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Taphonomic and Depositional Analysis of Megaflora of the Cretaceous Hell Creek Formation near Marmarth, North Dakota

Nelson Mallory
Winona State University

Chelsea Ames
Winona State University

Will Franta
Winona State University

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Mallory Nelson, Chelsea Ames, Will Franta

Department of Geoscience, Winona State University, Winona, Minnesota 55987

ABSTRACT

The Hell Creek formation of western North Dakota and eastern Montana contains a large variety of plant, pollen, and vertebrate fossils. A high quality plant fossil site near Marmarth, North Dakota was studied to obtain megafloral fossils characteristic of the unit. Plant fossils from the unit were obtained, photographed, and identified so as to obtain a more thorough knowledge of the depositional environment and climate of the region during the Cretaceous period. Fossils identified indicate a forested, deltaic environment rich in water and sediment influx.

Introduction

The Hell Creek formation of Western North Dakota and Eastern Montana has long been considered one of the richest Cretaceous vertebrate fossil sources in the globe. During the Cretaceous period, a large inland sea covered much of what is now the central United States. This large waterway deposited a wide variety of lithologic facies, ranging from ash beds to coarse, cross-bedded sandstones. Many of the facies within the Hell Creek contain fossils of large vertebrate species, such as the Tyrannosaurus rex and Triceratops. While these sensational finds have given the Hell Creek its fame, much more can be learned from the plant and pollen fossils also preserved.

The Hell Creek formation and the overlying tertiary Fort Union formation provide much of the data needed to properly understand the environment of the Cretaceous period, the extinction of many Cretaceous species, and the transition to the tertiary period (Johnson, 330). While vertebrate fossils have been extensively sought after and analyzed by paleontologists, plant and pollen fossils receive far less study (Johnson, 330).

Plant fossils provide unique insight into the paleoenvironmental conditions of the Hell Creek due to their widely varied water and nutrient needs. Specific species may be indicative of a dry, plains-like environment while others may point to a swampy or shoreline location. By recording and identifying the identities and abundances of plant species in a location, a detailed picture of its former environment can be obtained.

Methods

To further understand the environmental conditions of the Hell Creek's depositional environment, a team of four students and two faulty members from Winona State University partnered with Hell Creek Fossils, LLC. Researchers visited various outcroppings of the Hell Creek formation near Marmarth, North Dakota to gather and

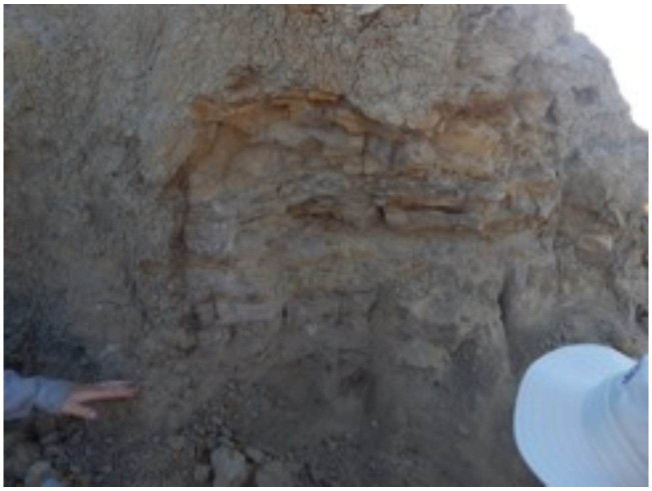


Figure 2. Fossil Site near Marmarth, ND.

document various plant, pollen, and small vertebrate fossils (figure 1). These fossils were then further analyzed by the student researchers to gain a more accurate picture of the paleoenvironment of the region.

