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SHALLOW MARINE SEDIMENTS OF THE PATALA FORMATION OF PALEOCENE AGE, KOHAT AREA, PAKISTAN

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ABSTRACT

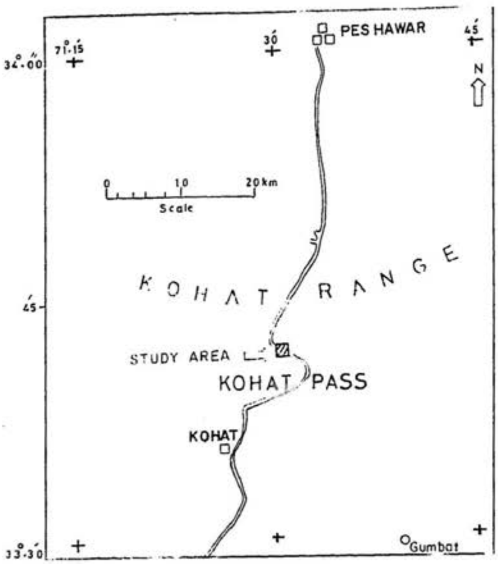
The Patala Formation in Kohat area consists of four lithofacies which are; PF1 sandstone with shale interbeds, PF2 shale and siltstone with limestone interbeds, PF3 shale with interbeds of siltstone, and PF4 shale and marl interbeds. These facies were deposited in shallow marine shelf environments ranging from upper shoreface to offshore possibly middle to outer shelf environments.

Facies PF1-PF4 in general depict deposition in a continuously deepening or transgressive conditions. The lateral variations in lithology within the Patala Formation are suggested to be mainly related to the local variations in paleogeographic setting.

INTRODUCTION

The Patala Formation is the youngest Paleocene formation exposed in Kohat-Potwar Plateau, Hazara and Salt Range (Shah, 1977). The present study is confined only to the exposures in the Kohat area (Figs. 1 and 2). In this area, the formation overlies the Lockhart limestone (more correctly Lockhart Formation). The upper contact of the Patala Formation is not exposed in the Kohat Pass but at some localities in the Kohat area such as at Panoba it is underlain by the Panoba Formation. In Kohat Pass the area is structurally disturbed and the sequence is locally overturned (A.A.K. Ghauri, personal communication, 1989).

Only previous sedimentological study on the Patala Formation is by Rashid et al. (1988) but they misunderstood the overturned sequence as normal (A.A.K. Ghauri & Obaid-ur-Rehman, personal communication, 1989). General structural and stratigraphic studies in the Kohat Pass have been done by Ghauri et al. (1983).



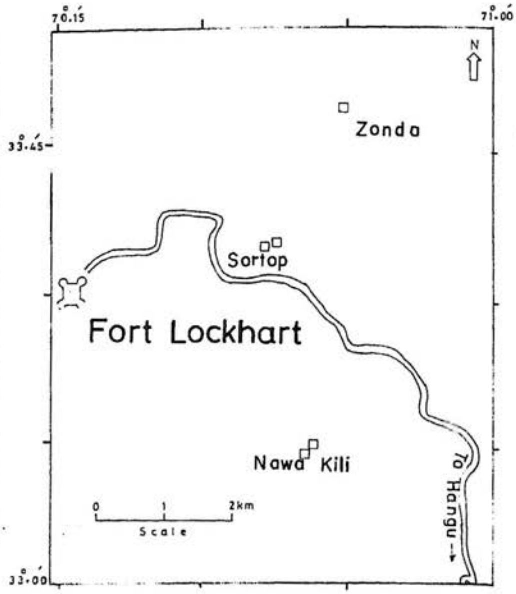


Fig. 1 (Left). Location map of the section at Kohat Pass.

Fig. 2 (Right). Location map of the section near Fort Lockhart.

Meissner et al. (1974) described the Patala Formation from various localities within the Kohat Quadrangle. The present study deals with the lithofacies and paleoenvironments of the Patala Formation, based on two relatively better exposed and easily accessible sections; one at Kohat Pass in Khyber Agency and the other at Samana Fort in Orakzai Agency (Figs. 1 and 2). No coal association is present at these localities in these strata.

