Paleopalynology of the Eocene/Oligocene Transition in the White River Badlands of WY

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Abstract

The White River Formation stretches across parts of South Dakota, into Nebraska and Wyoming and terminates in Colorado. This formation contains well-preserved vertebrate fossils in sedimentary rock strata, extending from the lower layers of the late Eocene to the upper layers of the early Oligocene. During this period, there was a worldwide climate change event that caused a shift from warm and wet in the late Eocene to cooler and drier in the Oligocene. This climate shift has been previously recognized in the rock strata based primarily on the differences in fossil vertebrate types throughout this stratigraphic section. In some cases these vertebrates were going extinct, and in other cases they were expanding their evolutionary numbers. Whereas fossil plant leaves were not preserved in this specific environment, pollen and spores were, and have been used in numerous studies in nearby localities (Colorado and Nebraska) as a proxy for various environmental conditions. If climatic conditions were changing as suggested by the animal fossil record, then the pollen and spores should similarly have been changing to reflect new plant groups that were moving into this area and emerging as dominant flora. Based on standard palynological procedures, over 52 taxa of pollen and spores were identified, including pine, alder, birch, elm, asters, grasses, and several fern species. The pollen and spore data collected is indicative of an environment that was temperate with moderate rainfall. This is contrasted with the worldwide climate shift in the Oligocene where cooler, arid conditions prevailed suggesting this region of Wyoming was lagging behind the climate shift being experienced by much of the rest of the world. This data coincides well with the Antero locality of the lower Oligocene of Colorado.

Background

- Major global climate changes that occurred during the Eocene and Oligocene epochs were marked by increased aridity and an abrupt decrease in temperature
- Eocene-Oligocene Transition (EOT) cooling in nearby locality (Colorado) was correlated with Oi-1 Antarctic glaciation and global cooling trend of ~5 °C
- This climatic cooling caused vegetational and faunal changes, seen in regional extinctions of vertebrates and invertebrates
- The loss of exotic woody taxa and the increased appearance of xeric shrubland, grasses, and herbaceous taxa suggested a floristic turnover of taxa better adapted to the cooler climate

Purpose and Hypothesis

- The purpose of this study was to examine the pollen and spores in a stratigraphic sequence of sediments from the late Eocene to the early Oligocene Epochs (33-32 mya specifically) collected from the White River Formation in Wyoming, and identify ecologically significant plants that were living in this area during the time when worldwide climates were changing from temperate-moist to cool-arid.
- Hypothesis: If climatic conditions were changing, then the pollen and spores should also be changing to reflect the new plant groups that were moving into this locality and emerging as dominant flora.

Materials and Methods

- Sediment samples were collected from the White River Formation near Douglas, WY
- Sediments were sent to Global GeoLabs Ltd. in Canada and were prepared using standard palynological techniques
- Palynomorphs and cuticular material were imaged using Jenoptik Gryphax camera in conjunction with a Motic BA410E microscope
- Images were compared to various palynological publications for identification of pollen and spores
- Pollen counts were conducted to calculate distributions and relative abundance

