*Chemical composition of biotite-nepheline syenite:* The nepheline syenite of Kundulur has lower silica content relative to syenites of Kunavaram and Koraput, but it has higher potash content. The $Na_2O$ content is much less than the $K_2O$ content in the biotite nepheline syenite of Kundulur. The total normative alkali feldspars is lower and normative nepheline higher in Kundulur syenite. The chemical analyses of the rock type of Kundulur, Kunavaram and Koraput are given in Table II.

With reference to co-ordinates for petrogeny's residua system, it is observed that the nepheline syenite of Kundulur has a composition lying more towards Kalsilite corner relative to nepheline syenites of Kunavaram and Koraput.

Petrography and association of the nepheline syenite of Kundulur with perthite syenite strongly suggest the rock to be related to those of Kunavaram and Koraput complexes; but unlike that in Koraput, the Kundulur syenites are not spatially associated with any basic member.

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## References

BOSE, M. K., (1970) Petrology of the intrusive alkalic suite of Koraput, Orissa. *Jour. Geol. Soc. Ind.*, v. 11, No. 2, pp. 99-126.

BOSE, M. K., CHAKRAVARTI, S. and SARKAR, A., (1971) Petrological observation on the alkalic Syenites of Kunavaram, A.P., India. *Geol. Mag.*, v. 108, No. 4 (in press).

NAIR, K. B. and MAHADEVAN, T. M., (1968) 'Studies on the syenite complexes north east of Kunavaram, A.P. (Abstract)'—*Seminar on Plutŏnic Complexes of India*, Hyderabad, p. 39.

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# SIGNIFICANCE OF CM DIAGRAMS OF SOME JURASSIC AND CRETACEOUS SEDIMENTS OF KUTCH (GUJARAT)

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*Introduction:* Sedimentary petrologists of late have emphasized the importance of grain-size studies to understand the nature of deposition of clastic sediments, and the recent trend has been towards definition of individual samples by their textural parameters and definition of the deposit as a whole by the variation shown by these parameters. Textural parameters thus give useful information about the environment. Passega (1957) has established the relationship between texture of sediments and processes of deposition, rather than between texture and environment as a whole. According to him (Passega, 1964), fairly precise relationships exist between texture and mechanism of transport, and these relationships can have a wide application as a means of geological investigation.

A clastic deposit is formed by sediments transported in different ways. In particular, the finest fractions may be transported independently of the coarser particles. Swift sedimentary agents can be characterised best by parameters which give more information on the coarsest than on the finest fractions of their sediments. Two parameters of the grain-size distribution of individual samples are particularly significant: C, the one percentile, and M, the median diameter. It was shown that CM patterns on a logarithmic diagram are characteristic of the depositional agent (Passega, 1957). Passega (1964) has prepared a number of standard CM diagrams of tractive current deposits, based on his studies of a large number of recent sediments.

Sediments are transported by rolling or in suspension. Suspensions could be graded bottom, uniform bottom and pelagic suspensions. Transport of sediments depend upon the size available. Bottom currents capable of transporting sediments are of two types. Tractive currents are capable of transporting their load either by rolling or in suspension; rivers, marine currents and waves touching sea bottom belong to this class. Turbidity currents generally flow during limited time and are so rapid that they can not be followed by rolling grains; their load is entirely a suspension load. Exceptionally, turbidity currents can roll particles for relatively short distances from their origin, if the currents are formed continuously during a certain time, or larger distances, in an area of deposition, the particles are rolled by successive currents.

An attempt to apply Passega's principles, in studying some Juro-Cretaceous rocks of Kutch has been made here. These famous Mesozoic formations of India have received comparatively little attention from the point of view of their sedimentation; in this paper, the authors, utilizing the grain size analysis of selected samples from these rocks in the neighbourhood of Bhuj town, have attempted to establish the likely mechanisms of transport of sediments of various series and thereby understand the environments of deposition.

