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Impact of wildfires on Gondwanan flora during the Permian-Triassic transition

S. Bhattacharya, R.E. Summons, S. Murthy, C. Foster, F. Husain, Y. Ankit

Supplementary Information

The Supplementary Information includes:

- Methods of Hydrocarbon and Charcoal Analyses
- A Note on Field Excursion and Outcrop Sampling
- Table S-1
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Methods of Hydrocarbon and Charcoal Analyses

For analyses of PAHs and tri- and tetra- terpenoids, soluble organic matter was extracted from powdered sediment samples in a speed extractor (Buchi E-914) using a mixture of dichloromethane and methanol (9:1 ratio, respectively; v/v) at 100 °C and 1500 psi. Asphaltene in the total extract was precipitated in *n*-pentane and the supernatant maltene fraction was pipetted out and left to dry in a fume hood. Silica gel chromatography was performed to isolate the saturated and aromatic hydrocarbon fractions together using activated silica gel (100–200 mesh). The combined saturated and aromatic hydrocarbon fractions were eluted using a mixture of *n*-hexane and dichloromethane following calculation of the dead volume. The separated aliquot was analysed in a GC (Agilent 7890B) coupled to a triple quadrupole mass spectrometer (Agilent 7010A) via multiple reaction monitoring modes (Ma *et al.*, 2021; Cui *et al.*, 2023) at the Summons Lab, Massachusetts Institute of Technology, USA. Chromatography was performed on a DB-5MS fused silica capillary column (60 m × 0.25 mm × 0.25 µm). The initial temperature of the GC oven was 60 °C isothermal for 2 min, ramped to 220 °C at a rate of 8 °C/min and then ramped to 325 °C at a rate of 2 °C/min that was held for 30.5 min. The transfer line temperature was 320 °C, while the source temperature was 270 °C. The electron energy used was 70 eV. The same instrumental method was maintained for both the terpenoids and PAHs. The data were processed using MassHunter QQQ software.

For the charcoal analysis, microscopic charcoal fragments were separated from macerated residue with a dropper, smeared on a piece of glass under an illuminated magnifier with a flexible arm and dried in normal room temperature. The samples were studied and photographed with the aid of a JEOL 7610F Field Emission Scanning Electron Microscope (FESEM) at Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow. Palynomorphs, including some sparsely present miospores, were revealed by macerating ~50–100 g powdered sediment samples. A total of 300 grains were counted in each sample and categorized as charcoal, wood, cuticle, pollen non-taeniate, pollen taeniate, bisaccate unidentified, spores, algae as provided in Table S-1. The details of maceration technique are provided in Bhattacharya *et al.* (2021).

A Note on Field Excursion and Outcrop Sampling

During a field excursion in Madhukunda region (Banspetali nala) in Raniganj sub-basin, outcrop samples (mainly shale, coal, sandstones) were collected from the Raniganj and Panchet formations. However, these samples were highly weathered and not used for the Organic Geochemistry and Palynology analyses. Later, during a drilling operation by Coal India Limited in Madhukunda, core samples were collected from the Raniganj and Panchet formations that were used in the present study. Field photographs taken during the excursion are used to prepare the graphical abstract.

Supplementary Table

Table S-1 Palynomorph groups expressed as absolute counts in the upper Permian (R/M/XX/69 to R/M/XX/59), transition (R/M/XX/58) and Lower Triassic (R/M/XX/51 to R/M/XX/19) samples from Raniganj sub-basin, eastern India.

Sample no.	Depth (m)	Charcoal	Wood	Cuticle	Pollen non-Taeniate	Pollen-Taeniate	Bisaccate unidentified	Spores	Algae	Total
R/M/XX/19	50.5	65	15	2	2	0	0	1	0	85
R/M/XX/24	70.3	0	30	8	94	18	6	122	22	300
R/M/XX/25	73.5	50	14	6	70	8	8	136	8	300
R/M/XX/27	85.3	0	0	0	0	0	0	0	0	0
R/M/XX/28	91.5	30	16	2	88	14	6	140	4	300
R/M/XX/32	112.1	4	48	24	85	28	0	95	16	300
R/M/XX/33	115.0	14	28	8	98	16	0	128	8	300
R/M/XX/34	134.0	44	8	0	0	0	0	0	0	52
R/M/XX/38	147.4	4	30	2	106	12	6	128	12	300
R/M/XX/41	150.5	0	46	6	70	16	4	110	48	300
R/M/XX/44	158.0	50	0	0	0	0	0	0	0	50
R/M/XX/47	178.0	0	40	20	176	14	14	26	10	300
R/M/XX/48	180.7	0	0	0	0	0	0	0	0	0
R/M/XX/50	185.3	80	0	0	0	0	0	0	0	80
R/M/XX/51	193.8	70	0	0	0	0	0	0	0	70
R/M/XX/58	205.0	0	0	0	0	0	0	0	0	0
R/M/XX/59	214.3	88	14	8	8	130	0	52	0	300
R/M/XX/60	220.0	24	36	8	0	166	36	30	0	300
R/M/XX/61	226.0	221	9	0	0	50	6	14	0	300
R/M/XX/63	231.5	50	90	8	0	118	12	22	0	300