Results

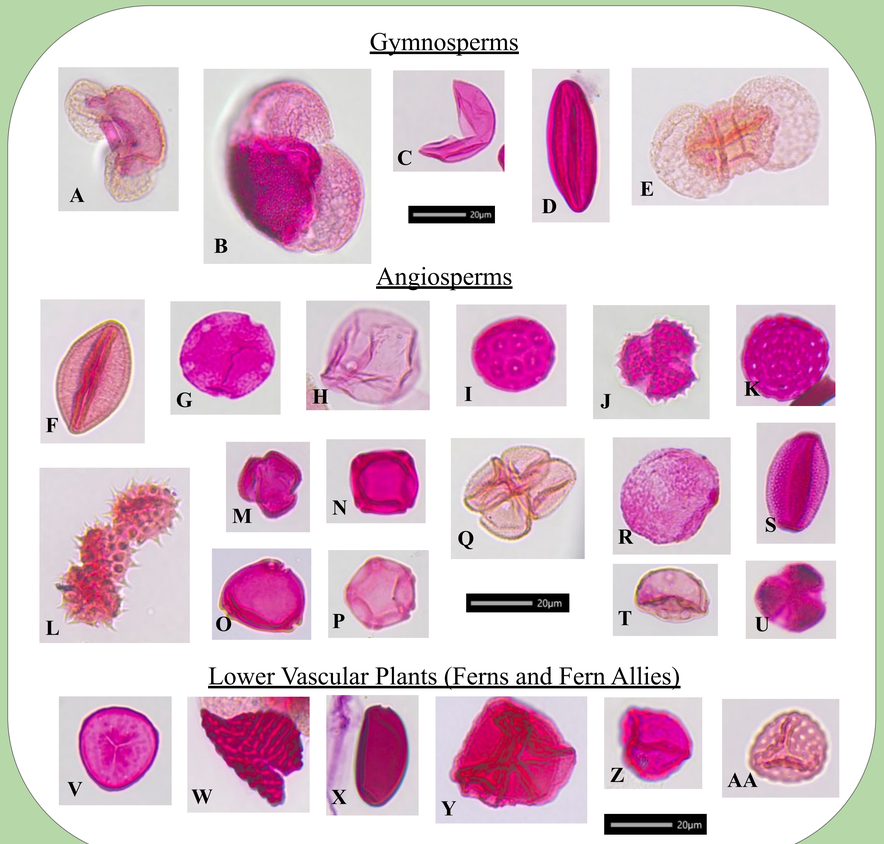

Figure 1: Significant palynomorphs used to determine paleoenvironment; **A:** Pinus, **B:** Picea, **C:** TCT, **D:** Ephedra, **E:** Podocarpus, **F:** Trilobapollis laudabilis, **G:** Ulmaceae, **H:** Poaceae, **I:** Sarcobatus, **J:** Asteraceae, **K:** Chenopodium, **L:** Compositopollenites, **M:** Artemisia, **N:** Alnus **O:** Betula, **P:** Alnus, **Q:** Populus, **R:** Rosaceae, **S:** Salix, **T:** Juglanspollenites, **U:** Acer, **V:** Laevicorpus albertensis, **W:** Cicatricosisporites, **X:** Laevigatosporites, **Y:** Selaginella-type, **Z:** Undulatosporites, **AA:** Foveosporites

Conclusions

- The identified pollen and spore data indicate an environment that was warm with moderate rainfall
- This is supported by the presence of mesic streamside elements, such as *Ulmus, Betula,* and *Salix*, and the lack of significant cool indicators such as *Abies* or *Tsuga*
- This data coincides with the Antero locality in Colorado (Leopold et al. 2019) based on the relative abundance of key pollen taxa (Figure 3)
- Worldwide climate shift towards cooler, drier conditions is not supported with the palynomorphs identified in this locality, but may support an east-to-west progression of dryland deposition (Evanoff et al., 1992)

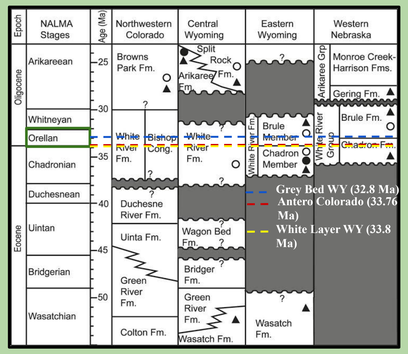

Figure 2: Stratigraphy and NALMA stages of the White River Formation in Wyoming (Fan et. al 2015)

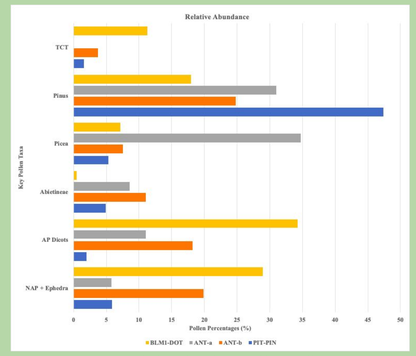

Figure 3: Relative abundance of key pollen taxa
TCT- Taxaceae/Cupressaceae/Taxodium-type pollen. Abietineae- Abies and cf. Keteleeria. AP Dicots- arboreal dicot pollen. NAP+Ephedra- other non-arboreal pollen.

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