Plant fossils were obtained from a 10 meter

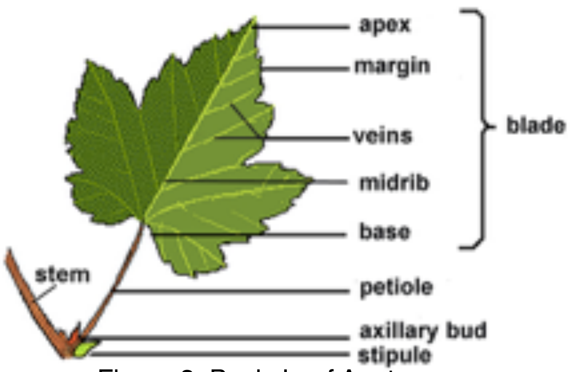


Figure 3. Basic Leaf Anatomy.

outcrop of the Hell Creek near Marmarth, North Dakota (figure 2). Matrix material was composed of a moderately sorted, medium grained, poorly indurated lithic wacke. This material was dominantly tan to yellow in color with occasional darker, red bands that were higher in iron content. Faint cross-bedding was present in the rock. These factors indicate a near-shore, aquatic environment consistent with the inland sea deposits commonly attributed to the Hell Creek formation.

Due to the fragile nature of these fossils, it was imperative that they be properly photographed so that they could be later identified. These samples would likely not have survived transport from the fossil site to the University, so nearly seventy photographs of approximately 40 samples were gathered. These photographs, taken with a Nikon L280 at 16 megapixels were then used to identify the samples by comparing them to previously identified photographs.

To properly identify each sample, four major characteristics were compared. These were leaf body size, lateral venation type, margin type, and longitudinal venation (figure 2). By comparing these factors with photographs from prior research, positive identifications were made and are listed in table 1 (Johnson 344-360). After identification, samples were grouped by class, order, family, and genus to determine relative abundances of each plant type. These abundances were then used to determine a likely depositional environment for the fossilized flora.

Data:

Table 1. Identification of Plant Fossils

Sample Number	Lowest Taxonomic Category	Alternate Identification
300	*Celastrus taurenesis*	-
301	*Celastrus taurenesis*	-
302	*Leepiercia preartocarpoides*	-
303	*Leepiercia preartocarpoides*	-
306	*Humulus**	-
313	*Hydropterus pinnata*	-
314	*Hydropterus pinnata*	-
317	*Celastrus taurenesis*	-
318	*Platanites marginata*	-
323	*Ginko adiantoides*	-
324	*Ginko adiantoides*	-
325	*Ginko adiantoides*	-
326	*Metasequoia occidentalis*	-
327	*Metasequoia occidentalis*	-
329	*Metasequoia occidentalis*	-
332	*Rhamnus cleburni*	-
333	*Grewiopsis saportana*	-
334	*Grewiopsis saportana*	*Celastrus taurenesis*
335	*Cissites puilosokensis*	-
336	*Cissites puilosokensis*	-
339	*Grewiopsis saportana*	-
340	*Cannabacae*	-
341	*Leepiercia preartocarpoides*	-
345	*Marmarthia trivialis*	*Ficus planicostata*
346	*Marmarthia trivialis*	*Ficus planicostata*
347	*Marmarthia trivialis*	*Ficus planicostata*
348	*Platanites marginata*	*Ficus planicostata*
349	*Platanites marginata*	*Cissites acerifolia*

Sample Number	Lowest Taxonomic Category	Alternate Identification
350	*Dicotyledon**	-
355, 356	*Platanites marginata*	-
358, 359, 360, 361, 362	*Platanites marginata*	-
364	*Leepiercia preartocarpoides*	-

*Not included in floral list

Table 2. Floral List for Hell Creek Fossil Site*

Class	Order	Family	Genus	Abundance %
Magnoliopsida	Rhamnales	Rhamnaceae	*Rhamnus cleburni*	3.3%
	Hamamelididae	Urticales	*Cannabaceae*	3.3%
		Plantanaceae	*Platanites marginata*	16.7%
			Leepiercia preartocarpoides	13.3%
			Celastrus tauranensis	10.0%
			Grewiopsis saportana	10.0%
	Magnoliidae	Laurales	*Marmarthia trivialis*	10.0%
			Cissites puilosokensis	6.7%
TOTAL				**73.3%**
Gymnospermopsida	Coniferalis	Taxodiaceae	*Metasequoia occidentalis*	10.0%
	Ginkogoales		*Ginko adiantoides*	10.0%
TOTAL				**20.0%**
Filicopsida	Hydropteridales	Hydropteridaceae	*Hydropterus pinnata*	6.7%
TOTAL				**6.7%**
				100.0%

