PETROGRAPHIC INVESTIGATIONS OF CUDDLORE SANDSTONE, FROM SOUTH INDIA

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ABSTRACT

The subarkosic Cuddlore sandstone occurring at Neyveli, derived from a provenance of acid igneous and low grade metamorphic rocks, was deposited rapidly in a marine (estuarine and/or deltaic) environment.

GEOLOGICAL SETTING

The paper deals with the petrographic study of Cuddlore sandstone collected from Neyveli, 35 km west of Cuddlore, Tamil Nadu State. The sandstone formation extends intermittently from near Rameshwaram through Pudukottah, Tanjore, Cuddlore, Pondicherry, Madras, Nellore to Rajamahendri (KRISHNAN, 1968). The sandstone comprises laterised yellow, red soft ferruginous sandstone with intercalated sands, clays and pebble beds. The beds show a gentle easterly dip. The outcrops exhibit current bedding markedly. They are considered to belong to Burdigalian age on stratigraphic and palaentologic evidence (VREDENBURG, 1908). The petrographic work on these sandstones is scanty in literature.

METHODS OF STUDY

A large bulk sample (20 kg) comprising several random spot samples collected all over the Neyveli area, has been studied intensively for size distribution, heavy and light minerals, nature of grain-cement-matrix, major and trace element composition (Emission spectroscopy and Atomic absorption spectrometry). The opaques magnetite and ilmenite were identified after the method of BABU (1967). The nature of clays present is determined to delineate the type of environment (D.T.A. and X-ray diffractometry).

RESULTS AND DISCUSSIONS

(i) *Size analysis:* The samples were disaggregated by soaking the sandstone in water and in a few cases by boiling it in acetic acid. As the matrix in the sandstone is essentially clay, it was easy to disaggregate the sample by the above procedure. Much of the clay was removed by suspension. The material after drying was subjected to sieve analysis using a mechanical sieve shaker. The mechanical analysis together with the calculated statistical parameters after INMAN (1952) is presented in Table 1.

Table 1 shows a very poorly sorted, near symmetrical very platykurtic distribution (FOLK, 1958). The characteristic of the cumulative curve, in Text-fig, 1, shows a steep

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TABLE 1

Mesh Size	Phi Scale	Weight % Retained	Cumulative Percentage	Statistical parameters calculated after INMAN (1952)	
+8	—1	0.48	0.48		
+16	0	15.02	15.50	Median	=1.700
+30	+1	16.94	32.44	Mean	=1.762
+60	+2	25.61	58.05	Dispersion (Sorting).	=1.737
+120	+3	23.07	81.12	Skewness	=0.035
+240	+4	5.04	88.16	Kurtosis	=0.554
−240	+5	13.84	100.00		

