THE STUDY OF THE STRUCTURES HAVING DIRECTIONAL PROPERTIES AND DELINEATION OF PROVENANCE WITH THE HELP OF HEAVY MINERAL ANALYSIS IN THE KHEWRA SANDSTONE

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ABSTRACT

During Late Pre-Cam brian and Early Cambrian times, the Khewra Sandstone was being deposited in the Punjab Salt Range area. This formation, along with the development of a variety of sedimentary structures, is thoroughly cross-bedded especially in the lower and lower-middle part. Linguoid sole markings, though not abundant, were also observed at different levels. The study of the nature and attitude of these structures together with the heavy mineral analysis prove that the Khewra Sandstone was deposited in a shallow basin located at the northern shore of the Indian Table. The main bulk of the detritus was being supplied from a distant source area lying towars the south-east of the present location of the Salt Range.

INTRODUCTION

During the last few years, different geological aspects of the rocks exposed in the Salt Range have been the focus of the attention of many workers. Khewra Sandstone, because of the variety of features it exposes, has attracted geologists more than the other formations of the area. Thus many papers have been published on its petrography, structures, textures and the environments of deposition.

The only major sphere of study left was the palaeocurrent studies, heavy mineral analysis and ultimately deliniating the area from where the detritus might have been supplied.

The Khewra Sandstone is extensively cross-bedded. The nature of the outcrops and the development of cross-bedding make it possible to collect enough reliable data of the attitude of the fore-set beds. Besides, the linguoid sole markings, though not very common, have been observed at a few exposures. This structure is also utilized to supplement the main findings.

The directional studies of the sediments of the Khewra Sandstone have been integrated with its heavy mineral analysis in order to ascertain its generation and place of origin.

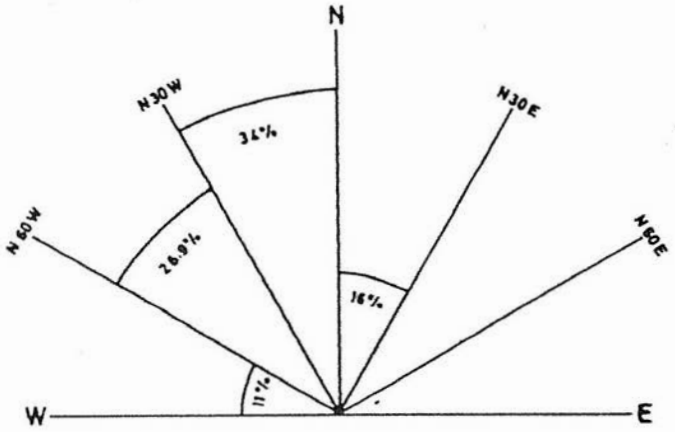
The work was started in June, 1974 by a group of students under the supervision of the author. During the course of the early work, the data was collected from a limited area in the eastern Salt Range. Besides, the different data and field observations could not be properly co-ordinated; as a result the first report of the work (Feb. 1975) was not satisfactory. The author later made new observations and recorded more evidences during his next visit to the area. The data was then processed more systematically and the entire work was revised in the form of this paper.

THE CROSS-BEDDING IN THE KHEWRA SANDSTONE

Nature and Attitude:

Though the Khewra Sandstone exhibits various types of cross-bedding, the most common are single sets of parallel laminae transverse to gently dipping beds. The attitude of the fore-set beds in this type, can be recorded with great ease (Pl-1). Since most of the sections in the eastern Salt Range run perpendicular to the strike of the original bedding of Khewra Sandstone, it is not difficult to find suitable exposures for data collection. Intersecting fore-set beds and compound cross-laminations are occasionaly present but considering the frequency of the development of the cross-bedding in the said formation, this type may be regarded as rare.

