Fungal palynology of high-latitude coals and interseam rocks from the Miocene Climate Optimum warming event, Victoria, Australia

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Introduction

Fungi are necessary elements in all ecosystems given their role in terrestrial carbon cycling, soil formation, plant growth, and more, and it's critical to understand how they may change with global warming. We know that fungal communities from the middle Miocene in the northern high latitudes vary with shifting climates, however, we do not know if this also occurred in southern high latitudes. The analysis of fungal assemblages from lower-middle Miocene sediments during the lead-up to and through the Miocene Climate Optimum (MCO; 18-13 Ma), especially from the Morwell 1A (M1A) coal, Yallourn Interseam Rocks, and Yallourn Coal in Victoria, Australia, is key to understanding these changes. We are examining changes across the MCO because it is the best analog for current and future climate change based on the IPCC AR6 report (IPCC, 2022). This study is part of a large-scale international project that is assessing the response of fungal assemblages to climate change across temporal and geographical scales. Based on existing paleoclimatological data and wood preservation information, we expect results to be similar to those for the Brassington site in the UK (Pound et al., 2022; Korasidis 2018). To date, our research suggests that fungal communities are changing in relation to climate-driven hydrosere changes previously documented by many other proxies (Steinthorsdottir et al., 2021; Korasidis, 2018); it is less clear whether they are themselves providing a robust paleoclimatological proxy, as has been previously demonstrated for the Brassington site and Clarkia, USA (O'Keefe et al., 2022).

Study Area

The uppermost coals in the Western Gippsland Basin of Victoria, Australia are the Morwell 1 A (M1A) and the Yallourn which, together with the intervening Yallourn Interseam, are over 100 meters thick. They are exposed in the Loy Yang and Yallourn Open Cut Mines, respectively (Figure 1), and capture the lead up to and peak warming of the MCO (Figure 2).

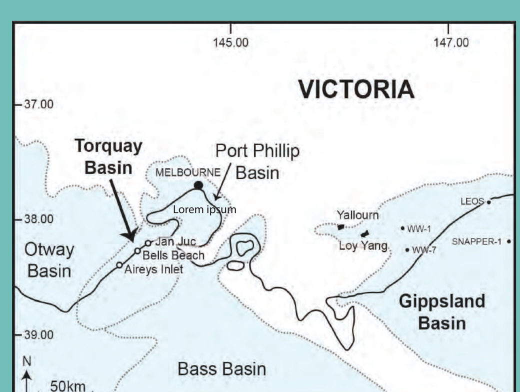


Figure 1. Mine Locations in the Gippsland Basin. From Korasidis, 2018.

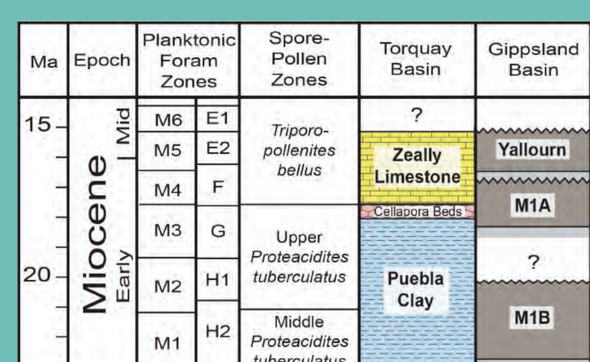


Figure 2. Ages of Rocks in the Miocene succession in the Gippsland Basin based on Microfossil Zones. From Korasidis, 2018.

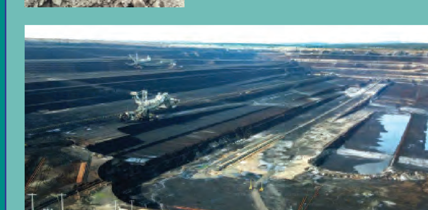
Study Localities

The Yallourn Open Cut Mine.

The base of the Yallourn Interseam.

Yallourn Coal with abundant mummified logs.

The top of the Yallourn Interseam; mangrove roots in sand.



The Loy Yang Open Cut Mine. Image from Australian Mining.

