SUMMARY

The Kussak Formation is well exposed in Khewra and Nilawahan and easily accessible. Petrography of the collected samples has been carried out very carefully and we placed the Kussak Formation in the QFL diagram. All samples of sandstone of the Kussak Formation belong to the category of quartz arenite in Folk (1974). Textural and mineralogical studies of systematically obtained sandstone samples were carried out the cross and polarizing microscope and estimates of the main constituents made in order to classify them. Samples of the Kussak Formation were collected from two sections Khewra Gorge and Nilawahan Gorge in Central Salt Range. The Kussak formation consists of grey silty and sandy glauconitic shale with some sandstone intercalations and a few black shales. The shale is grey, greenish grey in color, and in sandy, micaceous and calcareous. Medium hard to friable and coarse grained sandstone is present. Bioturbation and glauconite is abundant in middle part of the Formation. The lower part of the formation yellow dolomitic beds and gypsum lenses appear. The sandstone is fine to medium grained, subangular to subrounded, moderately to well sorted. Sedimentary features like cross bedding, ripple marks, mud cracks and bioturbation etc, are common in the formation.
Introduction

Early Middle Cambrian Sandstone from Nilawan Gorge and Khewra Gorge (Pakistan) has been studied from Sedimentological and sequence stratigraphic point of view.

There are about eleven lithofacies/ subfacies. The Kussak Formation has several sandstone, siltstone, claystone, sandy dolomite and mudstone. Eleven lithofacies are observed in the Kussak Formation and these are arranged in several distinctive fining upward cycles. Coarse grained laminated sandstone $C_L$, Medium grained laminated sandstone $M_L$, Medium grained massive sandstone $M_M$, Fine grained laminated sandstone $F_L$, Fine grained massive bedded sandstone $F_M$, Fine grained bioturbated sandstone $F_B$, Fine grained flaser bedded sandstone $F_F$, Sandy dolomite $S_D$, Bioturbated mudstone $B_M$, Laminated claystone $Z$, Bioturbated siltstone and claystone $Z_B$.

The presence of Hummocky Cross Stratification indicates large storm in which large amount of water was pushed on a tidal flat. Large scale cross stratification indicates on shallow tidal flats having storm surges and tidal currents. Presence of ripple cross lamination and oscillatory ripple marks shallow water conditions. The complicated pattern of oscillatory ripple marks show deposition in a changing depth tidal flat environment. Mudcracks indicates supratidal conditions. Pseudonodules show that the beds are disconnected.

The Kussak Sandstone exhibits a variety of sedimentary structure which gives information about the depositional environment of the formation. The most common sedimentary structure in the formation is bedding, cross bedding, ripples mark, mudcracks, bioturbation, plant roots and iron-nodules. The bedding of the formation is thin to thick.

The Kussak formation exhibits fining upward sequence and shows cyclic deposition in the base. At the top of the succession medium grained sandstone with shale intercalations is present. Silt and claystone intercalations are present throughout the succession.

Most of the classifications of sandstone are based on the three end members Quartz, Feldspar and Lithic fragments and known as QFL diagram. The thin section study of Kussak Formation was carried out and the percentages of detrital grains of quartz, feldspar and rock fragment are plotted on QFL diagram. The sandstone contains about 85-86% quartz, 3-4% feldspar and 1% rock fragment.

In Pettijohn (1975) classification of the sandstone, percentages of three framework grains quartz, feldspar and rock fragment are plotted on QFL diagram (Fig. 4.6a). In Folk (1974) classification of sandstone, percentages of quartz, feldspar and rock fragments are plotted on QFL diagram (Fig. 4.6b).

The percentages in 100% of three end members were calculated and plotted according to Folk (1974) and Pettijohn (1975) classification of sandstone. All samples of sandstone of the Kussak Formation belong to the category of quartz arenite in Folk (1974).

Theory

Facies analysis is an important part if any stratigraphic study. The basic idea is to recognize how different depositional environments are expresses by the development of characteristic structures, lithologies and organic components in sedimentary rocks. The usual way to reconstruct the depositional history of an area is to group strata into facies assemblages; that is measuring numerous stratigraphic sections, examining the rocks, and assigning those rocks a depositional environment based on sedimentary structures, paleontological evidence and lithology.

In our case, two sections of Early Cambrian were measured at Khewra and Nilawan. The purpose was to identify the Lithofacies assemblage of the Cambrian sequence in studied area.
The Kussak Formation has several sandstone, siltstone, claystone, sandy dolomite and mudstone. Eleven lithofacies are observed in the Kussak Formation and these are arranged in several distinctive fining upward cycles. Mainly 11 facies are present in the Kussak Formation.

The example of the one section is given in Figure 1.

![Figure 1](image_url)

**Figure 1** This panel diagram is showing the lithological log of the Kussak sandstone from the Nilawahan gorge, central salt range Pakistan.

**Conclusions**

The Kussak formation exhibits fining upward sequence and shows cyclic deposition in the base. At the top of the succession medium grained sandstone with shale intercalations is present. Silt and claystone intercalations are present through-out the succession. The Kussak Formation is meandering river to deltaic in origin and was deposited by a meandering river. This was determined from the facies pattern and architectural elements of the Kussak formation in the project area. The provenance studies of the Kussak Formation shows that its provenance was Arawali and melani ranges in the west of Pakistan. The sandstone is of sedimentary origin.

**References**