Palaeobotanist 51(2002) : 99-106
0031-0174/2002/99-106 $2.00

Depositional environment of Bagra Formation (Upper Triassic), Satpura Basin, India : a palynological approach

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(Received 31 March 2000; revised version accepted 31 January 2002)

ABSTRACT

Kumar P 2002. Depositional environment of Bagra Formation (Upper Triassic), Satpura Basin, India : A palynological approach. Palaeobotanist 51 : 99-106.

Bagra Formation is the youngest lithounit of non-marine Mahadeva Group in Satpura Basin. The recorded palynological assemblage from Bagra Formation contains prominence of fungal and algal remains. Palynomorphs of Denwa Formation such as *Falcisporites, Satsangisaccites, Samaropollenites, Arcuatipollenites, Striatopodocarpites* including *Callialasporites, Cycadopites, Corollina* (=*Classopollis*) *simplex* and *Haradisporites* are also represented in the Bagra Assemblage. The palynological assemblage (as a mixed flora) suggests a lateral continuity of the Denwa Formation with younger Bagra Formation, and the difference could be facies variations. The recovered palynological assemblage suggests a Rhaetian age of Upper Triassic to the Bagra Formation. The palynological associations indicate that Bagra Formation was deposited in lacustrine set up near shore -line under cool-temperate climate with derivation of palynomorphs from heavy rain forest upland areas.

Key-words—Upper Triassic (Rhaetian), Palynomorphs, Depositional environment, Bagra Formation, Satpura Basin, India.

भारत की सतपुड़ा द्रोणी के बागड़ा शैलसमूह (उपरि ट्रायसिक) का निक्षेपणीय पर्यावरण : एक परागाणविक परिप्रेक्ष्य

प्रमोद कुमार

सारांश

बागड़ा शैलसमूह सतपुड़ा द्रोणी के असमुद्री महादेवा समूह की नवीनतम अश्म इकाई है। बागड़ा शैलसमूह से अंकित किए गए परागाणविक समुच्चय में कवकीय एवं शैवालीय अवशेषों की प्रचुरता है। इस समुच्चय में देनवा शैल समूह के परागाणुरूप, जैसे—*फ़ाल्सिस्पोराइटीज़, सत्संगीसैक्काइटीज़, समारोपोलेनाइटीज़, आर्क्युआटीपोलेनाइटीज़, स्ट्रायाटोपोडोकार्पाइटीज़* के साथ-साथ *कैलियालास्पोराइटीज़, साइकेडोपाइटीज़, कोरोलाइना (क्लासोपोलिस) सिम्प्लेक्स* तथा *हरादीस्पोराइटीज़* भी अभिनिर्धारित किए गए हैं। परागाणविक समुच्चय अपेक्षाकृत नवीन बागड़ा शैलसमूह के साथ (एक सम्मिश्र वनस्पतिजात के रूप में) एक पार्श्व सततता प्रस्तावित करता है तथा भिन्नता संलक्षणी वैविध्य के कारण हो सकती है। खोजा गया परागाणविक समुच्चय बागड़ा शैलसमूह हेतु उपरिट्रायसिक कल्प के अन्तर्गत रीटियन आयु प्रस्तावित करता है। परागाणविक समुच्चय संकेत करते हैं कि बागड़ा शैलसमूह प्रचुर वृष्टि वाले उपरिभूमि वन क्षेत्रों से प्राप्त परागाणुरूपों के साथ-शीत-शीतोष्ण जलवायु के अन्तर्गत तटीय रेखा के समीप सरोवरी स्थितियों में निक्षेपित था।

संकेत शब्द—उपरि ट्रायसिक (रीटियन), परागाणुरूप, निक्षेपणीय पर्यावरण, बागड़ा शैलसमूह, सतपुड़ा द्रोणी, भारत.

