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Early molasse sediments (Murree Formation) in Pathan Algad, southern Kohat

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ABSTRACT: *Of the southern most exposures of the Murree Formation in Kohat those of the Pathan Algad are considerably thick. These consist of interbedded maroon sandstone and red clay with subordinate conglomerate. The conglomerates within the formation are intrabasinal and lag in nature while conglomerate at base of the formation consists of reworked limestone clasts of the underlying Kohat Formation. Two main sand-bodies, one SB1 starts at 13m level and is 21m thick and second SB2 at 52m level ranging 2-4m in thickness, were observed. These sand-bodies consist of main channel, point bar, and chute bar deposits. Interbedded sandstone and clay facies which overlie the composite sandstone facies represent levee or crevasse splay deposits. The red clay was deposited in flood plain areas out of suspension. As a whole the Murree Formation in this area displays typical meandering river deposits. Our analysis suggests that the Pathan Algad area lied the margin of the Murree river system where only occasionally the main river flowed. Additionally, there may be a considerable age difference between the exposures in Pathan Algad and those at Dhok Maiki, the stratotype in Potwar area.*

INTRODUCTION

The strata of the Murree Formation of Rawalpindi group presents the initiation of the molasse sedimentation in North Pakistan. The sediments were deposited after the collision of the Indian plate with the Eurasian plate (Powel, 1979). They are distributed in the Kohat-Potwar province, Salt Range, Hazara-Kashmir syntaxial belt, Jammu and the North Indian plain. (Shah, 1977; Bossart and Ottigar, 1989) The lithology is mainly reddish brown and grey sandstone, siltstone, clay and conglomerate.

Previous stratigraphic studies on the Murree Formation are mentioned in detail in Shah (1977). A section exposed to the north of Dhok Maiki (Lat 33° 25´N, Long. 72° 35´E) was designated as the type section of the Murree Formation.

Although structural and stratigraphic studies of the Murree Formation and related strata have been published (Fatmi, 1973; Meissner et al., 1974; Bossart and Ottiger, 1989; Ahmad, 1989), but there has been no detailed study of its lithofacies and depositional environments in the Kohat area.

The present study is based on the strata exposed in Pathan Algad, northwest of the village of Braghdi on the Kohat-Shakardarra road in Kohat district (Lat 33° 17´ 20´´ N, Long 71° 27´ E), (Fig. 1). These are the known southermost considerably thick exposures of the Murree Formation in the Kohat area.

The aim of the present study is to present our findings regarding the depositional conditions of the Murree Formation in southern Kohat with special reference to the exposures in Pathan Algad area.

DESCRIPTION OF THE MURREE FORMATION IN PATHAN ALGAD

The Murree Formation in Pathan Algad is composed of sandstone, siltstone, clay and conglomerate (Fig. 2). At the base of the Murree Formation is a conglomerate body of 50cm thick consisting of 10-15cm thick apparently laterally pinching conglomerate beds. The clasts are of the underlying Kohat Formation and are up to 10cm in diameter. This conglomerate is overlain by 1m thick poorly developed semilithified calcareous clay horizon which is followed by 12m thick massive red clay, which marks the initiation of the actual Murree's deposition. Overlying this clay is the major sand-body SB1.

