# A PRELIMINARY ACCOUNT OF THE TEXTURE, STRUCTURE, AND MINERALOGICAL COMPOSITION OF THE KHEWRA FORMATION, CIS-INDUS SALT RANGE, WEST PAKISTAN

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## ABSTRACT

*This paper includes an elementary study of the sedimentary properties of the Khewra Formation which is an important rock unit in the Precambrian-Cambrian section exposed in the Salt Range area. Although a lot of work is carried out on the stratigraphy and the age problems of this formation, much more is to be done in order to get some idea about the provenance and the environments of deposition.*

*The present work is an attempt towards solving the same problem but the final conclusions are not drawn because the study was based on limited data collected from one section only, i.e. the Khewra Gorge. The paper gives a brief description of the analysis of the size distribution, shape and roundness of the particles, the study of the sedimentary structures and an estimate of the percentages of the common minerals present in the sandstone.*

## INTRODUCTION

The Khewra Formation (formerly Purple Sandstone), consists of yellowish-brown, rusty red and purple sandstones. They are often thick-bedded but thin-bedded sandstones are not uncommon. In a Precambrian-Cambrian section exposed in the Khewra Gorge, the Khewra Formation is very conspicuous due to its continuous exposures, eye catching colours and a variety of well preserved primary sedimentary structures.

The Salt Range area has been very frequently visited by the local and foreign geologists since long and, as a result, much has been written on the stratigraphy, age and the nature of the rocks of this area. Literature on the various particular aspects like the sedimentology and the structures of the individual formations is lacking. The author feels that detailed work should now be carried out on the sedimentary properties of the different rock units and the conditions of their deposition and the provenance be inferred with a greater degree of accuracy.

Fig. 1

Fig. 2

Diagrammatic representation of the clastic texture of the Khewra Formation (camera lucida sketches)

The present paper includes some of the sedimentary properties of the Khewra Formation. It is by no means a complete work as the author has discussed only the most important and easily identifiable characters of the Khewra Formation and thus no attempt has been made to draw inferences from this study. It is, however, intended that the present work shall be further extended and more geological details gathered in order to discuss the provenance and the environments of deposition of the Khewra Formation.

## TEXTURE

The Khewra Formation exhibits typical clastic texture of the arenites (Figs. 1 and 2). The individual particles are sub-angular to sub-rounded and are embedded in a clayey and calcareous matrix. The entire formation shows a moderate to fairly good sorting. A gradual decrease in the frequency of the grain size is observed from the base of the formation towards its top.

### Size Distribution.

Mechanical analysis of the representative samples of the Khewra Formation was performed using the common seiving method. The frequency of various convenient size grades was calculated and represented in the form of histograms and cumulative curves (Figs. 3a, 3b, 3c and 4).

The size distribution of the samples representing the lower part of the formation (Fig. 3a) has its modal class formed by very fine sand-sized particles (Wentworth's Particle Size Classification, 1926). About 65 per cent of the total weight of the particles is from this size grade. Coarse to fine silt-sized particles constitute about 23% while medium to fine sand-grade particles are only 12% of the total weight.

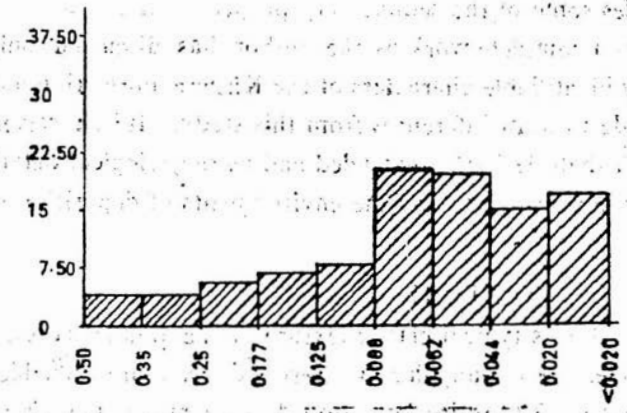
The size distribution in the middle part of the Khewra Formation (Fig. 3b) is much similar to the one discussed above. The modal class is constituted by very fine sand-sized particles which are about one half of the total weight of the samples. The finer fractions are about 31% and the coarser ones are 19% only.