INTRODUCTION

MEDLICOTT (1873) studied the geology of Mahadeva Group in Satpura Basin, and subdivided it into three lithounits in ascending order: Pachmarhi sandstones, Denwa clays and Bagra conglomerates. Crookshank (1936) also studied the geology of Satpura Basin in detail, and described the Bagra rocks as coarse conglomerates which were deposited along the northern border of the Satpura Basin, and considered them to be contemporaneous with the Denwa beds. Singh and Ghosh (in Sastry *et al.*, 1977) observed the extentions of conglomerate beds further southward, where they become gradually fine grained and ultimately pass into sandstones and clays of the Denwas. Casshyap (1999) stipulated (?) a Late Jurassic age for Bagra Formation based on the paleocurrent studies, i.e., during underlying Denwa Formation shows a reversal of direction of sediments transported from north-northeast to south-southwest during Bagra sedimentation.

Crookshank (1936) recorded two imperfect casts of some gastropod shells from Bagra sediments in a *nala* north of Budhimai, being slitghly younger than the Denwas. It was suggested to be of Late Triassic age and unconformably overlain by the Jabalpur Formation. Raja Rao (1983) considered that Bagra sediments succeeded unconformably Denwa beds and a possible Rhaetic age was suggested. Crookshank (1936), Singh and Ghosh (in Sastry *et al.*, 1977), Krishnan (1982) opined that when followed southwards, the Bagras passes laterally into the Denwas, and considered the formation to be a shoreline deposit of Rhaetic age, partly equivalent to and partly younger than the underlying Denwas.

The palynomorphs and other remains have been recovered from the matrix of Bagra conglomerates (sample-1) exposed in the Jamani *Nala* (Figs 1, 2) near Khatama Caves