*Samples denoted in table 1 with an asterisk not included due to lack of taxonomic detail

Discussion

Identifications of the plant fossils obtained from the site were used to determine relative abundances of each species and their corresponding families. The dominant family, Magnoliopsida, comprise 73.3% of the total fossil plant population. The second most abundant family, Gymnospermopsida, contained 20% of the species identified and the family Filicopsida comprised the remaining 6.7%. The two most abundant species, in order, were *Platanites marginata* (16.7%) and *Leepiercia preartocarpoides* (13.3%). Single-lobed Dicotyledons were the most dominant morphotype found.

The plant site was found to be highly dominated by taxa from the family Magnoliopsida. These plants, related to the modern magnolia tree, grow in a wide variety of conditions*. High relative abundances of plants in this family, commonly referred to as dicotyledons, are common to Hell Creek deposits (Johnson. 341.) The presence of the conifer *Metasequoia occidentalis* and *Ginko adiantoides* indicate a location capable of supporting a large spectrum of plant types. In addition to the fossil identities, the high quality of preservation is indicative of a wet, forested environment consistent with the deltaic deposits seen throughout the unit (Johnson, 388).

Conclusions

To better understand the plant species of the Hell Creek, and specifically at this site, it is necessary that a much larger number of plants be identified, catalogued, and examined. By obtaining a highly detailed data set for the identities and abundances of plant types, a more accurate picture of the environment of this Hell Creek site can be constructed. Additionally, by unifying megafloral identification with that of pollens and microfossils, it is possible to assemble a highly detailed picture of the Hell Creek and its climate in the Cretaceous period. Pollens and vertebrate fossils show much about climate conditions and the ability of the location to support vertebrate life. By determining the paleoenvironment of the Hell Creek formation, valuable information about the evolution and extinction of the dinosaurs, the development of modern plant life, and the Earth's response to changing climatic conditions can be gathered and examined.

References

Johnson, Kirk R. "Megaflora of the Hell Creek and Lower Fort Union Formations in the Western Dakotas: Vegetational Response to Climate Change, the Cretaceous-Tertiary Boundary Event, and Rapid Marine Transgression." *Geological Society of America.* Special Publication 361 (2002): 329-72. Web.

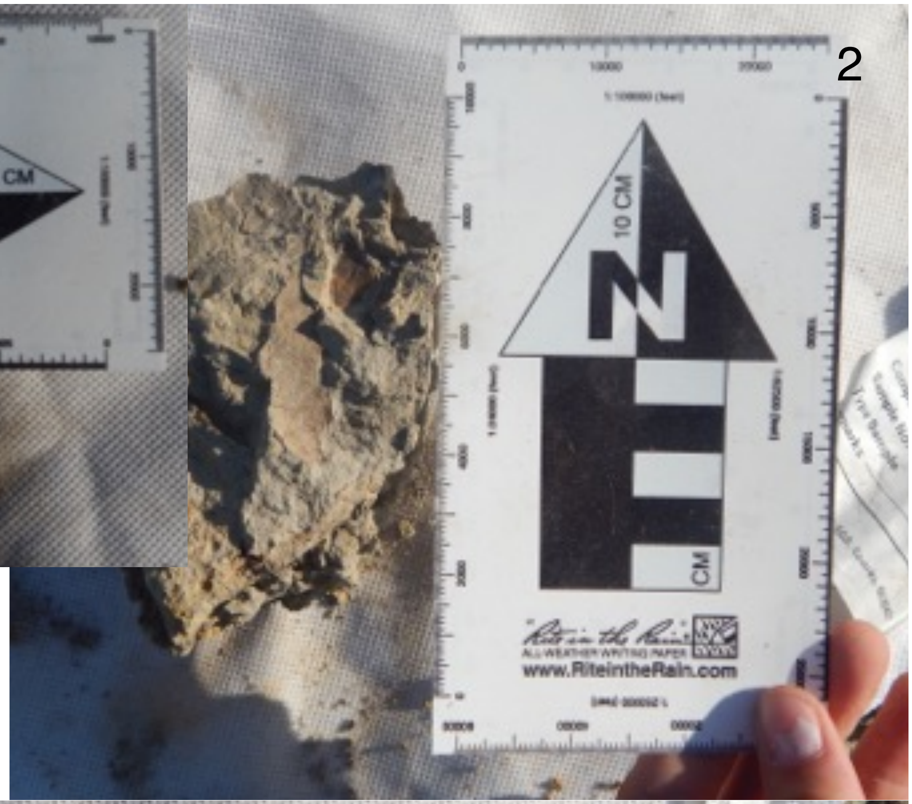
"The Leaf: Site of Photosynthesis & Transpiration." *Leaf Overview.* University of Miami, n.d. Web. 12 Jan. 2016.