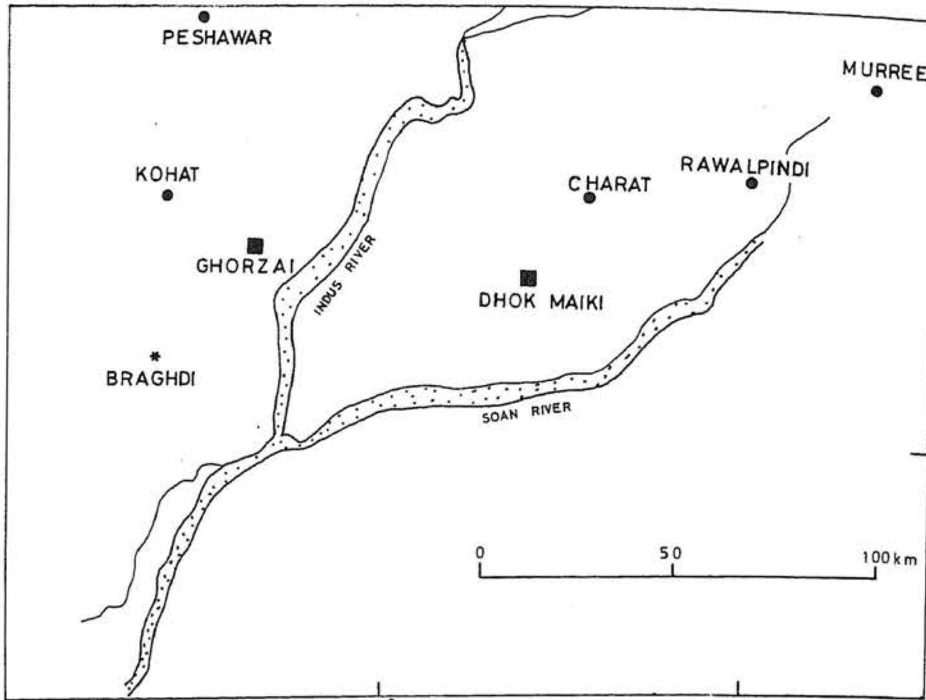

Fig. 1. Simplified map showing locations of Dhok Maiki, Ghorzai, and Pathan Algad (near Braghdi) sections of the Murree Formation. Exposure near Braghdi marked as star was studied in detail.

The SB1 is 21m thick and has a sharp erosional contact with the underlying clay (Fig. 3a). Although the unit is composite-bedded, without any intervening shale, still the individual beds can be demarked. The basal sandstone bed has scoured into clay . The sandstones are mainly cross-bedded but bioturbation has obscured the primary structure in several beds. Above the 6m level within this sand-body 2.5m thick pebbly sandstone and conglomerate is present (Figs. 3a & 4). Red siltstone or clay clasts of up to 20 cm in diameter are locally concentrated at the base of several beds (Fig. 3c). There is 1m thick horizon of three composite conglomerate beds that pinch out laterally over a short distance and are represented by lateral equivalent sandstone beds (Fig. 3a). The conglomerate in the thicker portion consists of rounded 1 to 2cm in diameter maroon siltstone pebbles. A 10cm thick bed of the conglomerate continues laterally over a distance of more than 10m at one end of the main body (Fig. 4). Maturity decreases with distance from the main body and locally up to 30cm in diameter angular red siltstone/clay clasts are present (Fig. 3b) giving thickening and thinning impression to the bed. A similar conglomerate bed is repeated again upwards with only one sandstone bed in-between the conglomerates. This conglomerate bed pinches out laterally and equivalent sandstone bed have small troughs and horizontal lamination at the top. Overlying is a 50cm thick pebbly sandstone and conglomerate bed which consists of red siltstone/clay pebbles and clasts (Fig. 3d). Overlying 4m consists of horizontally laminated sandstone beds in the lower portion. Within these beds localized clasts of up to 20cm in diameter of carbonate cemented material (caliche) are present (Fig. 3e). Uppermost 3m of the sand-body consists of apparently massive and possibly bioturbated sandstone.

The second major sand-body SB2 is at 50m level from the base. The sandstone beds are sharply and erosively based. On eastern end of the exposure the sand-body is 4m thick (Fig. 5a). The middle 2m of the unit consists of sandstone beds with internal horizontal

