Preliminary tropical fungal palynology of early-middle Miocene sediments from North-western Peru

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Introduction

Fungal communities are a vital part of terrestrial ecosystem functions and understanding how they respond to climate change is necessary for predicting future assemblage dynamics. Sediments deposited during the Miocene Climate Optimum (MCO), 18-13 million years ago, provide an opportunity to examine fungal responses to a warming event with CO2 values similar to those today. Few fungal datasets exist for tropical regions during the MCO, and only one uses modern methods to identify fossil fungi and complete paleoecological inferences and paleoclimatological reconstructions using the nearest living relative method.

Two past studies examined fungal diversity in northwestern Peru, but did not utilize stratigraphically controlled samples. Without this control, it is impossible to explain how fungal communities changed prior to, during, or following the MCO. For this study, new samples with stratigraphic control were collected in Summer 2022 and are being studied for fungal content. Here we present extended preliminary results of fungal diversity from the lowermost part of the section to the uppermost. Samples from the lower part of the section contain a sparse, low-diversity assemblage, while the uppermost part of the section contains an abundant, diverse assemblage, suggesting that fungal diversity increased during this period of climate change.

When completed, this study will be the first stratigraphically controlled, detailed record of microfungal assemblages for Peru This data will be added to a worldwide database of fossil fungal records, providing evidence for local climatic changes during the MCO, and permitting the first forecasts of fungal guild dynamics related to current climate changes.

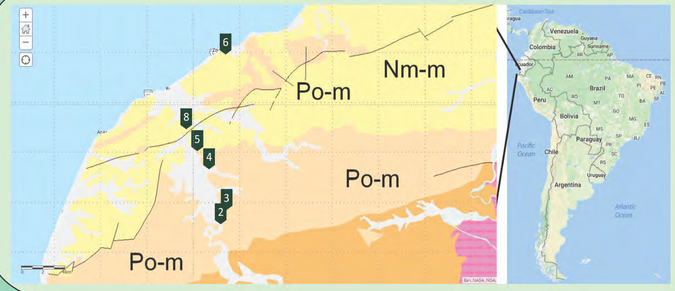


Figure 1. Study Area in extreme northwestern Peru, along Quebrada Bocapán and the Pan American Highway. Po m = Heath Formation; Nm m = Zorritos and Cardalitos Formations.

Materials and Methods

Stratigraphically constrained samples were collected from localities east and north of Bocapán, Northern Peru in Summer 2022 (Figure 1). These samples were processed to extract fungal palynomorphs using modifications of O'Keefe and Eble (2012) and Pound et al. (2021) low-acid palynology methods in the OPaL Lab at Morehead State University. The samples are currently being examined using brightfield microscopy at 1000x magnification using Leica DM 750P microscopes with integral ICC50W or c-mount Excelis cameras, along with Leica Application Suite® and CaptaVision® software Multiple focal planes of each specimen are captured and z stacked using Helicon Focus® to obtain most representative images, with measurements embedded. Images and their measurements are being compared to known fossil and modern taxa to arrive at an identification This step is in process, and not all taxa pictured have been identified Once completed, Köppen-Geiger classes will be compared for all identified taxa, and a best fit climate is identified using the nearest living relative method (Utescher et al. 2014).

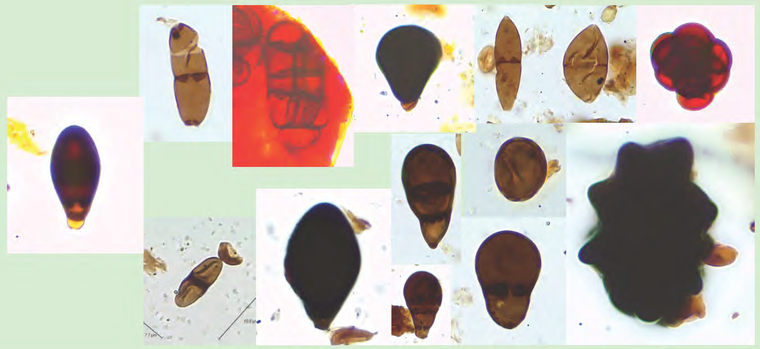
Preliminary Paleoclimate Reconstruction

Formation	Sample Number	Köppen-Geiger Climate Zone(s)	Number of taxa used in the reconstruction	Important Indicator Taxa: Apiosporaceae <9 micrometers	Apiosporaceae >19 micrometers	Apiosporaceae 10-17 micrometers	*Ascotaiwania*	*Bactrodesmiostrum* aff. *domesticum*	*Balaniopsis*	Stachybotrys	cf. *Submersisphaeria*	Xylariaceae	*Zopfiella neogenica*
?Cardalitos?	2152	Cfb	n=12	●	●	●	●	●				●	●
	2150	Cfa	n=15	●	●	●	●	●		●	●	●	●
	2148		N/A										
	2145		N/A										
	2143		N/A										
	2140		N/A										
	2139	Af Cfa	n=9	●	●	●		●		●	●	●	●
	2136	Af Aw Cfa Cfb	n=3	●	●			●				●	
	2135		N/A										
	2134	Cfb	n=11	●	●		●			●	●	●	
?Zorritos?		Not yet examined											
P5 - Top ?Heath?		Not yet examined											
P4 - Upper ?Heath?	2099	Af Aw BWh BWk BSh BSk Csa Cwa Cfa Cfb	n=2			●						●	
	2097		N/A										
	2095		N/A										
	2093	Af Aw BWh BWk BSh BSk Cfa Cfb	n=3	●	●					●			
	2091	Af Aw BWh BWk BSh BSk Csa Cwa Cfa Cfb	n=1	●									
	2089	Af Aw BWh BWk BSh BSk Cfa Cfb	n=4	●	●	●							
	2087	Af Aw BWh BWk BSh BSk Cfa Cfb	n=3	●	●								
	2085	Af	n=2	●					●				
P3 - Middle ?Heath?	2068	Af Aw BWh BWk BSh BSk Cfa Cfb	n=4		●	●				●			
	2066	Af Aw BWh BWk BSh BSk Cfa Cfb	n=2		●								
	2064	Af Aw BWh BWk BSh BSk Csa Cwa Cfa Cfb	n=2			●							
P2 - Lower ?Heath?	2052	Af Am Aw BWh BWk BSh BSk Csa Csb Csc Cwa Cwb Cfa Cfb Dwa Dwb Dwc Dfa Dfb Dfc ET EF	n=1									●	
	2047		N/A										
	2042	Af Aw BWh BWk BSh BSk Cfa Cfb	n=5	●	●	●				●		●	