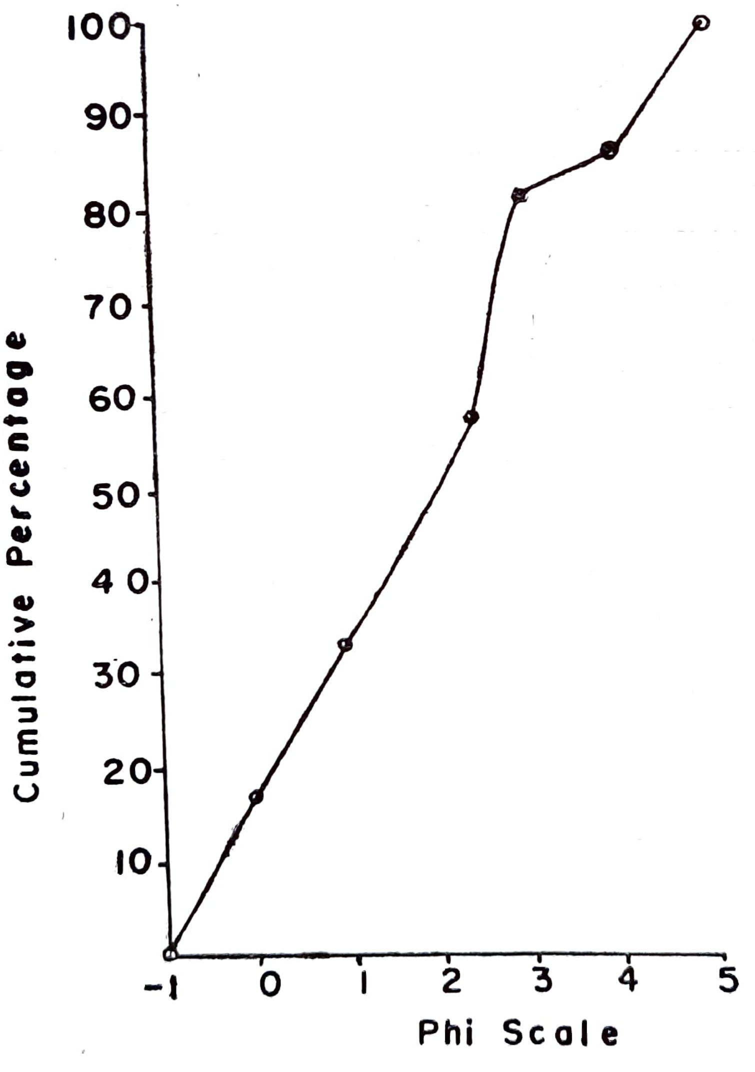

Fig. 1

slope with tail in the fines. The cumulative curve is comparable to the cumulative curves given for alluvial zone deposits (HODGSON & SCOT, 1970).

(ii) *Heavy and Light mineral Study:* The various fractions obtained in the mechanical sieve analysis were subjected to heavy and light mineral separation. The heavy minerals encountered are classed into normal, pneumatolytic and unstable accessories after WELLS (1937). The normal accessories namely magnetite, ilmenite, apatite, zircon, staurolite and pyroxene show a gradual increase from coarser to finer fractions; the pneumatolytic accessories namely rutile and tourmaline show an increase from +60 to +240 fraction and then a decrease towards-240; while the unstable accessories namely epidote, zoisite do not show any distribution in various size fractions. The heavy mineral percentages have been calculated into frequency numbers after the method of EVAN *et al.* (1965). These frequency numbers are presented in Table 2, and the variation of the heavy minerals in the various fractions is shown in Text-fig. 2.

TABLE 2

Mesh size	Normal Accessories								Pneumatolytic accessories			Secondary (Unstable) accessories			
	Zircon	Apatite	Magnetite	Ilmenite	Staurolite	Pyroxene	Kyanite	Sillimanite	Tourmaline	Rutile	Anatase	Epidote	Zoisite	Haematite	Leucoxene
+60	2	2	5	5	1	—	—	—	—	1	—	5	—	8-	—
+120	2	2	6+	4	1*	1*	—	—	1	4	—	6	2	7	—
+240	5	8	7+	5	1*	1*	1*	1*	3	6	1*	3	1	—	1
—240	6+	3	7-	5	1	2	1*	—	—	3	—	4	1	—	—