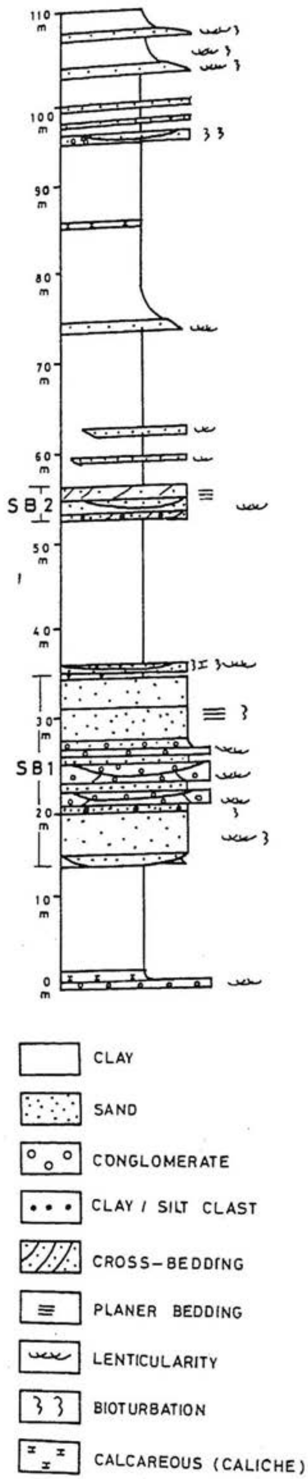

Fig. 2. Lithologic column of the Murree Formation in Pathan Algad.

lamination. Both the basal and the topmost sandstone beds are, however, internally cross-bedded. The basal bed locally consists of low angle cross-bedding (Fig. 5a). Tracing westward at a distance of 15m the same unit is only 2m thick (Fig. 6). Basal two thirds are made up of beautifully preserved megaripples with vertical thickness up to 60cm each and lateral extent of around 3m each. Upper one third is made up of superimposed small ripples cross-lamination with foreset thickness up to 8cm (Fig. 5b). 1 to 3cm in diameter red clay pebbles are scattered all through the unit. Further 10m westward this sandstone unit loses its cohesiveness as a single sand-body but instead sandstone and clay beds alternate (Figs. 5c, 5d, 6). The sandstone is gradually replaced by red clay further westward.

Besides these major sand-bodies, the red clays make a considerable portion of the formation. Above SB2 a thick clay horizon consists of interbeds of 3 to 20cm thick sandstone beds in the lower portion (Figs. 5c & 5d). At 74m level from the base 19m thick clay unit consists one 40cm thick calcareous clay zone (semicaliche) in its middle portion. The topmost 7m of the formation consist of two fining upward units. The upper unit grades from sandstone up into siltstone and then into red clay.

INTERPRETATION

The lithofacies in the Murree Formation as described above are similar to those which has been previously observed in many fluviatile deposits (e.g. Stewart, 1981; Walker and Cantt, 1984; Miall, 1985). The lithofacies association, cyclic sedimentation, fining upward cycles and coarse to fine sediments ratio combinely suggest that the sediments of the Murree Formation were deposited by meandering streams (cf. Friend 1978).

Paleochannel analysis of the Murree Formation suggests it generally to be the result of mixed-load channel setting (cf. Galloway, 1985). Nevertheless, in lower half of the formation the tendency is towards bed-load channel and in the upper half towards suspended-load channel.

Base of SB1 makes the initiation of a new river course in previously flood plain area