Materials and Methods

Evenly spaced samples were collected through the M1A and Yallourn coals by Drs. Korasidis and Wallace from the Loy Yang Open Cut Mine and the Yallourn Open Cut Mine, respectively, while samples for the Yallourn Interseam were collected from the top, middle, and bottom of each rock type present by Dr. O'Keefe. Samples were then processed utilizing acid free methods to extract palynomorphs (Pound et al., 2021). The processed samples were then mounted on slides and analyzed under 100x magnification using Leica DM750P microscopes with integral ICC50W cameras and Leica Application Suite software.

Preliminary Climate Reconstruction

Unit	Sample Number	Köppen-Geiger Climate Zone(s)	Number of taxa used in the reconstruction	Apiosoraceae (<9 micrometers)	Apiosporaceae (~19-26 micrometers)	Apiosporaceae (9-17 micrometers)	cf. *Balaniopsis ca. 20-28 micrometers*	cf. Endophragmia	cf. *Trichocladium*	Xylariales
Yallourn coal	MD-68.5	Af, Cfa	n=6		●		●	●		●
	MD-64	Af, Aw, BWh, BWk, BSh, BSk, Csa, Csb, Cfa, Cfb	n=2			●				●
	M-62.25	Af, Am, Aw, BWh, BWk, BSh, BSk, Csa, Csb, Cwa, Cfa, Cfb, Dfa, Dfb, Dfc	n=1					●		
	MD-42	Af, Aw, Cwa, Cfa, Cfb	n=3	●					●	●
	MD-40	Af, Am, Aw, Cwa, Cfa, Cfb	n=3							●
	LD-38	Af, Aw, BWh, BWk, BSh, BSk, Cwa, Cfa, Cfb	n=2		●				●	●
	MD-18.9	Af, Aw, BWh, BWk, BSh, BSk, Csa, Cwa, Cfa, Cfb	n=2		●					●
	1878	Af, Aw, BWk, Cfa, Cfb	n=5	●		●			●	●
	1873	Af, Aw, Cfa	n=7	●		●			●	●
Yallourn Interseam	1857	Af	n=10	●		●		●	●	●
	1856	Af, Cfa	n=9	●		●		●	●	●
M1B coal	1961	Af	n=6	●	●	●	●		●	●
	1946	Af, Am, Aw, BWh, BWk, BSh, BSk, Csa, Csb, Csc, Cwa, Cwb, Cfa, Cfb, Dwa, Dwb, Dwc, Dfa, Dfb, Dfc, ET, EF	n=1							●
	M1B-9	Af	n=3		●		●			●

Preliminary paleoclimate modelling suggests humid tropical to sub-tropical (Af-Cfa) conditions persisted in the Gibbsland Basin during the early-middle Miocene, although the signal is very noisy, especially in the Yallourn coal, as relatively few non-cosmopolitan taxa have been identified to date. This is contrary to the findings of Korasidis (2018), which suggest warm-temperate conditions. In general, the greater the number of identified fungi (n, above), the better the climatological signal, however, when taxa with highly restricted modern distributions occur, *Balaniopsis* sp., for example, which only occur in tropical wet climates (Af), a clear signal can be obtained. Samples dominated by cosmopolitan taxa tend to produce poorer climate reconstructions.