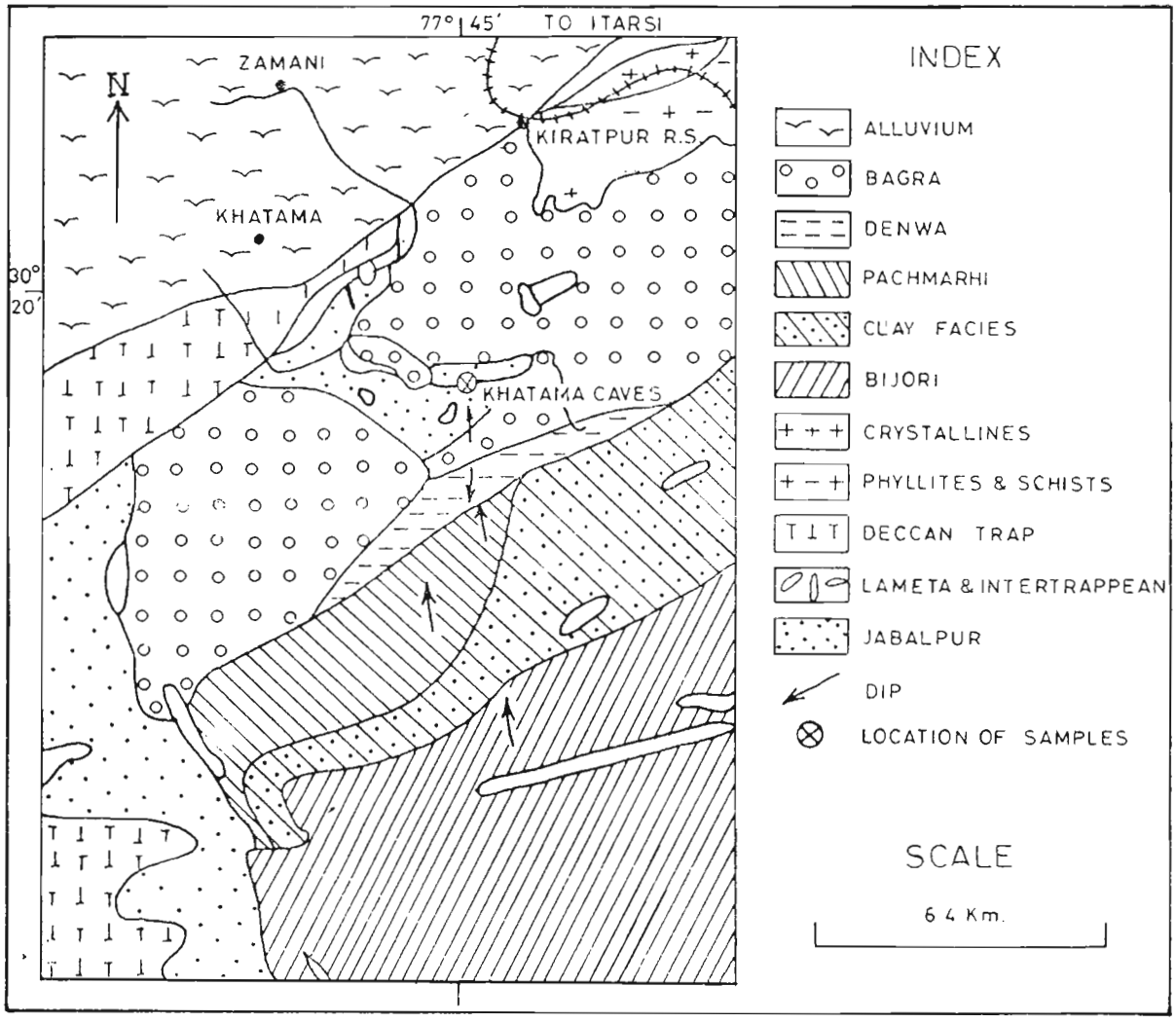

Fig. 1—Geological map of the study area (after Crookshank, 1936).

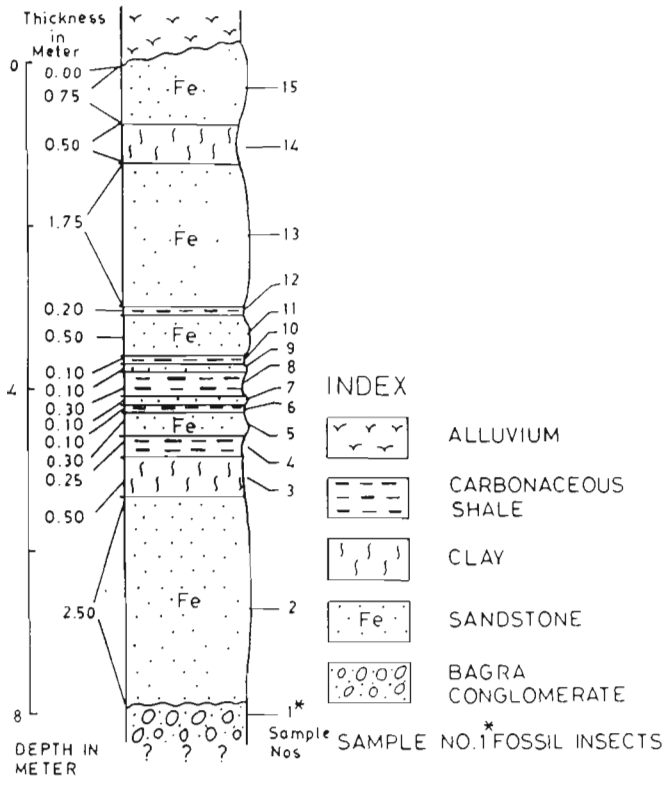

Fig. 2 — Lithostratigraphic succession of the Bagra Formation exposed in Zamani Nala near Khatama caves, Hoshangabad district, M.P., showing stratigraphic positions of studied sample.

(30°10' : 77°45'), Hoshangabad District, Madhya Pradesh. The Bagra conglomerates consist of different kinds of rounded boulders derived from local and distant sources including metamorphic rocks (local), quartzites, banded jaspers, jasperoid conglomerate, etc., loosely cemented by argillaceous matrix (yellowish to reddish sandy clay). The generalised stratigraphic sequence in Satpura Basin as given by Raja Rao (1983) is followed here.

PALYNOLOGY OF BAGRA FORMATION

The palynomorphs (pollen-spores, fungal spores, fungal fruiting bodies, vesicular-arbuscular mycorrhizae (VAM fungi) or algal germinating spores, algal spores, acritarchs, chitinozoa, etc.) have been recovered for the first time from the matrix of the Bagra conglomerates. Kumar and Kumar (1999) recorded mallophagan insect remains from Upper Triassic sediments (Bagra and Denwa Formations) of Satpura Basin. Recently an anopluran insect has also been identified from the same Bagra conglomerates (Kumar & Kumar, 2001).