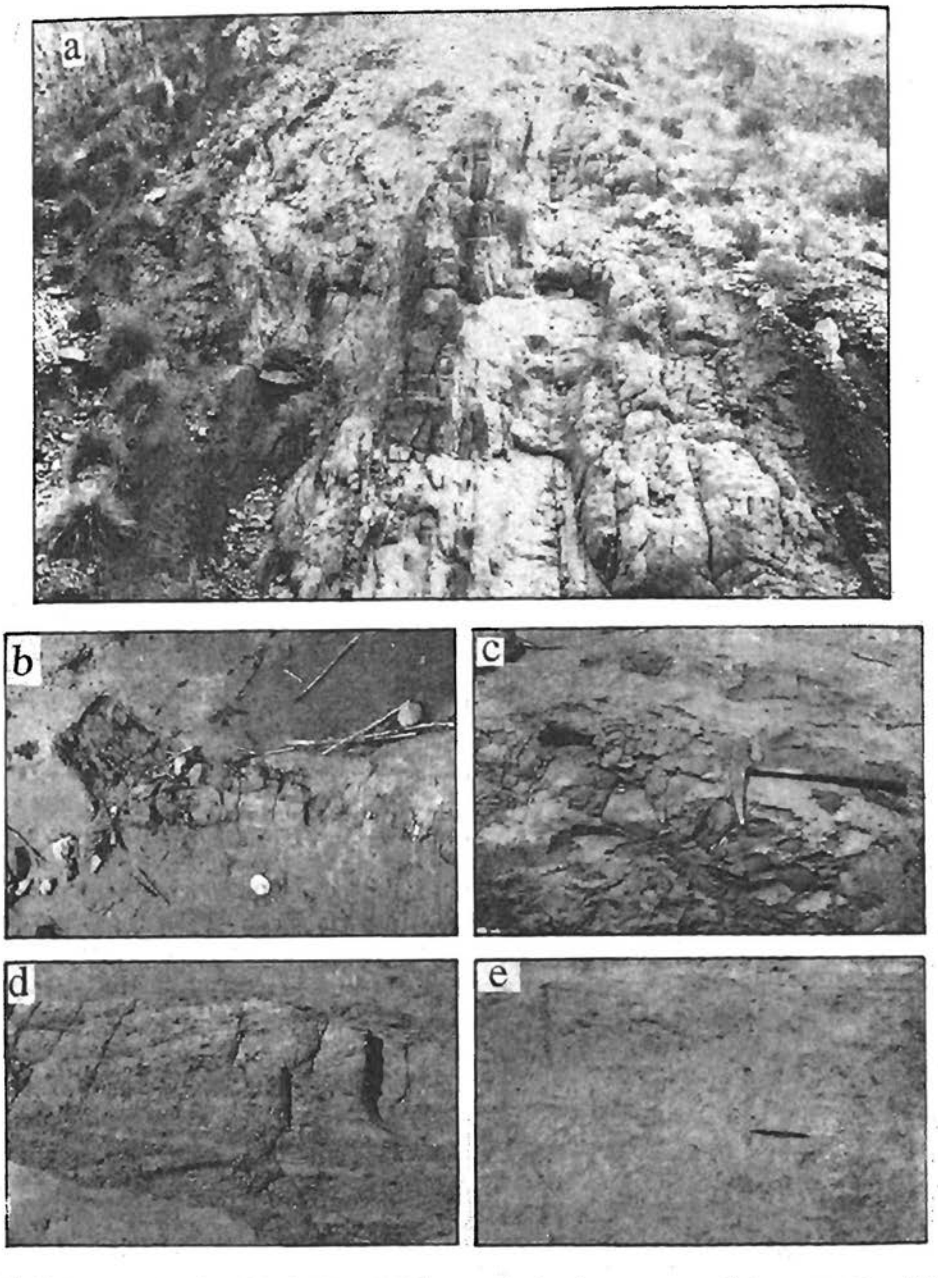

Fig. 3. Field photographs of sand-body SB1. (a) Photograph showing complete thickness 21-22m of SB1. Top is towards right. Note the scoured base and other features, particularly dark colour conglomerate beds in lower half of the sand-body. (b) A part of the lateral extension of conglomerate beds showing angular silt/clay clasts up to 30cm in diameter. Pencil is 14cm long. (c) Red silt/clay clasts at base of a sandstone bed. Hammer is 33cm long. (d) Pebbly and conglomeratic bed with red silt/clay clasts. Upper part shows cross-bedding. (e) Calcareous siltstone (caliche) ball 20cm in diameter embedded within a sandstone bed. Note also bioturbation in the bed.

