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Origin and Palaeo-Depositional Vicissitudes of Late Quaternary Sediments of Central Kerala, South India

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ABSTRACT

Study of Late Quaternary sediments has received much attention in recent years, as these particular sediments are associated with the finer particles and plays a pivotal role in elemental exchange between sediments and water. Clay minerals are reactive geological materials or particulates that regulate the overall physico-chemical milieu of aquatic environments. The clay mineral composition of sediments may give important clues to the conditions under which the sediments were deposited in addition to the climatic conditions, provenance etc. of the sediments. The composition and distribution of clay minerals have been used as indicators of sediment dispersal in various environments. Information on clay minerals is essential for a better understanding of the origin, early digenetic reactions and environment of deposition of the sediments. This clay mineral rich top layer containing organic matter and other nutrient elements which is the major life supporting systems of the wetland ecosystems. The nature of the nutrient dynamics in the wetland system is dependent on the quality and quantity of the clay minerals in the sediments. The present study is an attempt to understand the origin, geochronology and depositional environments of the clay sediments of the two river basins of central Kerala

KEYWORDS: *Origin, Geochronology, Depositional environments, Quaternary, Central Kerala*

INTRODUCTION

Ecologically, wetlands are important ecotones, which are transitional between open waters and land endowed with definite structural and functional attributes and performing specific ecological rules. Wetlands are water saturated and submerged areas, which include both natural and man-made, permanent, or temporary, fresh water or marine habitats. These areas occur in almost all climatic regions and differ widely on their biotic and abiotic structure. Clay mining from paddy lands (a major wetland system of Kerala used traditionally for paddy cultivation) and other wetlands for tile and brick making can be found in many districts of Kerala (KSLUB, 1981). Our environment is degrading in large

scale due to over exploitation, unscientific development and improper management. Major anthropogenic activities like mining, pollution, deforestation etc. can contribute major threat to our environment. The only way of protecting our environment and land resources is through sustainable management practices. All these areas are demanding urgent focus and proper fallow up.

The clays are one of the major mineral deposits used in a wide variety of industries. The composition and distribution of clay minerals have been used as indicators of sediment dispersal in various environments. (Biscaye, 1965; Griffin *et al.,* 1968). Statistical analysis revealed that proper selection and combination of size parameters can be used as an effective tool to discriminate various depositional environments of sediments of ancient as well as recent origin (Freidman, 1967; Folk, 1966). Each environment leaves its imprints on sediments and therefore the various sediment characteristics can reflect their respective environment of deposition. Further the particle size distribution of ancient as well as modern sediment has a bearing on the mineralogy and chemistry of sediments (Forstner and Wittman, 1983). Study of sediments is able to find out a number of depositional environments from size spectral analysis as particle distribution is highly influenced by the environment of deposition (Folk and Ward, 1957; Padmalal, 1992 and Ngusaru, 1995 and Visher 1969). The present study covers a spectrum of subject components related to almost all aspects especially the origin, geochronology and depositional environments of the of tile and brick clay sediments of Chalakudy and Periyar river basins of central Kerala.

STUDY AREA – A BRIEF PROFILE

The Chalakudy and Periyar river basins, selected for the present study, are located in the central part of Kerala State (Fig.1). The Chalakudy river basin lies between 10°30'–10°32'N latitudes and 76°14'–77°2' E longitudes and the Periyar River between 9°31'–10°13' N latitudes and 76°8'-77°7' E longitudes. The basins are mainly located in the Thrissur and Eranakulam districts of Kerala State. The total catchment areas of the Chalakudy and Periyar river basin measures to about 1448 km^2 and 5398 km^2 respectively. Out of the total catchment area approximately 300 km^2 area of Chalakudy river basin and 114 km^2 area of Periyar river basin fall in Tamil Nadu State (CWRDM, 1995).

