JOURNAL OF THE PALAEONTOLOGICAL SOCIETY OF INDIA
VOLS. 23 & 24, 1980, pp. 136—139 (*For* 1978-79).

DEPOSITIONAL ENVIRONMENT OF MESOZOIC SEDIMENTS OF SAURASHTRA, REVEALED BY TEXTURAL PARAMETERS

D. C. SRIVASTAVA, P. V. RAO[1], AND M. G. HARDAS

GEOLOGICAL LABORATORIES, ONGC, BARODA-390009

ABSTRACT

Mesozoic sediments are exposed in north-eastern Saurashtra occupying an area of about 4900 sq. kms. The Mesozoic sequence has been subdivided into "Dharangadhra Formation" and "Wadhwan Formation" by Shrivastava (1973). In the present paper on the basis of grain size parameters and heavy minerals, depositonal environment and provenance for sediments of two Formations have been discussed. The studies indicate that sandstones of Dhrangadhra Formation were transported by saltation and suspension mechanism and were deposited in a fluvial to deltaic environment. On the other hand the overlying conformable sandstones of Wadhwan Formation were transported by suspension mechanism and seems to have deposited in a subsequent shallow marine transgressive phase.

The heavy mineral suite indicates that the source of these sediments remained same throughout its deposition and were metamorphic and intermediate igneous rocks.

INTRODUCTION

Mesozoic sediments are exposed in north-eastern Saurashtra occupying an area of about 4900 sq. kms. Since 1884, work in the area has been carried out by large number of geologists viz., Fedden (1884), Oldham (1893), Pascoe (1956), Shrivastava and Rizvi (1960), Rao (1961), Bhandari et al. (1970) and Shrivastava (1973). The Dhrangadhra and Wadhwan Formations were formally defined by Shrivastava and Rizvi (1960). Shrivastava (1973) has defined these terms in a rock stratigraphic sense, designated type sections and indicated stratigraphic relationships and also classified Wadhwan Formation in three members.

Sandstones from Dhrangadhra and lower member of Wadhwan Formation were subjected to granulometric and heavy mineral analyses. In the present paper, on the basis of textural parameters and heavy mineral constituents, the authors have suggested depositional environment and provenance of sandstones of aforesaid formations.

METHODS

Mechanical sieve analyses (1 ϕ) were carried out. The data were plotted as cumulative curves on probability paper. Statistical measures for average grain size, sorting, skewness and kurtosis proposed by Folk and Ward (1957) were then obtained from values intercepted at specific percentiles on these curves.

Micropetrological methods involving study of heavy minerals for sandstones of Dhrangadhra and lower member of Wadhwan Formation were carried out. The heavy minerals were isolated from +120 mesh by bromoform (sp. Gr. 2. 89). The residue were counted for quantitative estimation.

RESULTS

Table 1 summarises the grain size parameters derived from Folk and Ward's (1957) graphic measures, for 31 samples analysed. Half of the Dhrangadhra sandstones samples studied are medium grained and equal percentage of sandstones are fine grained, majority of samples (63%) are poorly sorted and (37%) are moderately sorted, positively to negatively skewed and platykurtic to leptokurtic grain size distribution.

Sandstones of Wadhwan Formation are fine grained, moderately sorted (65%) and poorly sorted (35%), negatively skewed, mesokurtic and leptokurtic grain size distribution.

STRATIGRAPHIC VARIATION IN GRAIN SIZE PARAMETERS

Vertical profile for both traverses show the wide stratigraphic variation in mean size, standard deviation, skewness and kurtosis (Fig. 1). For Dhrangadhra Sandstones, the mean diameter exhibits variation, fluctuating erratically about the 2 ϕ boundary between medium and fine sand (Fig. 1). In case of sandstones

---

[1]Present Address : Sr. Geologist, Bombay Offshore Project.

The views expressed in the paper are of the authors and not necessarily of Oil & Natual Gas Commission. No confidential information of ONGC is divulged in the paper.

Table 1. Average textural parameters and their ranges for the Dhrangadhra and Wadhwan Sandstones of Saurashtra.

