



# The Permian – Triassic boundary in Peninsular India and the extinction of the Glossopteridales

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## ABSTRACT

The Glossopteridales was a distinctive order of gymnospermous seed-plants that occurred widely in the Permian of Gondwana. Some authors have suggested that they may also have occurred in the Triassic and so had survived the catastrophic Permian – Triassic extinction event. This suggestion was mainly based on records from peninsular India such as from the Panchet Formation, which traditionally was regarded as Triassic in age. This paper reviews the evidence for a Triassic age for these floras and it is argued that they are in fact late Permian. There is no clear evidence that the Glossopteridales survived the P/T biotic crisis in India and only unequivocal evidence is in China that they survived into the Triassic.

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## 1. Introduction

The Glossopteridales were in many ways the quintessential Palaeozoic Gondwana plants, whose remains are widespread and abundant in Permian terrestrial deposits of India, Australia, southern Africa, Antarctica and south America (Anderson et al., 2007; McLoughlin, 2012, 2021). A recent study on the vegetation response to the Permian – Triassic (P/T) extinction event (Nowak et al., 2019) suggested that there are also a few records from the Triassic of Gondwana, mostly from the Panchet Formation and similar-aged strata in India. However, these were mainly taken from secondary literature (e.g., Boersma and Broekmeyer, 1986; Dobruskina, 1994) and does not agree with our experience. For instance, the stratigraphically-youngest occurrences of *Glossopteris* in the Son-Mahanadi basins in the Lower Kamthi/Pali /Panchet formations are accompanied by rich and diverse macrofloras that do not differ substantially in general composition from those found in the underlying Raniganj Formation usually accepted as Permian in age (Goswami et al., 2018). Similarly, the ‘Handapa locality’ in the Lower Kamthi Formation of the Mahanadi Basin is famous for well-preserved abundant macrofloral remains of *Glossopteris* and allied genera in a reddish-pink siltstone/mudstone lithology (probably reflecting climatic warming) and are interpreted as Lopingian in age.

In view of the importance of this issue for understanding the evolution of Palaeozoic Gondwana vegetation, as well as the wider

impact of the Permian / Triassic biotic crisis on plant evolution, we felt that the primary literature on the late occurrences of *Glossopteris* needed to be checked. We have also looked at the records in the literature from other areas claiming to be Triassic occurrences of Glossopteridales remains, with the aim of seeing if the order really did survive the P/T extinction event.

## 2. Geological context

Most of the Palaeozoic Gondwana basins of peninsular India fall into two groups (Mukhopadhyay et al., 2010): (1) the Trans-Indian basin belt that includes the Satpura, Son-Mahanadi Valley and Damodar-Koel Valley basins and (2) the Wardha-Pranhita-Godavari Valley basins (Fig. 1). The basins represent half-grabens bounded by high-angle faults that were re-activated lineaments in the Precambrian basement (Tewari, 1999).

Much of the stratigraphical sequence is broadly similar in these basins, with a basal Talchir Formation that includes diamictites reflecting glacial conditions, overlain by two post-glacial coal-bearing intervals (the Barakar / Karharbari formations and Raniganj Formation) that are separated by a coal-poor Barren (or Kulti) Formation. The Raniganj Formation is then overlain by a heterogeneous sequence of coal-barren shales, and interbedded arkosic and micaceous sandstones representing bed-load deposits of braided rivers (Veevers and Tewari, 1995); these beds are often red, purple or green, although in the Satpura Basin the sandstones are mostly white. The correlation of these supra-Raniganj sequences has been controversial and different formation names have been applied in different basins (Sastri et al., 1977; Dutta, 2002; Mukhopadhyay

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