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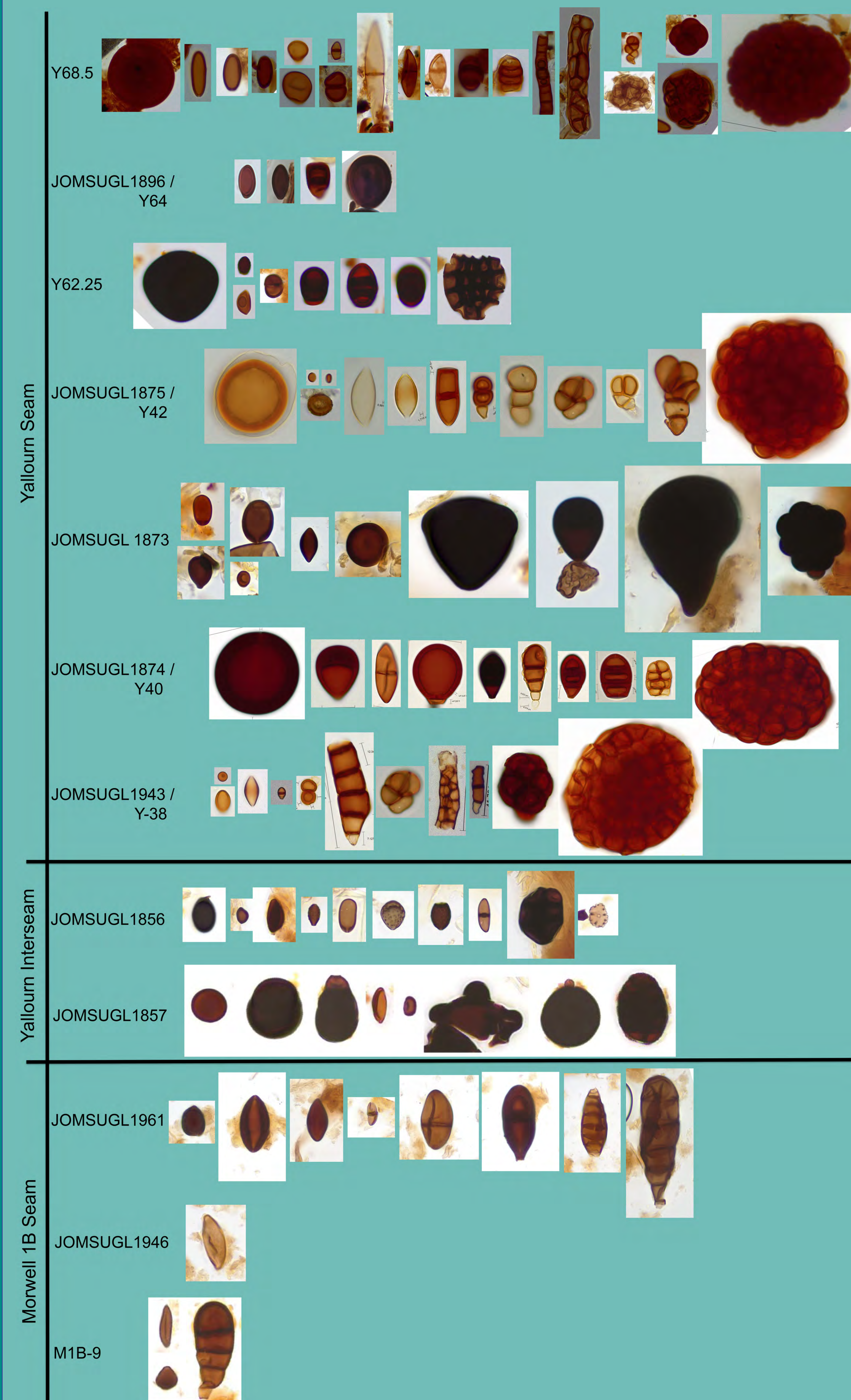
Primary Fungal Assemblages



Y68.5
- 6 identified taxa to date
- High diversity assemblage
- Standing water at least part of the year

JOMSUGL1896 / Y64
- 2 identified taxa to date
- Low-divesity assemblage

Y62.25
- 1 identified taxon to date
- Moderate diversity assemblage

JOMSUGL1875 / Y42
- 3 identified taxa to date
- High diversity assemblage
- Standing water at least part of the year

JOMSUGL 1873
- 3 identified taxa to date
- High diversity assemblage

JOMSUGL1874 / Y40
- 2 identified taxa to date
- High diversity assemblage
- Standing water at least part of the year

JOMSUGL1943 / Y-38
- 3 identified taxa to date
- Moderate diversity assemblage
- Standing water at least part of the year

JOMSUGL1856
- 10 taxa identified to date
- High diversity assemblage

JOMSUGL1857
- 9 taxa identified to date
- High diversity assemblage

JOMSUGL1961
- 8 taxa identified to date
- High diversity assemblage

JOMSUGL1946
- 1 taxon identified to date
- Very low diversity assemblage

M1B-9
- 3 taxa identified to date
- Low diversity assemblage

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