Textural Parameters	Traverses	Wadhwan Sandstones: Muli-Umarda	Wadhwan Sandstones: Navagam—Chotila
ϕ M_Z	Avg.	2.30	2.40
	Rng.	2.05—2.56	2.15—2.63
ϕ σ_I	Avg.	1.02	0.97
	Rng.	0.89—1.41	0.71—1.31
Sk_I	Avg.	—0.12	—0.19
	Rng.	—0.04 — —0.28	—0.17 — —0.23
K_G	Avg.	1.19	1.15
	Rng.	0.91—1.49	0.96—1.30
No. of samples analysed.		9	5

Textural Parameters	Traverses	Dhrangadhra Sandstones: Muli—Umarda	Dhrangadhra Sandstones: Navagam—Chotila
ϕ M_Z	Avg.	1.86	1.75
	Rng.	1.08—2.90	1.03—2.30
ϕ σ_I	Avg.	1.00	1.32
	Rng.	0.71—1.35	1.03—1.68
Sk_I	Avg.	+0.01	—0.06
	Rng.	—0.33 — +0.29	—0.23 — +0.28
K_G	Avg.	1.06	0.99
	Rng.	0.82—1.60	0.80—1.40
No. of samples analysed		10	7

conformably overlying Wadhwan Formation, mean size shows little variation (2.05 ϕ—2.63 ϕ). Mean size indicates fining upward trend in the two stratigraphic sequences. In general Dhrangadhra Sandstones are poorly sorted whereas sandstones of Wadhwan Formation are moderately sorted, show improvement in sorting in sandstones of the formations in a veritical sequence.

Skewness and kurtosis show contrasting trends for sandstones of Dhrangadhra and Wadhwan Formations. For Dhrangadhra sandstones skewness and kurtosis variability is greater as compared to Wadhwan Sandstones (Fig. 1).

REGIONAL VARIATION IN GRAIN SIZE PARAMETERS

Sandstone samples of Dhrangadhra and lower member of Wadhwan Formation were collected from two traverses. Muli-Umarda in east and Navagam-Chotila in west. Average grain size parameters of samples from both the traverses were compared to determine if there are regional differences. For Dhrangadhra Sandstones it has been found that there is no appreciable change in grain size and sorting from east to west. However, skewness and kurtosis do show variations ; in the east the sandstones are mostly positively skewed, mesokurtic and leptokurtic, and in west, are negatively skewed and platykurtic in most of the cases. In case of sandstones of Wadhwan Formation change in the grain size characters from east to west is not appreciable.

ENVIRONMENTAL INTERPRETATION

The range of graphic mean (1.03 ϕ to 2.90 ϕ) and standard deviation (0.71 to 1.41 ϕ) of Dhrangadhra Sandstones suggests that material was transported by saltation and suspension mechanism, following Friedman (1967), and were deposited in a river system (Friedman, 1967, Folk, 1968). Association of positive skewness and leptokurtic (unimodal) nature of sandstones in east and negative skewness and platykurtic (bimodal) in west indicates that in east sandstones were definitely deposited in a river (Friedman, 1961, 62) whereas in west it represents a transitional environment—possibly deltaic.

These observations lend support to palaeocurrent analysis of Dhrangadhra Formation by Bhandari and Kumar (1970), who have suggested that sediments were transported by westerly flowing river regime and were deposited in fluvial to deltaic environment. Parallel inferences have also been drawn by Verma and Rawat (1964) who have recorded along with a large number of spore pollen genera, *Classopollis* pollen belonging to the genus *Cheirolepis* from Dhrangadhra Formation. These pollen being not transportable over large distances are considered to be representative of place of sedimentation and indicate the prevalence of coastal environment. Absence of microplanktonic and presence of pteridophytic spores further suggest larger influxes of fresh water.

Mean size (2.05ϕ—2.63ϕ) of conformably overlying lower member (sandstones) of Wadhwan Formation indicates that sediments were dominantly transported by suspension mechanism and less by saltation mechanism (Friedman, 1967). Srivastava (1977), on the basis of CM diagram had earlier suggested that sandstones are of tractive current deposits and were transported by suspension mechanism. Considering other size parameters, i.e., sorting (mostly moderately sorted), negative skewness and leptokurtic grain size distribution, it appears that these sediments might have been deposited either in beach or infralittoral environment. The possibility of these sandstones belonging to beach environment can be ruled out because beach sands are most commonly deposited by saltation mechanism, excellently sorted or well sorted with sorting values less than 0.80ϕ (Friedman, 1967, Folk, 1968, Visher, 1969). Hence it may be concluded that lower member (sandstones) of Wadhwan Formation was deposited in an infralittoral environment.