Table S-1 continued

Sample no.	Depth (m)	Charcoal	Wood	Cuticle	Pollen non-Taeniate	Pollen-Taeniate	Bisaccate unidentified	Spores	Algae	Total
R/M/XX/64	234.1	70	70	0	16	116	20	8	0	300
R/M/XX/65	240.3	92	60	8	8	108	16	8	0	300
R/M/XX/66	242.0	75	34	20	8	137	8	18	0	300
R/M/XX/67	244.0	55	60	11	9	145	6	14	0	300
R/M/XX/68	245.7	120	30	4	4	90	30	22	0	300
R/M/XX/69	257.0	70	34	6	2	149	11	28	0	300

Supplementary Figures

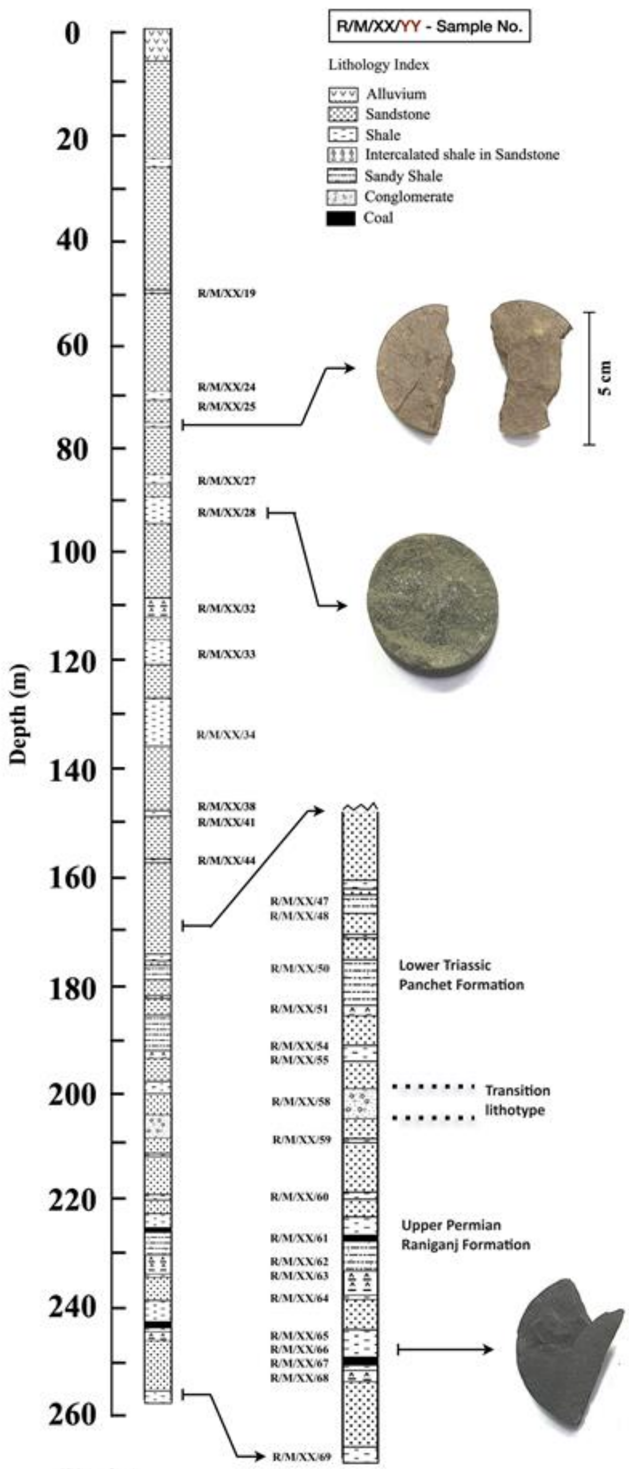

Fig. S-1

Figure S-1 The 257 m section constructed from the studied upper Permian (R/M/XX/69 to R/M/XX/59), transition (R/M/XX/58) and Lower Triassic (R/M/XX/55 to R/M/XX/19) sediment core samples from Raniganj sub-basin, eastern India. The studied samples and depth details are provided.