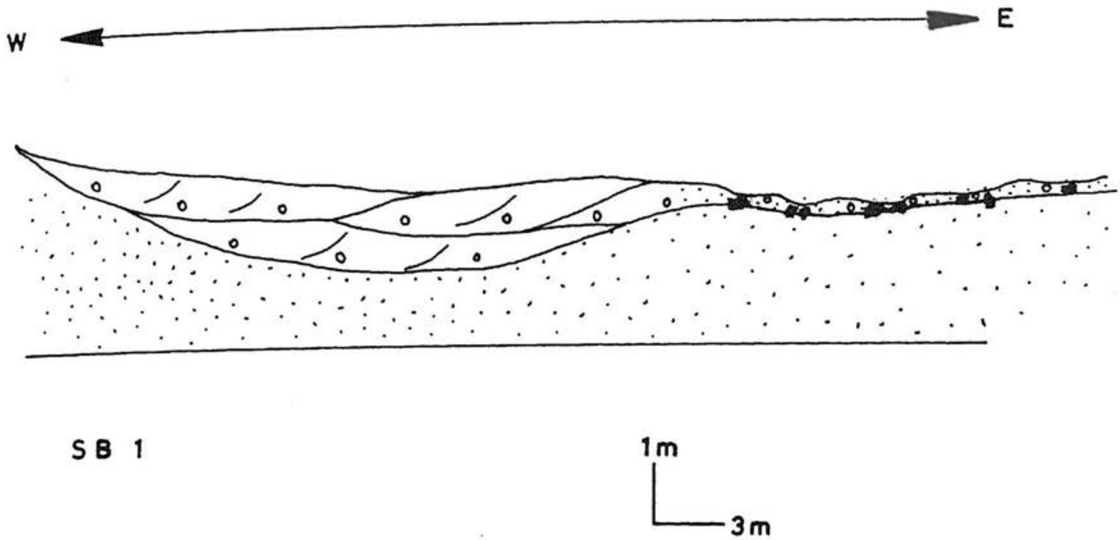

Fig. 4. Sketch of the mature conglomerate horizon in SB1 showing more clearly its lateral tapering.

and, therefore, a major shift in the river channel. Initially as suggested by the small lateral extent of the basal sandstone beds the river was mostly restricted to a narrow channel with slight lateral shifts from time to time. However, upwards within the sand-body the channel became more wide as attested by more lateral persistence of the beds. This is further supported by the presence of silt and clay clasts at base of beds which were derived either by bank collapse, erosion of the outer bank margin, abandoned channel or flood plain deposits. This simply indicates more freedom in water flow (Arche, 1983; Collinson, 1986).

The mature 1m conglomerate horizon was developed during more than normal flood conditions which eroded sediments from the flood plain area and incorporated them as a stream load. There was either a shift in a channel direction which eroded parts of the previously deposited channel sand or alternatively another channel was entering obliquely into the main channel which deposited these conglomerates. The possibility of a chute channel cannot be ignored in which flow was channelized and one flank of the channel was well preserved. The chute bar deposits typically develop at top of the point bar deposits (Galloway, 1985).

Overlying sandstones with horizontal lamination were deposited in shallow and broad channels in which upper flow regime conditions prevailed. Uppermost part of SB1 consists of massive looking sandstone beds in which the original structures might have got destroyed by bioturbation or were never developed due to rapid sediment dumping from high energy flows (Fielding, 1986) at top of a point bar. Caliche bed at top of this sand-body suggests the long areal exposure, therefore, abandonment of the channel and major shift in stream course and termination of SB1 deposition.

Limited exposure of SB2 shows great lateral variations in thickness, internal sedimentary structures and lithology. At the eastern extremity, where the sand-body is 4m thick, the basal 1m sandstone, with siltstone and red clay rounded clasts at base as channel lag, was deposited in the main channel. The middle 2m sand with horizontal lamination, and which sharply overlies the underlying channelized sand (Fig. 5a), was either deposited in a shallow channel or it may represent part of a point bar. The horizontal lamination results where the water depth is shallow and velocity is comparatively high and upper flow regime conditions prevail (Stewart, 1981; Allen, 1984). Topmost 1m with megarippled cross-lamination is interpreted as middle to upper part of a point bar.