*Brief geology:* The sedimentary rocks of the area comprise varieties of sandstones, siltstones and limestones of Mesozoic age. These are intruded by dykes of dolerite and overlain by basalts of the Deccan Trap. The structural succession of the various stratigraphic formations encountered in the area is shown in Table I.

The Cretaceous rocks are repeated on account of the Katrol fault. This fault runs almost E–W and dips rather steeply due south, thus being more of the nature of a reverse fault. The dips of the strata in general are due south, but a most striking structural feature of the rocks is the existence of elongated (E–W) domes and flexures in the vicinity of the faults to its south.

On the whole, the rocks in the central part of the area are better exposed. The degree and extent of exposures is very good and individual beds can be easily traced for considerable distances. The general trend of the strike is east-west and the various beds are seen gently dipping (5°–10°) due south. However in the vicinity of the faults high, dips as much as 30° to 60° are noted.

*Methods of study:* Following the procedure suggested by Passega, the authors selected in all 70 samples from various rock types of Chari (10), Katrol (30), Umia (10) and Bhuj (20) series, for preparing CM diagrams.

The grain size analysis both by sieving (sand) and pipette (silt and clay) methods was carried out and data was represented on a semi-log paper obtaining the cumulative curves. From these curves, the values of one percentile C and median percentile-M were obtained by intersecting the cumulative curves at 1 per cent and 50 per cent, and reading the diameters (in millimetre) equivalent to their percentile values.

(The one percentile grain size is such that one per cent of the sample is coarser than this size; while the median grain size is the size such that 50 per cent of the sample is coarser than this size). The values of C and M for different samples thus obtained were plotted on double-log paper to obtain CM diagrams.

*Interpretation of CM patterns:* The significance of the CM patterns obtained has been worked out mainly on the basis of Passega's (1964) interpretations of the CM patterns prepared by him for recent sediments with known transport mechanisms.

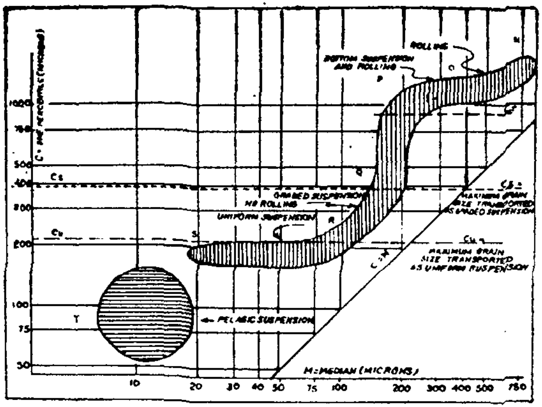
The CM diagram for the rocks of Chari series (Fig. 1) shows similarity with the segments like 'QR' and 'T' of Passega (1964) and thus suggests that the processes of transportation for the sediments of this series were mainly of two types viz: (1) graded suspension—mostly sand particles and (2) pelagic—clay particles of shale.

TABLE I

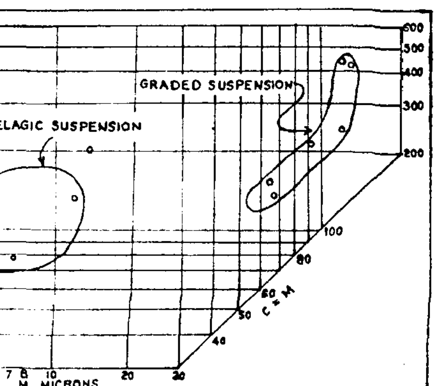
| | | | |
|---|---|---|---|
| Alluvium, blown sands etc. | — | Recent | |
| Sandy oolitic limestones | + 20 m | Sub-Recent | |
| Green sandstones | 5 to 7 m | Supra-trappean | (?) PALAEOCENE |
| Basalt flows with intrusive dolerites | 3 to 15 m | Deccan trap | CRETACEO-EOCENE |
| Sandstones, ferruginous sandstones, silty shales | 274 m | Bhuj series | LOWER TO MIDDLE CRETACEOUS |
| Sandstones, siltstones, shales | 82 m | Umia series | |
| Shales, sandstones, calcareous sandstones and siltstones | 329 m | Katrol series | JURASSIC |
| Shales, sandstones, oolitic limestones | 122 m | Chari series | |
| ------ Katrol Fault ------ | | | |
| Sandstones, ferruginous sandstones, silty shales | + 140 m | Bhuj series | LOWER TO MIDDLE CRETACEOUS |
| Sandstones, siltstones, shales | + 15 m | Umia series | |

