LOWER TRIASSIC ARGILLACEOUS SEQUENCE OF PAHLGAM (KASHMIR HIMALAYA) AND PALAEOECOLOGICAL OBSERVATIONS

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(*Received 2 September 1975; after revision 7 April 1976*)

The Lower Triassic argillaceous sequence of Pahlgam (Kashmir Himalaya) area is described for the first time. This sequence is enriched with disaccate pollen and consists of microplankton (acritarchs, tasmanitids) in fair distribution. The stratigraphic distribution of these organic-walled microfossil groups in the Lower Triassic horizons is included and it is concluded that this is environmentally influenced. The occurrence of miospore in combination with microplankton (phytoplankton) and nature of associated mineral matter provide information regarding palaeoenvironmental conditions of the sediments.

INTRODUCTION

This paper deals with the Lower Triassic argillaceous sequence of Pahlgam (Kashmir Himalaya) area. The palaeoecological observations are inferred on the basis of organic-walled microfossils. Literature survey indicates that the argillaceous sequence has not been described since the pioneering work of Bion (1914). In addition, the palaeoecological study of the sequence has not previously been made, although a brief reference to it was made by one of the authors (Nautiyal 1975*b*).

The sequence of Pahlgam studied (Table I) is confined between the coordinates 34° 1′ 18″N and 34° 1′ 30″ N (Lat.) and 75° 18′ 36″ E and 75° 18′ 42″ E (Long.). A section about 60 metres thick, consisting mainly of Lower Triassic shales (light to dark gray and black) with discontinuous limestone layers and siltstone bands, was sampled throughout at about 6 metres interval, constituting the ten horizons P1 to P10 (in ascending order).

The monotonous argillaceous sequence of Pahlgam is marine and contains sporadic distribution of ammonoids and lamellibranchs. Sometimes the megafossils are not revealed in the outcrop sections and thus palaeoecological and biostratigraphic investigations get hampered. The rocks, however, yield organic-walled microfossils (disaccate pollen, acritarchs and tasmanitids) in fair quantitative composition (Nautiyal 1975*a, b, c*) and are useful to provide biostratigraphic and palaeoecological information.

Organic-walled microfossils occur in most marine and several terrestrial sediments. Their walls are commonly composed of compounds of oxygen, hydrogen, nitrogen and carbon. The microfossil groups considered in this paper incorporate acritarchs (problematical micro-organisms), tasmanitids (a unicellular group of *Prasinophyceae*), and disaccate pollen (belonging to infraturma: Disacciatrileti). The association of these microfossil groups helps to elucidate some palaeoenvironmental conditions of these sediments.

Previous Work

Published reports on the geology and fossil occurrences from the Lower Triassic sediments of Kashmir are scarce (Bion 1914). In addition, the palaeoecological study on these sediments has not been attempted so far. Therefore, a summarized account of data from other parts of Kashmir, as incorporated below, may provide subsidiary information regarding the palaeoenvironmental condition for the sequences close to the area of study.

The marine, shallow water cephalopods, lamellibranchs, brachiopods, gastropods and conodonts have been reported from different parts of Kashmir mainly by Middlemiss (1909), Diener (1913), Krishnan (1968), Nakazawa *et al.* (1970) and Sweet (1970).

In general, the Lower Triassic sequence of Kashmir (over 92 metres thick) contains the following fossiliferous succession, in ascending order (Wadia 1975); *Otoceras* beds, *Ophiceras* limestones, *Meekoceras* limestones and shales, and *Hungarites* shales. In the Sind Valley, the basal *Otoceras* zone with some *Productus* is overlain by the shaly *Hungarites* zone. The best Lower Triassic sections occur at Pastanah and at Lam (Vihi district) and contain ammonoids: *Xenodiscus, Otoceras, Ophiceras* (*O. sakuntala*), *Flemingites, Vishnuites, Hungarites, Meekoceras, Sibirites,* and *Kashmirites;* other cephalopods, *Orthoceras, Gryphoceras;* and lamellibranch, *Pseudomonotis.*

At the Guryul Ravine (Kashmir) section, a large number of invertebrate fossils have been observed in the Lower Triassic sequence (Nakazawa *et al.* 1970). The rocks consist predominantly of the bellerophonid gastropods, lamellibranch, *Claraia,* and ammonoids: *Otoceras, Ophiceras, Glyptophiceras, Metophiceras, Proptychites* and *Lytophiceras,* and conodonts, *Neogondolella nevadensis* and *Neospathodus cristagalli.* Sweet (1970) on the basis of conodont assemblages has shown the similarity between the Lower Triassic sections of the Salt Range and Guryul Ravine.