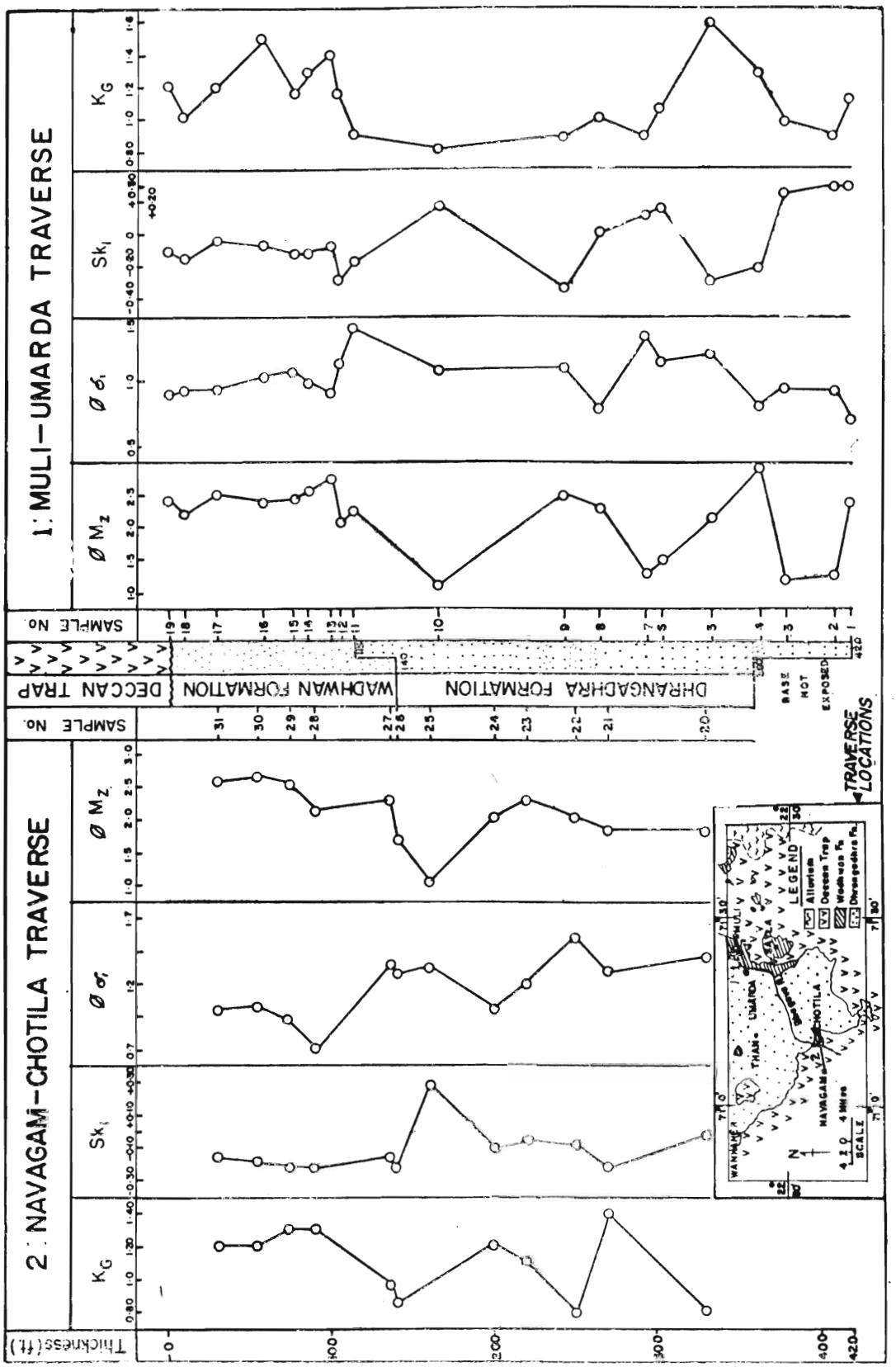

Fig. 1. Stratigraphic variation in grain-size parameters of sandstones.

THE HEAVY MINERALS

A total of four nonopaque heavy minerals were recognised from sandstones of Dhrangadhra and Wadhwan Formations. In both the sandstones heavy mineral suite is same and the heavies are zircon, tourmaline, staurolite and rutile. Andalusite, epidote and kyanite are noted sporadically. A few tourmaline grains in sandstones of Wadhwan Formation are rounded. The yields of heavies are moderate.

