964-1967), Vol. II, E.P. WAPDA Water supply paper 316 (1968).