The Lower Triassic faunal occurrences of Kashmir are commonly compared with those from the adjoining region, Salt Range in Pakistan, which are summarized below.

The marine, shallow water Lower Triassic sediments of Salt Range constitute the Ceratite Beds due to the dominance of *Ceratite* (Krishnan 1968). In general, they contain the ammonoids: *Gyronites fallax, Flemingites radiatus, F. flemingianus, Stephanites superbus, Sibirites chidruensis;* brachiopods, *Cardinia, Gervillia, Rhynchonella, Terebratula;* and gastropod, *Stachella.*

The Kathwai Member (of Lower Triassic Mianwali Formation) in Salt Range and Trans-Indus Ranges of Pakistan contain shallow water ammonoids, lamellibranchs, brachiopods (especially *Lingula*), conodontophorids, fishes, pollen grains, spores and planktonic acritarchs. The sequence is of an infratidal environment on the basis of sedimentological evidence (Kummel & Teichert 1970).

At generic level some forms from the Mianwali Formation are comparable to those from the Lower Triassic of Kashmir and include ammonoids: *Ophiceras, Glyptophiceras, Proptychites, Sibirites, Flemingites;* lamellibranch, *Pseudomonotis;* conodonts: *Neogondolella, Neospathodus;* disaccate pollen: *Sulcatisporites, Platysaccus,* *Klausipollenites;* and organic-walled microplankton, *Leiosphaeridia,* and *Tasmanites* (Kummel *et al.* 1970; and Sarjeant 1973).

LITHOLOGY AND PETROGRAPHY

The lithological characters of the Pahlgam sequence, incorporating P1 to P10 horizons, are furnished in Table I. In addition, the microfloral (microfaunal) contents and petrographic characters are included. The sequence is dominated by shales (light to dark gray, black) with subordinate discontinuous limestone layers and siltstone bands.

TABLE I

Lower Triassic argillaceous sequence (from top P10 to bottom P1) of Pahlgam and palaeoecological observations

P10 A	Siltstone with shale bands: light gray, fine grained, muscovite laths in shale bands and long quartz grains in siltstone indicate some preferred orientation; black carbonaceous matter in black shale bands; with disaccate pollen and acritarch, *Sulcatisporites sahnii, Platysaccus* cf. *P. papilionis,* and *Leiosphaeridia minuta.*
B	Fine grain size and preferred orientation of mineral grains indicate moderate current; concentration of black carbonaceous matter in shaly bands indicates partly reducing conditions.
C	Moving water.
P9 A	Shale, light gray, very fine grained and finely laminated, rich in fine muscovite laths of preferred orientation, some black carbonaceous matter; with disaccate pollen and acritarchs, *Klausipollenites* cf. *K. decipiens, Platysaccus* cf. *P. papilionis,* and *Leiosphaeridia* sp. A.
B	Very fine grains indicate slow current; smooth laminae suggest lack of bottom disturbance; preferred orientation of mica laths, argillaceous partings and carbonaceous matter indicate slow current.
C	Slightly moving water with partly reducing environment.
P8 A	Shale, black, very fine grained, finely laminated, abundant black carbonaceous matter and fine grains of pyrite; with abundant disaccate pollen and rare acritarch, *Klausipollenites* cf. *K. decipiens, Platysaccus* cf. *P. papilionis,* and *Leiosphaeridia minuta.*
B	Very fine grain size and lack of preferred orientation of muscovite laths indicate slow current; smooth laminae suggest lack of bottom disturbance; abundant black carbonaceous matter and pyrite grains demonstrate rich and fast-decaying vegetation.
C	Quiet water with reducing environment at bottom.
P7 A	Shale, light olive gray, very fine grained and finely laminated; fine muscovite and biotite laths do not show preferred orientation; abundant disaccate pollen and some acritarchs, *Sulcatisporites sahnii, Klausipollenites* cf. *K. decipiens, Platysaccus* cf. *P. papilionis, Leiosphaeridia minuta,* and *Leiosphaeridia* cf. *L. wenlockia.*

(Contd.)