Towards the top of the formation the size distribution is much different from the rest of it (Fig. 3c). Here the finer fractions are more abundant. The silt-sized particles are 55%. Medium to fine sand classes contribute only 18% and the very fine sand fraction, which is almost everywhere a modal class, is reduced to 25%.

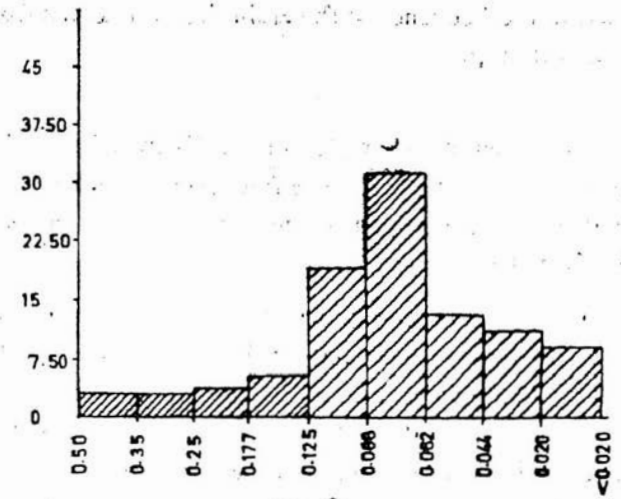
Table I gives the results of the size distribution analysis.

### Shape and Degree of Roundness of the Particles.

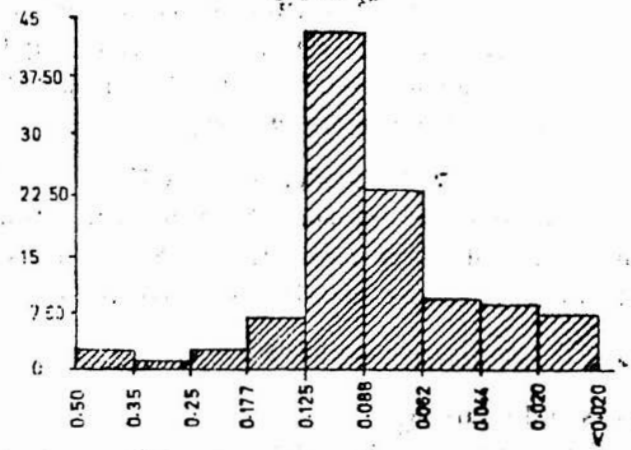
More commonly, the particles are of irregular shapes, forming many edges and corners. It is difficult to measure their exact sphericity because of their small size. Rough estimation of the sphericity of the particles was attempted by comparing




c. Upper part samples.




b. Middle part samples.




a. Lower part samples.

Fig 3. Histograms showing size distribution of sediments of the Khewra Formation.

