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Paleobotanical remains from the Paleocene–lower Eocene Vagadkhol Formation, western India and their paleoclimatic and phytogeographic implications

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Abstract

A small assemblage of macro- and micro floral remains comprising fossil leaf impressions, silicified wood, spores, and pollen grains is reported from the Paleocene–lower Eocene Vagadkhol Formation (=Olpad Formation) exposed around Vagadkhol village in the Bharuch District of Gujarat, western India. The fossil leaves are represented by five genera and six species, namely, *Polyalthia palaeosimiarum* (Annonaceae), *Acronychia siwalica* (Rutaceae), *Terminalia palaeocatapa* and *T. panandhroensis* (Combretaceae), *Lagerstroemia patelii* (Lythraceae), and a new species, *Gardenia vagadkholia* (Rubiaceae). The lone fossil wood has been attributed to a new species, *Schleicheroxylon bharuchense* (Sapindaceae). The palynological assemblage, consisting of pollen grains and spores, comprises eleven taxa with more or less equal representation of pteridophytes, gymnosperms, and angiosperms. Angiospermous pollen grains include a new species *Palmidites magnus*. Spores are mostly pteridophytic but some fungal spores were also recovered. All the fossil species have been identified in the extant genera. The present day distribution of modern taxa comparable to the fossil assemblage recorded from the Vagadkhol area mostly indicate terrestrial lowland environment. Low frequency of pollen of two highland temperate taxa (Pinaceae) in the assemblage suggests that they may have been transported from a distant source. The wood and leaf taxa in the fossil assemblage are suggestive of tropical moist or wet forest with some deciduousness during the Paleocene–early Eocene. The presence of many fungal taxa further suggests the prevalence of enough humidity at the time of sedimentation.

Keywords: Macroflora; Microflora; Paleoclimate; Paleocene; Vagadkhol Formation; India

1. Introduction

Biota from the continental Paleocene of South Asia is crucial in understanding faunal and floral affinities on the drifting Indian Plate with regard to its Gondwanan association with continental Africa, Madagascar, and South America on the one hand and Eurasia on the other. Unfortunately, the continental Paleocene has limited exposures in India and generally occurs with the lower Eocene lignite/coal sequences in Rajasthan and Gujarat along its western margin (e.g., Saxena, 1981; Singh and Dogra, 1988; Kar and Sharma, 2001; Tripathi et al., 2009) and in Meghalaya in the northeastern region (e.g., Kar and Kumar, 1986; M. Kumar, 1994; Saxena et al., 1996; Mehrotra, 2000). The Paleocene sections mapped so far in the northwestern Himalayan region are all shallow marine deposits. Paleocene fossiliferous sites of the Indian subcontinent are shown in Fig. 1. Pollen-bearing continental sediments associated with the Late Cretaceous Deccan volcanics have been reported at a few places (e.g., Singh and Kar, 2002; Samant and Mohabey, 2009; Saxena and Ranhotra, 2009). Their pollen content shows affinity to the best described Paleocene pollen assemblage from the classic Matanomadh Formation of Kachchh (Gujarat) in western India (Saxena, 1978, 1979). In general, there is a large gap in our knowledge of terrestrial biotas between the terminal Cretaceous (Khosla and Sahni, 2003) and the lower Eocene (Ypresian) sediments, well illustrated by the Vastan mine section (Cambay Shale Formation) close to Vagadkhol (Singh et al., 2010) in

Abbreviations: BSIP, Birbal Sahni Institute of Palaeobotany, Lucknow (India); CNH, Central National Herbarium (Botanical Survey of India).