1. ***Monosulcites minimus*** **(Cookson 1947) Couper 1953**
2. ***Chasmatosporites apertus*** **(Rogalska 1954) Nilsson 1958**
3. ***Chasmatosporites rimatus*** **Nilsson 1958**
4. ***Chasmatosporites*** **sp. cf.** ***C. elegans*** **Nilsson 1958**
5. ***Cycadopites*****? sp.**
6. ***Cycadopites*****? sp.**

Figure S-2 Miospore genera having affinity with Mesozoic gymnosperms (Balme, 1995) in selected Lower Triassic (R/M/XX/25, R/M/XX28, R/M/XX/41) samples from Raniganj sub-basin, eastern India.

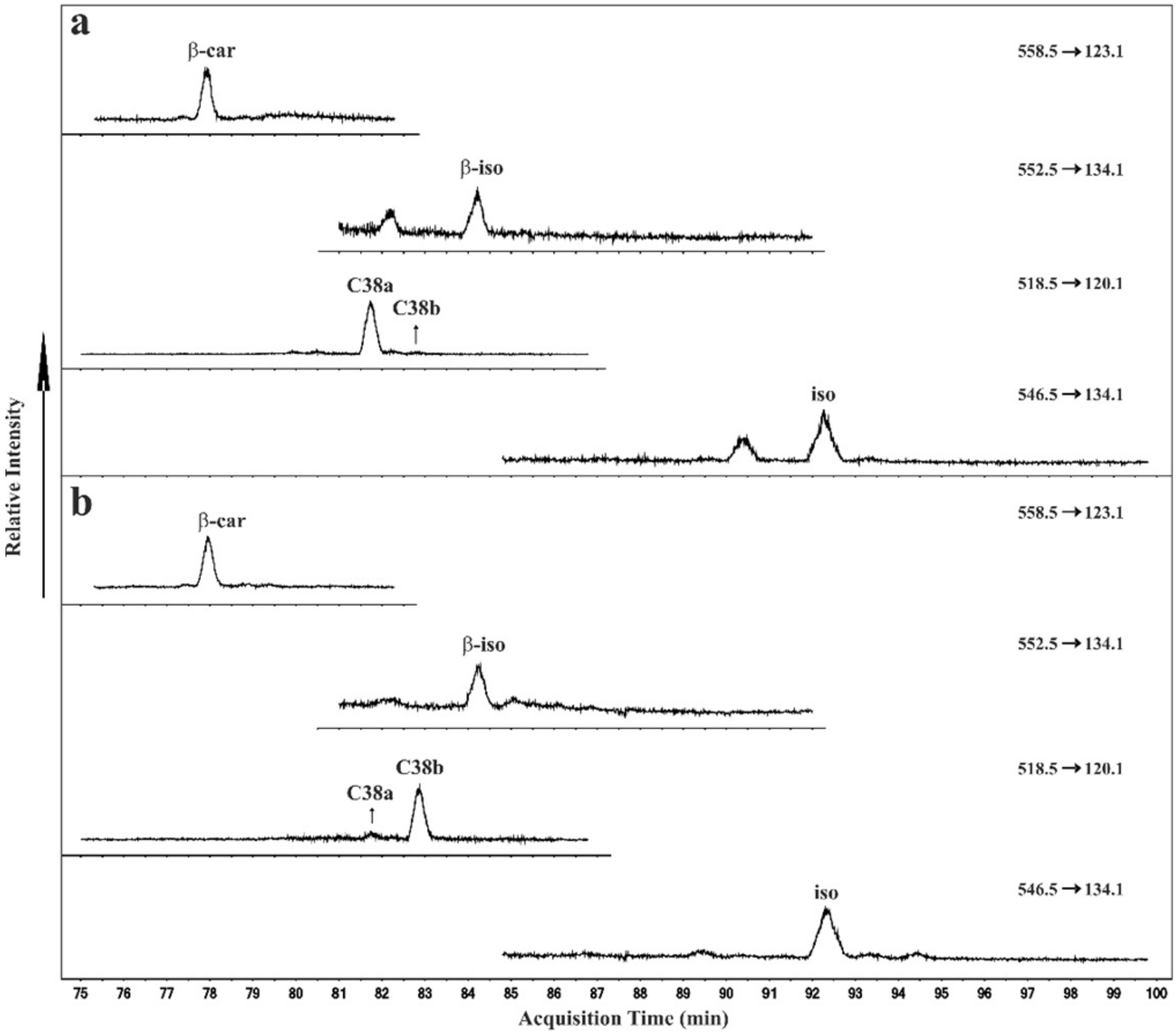

Figure S-3 Representative MRM chromatograms obtained from GC-QQQ-MS analyses showing distributions of selected carotenoids in Lower Triassic (R/M/XX/55) and transition (R/M/XX/58) samples from Raniganj sub-basin, eastern India. β-car: beta carotane; iso: isorenieratane; β-iso: β-isorenieratane.

Supplementary Information References

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