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Palynofloristics and wildfire evidence from Permian deposits of the Satpura Gondwana Basin, India: a multiproxy approach

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ABSTRACT

Miofloral and fossil charcoal analyses of the Permian deposits of the Barakar and Motur formations from core PKK-2B, located in the Pench-Valley Coalfield, Satpura Basin (India) were carried out to assess the floral diversity, evidence for palaeo-wildfire and age. Two distinct palynoassemblages are identified: *Faunipollenites varius* palynoassemblage and *Gondisporites raniganjensis* palynoassemblage dated as Kungurian (Cisuralian) and Guadalupian (Wordian-Capitanian), respectively. These assemblages show dominance of pollen attributable to Glossopteridales followed by Cordaitales and Coniferales. The occurrence of charcoal at two levels in the sedimentary sequence indicates the occurrence of repeated wildfires in the surrounding area. Macroscopic charcoal fragments exhibit anatomical features such as bordered pitting, rays and helical thickenings on cell walls of tracheids suggesting a gymnospermous wood affinity. Most of the charcoal specimens exhibit rounded edges suggesting an allochthonous origin. Furthermore, fusinite reflectance (1.03–6.61%) of studied charcoal/inertinite fragments suggests that the temperature was in the range of ~305–962°C during charring. This indicates co-occurrence of high-temperature crown fires, together with medium- and low-temperature surface and ground fires, respectively. Our data emphasise the dominance of gymnospermous vegetation during the Permian in India and adds further evidence for the widespread occurrence of wildfires during this period in India and on entire Gondwana as well.

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Introduction

During the Permian, the global climate changed from an ice-house world to a green-house world, with tremendous effects on many ecosystems (Visscher et al. 1996; Shen et al. 2019) culminating in the most destructive mass-extinction event during entire Earth history at the Permian-Triassic boundary (Benton 2018 and references therein). However, climate and vegetation changes during the Permian followed complex patterns at a different pace in different regions worldwide (Cascales-Miñana and Cleal 2014; Cascales–Miñana et al. 2016; Novak et al. 2019; Zhang et al. 2022). While many regions on the northern hemisphere and Western Gondwana experienced significant aridisation during the Permian, Eastern Gondwana, including India, Australia and Antarctica seem to have experienced more stable humid conditions up to the late Permian, with peat/coal forming environments existing until the late Permian (Retallack 1995; Isbell et al. 2003; Montañez et al. 2007; Fielding et al. 2023 and references therein). The in-depth study of such coal-forming environments on Eastern Gondwana may help to better understand why these ecosystems had a larger resilience against climate change than ecosystems in other regions.

There are five major Gondwana sedimentary basins in India, namely, Damodar, Son, Mahanadi, Satpura and Wardha-Godavari. The deposition in these basins took place primarily in fluvial-lacustrine environments with very few episodes of marine incursions (Bhattacharya et al. 2021; Pillai et al. 2023) and lithological sequences of Permian in stratigraphic order are generally known as Talchir, Karharbari, Barakar, Barren Measures and Raniganj formations. The deposition in these Gondwana basins commenced with the melting of glaciers following late Carboniferous deglaciation. The subsequent sedimentation took place in varying environments ranging from fluvial-lacustrine to marine as evidenced by the occurrence of a marine bivalve fauna including *Eurydesma* from the upper part of Talchir Formation (basal-most Formation) (e.g. Varshney and Bhattacharya 2023) suggesting a rise in sea level and marine inundation during the deposition of the upper part of the Talchir Formation. Similarly, prevalence of fluvial-lacustrine conditions can be envisaged on the basis of occurrences of macroplant remains from the Talchir Formation (Saxena et al. 2022a and references therein). Fluvial environmental conditions prevailed during the deposition of the Karharbari, Barakar and younger Permian formations (Casshyap and Tewari 1987; Chakraborty et al. 2003; Mukhopadhyay et al. 2010) and climate became warmer and humid supporting the development of huge coal deposits. These sedimentary sequences range in age from the Cisuralian (early Permian) up to the Jurassic/Cretaceous and are very well exposed in all the basins. The Satpura Basin is unique among all the Gondwana basins because of the long-ranging stratigraphic record from the Permian up to the Cretaceous (Crookshank 1936) and these sediments are exposed in Narsinghpur, Chhindwara, Betul and Hoshangabad districts of Madhya Pradesh State. The basin shows a well-developed section of the Lower and Upper Gondwana formations. The main coalfields of this basin are Pench-Kanhan Valley, Mohpani, Tawa Valley and Pathakhera. The Pench Valley Coalfield is situated in the northwest in Chhindwara district of Madhya Pradesh State, India (Figure 1).

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