Appendix One. Plant Fossil Identifications and Photos.

1. 299. Celastrus taurenesis.
2. 300. Celastrus taurenesis.
3. 301. Leepiercia preartocarpoides.
4. 302. Leepiercia preartocarpoides.

*Indicates uncertain identification

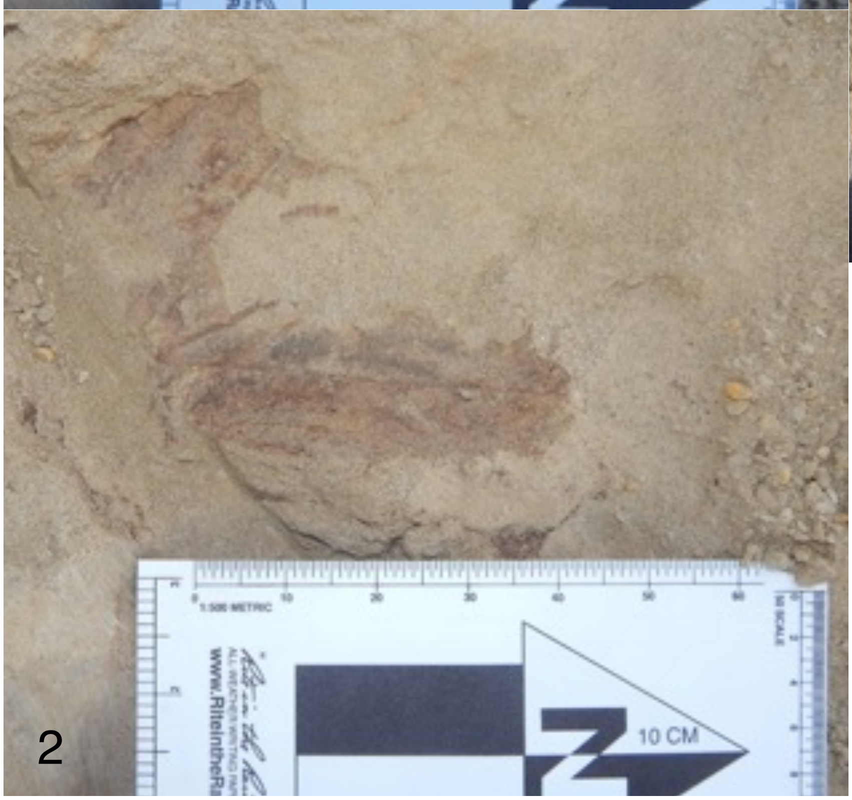
1. 306. Rhamnus cleburni
2. 313. Grewiopsis saportana
3. 314. Grewiopsis saportana
4. 317. Celastrus taurenesis
5. 318. Platanites marginata



1. 332. Rhombus cleburni.
2. 333. Grewiopsis saportana.
3. 334. Grewiopsis saportana.