Palynomorphs

TRILETE SPORES

Haradisporites mineri Singh & Kumar 1972
Biretisporites sp. (Pl. 1.1, size 60 μm)
MONOSUBSACCATE POLLEN
Callialasporites trilobatus (Dev) Bharadwaj & Kumar 1972
MONOSACCATE POLLEN
Scheuringipollenites triassicus (Bharadwaj & Srivastava) Tiwari 1973b
DISACCATE (nontaeniate) POLLEN
Falcisporites nidpurensis (Bharadwaj & Srivastava) Kumaran & Maheshwari 1980
Satsangisaccites triassicus Bharadwaj & Srivastava 1969
Samaropollenites speciosus Goubin 1965
DISACCATE (taeniate) POLLEN
Arcuatipollenites ovatus (Goubin) Tiwari & Vijaya 1995
Guttulapollenites hannonicus Goubin 1965
DISACCATE (striated) POLLEN
Striatopodocarpites dubrajpurensis Tripathi *et al.*, 1990
MONOCOLPATE POLLEN
Cycadopites follicularis Wilson & Webster 1946
OPERCULATE POLLEN
Corollina cf. *simplex* (Maljawkina) Venkatachala & Goczan 1964
Fungal spores: *Brachysporisporites* sp., *Diporicellaesporites* sp.
Fungal hyphae (VAM fungi)
Fungal fruiting bodies: *Phragmothyrites* spp.
Algal spores: *Lecaniella* sp., *Schizosporis* sp., *Oedogonium* sp.
Chitinozoan like-vesicles
Mallophagan (Kumar & Kumar, 1999) and Anopluran insects (Kumar & Kumar, 2001).

Percentage frequencies of palynomorphs in the Bagra Formation, is given below.

Genera		Frequency in %
Haradisporites	-	01·00
Biretisporites	-	01·00
Cycadopites	-	02·00
Corollina	-	02·00
Callialasporites	-	02·00
Scheuringipollenites	-	03·00
Falcisporites	-	03·00
Satsangisaccites	-	03·00
Samaropollenites	-	02·00
Arcuatipollenites	-	01·00
Guttulapollenites	-	01·00
Striatopodocarpites	-	03·00
Fungal Spores (Vam)	-	10·00
Fungal Hyphae	-	05·00
Fruiting Bodies	-	10·00
Algal Germinating Spores	-	32·00
Algal Spores	-	05·00
Chitinozoa	-	02·00
Insect Remains	-	02·00
Unidentified	-	10·00

COMPARISON

The palynological assemblage recovered from the cementing matrix of the Bagra conglomerate contains poor

representation of pteridophytic/pteridospermic and gymnospermic spores-pollen. It is characterised by the prominence of vesicular arbuscular mycorrhizae (VAM Fungi)/ germinating algal spores, fungal spores, microthyriaceous fungi (fruiting bodies) and algal spores.

The palynological assemblage comprises 12 spore pollen genera and species, of which striated disaccates are present in negligible amount. Three non taeniate disaccates (*Falcisporites, Satsangisaccites* and *Samaropollenites*) are also represented. Two trilete spores, one monocolpate pollen, two taeniate pollen genera and one operculate pollen are also recorded. It is comparable to the Late Triassic Denwa (clays) palynological assemblage of the Satpura Basin (Kumar, 2000) in containing *Falcisporites, Satsangisaccites, Samaropollenites* and *Haradisporites*. However, differs from the latter in the absence of *Brachysaccus, Minutosaccus, Ashmoripollis, Krempipollenites, Staurosaccites* and *Aratrisporites*. The Denwa palynological assemblage has poor representation of fungal/algal remains, whereas these become important (±80%) in the Bagra palynological assemblage. Though both formations possess *Callialasporites, Cycadopites, Haradisporites* and *Corollina* (=*Classopollis*). The presence of *Falcisporites, Satsangisaccites, Samaropollenites* and *Guttulapollenites* indicates a closer association with Denwa palynological assemblage. The similarity in fungal and algal remains in both the assemblages, further emphasises a closer affinity.

