PALEOENVIRONMENTS OF THE FORT CRITTENDEN FORMATION, SOUTHEAST ARIZONA

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Abstract

The University of Wisconsin-Stevens Point was recently asked by the Arizona Museum of Natural History (AZMNH) to analyze eleven late Cretaceous sedimentary rock samples from the Fort Crittenden Formation in southeastern Arizona for fossil pollen and other palynomorphs (Table 1). The Fort Crittenden, well-known for its Campanian faunal assemblages, outcrops in the Santa Rita Mountains near Tucson (Figure 1). In the spring of 2014, researchers affiliated with the AZMNH collected the samples from layers that harbor dinosaur and other vertebrate remains. The Fort Crittenden members are comprised of conglomerates, shales, and sandstones that are interpreted to be freshwater (fluvial and lacustrine) and subaerially-derived valley deposits. Despite ample fossiliferous faunal material and fossilized wood, little is known of the flora or the micropaleontology. To better understand the environments in which these dinosaur remains accumulated, we are using physical and chemical maceration techniques to disaggregate the rock and isolate palynomorphs. Light and scanning electron microscopy are being used for pollen identification. Experimental use of x-ray diffraction to detect cellulose presence will be tested for pollen recognition. Preliminary results show a high degree of sediment oxidation with several possible pollen and non-pollen palynomorphs that may be useful paleoenvironmental indicators.

Methods

Subsamples of the rocks were crushed into sand sized particles. Then the particles were disaggregated in distilled water and 4 ml of 10% HCl. After this was done, the mixture was tested for effervescence and the color was recorded. Next, additional 10% HCl acid was added until effervescence was completed. After washing, 10 ml of KOH was added the samples to remove organic acids. Samples were again washed and test slides made from each sample after this step. To dissolve silicates, hydrofluoric acid was added to the samples and the samples placed in a hot bath. Following HF, the samples were refilled with HCL to remove colloidal silica precipitates, then decanted and followed by a double washing with distilled water. Next, Sodium Metaphosphate (SMP) was used to disaggregate clays not removed by HF. Finally, the samples were centrifuged at low speed and the clays decanted. After a final wash, tertiary butyl alcohol (TBA) was added to dehydrate the samples and silicon oil was added to each vial and heated at low temperature to evaporate the remaining TBA. Additional silicon oil was added as needed to each sample for slide preparation.

Sample ACO4, a black shale, was found to be very rich in organic substances and additional steps were needed to dissolve suspected kerogen and other organic matter. ACO4 was split into two samples in which one was additionally retreated with KOH and hot H2O2. These additional steps did appear to lighten the sample slightly but did not clearly remove enough to reveal more pollen.

Before preservation in silicon oil, the samples were taken for SEM analysis. Using a vacuum tube and non-conductive adhesive disks, a drop of each sample was adhered to a 10 mm platform. The samples were then allowed to dry and placed in the Scanning Electron Microscope for analysis. The SEM was calibrated and used the Environmental Scanning Electron Diffraction for observation. Only sample LC01 has been analyzed to date.

Sample	Munsell color	Rock type	Site	Weight	Pollen
AC01	2.5Y 6/4	Light brown limestone	Adobe Canyon	0.5g	*Tsuga*
AC01(b)	2.5Y 6/4	Light brown limestone	Adobe Canyon	0.11g	*Pinus*
AC02	10YR 6/3	Light brown siliceous limestone	Adobe Canyon	0.5g	*Chenopodium*
AC03	2.5YR 5/4	Red shale	Adobe Canyon	0.5g	None
AC04	10YR 2/2	Black shale	Adobe Canyon	0.52g	None
LC01	5YR 6/3	Light brown mudstone	Las Cienegas	0.52g	Fungal
LC02	5YR 5/2	Light brown mudstone	Las Cienegas	0.2g	None
LC201	5YR 6/4	Reddish brown mudstone	Las Cienegas	0.13g	*Glomus sp.*
LC202	7.5YR 5/6	Reddish-brown sandstone	Las Cienegas	0.59g	None
LCA01	10YR 7/3	Tan silt and sand	Las Cienegas	0.59g	None
RDM	10YR 7/2	Light greyish white mudstone	Las Cienegas	0.2g	None
LC2 SSF	5YR 6/6	Reddish-brown sandstone	Las Cienegas	0.69g	None

Table 1: Eleven sedimentary rock samples collected by the Arizona Museum of Natural History

Figure 1: Location of Adobe Canyon and Las Cienagas, Arizona (red star).

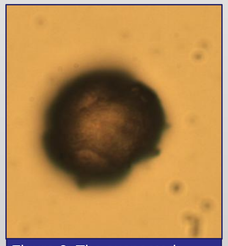

Figure 2: The suspected *Tsuga* pollen grain measuring with low resolution from sample AC01.

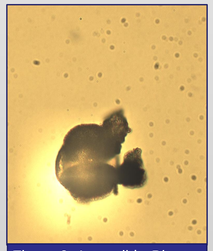

Figure 3: A possible *Pinus* grain from sample AC01B.