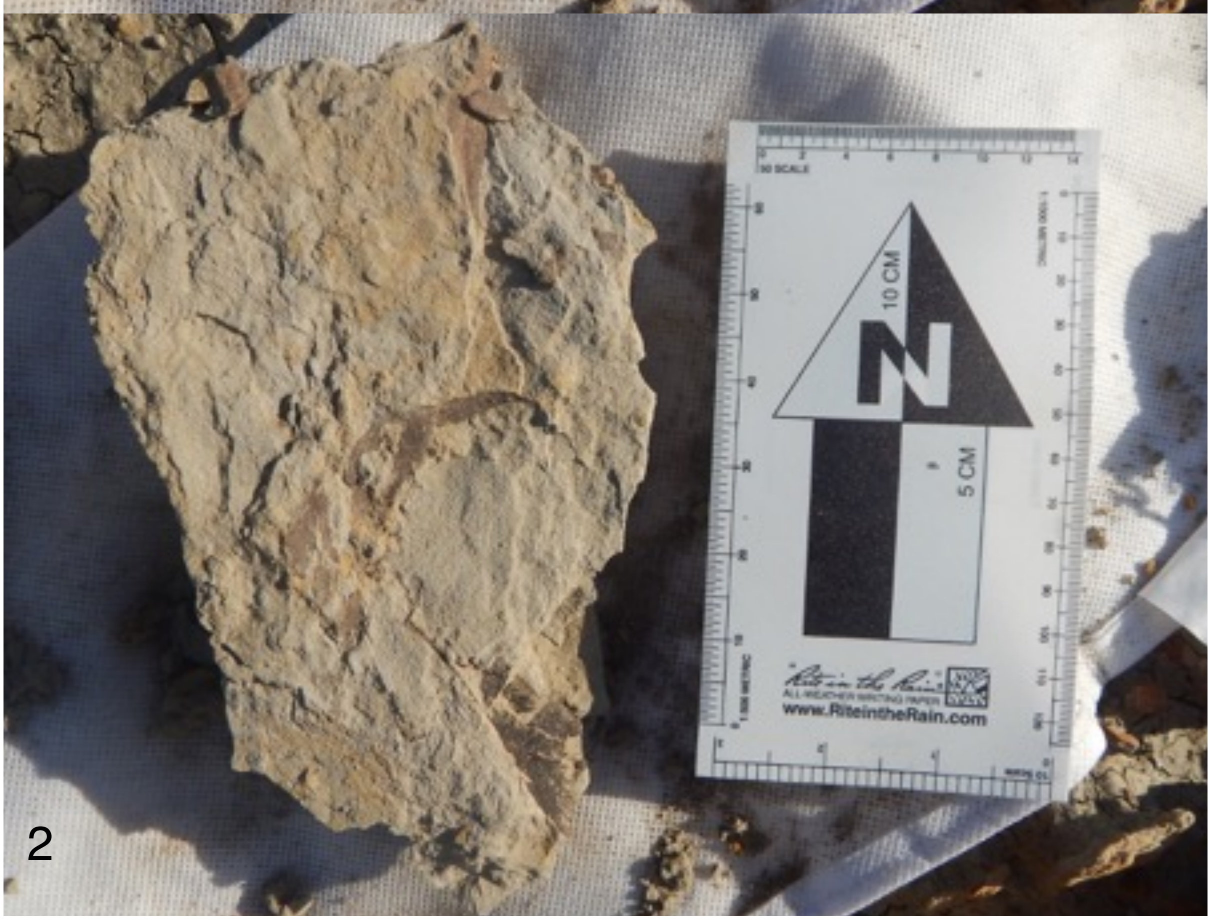
1, 2, 3. 323, 324, 325. Ginko adiantoides.

4, 5, 6. 326, 327, 329. Metasequoia occidentalis.