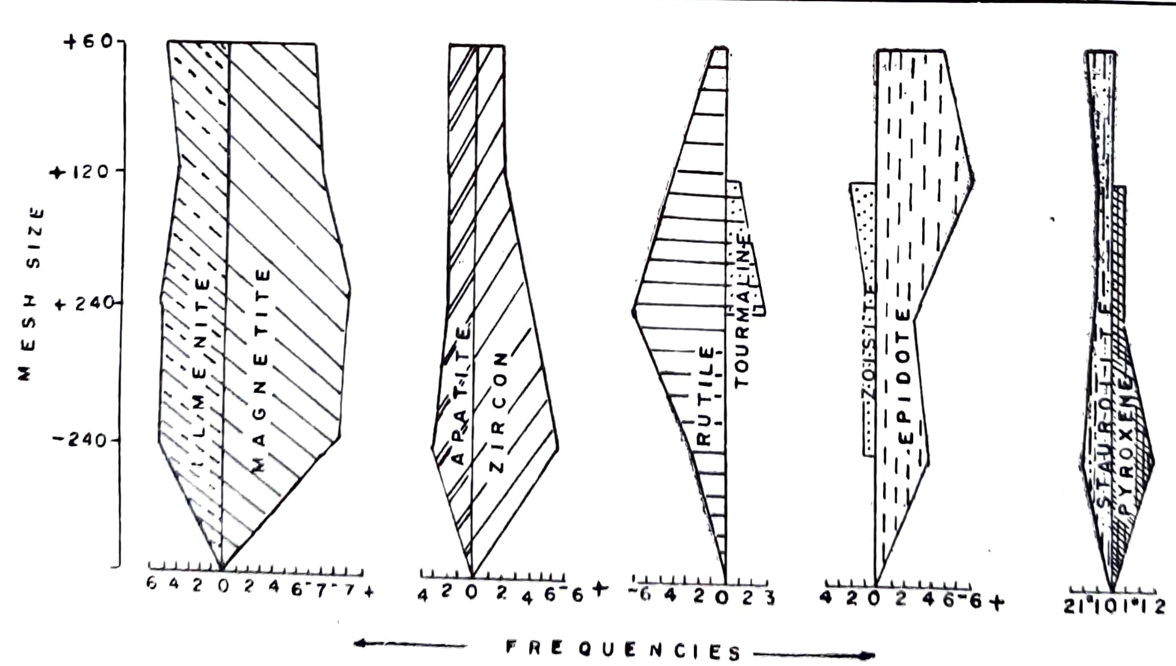

Fig. 2

The various heavy minerals present in the sandstone point to an acid igneous and to a subordinate extent, to low rank metamorphic rocks. The abundance of unstable accessories like epidote, zosite, haematite and leucoxene indicate rapid erosion as well as rapid deposition, whereby they escaped chemical alteration and decay. Such a deposition is possible under estuarine or deltaic condition.

The light minerals encountered chiefly consist of quartz, felspar and rock fragments. The quartz is distinguished into several types on the basis of inclusions and shapes. The felspars comprise chiefly potash felspar represented by orthoclase and subordinately microcline. Soda felspar (albite) occurs sporadically. The rock fragments are essentially polycrystalline quartz and quartz-feslpar fragments. The rock fragments do not constitute more than 5% of the entire rock.

The quartz is mostly subrounded to subangular. Rounding is not pronounced and is seen sparingly. The quartz is mostly anhedral with smooth borders. The borders are occasionally somewhat curved, but generally straight. 50% of the inclusions seen in quartz are mineral inclusions (zircon, apatite and rutile). The quartz mostly exhibit normal extinction. A small percentage of quartz grains show slight elongation and are characterised by a few inclusions or no inclusions in them. The few inclusions seen are mostly bubble-trains or dusted acicular inclusions. A small percentage of the quartz grains show strain shadows and undulose extinction. The light mineral analysis is presented in Table 3.

TABLE 3

Minerals	Percentage	Quartz Types			
Quartz	65.20	Qz. with mineral inclusions	Qz. without inclusion	Qz. with bubble trains	Qz. with acicular inclusion
		50.56	28.09	11.23	10.11
		Shapes of Quartz			
		Rounded	Sub-rounded	Sub-angular	Angular.
		13.01	38.28	36.05	12.63
		Felspar Types			
Felspar	29.31	Orthoclase	Microcline	Albite	
		66.25	2.5	31.25	
		Types of Rock Fragments			
Rock-fragments	5.49	Polycrystalline Quartz	Quartz-felspar fragment		
		53.33	46.67		

The nature and type of the quartz, the felspars and the rock fragments encountered, point to an essentially acid igneous and to a minor extent to low rank metamorphic rocks. It is suggested that the type of quartz and the abundant felspar in the rock points to a post-geosynclinal diastrophic stage of KRYNINE (1942). The felspars are both, fresh and altered. This suggests that both decay and erosion were active in the source area as well as the conditions associated with humid climate and steep relief.