LITHOFACIES OF THE PATALA FORMATION

Four lithofacies were distinguished within the two sections of the Patala Formation on the basis of lithology and other sedimentary features. These lithofacies are PF1 sandstone with shale interbeds; PF2 shale and siltstone with limestone interbeds; PF3 shale with interbeds of siltstone, and PF4 shale and marl interbeds (Fig. 3).

DESCRIPTION AND INTERPRETATION OF LITHOFACIES

Facies PF1: Sandstone with shale interbeds

Location: The strata of this facies are exposed at Kohat Pass in Khyber Agency (Fig. 1) and ca. 500 m north of Fort Lockhart in Orakzai Agency (Fig. 2).

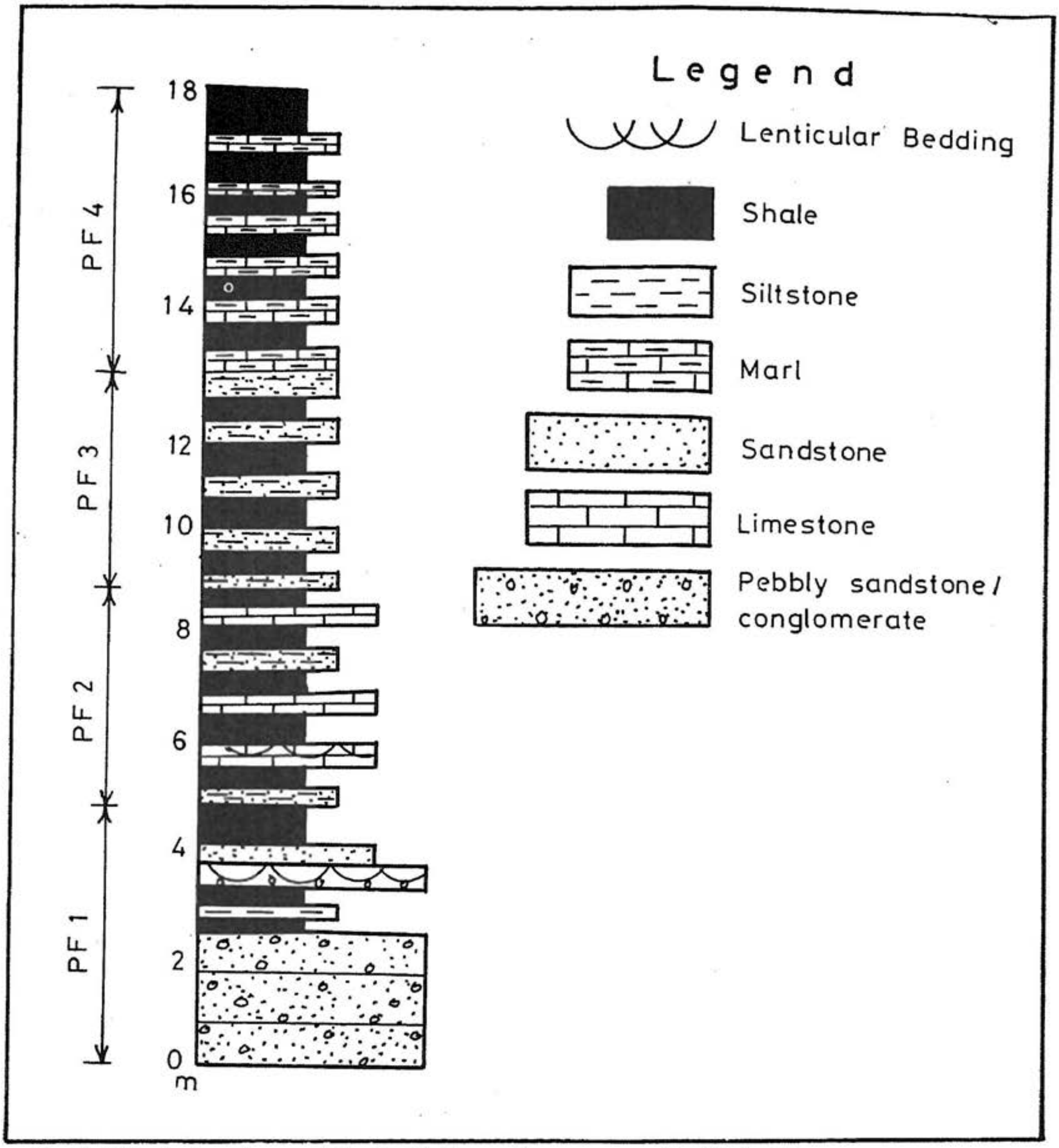


Fig. 3. Lithologic column of the Patala Formation as exposed at Kohat Pass.

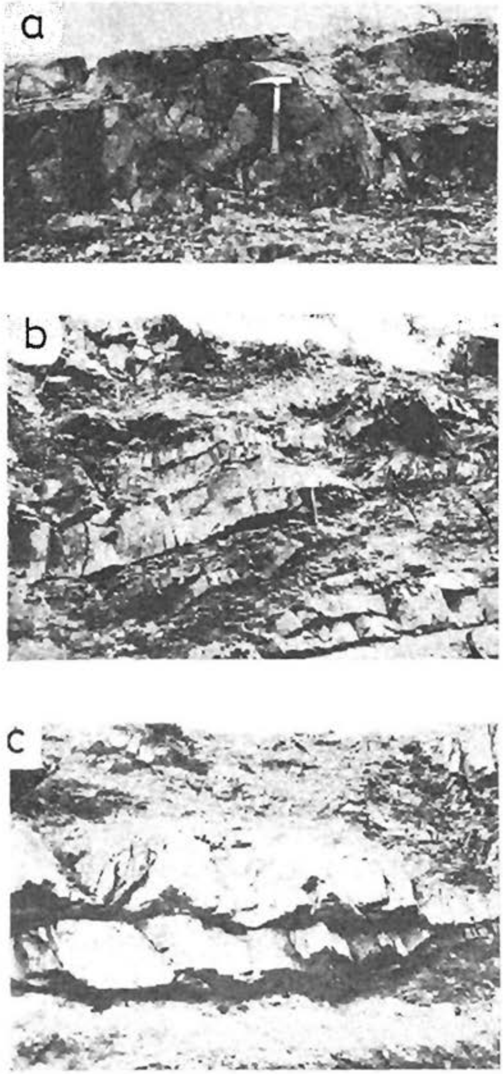
Description: The lower portion of this facies consists of predominantly coarse-grained pebbly sandstone beds of dark brown to black in colour (Fig. 4a). These beds are composite and lateral lenticularity or continuity of individual beds is not clear due to exposure difficulties, though in some cases they appear lenticular. Generally the coarse pebbles, 1-3 cm in diameter, are randomly distributed, nevertheless, concentrated zones or bands of this relatively coarse material are also present.

The upper portion of this facies consists of sandstone and shale interbeds; the shale ratio generally increases upwards (Fig. 4b). The shale is silty and brownish grey in colour. The thickness of individual intervening shale beds is 1-30 cm. The sandstone beds may be composite attaining thicknesses of more than a meter, however, the actual thickness of a single non-composite bed does not exceed 70 cm. These sandstone beds are generally lenticular when traced laterally (Fig. 4c). The sandstone beds are both fine-grained and coarse-grained. These coarse-grained beds are generally pebbly. The pebbles are apparently subrounded to rounded in shape and are of chert, quartz andsubordinate feldspar. The sandstone beds are with sharp lower and upper bedding planes. Additionally, there are a few siltstone interbeds in upper reaches of the facies. These are maroon in colour, range from 3-20 cm in thickness and appear massive. Due to structural complexities and exposure difficulties exact thickness of the facies is difficult to assess and is estimated ca. 7 m.