Geologic setting of an area is a major factor, which influences the various human activities of that region. The major rock types or lithological units make its structural features and has general relevance to landscape and landuse (Vink, 1975). The Chalakudy and Periyar river basins record all the three major geologic formation such as, archaean crystallines, tertiary sedimentaries and quaternary deposits. Laterite caps over crystalline and sedimentary rocks. Recent to Sub-Recent sediments cover the low lying areas and the river valleys. The crystallines are represented by a spectrum of rock types which include charnockites, charnockite gneiss, hypersthene–diopside gneiss, hornblende gneiss, hornblende–biotite gneiss and quartz-mica gneiss / biotite–gneiss (composite). These crystalline rocks are intruded at many places by quartzite, pyroxene granulite and calc granulite. These pre-Cambrian crystallines comprises about more than 90% of the total rock formations in the study area and the coastal sand and alluvium include only about 4% of the total study area. Sedimentary formations ranging in age from Miocene to Recent overlie the crystallines along the coastal tract. The Sub-Recent formations consisting of a great thickness of sand with shell fragments, black clays, peat beds etc. are also seen mostly in low lying areas (Fig. 2).

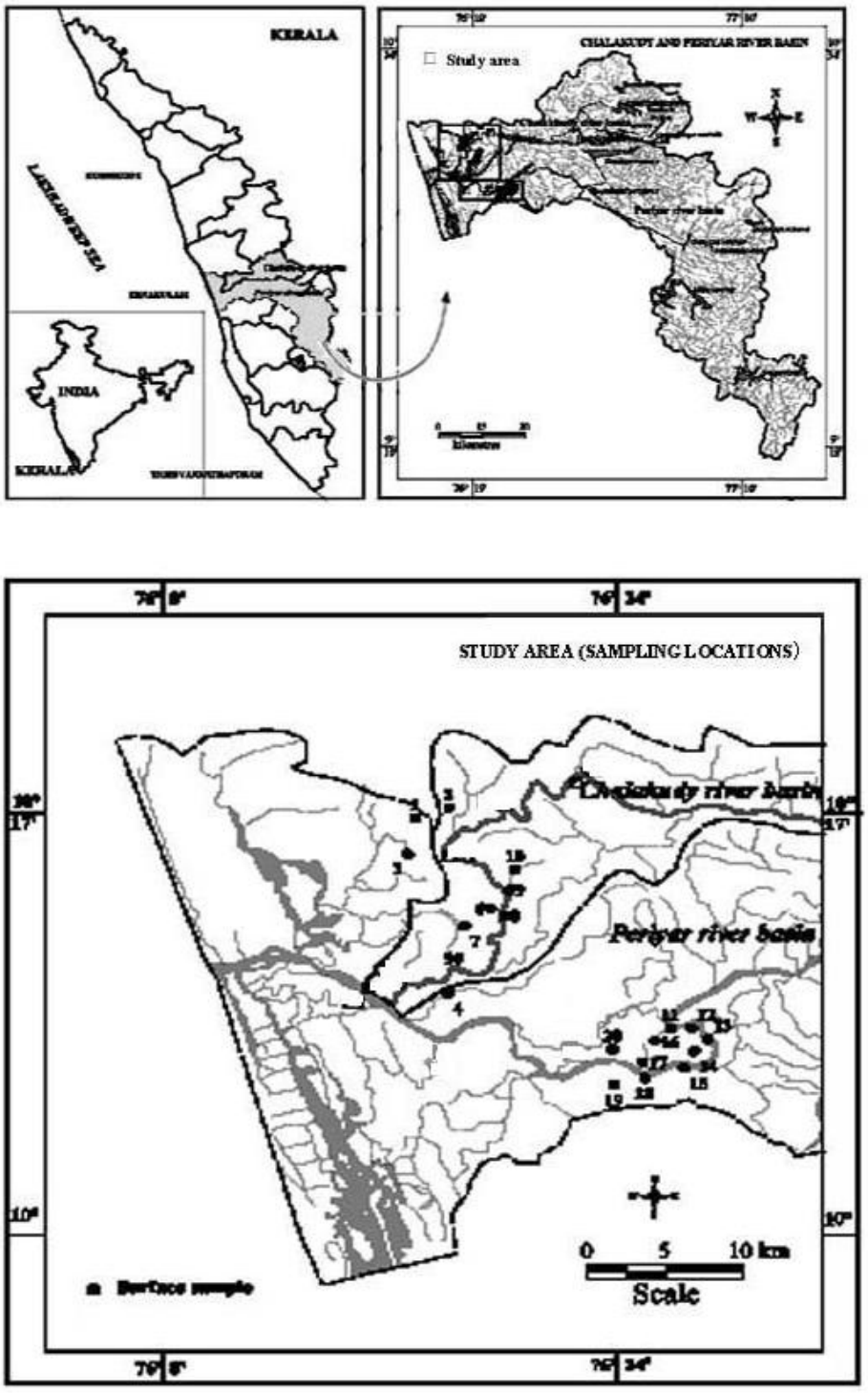

Figure 1: Study area showing sampling locations

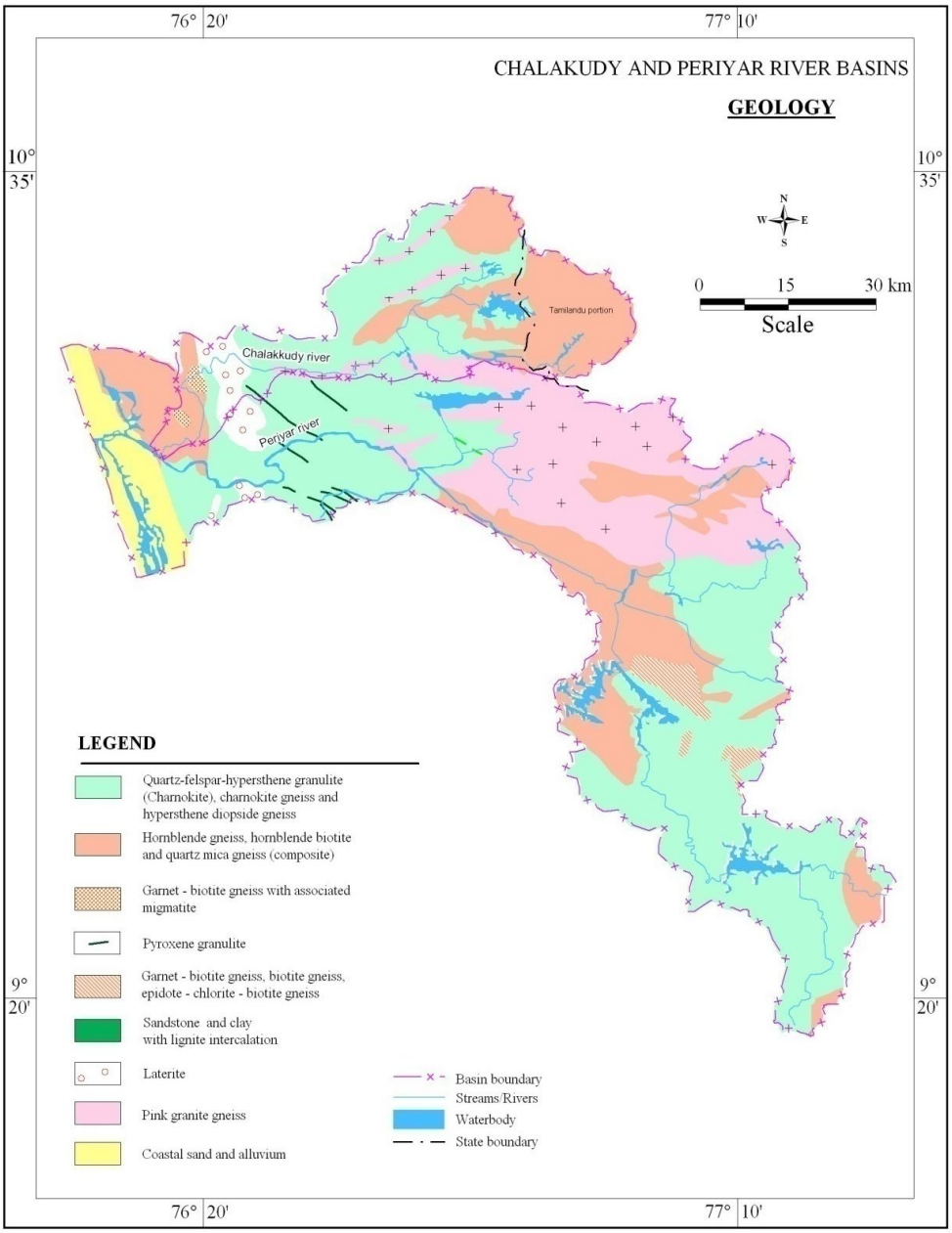

Figure 2: Geology map of the study area

MATERIALS AND METHODS

A systematic fieldwork was carried out in the entire study area (Fig. 1) to collect the relevant field information, secondary data from various sources and collection of sediment samples for laboratory analysis. The areas, where clay mining activities take place, were mapped using Survey of India (SOI) topo base maps in 1:25000 scale. A total of 20 surface samples from the major clay mining