Nandi (1996) reported palynological assemblage I from carbonaceous shales at 100 m depth and II at 200 m depth (Late Triassic) in the Anhoni region, which possess the dominance of *Falcisporites* followed by *Satsangisaccites*. Other palynomorphs of the Denwa Assemblage which are absent in the Bagra palynological assemblage are *Brachysaccus, Minutosaccus, Aratrisporites, Staurosaccites,* etc. *Haradisporites, Callialasporites, Corollina*, VAM Fungi, Algal germinating spores, Fruiting bodies and algal spores are lacking in the palynological assemblages-I and -II of the Denwa Formation. Hence, it is younger than the palynological assemblages from Anhoni.

Palynological assemblages described from Nidpur and Gopad River, South Rewa Basin by Bharadwaj and Srivastava 1969 and Tiwari and Ram-Awatar 1990, 1992 were dated as Early to Middle Triassic on the basis of *Satsangisaccites, Nidipollenites* and *Weylandites*. Tiwari and Rana (1980) dated the Nidpur palynological assemblage of Bharadwaj and Srivastava (1969) as Late Triassic (Carnian) in view of the presence of *Praecolpatites, Alisporites* and *Klausipollenites*. The Bagra palynological assemblage is not comparable with the above palynological assemblages because *Weylandites, Praecolpatites* are absent. It is younger (Rhaetian ?) in having *Biretisporites, Haradisporites, Samaropollenites, Callialasporites trilobatus, Cycadopites* and *Corollina* (=*Classopollis*) which are absent in Nidpur palynological assemblages.

Maheshwari and Kumaran (1979) and Kumaran and Maheshwari (1980) studied palynomorphs from the Tiki Formation (Carnian-Norian) argillaceous shales exposed in the Son River and Janar *nala* sections in South Rewa Basin. Palynological assemblage from Tharipathar is dominated by *Samaropollenites* which is poorly known in the Bagra assemblage. The dominant element *Rimaesporites* of the Ghiar section is lacking in the studied assemblage. Hence, it is not comparable with palynological assemblages of South Rewa Basin.

Palynological assemblages A-F from Bore core RJR2, Kazigaon in Rajmahal Basin were described by Tiwari *et al.* (1984). The assemblage - A belonging to Dubrajpur Formation has dominance of *Satsangisaccites* and *Falcisporites* but they are poorly represented in Bagra Assemblage. The characteristic forms *Rajmahalispora, Nidipollenites, Lundbladispora, Playfordiaspora* and *Goubinispora* are absent in the Bagra Assemblage. The palynological assemblages B and C of Rajmahal Basin compare with Bagra Assemblage only in having *Satsangisaccites* and *Samaropollenites*, otherwise it has no comparison with Bagra Assemblage as the former contains *Infernopollenites, Lundbladispora* and *Playfordiaspora* which are absent in the present studied assemblage.

Prasad and Jain (1994) and Prasad (1997) recorded palynological assemblages of Early, Middle and Late Triassic age from the sub-surface Triassic sediments in deep bore cores at Kommugudem-A and Mandapeta - A, C and D wells in the Krishna-Godavari Basin. Prasad (1997) assigned *Rimaesporites*

PLATE 1

(All photomicrographs are x 500. Co-ordinate of specimens in slides referred to the stage of Labor Lux D Microscope no. 077055)

1. *Biretisporites* sp. Slide No. BSIP 12431 · 43·5 x 104.
2. *Callialasporites trilobatus* Slide No. BSIP 12431 · 25 x 104·5.
3. *Guttulapollenites hannonicus* Slide No. BSIP 12434: 20 x 94.
4. *Corollina* cf. *simplex* Slide No. BSIP 12429: 27 x 95·5.
5. *Cycadopites follicularis* Slide No. BSIP 12433 . 45 x 102.
6. *Phragmothyrites* sp. Slide No. BSIP 12431 : 28 x 108·5.
7. *Phragmothyrites* sp. Slide No. BSIP 12429 : 18 x 107·5.
8. *Corollina* cf. *simplex* Slide No. BSIP 12428: 20 x 102.
9. *Brachysporisporites* sp. Slide No. BSIP 12428 :20.5 x 110·2.
10. *Diporicellaesporites* sp. Slide No. BSIP 12429: 45 x 104.
11. Chitinozoan-vesicle Slide No. BSIP 12432 : 30·5 x 104.
12. *Phragmothyrites* sp. Slide No. BSIP 12429: 26 x 110·5.
13. *Lecaniella* sp. Slide No. BSIP 12431 · 19 x 103.
14. *Schizosporis* sp. Slide No. BSIP 12429 : 16·0 x 95·0.
15. *Lecaniella* sp. (germinating stage) Slide No. BSIP 12350: 23 x 107·5.
16. Vesicular-Arbuscular Mycorrhizae Slide No. BSIP 12428 · 30 x 97·5.
17. *Oedogonium* sp. Slide No. BSIP 12430 : 30 x 102·5.