Towards the lower and lower middle part of the Khewra Sandstone, the cross-bedding is the most characteristic feature of the formation. Almost all the thick beds here are frequently cross-bedded. Most of the data has been collected from this part in all the sections. From the middle part of the formation onward towards the upper stratigraphic levels, there is observed a gradual decline in the abundance of the cross-bedding. In the uppermost

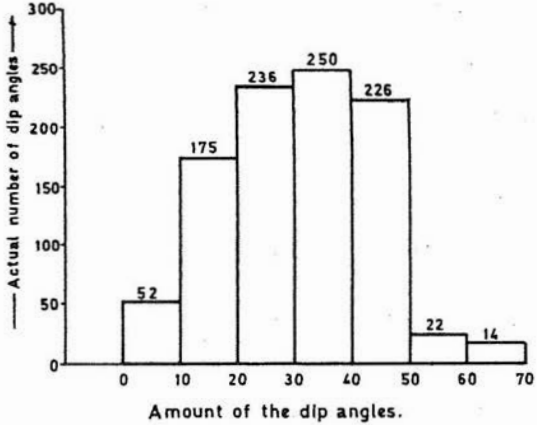


Total Readings = 975

ROSE DIAGRAM SHOWING
THE DIP DIRECTIONS OF THE FORE-SET BEDS IN
KHEWRA SANDSTONE.

Figure 2

HISTOGRAM SHOWING THE AMOUNT OF DIP ANGLES
OF FORE-SET BEDS IN KHEWRA SANDSTONE.
(Class interval. = 10°)



Total readings = 975

Figure 1

part, specially near the contact with the overlying Khussak Formation, the Khewra Sandstone is nearly devoid of this structure. The fore-set beds are more often short and show moderate to steep inclinations (20° to 40°). The large fore-sets with comparatively steeper inclination are quite common. The statistical analysis of 975 fore-set measurements in the Khewra Sandstone showed that the value of the mean inclination is 32°. The angle of inclination, however, varies a great deal in amount, as such no preferred plunge angle can be worked out (Fig.1).

Towards the middle part and onwards, the fore-sets are mostly large with gentle inclinations (never exceed 20°).

The bearing of the maximum inclination of the fore-set beds again lacks any preferred direction (Fig. 2). It shows a general spread between NS and N 60°W on the basis of 679 dip directions. The data, plotted with 30° class interval, gave four classes. Following is the detail.

Class	I	(Between N 30°E and N)	16.0%
Class	II	(Between N and N 30°W)	37.4%
Class	III	(Between N 30°W and N 60°W)	29.6%
Class	IV	(Between N 60°W and W)	11.0%
		Total	94.0%

Six per cent of the total readings show erratic trends of dips, i.e., towards SE, SW and south.

Linguoid Sole Markings:

Sole markings and transposition structures of many different types and origin are developed in the Khewra Sandstone. Though majority of these and other related structures have originated because of the different physical properties of the constituent layers or beds, the linguoid sole markings in the Khewra Sanstone definitely indicate the direction of the flow of current (Pl.2)

Since the dip of the formation is gentle in most of the eastern part of the Salt Range, the linguoid sole marks or flow casts do not have enough exposures. They are present at the lower surfaces of the beds and have chance exposures where parts of the lower layers have been exposed.

However, three such localities could be discovered where the measurements of the long axes of these flow casts could be carried out. The data was not enough to be plotted for determining the mean direction. Out of a total of seventeen measurements, thirteen were found to lie between N 30°W/S 30°E and N 45°W/S 45° E.

The Heavy Mineral Analysis:

This analysis is based on the study of 1937 grains of the most common heavy minerals. Hematite turns out to be the most abundant constituant of the heavy mineral suite. Subrounded to subangular grains of hematite showing dark colour, are found scattered in each slide. On the basis of the count of the grains, hematite constitutes 54 percent of the heavy minerals.

Zircon contributes 42.5 percent to the heavy minerals in the Khewra Sandstone. A very significant property of the zircon grains is their roundness. About 75 percent of the grains can be regarded as rounded to subrounded. (Pl.3 and 4)

Garnet content in the heavy minerals is 2.5 percent. Most of the grains are rounded, subrounded or oval in shape. A wide range of size variation is observed. Some grains show pitted surfaces. Garnet displays different colours. In addition to the light coloured varieties, yellowish-brown and green varieties are also found.