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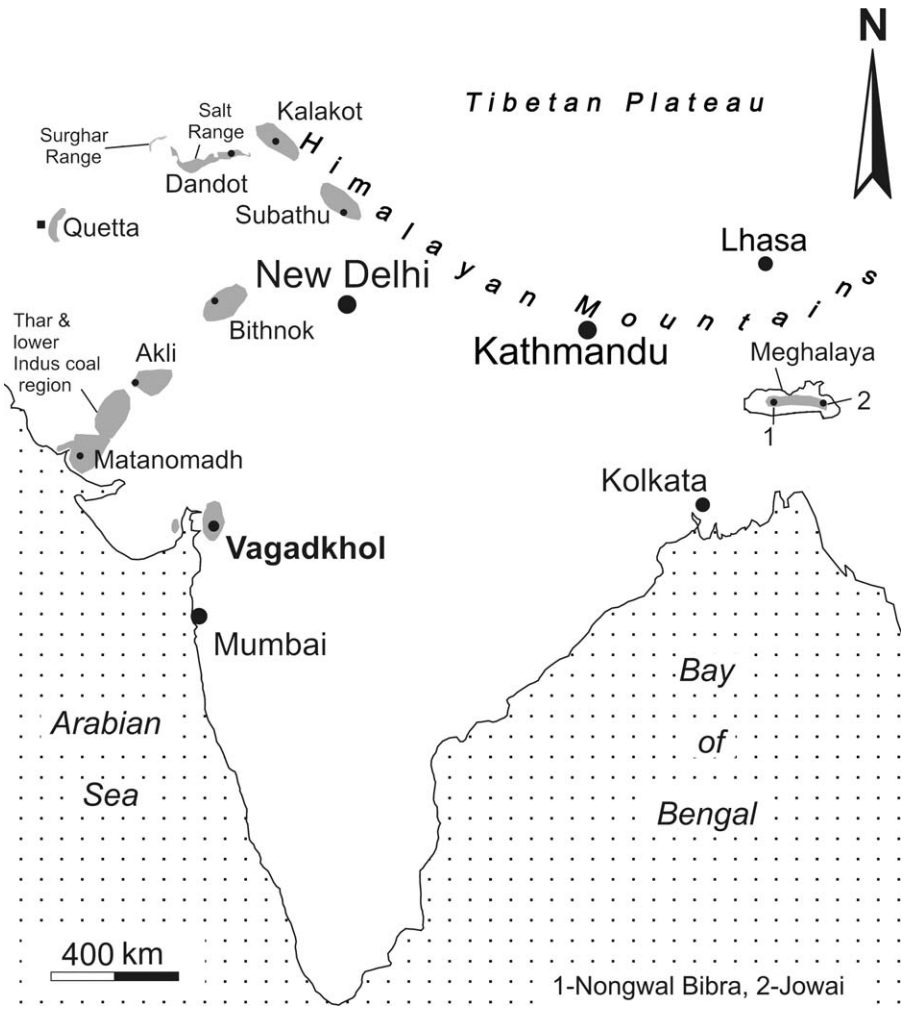

Fig. 1. Map of the Indian subcontinent showing distribution of plant fossil-yielding Paleocene outcrops (grey areas) and the location of the study site — Vagadkhol in western India.

western India. The terminal Cretaceous (Maastrichtian) sediments associated with the Deccan volcanics are dominated by *Aquilapollenites bengalensis*, *Ariadnaesporites*, *Gabonisporites*, etc. (e.g., Prakash et al., 1990; Singh and Kar, 2002; Dogra et al., 2004; Singh et al., 2006), whereas the Matanomadh Paleocene sections (Matanomadh Formation) are dominated by *Lygodiumsporites*, *Todisporites*, *Dandotiaspora*, etc. among the pteridophytic spores (Saxena, 1978) and by *Couperipollis*, *Liliacidites*, *Palmaepollenites*, *Proxapertites*, *Tricolpites*, *Lakiapollis*, *Meliapollis*, *Triorites*, etc. among the pollen (Saxena, 1979).

The present study focuses on the Vagadkhol Formation, which is an outcrop counterpart of the hydrocarbon rich Olpad Formation (these two formational names have sometimes been used interchangeably in the literature) and occurs in the Cambay rift-sag basin non-conformably overlying the Late Cretaceous Deccan basalts in western India (Chandra and Chowdhary, 1969; Sudhakar and Basu, 1973; Merh, 1995). The Vagadkhol Formation is generally considered to be exclusively of Paleocene or Paleocene–early Eocene in age based on meager fossil evidence and stratigraphic parameters. Prior to this work, the Vagadkhol Formation was thought to be largely unfossiliferous except for some fragmentary wood fossils.

Here we report and systematically describe a small assemblage of plant fossils comprising leaf impressions, silicified wood, spores and pollen from the Vagadkhol Formation exposed around the village Vagadkhol near Valia town in the Bharuch District of Gujarat, western India (Fig. 2). This paper is based on sampling of a small thickness (~10 m) of the Vagadkhol Formation, and it is likely that further work on the rest of the sequence and in other localities, for example that exposed in the type area, will provide a richer collection of plant as well as animal fossils.

Elsewhere in India, Paleocene plant and other fossil material has been reported from Fatehgarh, Palana, and Akli formations in Rajasthan (e.g., Verma, 1982; Kulshreshtha et al., 1989; Kumar et al., 2005; Rana et al., 2005, 2006; Tripathi et al., 2009), Matanomadh Formation, Gujarat (e.g., Saxena, 1978, 1979), and from northeastern India (e.g., Kar and Kumar, 1986; M. Kumar, 1994; Saxena et al., 1996; Mehrotra, 2000). However, a Paleocene age of some of these finds has not been confirmed by any index fossil assemblages, and some of the mentioned lithounits