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RESEARCH ARTICLE

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Amended lithostratigraphy of the Cretaceous Bagh Group, Western Lower Narmada Valley, India: A comparison with pervasive Tethyan basins

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The evolution of the Narmada, Saurashtra, and Kachchh basins in the western margin of the Indian Craton is associated with the Middle Jurassic segmentation of Gondwana. The Narmada Basin was evolved during the Early Cretaceous and preserved a thick clastic and non-clastic sequence of the Bagh Group. The succession lies unconformably on the Precambrian rocks, and a complete sequence is exposed in the Western Lower Narmada Valley (WLNV). Until now, it has been described using various informal lithostratigraphic units emphasizing local lithic characters, which have no relevance with the stratotypes and do not fit into the concept of the International Subcommission on Stratigraphic Classification (ISSC). In the present study, the Bagh Group succession is mapped across the Lower Narmada Valley (LNV) and correlated between sections. The units in WLNV were revised and redefined assigning the stratotypes as per the ISSC. The amended lithostratigraphy of the Bagh Group comprises five formations, viz. Songir, Vajepur, Bilthana, Nodular Limestone, and Uchad. The Uchad Formation is a newly recognized youngest unit and is subdivided into the Narmada sandstone and the Men Nadi Limestone members. The lithological and palaeontological evidences indicate that the Bagh Group succession of the WLNV developed in a fluvio-marine environment during the Berriasian? (Neocomian) to Coniacian age. The Cretaceous succession of the WLNV is also compared with the pervasive Tethyan basins, including the Eastern Desert (Egypt), Saurashtra–Kachchh (India), Mahajanga (Madagascar), and Carnarvon (Australia). The Albian–Coniacian lithostratigraphy of the Narmada Basin is comparable to the Eastern Desert, although located at different palaeolatitudes, which suggest similar eustatic and tectonic conditions. It also shows a similar sedimentation pattern compared with the adjoining Saurashtra Basin during the Cenomanian–Coniacian. However, it differs from the Kachchh, Mahajanga, and Carnarvon basins, which can be attributed to different palaeolatitudes, as well as the development of rift-related events. The deposition of the Bagh Group in WLNV terminated with the separation of the Indian Plate from Madagascar and the outpouring of flood basalts during the Coniacian.

KEYWORDS
Gondwana, Gujarat, lithostratigraphic revision, Lower Narmada Valley, Tethys Sea

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Ethological and environmental significance of *Bergaueria hemispherica* from the Late Cretaceous of the Bagh Group, Western India

Signification éthologique et environnementale de Bergaueria hemispherica *du Crétacé supérieur du groupe de Bagh, Inde occidentale*

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ABSTRACT

The probable trace maker of *B. hemispherica* is the fact that one encounters different age groups of sea anemone burrows extended at variable depths in soft, unconsolidated, non-fluidized mud to get stability. It occurs as densely packed, vertical to subvertical, usually unornamented, occasionally showing faint, thin, ring-like structures, allochemic sandstone-filled cylinders with hemispherical base extending to variable depths in the shale. The diameter-to-height ratio calculated for 44 burrow specimens shows that the diameters of most of the specimen are smaller than their height. The probable trace maker of *B. hemispherica* is the fact that one encounters different age groups of sea anemones, which extended their column at variable depth in soft, unconsolidated, non-fluidized mud to get stability. The inclined nature of paired burrows towards each other suggests social aggression while unpaired inclined burrows suggest swaying in search of food. The monodominant occurrence of *B. hemispherica* as pre-storm colonization of r-selected organisms (sea anemones) suggest sstressed environment and simultaneous vacation of the burrower reflects rapid sedimentation due to high-energy storm events. Further, storm and inter-storm events deposited sandy allochemic limestone and shale series, respectively, but did not form an identical condition for the colonization of the sea anemone. The species *B. hemispherica* of the Bagh Group revealed physicochemical parameters (energy conditions, turbidity, sedimentation rate, bathymetry, suspended organic matter, substrate consistency, oxygen, and salinity) of the Late Cretaceous transgressive sea.

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Mots clés :
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RÉSUMÉ

La trace fossile de *Bergaueria hemispherica* appartenant à un groupe de terriers en forme de bouchons est préservée sous l'aspect d'hypichnia dans le calcaire sableux allochimique du Crétacé supérieur du groupe de Bagh affleurant près du village de Karvi, district de Chlota Udepur, Inde occidentale. Elle apparaît très tassée, verticale à subverticale, en général non ornementée ; elle présente occasionnellement des structures en forme d'anneaux, minces et décolorés, des cylindres remplis de grès allochimique à base hémisphérique s'étendant

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Plug Shaped Burrows *Conichnus - Conostichus* from the Late Cretaceous of Bagh Group, Gujarat, Western India

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ABSTRACT

Plug-shaped ichnofossils *Conichnus conicus*, *Conostichus broadheadi* and *C. stouti* are found in the intercalated micritic sandstone and sandy allochemic limestone shale sequence of Bagh Group, Narmada district, Gujarat. These ichnospecies occur at two stratigraphic levels and shows distinct morphological features interpreted as resting/dwelling structures of sea anemone. The occurrence of these ichnospecies along with oyster fossils genera like *Bosostrea* and *Indostrea* indicate shallow marine environment.

