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The Karharbari Formation (late Sakmarian–early Artinskian), India: A biostratigraphic, palaeoclimatic, and vegetational framework for Cisuralian Gondwana correlation

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ABSTRACT

The Karharbari Formation of Peninsular India, long considered a transitional unit between the Talchir and Barakar formations, is re-evaluated here as a distinct palaeoecological and stratigraphic interval of Late Sakmarian to Early Artinskian age. Integrating megafloral, palynological, petrographic, coal, and lithostratigraphic data, this review synthesizes records from multiple Lower Gondwana coalfields to clarify the formation's spatial extent, floral composition, and environmental character. Biostratigraphically anchored by the *Crucisaccites monoletus* Assemblage Zone, the Karharbari strata exhibit strong regional coherence across basins, supported by floral and faunal correlatives in peri-Gondwanan and southern high-latitude Gondwanan settings, including Australia, South Africa, and South America. The vegetation reflects two interrelated ecological domains: a terrestrial forest system dominated by *Gangamopteris*, *Noeggerathiopsis*, and early *Glossopteris:* and a marshy wetland system comprising *Schizoneura*, *Gondwanidium*, and lycopsid groundcover. Conceptual models of floral transition, coal petrography, and climatic trajectory illustrate the formation's role as a post-glacial recovery phase and precursor to widespread *Glossopteris*-dominated swamps. Collectively, the Karharbari Formation emerges as a regionally mappable, biostratigraphically distinct, and ecologically transitional unit within the Lower Gondwana, offering a valuable reference point for Cisuralian correlations across Gondwana continents.

1. Introduction

The Karharbari Formation occupies a stratigraphic and palaeobotanical position of singular importance within the Lower Gondwana sequence of Peninsular India. Positioned between the glaciogenic Talchir Formation and the coal-rich Barakar Formation, it captures a narrow but critical interval of climatic, floral, and sedimentological transition during the Early Permian (Ghosh et al., 1964; Srivastava, 1973; Tiwari and Kumar, 2002). Long viewed as a lithological intermediary, the Karharbari is now recognized as a distinct chronostratigraphic unit, anchored by the *Crucisaccites monoletus* palynozone (Tiwari and Tripathi, 1991), and marked by a unique assemblage of megaflora, palynoflora, and coal petrographic traits (Banerjee, 1987; Chandra and Chandra, 1987; Prasad and Pundir, 2017). Its records span multiple Gondwana basins, offering insight into regional vegetational patterns, basin evolution, and post-glacial recovery processes (Hota and Sahoo, 2009; Mukhopadhyay et al., 2010).

This study synthesizes megafloral and palynological data from well-documented coalfields across Peninsular India (e.g., Chandra and Surange, 1979; Chandra and Tewari, 1991), peri-Gondwanan outcrops including the Salt Range and Arunachal Himalaya (Venkatachala and Kar, 1967; Singh, 1981), and selected Gondwanan successions in South America, South Africa, and Australia (MacRae, 1988; Backhouse, 1991; Souza and Marques-Toigo, 2005). Lithological, palynological, and coal petrographic observations are integrated across these domains, to reassess the Karharbari Formation not merely as a transitional facies, but as an ecologically zoned and biostratigraphically stable unit. Vegetational transition, climatic trajectory, and coal evolution are discussed to frame the Karharbari both within regional stratigraphy and global Cisuralian correlation frameworks (Balme, 1980; Stephenson, 2016).

The aims of this review are fourfold: (1) to establish the Karharbari Formation's stratigraphic definition and historical nomenclatural development; (2) to compile and analyse its megafloral and palynofloral assemblages; (3) to interpret its palaeoenvironmental and depositional

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