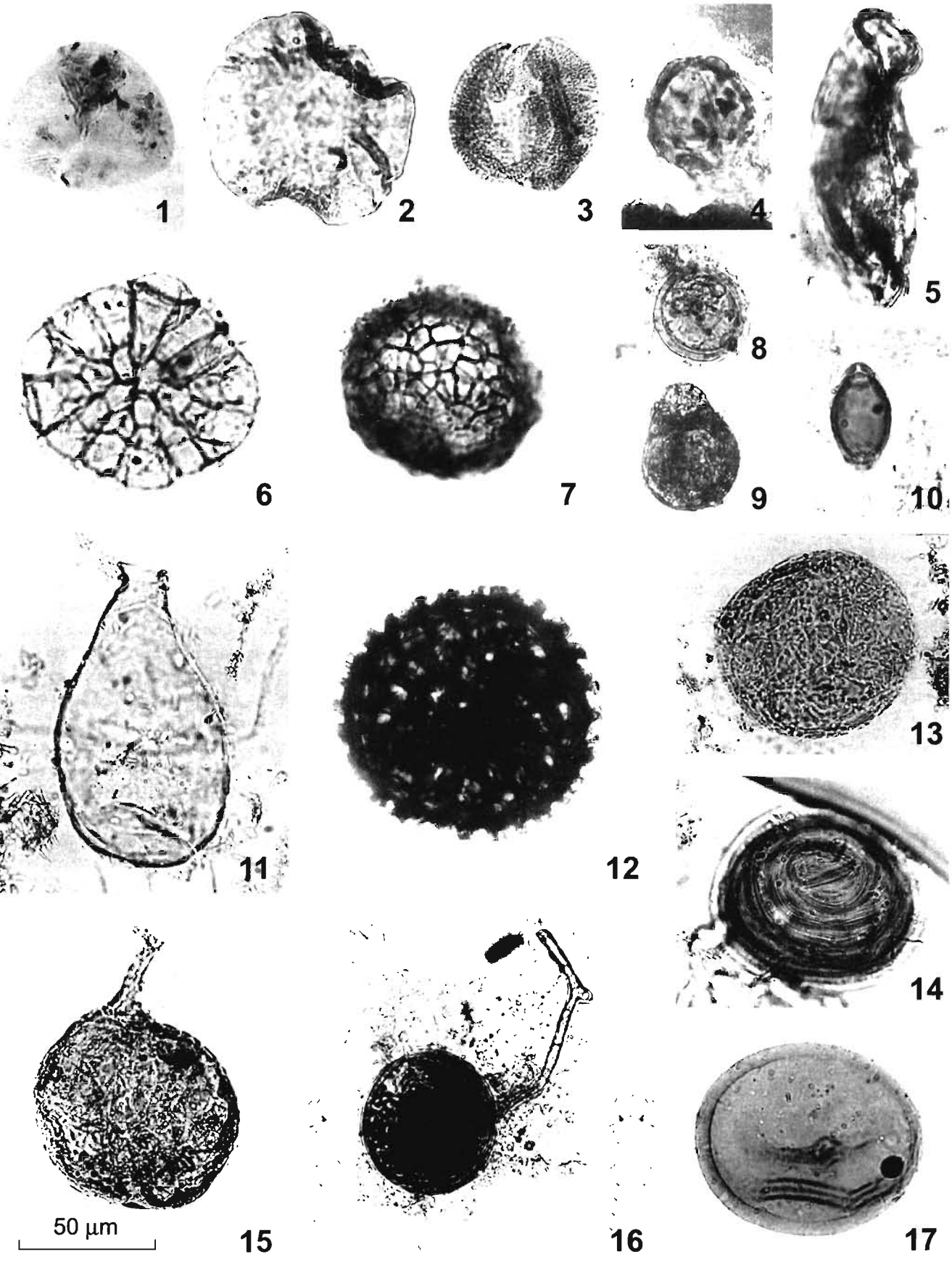

PLATE 1

potoniei - Samaropollenites speciosus Assemblage Zone for the Ladinian-Carnian Assemblage of the K-G Basin. The Bagra Assemblage compares with zone II of K-G Basin only in having *Samaropollenites*, otherwise the former differs from the latter in having *Callialasporites, Classopollis* and *Haradisporites*.

Lukose and Misra (1980) recorded a Late Triassic palynofossils in the subsurface sediments drilled in Jaisalmer Basin, Rajasthan. The palynoflora shows some similarities with Bagra palynological assemblage in having *Samaropollenites* in both the assemblages, but differs from the studied assemblage in having *Staurosaccites, Ovalipollis* and *Camerosporites* which are lacking here. The Late Triassic (Rhaeto-Liassic) palynological assemblage recovered from Banni Well No. B in Kutchch Basin possesses dominance of *Gliscopollis* and *Rhaetipollis*, but *Corollina* (=*Classopollis/ Gliscopollis*) is poorly represented in Bagra Assemblage and shows an equivalent to or younger aspect in having *Callialasporites trilobatus* and *Haradisporites mineri*. The latter two elements are known in the overlying Jabalpur Formation (Jurassic - Lower Cretaceous) in Satpura Basin (Bharadwaj *et al.*, 1972; Singh & Kumar, 1972). The presence of these two palynomorphs in Bagra sediments might be the earliest and the First occurrence datum of their occurrences during Rhaetian time.