About 10m westward the sand-body de-

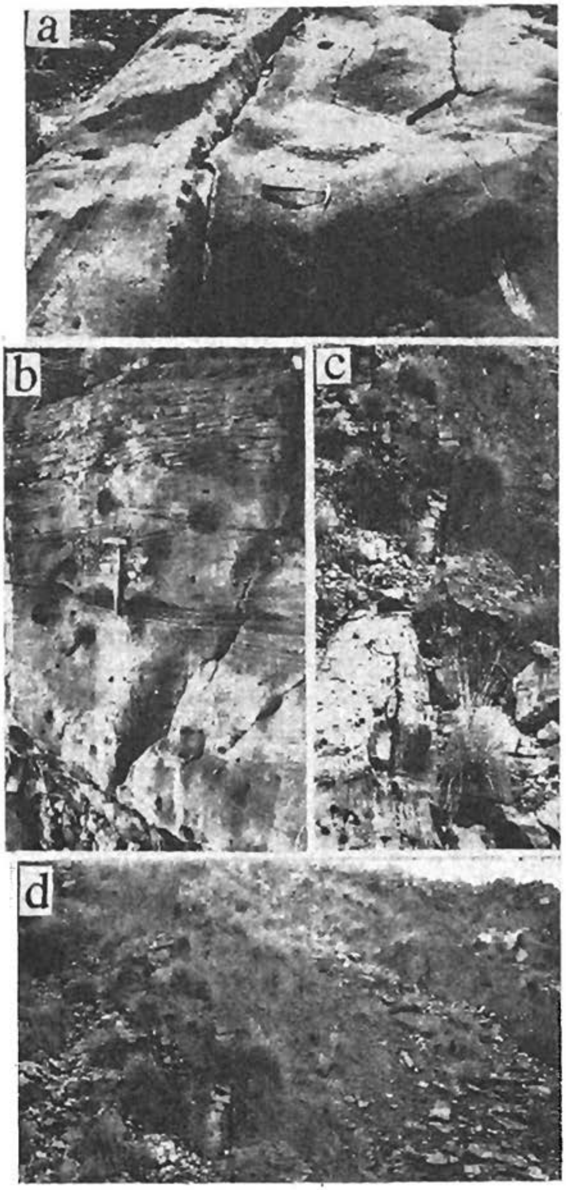

Fig. 5. Sand-body SB2. (a) Eastern part of SB1 with lower bed showing low angle lamination and cross-lamination. The middle part with hammer shows horizontal lamination. Hammer is 33cm long. (b) Laterally middle zone of the sand - body. Base of the basal bed consists of silt/clay clasts and the overlying sand beds consist of cross-laminations, mainly of megaripples, and the top consists of small scale ripple lamination. (c) West of (b), the sand-body thins out and changes to interbedded sandstone and red clay facies. (d) Further west of (c) showing more clearly interbedded sandstone and red clay facies.

creases in thickness to 2m. The basal channelized bed, which consists of flood plain reworked sediments as lag at base, pinches out laterally and was deposited in the main channel. Overlying sand beds with megaripple cross-bedding overlain at top by small scale climbing ripple cross-lamination were formed in the middle and upper part of a point bar. A short distance further westward the sand-body fizzles out as a coherent unit and instead is represented by interbedded sandstone and shale beds. This facies represents deposits of either one or combination of the three mechanisms; first in the small side channel on the other side of the bar, second crevasse-flood plain sediments and third levee deposits (Plint, 1983).

From the above discussion it could be concluded that the sand-body SB2 shows gradation from main channel in the east to the bar and small side channel or crevasse and levee to flood plain sedimentation in the west. Therefore, it is suggested that the main channel existed eastward and as a result this sand-body might become more thick further east due to superimposition of channel sands.

Upper 7m of the sequence displays two fining-upward cycles. Fine grain size and apparent massiveness of these beds does not qualify them as classical channel sands but may in fact be either leftovers of point bars or the crevasse splays or levee deposits within the flood plains developed by sheet like flood flows. Although any one of these processes may be involved but gradational grain size change in these cycles is more supportive of crevasse splay mechanism.