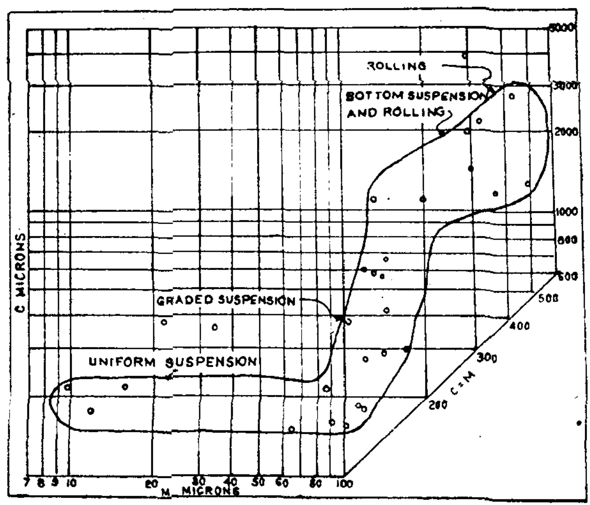
In contrast to Chari series, the CM diagram for the rocks of Katrol series (Fig. 1) is typically similar to the complete CM patterns of Passega and reveals all the transporting mechanism of tractive currents in marine water. The sediments ranging from 1000 microns to 3000 microns (C percentile) and from 200 microns to 500 microns (M percentile) show a transporting process by rolling and bottom suspension. The segment below the above mentioned values tallies with 'QR' of Passegas's standard pattern and thus represents a typical graded suspension of rather coarser sediments. On the other hand, the sediments like those of siltstones and silty shales with 200 microns (C) and 100 microns (M) reveal their traction by uniform suspension (Fig. 1).

CM diagrams (Fig. 2) for the rocks of Umia and Bhuj series are different from those of Chari and Katrol series. Both the former diagrams are wide and long and somewhat similar to those for the recent beach sands constructed by Passega (1957).



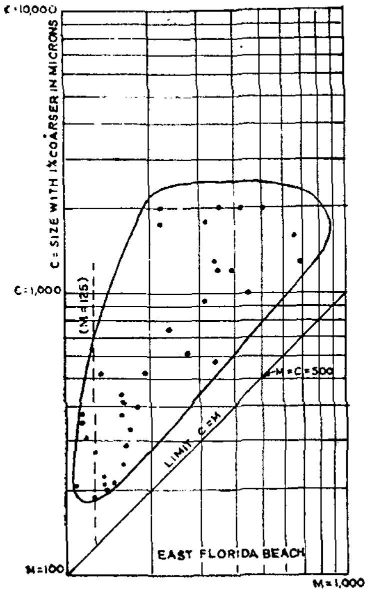

Complete CM pattern of
tractive current deposite(Passega,1964)



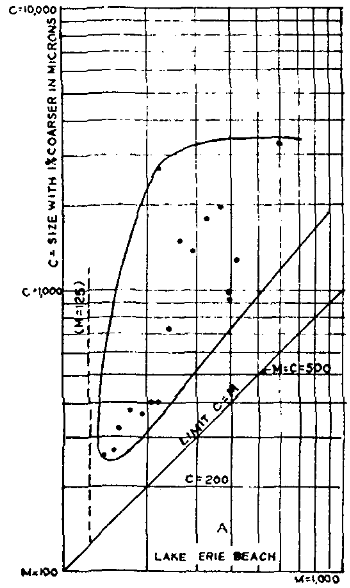



In a CM pattern of typical beach sands, points are concentrated near the minimum value of the medium (M), and scattered near the largest values of C. The CM diagrams of both Umia and Bhuj series show identical distribution of points, and