Preliminary Fungal Assemblages

P6 - Cardalitos Fm.

- Succession of mollusc and gastropod-rich shale overlain by coal with two shaly interbeds containing fossil intertebrates, followed by intertebrate-rich shale, and capped by siltstone to sandstone.
- Contains a diverse assemblage of fungal remains that are rich in helicosporous conidia, as well as didymo-ascospores (two-celled ascopores). These include *Delitschia* sp. dung fungi and the wood deay fungus *Submersisphaeria* sp.

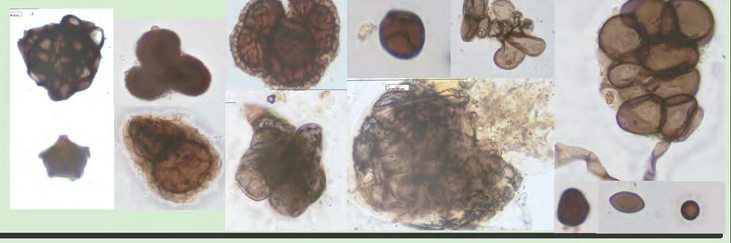


P8 - Zorritos Fm. - Not Yet Examined

P5 - Uppermost Heath Fm. - Not Yet Examined

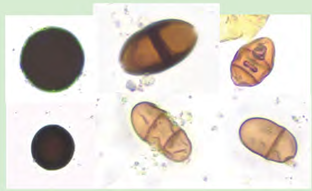
P4 - Upper Heath Fm.

- Rhythmically-bedded clay-rich siltstone with common to abundant plant
- Contain a sparse assemblage of fungal palynomorphs co-dominated by small ascospores and conidia belonging to the Xylariales and Apiosporaceae, respectively, as well as very large ornamented ascocarps, many of which contain large didymospores.



P3 - Middle Heath Fm.

- Weakly bedded clay-rich siltstone with common invertebrate and plant remains; some evidence of paleosol development toward the top of the exposure.
- Very low diversity assemblage. Dominated by large, dark brown, round amerspores. Oviod amerospores with a germ slit are lesson common, and most rarely, light brown didymo conidia occur.

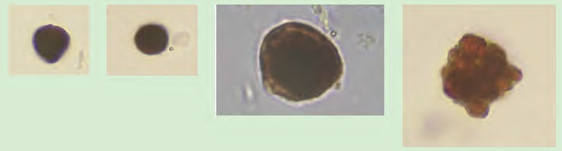


P2 - Lower Heath Fm.

Wood

Molluscs

- Rhythmically bedded clay-rich siltstone to sandstone with abundant woody remains and Molluscs. Some gypsum cement.
- Fungi are very rare; experimentation with a newly developed processing technique for gypsum (Klug, 2022) is underway to determine if it is a processing problem or an actual scarcity of fungal remains.
- Apiosporaceae are the most abundant taxa present, and forms resembling small *Arthrinium* and large *Nigrospora* are present. Rare bubils and phragmoconidia also occur.



Discussion and Future Work

Samples from the lower part of the section contain a sparse, low diversity assemblages, while the uppermost part of the section contains a series of abundant, diverse assemblages. These results may indicate that at and prior to the MCO onset, there was a low level of moisture and lower amounts of vegetation. As the climate changed throughout this time period, with increasing precipitation and vegetation (Ochoa et al., 2021) so too did the diversity and abundance of the fungi. Alternately, they may be an artifact of gypsum mineralization; on-going work will determine if recovery can be improved.

While the legacy AMOCO materials studied by O'Keefe 2017 also had barren and sparse horizons, the overall diversity was much higher, and many taxa noted in that study have yet to be identified in the present study.

Taxonomic identifications of fungi are in progress, and we expect to present revised ecological and climatological interpretations as well as more complete analyses of each segment of the study section in Fall 2023. The aim is to present this work in tandem with an on-going new biostratigraphic study to improve age control for the studied units.

Regardless of the challenges in examining this material, the initial paleoclimate reconstructions, based on relatively few taxa present in each sample, portray a warm, variably dry to moist lower portion of the exposure that becomes clearly suptropical (Cfb, Cfa) to tropical (Aw, Af) upward with increased moisture supply coeval with likely warming. While an early interpretation, it seems to support the findings of Ochoa et al. (2021).

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