(iii) *Thin Section Study:* Thin sections were prepared for the study of grain-cement-matrix studies. The rock is oligomectic composed essentially of quartz grains, clay matrix and ferruginous cement. The mode of cementation is filled-in type. The quartzes are mostly subangular to subrounded and show poor sorting. The chemical cement exceeds the matrix. The felspars exceed the rock fragments. According to the classification suggested for sandstones by PETTIJOHN (1957), these rocks can be termed sub-arkose or felspathic sandstones. The source rock index (ratio of felspars to rock fragments), maturity index (ratio of quartz +chert to felspar and rock fragments), and fluidity index (ratio of cement to matrix) for the sandstone is presented below:

Source Rock Index	1: 5.337
Maturity Index	1: 1.874
Fluidity Index	1: 1.115

(iv) *Study of clay associated with sandstone:* The clay in the sandstone constitutes about 15% of the rock. In order to know the environment, the clay was studied to decipher its mineral and chemical composition both by X-ray diffraction and D.T.A. The X-ray and D.T.A. data are presented in Table 4.

TABLE 4 (a)

X-ray data			D. T. A. of the clay fraction		
'd' Values	I/I_1	Inferred Clay minerals	Reaction Peaks	Tempera-tures	Intensity
10.048	15	Illite (I)	Initial endothermic peak	145°C	Pronounced
7.1379	100	Kaolinite (K)			
4.615	45	Illite			
4.1520	43	Kaolinite	Mid. Temp. endothermic peak.	Near 600°C	Feeble.
3.5758	82	Kaolinite			
3.3510	20	Illite			
2.8225	20	Illite	High Temp. exothermic peak	near 900°C	Pronounced
2.5565	22	Illite+(K)			
2.4947	22	(K)+(I)			
2.3382	30	(K)+(I)			
1.9935	10	(K)+(I)			
1.6612	5	(K)+(I)			
1.5541	5	(I)+(K)			
1.4881	10	(K)+(I)			

The X-ray analysis points to the clay to be essentially composed of illite and subordinately by kaolinite. The D.T.A. carried out on the sample points to endothermic peaks given by illite. The partial chemical analysis of the clay and the trace elements determined is presented in Table-4(a).

Table 4 (b)

Chemical Analysis (Partial)		Trace Element Analysis (In ppm)							
Constituents	Weight%	B	Mn	Ni	V	Cr	Cu	Rb	Ga
SiO_2	47.62	80	1000	60	40	70	50	100	10
Al_2O_3	31.22								
MgO	1.76	Analyst: S. K. Babu.							
Cao	0.43								
Na_2O	0.75								
K_2O	4.83								
$FeO+Fe_2O_3$	2.62								

The partial chemical analysis conforms more towards the composition of illite, although the MgO and Al_2O_3 points to kaolinite. The illite might have been formed due to marine diagenesis, deep burial and slight metamorphism (Folk, 1957). According to Degens *et al.* (1967) who distinguish marine shales from the fresh water shales, based on the criteria of distribution and abundance of elements, the trace element distribution particularly the abundance of boron, rubidium, nickel and vanadium, indicate a marine environment to the Cuddlore sandstone of Neyveli area.

Mukherjee (1963) reports illite mainly from the tertiary sediments with kaolinite as the subordinate component in his studies of clay minerals from India. He points out that the abundance of illite with subordinate kaolinite indicates to a marine environment.

The trace elements boron, rubidium and gallium recalculated to 100 and plotted on the diagram given by Degens *et al.* (1967), falls in the field of marine sediments (Text-fig 3). Thus the clay studies carried out point to a marine environment to the Cuddlore sandstones of Neyveli area.

CONCLUSIONS

From the various petrographic parameters, the following broad generalised conclusions can be drawn about the Cuddlore sandstones of Neyveli area: (1) The rocks can be termed as sub-arkose or felspathic sandstones, (ii) The size analysis indicates that the rock is a very poorly sorted, granular, medium to fine sand, near symmetrical, very platykurtic, (iii) The heavy and light minerals present in the sandstone point to an acid igneous and to a subordinate extent, to low rank metamorphic rocks. The abundance of unstable accessories like epidote, zoisite, haematite and leucoxene indicate rapid erosion as well as rapid deposition, whereby they escaped chemical alteration and decay, (iv) The altered and fresh nature of the felspars constituting the light crop indicate that both chemical decay and erosion were active at the time of formation of the rock and further points to humid climate, (v) The clays are chiefly constituted by illite and kaolinite. Further the trace element and D.T.A. studies point to a marine environment to the Cuddlore sandstones of Neyveli area.