Rutile constitutes 0.7 percent of total heavy minerals. The grains are subrounded and the colour is dominantly reddish-brown.

Hornblende has the lowest representation. Only few grains are present which constitute 0.3 percent. Crystals of hornblende which are lath like in appearance, have rounded edges (Pl-5). Broken fragments of crystals are also present. The colour of hornblende is brown or green.

Figure 3 gives concentration of the heavy minerals in the Khewra Sandstone.

CONCLUSIONS

Conditions of the Basin of Deposition:

On the surface it appears that during the deposition of the Khewra Sandstone, the basin was frequently pulsating with fluctuating and shifting currents. The rate of the supply of the material also looks to be frequently changing.

HISTOGRAM SHOWING THE CONCENTRATION OF THE HEAVY MINERALS IN KHEWRA SANDSTONE.

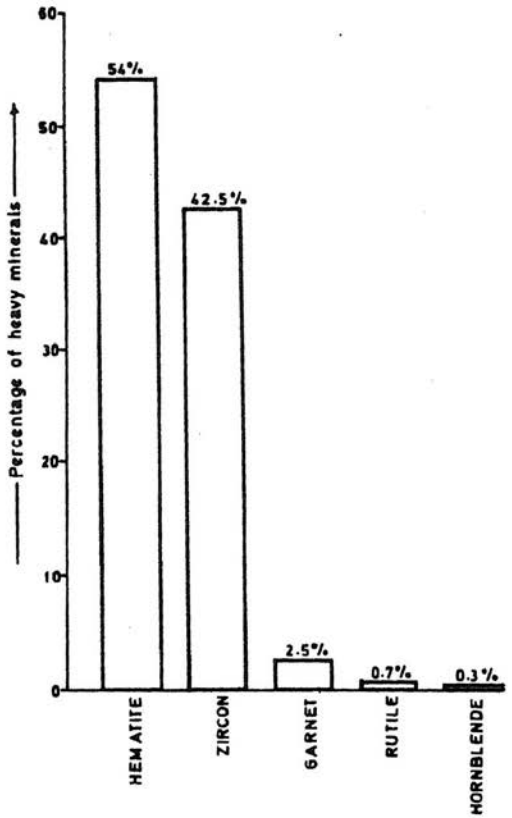


Figure 3

More closer examination makes it evident that there was a general tendency of gradual deepening of the basin. The inflow of the material was gradually decreasing during the later stages of deposition. This statement can be confirmed by the following observations.

i. The lower and lower middle part of the Khewra Sandstone is extensively cross bedded, The fore-set beds have invariably steeper inclinations. Majority of the fore-sets are large but small fore-sets are also common. These features indicate that although the supply of the material was not constant, the currents were moving slowly on gentle slopes. Abundance of primary structures like ripple marks and mud cracks in this part, is also an indication of shallow water conditions prevailing in the early stages of the deposition of this formation.

ii. From the middle to upper part of the Khewra Sandstone, there is a definite and gradual decrease in the frequency of cross-bedding and the other related primary structures. The fore-set beds are large and gently inclined. This feature points towards the decrease in the quatity of supplies and that the currents moving on steep slopes.

The Palaeocurrent Orientation:

The palaeocurrent study is not very conclusive. It shows that the currents bringing the material for deposition were changing their courses from time to time. No single dominant trend of the plaeocurrent orientation could be worked out. One significant feature, however, is that north-easterly inclinations of the fore-sets are not present. It can be concluded that the currents might have moved from some area of the Indian Shield, lying towards south east.

The Heavy Minerals:

At the present stage of work, this analysis is incomplete. Few observations give some idea about the nature of some of the heavy minerals. The details are given in table-1. Some of the significant features of heavy minerals are listed below.

i. Zircon, which is the second most dominant mineral, shows exceptionally rounded grains, Euhedral to subhedral grains of zircon are most common. The roundness of zircon grains may be attributed to multicyclic deposition or a very distant source.

ii. The fewer number of the heavy minerals may be taken for long distance of transport or an othoquartzite of a second or third order generation to be present as the source rock.

iii. The Precambrian shield area of north India contains numerous occurences of biotite and sillimanite schist (Dunn, 1929). If this was the source area, there should have been higher percentage of rutile.