PROVENANCE

The sandstones of Dhrangadhra and Wadhwan Formation consists of rock fragments, light crop minerals (Sp. Gr. less than 2.89) and heavy minerals. The light crop consists predominantly of quartz, some times fractured and strained, and minor amount of feldspar. From heavy minerals suite and light crop, it can be concluded that metamorphic rocks and intermediate igneous rocks were the main contributors for the Mesozoic sediments of Saurashtra. Occurrence of a few rounded tourmaline grains in sandstones of Wadhwan Formation suggests that they might have been contributed by pre-existing sedimentary rocks.

CONCLUSION

The vertical and lateral variation of textural parameters, related sedimentary processes and heavy mineral constituents have enabled to conclude that—

(1) The sandstones of Dhrangadhra Formation were deposited in fluvial to deltaic environment from east to west.

(2) Deposition of Dhrangadhra Formation was followed by marine transgression and conformably overlying sandstones of Wadhwan Formation were deposited in infralittoral environment.

(3) Metamorphic rocks and intermediate igneous rocks were dominant source, remained same during deposition of Mesozoic sediments in Saurashtra. The sediments were possibly derived from Archaean, Aravalli and Delhi rocks exposed across Cambay Basin.

ACKNOWLEDGEMENT

The authors are indebted to Shri C. K. R. Sastry, General Manager, ONGC, Western Region, Baroda for permission to publish this paper. They are grateful to Dr. S. Ramanathan, Chief Geologist, for encouragement and valuable guidance. Sincere thanks are also due to geologists of field party No. 9 for providing the samples and to Dr. S. V. Deshpande, Senior Geologist for useful suggestions.

Sincere appreciation is expressed to Shri M. M. Maindarkar, Assistant Geologist, for preparation of figure, to Shri Hotilal for drawing and to Mrs. Leelamma Rajan for typing the manuscript.

REFERENCES

BHANDARI, L. L. AND KUMAR, S. 1970. Palaeocurrent analysis of Dhrangadhra Formation, Gujarat, India. *Bull. ONGC.* **7** (2) (Dec. 1970) : 101-108.

FOLK, R.L. AND WARD, W.C. 1957. Brazos river bar. A study in the significance of grain size parameters. *Jour. Sed. Petrol.* **27** : 3-26.

FOLK, R. L. 1968. *Petrology of Sedimentary Rocks.* Hemphill's, Drawer M. University Station, Austin, Texas.

FRIEDMAN, G. M. 1961. Distinction between dune, beach and river sands from their textural characteristics. *Jour. Sed. Petrol.* **13** :514-520.

FRIEDMAN, G. M. 1962. On sorting, sorting coefficients and log normality of grain size distribution of sandstones. *Jour. Geology.* **70** : 737-753.

FREIEDMAN, G. M. 1967. Dynamic processes and statistical parameters compared for size frequency distribution of beach and river sands. *Jour. Sed. Petrol.* **37** : 327-354.

FEDDEN, F. 1884. Geology of Kathiawar Peninsula in Gujarat *Mem. Geol. Surv. India.* **21** (2).

OLDHAM, R. D. 1893. *Manual of Geology of India.* Govt. of India Publication.

PASCOE, E. M. 1956. *A Manual of Geology of India and Burma.* Govt. of India Publication. **2.**

RAO, P. V. 1961. Progress report on work done in Wadhawan-Dhrangadhra area, Gujarat (unpublished report of ONGC).

SHRIVASTAVA, P. K., AND RIZVI, S. S. A. 1960. Progress report on work in Wadhwan-Dhrangadhra Area, Gujarat (Unpublished report of ONGC).

SHRIVASTAVA, P. K. 1973. Stratigraphy of Mesozoic sediments of Saurashtra. *Bull. ONGC.* **10** (1-2) : 127-130.

SRIVASTAVA, D. C. 1977. Significance of CM diagram of Wadhwan Sandstones, Saurashtra. *64th Session of Ind. Sci. Cong. Bhubaneshwar.*

VISHER, GLENN. S. 1969. Grain size distribution and Depositional Processes. *Jour. Sed. Petrol.* **39** (3) : 1074-1106.

VERMA, C. P. AND RAWAT, M. S. 1964. Note on age of Dhrangadhra Formation, Western India, in the light of pollen and spores recovery. *Pollen et Spores.* **6** (1).