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FULL LENGTH ARTICLE

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## Megaspores of heterosporous lycopsid affinity from the late Permian of Chhattisgarh, Central India and their evolutionary significance

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Dispersed fossil megaspores of heterosporous lycopsids have been recorded for the first time from the late Permian (Raniganj Formation) sediments exposed along the left bank of Banki River, near the village Chaki in Chhattisgarh, India. The outcrop has been palynologically dated based on miospore assemblage of typical late Permian affinity. The assemblage is represented by 7 species of trilete megaspores belonging to the genera *Noniasporites*, *Maiturisorites*, *Pantiella*, *Bokarosporites*, *Biharisorites*, *Hughesisorites* and a newly instituted genus of monolete megaspore i.e., *Monoletosporites* gen. nov. For the first time, the genera *Maiturisorites*, *Pantiella* and *Hughesisorites* have been recorded from the late Permian sediments; which were known earlier only from the Triassic sediments of Peninsular India. This indicates that the opportunistic species which successfully radiated during the Mesozoic had started colonizing themselves in the late Permian. A comparative study reveals that the megaspores possess affinity with the modern day lycopsids.

Key-words: Fossil megaspores, affinity, Raniganj Formation, late Permian, Peninsular India.

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## INTRODUCTION

The sexual life cycle of plants was a progressive evolutionary innovation that is vividly documented in the fossil records (Chaloner, 1967, 1970; Stewart, 1983). The evolutionary innovations (Niklas *et al.*, 1980) in the reproductive biology of vascular plants have been thoroughly characterized by several workers namely Chaloner (1967), Stewart and Rothwell (1993) and Bateman and DiMichele (1994). In early land plants, these innovations in sexual life

cycle can be categorized into homosporous, incipient heterosporous and advanced heterosporous i.e., reduction in the number of functional megaspores to one, including gymnospermous reproduction. These newly induced innovations impart significant selective advantages over the less specialized grades (Chaloner, 1967; Niklas *et al.*, 1980; Chaloner and Pettitt, 1987). The conjectural selective advantages are widely believed to play a major role in heterosporous plants that became dominant over homosporous pteridophytes and thereby the widespread dominance of flowering plants over the rest of the plant groups (Niklas *et al.*, 1983; Stewart, 1983; Chaloner and

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## Burdigalian to Early Serravallian Diatom Biostratigraphy from Havelock Island, Northern Indian Ocean

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**Abstract**—In the Ritchie's Archipelago of the Andaman group of islands (Northern Indian Ocean), Havelock Island is the largest one. The present study on diatoms has been carried out on three outcrops of Havelock Island situated in Kalapathar, South Point and Laccam Point localities. Samples collected from the three Neogene outcrops yielded poor to moderately preserved diatom valves. Two lithological units are exposed in this island, i.e., Inglis and Long formations. The diatoms have been recovered from the Inglis Formation and the diatom assemblages are represented by the marker diatom species, viz., *Actinocyclus ingens*, *Anellus californicus*, *Araniscus lewisianus*, *Cestodiscus peplum*, *Craspedodiscus coscinodiscus*, *Denticulopsis simonsenii*, and *Rossiella paleacea* that indicate the age as Burdigalian to early Serravallian.

**Keywords:** biostratigraphy, diatoms, late early to middle Miocene, Ritchie's Archipelago, Andaman and Nicobar Islands

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### INTRODUCTION

The Ritchie's Archipelago in the Andaman group consists of several islands, namely, Havelock, Neil, Henry Lawrence, John Lawrence, Peel, Wilson, Outram, Hugh Rose, Northern Button etc. including some islets. Sporadic works on fossil diatoms from Neogene sediments have been carried out from some of these islands though Neogene deposits are widely distributed in the Ritchie's Archipelago (Sharma and Srinivasan, 2007). Pioneering work from the Ritchie's Archipelago was done by Jacob and Shrivastava (1952). From the Miocene of Colebrook and other islands of the Ritchie's Archipelago, they reported the occurrence of diatoms along with radiolarians and silicoflagellates. Fifteen diatom taxa were reported by Mathur (1973) from the early Miocene of Havelock Island. Subsequently, seven diatom taxa were listed from the early Pliocene of Neil Island (Singh and Vimal, 1973). Thirty taxa of fossil diatoms belonging to 13 genera were recorded from the same sequence of Neil Island (Singh et al., 1978). Later on, Singh (1979) reported some additional diatom taxa. From the Outram Island, Mathur (1981) described 10 species of diatoms and correlated them to the middle Miocene *Craspedodiscus coscinodiscus* Zone of Bukry and Foster (1973). Further, Mathur (1985) identified 18 genera of diatoms with one new species *Liostephania ovalis* from the middle Miocene of Nicholson Island.

After a decade, Singh and Sharma (1996) worked on the diatoms of Neil East Coast Section of Neil Island and recognised ten diatom zones. Chakraborty and Ghosh (2016) studied the late Miocene sediments (Tortonian) of the Neil Island and reported 82 planktonic and benthic diatoms. Recently, Chakraborty et al. (2019) have identified 22 taxa belonging to 17 genera of diatoms from Havelock Island. They are assigned to the late early to early middle Miocene based on multiple microfossils.

It may be mentioned here that planktonic diatoms are useful tool for biostratigraphic interpretation, dating and correlation of Neogene marine sediments (Barron, 1985a) and consequently the planktonic diatoms are frequently used in biostratigraphic studies (Barron, 1992). In view of this, the present study has been undertaken to make more precise age determination based on the study of diatoms from three outcrops exposed at Havelock Island, to identify the palaeoecological zones based on diatoms, and to decipher the diversity patterns of diatom taxa recovered from three different outcrops of Havelock Island.

### MATERIALS AND METHODS

Andaman and Nicobar group of islands consists of two major groups, i.e., Andaman group and Nicobar group (Fig. 1a). Amongst these, the Andaman group