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Glacial sedimentation in Northern Gondwana: insights from the Talchir formation, Manendragarh, India

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Abstract

Among the vast swathes of Gondwanan sedimentary rocks in India, exposures of the Lower Permian Talchir Formation at Manendragarh in India are exceptional for their cold marine faunal assemblage and muddy conglomerates of possible glacial origin. They may represent a record of the late Palaeozoic glaciation that affected Gondwana in the Permo-Carboniferous. Although the fossil record is relatively well documented, the sedimentology of this area is not well understood. This paper intends to fill the gap in knowledge regarding palaeogeography and the palaeoenvironmental changes within the basin through space and time. We distinguish conglomerates that are formed by glacial and mass flow processes. The lateral variation in facies associations along a NNE-SSW transect in the study area identifies the depositional basin as an interior sea that formed when the sea spilled over a steep basement ridge during a transgression. The benthic organisms remained confined to the seaward basin margin where they only flourished in the initial stage of basin filling. Locally derived, bioclastic storm beds are limited to the seaward flank of the basin. Alternating phases of glaciation and interglaciation resulted in an interbedded succession of grey shales and interglacial density flow deposits. The channels that fed these density flows are preserved closest to the landward margin of the basin. Co-existence of glacial diamictites and interglacial density flow deposits highlights the climatic changes in this part of Gondwana during the Late Palaeozoic.

1. Introduction

Amidst the vast areal coverage of the Gondwanan rocks preserved in India, the Early Permian Talchir Formation at Manendragarh is exposed over a short 2.5 km stretch and is the only site in India where marine fossils are found. The fauna, which includes cold water varieties in association with muddy conglomerates, is claimed to be linked to the Gondwana glaciation in the Southern Hemisphere (Shah & Shastry, 1975; Dickins & Shah, 1979). Presently, the Indian government is developing the area as a geological museum to preserve this fossil suite, which is exceptional in an Indian context (Sinor, 1923; Reed, 1928; Ghosh, 1954; Bhatia & Saxena, 1957; Dutta, 1957; Tiwari, 1958; Bhatia & Singh, 1959; Bharti & Chakraborty, 2014). Although the fossil assemblage includes equivalents of those found in glacial Gondwana deposits on other continents, conclusive glacial features have not been reported from this locality. Muddy conglomerates are present, but they could simply be nonglacial mass flow deposits (Dietrich *et al.* 2019). Paradoxically, deposits of mudflows or debris flows often coexist with deposits enriched in glacial dropstones (Chiarle *et al.* 2007; Tiranti & Deangeli, 2015; Vesely *et al.* 2018; Le Heron *et al.* 2022). A convincing explanation for the presence of marine black shale directly overlying the granitic basement is still absent. This field-based work aims to account for the sudden and dramatic change in hydraulic conditions implied by this unusual stratigraphic relationship (marine black shale onlapping the granite basement) and to reconstruct the variation in palaeogeography of the basin in tandem with the palaeoenvironment and depositional dynamics. We distinguish between sedimentary features that are of direct glacial origin and those that are more likely formed due to density flows.

2. Late Palaeozoic glaciation in Gondwana

Late Palaeozoic glaciation was conceived traditionally as a single and massive ice sheet covering all of southern Gondwana for duration of 100 million years (cf. Veevers & Powell, 1987; Frakes & Francis, 1988; Frakes *et al.* 1992; Ziegler *et al.* 1997; Hyde *et al.* 1999; Blakey, 2008; Buggisch *et al.* 2011). Glaciation started in western South America during the Visean (Caputo *et al.* 2008; Pérez Loinaze *et al.*, 2010) and ended in eastern Australia during the Middle to earliest Late Permian (Fielding *et al.* 2008a, 2008b, 2008c; Fielding *et al.* 2022). However, recent