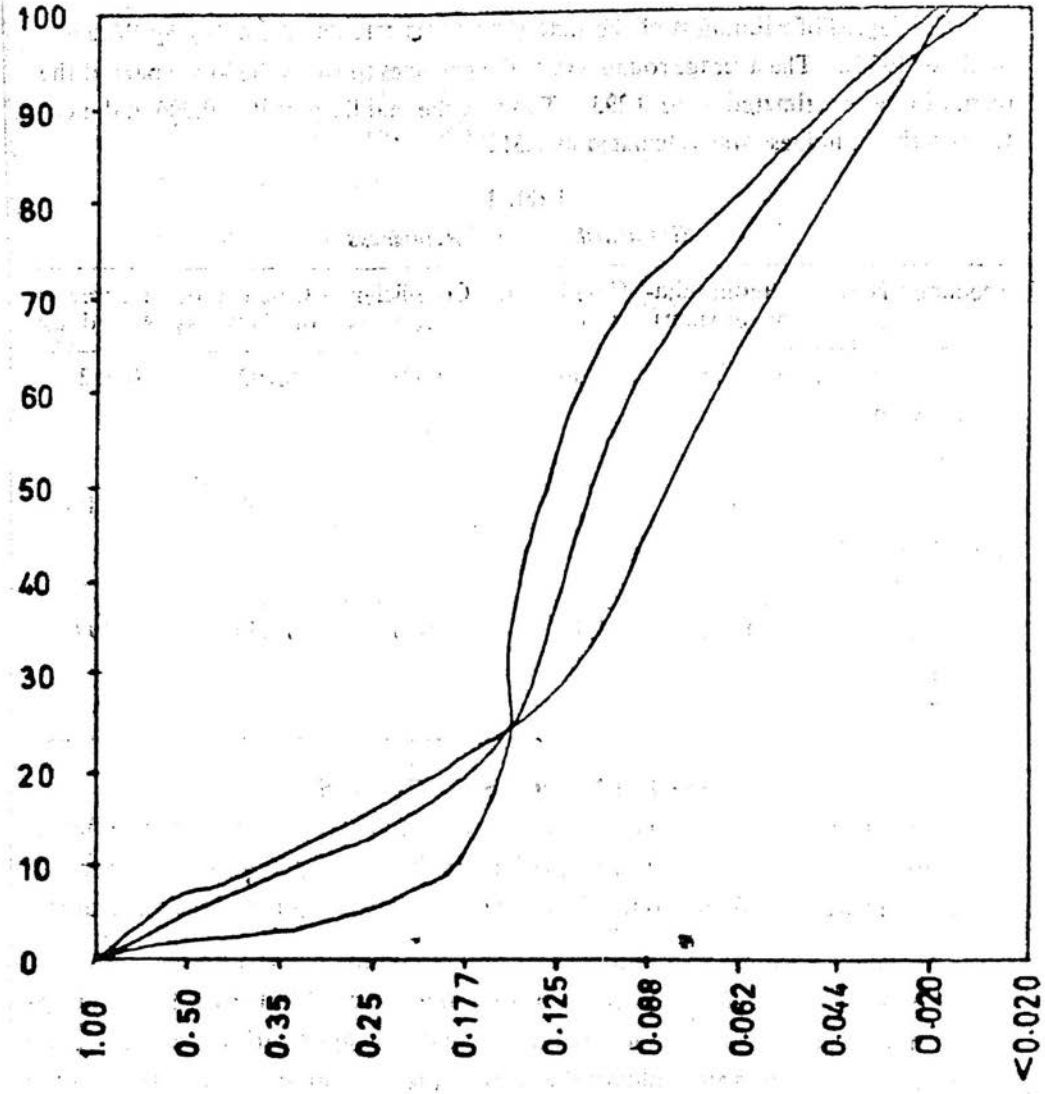



Fig. 4.

Size composition of the Khewra Formation shown by the cumulative curves.

figures 1 and 2 with the chart for visual estimation of the sphericity, given by Krumbein and Sloss (1963). The sphericity thus estimated is about 0.5.

The degree of roundness of the sand grains was calculated employing Wadell's method (1935). The average roundness of the particles towards the lower part of the formation was estimated to be 0.293. Towards the middle part it is 0.306 and near the top the roundness was calculated as 0.312.

**Table I**

*Size distribution and Roundness*

| Specimen Nos. | Median diameter (mm) | Co-efficient of Sorting | Co-efficient of Kertosis | Co-efficient of Skewness | Degree of Roundness |
|---|---|---|---|---|---|
| 1 (From Upper Part) | 0.125 | 1.46 | 0.321 | 0.792 | 0.312 |
| 2 (From Middle Part) | 0.103 | 1.67 | 0.170 | 0.946 | 0.306 |
| 3 (From Lower Part) | 0.081 | 1.42 | 0.090 | 1.054 | 0.293 |

## SEDIMENTARY STRUCTURES

A great variety of the primary sedimentary structures is preserved in the Khewra Formation. Majority of the structures discussed below are present in the lower and the middle part of the formation. Following is a brief description of the structures.