Interpretation: No characteristic sedimentary features are present in this facies to help in the recognition of its exact environments of deposition. However, the lithologic characteristics such as thick beds and the coarse grain size and absence of intervening shale in basal portion, which is suggestive of continuous agitation of water, indicate very shallow marine, such as foreshore or upper shoreface environments of deposition (cf. Reineck & Singh, 1972; Kreisa, 1981; Bourgeois & Leithold, 1984).

The study of thin sections from the samples of this facies show an abundance of quartz and chert grains many of which are well rounded. The general scarcity of feldspar grains, if initially present, could be due to wear and tear inflicted by highly agitated waters. The roundness of hard and resistant grains such as chert and quartz in addition to absence of relatively easily breakable minerals again suggests a very high energy environment of deposition for these basal strata (cf. Folk, 1974; Mack, 1978; Cotter, 1983).

The upper portion with sandstone and shale interbeds is considered to be deposited more seaward of the basal portion. Channeling of the sandstone beds is considered to be the result of two phenomena: 1) Coarse pebbly sandstone beds were most probably introduced during very high energy conditions such as would be attained during storms. 2) The fine-grained pinching sandstone beds were most probably the result of weaker storm and or longshore currents. The longshore currents in conjunction with the weaker storm currents do have the ability to erode, transport and finally deposit these sediments (cf. McCubbin, 1982). The shale, as usual, would have been deposited during fairweather quieter conditions or as the trailing deposits of the waning energy conditions (Swift et al., 1986).



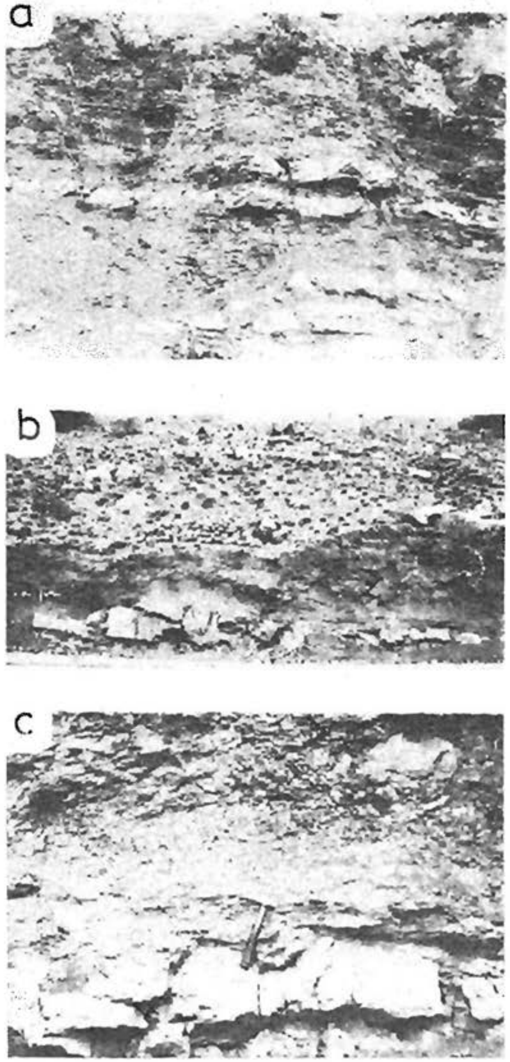


Fig. 4(Left). Facies PF1 at Kohat Pass. (a) Composite beds of basal dark colour pebbly sandstone. (b) Interbedded shale and sandstone beds in the upper portion of facies PF1. The sandstone beds, some fine-grained and others pebbly and coarse-grained, are lenticular or are of uneven thickness laterally. (c) Close-up of a portion of (b) clearly showing lenticularity of the sandstone beds. Note sharp and uneven lower bedding planes of these beds. Hammer is 32 cm long.

Fig. 5(Right). Facies PF2 at Kohat Pass. (a) Siltstone interbeds in the dominant shale + siltstone lithology. (b) Limestone interbeds in shale-siltstone consist of sharp lower bedding planes and atleast locally gradational upper bedding planes and are lenticular. (c) Close-up of a portion of (b) showing sharp lower bedding plane and gradational upper bedding plane of a limestone bed. Just beneath the hammer thin alternating limestone and shale-siltstone beds are visible and above the hammer only shale-silstone is present.