FLOOD PLAIN FACIES

The red clays in fluviatile environments are traditionally interpreted as flood plain deposits (Reineck & Singh, 1980). During flood conditions in rivers the existing channel may not be able to hold the flow of water resulting in the overflow out of the channel. As flood subsides, the competency of water in the flood plain area decreases leading to complete stoppage in flow. This results in deposition of fine-grained sediments such as siltstones and clays. The clay deposition occurs out of suspension in standing water. Thick clay units suggest that the river must

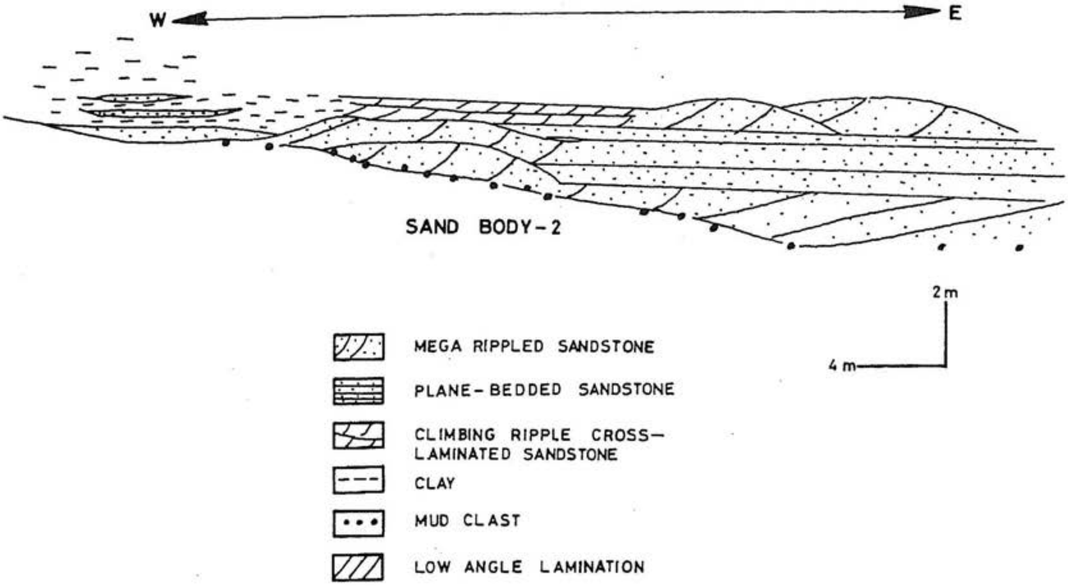

Fig. 6. Field sketch of sand-body SB2.

have stabilized in one position on the flood plains for longer times or that the river was more prone to flooding due to its maturity (Moody-Staurt, 1966; Harms et al., 1975).

COMPARISON WITH EXPOSURES IN OTHER AREAS

The Murree Formation in northern Kohat and Potwar is more thick than in southern Kohat at Pathan Algad. For instance at Dhok Maiki, the stratotype (Figs. 1 & 7), it is more than 500m thick and in northeastern Kohat at Ghorzai (Figs. 1 & 7) it is 270-300m thick. At stratotype the basal unit consists of conglomerate and sandstone and is 62m thick. Here sand to clay ratio in lower levels is approximately 85:15 and changes roughly to 10:90 in upper levels of the formation (Fig. 7). At Pathan Algad sand to clay ratio does not change so drastically but does change from 40:50 in lower levels to roughly 30:70 in upper levels (Figs. 2 & 7). At both these exposures, prominent sand units lie in lower half of the formation while at Ghorzai in northeastern Kohat the sandstone and clay units are similar at all levels of the formation and sand to clay ratio is almost the same (~45:55; Fig. 7).

As stated earlier major sand-bodies lie towards the base in both at stratotype and at Pathan Algad . The same river could not have flowed at the same time in two widely apart east-west parallel locations specially when flow was generally from north to south. This suggests that either there was a considerable time gap between strata of the Murree Formation at these localities or alternatively they were deposited by different streams or some combination of both. The basal strata at stratotype which appears to represent the initial river path could, therefore, be older than the basal part of the exposure at Pathan Algad.

Initially during deposition of the basal thick sand-body at stratotype, the absence of intervening shale suggests that either subsidence rate was low or fine material was not available from the source. During deposition of the upper half of the formation, however, the subsidence rate was invariably high as is suggested by the thickness as well as abundance of fine-grained material in upper levels.