TABLE I (*Contd.*)

B	Very fine grain size shows slow current, smooth laminae and absence of preferred orientation of mica laths suggest lack of bottom disturbance.
C	Tending to quiet water.
P6 A	Shale, dark gray, very fine grained, finely laminated; muscovite laths and fine grains of quartz lack preferred orientation; abundant black carbonaceous matter; flooded with disaccate pollen and common occurrence of microplankton, *Sulcatisporites sahnii, Klausipollenites* cf. *K. decipiens, Platysaccus* cf. *P. 'papilionis, Leiosphaeridia minuta,* and *Tasmanites* sp. A.
B	Very fine grain size and lack of preferred orientation of mineral grains indicate slow current; fine smooth laminae suggest lack of bottom disturbance; abundant black carbonaceous matter indicates introduction of reducing conditions.
C	Tending to quiet water.
P5 A	Limestone (with interbeds of medium gray shales), medium gray, medium crystalline, rich in black carbonaceous matter, muscovite and calcite grains lack preferred orientation; rare with acritarchs, *Leiosphaeridia minuta.*
B	Microcrystalline aggregates of calcite with rich carbonaceous matter and devoid of calcareous fossils indicate introduction of reducing conditions unsuitable for habitat of organisms; mineral grains with lack of preferred orientation suggest slow current.
C	Slightly moving water with partly reducing environment.
P4 A	Shale, medium gray, very fine grained, black carbonaceous matter, muscovite laths lack preferred orientation; with common occurrence of disaccate pollen and microplanktons, *Klausipollenites* cf. *K. decipiens, Leiosphaeridia minuta, Leiosphaeridia* cf. *L. wenlockia,* and *Leiosphaeridia* sp. B.
B	Very fine grain size and lack of preferred orientation of mineral grains indicate slow current.
C	Slightly moving water.
P3 A	Shale, light gray, very fine grained, calcareous, fine laminae obliterated due to impregnation of rich calcitic matter; black carbonaceous matter sporadically distributed; calcite and muscovite laths lack preferred orientation; common occurrence of disaccate pollen and acritarchs, *Klausipollenites* cf. *K. decipiens, Leiosphaeridia minuta,* and *Leiosphaeridia* cf. *L. wenlockia.*
B, C	Same condition as in P4, B, C.
P2 A	Shale, medium gray, very fine grained, muscovite laths show preferred orientation.
B	Very fine grain size and preferred orientation of mica laths indicate water current.
C	Moving water.

(*Contd.*)

TABLE I (*Contd*).

P1	A	Shale with siltstone, medium gray, very fine to fine grained, black carbonaceous matter in shales; muscovite laths in shales show preferred orientation; siltstone (with fine grains of quartz) bands and lenticles occur oriented along the bedding planes; abundant dis: accate pollen and common occurrence of acritarchs, *Sulcatisporites sahnii, Klausipollenites* cf. *K. decipiens, Leiosphaeridia minuta,* and *Leiosphaeridia* cf. *L. wenlockia.*
	B	Fine grains size with preferred orientation of muscovite laths and siltstone lenticles along the bedding planes indicate water current.
	C	Moving water.

P10—P1, refer to Unit Horizon number.
A, Rock Evidence, Microflora (Microfauna).
B, Postulates.
C, Deduced palaeoenvironments.

There are certain features in the gray and black shales of the sequence that appear distinct only after careful megascopic and petrographic examinations (Table I, Plate I). These are the thin argillaceous and black carbonaceous laminae containing various mineral species and organic structures oriented (or unoriented) along the current direction, depending upon the type of deposit (Table I).

The shale laminae appear distinct from the siltstone and limestone layers due to varying amount of black organic matter, mineral contents and colour pattern. Petrographically, they show both preferred and nonpreferred orientation of fine mica laths (Plate 1a–f) in the argillaceous and black aphanitic organic matter. The organic matter and brown argillaceous partings are seldom aggregated together to form fine laminae (Plate 1c) and, in combination with fine mica laths, appear distinctly.