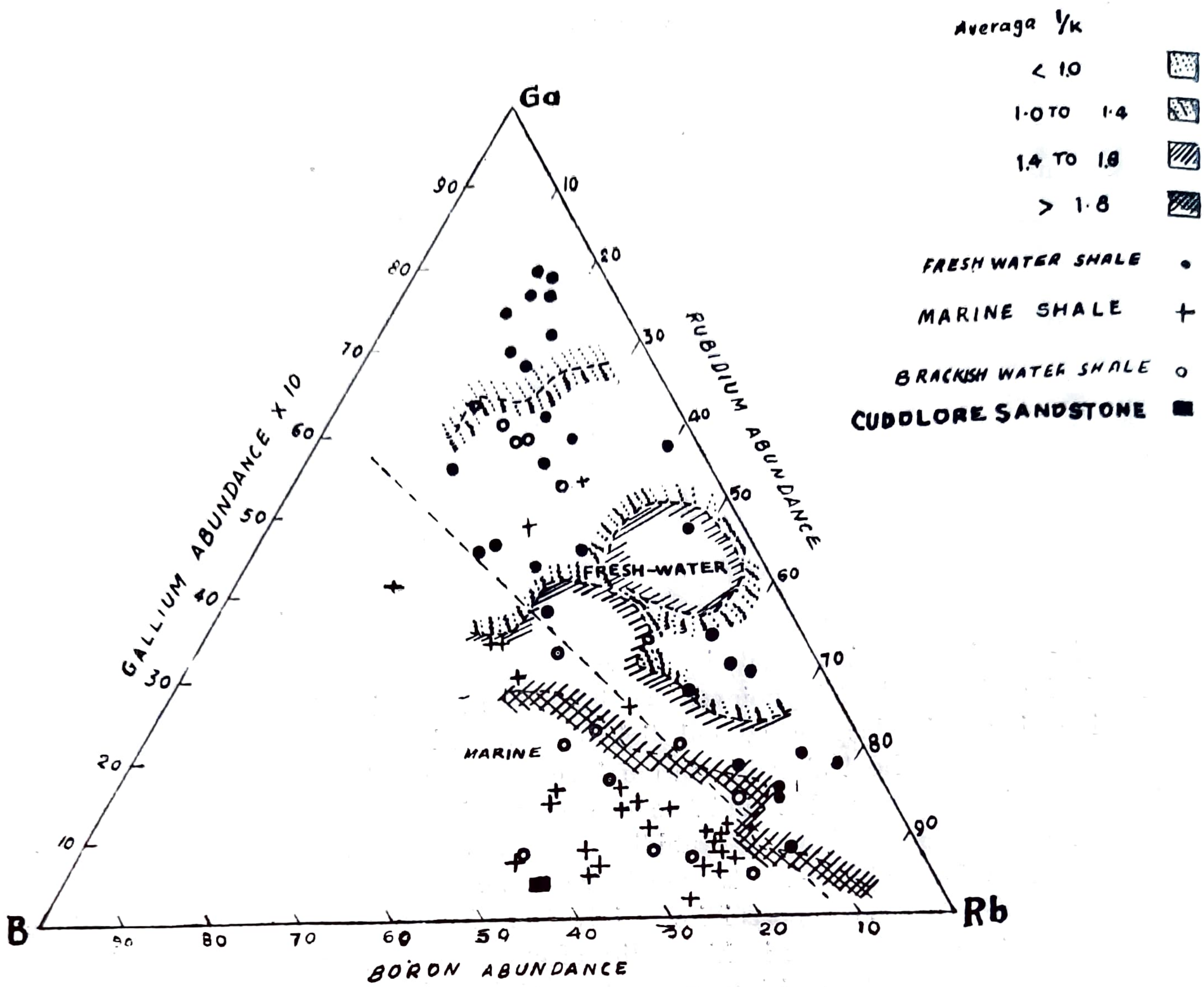

Fig. 3.

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