Facies PF2; Shale and siltstone with limestone interbeds

Location: This facies is exposed at Kohat Pass in Khyber Agency (Fig. 1).

Description: This facies comprises khaki and maroon shale, maroon siltstone and interbeds of grey limestone. The general thickness of the maroon siltstone beds is between 1 and 3 cm, however, occasionally maximum thickness of the siltstone beds may reach to 17 cm (Fig. 5a). Siltstone beds interbed with shale on small scale, on large scale these (shale and siltstone) are interbedded with limestone beds (Fig. 5b). The combined minimum thickness of shale and siltstone beds is about 2.5 m. The siltstone beds consist of sharp lower bedding planes and in several instances gradational upper bedding planes. The minimum total thickness of the limestone beds is 1.5 m. Some of the limestone beds are composite and their lateral extension could not be confirmed due to exposure difficulties. However, others are either invariable in thickness or are laterally lenticular with the lateral extent of more than 15 m (Fig. 5b). The base of some of these limestone beds are erosive and undulatory (Fig. 5c). The upper bedding planes of those beds appear gradational, so that millimeter thick limestone layers interbed with shale before passing upward into shale and siltstone beds (Fig. 5c). No bioturbation has been observed in strata of this facies. The total thickness of this facies is about 4 m.

Interpretation: The interbedded shale, siltstone and limestone beds are more puzzling in terms of their origin. The shale was deposited in quiet water out of suspension while the thin intervening siltstone beds were deposited as distal deposits by occasional strong currents which were possibly storm related. Conventionally interbedded fine-grained sediments (i.e. shales), in the storm dominated shelf sequences, are considered to have been deposited during fairweather conditions in the offshore areas (e.g. Kreisa, 1981; Brenchley & Newall, 1982; Dott & Bourgeois, 1982; Simonson, 1984; Johnson & Baldwin, 1986). It is also possible that shale, at least partially, may have been related to the last phase of waning storm currents (cf. Swift et al., 1986). The presence of the limestone beds in this facies may suggest local fluctuations between clastic and non-clastic environments of deposition. Alternatively, the calcium carbonate was being deposited in the vicinity of the site of deposition of shale and siltstone of this facies or some combination of both the possibilities (cf. Mount, 1984). In the latter case currents during high energy conditions would have transported the calcareous material from its site of origin and deposited it in its present location where predominant clastic deposition was taking place. This is indeed supported by the fact that some of the limestone beds are either laterally uneven in thickness or are lenticular and consist of erosional lower bedding planes. The upper gradational contacts with shale and siltstone of these beds also support this interpretation. The channels could have been incised by erosion into the previously deposited sediments by storm related currents. The deposition of these limestone beds took place during waning stage of the high energy conditions.

Facies PF3: Shale with interbeds of siltstone

Location: The strata of this facies are exposed at Kohat Pass in Khyber Agency. It is also exposed about 1/2 km north of Samana Fort in Orakzai Agency (Fig. 2).

Description: There are alternate beds of khaki shale and maroon siltstone. Thickness of the siltstone beds ranges from 1 to 6 cm but usually range from 1 to 3 cm (Fig. 6). Beds are generally massive and do not show any sedimentary structures. Mostly the lower bedding planes of siltstone beds are sharp and wavy, while the upper bedding planes are sharp to gradational with shale. The thickness of this facies is about 4 m. At some places thickness of this facies reaches 13 m which is presumably due to intense folding.