centers were collected from selected locations in the Chalakudy and Periyar river basins. The sediment samples collected from the Chalakudy and Periyar river basins were subjected to sedimentological and geochemical analysis following standard procedures. A portion of each of the sediment samples were dried and powdered well for geochemical analysis. The sand, silt and clay content of the bulk sediments were determined by pipette analysis following the method of Lewis (1984).

Mud fraction was separated from the respective samples using 230 mesh (63 μm) ASTM sieves. The textural facies (sediment types) were identified following the ternary model of Picard (1971). Organic carbon rich sediment and shell samples were used for C^{14} dating. Radiocarbon dates of the samples were determined following standard procedures by Birbal Sahni Institute of Paleobotany (BSIP), Lucknow.

RESULTS AND DISCUSSIONS

Origin of Clays

The formation of tile and brick clay deposits of Kerala, according to Nair and Padmalal (2003), is related to the evolution of fluvial systems and monsoonal activity coupled with sea level changes during the late Quaternary Period. Palaeoclimatologically, the period from 10000–4000 ybp is reported to have witnessed high monsoonal activity. The radiocarbon dates of the tile and brick clay sediments / samples are also of this age (Table 1). The abundant occurrences of marine shells with C^{14} date of 5440±80 ybp, recorded 2.5m bgl at Puthenvelikara shows the prevalence of marine activity at this site during middle Holocene. The corresponding tidal zone with mangrove vegetation might have extended upto the Valur or even to Vynthala-Annallur stretches which are located ~10 km east of Puthenvelikara. The dominance of Rhizophoraceae pollens in the sediments collected ~3 m bgl at Valur and C^{14} age (5520 ±160 ybp) of organic matter recovered at the level confirms this view. The sediment types of the study area are illustrated in the table 2 and the corresponding sediment type is shown in the Figure 3.