Helby *et al.* (1987) recorded palynological zones in the Mesozoic sediments of western Australia. They have established several Oppel Zones in *Falcisporites* Super Zone. The Bagra Assemblage compares with Australian Oppel Zones only in having *Falcisporites, Samaropollenites* and *Corollina*. But the former differs in lacking *Enzonalasporites* during Carnian time and *Ashmoripollis, Zebrasporites* (during Rhaetian time). The presence of *Haradisporites, Callialasporites trilobatus* and *Corollina* (= *Gliscopollis/ Classopollis*) in the Bagra Assemblage certainly shows not only a point of difference but shows a younger aspect too.

DEPOSITIONAL ENVIRONMENT

The Upper Triassic Bagra Formation is the youngest lithounit of the Mahadeva Group in Satpura Basin. It consists of conglomerates, variegated clays and limestones. The Bagra conglomerates contain many different kinds of boulders derived from local (metamorphics) and distant sources (red jasper), suggesting varied provenance bringing in sediments with reworked elements.

Singh (1976) opined that Mahadeva Group deposited under rapidly flowing rivers and sub-tropical with pronounced seasonal droughts.

Casshyap (1982) on the basis of palaeocurrent studies, suggested palaeodrainage since Talchir time was from southeast to northwest and shifting towards west northwest near the western margin upto Upper Gondwana (Triassic) time and the sediments supply from highlands of northern side to the southerly Gondwana Basin was occasional and minimal. Later, Casshyap (1999) opined that palaeocurrent during underlying Denwa Formation shows a reversal of direction of sediments transported from north-northeast to south-southwest during Bagra sedimentation.