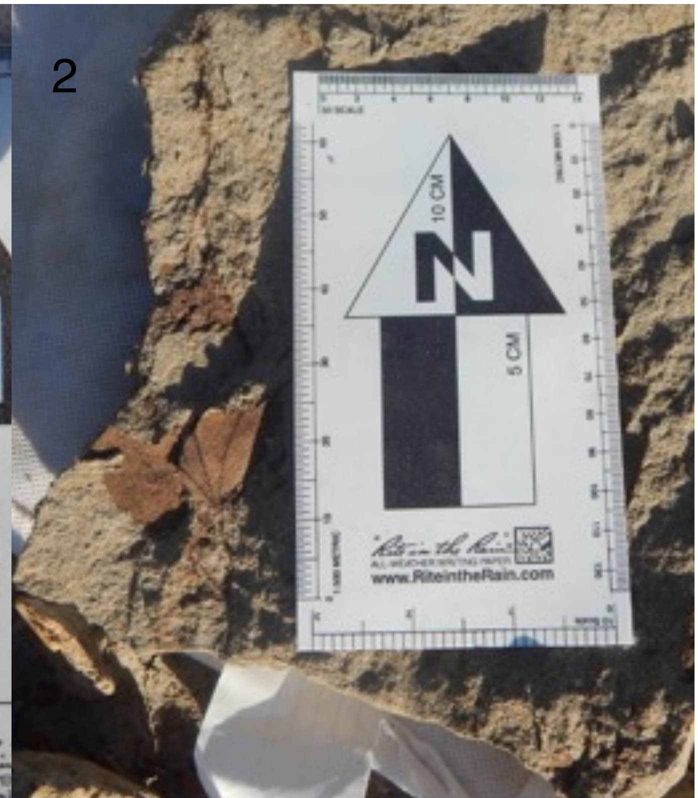


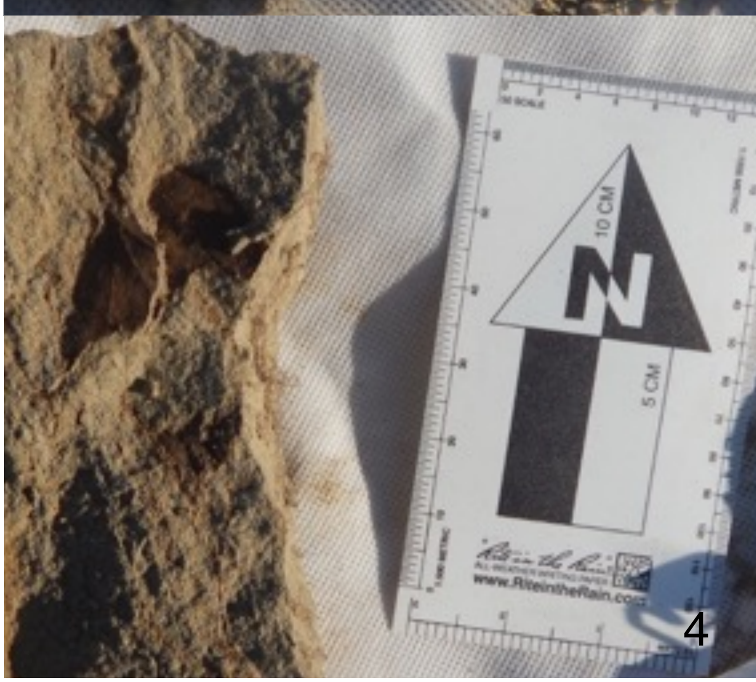
1. 335. Cissites puilosokensis.
2. 336. Cissites puilosokensis.
3. 338. Cissites puilosokensis.*