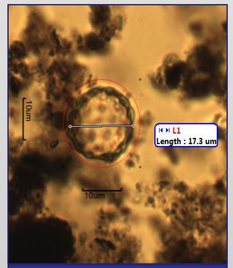

Figure 4: Light microscopy of a *Chenopodium* grain from sample AC02

Figure 5: A possible *Glomus* spore with a hyphal attachment as found by light microscopy in sample LC201

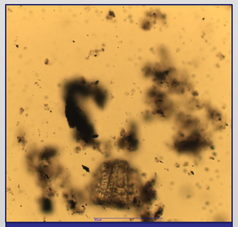

Figure 6: Plant material found in AC03

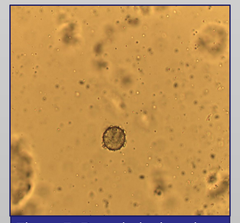

Figure 7: Rounded mineral grain found in LCA01

S.E.M. Results

Only LC01 has any conclusive results to date using the Scanning Electron Microscopy and the Energy Dispersive X-ray Spectrometer was not working properly for any analytics. Several suspect round grains were found and analyzed. Figures 8, 9, 11, and 12 display deep sculpturing typical of spores or pollen grains; however, most pteridophyte spores are at least 30 microns but these are only 5-12 microns. Due to the small size, the most reasonable explanation is fungal spores, including Figure 9. Figure 11 could possibly be a *Pinus* (or other gymnosperm) saccus displaced from the original grain because of its size and reticulate texture.

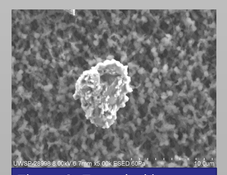

Figure 8: Fungal with remnant of a hypha attachment

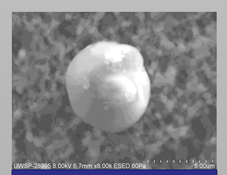

Figure 10: Fungal spore

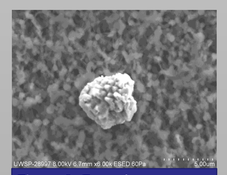

Figure 9: Fungal spore

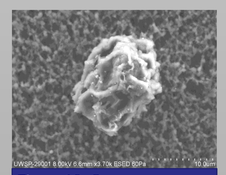

Figure 12: Gymnosperm saccus

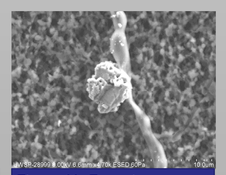

Figure 11: Fungal spore

Results

Findings were sparse using light microscopy. Isolated pollen grains were found in ACO1, ACO1B, AC04, and LC201. ACO1 (Figure 2) presented an imperfect and suspected *Tsuga* pollen grain. ACO1B (Figure 3) had a more obvious and well intact *Pinus* grain along with an unidentifiable round palynomorph. ACO2 (Figure 4) presented a well preserved *Chenopodium* grain. Lastly, LC201 (Figure 5) presented a non-pollen microfossil and a cf. *Glomus* spore with hyphal attachment (Van Geel, 2001). We see "shadows" of what appear to be palynomorphs in some samples, but the grains are too oxidized or degraded to identify. We have seen plant and insect parts which are well preserved, but there is nothing sufficiently diagnostic to be certain they are Campanian in age. AC04 (black shale) contains a lot of amorphous organic matter. There are definite remnants of what look like trilete spores in AC04, but they are eroded beyond recognition. In this case it seems that oxidation of the organic matter (and pollen) probably happened at or not long after deposition, possibly by fire, although no obvious charcoal is preserved.

The most likely explanation for a lack of palynomorphs, or the highly degraded grains we did observe, relates to the collection of the samples. We do not have much information about the field collection of the samples, but the highly weathered nature of the rock suggests they came from, or very close to, the surface. Proper collection as described by Finkelstein (2005) indicates rock samples should be collected from a depth of 40-80 cm to avoid surface oxidation and contamination. Also, as cited by Traverse (2007), the likelihood of even finding a statistically significant number of grains (200 per slide) decreases dramatically with smaller beginning samples. Due to the limited amount of rock we received, we had to use a sample size of 0.5 grams, whereas most procedures call for upwards of 5 grams. Lastly, there is evidence that some of the Fort Crittenden strata were wash layers deeply impacted by the constant presence of forest fires (Finkelstein et al, 2005). These channel environments (Finkelstein et al, 2005) were also likely to have been constantly changing and probably did not preserve pollen well.

Conclusions

Only five of the samples contained any identifiable pollen, and the strong preservation of these grains suggests they are more recent contaminants. The presence of highly eroded grains in some samples indicates strong weathering or oxidation of the microfossiliferous material. The collection of surface rocks instead of deeper samples is believed to have decreased the likelihood of finding any palynomorphs while also increasing the likelihood of contaminants present in the sample. Future attempts at palynology on these strata will require sampling below any surface weathering and inclusion of larger samples sizes.

References

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Acknowledgements

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