In general, the argillaceous and organic laminae of shales suggest that deposition was probably slow, and the fine grained character of the sediment indicates that it was largely derived from suspension. Moreover, the incorporated microfloral (micro faunal) assemblages suggest that the sediments are the product of low-energy environmental condition. This is because pollen grains, microplankton (acritarchs and tasmanitids) and very fine grains of shales, all being very light, can never accumulate in areas of high turbulence.

PALAEOECOLOGICAL OBSERVATIONS

The disaccate floral assemblage in the Lower Triassic sediments of Pahlgam include three basic types: *Klausipollenites* cf. *K. decipiens, Platysaccus* cf. *P. papilionis,* and *Sulcatisporites sahnii* (Nautiyal 1975*c*). In addition, one dominant type of microplankton assemblage, leiospheres, can be distinguished in general. The assemblage shows a tendency towards uniformity of composition (without species diversification) by strong domination of leiospheres (*Sphaeromorphitae*: *Leiosphaeridia* spp., *Prasinophyceae*: *Tasmanites* sp.). The leiospheres include: *Leiosphaeridia minuta, Leiosphaeridia* cf. *L. wenlockia, Leiosphaeridia* spp. A, B, and *Tasmanites* sp. A (Nautiyal 1975*a*).

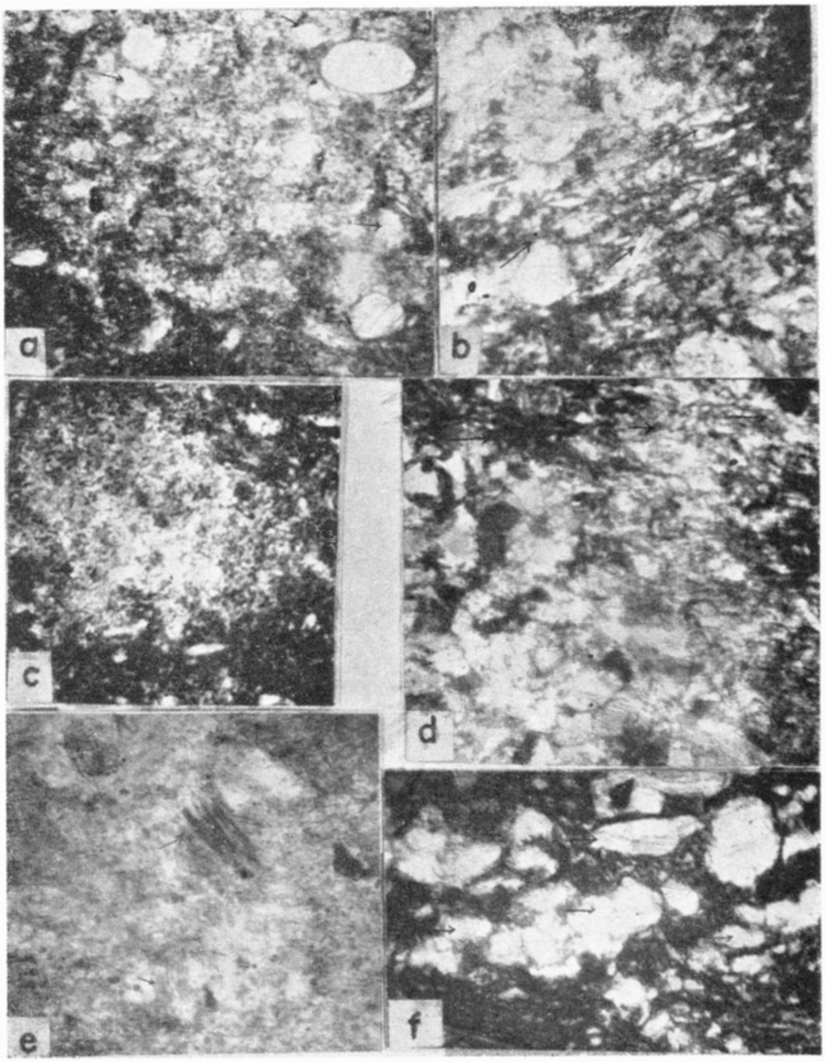

PLATE I. (a) Shale, P8, showing organic-rich black carbonaceous matter: fine grains of muscovite (see arrow) in argillaceous and carbonaceous matrix lack preferred orientation. (b) Shale, P9, showing laminae of black organic matter and brown argillaceous partings, these laminae with fine muscovite laths show preferred orientation (see arrow); some calcareous matter in the matrix. (c) Shale, P6, very fine grained, finely laminated, showing abundant black carbonaceous matter, muscovite laths and fine grains of quartz lack preferred orientation. (d) Siltstone with shale bands, P10, siltstone (lower part of section) showing subangular quartz grains and muscovite laths of indistinct preferred orientation; shale (upper part of section) black carbonaceous matter and muscovite laths in argillaceous matrix demonstrating preferred orientation (see arrow). (e) Shale, P7, showing fine muscovite and biotite laths (see arrow) and fine grains of calcite cemented in argillaceous matrix; the mineral grains do not show preferred orientation. (f) Shale with siltstone, P1, muscovite laths in shales (lower part of section), some muscovite laths and subangular grains of quartz (see arrow) in siltstone demonstrating preferred orientation; mineral grains cemented in brown argillaceous and black carbonaceous matrix.