The Pathan Algad area on the other hand possibly was on the margin of the Murree river system and therefore, river flowed here occasionally only relatively for a shortwhile and avulsed again towards east. Ghorzai area

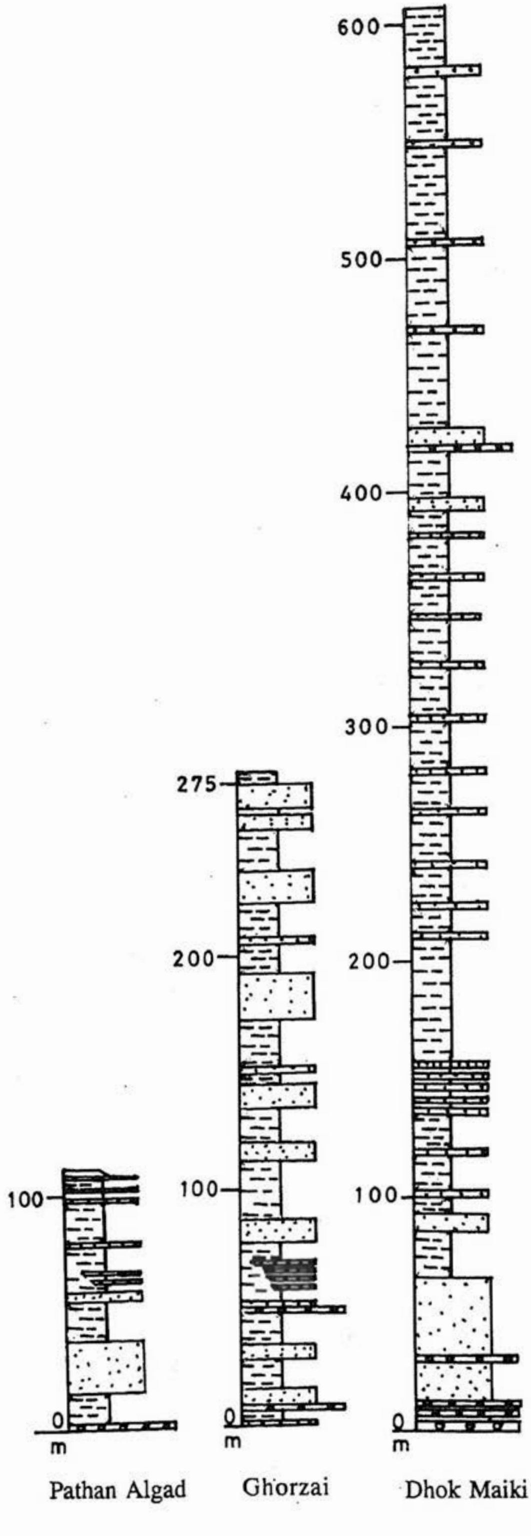

Fig. 7. Lithologic columns of the Murree Formation at three different localities.

experienced repeated river passage and was repeatedly acting as flood plain area of the Murree river, consequently, developing cyclic sand-clay units.

SUMMARY

The sediments of the Murree Formation represents the initiation of the molasse sediments in northern Pakistan as a result of collision between the Eurasian and Indian plates. The exposures of the Murree Formation at Pathan Algad are the known southernmost relatively thick exposures which thins-out further south and at Banda Daud Shah is only 9m thick (Shah, 1977). The sedimentological analysis reveals that the Murree Formation was deposited under the fluvial environments mainly by the meandering streams. The formation consists of two noticeable sand-bodies; sand-body SB1 which is in the lower part of the formation and is 21m thick, and sand-body SB2 which is in the middle part of the formation and is 2-4m thick. Generally the sandstones are sharply and erosively based and the interchannel migration kept going-on which resulted in superimposition of channelized beds. After the channel migrated away laterally, thick deposits of overbank fines were deposited in the form of red clays. The formation ,therefore, consists of channel floor lag, in-channel bar (by lateral accretion processes) and flood plain deposits (by vertical accretion processes). As compared with the total thickness as well as thickness and frequency of sand-bodies at Ghorzai and at Dhok Maiki, the stratotype, it is concluded that the Pathan Algad area was on the margin of the Murree Basin. Poor caliche development suggests that the climate was possibly not too dry during the deposition of these sediments.

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