It may be finally concluded that in the Late Precambrian to Early Cambrian times, the Eastern part of the Salt Range was a shallow basin of the continental margin towards north of the Indian Shield, in which Khewra Sandstone was being deposited. The source area might have been some distant part of the Shield lying towards south east of the Salt Range. This direction is with reference to the present geographical position of Indian Subcontinent.

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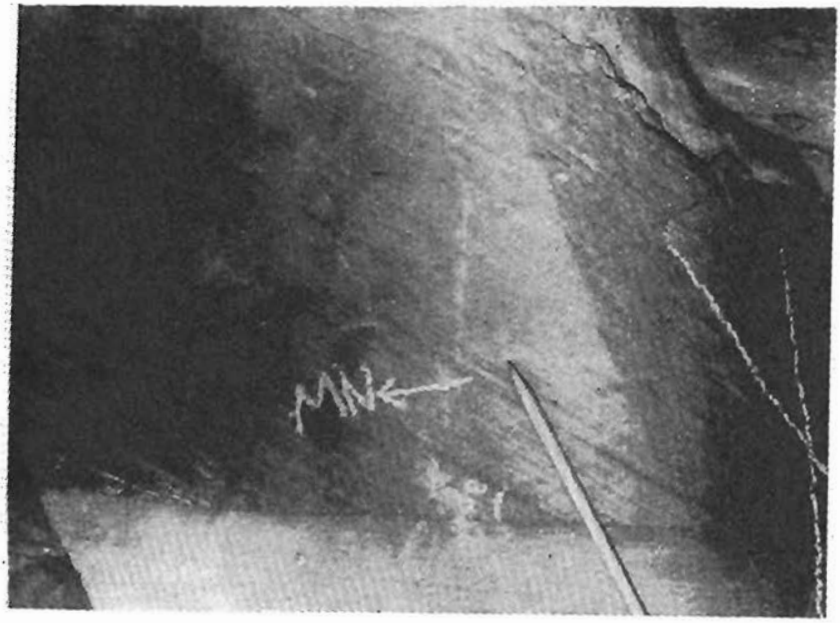

Plate 1. Cross - bedding in the Khewra sandstone. The attitude of foreset beds can be observed in relation to the orignal bedding.

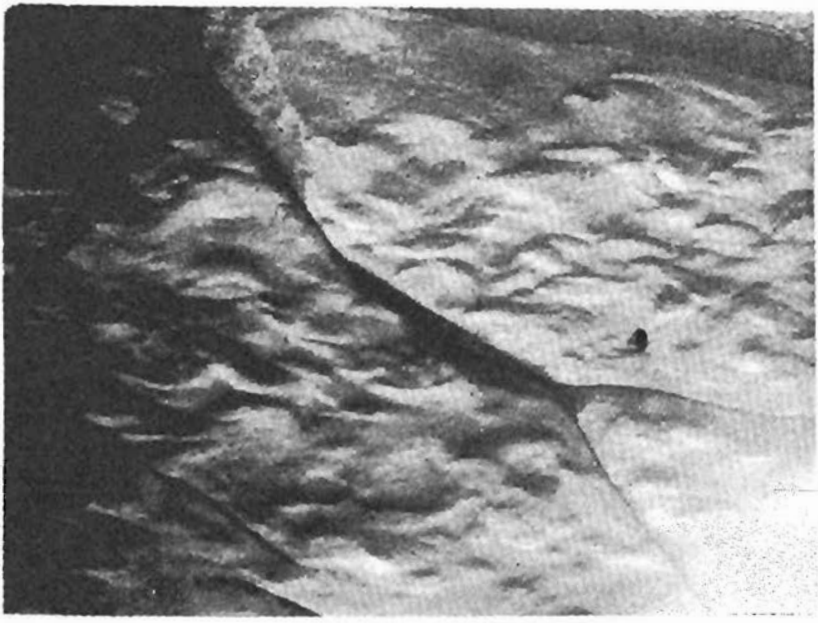

Plate 2. Linguoid sole markings as seen on the lower surface of Khewra sandstone.