Table 1: Radio Carbon dates of samples of study area associated with tile and brick clays

Location	Latitude Longitude	Depth (m, bgl)	Material	Age (Year bp)	Source
Valoor	10°14'30" 76°20'25'	2	Peat	3390±110	Shajan (1998)
Valoor	10°14'30" 76°20'25"	3	Peat	5520±160	Shajan (1998)
Annallur	10°18'08" 76°14'44"	4	Peat	6630±120	Padmalal (1992)
Puthenvelikara	10°11'45" 76°14'37 "	2.5	Shell	5440±80	Padmalal (1992)
Puthenvelikara	10°11'45" 76°14'37 "	4.7	Sediment	7050±140	Present study

The presence of mangrove vegetation from inland to the present day coast-line at about 6000-5000 ybp, according to Shajan (1998), might have resulted from the shifting of coastline inland, consequent to the early Holocene transgression which culminated around 6000 ybp. The regressive phase during late Holocene (~3000 ybp) which gave rise to the present position of coastline might have resulted in the westward advancement of fluvial dominated sediments over the organic matter rich mangrove detritus dominated sediments (locally known as 'Kandal'). The peculiar sedimentary sequence (grayish black to black carbonaceous clay/mud–reddish brown to brownish red silty sediments) of Annallur and Cherukadappuram might have evolved in this way. In short the tile and brick clay sediments of Chalakudy and Periyar river basins are of fluvial or fluvio-marine origin and are formed during the coastal evolution processes of Holocene. But the region further inland, particularly, near Melur and surrounding regions were influenced by fluvial sedimentation as indicated by the lithological suite with fining upward sequence and comparatively low organic matter. In short, the tile and brick clay sediments of Chalakudy and Periyar river basins are of fluvial or fluvio-marine origin and are formed during the coastal evolution processes of Holocene (Table 2).

