



Palaeodepositional consequences for hydrocarbon generation using geochemistry and palynology: example from Auranga coalfield in India

Divya Kumari Mishra¹ · Neha Aggarwal¹ · Atul Kumar Varma²

Received: 23 December 2024 / Accepted: 5 October 2025
© The Author(s) 2025

Abstract

Understanding the depositional environment is essential for evaluating hydrocarbon generation potential. This study examines the Lower Permian Barakar Formation in the Auranga Basin, part of the Damodar Valley within the Gondwana succession, by integrating geochemical and palynofacies analyses to reconstruct palaeodepositional conditions and assess organic matter preservation. 38 shale samples were analyzed for bulk $\delta^{13}\text{C}$ (– 25.05 to – 21.76‰) and $\delta^{15}\text{N}$ (– 2.98 to 2.55‰), indicating a predominant contribution from C_3 plants. Total Organic Carbon (TOC) content (average 14.65 wt%) and Total Nitrogen (average 0.29 wt%) suggest a high organic content with variable preservation potential. Palynofacies analysis and redox-sensitive trace element ratios (U/Th, Ni/Co, V/Cr) indicate deposition in a suboxic to oxic palaeomire, influenced by freshwater conditions with limited brackish water influence (Sr/Ba, Sr/Cu). The presence of swampy conditions alongside fluvial depositional features, such as point bars and meandering channels, suggests a dynamic sedimentary environment. These findings suggest limited hydrocarbon generation potential in the basin. Notably, the study reveals for the first time that terrestrial-dominated organic matter, when deposited under persistently oxic conditions, underwent extensive degradation and poor preservation, which directly constrained hydrocarbon generation. This explicit linkage between organic matter source, redox state, and sedimentary processes in a continental rift setting provides a novel framework for evaluating exploration risk in Gondwana basins and analogous depositional systems.

Keywords Stable isotope · Nitrogen isotope · Organic matter · Hydrocarbon generation · Lower permian · Indian gondwana basin · Palynofacies

Introduction

Historically, the significance of the depositional environment in the formation of organic-rich shales has been a topic of considerable debate. However, a comprehensive and universally accepted model to explain this process remains elusive. Researchers continue to investigate the relative contributions of organic matter production versus preservation

in controlling its accumulation. Various factors—including tectonic activity, geographic setting, and eustatic sea-level changes have been shown to influence sedimentation rates, redox conditions, and nutrient recycling, thereby affecting both the sources and types of organic matter deposited (Schultz and Rimmer 2004). Several workers such as Khan et al. (2022), Hakimi et al. (2023) and Ahmad et al. (2024) has approached the hydrocarbon generation potential study through an integrated approach of geochemistry. They have tried to retrieve the complexity within the shales is controlled by its depositional environment and organic matter type.

Microscopic organic components pollen, spores, phytoclasts, and degraded organic matter combined with geochemical tools such as stable carbon and nitrogen isotopes, Rock-Eval pyrolysis, and ICP-MS, effectively reveal shale provenance, palaeoweathering, and depositional conditions

✉ Divya Kumari Mishra
dmddivya2112@gmail.com

¹ Birbal Sahni Institute of Palaeosciences (BSIP), 53
University Road, Lucknow 226007, India

² Department of Petroleum Engineering and Earth sciences,
Indian Institute of Petroleum and Energy, Visakhapatnam,
Andhra Pradesh, India