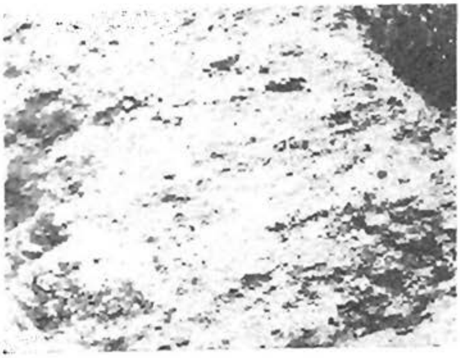
Interpretation: This facies generally indicates deep water conditions as compared to the underlying facies PF2. Normally in the offshore quiet environments, mostly shale gets deposited. However, the presence of relatively coarser siltstone beds in this facies is indicative of time to time high energy conditions i.e., storm related beds (cf. Hobday & Reading, 1972; Tanoli & Pickerill, 1989). The presence of these siltstone beds shows that the storms were prevailing from time to time during the deposition of this facies. The lower sharp and wavy contacts of siltstone with shale are indicative of erosion by high energy currents in the previously deposited sediments (cf. Banks, 1973). During longer periods of low energy conditions shale continued to be deposited out of suspension. Short-lived high energy conditions were responsible for relatively coarse-grained (i.e. silt stone) beds. No calcareous beds are present in this facies suggesting a general lack of availability of calcareous material at the time of deposition of these strata.

Facies PF4: Shale and marl interbeds

Location: Strata of this facies are exposed along the road cuts on southern slopes of the Kohat Pass in Khyber Agency (Fig. 1).

Description: This facies overlies the khaki colour shale of facies PF3 whereas upper contact of this facies, as well as of the formation, is covered. Observed thickness of the facies ranges from 4 to 9 m. This thickness estimate, however, does not properly count for the folding, which is intense in the area. Therefore, actual thickness might be lesser than the observed thickness.

The lower portion of this facies is composed of thin marl and shale interbeds (Fig. 7). The marl to shale ratio in the middle portion approaches 1:1. Marl beds are maroon in colour and vary in thickness from ca. 1-8 cm, but usually ranges from 2-4 cm. The lower bedding planes of the marl beds are smooth to irregular. Thickness of the intervening shale beds ranges from 1-2 cm. Lateral change in thickness of the individual beds cannot be ascertained due to limited exposures. No sedimentary structure was observed, and both the marl and shale beds apparently appear massive.



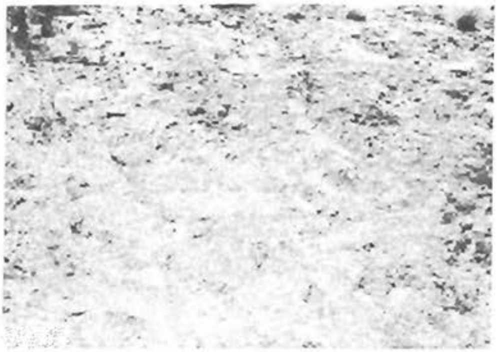


Fig. 6(Left). Alternating thin siltstone and shale beds of facies PF3. Hammer is 32 cm long.

Fig. 7(Right). In upper portion of the photograph which is actually the lower portion of facies PF4 thin marl and shale beds alternate. In lower portion, which is the uppermost exposed part of facies PF4 and the Patala Formation, dominant lithology is shale with scarce marl interbeds.

From middle portion upward in the facies marl beds begin to decrease. Consequently upper portion of the facies is predominantly composed of maroon coloured shales. Nevertheless, occasional marl beds do appear in shale even in the uppermost parts of the formation. The shale appears completely massive and non- bioturbated.

Interpretation: The presence of predominant shale in upper portion of this facies indicates quieter and less agitated conditions of deposition. Within a shelf setting, which is envisaged for the Patala Formation, such strata, specially when considered in context of the underlying facies, may be suggestive of an outer shelf environment (cf. Stanley et al., 1983).

The shale was possibly deposited out of suspension (cf. Simonson, 1984). The dark maroon colour of shale may be suggestive of the presence of iron in these strata. The iron was possibly partially oxidized during diagenesis since there would have been primarily not much oxygen available in the outer shelf conditions.