INTRODUCTION

The Late Cretaceous Bagh Group is well developed on the northern side of the Narmada river in the western Madhya Pradesh and Gujarat. Many workers have explored Bagh Group on different aspects such as sedimentology, paleontology and tectonics. Few of them focused on ichnological aspects of Bagh Group exposed in Madhya Pradesh (Chiplonkar and Badve, 1970, 1972; Chiplonkar and Ghare, 1977; Singh and Dayal, 1979; Badve, 1987; Nayak, 2000) and Gujarat (Ghare and Badve, 1980). Chiplonkar and Badve (1978) have reported bivalve species of *Bosostrea* (*B. bosei, B. lata, B. trigonoides, B. flexuosa and B. scidiformis*) and *Indostera* (*I. indica, I. falciformis, I. oclavat, I. reniformis and I. deflecta*) from the oyster limestone of Ambadungar region of Gujarat.

The present work describes the plug shaped burrows *Conichnus* and *Conostichus*, collected from sandy allochemic limestone and micritic sandstone beds intercalated with shales, exposed at Uchad (Lat. 21°56' 0" N, Long. 73°37'43" E) and Bhekhediya (Lat. 21°57' 55" N, Long. 73°40'28" E) villages of Tilakwada taluka of Narmada district (Fig.1).

MATERIAL AND METHOD

The present study was carried out in Men River basin at Uchad and Bhekhadiya villages. Lithologs were measured; systematic samples collected and positions of plug shaped burrows are marked on litholog. The ichnofossil specimens were photographed and identified as *Conichnus* and *Conostichus*; and preserved in museum of Department of Geology, The Maharaja Sayajirao University of Baroda. Total three ichnospecies of two ichnogenera were identified and classified according to ICZN. It is further described considering the morphology and preservational aspects in order to decipher paleoecology.

SEDIMENTOLOGY

Ray (1981) has classified Bagh Group of Gujarat into two formations viz. lower Songir and upper Uchad. The Songir Formation is subdivided into Mohanfort member and Raisingpur member while the Uchad Formation is subdivided into Bilthana member and Galesar member. The Songir Formation comprises of conglomerate, grit and shale intercalation, mudstone, micritic sandstone, ferruginous sandstone, muddy micrite and sandy micrite.

Uchad and Bhekhadiya section attains a thickness of 37.2 m and 20.6 m respectively (Fig.2) and exposes the rocks of the Raisingpur member of Songir Formation, and Bilthana and Galesar members of Uchad Formation. Raisingpur member comprises of fine grained rippled micritic sandstone. Bilthana member comprises of fissile rippled micritic sandstone with shales and oyster-rich sandy allochemic limestone while Galesar member comprises of thinly bedded mudstone, sandy micrite, and micritic sandstone having nodular appearance, pink to grey shales, fine to medium grained x-bedded ferruginous sandstone and quartz arenite and muddy micrite.

PLUG SHAPED BURROWS

Plug shaped burrows occur abundantly in clastic and non-clastic sediments of shallow marine environments throughout the Phanerozoic Eon. A large group of single entrance plug shaped burrow exhibit narrow range of morphological variations. Pemberton et al. (1988) revised the ichnotaxonomy of the plug shaped burrows and related ichnogenera and differentiated the structures based on overall burrow geometry, wall ornamentation, distal termination and internal structure and observed that diameter/height ratios remain remarkably consistent for specimen displaying similar configuration and thus recognized four basic patterns. Other morphological features show substantially different degrees of importance resulting from behavioural patterns (Fürsich, 1973; Bromley and Frey, 1974). On the basis of the above criteria, Pemberton et al. (1988) described five distinct valid ichnogenera amongst the plug-shaped burrows namely *Astropolichnus, Bergaueria, Conichnus, Conostichus* and *Dolopichnus*. Two ichnogenus, namely *Conichnus* and *Conostichus* are identified from sandy allochemic limestone and micritic sandstone of Bagh Group is described in detailed below.

Ichnogenus: *Conichnus* Myannil, 1966

Diagnosis: Conical, amphora-like, or acuminated subcylindrical structures oriented perpendicular to bedding plane; base may be rounded or may exhibit a distinct, papilla-like protuberance. Fillings may reveal patterned internal structures such as chevron laminae but not radial medusoid symmetry.

Ichnospecies: *Conichnus conicus* Myannil, 1966
(Fig. 3a-c)

Diagnosis: Indistinctly to thinly lined conichnians tapering to a smooth, rounded, but distinctly basal apex.

Category: Conical-shaped.

Stratinomy: Hypichnia in micritic sandstone and sandy allochemic