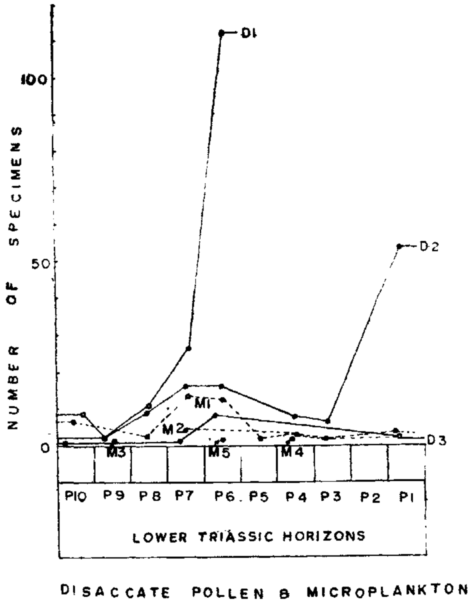

FIG. 1. Quantitative composition of disaccate pollen and organic-walled microplankton (acritarchs and tasmanitid) reported in the rocks representing Lower Triassic horizons (Pl–P10) of Pahlgam. D1, *Platysaccus* cf. *P. papilionis;* D2, *Klausipollenites* cf. *K. decipiens*; D3, *Sulcatisporites sahnii*; M1, *Leiosphaeridia minuta;* M2, *Leiosphaeridia* cf. *L. wenlockia*; M3, *Leiosphaeridia* sp. A; M4, *Leiosphaeridia* sp. B; M5, *Tasmanites* sp. A.

The rich terrestrial-derived disaccate pollen is due to close proximity of the basin, as well as to an almost homogeneous coastal vegetation. The proximity of land to the basin of deposition is also supported by the occurrence of an appreciable amount of sandy clastic material (fine sands and silt) in the dark argillaceous sequence. In contrast, the paucity of microplankton (phytoplankton), as compared to the accompanied rich disaccate pollen assemblage, is quite apparent (Fig. 1). Their reduction in diversity and quantitative composition may be connected with the unfavourable physical conditions existing in the basin of deposition. Indeed, the phytoplankton show a considerable decrease in the diversity during the late Permian on a world-wide scale. Their low diversity was continued through the Lower Triassic due to coincidence of adverse physical conditions with significant biologic changes (Tappan & Loeblich 1973).

It appears that the Pahlgam microflora (microfauna) was related to accumulation in a shoreward (or inshore), not apparently enclosed or partly restricted, basinal environment. Moreover, a part of the leiosphere population (phytoplankton) of reduced diversity was derived probably from algae inhabiting shoreward (or inshore) waters. Hulburt (1963) and Wall (1965) also suggest a possibility of reduction in species diversity of phytoplankton population in the shoreward environments as in the present day Atlantic Ocean waters and in the British Lias sediments respectively.

CONCLUSION

The Pahlgam Lower Triassic microflora comprises a quantitatively rich but poorly diversified assemblage of disaccate pollen belonging to three species. Five species of leiospheres are also represented in the assemblage. The stratigraphic distribution of both pollen and microplankton, in qualitative and quantitative compositions, is environmentally influenced.

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