Table 2: Sand, silt and clay content of surface sediments of Periyar and Chalakudy river basins with mud content and sediment type.

Location	Sand %	Silt %	Clay %	Mud %	Sediment type (after Picard, 1971)
Periyar river basin					
Madanpilli	2.09	64.41	33.50	97.91	Clayey silt
Puthyedam	23.54	39.46	37.00	76.46	Silty mud
Ezhippuram	15.00	45.50	39.50	85.00	Silty mud
Parappuram	26.44	36.56	37.00	73.56	Silty mud
Koovapadam	5.42	54.58	40.00	94.58	Clayey silt
Vazakulam	5.11	51.88	43.01	94.89	Clayey silt
Mudickal	6.19	72.31	21.50	93.81	Clayey silt
Sreemulanagam	24.50	38.80	36.70	75.50	Silty mud
Mattoore	24.53	38.45	37.02	75.47	Silty mud
Ockal	18.63	42.50	38.87	81.35	Silty mud
Chalakudy river basin					
Annallur (I)	46.88	24.25	28.71	52.96	Sandy mud
Annallur (II)	33.97	33.84	32.17	66.01	Silty mud
Vynthala	70.93	12.13	17.06	29.07	Clayey sand
Unjakadavu	19.67	24.94	55.38	80.32	Silty clay
Kochukadavu	10.82	27.03	62.21	89.18	Silty clay
Kumbidi	56.79	23.37	20.48	43.21	Silty sand
Melanthuruthu	19.67	23.13	56.87	80.00	Silty clay
Erayankudi	34.49	41.64	23.44	65.08	Silty mud
Mambrakadavu	56.26	12.11	31.6	43.71	Clayey sand
Valurpadam	41.49	17.34	41.16	58.50	Sandy mud

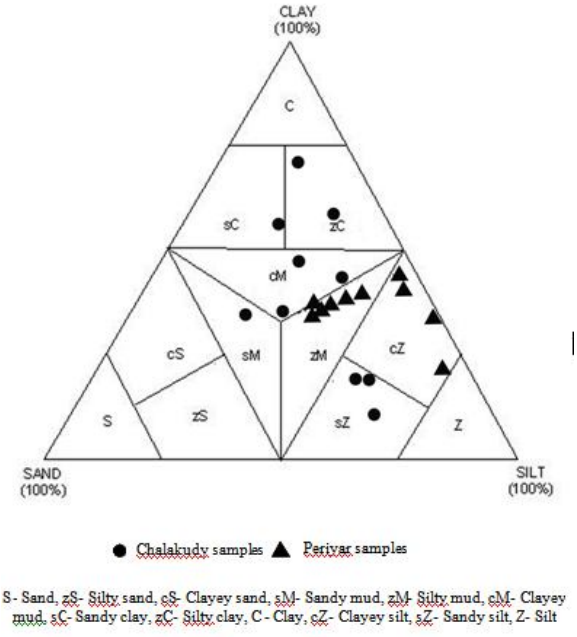

Figure 3: Ternary diagram shwoing the textural type of surface sample collected from Chalakudy and Periyar river basins (modified after Picard, 1971)

GEOCHRONOLOGY

The analysis of fossil pollen assemblages in sediments/sedimentary deposits can give inferences on the relative age of sediments, vegetative history, climatic conditions, sea level changes and even cultural development of human beings (Tooley, 1980; Shajan, 1998). The palynodebris/peaty material collected from 5m below the ground surface at Valur reveals the occurrence of Rhizophoracea, Poacea, Arcacea, Meliacea and Moracea, in addition to some unidentified spores and pollens. Of these, Rhizophoracea are present in abundance, indicating mangrove vegetation in contributing palynodebris to the sedimentary deposit of the Chalakudy river basin. It is important to note from the Valur section that a sample collected 3m bgl is C^{14} dated to 5520 ± 160 years and another one from 2m bgl is dated to 3393 ± 110 years (Shajan 1998). The results of the C^{14} dates of samples analyzed are given in Table 1 along with some of the dates collected from the available literature. Peat deposits of variable thickness (a few cm to even half a meter) are encountered in some of the borehole samples at different levels. Detailed analysis of peaty debris reveals that the provenance of organic debris is very near, and the bottom part of some of the peat beds are with distinct roots penetrating the subsoil, indicating insitu appearance. But, the shells are recorded only in boreholes, which are located near the coast. All the dates indicate that the clays used for tile and brick making are of Holocene age (7000 ybp and 3000ybp). The lithological sequence in the study area have been evolved due to sea level changes affected the area during Holocene time.