In lower portion of this facies, there is an increase in the marl beds where they reach up to 50 % of shale by volume. This indicates that there was a continuous supply of clay and calcareous material during the deposition of this phase of the facies. The presence of marl beds may be explained by : 1) supply of calcareous material which was not available during the deposition of upper portion of the facies, or 2) deepening upward environments. The former hypothesis implies that there was no transgression but only the change in available material. The latter hypothesis, however, would imply a gradual deepening of conditions in which relatively coarser material in the later stage was not reaching the depth where shale of the upper portion of the facies was depositing. This latter view appears more appropriate considering the overall situation of underlying facies which also suggest deposition of strata of this formation in a more or less continuously deepening environment.

DISCUSSION

The Patala Formation consists of abundant fauna such as foraminifers, mollusks, and ostracodes (Shah, 1977) which evidently suggests that these strata were deposited in marine environments. Locally, the formation predominantly consists of clastic sediments ranging from conglomerate/pebbly sandstone to fine-grained sandstone, siltstone and shale. Limestone and marl beds are also present in certain horizons of the formation.

The pebbles in strata of basal portion of the formation are in general rounded. Microscopic studies of these sandstones reveal the dominance of quartz and chert grains with subordinate proportions of feldspar and other minerals. These grains in general are texturally mature. This textural and to a large extent compositional maturity of the pebbly sandstone beds of facies PF1 as well as composite bedding in lower portion suggests their deposition under high energy conditions (cf. Folk, 1974; Kumar & Sanders, 1976; Cotter, 1983). The upper portion of facies PF1 consists of lenticular, coarse pebbly and non-pebbly medium- grained sandstone beds which are interbedded with shale beds. This points to the interchange of quiet and high energy intervals (cf. Reineck & Singh, 1972; Kreisa, 1981) thus suggesting seaward deposition of these strata compared to the lower portion of facies PF1.

There is a possibility that the conditions of deposition fluctuated briefly during the deposition of facies PF2 from purely clastic to alternating between clastic and non-clastic environments locally. However, the limestone beds in this facies may also suggest that limestone was being deposited in a nearby location and overpassing storms may have eroded these sediments and carried to the location of deposition of facies PF2 which was depositing in a dominantly clastic regime. The overlying shale and siltstones of facies PF3 were deposited more seaward of facies PF1 and PF2 in an offshore setting. Thin marl interbeds of facies PF4 appear to be distal storm beds (cf. De Raaf et al. 1977; Brenchley, 1985) in an offshore setting and the uppermost portion of the formation consists mainly of shale with scarce thin marl beds suggesting it to be further offshore in origin. The absence of well developed shoreface facies and rapid transition from foreshore or upper shoreface to offshore sediments suggests a narrow shelf with relatively steep gradient in Kohat area during deposition of the Patala Formation.

The sediments of this formation are not bioturbated. The conditions for survival of organisms were hospitable during deposition of these strata as is evident from the presence of abundant body fossils (Shah, 1977). The absence of bioturbation could then be considered due to fast rates of sedimentation. The organisms were unable to churn down the fast depositing sediments.

From the above discussion, it is clear that the Patala Formation in Kohat area generally exhibits fining upward sequence (Fig. 3). This fining upward trend is most probably related to the continuous deepening environments of deposition during sea transgression. Rashid et al. (1988) mistakenly considered the overturned strata (A.A.K. Ghauri & Obaid-ur-Rahman, personal communication, 1988) of the Patala Formation at Kohat Pass as a normal sequence. Consequently, strata of the basal facies PF1 makes top of their lithologic column and uppermost facies PF4 in this article makes their basal strata. Based on their lithologic column Rashid et al. (1988) had suggested a prograding upward sequence for the Patala Formation. In reality the sequence is transgressive upward.

The Patala Formation depicts lateral variations in lithology. The most pronounced change, comparing with lithology of the formation in Kohat area, is the presence of coal seams of economic value locally in Dandot area of the Salt Range (Shah, 1977). Whereas no coal seam is reported in the literature from the study area and surrounding localities. No direct evidence of stream entrance in the studied sections is present. The sediments of these localities may have been transported by longshore currents and/or brought in by flashy streams with no delta consisting of marshes and swamp build-ups.

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