*Bedding.* Various types of bedding is observed in the Khewra Formation. The lower part of the formation is comparatively thinly bedded but when followed upwards, the bedding gradually thickens though not very systematically and there are occasional thick and thin bedding throughout the formation. Lenticular bedding (plano-convex; orginally channel sand) is also commonly observed, especially where the bedding is thick. Convolute bedding (Plate 1)is a characteristic feature of the Khewra Formation.

Cross-bedding, perfectly developed, can be seen almost every where in the formation (Plate 2). Palaeo-current study can be carried out with great accuracy on the basis of the cross-bedding. Ripple-cross-bedding was also observed at a few places. Some cross-beddings show characters very close to eolian cross-bedding and it is likely that quite a few of these structures might be of eolian origin.

*Ripple Marks.* Most of the exposed bedding surfaces of the Khewra Formation show fine impressions of the ripple markings preserved on them (Plates 3, 4 and 5). A number of the following different kinds of ripple marks have been identified:

(*a*) Oscillation Ripple Marks

(*b*) Wave and Current Ripple Marks

(*c*) Transverse Ripple Marks

(*d*) Linguoid or Cuspate Ripple Marks

It is possible that almost every kind of ripple marks, identified uptil now, may be present in this formation as the swiftly changing currents and the deposition in the shallow deltaic conditions are most suited for such structures especially when it persisted for a very long time.

*Mud Cracks.* Mud cracks preserved as such or their impressions, are very common towards the lower part of the formation (Plates 6). Near the contact between the Khewra Formation and the underlying Salt Range Formation, polygonal fossil mud cracks can be seen on the bedding surfaces over large areas.

*Sole Markings.* Sole markings of various sizes and shapes are abundantly found in the formation. At the contact of the bedding, irregular cavities can be seen on one plane and befitting buldged portions on the adjoining plane.

*Rill Marks.* Rill marks, though rare, are present in the Khewra Formation. They could be observed only at two localities in one section.

## MINERALOGICAL COMPOSITION

Table II gives the mineralogical composition of the Khewra Formation. The percentages of the various components of the sandstone were calculated with the help of a point counter. About 600 points were counted in each slide.

Quartz and carbonate are the two dominant minerals constituting the Khewra Formation. Most of the quartz grains show uniform extinction. Inclusions are insignificant. Carbonate may be calcite or dolomite, or both. Feldspar, mostly plagioclase with minor microcline, comes next in order of abundance. Some of the feldspar was found to be fairly altered and gave a clayey look.

Chlorite, iron ore and lithic fragments are the accessory constituents. Muscovite and tourmaline are minor and only in some sections.

Table II

*Mineralogical Composition*

(based on a count of 600 points per section)

| | SLIDE NO | | | | |
|---|---|---|---|---|---|
| | I | II | III | IV | V |
| Minerals | From Lower Part | From Lower Part | From Middle Part | From Middle Part | From Upper Part |
| Quartz | 72% | 70% | 64% | 46% | 59% |
| Carbonates | 24% | 25% | 27% | 50% | 39% |
| Feldspar | 2% | traces | traces | — | traces |
| Iron Ore | 2% | 4% | 1% | 3% | traces |
| Muscovite | traces | — | 1% | — | — |
| Chlorite | traces | traces | 6% | 1% | 1% |
| Rock fragments | traces | traces | 1% | traces | traces |
| Tourmaline | — | — | traces | traces | traces |