SUMMARY AND CONCLUSION

The tile and brick clay blanketed zones of Chalakudy and Periyar river basins have been evolved to the present state thorough several episodes of geological events. The tile and brick clays are a part of the Late Quaternary deposits, which is underlined by 40-55 thick tertiary deposits and then by Precambrian crystalline. The surface of the Tertiary is often lateritised at many places. Two types of clays are seen in the study area–yellowish brown to brownish red type and grayish black to black type. The former is with appreciable amount of sand and silt, and are used for ordinary brick manufacturing. The black clays collected from Valur revealed the presence of mangrove spores of rhizophoraceae in it, indicating a swampy environment during early –middle Holocene. The C^{14}dates of the carbonaceous clays underlying the reddish brown clays yielded age date between 7050± 140 ybp and 3390±110 ybp. The red earth type of material found above this carbonaceous clay might be slightly younger in age and may be flood plain origin. In short, the deposition of the tile and brick clay in Kerala is related to the evolution of fluvial drainage system and monsoonal activities coupled with sea level oscillations during Holocene.

REFERENCES

1. Biscaye, P. E. (1965). Mineralogy and sediments of recent deep sea clays in the Atlantic Ocean. *Geol. Soc. Amer. Bull.,* 76, 803 – 8032.
2. CWRDM. (1995). Water Atlas of Kerala. Centre for Water Resource Development and Management, Kozhikode; pp.75-78.
3. Folk, R.L. 1966. A review of grain size parameters. Sedimentology, 6: pp. 73-93.
4. Folk, R.L., and W. Ward. (1957). Brazos river bar: A study in the significance of grain size parameters. *Jour. Sed. Petrol*., 27, 3-26.
5. Forstner, U., and G. T. W. Wittman. (1983). Metal pollution in the aquatic environments, Springer- Verlag, New York, 486p.
6. Freidman, G. M. (1967). Distinction between dune, beach and river sands form their textural characteristics. *Jour. Sed. Petrol.* 31, 514 – 529.
7. Griffin, J. J., H. Windom and E.D. Goldberg. (1968). *Deep sea. Res.,* 15, 433.
8. KSLUB. 1981. Report of the study of clay mining areas in Thrissur district. Kerala State Land Use series No.14, Kerala State Land Use Board, Thiruvananthapuram, 21p.
9. Lewis, D. W. (1984). Practical sedimentology. Hutchinson Ross Publishing Company, Pennsylvania, 227p.
10. Nair. K. M and D. Padmalal, (2003). Quaternary Sea Level Oscillations, Geological and Geomorphological Evolution of South Kerala Sedimentory

Basin. Project Final Report. Department of Science and Technology, Govt. of India.
11. Ngusaru, A. S. (1995). Grain size analysis and facies interpretation of backshore sediments along the beach area, North of Dares – Salam, Tanzania. *Ind. Jour. Mar. Sci.* 24, 87 – 90.
12. Padmalal, D. (1992). Mineralogy and Geochemistry of the sediments of Muvattupuzha River and central Vembanad estuary, Kerala, India. Ph.D thesis. Cochin University of Science and Technology, Kochi.
13. Picard, M. D. (1971). Classification of fine-grained sedimentary rocks. *Jour. Sed. Petrol*. 41, 179-195.
14. Shajan, K. P. (1998). Studies on late quaternary sediments and sea level changes of the Central Kerala coast, India. Ph D Thesis unpublished. Cochin University of Science and Technology, Kochi.
15. Tooley, M. J. (1980). Methods of reinstruction in the environment in Britoric pre-history. Eds. I. G. Simmons, and M. J. Tooley, Oxford university press.
16. Vink, A.P.A. 1975. Land use in advancing agriculture, Springer-Verlag, New York, 394p.
17. Visher, G. S. (1969). Grain size distributions and depositional processes. *Jour. Sed. Petrol.,* 39, 1074-1106.

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