*unclear identification



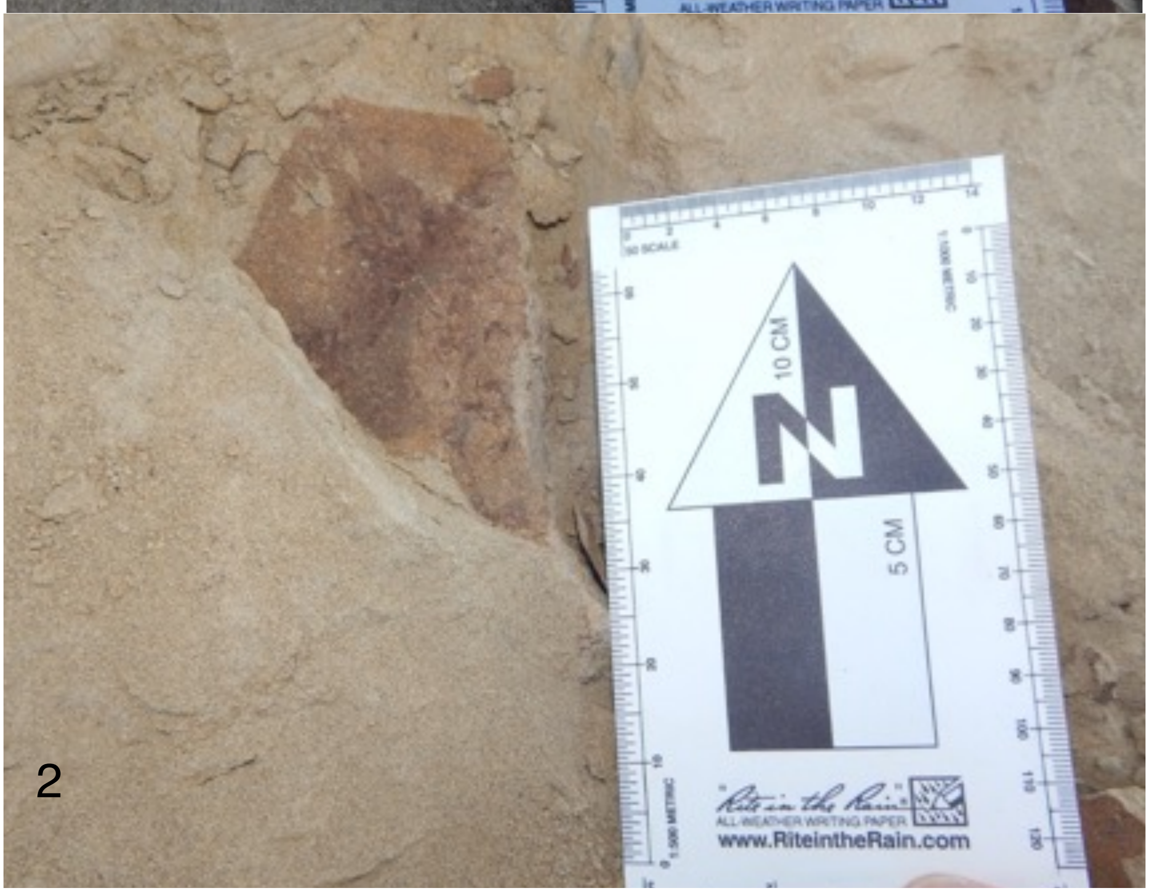
1. 339. Grewiopsis saportana.
2. 340. Cannabacae.





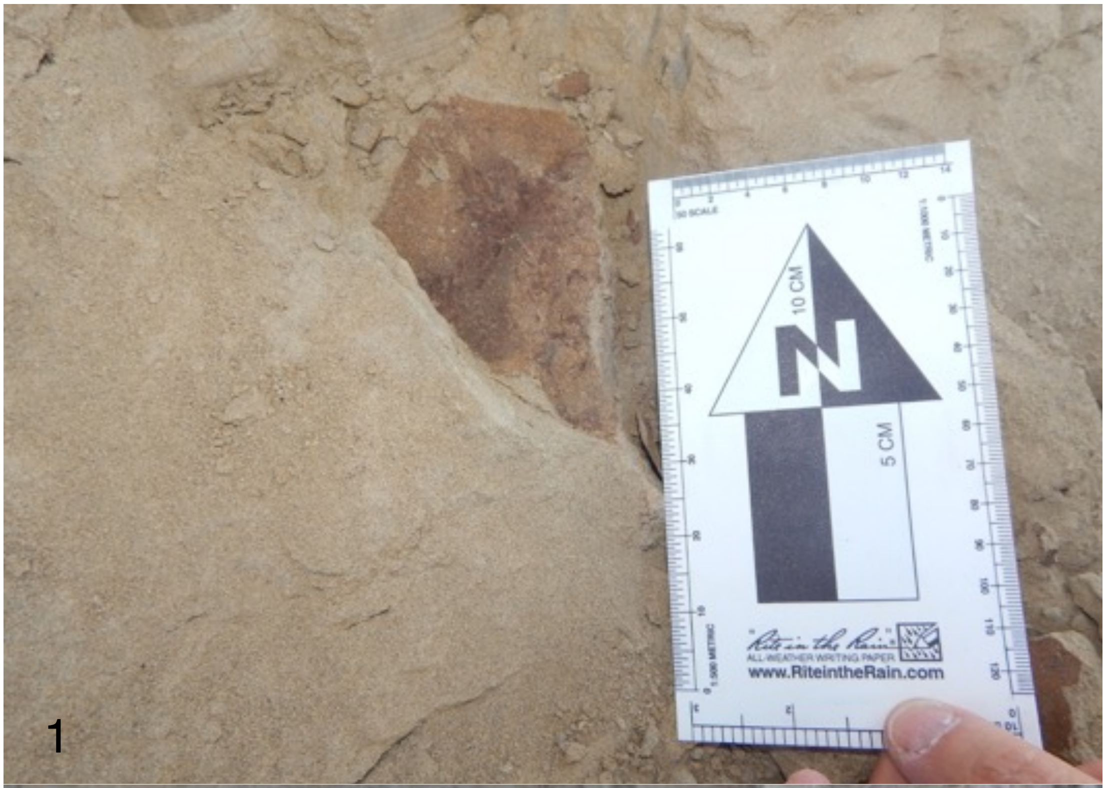
1. 341. Leepiercia preartocarpoides.
2. 345. Marmarthia trivialis.
3. 346. Marmarthia trivialis.
4. 347. Marmarthia trivialis.