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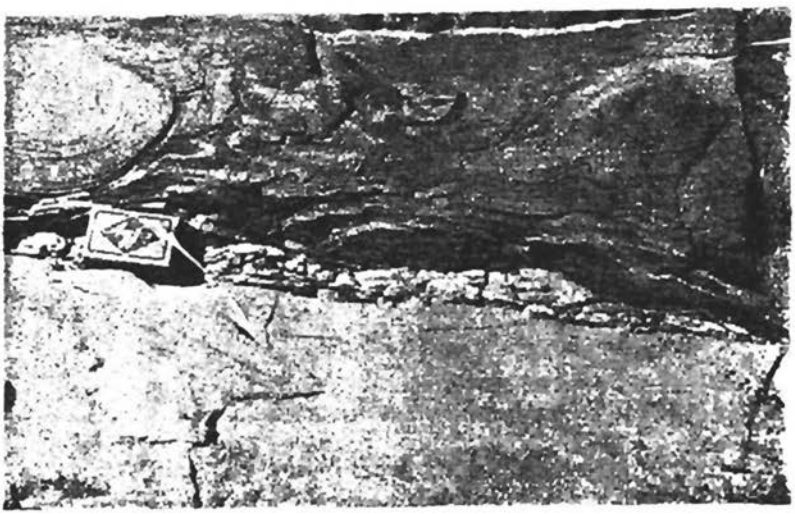

Plate 1. Convolute bedding (current from left to right)

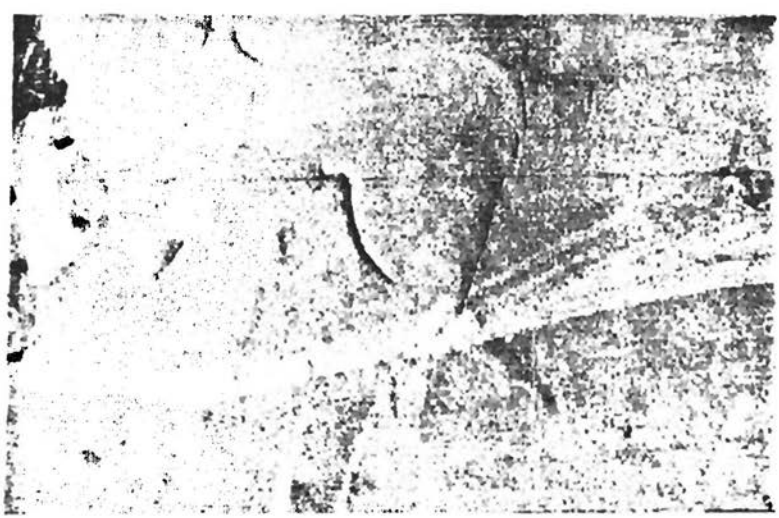

Plate 2. Cross bedding (Current from right to left)

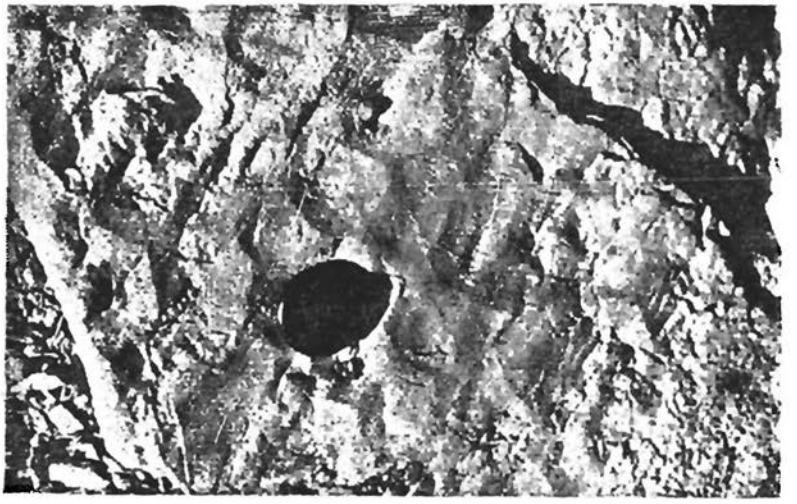

Plate 3. Interference Ripple marks

Plate 4. Small. symmetrical, transverse ripple marks

Plate 5. Branching ripple marks with development of secondary ripple marks on crests

Plate 6. Fossil mud cracks