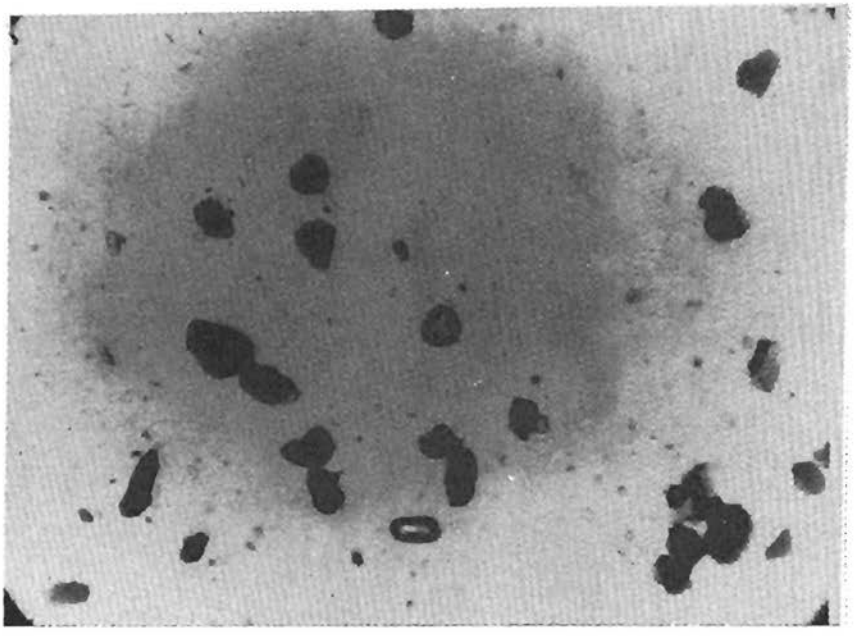

Plate 3. Micrograph (× 32) showing the rounded and prismatic grains of zircon.

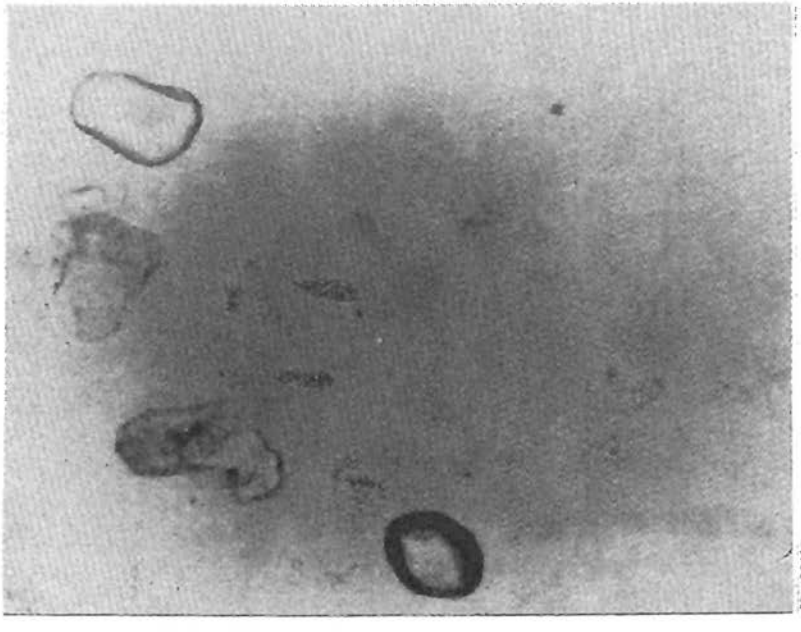

Plate 4. Micograph (× 166) showing two grains of zircon. One is rounded and the other is slightly elongated.