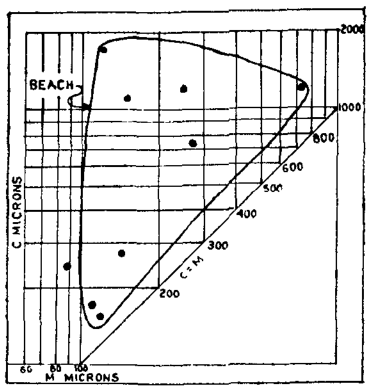
CM DIAGRAMS



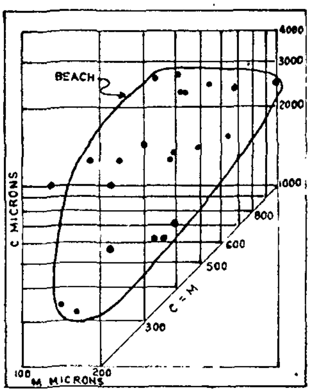

Beach diagram for
East Florida (Passega, 1957)




Beach diagram for
Lake Eria (Passega, 1957)




Umia Series




Bhuj Series

hence it could be inferred that the processes of transportation of sediments of both were of beach type.

However, there are some differences in the diagrams of Umia and Bhuj series. In the former, the cluster of points shows a marked scattering, indicating poorly sorted sands. While the diagram for the latter, shows a concentrated cluster of points. This is suggestive of better sorting. Thus, the sands of Bhuj Series are indicative of considerable winnowing preceding their deposition.

*Depositional history of Juro-Cretaceous rocks:* The lithology, texture and the CM diagrams for the rocks of the various series of the study area, reveal that the deposition of the Juro-Cretaceous sequence was more or less a continuous process; of course the sedimentation took place under a gradually changing environment. The entire succession of rock formations points to a shallow water marine environment, progressively becoming more and more shallow. The tractive currents responsible for the deposition of rocks of Chari and Katrol series, essentially transported the sediments under marine environment, the mechanism being that of graded suspension, bottom suspension and rolling along the bottom. With the shallowing of the basin, the mechanism of transport is seen to have radically changed and the diagrams clearly show a beach environment, the sands being transported mainly by rolling. The sands of Bhuj series give indications of considerable winnowing by wind, pointing to the extreme shallowing of the basin, perhaps heralding the close of sedimentation. The changing patterns of depositional sequence in all series is given in the following Table II.

TABLE II

SHOWING THE DEPOSITIONAL SEQUENCE

| Era | System | Age | series | Lithology | Sedimentary environments |
|---|---|---|---|---|---|
| MESOZOIC | Lower to Middle Cretaceous | Neocomian to Albian | Bhuj | Quartz wacke, quartz arenite, feldspathic arenite and silty shale | Fluvial and deltaic |
| | | | Umia | Quartz wacke and arenite, feldspathic wacke, fine grained quartz wacke, silty shale | Littoral to lagoonal |
| | Upper Jurassic | Kimmerdgian to Tithonian | Katrol | Quartz wacke, quartz arenite, calcareous quartz arenite and wacke, fine grained quartz wacke, feldspathic wacke, silty shale | Infralittoral to paralic sedimentation |
| | | | Chari | Gypsiferous silty shale, fossiliferous pelmicrite and oomicrite, calcareous quartz arenite and wacke; interformational conglomerate | Circalittoral (with shallow and agitated water at the top) |

## REFERENCES

PASSEGA, R., (1957) Texture as characteristic of clastic deposition, *Amer. Assoc. Petroleum, Geologists, Bull.*, v. 41, no. 9; pp. 1952-1984.

——— (1964) Grain size representation by CM patterns as a geological tool. *Jour. Sedimentary Petrology*, v. 6, pp. 830-847.