1. 348. Platanites marginata.
2. 349. Platanites marginata.
3. 350. Dicotyledon, unknown.



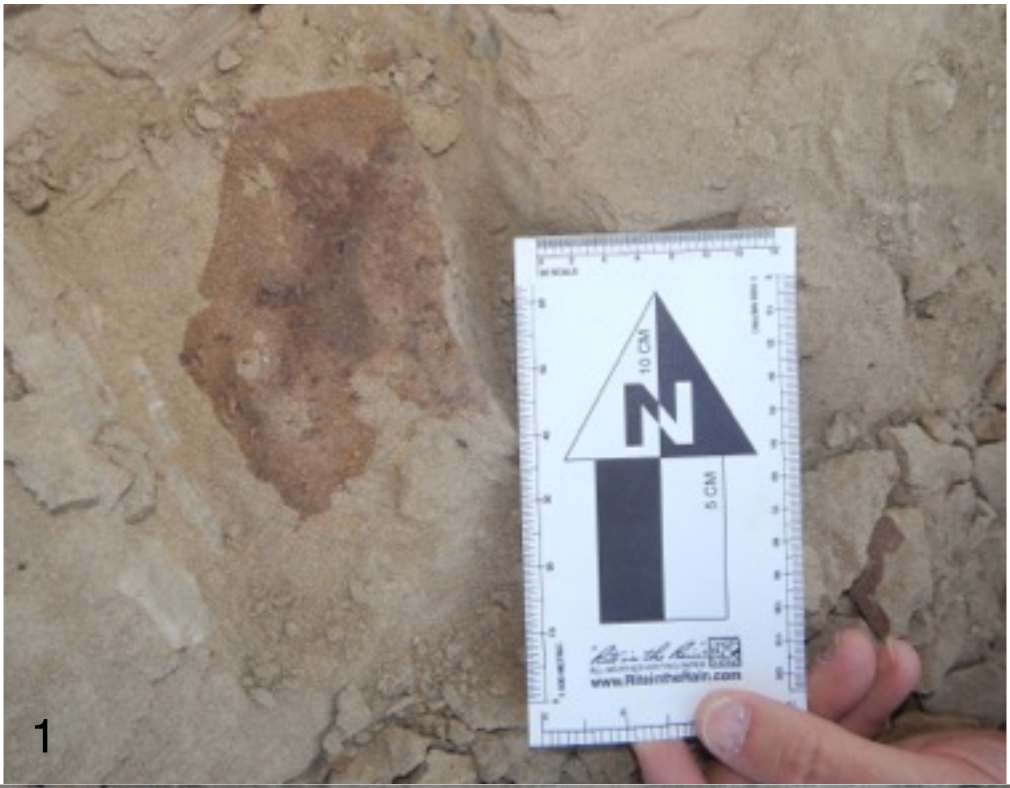
1. 355. Platanites marginata.

2. 356. Platanites marginata.



1. 358. Platanites marginata.

2. 359. Platanites marginata.



1. 361. Platanites marginata.

2. 362. Platanites marginata.

1. 364. Leepiercia preartocarpoides.