Palynomorphs recorded from the matrix of Bagra conglomerates exposed near Khatama Caves contains some forms which are described from the underlying Denwa beds by Kumar (2000) such as *Falcisporites, Satsangisaccites, Samaropollenites, Arcuatipollenites, Striatopodocarpites, Guttulapollenites* and forms of the younger age of Jurassic such as *Haradisporites, Biretisporites, Callialasporites* and *Corollina* (=*Gliscopollis/Classopollis*) (Singh & Kumar, 1972; Kumar, 1973) indicate that such palynomorphs were coming from the opposite areas lying northern side of the basin. The pteridospermic/gymnospermic, haploxylonoid disaccates such as *Falcisporites, Satsangisaccites* and *Samaropollenites*) are indicative of upland vegetation brought through the wind and deposited by water channels of the southern side of the basin. Ueno (1958, 1979), Tiwari (1982), Tiwari and Tripathi (1987), Kumar (1996) opined that haploxylonoid sacci bearing pollen grow in the cool temperate and subpolar or sub-alpine zones. Whereas taeniate pollen such as *Arcuatipollenites* and *Guttulapollenites*) and flange bearing sub-saccate pollen *Callialasporites* indicate towards the warmer and dry conditions with seasonal fluctuations at low lying areas.

An operculate non-saccates intrabaculate pollen *Corollina/Classopollis* (Cheirolepidaceae) represents shallow marine near shore areas (Ramanujam, 1993).

Cookson (1947a, b in Elsik, 1978) noted that Microthyriaceae is most abundant in warm temperate to tropical zones especially where high humidity is present. These fungi inhabit either rain forest areas or moist mountain gullies.

Stubblefield *et al.* (1987) reported vesicular arbuscular mycorrhizae (VAM Fungi), septate hypha, terminal swellings comparable to clamydospores from Antarctic roots of Triassic time shows a closer affinity with the Bagra's fungal remains.

The occurrence of chitinozoan like-vesicles indicates a lacustrine environment during the sedimentation of Bagra beds as similar chitinozoans like assemblages are known from elsewhere (Tiwari *et al.*, 1981 from Talchir sediments of Jharia Coalfield, Bihar) and evidently depicted as marine influence.

DISCUSSION

Crookshank (1936) considered narrow conglomeratic strip of Bagra beds is to some extent a shore deposit and its southward extensions are in the nature of fans at the mouths of rivers draining from the mountains which lay north of the Satpura Gondwana Basin. Present studies also suggest that the palynological assemblage of the Bagra conglomerate comprises similar palynomorphs recorded in the Denwa Formation e.g., *Falcisporites, Satsangisaccites,*

Samaropollenites, Guttulapollenites, Arcuatipollenites, Striatopodocarpites and *Scheuringipollenites*. Some fungal spores and fruiting bodies including *Haradisporites, Cycadopites, Callialasporites, Corollina* (=*Classopollis*), found in Denwa sediments are continued to occur in Bagra Formation. The palynological assemblage depicted as mixed flora which were fluorishing in the mountains of the southern side of the Gondwana Basin and coming through the river channels which were still continued to drain from the southern hillocks and were not completely vanished during the Bagra sedimentation. The present palynofloral studies do not support the Casshyap's view as no northern palynomorphs are identified except chitinozoan vesicles which are absent in Denwa clay's assemblage.

An operculate non-saccate pollen *Corollina/ Classopollis* (Cheirolepidaceae) represents shallow marine near shore areas (Ramanujam, 1993).

CONCLUSION

1. Bagra conglomerates were deposited under a lacustrine set up near shoreline.
2. Palynological assemblage of Bagra Formation contains dominance of fungal/algal spores with non-striated, haploxylonoid disaccates and a few striated and taeniate pollen grains belonging to Late Triassic time could be Rhaetian in age.
3. The presence of polar or subpolar or cool-temperate palynomorphs (disaccates) with warmer/dry low land palynomorphs, and the presence of microthyriaceous fungi, fungal and algal spores, fungal hyphae (as a mixed palynological assemblage) indicates fluctuating warm-humid climate at depositional site.
4. The occurrence of algal spores (Zygnemetaceae), fungal spores, microthyriaceous fungi (fruiting bodies) indicates fresh water lake deposits. On the other hand presence of chitinozoan like-vesicles may also strandline indicate a lacustrine set up for the Bagra sedimentation.
5. Bagra Formation was deposited by rapidly flowing rivers and subtropical with pronounced seasonal droughts.

Acknowledgements—*Author is grateful to the Director, BSIP, Lucknow for kind permission to publish this work (BSIP/RP/PUBL/ 2000-46) and further highly thankful to Prof. G Playford for valuable suggestions and critically going through the manuscript.*

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